Critical Care Canada Forum 2019
Abstracts
## Contents

"We Are Preventing Pneumonia and Saving Lives, One Clean Mouth at a Time": A Content Analysis of the Use of Research Evidence in Support of Oral Health Claims Made in Clinical Educational Materials Produced by Industry ................................................................. 6

A Prospective Cohort Study of Cognitive Function in ICU Survivors Using the Cambridge Brain Sciences 6-Test Battery (CBS-6) ......................................................................................................................... 7

A Rare Case of New Onset Refractory Status Epilepticus (NORSE) with Extensive Mesial Temporal Sclerosis .............................................................................................................................. 9

A Rare Case of Trimethoprim Induced Drug Reaction with Eosinophilia and Systemic Symptoms (Dress) Leading to Acute Liver Failure Requiring Liver Transplantation 10

A Scoping Review of Passive Exercise in Healthy Subjects and ICU Patients .......... 12

Acute Herpes Simplex Supraglottic Infections of the Neonate: Report of Stridor and Respiratory Distress in a 6-Day-Old Female ........................................................................................................ 14

Advancing Implementation Science in Alberta’s Critical Care Community and Supporting a Learning Health System through Collaboration: The Provincial ICU Delirium Initiative ........................................................................................................ 16

Agitation, Confusion and Aggression in Critically Ill trAumatic Brain Injury Patients – a Pilot Cohort Study (ACACIA-PILOT) ..................................................................................................................... 21

Analysis of Operational Costs of Bronchoscope Usage in the Queen Elizabeth II Health Sciences Centre Medical-Surgical Intensive Care Units ......................................................... 19

Association Between Cause of Death and Organ Yield in Organ Donation After Circulatory Death in Canada .......................................................................................................................... 20

Baseline L-ascorbic acid levels in OVATION65 ................................................................ 23

Biomarkers and Lung Ultrasound to Predict Pneumonia in Patients of Lung Laceration or Contusion After Traumatic Chest Injury ................................................................. 24

Cardiac Arrest & CPR Quality in a Tertiary PICU: Recognition, Challenges & Opportunities .............................................................................................................................. 27

Chlorhexidine Locking Device for Central Line Infection Prevention in ICU Patients: an Open-Label Pilot and Feasibility Randomized Controlled Trial ..................................................................... 29

Clinical and Social Implications of Acetaminophen Intoxication: A Retrospective Study ................................................................................................................................................ 31

Clinically Significant Gastrointestinal Bleeding Events: Development and Validation of an Electronic Detection Algorithm and Application in a Population-Based Retrospective Cohort Study of Adult Critically Ill Patients in Alberta ........................................ 32

Corticosteroid Therapy in Deceased Liver Donation ....................................................................................... 33

Creating Personalized Patient Paintings to Ease Family Grief after Critical Illness: The ARTICU Project ........................................................................................................................................ 37

CT-Perfusion for Neurological Diagnostic Evaluation: Study Update of a Prospective Multicenter Diagnostic Test Study ........................................................................................................ 38
Current Diagnostic Approaches to Patients with Hypernatremia at University Health Network Hospitals .................................................................40
Development of a Clinical Guide for Identifying Spiritual Distress in Family Members of Patients in the Intensive Care Unit ........................................42
Diagnosis of Ventilator-Associated Pneumonia in Mechanically Ventilated Adult Patients: A Systematic Review and Meta-Analysis ........................................44
Drug Utilization Evaluation of Chlorothiazide in a Paediatric Quaternary Centre .....46
Efficacy and Safety of Intravenous Iron in Critically Ill Patients: A Systematic Review and Meta-Analysis ...........................................................................48
Emergent Spinal Drain Placement Rapidly Improves Neurological Deficits in Anterior Spinal Artery Syndrome ............................................................52
EPICC: The Evaluation of Post Intensive Care Unit Clinics in Canada ....................54
Esophageal Pressure Guideline in the Intensive Care Unit .......................................56
Evaluation of Clinical Features and Prognostic Factors in Critically Ill Patients with Rheumatic Diseases ............................................................................................57
Evaluation of Immunosuppression and Pneumonia Following Endothelin 1-Induced Stroke ...........................................................................................................59
Feasibility of a Multicentre Trial of Stress Ulcer Prophylaxis in Critically Ill Children60
Frailty and Associated Outcomes Following Invasive Mechanical Ventilation ..........61
Hemorrhagic Shock from Bleeding Pseudoaneurysm of Deep Circumflex Iliac Artery After Abdominal Paracentesis .................................................................62
High Flow Nasal Cannula Compared to Conventional Oxygen Therapy or Non-Invasive Ventilation in The Immediate Post-Extubation Period: A Systematic Review and Meta-Analysis ..................................................65
High Flow Nasal Cannula Oxygen Therapy: Mechanisms Driving the Physiological Effects ..............................................................................................................67
Implementation and Evaluation of an Experiential Randomized Trial Activity for High School Students ..................................................................................69
Implementation of an Intensive Care Registry in India (IRIS): Barriers and Opportunities ...................................................................................................................73
Improving Mobility in Critically Ill Adults in a Lower-Middle Income Country: Opportunities and Challenges .................................................................74
Introducing High School Students to Critical Care: 2nd Annual Interactive Workshop ...............................................................................................77
Introduction and Evaluation of a Novel Clinical Decision Support Tool to Improve Extubation Decision-Making in the ICU ...................................................80
Liberation from PICU-Acquired Complications – A Bi-Center Implementation Study83
Long-Term Clinical Outcomes and Health Care Costs of Canadian Adults with Sepsis: A Population-based, Retrospective Cohort Study .................................86
Mechanical Ventilation in ARDS Patients Managed With and Without VV-ECMO .....87
Methicillin-Resistant Staphylococcus Aureus (MRSA) Isolation in the Hospital Setting, a Necessity or Double Whammy? .................................................................88

Mir-187 Regulation in Primary Cardiomyocyte and Murine Model of Experimental Sepsis-Induced Myocardial Dysfunction .........................................................89

New-Onset Atrial Fibrillation and Associated Outcomes and Resource Utilization Among Critically Ill Adults ................................................................................90

Optimal Strategy and Timing of Left Ventricular Venting During Veno-Arterial Extracorporeal Life Support for Adults in Cardiogenic Shock - A Systematic Review and Meta-Analysis ........................................................................................................92

Outcomes and Costs Following Extracorporeal Membrane Oxygenation in Critically Ill Adults – A Population-Based Cohort Study ..................................................97

Outcomes and Costs Following Extracorporeal Membrane Oxygenation in Critically Ill Pediatric Patients – A Population-Based Cohort Study ........................................99

Outcomes and Costs of Patients with Cirrhosis Admitted to Intensive Care Unit ...101

PEDIATRIC VIRTUAL CRITICAL CARE Pilot Study: A Qualitative Assessment Survey ......................................................................................................................102

Peri-Operative Hypertensive Urgencies; Etiologic Factors and Therapeutic Modalities Used ...............................................................................................................105

Predicting Delirium in ICU Patients Using Time Series Physiological Data and Convolutional Neural Networks ...................................................................................107

Predicting Safe Liberation from Venovenous Extracorporeal Life Support in Patients with Severe Acute Respiratory Distress Syndrome ................................................................109

Preliminary Results of the Incidence, Predictors, and Recovery of Post-Extubation Dysphagia in Critically Ill Patients ..............................................................................112

Prone Position Enhances Regional Homogeneity at High and Low Peep Assessed by Direct Pleural Pressure Measurement .................................................................114

REACT: A Pre-Clerkship Bootcamp to Improve Student Knowledge and Interest in Critical Care Specialties ..........................................................................................117

Reducing Hyperoxia in the Critical Care Unit: A Quality Improvement Initiative......120

Resumption of Diaphragmatic Activity After Intubation Often Occurs with a Pattern Consistent with Reverse Triggering .........................................................................122

Reverse Triggering, A Missed Phenomenon in the Literature ...................................125

Sedative, Analgesic and Neuromuscular Blocker Use in TBI Patients Admitted to Canadian ICUs: A Multicenter, Observational Study .....................................................127

Sex-Specific Prevalence, Correlates and Outcomes of Frailty in Critically Ill Patients .............................................................................................................................129

Single-Centre Evaluation of Differential Leukocyte Ratios as Biomarkers of Mortality in Patients with Acute-On-Chronic Liver Failure Admitted to the Intensive Care Unit .................................................................................................................................131

Skeletal Troponin I In Serum and Diaphragmatic Ultrasound in Mechanically Ventilated Intensive Care Unit Patients: A Prospective Observational Study ..............133
Spirituality and End-of-life Wishes in the ICU: A Multicenter Quantitative Analysis of the 3 Wishes Project.................................................................................................................134
Survival Outcomes of Cancer Patients Who Experience a Code Blue ..................135
Targeting the NO-sGC Axis to Monitor and Treat Vascular Dysfunction and Vasoplegia in Sepsis ........................................................................................................137
The Cerebral Perfusion Index: Developing a Novel Model of Cerebral Perfusion in the Intensive Care Unit ...........................................................................................................139
The ICU Family Education on Delirium (iFAM-ED) Study: Educating Family Caregivers of Critically Ill Patients to Prevent, Detect and Manage Delirium ....141
The PROMIZING Study Enrolment Algorithm May Be a Useful Clinical Tool for Early Identification of Patients Ready to Liberate from Mechanical Ventilation ........143
Through the Video Lens: Art as Healing for Grieving Family Members ...............145
Trainee Conceptual Understanding of Cardiac Physical Examination .................147
Trends in Opioid Use Before Critical Illness Among Elderly Patients in Ontario ...149
Understanding Decision Making in Organ Donation - A National Study: Progress Update .................................................................................................................................152
Updates from the Canada-DONATE Data Link Survey: National Efforts to Link Donor and Recipient Data for Research in Canada ..............................................154
Urinary Biomarkers of Acute Kidney Injury in the Ovation-65 Trial: A Nested Analysis of the Urinary Proteome ............................................................157
Vein of Galen Malformations Presenting as Neonatal Heart Failure ....................159
What is Known About Parental Attitudes Towards Participation in Pediatric Critical Care Research? A Scoping Review ...........................................................162
"We Are Preventing Pneumonia and Saving Lives, One Clean Mouth at a Time": A Content Analysis of the Use of Research Evidence in Support of Oral Health Claims Made in Clinical Educational Materials Produced by Industry

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Background: Oral health care comprises a unique nursing accountability and an essential intervention to oral health deterioration and pneumonia in critically ill patients. Due to insufficient pre- and post-licensure education in oral health care, industry has become a principle source of information about oral health products. Nurses may look to pharmaceutical and device manufacturers for education to inform oral care delivery supported by scientific evidence. To date, there has been little research into the evidence-based claims within industry-provided educational resources accessible to nurses.

Objective: To investigate the amount, type and accuracy of citation use in support of oral health product-related claims from industry-authored educational materials targeted at critical care nurses.

Methods: Two researchers independently sampled educational offerings from the websites of four major international device manufacturing companies (Avanos, Intersurgical, Medline, and Sage Products). Documents (web pages, downloadable documents, videos, etc.) were included if they were produced and/or authored by the company, focused on oral health conditions and/or practices, targeted at clinicians, and identified as related to education. Based on previous analyses of drug and device claims in advertising, we created a data extraction tool in Redcap with three sections: products, product-related claims, and citations supporting the claims. Each instrument went through pilot phases until we reached an acceptable level of agreement. Two independent coders extracted data and assessed whether the evidence in the citation supported the product-related claims. Coding discrepancies were discussed and resolved with a third author. A descriptive analysis of the findings was carried out using Excel.

Results: 69 documents met inclusion criteria (9 Avanos, 10 Intersurgical, 7 Medline, 43 Sage/Stryker). Products were divided into three categories: pharmaceutical products (oral rinses, moisturizers, etc.), devices (bite blocks, toothbrushes, suction catheters, etc.) and combination products (e.g., oral care kits designed for up to 24 hours use). Document formats included web pages providing information about a particular health outcome (such as ventilator-associated pneumonia), continuing education courses, instructional videos, posters and hospital protocol templates.

Preliminary analysis based on a random sample of documents (n=19, 28%) found that 100% of these documents made efficacy claims. Of 110 claims extracted so far, 51% (56) were not cited. We found 284 total citations representing 90 unique sources, 40% of which were published more than 10 years ago (range 1975-2008). Preliminary analysis of claims with citations demonstrates limited supports for efficacy claims due to inappropriate study design (e.g., non-randomized study), contained statistically non-significant findings, or related to a non-critical care study population (e.g. long term care).

Conclusion: The findings of this study indicate that claims made by device manufacturing companies are not always supported by evidence, and when they do reference evidence, it is not always current or valid. Critical care nurses should critically appraise claims provided by manufacturers. Device manufacturing companies need to be held to a higher level of accountability through the development of policies that draw a clearer line between marketing and education.

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A Prospective Cohort Study of Cognitive Function in ICU Survivors Using the Cambridge Brain Sciences 6-Test Battery (CBS-6)

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Introduction: Long-term cognitive impairment is a common consequence of critical illness (1). Various instruments are often used to assess cognitive function in intensive care unit (ICU) survivors. Cambridge Brain Sciences (CBS) is a 12-test, web-based, self-administered neurocognitive test battery that has been widely validated in various patient populations. We previously conducted a pilot feasibility study to show that the CBS battery to assess cognition in ICU patients is feasible and that the 6-test version of the battery (CBS-6) was adequate in detecting cognitive impairment relative to the 12-test battery (2).

Objectives: We conducted a prospective cohort study to describe the cognitive performance of ICU survivors using the CBS-6 battery.

Methods: We recruited adult (≥ 18 years of age) ICU patients who were intubated for a minimum of 24 hours and had recovered from critical illness from two ICUs in London, Ontario. Patients who were actively delirious, or had a documented history of dementia or neurological diseases were excluded. Demographic and disease-related characteristics were recorded from patients’ medical records. Patients completed the CBS-6 while in the ICU or shortly after discharge from ICU. Z-scores were calculated using age- and sex-matched normative data for each CBS-6 test and for three cognitive domains: short-term memory, reasoning skills, and verbal skills.

Results: Thirty-six ICU survivors (12 women) underwent cognitive testing. Median age was 56.5 years (IQR: 45.25, 63.75), median MODS was 6 (IQR: 4, 8), and median ICU length of stay was 8 days (IQR: 5, 14.25). Twenty-four patients were tested in the ICU and 12 were tested within 1-4 days of transfer to ward. All but two patients were impaired on at least one test and 32 of 36 were impaired on at least two tests. Patients were impaired on a median of 3 tests (IQR: 2.25, 4). Patients' performance on all 6 CBS tests are shown in Figure 1 and performance on the cognitive domains are shown in Figure 2.

Conclusion: The CBS-6 can help detect cognitive impairment in ICU survivors. Patients were impaired on all CBS-6 tests and all 3 cognitive domains (short-term memory, reasoning skills, and verbal skills). Longitudinal studies using the CBS-6 can establish the natural history of cognitive impairment in ICU survivors.

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Figure 1: Patients' performance on all 6 CBS tests

Figure 2: Patients' performance on the cognitive domains
A Rare Case of New Onset Refractory Status Epilepticus (NORSE) with Extensive Mesial Temporal Sclerosis

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Objective: To highlight the management of NORSE in a Neuro ICU setting.

Introduction: A 46-year-old man with no pertinent past medical history was transferred to our hospital with status epilepticus (SE). Prior to and immediately after transfer, EEGs performed showed continuous seizure activity with a right temporal focus that secondarily generalized. First line AEDs, including levetiracetam and phenytoin, were ineffective requiring intubation and use of continuous EEG. Despite the use of propofol, midazolam, ketamine, and pentobarbital, EEG recordings were consistent with super refractory SE. A hypothermia protocol for 72 hours was unsuccessful as was high dose steroids and 5 days of plasmapheresis. SE was refractory to multiple attempts to wean him from anesthetic medications and resulted in a protracted hospitalization and eventual death.

Methods: Retrospective chart review.

MRI brain: No acute intracranial abnormalities.
EEG: As mentioned above.
CSF: 9 WBC with lymphocytic predominance, protein 38 and glucose 66.
Meningitis/Encephalitis panel: Negative.
Paraneoplastic panel: Negative
Autoimmune panel: Negative
Autopsy: Evidence of extensive mesial temporal sclerosis with no neurons visualized in the CA1 region of the hippocampus.

CT TAP: Negative

NORSE has been described as a manifestation of an underlying infectious, autoimmune, or paraneoplastic disorder. There have been no proven effective therapies for this disorder. However, a combination of the above-mentioned therapies has been effective previously in achieving burst suppression and weaning from anesthetic medication without refractory seizures. Mesial temporal sclerosis found postmortem in our patient highlights the ability of Super refractory SE to cause parenchymal injury to hippocampal structures likely involved in the persistence of continuous discharges in NORSE and highlights the challenges in achieving seizure control. In addition, infectious complications from excessive anesthetic use possess further challenges with choice of management, especially when it pertains to plasmapheresis.
A Rare Case of Trimethoprim Induced Drug Reaction with Eosinophilia and Systemic Symptoms (Dress) Leading to Acute Liver Failure Requiring Liver Transplantation

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Case: 22-year-old Caucasian female transferred from the emergency department of her local hospital to King's College Hospital (KCH) Liver Intensive Therapy Unit (LITU) after presenting with deranged liver enzymes. She had a 3-week history of fluctuating malaise, sweats, myalgias, fevers, and macular rash. She was prescribed trimethoprim for acne 4 to 6 weeks prior to her onset of symptoms. There was no contributory past medical, family, or social history.

On admission to LITU, the patient was hemodynamically stable with no signs of encephalopathy. Physical examination revealed jaundice, widespread macular rash, axillary and cervical lymphadenopathy, and hepatosplenomegaly. Investigations revealed an ALT of 4143 IU/L, AST of 5895 IU/L, ALP of 246 IU/L, total bilirubin of 120 μmol/L with conjugated bilirubin 84 μmol/L, platelets of 106 × 10^9/L, INR of 4.45, serum creatinine of 129 μmol/L, and urea of 12.5 μmol/L. Arterial blood gas showed pH 7.40, glucose 5.2 mmol/L, bicarbonate 19.2 mmol/L, lactate 8.2 mmol/L and arterial ammonia 126 μmol/L. Work up for etiology of acute liver injury was negative. CT of the abdomen and pelvis showed inhomogeneous liver parenchyma, periportal oedema, collapse of the central quadrant, a spleen of 16 cm, and generalized lymphadenopathy. N-acetylcysteine was started for the acute liver injury. DRESS was suspected as a possible cause.

One day after admission, the patient developed grade 4 hepatic encephalopathy, hypotension, worsening renal dysfunction, and worsening hyperammonemia. Tracheal intubation and mechanical ventilation, vasopressor support, and continuous veno-venous hemodialysis were commenced. Over the following 48 hours, biopsies of the skin and lymph nodes were performed and histology confirmed DRESS. Pulsed methylprednisolone was added to the treatment regimen. No clinical or biochemical improvements were seen and emergent listing for liver transplantation was deemed appropriate.

Orthotopic liver transplantation occurred on the fifth day of her LITU admission. Histology of the explanted liver showed features consistent with a hepatocellular type drug-induced liver injury. Post-operatively, the patient steadily improved and was extubated on post-operative day 5 and dialysis was discontinued on post-operative day 7. Transfer to the ward occurred on post-operative day 8.

Discussion: DRESS represents a severe idiosyncratic cutaneous response to medications that also has systemic involvement in the form hematologic and solid organ dysfunctions. There is usually a latency period from exposure to the drug and onset of clinical symptoms. Drugs commonly associated with DRESS include anticonvulsants and antibiotics. Liver involvement is the most common internal organ involvement in DRESS. Liver injury can be cholestatic, hepatocellular, or mixed. Although liver involvement is usually mild, severe impairment progressing to acute liver failure (ALF) can rarely occur.

Management of DRESS typically requires withdrawal of the suspected offending medication and supportive care. Although systemic corticosteroids have been used to treat DRESS with liver injury, there is currently no consensus on their use in such cases. Ultimately, lifesaving liver transplantation may be required and a few cases have been reported in the literature with good post-transplant outcomes. Our case adds to the body of literature regarding DRESS-induced acute liver failure requiring rescue liver transplantation.
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A Scoping Review of Passive Exercise in Healthy Subjects and ICU Patients

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Introduction: Early mobilization of intensive care unit (ICU) patients has been found to decrease patients’ hospital and ICU length of stay [1], decrease delirium duration [2], and increase ambulation distance at hospital discharge [3]. These early mobilization studies often combine the use of both passive and active exercise [2–4], with passive mobilization used when patients are unable to actively participate. Although early mobilization has been deemed to be safe and feasible in ICU patients [4, 5], few studies in ICU cohorts focus solely on passive exercise. Given the critically ill nature of these patients, it is important to have a comprehensive understanding of early passive exercise and its dosage on hemodynamic, metabolic, perfusion, and patient outcomes, and to contextualize the responses of ICU patients when compared to healthy subjects, to guide its application in ICU settings.

Objectives: 1) To determine common methodologies used to conduct early passive mobilization studies in ICU patients and healthy subjects, and 2) To identify commonly measured outcome parameters following passive exercise

Methods: We conducted a search of Ovid Medline and Embase to identify potentially relevant articles. We included studies that reported global hemodynamic parameters, measures of cerebral perfusion and cardiac function, local limb blood flow, and clinical outcomes in adult ICU patients and healthy subjects. We extracted the following data from each study: primary objective, study design, patient population assessed, modality of passive exercise used, protocol of passive exercise implemented, hemodynamic parameters, metabolic parameters, cerebral blood flow/perfusion parameters, measures of cardiac function, local blood flow, and clinical outcomes.

Results: Most studies on passive exercise were conducted in healthy subjects, with only eight of fifty-two studies including ICU cohorts. In both healthy and ICU cohorts, a wide variety of passive exercise modalities were used with the most common two modalities being passive cycling and passive leg movement. Passive exercise in ICU patients was primarily conducted in the supine and semi-recumbent positions, while studies in healthy subjects were mainly conducted in upright, seated positions. Protocols used in both healthy and ICU subjects varied greatly in intensity, duration and frequency, and lacked a standardized method for determination of exercise dose in either cohorts. In healthy subjects, hemodynamic and metabolic responses were heterogeneous, and remained so even when accounting for age, sex, modality, and exercise dosage. Passive exercise in ICU patients did not elicit changes in mean arterial pressure, however, the remainder of hemodynamic and metabolic findings were either heterogeneous or inconclusive due to the small number of studies that reported these outcomes, and no ICU studies have yet reported outcomes on cardiac function nor brain perfusion.

Conclusions: Dosage of passive exercise remains yet to be standardized, in either healthy subjects or ICU patients. Furthermore, impact of passive exercise on organ function and long-term outcomes in ICU patients is poorly understood. Given the increased interest the use of early passive exercise in ICUs, along with heterogeneity of hemodynamic responses we have seen in both healthy and ICU subjects, it is important to further investigate the impact that passive exercise and its dosage will have on outcomes in ICU patients.
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Acute Herpes Simplex Supraglottic Infections of the Neonate: Report of Stridor and Respiratory Distress in a 6-Day-Old Female

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Introduction: Stridor in the newborn period suggests an anatomical deformity, such as tracheo-laryngomalacia or airway hemangiomas. By contrast, older children with laryngotracheitis (known as “croup”) have viral infections, such as human parainfluenza virus, influenza virus, or, atypically, herpesviridae (HSV). We report a neonate with stridor and respiratory distress from a supraglottic HSV-type 2 (HSV2) infection.

Case Description: A 6-day-old, ex-full term female, admitted for phototherapy treatment of jaundice, unexpectedly developed stridor, hypoxia, and respiratory distress. Her prenatal course had been complicated by maternal houselessness, tobacco use, trichomonas infection (status-post treatment), and hepatitis C; other routine prenatal testing was negative. Vaginal delivery was complicated by a prolonged rupture of membranes. Prior to admission, her mother did report some “squeakiness”; her respiratory exam had been normal. When administration of nebulized racemic epinephrine and 4 L/min of oxygen via high flow nasal canula failed to improve symptoms, she was transferred to the pediatric intensive care unit (PICU) for further management.

In the PICU, the baby received 0.5 mg/kg of intravenous (IV) dexamethasone and noninvasive positive pressure ventilation (NIV), leading to resolution of her symptoms. After flexible fiberoptic laryngoscopy demonstrated swelling, erythema, and crème-colored plaques on the epiglottis and bilateral arytenoids, empiric therapy of IV acyclovir at meningitic dosing was initiated. Tissue samples collected later via microlaryngoscopy and bronchoscopy (see figures 1 and 2) revealed “ulcerations/viral cytopathology consistent with HSV,” and were positive for HSV2 via PCR testing. Blood PCR testing for HSV was negative and cerebral spinal fluid (CSF) PCR testing was deferred due to patient instability – however, when done on day 18 of acyclovir treatment, it was negative. The patient was treated IV acyclovir for 21 days, 13 of which were in the PICU on NIV. She was discharged home with 6 months of oral acyclovir suppression therapy. 3 weeks after its completion, however, she developed lethargy, vomiting, and a bulging fontanelle, and was discharged home on continued oral valacyclovir prophylaxis. She is currently being evaluated for TLR3-deficiency.

Discussion: 5 cases of neonatal HSV croup have been reported. Each baby was born vaginally at term, with no history of maternal HSV. Each case presented with stridor but no fever between day of life 6 to 24. Bronchoscopy revealed lesions similar to those illustrated here, including supraglottic erythema and edema, with white plaques on the false cords, arytenoids, epiglottis, and pharynx. All were positive for HSV2. 4 babies required intubation. Treatment duration with IV acyclovir ranged from 10-45 days, however two of the babies required foscarnet therapy due to persistent viral shedding and one received two months of oral valacyclovir. One infant required readmission for HSV2 encephalitis – treated with 3 weeks of IV acyclovir – while the other 4 cases had uncomplicated post-neonatal courses.

Conclusion: In addition to anatomical malformations, the presentation of stridor in the neonatal period should raise concern for viral croup, including HSV. Such babies can be supported on NIV while they receive antiviral therapy.
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Figure 1

![Image](attachment:image1.png)

Figure 2

![Image](attachment:image2.png)
Advancing Implementation Science in Alberta’s Critical Care Community and Supporting a Learning Health System through Collaboration: The Provincial ICU Delirium Initiative

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Introduction/Background: Alberta’s critical care community consists of 20 adult and pediatric intensive care units (ICU) within Canada’s largest province-wide integrated healthcare system, that admits >12,800 patients/year, has 280 ICU beds and more than 2,400 multidisciplinary staff. Alberta’s Critical Care Strategic Clinical Network™ (CCSCN™) is a collaborative clinical strategy group that functions to bring together the perspectives of all stakeholders (including patients and family members) to co-develop care innovations to achieve improvement in patient outcomes and satisfaction, improve access to healthcare, eliminate evidence care gaps, and contribute to the sustainability of Alberta’s health system. ICU delirium was collaboratively identified as a priority area by frontline clinicians, medical and operational leaders, researchers, and patients and families. In Alberta, delirium affects over 42% (>5,400) of ICU patients/year and is directly associated with significant morbidity, mortality, longer hospital stays and increased resource utilization.

Objectives: The objectives of the Provincial ICU Delirium Initiative were to: 1) improve quality of care and minimize unnecessary practice variations by co-developing and implementing clinical standards, pathways, and best practices for ICU delirium care; 2) develop and disseminate improvement tools for audit and feedback; and 3) promote a collaborative learning health system and culture of continuous quality improvement.

Methods: Implementation of the ICU Delirium Initiative occurred from 09/2016 to 03/2019, and used an Innovative Learning Collaborative (ILC) methodology with five Learning Collaboratives, that included a Learning Session (LS) followed by an Action Period. The five individual Learning Sessions (LS) focused on quality improvement, change management skills and building capacity for and knowledge of implementation science. Each LS brought together multidisciplinary ICU teams from across the province to learn, network, strategize and plan for improvement using a score carding methodology. Each ICU had a multi-disciplinary implementation team of frontline, physician and operational staff. Implementation was supported by the CCSCN™, site visits, metrics and targets, and monthly audit and feedback.

Results: Screening for delirium, using a validated screening tool, increased from 50% (2015) to >90% (2019) in adult ICUs, and from no screening process (2015) to 63% (2019) in pediatric ICUs. Pain assessments in pediatric ICUs increased from 51% to 86%. And the proportion of patient days where adult patients were delirious decreased from 32% to 22%. Cost avoidance yield to date is estimated to be approximately $750,000 annually and is anticipated to increase with full implementation. One of the most noteworthy outcomes is the emergence of a collaborative practice culture in Alberta ICUs; a province-wide change that has occurred where frontline staff are engaged in the review of their data, performance, and patient outcomes.

Conclusion: The process of the provincial collaboration and the utilization of ILC methodology for implementing delirium best practice has advanced implementation science knowledge and skills, and contributed to the development of a collaborative learning culture within the Alberta critical care community. This increased capacity will be leveraged for and adapted to other large-scale initiatives and could accelerate quality improvement efforts in the future.
Agitation, Confusion and Aggression in Critically Ill trAumatic Brain Injury Patients – a Pilot Cohort Study (ACACIA-PILOT)

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Introduction: Agitated behaviours (AB) constitute hallmark behaviours of intensive care unit (ICU) patients recovering from traumatic brain injury (TBI). These behaviours create significant challenges for patients and healthcare providers including the need for pharmacologic treatment, delaying mechanical ventilation weaning and mobilization, and complicating bedside care. AB have been reported during the early stage of hospital recovery, but there are no data specific for the ICU setting as well as no clinical definition or assessment tools. In addition, the predictors, clinical phenotypes and impact of AB on clinical outcomes have yet to be described. Before moving towards a multicenter cohort study, we need to assess feasibility and pilot the screening of AB, and confirm study procedures.

Objectives: The main objective of this pilot study was to evaluate the feasibility of conducting a larger prospective cohort study of AB in critically ill TBI patients.

Methods: This was a prospective single center feasibility cohort study. Patients 18 years and older admitted to the ICU of Hôpital du Sacré-Coeur de Montréal with a mild complex, moderate or severe TBI were eligible. Exclusions criteria included: complete spinal cord injury, prior history of TBI, major neurological or psychiatric disease, high risk of short-term mortality, expected stay < 48 hours. Patients or substitute decision maker were approached for consent and study inclusion began within 48 hours of TBI. The primary outcome was feasibility defined as a recruitment rate greater 2-4 patients per month, more than 90% of AB logs completed and 90% actigraphy adhesion. Secondary outcomes included the incidence of agitation (RASS 2 or more) and characterisation of behaviors using subcategories of the nursing logs during ICU stay. Bedside nurses documented 14 possible pre-defined components AB with observation logs every 8-hour shift as well as RASS scores. Bedside video recordings were used to validate documentation log comprehension. Sleep-wake cycle monitoring and agitation was measured using wrist actigraphy.

Results: Between September and July 2019, a total of 127 patients were screened for study inclusion. A total of 47 patients were deemed eligible and 30 patients were recruited (64% consent rate and 3 patient/month recruitment rate). In 11 patients, consent was denied whereas in 6 others, no substitute decision maker was available. A total of 80 patients were excluded with the main reasons being: 1) screening beyond 48 hours following TBI (26 patients); 2) expected stay of less than 48 hours (19 patients); 3) imminent withdrawal of life support (13 patients); 4) past history of TBI (7 patients). The median age and APACHE 2 score were 64.5 years (IQR 41.3) and 16.5 (IQR 9.25), and 73% were men. TBI were severe, moderate and mild complex in 30%, 43% and 27% of cases, respectively. Falls (50%) and motor vehicle accidents (43%) were the main causes of TBI. In total, 96% of AB observation logs were completed and 100% of patients were monitored with actigraphs. During the ICU stay, a total of 17 patients developed agitation (57%). Restlessness, disorientation and violent behaviour were reported by nurses in 42.9%, 23.9% and 12.9% of 8-hour shifts.

Conclusion: This study confirmed the feasibility of a larger cohort study. Enabling inclusion
within 72 hours of TBI and exploring a differed consent could increase recruitment rates. Preliminary analysis suggests AB are frequent and problematic.

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Analysis of Operational Costs of Bronchoscope Usage in the Queen Elizabeth II Health Sciences Centre Medical-Surgical Intensive Care Units

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Background: Flexible bronchoscopy is a commonly performed procedure in intensive care units (ICU) and is associated with significant costs. Recently authors have raised concerns regarding the safety and cost-effectiveness of commonly used reusable bronchoscopes (Mehta & Gildea, 2018). Single-use bronchoscopes have been promoted as a solution to these problems, but the cost-benefit balance varies by institution depending on usage rates, disinfection procedures, local practice patterns and protocols, among other factors (Sohrt et al, 2018).

Objectives: We sought to evaluate the operational costs of currently used reusable bronchoscopes at two tertiary care intensive care units to inform resource needs and future procurement as part of a departmental quality improvement project.

Methods: Bronchoscope usage rates, and operational costs, including maintenance/repair, disinfection costs and non-reusable components, were calculated over a thirty-month period and compared to projected costs of single-use bronchoscopes.

Results: Bronchoscopies were conducted 8-13 times monthly in both ICUs with estimated operational costs of $300-380 per usage. The single greatest component of bronchoscope costs was repair and maintenance which comprised as much as 80% of all costs, with disinfection practices making up the second most costly component, comprising less than 25% of total operational costs. The expected costs of single-use bronchoscopes were comparable to the costs of operating the reusable bronchoscopes during the period analyzed.

Conclusion: In addition to helping inform future bronchoscope purchases in the intensive care units, this project highlighted several areas for quality improvement within the intensive care units studied. These included practices of documentation, financial record-keeping, and guideline-based infection control practices. The project had significant limitations including incomplete data availability, 30-month period of study, and lack of comparison of clinical performance of each bronchoscope system however it does provide valuable information that can inform future capital purchases.

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Association Between Cause of Death and Organ Yield in Organ Donation After Circulatory Death in Canada

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Introduction: Anoxic brain injury is the most common diagnosis leading to organ donation after neurologic determination of death (NDD) in Canada. Frequency and associations between causes of death and organ yield are unclear among donation after circulatory death (DCD) donors.

Objective: To describe the distribution of causes of death in DCD donors and the association between etiology of death and organ recovery.

Methods: Thirty-two Canadian hospitals participated in the prospective observational Canada-DONATE cohort study, enrolling 622 consecutive deceased adult organ donors (NDD and DCD) from 2015 to 2018. Data was collected prospectively, recording including: donor characteristics; medical history; primary cause of death; donor management interventions; organ donation specific therapies and death determination procedures, from one day prior to donation consent up to the time of organ recovery or the time that all organs are declined. We limited this analysis to DCD donors only. We defined patient descriptors (independent variables) by the primary cause of death. For this exploratory analysis, we determined the mean number of organs recovered for donation from those donors who were ultimately able to donate organs (dependent variable) and assessed the relationships between cause of death and other patient descriptors to the number of organ recovered using Chi-square analyses, the Student-T test or the Kruskal-Wallis test, as appropriate.
**Results:** Of 215 DCD donors, 155 (72.1%) had organs allocated prior to withdrawal of life sustaining therapies and 110 (51.2%) had at least one organ recovered. Mean DCD donor age was 53.6 ± 14.1 and 37.2% were female. Sixty-five (30.2%) had anoxic brain injury, 56 (26.0%) traumatic brain injury, 53 (24.7%) brain hemorrhage, 19 (8.8%) ischemic stroke, and 22 (10.2%) had other diagnoses leading to organ donation (e.g.; meningitis, cancer) (Table 1). Donor interventions were comparable between groups (Table 2). The average number of organs recovered per enrolled donor was 3.5 ± 1.6 with ischemic stroke, 3.1 ± 1.3 with TBI, 2.6 ± 1.1 with brain hemorrhage, 2.5 ± 1.0 with anoxic brain injury, and 2.4 ± 0.7 for other diagnoses (p = 0.05) (Table 3).

**Conclusion:** Anoxic brain injury is the most prevalent diagnosis leading to circulatory determination of death among deceased donors. In contrast to NDD, among DCD donors there is no apparent association between cause of death and organ recovery for transplantation. One potential explanation for these findings may be the potential impact of clinical judgment in the identification and selection of potential DCD donors.

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### Table 1: General characteristic of 215 DCD donors

|                     | Anoxic brain injury N=65 | Traumatic brain injury N=56 | Brain hemorrhage N=53 | Other N=22 | Ischemic stroke N=19 | p-value |
|---------------------|--------------------------|-----------------------------|-----------------------|------------|----------------------|---------|
| Age (years), mean (SD) | 51.8 (13.7)              | 50.4 (15.7)                 | 61.3 (8.7)            | 53.6 (14.6) | 47.5 (14.9)         | < 0.001 |
| Male, n (%)          | 43 (66.2)                | 40 (71.4)                   | 29 (54.7)             | 11 (50.0)  | 12 (63.2)           | 0.28    |
| BMI, mean (SD)       | 27.4 (6.6)               | 26.7 (4.8)                  | 29.2 (10.5)           | 27.6 (7.5) | 29.6 (7.0)          | 0.40    |
| Days in ICU before consent, mean (SD) | 5.0 (4.0)               | 5.0 (4.8)                   | 4.9 (6.8)             | 10.4 (8.8) | 8.3 (12.9)          | 0.03    |
| Comorbidities, n (%) |                          |                             |                       |            |                     |         |
| Hypertension         | 16 (25.0)                | 14 (26.9)                   | 23 (43.4)             | 8 (36.4)   | 5 (27.8)            | 0.23    |
| Smoking history      | 21 (32.8)                | 9 (17.3)                    | 14 (26.4)             | 5 (22.7)   | 1 (5.6)             | 0.11    |
| Diabetes             | 10 (15.6)                | 5 (9.6)                     | 10 (18.9)             | 3 (13.6)   | 4 (22.2)            | 0.61    |
| Coronary artery disease | 5 (7.6)                 | 3 (5.8)                     | 4 (7.5)               | 2 (9.1)    | 2 (11.1)            | 0.91    |
| Hepatitis B, C or HIV | 5 (7.6)                 | 5 (9.6)                     | 2 (3.8)               | 1 (4.5)    | 0                    | 0.66    |
| Baseline P/F ratio, mean (SD) | 268.4 (148.9)      | 296.2 (135.4)               | 338.8 (206.0)         | 224.8 (132.6) | 371.6 (304.4) | 0.03    |
| Highest Creatinine, final study day, umol/L, mean (SD) | 102.2 (105.4)        | 83.0 (51.6)                 | 102.6 (141.4)         | 110.3 (116.5) | 98.1 (71.8) | 0.79    |
| Highest Urea, final study day, mmol/L, mean (SD) | 11.3 (7.0)          | 9.4 (5.2)                    | 11.0 (12.2)            | 14.2 (9.9)  | 12.2 (8.9)        | 0.31    |
| Highest AST, final study day, U/L, mean (SD) | 171.9 (299.0)      | 138.5 (259.7)               | 65.2 (59.6)            | 287.1 (721.4) | 65.6 (44.9) | 0.08    |
| Highest ALT, final study day, U/L, mean (SD) | 199.8 (444.9)      | 92.6 (169.4)                | 53.9 (44.4)            | 346.3 (987.2) | 93.2 (94.6) | 0.04    |
| Highest Bilirubin, final study day, umol/L, mean (SD) | 11.7 (8.7)          | 18.8 (32.8)                  | 19.2 (41.2)            | 34.5 (50.5)  | 10.8 (5.7)        | 0.06    |
### Table 2: Treatments, from the day of consent to organ donation to the final day in study

| Treatment                          | Anoxic brain injury N=65 | Traumatic brain injury N=56 | Brain hemorrhage N=53 | Other N=22 | Ischemic stroke N=19 | p-value |
|-----------------------------------|--------------------------|------------------------------|----------------------|-------------|----------------------|---------|
| Vasopressors, n (%)               | 30 (46.2)                | 29 (51.8)                   | 25 (47.2)            | 11 (50.0)   | 9 (47.2)             | 0.98    |
| Sedative agents n (%)             | 59 (90.8)                | 54 (96.4)                   | 49 (92.5)            | 20 (90.9)   | 18 (94.7)            | 0.76    |
| Analgesic agents n (%)            | 54 (83.1)                | 54 (96.4)                   | 49 (92.5)            | 19 (86.4)   | 18 (94.7)            | 0.12    |
| Tidal volume (ml/kg PBW), mean (SD)| 8.2 (2.2)                | 8.6 (3.4)                   | 8.9 (2.6)            | 8.0 (2.2)   | 8.0 (2.7)            | 0.46    |
| Recruitment maneuvers, n (%)      | 41 (63.1)                | 33 (58.9)                   | 33 (62.3)            | 7 (31.8)    | 13 (68.4)            | 0.09    |
| Enteral nutrition, n (%)          | 53 (81.5)                | 41 (73.2)                   | 34 (64.2)            | 16 (72.7)   | 13 (68.4)            | 0.32    |
| Corticosteroids, n (%)            | 36 (55.4)                | 38 (67.9)                   | 36 (67.9)            | 13 (59.1)   | 12 (63.2)            | 0.58    |
| Thyroid hormone, n (%)            | 5 (7.7)                  | 12 (21.4)                   | 3 (5.7)              | 1 (4.5)     | 3 (15.8)             | 0.06    |
| Heparin bolus, n (%)              | 43/47 (91.5)             | 40/43 (93.0)                | 33/37 (89.2)         | 11/14 (78.6)| 12/13 (92.3)         | 0.61    |
| Donor management duration (hrs), mean (SD) | 33.6 (15.1) | 38.5 (17.1) | 34.6 (16.9) | 26.6 (11.9) | 35.0 (11.1) | 0.35 |

### Table 3: Organ outcomes from DCD donors

| Organ                | Anoxic brain injury N=65 | TBI N=56 | Brain hemorrhage N=53 | Other N=22 | Stroke N=19 | p-value |
|----------------------|--------------------------|----------|-----------------------|-------------|-------------|---------|
| Potential donors, n (%) | 65 (30.2)                | 56 (26.0) | 53 (24.7)             | 22 (10.2)   | 19 (8.8)    | 0.43    |
| Actual donors, n (%)         | 39 (60.0)                | 30 (53.6) | 28 (52.8)             | 8 (36.4)    | 11 (57.9)   | 0.05    |
| Number of organs recovered per actual donor, mean (SD) | 2.5 (1.0) | 3.1 (1.3) | 2.6 (1.1) | 2.4 (0.7) | 3.5 (1.6) | 0.09 |
| Organs recovered          |                          |          |                       |             |             |         |
| Lungs (single)            | 0 (0.0)                  | 0 (0.0)  | 0 (0.0)               | 0 (0.0)     | 1 (3.3)     | 0.09    |
| Lungs (double)            | 10 (15.4)                | 10 (17.9) | 11 (20.8)            | 2 (9.1)     | 6 (31.6)    | 0.41    |
| Liver                   | 7 (10.8)                 | 14 (25.0) | 5 (9.4)               | 1 (4.5)     | 4 (21.1)    | 0.06    |
| Kidneys (single)          | 2 (3.1)                  | 2 (3.6)  | 2 (3.8)               | 0           | 2 (10.5)    | 0.54    |
| Kidneys (double)          | 33 (50.8)                | 27 (48.2) | 22 (41.5)            | 7 (31.8)    | 9 (47.4)    | 0.57    |
| Pancreas                | 2 (3.1)                  | 3 (5.4)  | 0 (0.0)               | 0 (0.0)     | 1 (5.3)     | 0.39    |
Baseline L-ascorbic acid levels in OVATION65

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Introduction: Some evidence suggests that pharmacologic norepinephrine increases oxidative stress [1, 2] and low plasma ascorbic acid (AA) levels have been associated with higher C-reactive protein [3]. In OVATION65, patients with vasodilatory hypotension are randomized to permissive hypotension vs. usual care. Our overall goal is to determine whether lower norepinephrine exposure via permissive hypotension reduces organ injury to a greater extent in patients with low baseline AA. Our first step was to measure baseline plasma AA levels in OVATION65 participants and healthy volunteers.

Objectives: Describe baseline plasma L-AA in 1) OVATION65 participants and 2) healthy volunteers; 3) determine associations between baseline L-AA and prespecified baseline and outcome variables in OVATION65 participants.

Methods: This analysis includes 65 OVATION65 participants from 7 Canadian hospitals. Patients were ≥65 years old with vasodilatory hypotension, ≤12 hours since vasopressor initiation and anticipated to remain on vasopressors for ≥6 more hours. Exclusion criteria included acute spinal cord or brain injury; acute hemorrhage, ventricular failure or post-cardiopulmonary bypass vasoplegia; <1 year since solid organ transplantation; extracorporeal life support at baseline; lacking commitment to life-sustaining therapies; previous enrollment in OVATION65; and lack of physician equipoise. Patients were randomized to permissive hypotension (mean arterial pressure [MAP] target 60-65 mmHg) or usual care. We determined the association between baseline AA, measured immediately after randomization, and APACHE II score, duration of ICU stay, and the worst (lowest) MAP/vasopressor (VP) index during the first 24 hours following randomization (MAP and VP doses were measured hourly). AA was also measured in 11 healthy volunteers. All blood samples were collected in K2-EDTA vacutainers, packaged on ice, centrifuged within 1 hour and stored at -80°C. AA levels were measured using liquid chromatography with tandem mass spectrometry (LC-MS/MS). Analyses were blinded to group allocation.

Results: The mean age of OVATION65 participants was 75 years (standard deviation [SD] 7), and 24 (37%) were women. The mean APACHE II and clinical frailty scale scores were 24 (SD 6) and 4 (SD 1), respectively. Median (interquartile range [IQR]) duration of ICU stay was 6 (3-11) days. Median worst MAP/VP index was 465 (150-835) mmHg/µg/kg/min. Median (IQR) baseline AA level was 0.88 (0.0-0.95) µmol/L; 26/65 (40%) had a level below the detectable threshold (0.25 µmol/L). We found no association between AA and the 3 prespecified variables. In healthy volunteers, median (IQR) L-AA was 36 (29-43) µmol/L.

Conclusion: Using LC-MS/MS, AA levels in volunteers were comparable to those reported in other studies using high performance LC (HPLC), but levels were lower in OVATION65 participants compared to other cohorts of critically ill patients [3]. Current results preclude the evaluation of associations between baseline AA levels and outcomes. Further analyses of AA stability at different stages of sample processing are required to determine if and how samples may have been compromised.
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Biomarkers and Lung Ultrasound to Predict Pneumonia in Patients of Lung Laceration or Contusion After Traumatic Chest Injury

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Introduction: Pneumonia may present as a life-threatening infection with uncertain progression and response to treatment after lung laceration in traumatic chest injury patients. Early detection and initiation of antimicrobial agents are of utmost importance to save life.

Objectives: The objective of this study is to know whether biomarkers (procalcitonin and C reactive protein) and lung ultrasound can predict pneumonia in traumatic lung laceration patients as the literature is deficient in this regard.

Methods: This is a prospective observational study of 34 patients having traumatic lung laceration or contusion on computed tomography scan. Patients who had a clinical pulmonary infection score (CPIS) ≥ 5 (excluding microbiology variable) were included in this study. Patients with microbiologically confirmed pneumonia and consolidation on CT at admission were excluded from the study. Serum procalcitonin (PCT), N terminal brain natriuretic peptide (NT-Pro BNP), C-reactive protein (CRP) and culture of blood, sputum/endotracheal aspirate were sent within 8 hours of study inclusion. Twelve points lung ultrasound was also performed by intensivist at bedside within 8 hours of inclusion. Presence of consolidation in lung parenchyma and or air bronchogram were considered pneumonia. Sputum or endotracheal aspirate (ETA) culture ≥ 10⁴ was considered as confirmed diagnosis of pneumonia.

Results: Incidence of pneumonia was 32% (11/34) with the majority being male (91%). Patients with pneumonia and without pneumonia had PCT, CRP and NT-Pro BNP values of 5ng/ml; 85.4 mg/L; 689pg/ml and 0.3 ng/ml; 80 mg/L; 420 pg/ml respectively (p=0.001, p=0.33, p=0.25). CPIS (including microbiology variable) and SOFA score were more in the pneumonia group (7 versus 6; 7 versus 6 respectively). Sixty one percent (21/34) of patients were mechanically ventilated. Number of days of mechanical ventilation, ICU stay and hospital stay were more in the pneumonia group compared to the non-pneumonia group (4 versus 3, 7 versus 4 and 14 versus 7 days respectively). Two patients died in the pneumonia group and culture report showed extreme drug resistant Klebsiella pneumoniae. Sensitivity and specificity of PCT and CRP to predict pneumonia was 90%; 83% and 72%; 56% respectively at cut off values of 1ng/dl and 100mg/L. Sensitivity and specificity of Lung ultrasound to predict pneumonia were 82% and 87% respectively. Area under receiver operating characteristic curve for PCT, CRP and Lung ultrasound were 0.91, 0.60 and 0.84 respectively.

Conclusions: Serum procalcitonin was preferred biomarker over CRP to predict pneumonia in traumatic lung injury patients. Lung ultrasound yielded good sensitivity and specificity. Authors warrant prospective large trial combining biomarker with lung ultrasound to predict pneumonia in lung laceration or contusion patients.
Table 1: Biomarkers, scoring and outcome variables in both the groups

| Parameters           | Pneumonia | No Pneumonia | P value |
|----------------------|-----------|--------------|---------|
| Procalcitonin (ng/ml)| 5         | 0.3          | 0.001   |
| CRP (mg/L)           | 85.4      | 80           | 0.33    |
| NT-ProBNP (pg/ml)    | 689       | 420          | 0.25    |
| CPIS                 | 7         | 6            | 0.08    |
| SOFA                 | 7         | 6            | 0.011   |
| Ventilation Days     | 4         | 3            | 0.05    |
| ICU Stay (days)      | 7         | 4            | 0.001   |
| Hospital Stay (days) | 14        | 7            | 0.021   |

Figure 1: ROC for lung ultrasound to predict pneumonia is 0.844

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Cardiac Arrest & CPR Quality in a Tertiary PICU: Recognition, Challenges & Opportunities

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Introduction: Delaying cardiopulmonary resuscitation (CPR) and first defibrillation to patients in cardiac arrest decreases survival by 10%/minute (1). American Heart Association recommends starting compressions immediately in a pulseless patient (2); The Clinical Performance Tool (CPT), a pediatric resuscitation guideline-adherence tool with published evidence of validity (3) gives 30 seconds as a timeframe for this task. Skill decay, lack of training and uncertainty within nurses and resident physicians in recognizing cardiac arrest and properly initiating management have been reported (4-6).

Objectives: To describe time elapsed and behaviours of bedside providers during the initial phase of resuscitation during simulated cardiac arrest events.

Methods: Prospective, mixed methods observational study at Alberta Children’s Hospital PICU in Calgary, Alberta, from Sept 2015 to Sept 2016. Video-recorded simulated cardiac arrests using 9 clinical scenarios, where the patients were stable and arrested in front of bedside healthcare providers, were analyzed by two researchers. Descriptive statistics were determined for time elapsed and qualitative inductive analysis of the videos captured behaviours, skills, and interactions among the team.

Results: Nurses, respiratory therapists, resident physician, and attending physicians participated in 19 simulations. Compliance with recommended time to start CPR was low, with 9 of 19 teams (47.4%) starting CPR after 30 seconds, and 7 of those taking longer than 1 minute. Median time to start CPR was 29 seconds (IQR: 14, 63s) after recognizing cardiac arrest. Qualitative findings described how unnecessary delays in starting CPR also happened in most of the resuscitations where compressions started in 30 seconds or less. Hesitation, lack of urgency, and miscommunication were observed among bedside staff. They recognized the cardiac arrest (or at least an unusual rhythm) as they asked for the crash cart and the presence of a resident or doctor in the room, yet most of them did not attempt to start CPR until the physician gave the order.

Conclusion: Significant delays in starting CPR were observed in our study. These delays seem to be due to bedside staff failing to recognize cardiac arrest, calling for help, and starting compressions. Considering the impact that delays have on patient survival, we have identified multiple important targets for improvement. Contextual factors that limit nurses and other bedside providers ability to provide high quality resuscitative care in early stages of cardiac arrest must be further studied and addressed. Qualitative inquiry may elucidate in the decision-making process of first responders to enact CPR in a timely manner.

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Chlorhexidine Locking Device for Central Line Infection Prevention in ICU Patients: an Open-Label Pilot and Feasibility Randomized Controlled Trial

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**Background:** Intensive care unit (ICU) patients are at risk for central-line associated bloodstream infection (CLABSI) with an incidence up to 6.9 per 1000 catheter days (1). CLABSI has a significant attributable mortality and increases in-hospital length of stay (LOS), readmissions, and costs (2). Chlorhexidine gluconate (CHG) has been shown to reduce infections including CLABSI (3), however, few trials have utilized CHG for prevention of central line infections. Our preclinical work demonstrated a device that diffuses CHG into the intravenous lock solution of CVCs decreased bacterial growth in the catheter lumen (4). We designed a clinical trial to test the feasibility of using ChloraLock™ in ICU patients.

**Objectives:** To establish the feasibility of a CHG locking device by determining rates of: 1) eligible patients, 2) consent, 3) compliance with device use.

**Methods:** The ChloraLock™ pilot trial was a two-arm, parallel-group, open-label, single centre, prospective, feasibility, randomized controlled trial (RCT). Participants with a CVC in situ were enrolled within 72 hours of admittance to 3 ICUs at a single academic hospital. Informed consent was obtained from eligible participants or their substitute decision makers (SDM). Participants were randomized 1:1 to either usual care or the CHG locking device. We created a taxonomy and documentation log for flushing and locking procedures, consistent with hospital policy. A pre-specified volume of CHG locking solution was instilled into the lumen of each venous catheter that was not infusing for participants randomized to CHG locking device. Blood cultures were drawn from the CVC of all participants every 48 hours. Feasibility was determined through the following outcome measurements: 1) randomization of 2 participants per week, 2) ≥80% consent procurement, and 3) ≥90% compliance with use of device. Secondary objective was to determine rates of bacteremia, however, the trial was not adequately powered to detect clinical outcomes. We developed a paper-based survey to assess uptake of the ChloraLock™ protocol by ICU Registered Nurses (RNs) and determine rates of protocol adherence and level of comfort with the trial protocol. The survey was distributed to RNs who cared for study participants. We engaged 2 nursing champions to respond to questions and concerns about the study when research staff was unavailable.

**Results:** Participants were recruited over 18 months, November 2017-July 2019. Of the 3931 patients screened 183(4.7%) met our eligibility criteria and an average of 1.1 participants were enrolled per week. Eligible patients were missed over the weekend, when the research staff or SDMs were unavailable. Of the 123 patients and SDMs approached 100(81.3%) consented. The bedside documentation log was reviewed daily to ensure compliance with the protocol. Data on compliance rates will follow. On a Likert scale of 1-5, (5 being most comfortable) survey respondents indicated they felt “comfortable” 4/5 using the ChloraLock™ device.

**Conclusion:** This study is the first human RCT to investigate a CHG locking device for prevention of central line infection in ICU patients. Recruitment was slower than anticipated, target consent rate was achieved, and bedside nurses felt comfortable using the device. Compliance data are pending. Findings from this trial will inform the feasibility of conducting a large RCT and provide preliminary data on the clinical efficacy of a CHG locking device.
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Clinical and Social Implications of Acetaminophen Intoxication: A Retrospective Study

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Background: Acetaminophen (APAP) is the most common analgesic worldwide, and at doses of more than 4g/day it can lead to serious hepatotoxicity. Acetaminophen toxicity is responsible for approximately half of acute liver failure cases in Canada and the US, (Ostapowicz G, 2002) with 26,000 being hospitalized in the US for acetaminophen toxicity annually (Nourjah P, 2006). Overdoses can be intentional and unintentional since APAP related drugs have a safe reputation, but APAP overdose can induce acute liver failure (ALF) which requires supportive care and liver transplantation, and this treatment can be very costly. Typically, patients presenting within 24 hours of an acetaminophen overdose can be safely be managed in medical wards.

Objective: The objective of this study is to assess the clinical and social risk factors for acetaminophen toxicity and comorbidities that impact prognosis.

Methods: This is a retrospective observational study of patients admitted to the University Health Network (UHN) from 2015 to 2019. Study protocol was approved by Coordinated Approval Process for Clinical Research (CAPCR) at UHN. Clinical and demographic data were collected from the UHN electronic patient record. Missing data were omitted from the results, and not estimated.

Results: Based on preliminary results, 59% of the patients presenting with APAP toxicity were female. The age of the patients ranged from 19-78, and the median age was 39. 63% of the patients had an intentional overdose and 37% were unintentional. 87% of the patients presented with past psychiatric history with depression and bipolar disorder being the most notifiable conditions, and 27% of the patients presented with chronic pain. In total 93% of the patients presented with either chronic pain, psychiatric history, or both. 50% of the patients presented with a history of substance abuse. 38% had history of ethanol abuse, 37% had history of prescription drug overdose, and 28% had prior history of APAP overdose. The average time of patients presenting to the hospital was 18 hours. 5% of the cases required a liver transplant and 2% of the patients expired.

Conclusion: The most significant risk factors for APAP toxicity in our study were past psychiatric history and chronic pain. In cases with chronic pain, APAP was taken in excess for its analgesic properties. APAP toxicity in these cases could have been prevented if the patients knew the adverse effects of overdosing on APAP. Individuals with psychiatric backgrounds had a high risk of overdosing APAP for its wide availability over the counter, typically in a suicide attempt. Education programs on APAP toxicity, as well as limiting the amount of APAP in a single package can reduce overdoses associated with both patients with chronic pain and those with psychiatric histories. Education on APAP should outline the adverse effects associated with an overdose, as well as instructing individuals to seek medical attention as soon as possible.

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Clinically Significant Gastrointestinal Bleeding Events: Development and Validation of an Electronic Detection Algorithm and Application in a Population-Based Retrospective Cohort Study of Adult Critically Ill Patients in Alberta

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Introduction: ICU-acquired gastrointestinal bleeding (GIB) is estimated to occur in 1-3% of admissions (1, 2). Clinically significant GIB events have been defined as events associated with hypotension, initiation or increased dose of vasoactive agents, significant drop in hemoglobin or transfusion of ≥ 2 units of blood (1, 2). In Alberta, all ICUs are supported by the eCritical program which provides a comprehensive bedside clinical information system (eCritical MetaVision) and data warehouse and clinical analytics system (eCritical TRACER) (3). All data to detect clinically significant GIB events are part of routine clinical documentation within eCritical systems.

Objectives: 1. To create and validate an automated algorithm within eCritical systems to detect clinically significant GIB events
2. To define the clinical epidemiology of GIB events in a retrospective population-based cohort of adult ICU patients in Alberta

Methods: An automated electronic algorithm was developed using SQL coding within eCritical systems to detect clinically significant GIB events. The algorithm was tested from technical and calculation perspectives using test cases. Initial clinical testing was undertaken via manual review of archived eCritical charts enriched with GIB cases to test for positive and negative cases. Discordance between manual and electronic GIB identification was sourced to optimize the algorithm.

A final independent clinical validation was undertaken using a random sample of 60 adult ICU admissions enriched with GIB cases. Archived charts were independently reviewed by 2 investigators blinded to electronic algorithm results. Disagreements were resolved via discussion. The final consensus manual results were compared to the electronic algorithm to establish validation.

A retrospective population-based cohort study was then performed including all adult patients admitted to Alberta ICUs from Jan 1, 2015 to Feb 28, 2019, excluding those admitted with an admission diagnosis of GIB. GIB events occurring ≥24 hours from ICU admission were identified using the validated detection algorithm. The incidence and timing of GIB events is described.

Results: The electronic detection algorithm was successfully developed and optimized via technical and clinical testing. In the final validation, the agreement between the two reviewers prior to discussion for the presence of a GIB event was 97.5% (Kappa 0.95). The agreement between the final consensus of manual case review and electronic algorithm results for the presence or absence of a GIB event was 97.5% (Kappa 0.95). Cases with discrepancies between algorithm and manual review related to human errors with the manual review, in particular reviewing high fidelity (per minute) physiologic data. Clinically significant GIB events were detected in 3002 out of 48368 (6.2% 95%CI 6.0–6.4) ICU admissions (13.1 events per 1000 patient-days) with significant variation between ICUs. Events occurred a median of 4.0 (IQR 2.1-7.9) days after admission. 29.4% of events occurred ≥7 days after admission.
Conclusions: We successfully developed and validated an automated electronic algorithm to detect events of clinically significant GIB, which occurred in 6.2% of adult ICU admissions in Alberta. Automated detection of GIB events will enable real-time measurement of this complication of critical care and allow opportunity to perform pragmatic clinical trials with this endpoint being captured automatically.

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Corticosteroid Therapy in Deceased Liver Donation

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Introduction: Corticosteroids are often administered to neurologically deceased donors (NDD) prophylactically. While corticosteroids may improve liver transplant outcomes, this practice is not founded on strong scientific proof of benefit. Most RCTs administered steroids between 3 to 6 hours before organ recovery. We hypothesize that earlier administration of corticosteroids may be more beneficial than delayed therapy, on the rate of liver recovery for deceased donation.

Objectives: To compare NDD liver donors to non-liver donors, describing corticosteroid administration; and to analyze the association between time of first corticosteroid dose and liver recovery.

Methods: This study is a secondary analysis of the Canada-DONATE cohort study, a 12-month, National, prospective study in 32 hospitals from which 5 have a liver transplant program. We enrolled 622 consecutive adult deceased donors from 2015 to 2018. Data collection from hospital records and organ donation databases spanned a period starting 1 day before consent to organ donation (prospectively) or the time that all organs were declined. For this analysis, we included potential NDD liver donors, defined as those for which the liver was offered to a transplant program based on local organ donation organization criteria. Time of first dose was defined as the number of hours between consent to organ donation and administration of the first dose of steroids. We present unadjusted data, compared using Chi-square analyses and Student-T or Mann-Whitney U tests. We used multivariable logistic regression model to determine predictors of liver recovery. In the univariate analysis, factors affecting liver recovery with p value <0.2 were selected for the multivariable model, and we forced in the corticosteroid variable. In the final model, factors with a p value < 0.05 were considered statistically significant.

Results: The DONATE study includes 407 NDD donors. Of these, 376 (92.4%) donors’ livers were offered to transplant programs and 262 (64.4%) donors proceeded to liver donation. Liver donors were younger (48.1 ±18.2 years old vs 54.3 ±15.7 p=0.002), lower AST (56.0 U/L median vs 80.0 p = 0.006), ALT (36.0 U/L vs 54.0, p= 0.005) and bilirubin (11.0 umol/L vs 15.0], p=0.007) (Table 1). Beside thyroid hormone (183 [69.8%] vs 66 [57.9%], p=0.024) there was no difference in care between donors and non-liver donors (Table 2). Methylprednisolone (94.3%) was the type of steroid most often administered followed by hydrocortisone (2.1%). Time of corticosteroid initiation was comparable in liver donors and non-donors (2.5 [-5.6, 7.0] hours vs 2.4 [-2.0, 7.5], p= 0.475). In the regression
model, predictors of liver recovery were body mass index (OR: 0.91 [0.85, 0.97] p= 0.005) and AST at baseline (OR: 0.86 [0.76, 0.97] p=0.014).

**Conclusion:** Neither the administration of corticosteroids nor the timing of initiation were associated with liver recovery. While it has been hypothesized that the massive release of pro-inflammatory molecules after neurological death may be alleviated by corticosteroid therapy to the donor, and therefore timing of administration may be important, many other factors influence the rate of liver recovery. The Canada-DONATE program has laid the foundation for an RCT, the first now under development to analyze prophylactic treatment of deceased donors to improve liver graft function in recipients.

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**Table 1:** NDD Potential liver donors baseline characteristics

| Characteristic                              | Recovered N=262 | Not recovered N=114 | P value |
|---------------------------------------------|-----------------|---------------------|---------|
| Age (years), mean (SD)                      | 48.1 ± 18.2     | 54.3 ± 15.7         | 0.002   |
| Male sex, n (%)                             | 149 (56.9)      | 64 (56.1)           | 0.896   |
| BMI (kg/m²), mean (SD)                      | 27.0 ± 5.0      | 28.8 ± 6.6          | 0.012   |
| ICU stay prior to consent to organ donation, (days), median (IQR) | 1.0 (1.0, 3.0) | 1.0 (1.0, 3.0) | 0.388   |
| Dx leading to organ donation, n (%):        |                 |                     |         |
| -Anoxic brain injury                        | 88 (33.6)       | 46 (40.4)           | 0.208   |
| -Brain hemorrhage                           | 83 (31.7)       | 41 (36.0)           | 0.417   |
| -Traumatic brain injury                     | 69 (26.3)       | 19 (16.7)           | 0.042   |
| -Stroke                                     | 15 (5.7)        | 6 (5.3)             | 0.858   |
| AST (U/L), highest baseline, median (IQR)   | 56.0 (30.5, 102.0) | 80.0 (41.5, 341.0) | 0.006   |
| ALT (U/L), highest baseline, median (IQR)   | 36.0 (23.0, 93.0) | 54.0 (27.0, 273.0) | 0.005   |
| bilirubin, (umol/L), highest baseline, median (IQR) | 11.0 (8.0, 17.5) | 15.0 (9.0, 29.0) | 0.007   |
| Sodium, (mmol/L), worst baseline mean (SD)  | 147.3 (7.2)     | 146.0 (7.4)         | 0.126   |
### Table 2: Donor interventions

| Characteristic                                      | Recovered N=262 | Not recovered N=114 | P value |
|-----------------------------------------------------|-----------------|---------------------|---------|
| Vasopressin, n (%)                                  | 248 (94.7)      | 107 (93.9)          | 0.757   |
| Vasopressor, n (%)                                  | 246 (93.9)      | 102 (89.5)          | 0.252   |
| Fluid balance (mL), median (IQR)                    | 1.5 (0.8, 2.5)  | 1.7 (0.7, 2.8)      | 0.193   |
| Corticosteroids, n (%)                              | 224 (85.5)      | 93 (81.6)           | 0.337   |
| Thyroid hormone, n (%)                              | 183 (69.8)      | 66 (57.9)           | 0.024   |
| Hypothermia protocol, 34-35°C final study day, n (%)| 19 (7.9)        | 7 (6.9)             | 0.754   |
| Donor management duration (hrs), median (IQR)       | 34.8 (28.7, 51.0)| 42.8 (31.5, 53.3)  | 0.069   |

*Donor management duration = time of consent to deceased organ donation to organ recovery or decline of all organs*

### Table 3: Logistic regression model for liver recovered among NDD donors

| Risk factors                                      | OR (95% CI) | p-value |
|---------------------------------------------------|-------------|---------|
| BMI (Kg/m2)                                       | 0.91 (0.85, 0.97) | 0.005   |
| AST, highest baseline, 100 U/L increment           | 0.86 (0.76, 0.97) | 0.014   |
| Donor management duration in hours                 | 0.98 (0.96, 1.00) | 0.121   |
| Time of steroid initiation in hours                | 1.01 (0.98, 1.03) | 0.591   |
| Age, 5-year increment                              | 0.91 (0.80, 1.04) | 0.156   |
| Diagnosis leading to organ donation                |              |         |
| - Anoxic brain injury (reference)                  | 1            |         |
| - TBI                                              | 1.18 (0.43, 3.25) | 0.452   |
| - Brain hemorrhage                                 | 0.70 (0.27, 1.85) | 0.313   |

*Donor management duration = time of consent to deceased organ donation to organ recovery or decline of all organs*

*Time of steroid initiation = time of consent to deceased organ donation to first dose administration of corticosteroids*
Creating Personalized Patient Paintings to Ease Family Grief after Critical Illness: The ARTICU Project

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Introduction/Background: Art may be therapeutic and help alleviate suffering, but its influence is unexplored when used as an intervention for bereaving family members after a loved one's death in the Intensive Care Unit (ICU). The 3 Wishes Project (3WP) elicits and implements wishes of patients, families and clinicians to bring peace to the dying process. ARTICU is a resident-led study embedded in the 3WP at one hospital which extends upon this concept. Using art as a narrative medicine platform, ARTICU aims to assist families with navigating the grieving process by providing them with a personalized painting created in celebration of the life of their deceased loved one.

Objectives: To ease bereavement in family members of ICU patients through personalized paintings created in celebration of their loved one. To explore the potential influence of personalized paintings as a narrative medicine tool on the grieving experience of bereaved family members of ICU patients.

Methods: This was a qualitative descriptive study in a 21-bed medical-surgical ICU at St. Joseph's Healthcare, Hamilton. Participants included family members of 3WP patients. After reviewing patient wishes and conversing with families and clinicians about the patient's passions, values and life story, the Principal Investigator (the artist) created individualized, patient-specific paintings for families who agreed to participate. Paintings were presented by the artist and the 3 Wishes team to families, approximately 2-6 months after each death. The families were also invited to participate in a semi-structured interview immediately following the presentation of the painting. Clinicians involved in the ARTICU process were also interviewed. Transcripts were anonymized and analyzed using conventional content analysis.

Results: To date, 9 paintings have been created and 20 individuals from the 9 recipient families participated in an interview. The artist and 5 other clinicians involved in ARTICU were also interviewed. A total of 26 individuals participated in 15 interviews. Clinicians and families found meaning in the images captured in the paintings which deeply resonated with memories of the deceased patients. Families described the paintings as a legacy of their loved one that they would cherish forever. Paintings were also symbolic of the recognition of the care their family member received in the ICU, and their relationship with the clinical team. Families suggested that the paintings validated how the patient was remembered by the artist and clinical team, helping them to feel less alone in their time of grief. Clinicians observed that paintings honoring a loved one's life deepened connections between family members and the 3 Wishes team. Family members and clinicians described ARTICU as therapeutic, with some identifying the theme of art as medicine.

Conclusions: The creation of personalized paintings respecting and representing the lives of deceased patients fosters postmortem connections with clinicians and may help family members navigate the grieving process.

Grant Acknowledgment: This project was supported by the Regional Medical Associates of Hamilton Scholarship Award, Walmart Canada Community Grant, and Ontario Art Council: Artists in Communities and Schools Projects.
CT-Perfusion for Neurological Diagnostic Evaluation: Study Update of a Prospective Multicenter Diagnostic Test Study

Chassé, M1,2, Carvalho, LP2; English, SW3,4; Fergusson, DA4,5; D’Aragon, F6,7; Couillard P8; Hannouche M9; Turgeon AF10,11; Lauzier F10,11,12; Haj-Moustafa A13; Guilbert F14; Boyd F15; Wang HT1; Ball I14; Shahin J16; Singh J16,17; Kutsogiannis J18; Burns K19; Meade M20; Slessarev M21; Marsolais P22; Green R23; Dhanani S24; Darvesh S25; Zarychanski R26; Gibson A27; Binnie A28; Shankar J29

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**Introduction:** Neurological determination of death (NDD) raises diagnostic challenges for practicing clinicians. Clinical confounders (e.g. use of sedatives, traumatic injuries or therapeutic hypothermia), can render NDD via clinical exam, which is the current reference standard, impossible. In such scenarios, neuroimaging ancillary tests are invaluable for diagnosing neurological death. Currently, there is no clear standard among ancillary tests for NDD and their use varies widely according to physician and hospital setting. Most ancillary tests of neurological death were evaluated for their ability to detect false positives (sensitivity) but not for their ability to detect false negatives (specificity). Computed Tomography Perfusion (CTP) imaging test is theoretically ideal, providing information about both brain blood flow and brain perfusion; however, its accuracy is yet to be determined.

**Objectives:** To establish the diagnostic accuracy of CTP to identify neurologic death. Secondary objectives are to 1) confirm the safety of performing CTP in critically ill patients suspected of neurological death; 2) establish the CTP inter-rater reliability in identifying NDD; and 3) compare the diagnostic accuracy of CTP, CT-Angiography, and clinical evaluation for NDD.

**Methods:** In an ongoing prospective Canadian multicentre cohort study at 12 hospitals in 5 provinces, we plan to enrol 300 adults (age over 18 years) with severe brain injury characterized by a Glasgow Coma Scale score of 3 without sedation for 6 hours. We exclude those with contraindications to CTP, any confounding factors precluding a complete neurological examination, or due to technical or logistical obstacles. Study patients are recruited with informed consent from substitute decision-makers (SDMs) or deferred consent, according to legal and regulatory requirement. A CTP is completed followed by a complete clinical NDD assessment by 2 physicians shortly after (within 2 hours). Clinicians are blinded to the CTP result. Principal analysis of primary outcome measure will include true negative, true positive, false negative and false positive measures, along with corresponding 95%CI, for CTP when compared to the reference standard. Only patients that completed the full clinical evaluation and CTP will be included in the primary analysis. Trial registration number-NCT03098511.

**Preliminary results:** From April 2017 to June 2019, we have screened 441 patients, and enrolled 160 at an average rate of 1 patient per month per site. Reasons for non-enrolment have included: 27 patients did not meet inclusion criteria; 151 had one or more exclusion criteria (123 for clinical reasons and 28 for logistical or technical reasons); 32 SDMs declined, and for 71 patients SDMs were not approached. The anticipated end of patient enrollment is late spring 2020.

**Conclusion:** Our study will determine the diagnostic accuracy of CTP and determine if it is safe and reliable, therefore improving the accuracy of neurological death declaration. A more robust process may also foster our society’s trust in the NDD process. Current progress in this study supports the feasibility of multicentre research to establish standards of care in the diagnosis of neurologic death.

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Current Diagnostic Approaches to Patients with Hypernatremia at University Health Network Hospitals

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Background: Hypernatremia is a common electrolyte disorder where serum Na⁺ concentration is >145 mM, and is frequently identified as an issue in patients admitted under general internal medicine. The etiology can generally be classified as loss of free water or decreased intake, iatrogenic ingestion/infusion of hypertonic solution, or pseudo-hypernatremia. It is a common practice to assume decreased intake of free water or extrarenal free water loss as the etiology, and to treat the hypernatremia with administration of hypotonic crystalloid solution without investigation of serum or urine osmolality, electrolytes, urea, or creatinine to delineate etiology. In particular, the two often neglected diagnoses are diabetes insipidus and osmotic-induced diuresis. Etiology of hypernatremia is occasionally elusive and refractory to administration of crystalloid solution. However, laboratory investigations ordered by clinicians to properly determine underlying etiology of hypernatremia in these cases are not routine and may vary significantly.

Objectives: We hypothesized that appropriate ordering of serum and urine studies by clinicians to determine the etiology of hypernatremia is related to the severity of hypernatremia. In addition, we aim to determine the etiology of hypernatremia that triggers clinician ordering of serum/urine studies.

Methods: Patients admitted under general internal medicine at hospitals affiliated with the University Health Network (Toronto Western Hospital and Toronto General Hospital) between the dates of 2015 and 2019 with a serum sodium concentration of 150 mmol/L or greater were selected and assessed for completion of serum electrolytes, serum osmolality, urine electrolytes (Na, K, Cl), urine osmolality, urine creatinine, and urine urea. Discharge summaries were analysed to determine etiology and treatment of hypernatremia as well as treatments initiated. The research proposal was approved by Coordinated Approval Process for Clinical Research (CAPCR) at the University Health Network.

Results: Based on our preliminary results, we were able to identify 606 cases of admitted general internal medicine patients with hypernatremia meeting our criteria. In our preliminary analysis of 47 cases, we were able to identify 18 cases (38.3%) with serum osmolality, 19 cases (40.4%) with urine osmolality, 23 cases (48.9%) with urine electrolytes, 1 case (2.1%) with urine urea, and 1 case (2.1%) with urine creatinine. There were 11 cases (23.4%) with all of serum osmolality, urine osmolality, and urine electrolytes. In general, the severity of hypernatremia correlated poorly with the number additional investigations ordered beyond serum electrolytes (ie. serum osmolality and urine studies; \( r^2 = 0.0204 \)).

Conclusion: In this study of patients with hypernatremia we found that a significant portion of admitted patients were not evaluated for urine studies, especially urea or creatinine. Unexpectedly, the severity of hypernatremia correlated poorly with the number of studies ordered to determine etiology, suggesting that the severity of hypernatremia may play a minor role in clinician ordering habits in hypernatremia. The current study signifies the importance of proper ordering and understanding of pathophysiology of hypernatremia and could contribute to filling the knowledge gap in appropriate ordering in hypernatremia, which may reduce the morbidity and mortality rate of hypernatremic patients.

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Development of a Clinical Guide for Identifying Spiritual Distress in Family Members of Patients in the Intensive Care Unit

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Introduction: Current guidelines for family-centered care in the Intensive care unit (ICU) recommend offering spiritual support to families of critically ill patients.1 Spirituality is important for many family members of patients in the ICU,2 with many factors related to the patient, family, and ICU context can contribute to spiritual distress among family members.3 Clinicians without training in spiritual care experience have difficulty identifying when family members are experiencing spiritual distress.4,5

Objectives: The purpose of this study was to develop a guide to help clinicians working in the ICU identify family members who may benefit from specialized spiritual support.

Methods: We performed a cross-sectional study involving a national sample of spiritual health practitioners, family members and ICU clinicians. A panel of 21 spiritual health practitioners participated in a modified Delphi process6 to achieve consensus on items that suggest spiritual distress among family members of patients in the ICU. The survey was developed from a scoping review of the literature7 and interviews and focus groups with family members of previous ICU patients (n=10), spiritual health practitioners (n=18), and clinicians working in ICU settings (nurses, respiratory therapists, social workers, indigenous health liaison workers, physicians; n=32).8 The Delphi process involved 3 rounds of remote review followed by an in-person conference and a final round of panelist feedback. Feedback on the final set of items was obtained from an end-user group of 4 family members and 6 ICU clinicians (1 social worker, 2 nurses, 3 physicians). Quantitative data was summarized with descriptive statistics. Content analysis was used to analyze written comments.9

Results: A total of 220 items were iteratively reviewed and rated by Delphi panelists. By the end of the Delphi process, forty-six items had been identified as essential for inclusion. End-user feedback recommended minor revisions to wording and sequence. The final set of items was developed into a clinical guide, including an introduction (number of items, n=1), definitions (n=2), risk factors (n=10), expressed concerns (n=12), emotions (n=7), and behaviours (n=7) that may suggest spiritual distress, questions to identify spiritual needs (n=6), and an approach to introducing spiritual support (n=1).

Conclusions: We have developed an evidence-informed clinical guide to help clinicians in the ICU identify family members experiencing spiritual distress. Evaluation of the process and impact of implementing the guide in clinical practice is needed.

Grant Acknowledgment: This study was funded by the M.S.I. Foundation.

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Diagnosis of Ventilator-Associated Pneumonia in Mechanically Ventilated Adult Patients: A Systematic Review and Meta-Analysis

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Introduction: Ventilator-associated pneumonia (VAP) is a significant adverse event that can occur following mechanical ventilation, and is associated with morbidity and mortality in critically ill patients. Diagnosis of VAP is difficult, and often requires bronchoscopy with bronchoalveolar lavage (BAL), while culture results may be delayed. Therefore, clinicians often rely upon non-invasive clinical signs for presumptive diagnosis of VAP, and in deciding upon empiric antimicrobial therapy.

Objectives: We conducted a systematic review and meta-analysis, with the aim of summarizing and comparing the accuracy of physical examination signs, chest radiography, bronchoscopy (either bronchoalveolar lavage [BAL] or protected specimen brush [PSB]), and the Clinical Pulmonary Infection Score (CPIS) for diagnosis of VAP in critically ill adults receiving mechanical ventilation.

Methods: We searched six databases, including MEDLINE, Embase, and PubMed, from inception through May 2019. We included English-language studies investigating accuracy of physical examination, chest radiography, bronchoscopy, or CPIS among critically ill adults receiving mechanical ventilation for ≥ 48 hours. Gold standard was histopathologic diagnosis of VAP following lung biopsy. We followed PRISMA guidelines and the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy. Two reviewers independently extracted data and assessed study quality using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool. Summary estimates were generated using a Hierarchical Summary Receiver Operating Characteristic model.

Results: We included 26 studies. Of physical examination signs, pooled sensitivity and specificity for VAP were: leukocytosis (64.2% [95% CI: 46.9-78.4], 59.2% [95% CI: 45.0-72.0]), fever (66.4% [95% CI: 40.7-85.0], 53.9% [95% CI: 34.5-72.2] and purulent secretions (78.6% [95% CI: 65.1-87.9], 49.2% [95% CI: 34.9-63.6]). New or worsening infiltrates on chest radiography had a sensitivity of 88.9% (95% CI: 73.9-95.8) and specificity of 26.1% (95% CI: 15.1-41.4) for diagnosis of VAP. Among bronchosscopic tests,
pooled sensitivity and specificity for VAP were: BAL ≥ 10^4 CFU/mL (71.1% [95% CI: 49.9-85.9], 79.6% [95% CI: 66.2-88.6]) and PSB ≥ 10^3 CFU/mL (61.4% [95% CI: 43.7-76.5], 76.5% [95% CI: 64.2-85.6]). Finally, CPIS > 6 had a sensitivity of 75.7% (95% CI: 50.6-88.5) and specificity of 66.4% (43.9-83.3) for diagnosis of VAP.

Conclusions: No one particular physical examination feature had strong diagnostic accuracy for VAP. Changes in chest radiography had suitable sensitivity, but poor specificity. Among bronchoscopic tests, BAL culture had higher sensitivity and specificity than PSB culture. Increased CPIS score was neither sensitive nor specific for diagnosis of VAP. High suspicion of VAP may necessitate early empiric management, regardless of individual tests.
Drug Utilization Evaluation of Chlorothiazide in a Paediatric Quaternary Centre

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Introduction: Chlorothiazide (CTZ) is the only intravenous (IV) thiazide diuretic in Canada through the Health Canada Special Access Program (SAP) and has been used at the Hospital for Sick Children (SickKids) since 2011. Prescribing restrictions for SickKids formulary have been implemented due to limited published paediatric evidence and its high cost.

Objectives: Primary objectives are to evaluate CTZ usage, cost, and adherence to formulary guidelines. Secondary objectives were to explore associations between:

- indication for diuresis with guideline adherence and effective diuresis
- prescribing service with guideline adherence
- use of other diuretics at time of CTZ initiation with effective diuresis

Methods: This was a single-center, retrospective observational study. Patients were included if they initiated at least one dose of CTZ between June 2, 2018, and May 31, 2019, as per electronic health records. Drug utilization data included dose, duration, indication, service, and costs. Patient data included demographics, NPO status, diuretic intolerance, urine output and fluid balance. Usage was considered adherent if used in post-op cardiac patients for sternal closure or in patients in which other diuretics were optimized. Effective diuresis was defined as an increase in urine output of >0.5 mL/kg/hr from CTZ initiation. Costs were assessed using data from all courses while adherence and effective diuresis were assessed using data from initial courses. Descriptive statistics were used due to small sample size.

Results: A total of 181 CTZ courses were included for 74 patients. Of the 100 initial CTZ courses, 92 met inclusion criteria. Median (range) age, weight, and sex were 110 days (7 days - 11 years), 4.25 kg (1.05-32.5 kg) and 53.3% male respectively. Baseline urine output was <1 mL/kg/hr in 10.9% of initial courses and median fluid balance was 15.9 ml/kg (-85.7 - 128.3 ml/kg). Median dose, frequency and duration were 5 mg/kg/dose (1-5 mg/kg/dose), q12h (q6h-q24h) and 3.5 days (1-37 days) respectively. CTZ was most commonly prescribed for non-surgical cardiac indications (58.7%), sternal closure (27%), and respiratory indications (7.6%). Non-adherence to guidelines was 58.7% overall and was attributed to suboptimal use of enteral thiazides (28.3%), IV loop diuretics (20.7%) or both (50.9%). Non-adherence was most common in non-surgical cardiac indications (79.6%), then respiratory (12.9%) and other (non-cardiac/non respiratory) (7.4%) indications. Effective diuresis was seen in 53.6% of initial CTZ orders with a decrease in diuretic effect in patients who previously received metolazone (25% effective), bumetanide (0%) or optimized enteral diuretics (20%). Diuresis was least effective in respiratory indications (37.5% effective) and highest in other indications (66.6%). The total CTZ cost during the study period was $134,000. Costs of non-adherent initial orders ($37,500) contributed to 56.8% of the total costs of initial orders ($64,000).

Conclusion: Results indicate that there is room for improvement in adherence with approved guidelines for CTZ. Further efforts could be targeted at non-surgical patients who were not trialed or optimized on other diuretics. Cost savings may be realized with improved adherence and optimization of concurrent diuretics. Adherence to guidelines may be improved through clinical decision support systems such as computerized physician order
entry order-sets and alerts, and ongoing audit and feedback.

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Efficacy and Safety of Intravenous Iron in Critically Ill Patients: A Systematic Review and Meta-Analysis

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Introduction: Anemia is a common and challenging problem in critical care medicine (1, 2), often requiring red blood cell (RBC) transfusion in the absence of active bleeding in many critically ill patients (3, 4). Previous studies have reported that 16-85% of critically ill patients receive a RBC transfusion during the course of their ICU stay (5, 6). Over the past two decades, the benefit of RBC transfusion in critically ill patients has been questioned, and studies have suggested restricting the transfusion of blood products may benefit critically ill patients (1, 5, 7-9). Strategies exist to prevent and treat anemia in the ICU (7), but its management remains challenging. A recent meta-analysis that examined the use of both oral and intravenous (IV) iron formulations in critically ill adults demonstrated that supplementation was not associated with a reduced RBC transfusion requirement (10). However, a more recently published randomized trial of IV iron in critically ill patients demonstrated that patients’ hemoglobin upon discharge from hospital was significantly higher in the IV iron group versus placebo (11).

Objectives: To evaluate: (i) the efficacy of IV iron in critically ill patients based on the requirement for red blood cell transfusion; and (ii) the incidence of infection in patients receiving IV iron.

Methods: This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (12). Studies which report the administration of IV iron in patients admitted to a critical care unit were eligible, regardless of the outcomes measured. A comprehensive electronic search was conducted using Medline (Ovid), EMBASE (Ovid), PubMed, EBM Reviews (including Cochrane Central databases, Ovid), and CINAHL (EBSCOHost) from inception until April 17, 2019. Three independent reviewers screened study titles and abstracts, followed by full text review for eligible studies. Included studies were assessed using the Cochrane Risk of Bias Tool (13).

Results: After deduplication, title and abstract screening and full text review of 301 articles, five studies remained and were included in the analysis. All five studies were randomized, interventional trials. Two of the studies reported on cardiac surgical patients (14, 15), one reported on trauma patients (16) and two encompassed a broader variety of critically ill patients (11, 17). None of the trials had a low risk of bias across all domains. In this meta-analysis, there was no evidence that IV iron reduces the proportion of patients receiving a RBC transfusion (OR 0.76, 95% CI 0.51 – 1.11, I²=0%). In addition, there was no evidence that the administration of IV iron was associated with in-hospital infection (OR 0.88, 95% CI 0.53 – 1.45, I²=54%).

Conclusion: Our results indicate that while IV iron is not associated with an increased incidence of infection, it does not reduce transfusion requirements in critically ill patients. Therefore, the findings of this meta-analysis do not support routine use of IV iron in critically ill patients.
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**Table 1:** Characteristics of the included studies

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Figure 1: PRISMA Flow Diagram
**Figure 2:** Forest Plot of Proportion of Patients Receiving RBC Transfusion in Studies Reporting This Outcome

| Study or Subgroup   | IV iron Events | Total | No IV iron Events | Total | Weight | Odds Ratio M-H, Random, 95% CI | Odds Ratio M-H, Random, 95% CI |
|---------------------|----------------|-------|-------------------|-------|--------|-------------------------------|-------------------------------|
| Garrido-Marlin 2012 | 20             | 54    | 26                | 52    | 24.0%  | 0.59 [0.27, 1.28]             |                               |
| Pieracci 2014       | 47             | 75    | 55                | 75    | 30.0%  | 0.61 [0.31, 1.22]             |                               |
| Litton 2016         | 38             | 70    | 39                | 70    | 32.5%  | 0.94 [0.48, 1.84]             |                               |
| Madi-Jebara 2004    | 10             | 40    | 9                 | 40    | 13.6%  | 1.15 [0.41, 3.22]             |                               |
| Total (95% CI)      | 239            | 237   | 100.0%            |       | 0.76   [0.52, 1.11]           |                               |

Total events: 115, 129
Heterogeneity: Tau² = 0.00; Chi² = 1.83, df = 3 (P = 0.61); I² = 0%
Test for overall effect: Z = 1.42 (P = 0.16)

**Figure 3:** Forest Plot of Incidence of Infection in Studies Reporting This Outcome

| Study or Subgroup   | IV iron Events | Total | No IV iron Events | Total | Weight | Odds Ratio M-H, Fixed, 95% CI | Odds Ratio M-H, Fixed, 95% CI |
|---------------------|----------------|-------|-------------------|-------|--------|-------------------------------|-------------------------------|
| Litton 2016         | 20             | 70    | 16                | 70    | 34.7%  | 1.35 [0.63, 2.89]             |                               |
| Pieracci 2014       | 44             | 75    | 52                | 75    | 65.3%  | 0.63 [0.32, 1.23]             |                               |
| Total (95% CI)      | 145            | 145   | 100.0%            |       | 0.88   [0.53, 1.45]           |                               |

Total events: 64, 68
Heterogeneity: Chi² = 2.18, df = 1 (P = 0.14); I² = 54%
Test for overall effect: Z = 0.51 (P = 0.61)
Emergent Spinal Drain Placement Rapidly Improves Neurological Deficits in Anterior Spinal Artery Syndrome

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Introduction: Anterior spinal artery syndrome following abdominal aortic surgery is a known complication, giving rise to paraplegia, sphincter incontinence, and dissociated sensory loss.[1] It is very rare with an incidence of 0.1-0.2%. [1] Etiological factors comprise hypotension, prolonged aortic crossclamping, and embolization of the artery of Adamkiewicz. Complete recovery is uncommon.

Case presentation: A 72-year-old female with a history of thoracoabdominal aortic aneurysm was admitted to the intensive care unit (ICU) after undergoing open left aortoiliac to left renal bypass. Intra-operative course was unremarkable and anesthesia was maintained with propofol and remifentanil. Total length of surgery was eight hours and thirty minutes. Intra-operative mean arterial pressure (MAP) was over 80 mm Hg, and the lowest recorded MAP was 65 mm Hg. The patient was monitored with somatosensory and motor evoked potentials. Near-infrared spectroscopy (NIRS) was utilized and measured values between 70-79%. A total of 2.7 liters of crystalloid, 3 units of packed red blood cells, and 364 mL of autologous blood from cell salvage was given. A phenylephrine infusion was administered for the majority of the case running between 0.1 to 0.5 mcg/kg/min. Estimated blood loss was 740 mL. The lowest intra-operative hemoglobin was 7.4 g/dL.

During ICU admission, her neurologic exam revealed adequate strength bilaterally with intact sensation to touch. She was hemodynamically stable with a MAP between 70-75 mmHg, but she experienced a brief five-minute period with MAP at 67 mmHg. She was subsequently started on a norepinephrine infusion with goal MAP greater than 75 mmHg, and her neurological exam remained stable. One hour later, she experienced acute-onset paraplegia and was unable to move her lower extremities bilaterally, but reported intact sensation to touch. The NIRS device reported values at 50%. Vascular surgery was consulted, and a spinal drain was placed emergently and drained 25 mL of cerebrospinal fluid (CSF). Immediately, the patient was able to move her toes and partially flex her quadriceps bilaterally, although the strength was not at baseline. MAP was maintained above 100 mmHg and hemoglobin greater than 10 mg/dL, and a concurrent rise in NIRS oxygen saturation to a baseline of 70% was noted. The spinal drain was placed to drain at a level of 10 mmHg for 12 hours, then 15 mmHg for 12 hours, then clamped for 36 hours, and was removed when her neurological exam remained stable. Although her motor function did not return to baseline, she had 3/5 strength in her right lower extremity and 2/5 strength in her left lower extremity. An MRI of the spine revealed a subacute infarct in the distal thoracic cord extending to the conus medullaris. She was transferred to the floor where she underwent physical therapy with plans to continue care in an inpatient rehabilitation facility.

Conclusion: While our patient’s spinal cord ischemia might have resolved spontaneously, we are struck by the rapidity of partial reversal of her lower extremity paralysis after emergent spinal drain placement, which is a rare phenomenon.[2, 3] The rapid improvement in neurological deficits is presumably due to the reduction in CSF pressure and subsequent increase in spinal cord perfusion pressure.[4] Because paraplegia is a devastating complication and no proven treatment exists, CSF drainage should be investigated in future trials in the setting of spinal cord ischemia.

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**EPICC: The Evaluation of Post Intensive Care Unit Clinics in Canada**

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**Introduction:** Post Intensive Care Unit (ICU) Syndrome is defined as new or worsening impairment in physical, cognitive, or mental health status arising after critical illness which persists beyond the acute care setting. It is suggested to occur in 40% of ICU survivors. The recognition of this syndrome’s impact on the quality of life for ICU survivors and their families has been the impetus to develop Post ICU Clinics with the goal of diagnosing and managing the sequelae following ICU admissions.

**Objectives:** We sought to identify the number of existing and in-development Post ICU Clinics across Canada and obtain an understanding of the structure and process of follow up appointments at established clinics.

**Methods:** A 15 question, electronic-based survey was developed. A list of the ICUs across Canada was obtained with permission from a study completed by Fowler et al. (2015). Two hundred and seventy-one hospitals with adult ICUs were contacted via telephone to obtain the unit manager’s email address. Two hundred and forty-six electronic surveys were distributed. Participation was optional and anonymous.

**Results:** The response rate was 52%. Most ICUs had between 6-10 beds (n=36) or 11-20 beds (n=36). Referral to a Post ICU Clinic was rare (n=6). Since so few clinics were reported, only descriptive statistics were used. The six current Post ICU Clinics were established within the past four years and receive referrals from Medical/Cardiac, Neurological/Neurosurgical, Surgical and Mixed ICUs. Few (n=11) ICUs had plans to develop a Post-ICU Clinic. Clinic referral criteria included significant delirium (2/6), ICU stay greater than four or seven days (1/6 and 2/6 respectively), ECMO (1/6), direct ICU discharge (1/6) and invasive ventilation for greater or equal to four days (1/6). Exclusion criteria included palliative patients (2/6), homelessness (1/6), patients from outside catchment area (1/6) and cognitive impairment that would preclude meaningful interactions (1/6). Patients were seen in follow up anywhere from zero to greater than six months following ICU discharge. Clinic patients were assessed by various health care providers including physicians (5/6), social workers (3/6), nurses (1/6), nurse practitioners (1/6) and pharmacists (1/6). Referrals were triggered by either ICU physicians or nurses. Common clinic practices included counseling (4/6), education regarding the reason for ICU admission (3/6), reviewing metrics (3/6), medication reconciliation (3/6), physical exam (2/6), touring the ICU (2/6), and referral to physical rehabilitation (1/6). The most common metrics used were the MOCA (3/6) and the Impacts of Events Score (2/6). Most clinics saw between 0-50 patients a year with one clinic seeing 151-200 patients annually.

**Conclusion:** Despite the increase in recognition of the consequential impact Post ICU Syndrome has on ICU survivors and their families, there is a lack of formal ICU follow up across Canada which has been highlighted by this study. Acknowledgement of the necessity for Post ICU Clinics is evidenced by the number of clinics in various stages of development. Identification of barriers to clinic development may provide further insight into the large number of hospitals with no objective for a Post ICU Clinic. The results of this study emphasize the need for further research and knowledge translation in establishing Post ICU Clinics to meet the needs of patients and families with Post ICU Syndrome across the country.
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Esophageal Pressure Guideline in the Intensive Care Unit

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Introduction: Esophageal manometry enables partitioning of the pressures applied to the chest wall and lung (transpulmonary pressure, PL) [1]. It also permits direct measurements of patient inspiratory effort under mechanical ventilation and detection of patient-ventilator dyssynchrony [2]. Hence, esophageal manometry might be used to prevent ventilator-induced lung injury, self-induced lung injury, and ventilator-induced diaphragm dysfunction, thus improving clinical outcomes. Clinical uptake has been limited by a number of technical obstacles, such as clinician expertise in catheter insertion and placement, collecting accurate measurements, as well as the knowledge requirement for interpretation of the findings. At our hospital, there was no standard guideline for the use of esophageal manometry. We undertook to develop a guideline for local clinical implementation. In this abstract we describe the process and resulting guideline.

Methods: This guideline was created based on extensive literature reviews supporting the techniques and clinically relevant evidence to date. Additionally, expert user experiences and an intensive care unit (ICU) interdisciplinary team perspective was incorporated in order to enhance the success of implementation [3-4].

Results: The guideline includes criteria for consideration of insertion and contraindication for use and how to check the integrity of the catheter, the method of insertion and verifying placement. The clinical application of esophageal manometry is outlined. The guideline was designed to incorporate multiple measures of both lung stress and respiratory effort with the goal of monitoring risk for ventilator-induced lung injury and diaphragm myotrauma.

Routine measurements mandated by the guideline include: End-expiratory esophageal pressure (Pes), peak inspiratory P_{es}, end-expiratory P_L, peak inspiratory P_L, plateau P_L, inspiratory swing in Pes, inspiratory swing in P_L, and the elastance-derived plateau P_L.

Conclusions: We have developed a local practice guideline for the use of esophageal manometry with the aim of enhancing the safety of mechanical ventilation. Our goal is to improve comfort and address many of the barriers to the integration of esophageal manometry into the assessment of patients in the ICU. Ongoing assessments of clinician knowledge and comfort and monitoring the use of esophageal manometry in eligible patients will determine the effectiveness of the guideline implementation.

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Evaluation of Clinical Features and Prognostic Factors in Critically Ill Patients with Rheumatic Diseases

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Introduction: Rheumatic diseases (RD) affect multiple systems and hence predispose the patients to develop organ failures, often requiring ICU admission.

Objectives: Evaluation of the following in critically ill patients with RD admitted to ICU:
1. Demographic factors, indications and severity of illness scores at the time of ICU admission
2. Organ supports required in ICU
3. Factors affecting outcome

Materials and methods:
Setting: Mixed ICU of tertiary care teaching institute.
Patients: All patients with RD admitted to ICU from August 2003 till March 2016. Retrospective study with retrieval of information from electronic hospital information system, ICU flow sheets and discharge summaries. Demographic and clinical features including specific diseases of the patient before ICU admission was correlated with patient outcomes.

Results: A total of 54 patients with RD were analyzed, median age was 40 years (IQR: 29 - 49), 87% were female. The median APACHE II score was 19 (16-22.5) and SOFA score was 9 (7-10.5). 74% were in sepsis, commonest source being the lungs (85.7%). The commonest primary diagnosis was SLE (42.6%), followed by inflammatory myositis (20.3%). The causes for ICU admission were as follows: rheumatic disease flare-up in 12 patients (22.2%), infection in 36 patients (66.7%), infection and flare in 4 patients (7.4%) and acute serious illnesses unrelated to the rheumatic condition in 2 patients (3.7%). Indication for admission was respiratory failure in 46 (85%) followed by circulatory shock in 43 patients (79.6%). 74% had 3 or more organ failures. Forty-nine patients (90.7%) required mechanical ventilation for a median of 8 days (3-14.75); 87% required vasopressors for a median of 3 (2-7) days. RRT was required in 21 (38.8%) patients. Therapy for underlying disease given during the ICU stay included steroids in 92%, pulse steroid in 29.6%, IVIg and plasmapheresis in 24%, and others in 24%. The median length of ICU stay was 10 days (4.75-19.5). 27 patients survived till ICU discharge. On univariate analysis, factors associated with death included older age (45 vs 35, p= 0.04; odds ratio [OR] 1.044, 95% CI 1.004-1.085), higher APACHE II score (22 vs 17.5, p=0.002; OR 1.22, 95% CI 1.06-1.4) and SOFA score (10 vs 8, p<0.001; OR 1.99, 95% CI 1.31-3.03), while days free of vasopressors was associated with survival (12.5 vs 1, p=0.004, OR 0.89, 95% CI 0.81-0.96). SOFA score alone was associated with mortality on multivariate analysis. Area under the curve to predict outcome using APACHE II and SOFA scores was 0.76 and 0.86 respectively (p=0.002 and <0.001).

Conclusions: The most common RD requiring ICU admission is SLE and infection is the leading cause of ICU admission. Most patients have multi organ involvement. SOFA score is a good predictor of mortality, similar to non-RD patients. Younger patients and those requiring vasopressors for shorter duration have a better prognosis.

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Evaluation of Immunosuppression and Pneumonia Following Endothelin 1-Induced Stroke

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Introduction/Background: A stroke consists of the stoppage of blood flow in any part of the brain. Due to its seriousness and complications, it is the second most common cause of morbidity and mortality in the world and in critical care medicine. Mounting evidence links intracerebral events, such as strokes and hemorrhages, with dysfunctions of the innate immune system. Post-stroke patients have an increased risk of pneumonia associated with intrinsic innate immune defects. We have identified abnormal phagocytic function in monocytes and macrophages in rats 72 hours post focal ischemic stroke.

Objectives: There are two main objectives in this project. Firstly, to establish a stroke model in mice using endothelin-1 (ET-1) to induces focal cerebral ischemia. Secondly, to use this model to assess post-stroke phagocyte dysfunction to eventually study the physiological interaction between the immune and the nervous system.

Methods: We performed stereotaxic surgery to inject the vasoconstrictor compound ET-1 in the piriform cortex as a way to produce ischemia of the middle cerebral artery (MCA) territory of the striatum. The flow rate, concentration and volume of ET-1 were adjusted to have a more focal injury. Mice were divided into Sham (vehicle) vs. ET-1 (1 ug diluted in acetic acid). An intratracheal injection with $10^6$ colony-forming units (CFU) of Pseudomonas Aeruginosa was delivered to each mouse 72 hours after induction of stroke. Mice were sacrificed at 24 hours post-bacteria instillation. Bronchoalveolar lavage fluid (BALF), blood, lungs and brain were collected for cell count, differential and mediator measurement. The right lung and brain were used for histological analysis. BALF, lung and blood were homogenized and plated to quantify bacterial clearance by calculating the number of colonies forming units.

Results: Post mortem histological analysis showed that, compared to the sham, ET-1 administration was able to produce focal cerebral ischemia. Similarly, there is a correlation between stroke and the number of bacteria found in BALF and lungs homogenates. Mice randomized to ET-1 stroke demonstrated a marked decrease in bacterial clearance in the lungs compared to sham mice. Furthermore, preliminary results suggest the location of focal ischemia (striatum versus peri-MCA) may confer differential bacterial clearance capacity.

Conclusion: In contrast to other murine models of stroke which result in ischemia of the entire hemisphere, stereotactic ET-1 injection enabled the generation of focal (localized) ischemic strokes. We were further able to replicate the phagocytic defect in mice following focal cerebral ischemia.

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Feasibility of a Multicentre Trial of Stress Ulcer Prophylaxis in Critically Ill Children

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Introduction: Despite sparse pediatric data on effectiveness, the majority of critically ill children receive medications to prevent gastrointestinal (GI) bleeding. Stress ulcer prophylaxis may have unintended consequences—increasing the risk of nosocomial infections—which may be more serious and common than the bleeding which these drugs are prescribed to prevent. Randomized controlled trials (RCTs) in pediatric critical care are exceptionally challenging to complete, thus a rigorous pilot RCT is crucial.

Objectives: To assess the feasibility of enrolling patients into a large multicentre RCT of pantoprazole vs. placebo for stress ulcer prophylaxis to prevent upper GI bleeding.

Methods: We sought to enroll 120 children who were older than 4 months of age and expected to require >48 hours of mechanical ventilation, in this blinded, multicentre pilot RCT. Children were randomized to pantoprazole 1 mg/kg or placebo once daily until they no longer needed mechanical ventilation. We had four feasibility outcomes and will consider the trial successful if we achieve: 1. Effective screening: If >80% of eligible patients are approached for consent; 2. Timely enrollment: if >80% of participants receive their first dose of the assigned study drug within 1 day of becoming eligible; 3. Participant accrual: If the average monthly enrolment is two or more participants per centre per month; 4. Protocol adherence: if >90% of doses are administered according to the protocol.

Results: To date, we have randomized 107 of 120 children in 7 participating PICUs. Effective screening was 73% (target >80%); we approached the families of 249 of 241 eligible patients for consent. The three most frequent reasons for not approaching were physician preference for prescribing prophylaxis (33%), family refusal to meet research staff (18%), and study staff availability (12%). Timely enrollment was 95% (target >80%); 102 of the 107 participants received their first dose of the assigned study drug within 1 day of becoming eligible. Participant accrual was 0.7 children/centre/month (target >2). The most frequent reason that the 972 otherwise eligible patients were excluded was previous use of acid suppression, either at home (483, 50%), or in the PICU (251, 26%). 107 (43%) of the 249 parents approached for consent agreed to participate. The three most frequent types of reasons given by parents for refusing consent were: concerns about adding more drugs and adverse effects (33%), preferring the physician decide on therapy (21%), or being too stressed to decide (11%). Protocol adherence was 88% (target >90%). The most common reason for omitting doses of study drug was physician prescription of open label, non-protocol, stress ulcer prophylaxis in 5 (5%) participants.

Conclusion: We met 2 of 4 feasibility outcomes, but enrollment remains below our target. Frequent use of acid suppression, physician preferences for using stress ulcer prophylaxis, and parental hesitation are important challenges. Additional physician and parental engagement will be critical to the successful design and conduct of future similar trials.

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Frailty and Associated Outcomes Following Invasive Mechanical Ventilation

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Introduction: Invasive mechanical ventilation is a common form of life support provided to critically ill patients. Frailty is an emerging prognostic factor for poor outcome in the Intensive Care Unit (ICU), however its association with adverse outcomes following invasive mechanical ventilation is unknown.

Objectives: Evaluate the association between frailty, defined by the Clinical Frailty Scale (CFS), and outcomes of ICU patients receiving invasive mechanical ventilation.

Methods: We performed a retrospective analysis (2011-2016) of a prospectively collected registry from two hospitals of consecutive ICU patients ≥ 18 years of age receiving invasive mechanical ventilation. CFS scores were based on recorded pre-admission function at the time of hospital admission. The primary outcome was hospital mortality. Secondary outcomes included discharge to long-term care, extubation failure at time of first liberation attempt, and tracheostomy. We used multivariable logistic regression for adjust for relevant confounders.

Results: We included 8,110 patients, and 2,529 (31.2%) had frailty (CFS ≥ 5). Frailty was associated with increased odds of hospital death (adjusted odds ratio [aOR]: 1.24 [95% confidence interval [CI]: 1.10-1.40]) and discharge to long-term care (aOR 1.21 [95% CI: 1.13-1.35]). As compared to patients without frailty, patients with frailty had increased odds of extubation failure (aOR 1.17 [95% CI: 1.04-1.37]), hospital death following extubation failure (aOR 1.18 [95% CI: 1.07-1.28]), tracheostomy (aOR 1.17 [95% CI: 1.01-1.36]), and hospital death following tracheostomy (aOR 1.14 [95% CI: 1.03-1.25]).

Conclusions: The presence of frailty among patients receiving mechanical ventilation is associated with increased odds of hospital mortality, discharge to long-term care, extubation failure, and need for tracheostomy. This work provides novel data regarding the prognostic impact of frailty among mechanically ventilated patients, and may be utilized to facilitate goals-of-care discussions with critically ill patients and their families.
Hemorrhagic Shock from Bleeding Pseudoaneurysm of Deep Circumflex Iliac Artery After Abdominal Paracentesis

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Introduction: Abdominal paracentesis is a common diagnostic and therapeutic procedure in patients with ascites. However, a rare but lethal complication potentially affects the management. We reported a case of bleeding pseudoaneurysm after abdominal paracentesis.

Case report: A 63-year-old female with past medical history of decompensated cirrhosis was brought to the emergency department due to altered mental status and abdominal pain. Three days ago, in a regular clinic visit, she underwent an abdominal paracentesis. The 1.5-liter, clear, yellowish ascites was released. She was discharged with normal vital signs.

In this visit, her vitals were temperature of 37 degree Celsius, pulse rate of 94/min, respiratory rate of 20/min, and blood pressure of 80/50 mmHg. Her abdomen was markedly distended with generalized tenderness. The neurological exam revealed no focal deficits. Fluid resuscitation and empiric antibiotics was administered due to presumed sepsis. Laboratory testing revealed hemoglobin level of 7.2 g/dL, hematocrit of 21.6 %, WBC count of 25.2 x 10³ per microliter, platelet of 158 x 10³ per microliter and the INR of 3.46. The hemoglobin was decreased from the level of 11.4 g/dl three days ago. Subsequently, a repeated physical examination uncovered a palpable mass at left side of the abdomen. Computed tomography (CT) of the abdomen showed a 9.9 x 19.3 x 24.3-cm intramuscular hematoma with contrast extravasation at left lower abdominal wall (Figure 1 and 2). The angiogram revealed an extravasation from a pseudoaneurysm from a branch of left deep circumflex iliac artery (DCIA) (Figure 3). The glue embolization was performed successfully. Despite surviving this event, she developed hospital-acquired infection and septic shock and passed away.

Discussion: Abdominal paracentesis is, though generally safe, not without significant complications. The incidence of major hemorrhage or infection was 1.6 % of the patients who underwent this procedure (1). A common complication is bleeding and the inferior epigastric artery (IEA) pseudoaneurysm formation. However, as in this case, bleeding pseudoaneurysm from DCIA can cause a potentially fatal complication. Previously, pseudoaneurysm of the DCIA was scarcely reported after abdominal wall procedures including paracentesis (2). Nevertheless, a small case series recently reported that DCIA was the most commonly injured artery necessitating endovascular treatment. Patients with DCIA injuries can manifest with abdominal wall hematoma or hemoperitoneum which can be a late presentation after the procedure. Although conservative treatment with blood product transfusion was successful in some cases, endovascular therapy is recommended (3).

Prevention of this complication is paramount. Traditionally, the landmark for paracentesis is to position laterally to the rectus sheath to avoid puncturing the IEA. As this technique can be at risk of puncturing DCIA because it ascends more laterally. The recommendation to prevent this complication is to perform ultrasound-assisted paracentesis with color Doppler to identify the vessel and avoidance of the needle trajectory (4).

Conclusions: Bleeding DCIA pseudoaneurysm is a rare but significant complication of the abdominal paracentesis. Physicians should be aware of this condition as one of a cause of hemorrhagic shock in patient with cirrhosis. Ultrasound-assisted paracentesis can minimize the risk of developing this complication.
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Figure 1: Computed Tomography (CT) of the Abdomen Showing a 9.9 x 19.3 x 24.3-cm Intramuscular Hematoma with Contrast Extravasation at Left Lower Abdominal Wall
Figure 2 - Computed Tomography (CT) Showing a 9.9 x 19.3 x 24.3-cm Intramuscular Hematoma with Contrast Extravasation at Left Lower Abdominal Wall

![Figure 2](image1.png)

Figure 3 – Angiogram Revealing an Extravasation from a Pseudoaneurysm from a Branch of Left Deep Circumflex Iliac Artery (DCIA)

![Figure 3](image2.png)
High Flow Nasal Cannula Compared to Conventional Oxygen Therapy or Non-Invasive Ventilation in The Immediate Post-Extubation Period: A Systematic Review and Meta-Analysis

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Introduction: Previous meta-analyses examining the use of high flow nasal cannula (HFNC) after extubation have included heterogeneous populations, combining postoperative patients with patients who are extubated following critical illness in the ICU.

Objectives: To conduct a systematic review and meta-analysis of HFNC used immediately after extubation in critically ill adults admitted to the ICU.

Methods: We searched MEDLINE, EMBASE and Web of Science, screening for randomized controlled trials (RCTs) that compared HFNC to other non-invasive methods of oxygen delivery after extubation. Our main outcomes of interest included: need for reintubation, mortality, need for non-invasive ventilation (NIV), ICU and hospital length of stay (LOS), complications in the post-extubation period, and patient comfort. We performed analyses using a random effects model. We assessed for predefined subgroup effects based on patient population, risk of bias, risk of extubation failure and the comparator used. We assessed risk of bias using a modified Cochrane risk of bias tool.

Results: We identified 9 RCTs (n = 1636 patients total) that met eligibility criteria. Three trials compared HFNC to NIV and 6 trials compared HFNC to conventional oxygen therapies (COT) (i.e. nasal cannula, Venturi mask, non-rebreather mask, or high flow facemask). HFNC had no effect on the incidence of re-intubation compared to NIV (relative risk [RR] 1.16, 95% confidence interval [CI] 0.86 to 1.57). However, compared to COT, HFNC decreased the need for re-intubation (RR 0.46, 95% CI 0.30 to 0.70). HFNC had no effect on mortality when compared to COT (RR 0.93, 95% CI 0.57 to 1.52) or NIV (RR 1.12,
Further, HFNC did not impact the need for NIV when compared with COT (RR 0.64, 95% CI 0.34 to 1.22). Compared to COT, HFNC had no effect on ICU LOS (mean difference [MD] 0.05 days fewer, 95% CI 0.83 days fewer to 0.73 days more) or hospital LOS (MD 0.98 days fewer, 95% CI 2.16 days fewer to 0.21 days more). Compared to NIV, HFNC had no effect on hospital LOS (MD 3.0 days fewer, 95% CI 6.24 days fewer to 0.24 days more), however it did reduce ICU LOS (MD 0.99 days fewer, 95% CI 1.68 days fewer to 0.30 days fewer). There was no effect of HFNC on patient comfort measured by visual analog scale (VAS) when compared to COT (standardized mean difference (SMD) -1.26, 95% CI -2.81 to 0.29). In contrast when compared to NIV, HFNC reduced discomfort measured by VAS (SMD -0.75, 95% CI -1.38 to -0.12). There were no credible subgroup effects for any of the outcomes of interest for either comparator. Complications were variably reported between trials and could not be pooled.

**Conclusions:** In critically ill adults admitted to the ICU, HFNC used immediately after extubation reduced the need for re-intubation when compared to COT. Similar benefit was not evident when HFNC was compared to NIV. When compared to NIV, HFNC may be associated with a reduction in ICU LOS and less patient discomfort. There was no effect of HFNC on mortality, when compared to either standard oxygen or NIV.
High Flow Nasal Cannula Oxygen Therapy: Mechanisms Driving the Physiological Effects

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Introduction: High flow nasal cannula oxygen therapy (HFNC) is a promising treatment for adults with respiratory failure. It provides washout of anatomic dead space and generates positive pressure in the nasopharynx and the alveoli as illustrated by increased end-expiratory lung volume. Whether the effects of HFNC are similar to continuous positive airway pressure (CPAP) is unclear and changes in respiratory rate are not well explained. We wanted to compare the physiological effects of HFNC at 60 L/min with mouth closed to CPAP at a pressure of 4 cmH2O.

Methods: 1) We first performed a bench study using a manikin’s head connected to a breathing simulator generating steady inspiratory efforts with set lung compliance and airway resistance. Nasopharyngeal pressure was measured with a dedicated catheter and tidal volume was obtained from the simulator at different flows (from 0 to 60L/min, with 10L/min stepwise increase).

2) We then performed a physiological cross-over study on 10 healthy volunteers (8 males, median age 34) breathing mouth closed under HFNC at 20, 40 and 60L/min and under CPAP 4cmH2O. Nasopharyngeal pressure was measured using a dedicated 12 French catheter, as well as esophageal pressure. Tidal volumes were estimated using calibrated electrical impedance tomography. Added inspiratory and expiratory resistances were computed for each condition using esophageal pressure and flow. Diaphragm thickening fraction (TFdi) was assessed in the last three volunteers with diaphragm ultrasound as well as activity of the transversus abdominis. All values were compared between the different HFNC flows and CPAP by Friedman test followed by Nemenyi post hoc test.

Results: 1) In the bench study, mean and end-expiratory nasopharyngeal pressures were close to 4 cmH2O at a set flow of 60L/min. Muscular pressure, lung compliance and airway resistance were kept steady but tidal volume decreased with flow, suggesting that HFNC generated an additional resistance in the upper airways.

2) In the 10 healthy volunteers, end-expiratory nasopharyngeal pressure increased according to HFNC flow from 1.2 cmH2O (0.7-1.3) at 20L/min to 6.9 cmH2O (5.5-7.7) at 60L/min, whereas it was 3.3 cmH2O (3.0-3.6) under CPAP 4 cmH2O (p<0.05 for all comparisons, except between HFNC 40L/min and CPAP, see Figure 1). Esophageal pressure inspiratory swings, and tidal volumes were similar across all conditions. There was a trend in increasing TFdi with increasing flow in three volunteers. Dynamic compliance was different overall (p=0.04), although it did not differ in paired comparisons.

Respiratory rate under CPAP was 14 breaths/min (11-16) and decreased to 7 breaths/min (5-11) under HFNC 40L/min and to 7 breaths/min (5-13) under HFNC 60L/min. The highest tidal increase in expiratory esophageal pressure was 6.2 cmH2O (4.0-9.2) at HFNC 60L/min, but there were no differences between HFNC and CPAP; the highest calculated added expiratory resistance, however, was 76 cmH2O.s/L (71-100) under HFNC 60L/min, 60 cmH2O.s/L (39-88) at 40L/min, 38 cmH2O.s/L (30-45) at 20L/min, and 30 cmH2O.s/L (20-41) under CPAP 4 cmH2O (P<0.001, Figure 1).

Conclusions: In healthy volunteers, HFNC at a flow of 40L/min with mouth closed delivers end-expiratory pressures comparable to CPAP 4 cmH2O, whereas HFNC at 60L/min delivers pressures close to 7 cmH2O. HFNC increases expiratory resistance, which might explain the decrease in respiratory rate.
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Figure 1
Implementation and Evaluation of an Experiential Randomized Trial Activity for High School Students

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Introduction: Previous studies suggest that knowledge of key research concepts may help individuals better understand clinical research and critically appraise health claims¹,².

Objectives: To teach high school students 5 key randomized controlled trial (RCT) concepts: randomization, blinding, intervention and control groups, independent and dependent variables, and average treatment effect.

Methods: Grade 11 and 12 students enrolled in an “Introduction to Healthcare” course participated in an RCT experiential learning activity nested within an interactive ICU workshop hosted in Hamilton, Canada. Before the activity, we administered a questionnaire to collect demographic information and evaluate baseline knowledge of RCT concepts with 5 multiple choice questions (Table 1). Using sealed, opaque envelopes, we then randomized students to 1 of 2 groups using coloured indicators (orange=intervention, blue=control). Groups were separated and completed 2 ICU physical function outcome measures (30-second sit-to-stand (30STS)³, 2-minute walk test (2MWT)⁴) with equipment to simulate ICU-acquired weakness. The intervention group was incentivized by a prize if they surpassed age- and sex-matched mean scores on outcome measures. The control group received no incentive. To teach blinding of participants, neither group was aware of study conditions in the other group. The independent and dependent variable exemplars were incentivization, and performance on the 30STS and 2MWT, respectively. We tabulated individual and group scores for each outcome measure. Post-activity, students participated in a semi-structured discussion to reveal the intervention, identify key RCT concepts, and share outcome measure results. We then administered the questionnaire to re-test students' knowledge. We descriptively summarized demographics, and compared pre- and post-questionnaires using a paired t-test for overall scores, and McNemar’s test for individual questions. We compared outcome measure scores between intervention and control groups using Wilcoxon’s rank-sum test.

Results: Twenty students (90% female, mean (standard deviation) age 16.7 (0.8) years) participated, 8 (40%) of which had not previously learned about research outside of high school classes. Eighteen (90%) and 20 (100%) students completed pre- and post-questionnaires, respectively. Overall scores increased from pre- to post-questionnaires (mean difference=1.39, 95% confidence interval (0.80, 1.98), p<0.001). Two individual question scores increased: experimental variables (p=0.031) and blinding (p=0.004). Scores on the remaining 3 questions (treatment and control groups, randomization, and average treatment effect) did not demonstrate significant improvement (Table 2). Within the activity, students in the incentivized group achieved higher scores on both the 30STS (p=0.029) and the 2MWT (p=0.035).

Conclusion: An experiential learning activity improved students’ overall knowledge of 5 key RCT concepts and 2 questions on experimental variables and blinding. Lack of improvement on the remaining 3 questions may be due to high levels of baseline knowledge or small sample size. Interestingly, physical function outcome measure scores within the RCT activity favoured the intervention group. Future research to study the generalizability of our results to other high school students, critical care content, and health settings is warranted.
Grant acknowledgment: Dr. Kho is supported by the Ontario Ministry of Health Early Researcher Award.

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Figure 1: Flow diagram of RCT experiential learning activity
Table 1: Pre-post questionnaire

Q1. What is the name of the group that does not receive “the intervention” in a clinical trial?

A. The experimental group  
B. The participant group  
C. The treatment group  
D. The control group

Q2. What is the difference between an independent and a dependent variable?

A. Dependent variable is changed or controlled in a clinical trial. An independent variable is measured to identify changes caused by the dependent variable  
B. They are the same  
C. An independent variable is changed or controlled in a clinical trial. A dependent variable is measured to identify changes caused by the independent variable  
D. Both the independent and dependent variable are changed in a clinical trial. The independent variable is changed before the dependent variable

Q3. What is “blinding” and what is its purpose?

A. Blinding means you base your study conclusions totally on a statistical analysis of the data without any preconceived ideas  
B. Blinding refers to uncertainty regarding whether a new treatment is effective  
C. Blinding means that subjects and/or investigators do not know which treatment group the subject is in. The purpose is to prevent bias in assessing the outcome  
D. Blinding occurs when the results totally disagree with previously published studies. Its purpose is to cause a re-evaluation of data

Q4. What is meant by “randomization”?

A. Selection of research participants at random  
B. A method used to assign treatments such that each subject has an equal chance of receiving any of the possible treatments  
C. The process by which bias in research introduces random outcomes  
D. Describes the natural variation between participants in a study

Q5. In a clinical trial, what is the name of the measure used to compare treatments?

A. The causal effect  
B. The difference score  
C. The average treatment effect  
D. The effect size

Correct answers bolded
### Table 2: Pre-post questionnaire results

|                        | Pre Mean (SD) n=18 | Post Mean (SD) n=20 | Paired t-test MD (95% CI) | p value |
|------------------------|--------------------|---------------------|--------------------------|---------|
| **Overall Test Scores**|                    |                     |                          |         |
|                        | 2.50 (1.13)        | 3.89 (1.34)         | 1.39 (0.80, 1.98)        | <0.001 *|

| **Individual Question Scores** | Pre n correct (%) n=18 | Post n correct (%) n=20 | McNemar Test, p value |
|-------------------------------|------------------------|-------------------------|-----------------------|
| Q1. What is the name of the group that does not receive “the intervention” in a clinical trial? | 7 (38.9) | 13(68.4) * | p=0.219 |
| Q2. What is the difference between an independent and dependent variable? | 11 (61.1) | 19 (95.0) | p=0.031 * |
| Q3. What is “blinding” and what is its purpose? | 7 (38.9) | 18 (90.0) | p=0.004 * |
| Q4. What is meant by “randomization”? | 10 (55.6) | 12 (60.0) | p=0.687 |
| Q5. In a clinical trial, what is the name of the measure used to compare treatments? | 10 (55.6) | 16 (80.0) | p=0.344 |

* indicates p<0.05; α indicates denominator of 19
Implementation of an Intensive Care Registry in India (IRIS): Barriers and Opportunities

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Introduction: In India, data on the geographical location of ICUs, ICU resource availability, and case mix and outcomes from critical illness are sparse. ICU-based patient registries offer opportunities for quality improvement and research. We describe the initial development of an Indian critical care registry.

Objectives:
1. To implement an electronic national intensive care registry in India (IRIS)
2. To describe the barriers and potential opportunities

Methods: In partnership with clinicians and administrative stakeholders, we started by recruiting ICUs from private hospitals in Chennai, Tamil Nadu. Admission characteristics, diagnosis, and daily physiology are captured for each patient admitted to the ICU, adapted from the Sri Lanka Network for Improving Critical Systems Training (NICST) registry. De-identified information is displayed in dashboards, enabling administrators to evaluate trends in their ICU activity and bed occupancy. Anonymised aggregate data allows for comparisons across institutions.

ICU directors completed a survey of organisational factors. Data collectors (nurses, physician assistants, research assistants) were trained in data collection. The NICST team provided remote support during implementation and data are stored in servers in India. Anonymised aggregate data are backed up to a cloud-based repository and visualised to provide the user dashboards.

ICUs contributed data through a secure desktop portal. Daily telephone follow-up through nominated local coordinators was used to extract admission numbers from existing records within each ICU and to facilitate validation. Technical support was provided remotely by the NICST team. Information on completeness of reporting was displayed monthly through each participating ICU’s own dashboard, guiding the participating ICUs towards greater data completeness.

Results: The structure of IRIS helped overcome barriers related to data privacy and security; data collection started in January 2019 with 6 adult (115 beds) and 1 paediatric (9 beds) ICU. Results of the landscaping survey are described in Table 1. Data collectors were recruited from each ICU. The ICUs have reported 1367 ICU admissions with 23.19% planned (e.g. post op) and 76.81% unplanned admissions. The commonest admission diagnostic category is cardiovascular (393, 28.75%). Aggregate ICU mortality is 10.83% (148) and median LOS 2days (IQR=3 days)

Opportunities for database development and research include development of a mobile bedside application to facilitate clinician data entry; investigation of the prevalence of frailty at ICU admission and association with outcomes; and development and validation of severity of illness scoring systems.

Conclusion: We describe the implementation of an Indian critical care registry. We have demonstrated feasibility of the model and we see enormous potential for the registry in evaluation of critical care delivery and in improving outcomes from critical illness.
Improving Mobility in Critically Ill Adults in a Lower-Middle Income Country: Opportunities and Challenges

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**Background:** Critically ill patients in the Intensive Care Unit (ICU) are subjected to prolonged periods of bed rest secondary to critical illness and related therapies. Data suggests that physical impairment can affect nearly half of the patients and 50% of those are unable to return to premorbid levels of functional activity. There is limited data from India on mobilisation practices for critically ill patients and opportunities and barriers remain largely unexplored. We undertook a quality improvement (QI) initiative to understand our mobilisation practices, identify challenges and test interventions to improve mobility.

**Methods:** We carried out a 3 phase QI project comprising an initial audit, an intervention phase and a follow-up phase with post-implementation analysis. The study was conducted in our 24 bedded, multidisciplinary ICU at Chennai. Pre-intervention and post intervention mobility performance and scores were analysed. We also recorded data on adverse events and barriers to mobilisation. Descriptive statistics were used to report all the results.

**Results:** A total of 140 patients (1033 patient days) and 207 patients (932 patient days) were included in our initial audit and post implementation audit respectively. Pre-implementation, 31.3% of patients were mobilised with an average mobility score of 2. Post implementation, our mobility rates improved to 57.9% and the average mobility score increased to 3.4. We were also able to demonstrate improvements in the mobility scores of our intubated patients (49.8% achieving a mobility score of 3-5 as compared to 16.7% pre-implementation). Barriers to mobility were primary related to non-modifiable disease related factors.

**Conclusion:** A multi-disciplinary collaborative approach is feasible and resulted in significant improvements in early mobility among critically ill adults in a lower-middle income country.
Figure 1: Protocol for mobilisation in the ICU

- Patient screened by staff nurse prior to morning rounds for contraindication to mobilisation.
  - Is patient fit to be mobilised?
    - No: Do not Mobilise and review the following day
    - Yes: Physiotherapist evaluation: Is patient able to follow commands?
      - No: Patient mobilised passively (IMS 0-2)
      - Yes: Physiotherapist evaluation: What is the muscle strength? (MRC grading of power)
        - Muscle strength \(<=3\):
          - In bed active mobilisation (IMS 1)
        - Muscle strength \(\geq4\):
          - Passively mobilised to sofa (IMS 2)

- If specific contraindications present, order placed by ICU Physician to avoid mobilisation.

- ICU Physician: Improving mobilisation rates
  - Opt-out system for mobilisation
- Staff Nurse: Ensuring patient safety
  - Daily screening for contraindications based on predefined criteria
- Physiotherapist: Improving extent of mobilisation
  - Provide active mobilisation to all eligible patients and adjust level of mobilisation intensity.

- Sitting on edge of bed (IMS 3)
- Standing (IMS 4)
- Stepping to sofa (IMS 5)
- Marching on spot and walking with or without support (IMS 6-10)
**Table 1:** Level of Mobilisation on all Mobilised Patient Days

|                                      | Pre-intervention | Post-intervention |
|--------------------------------------|------------------|-------------------|
| Total number of days mobilised       | 323              | 540               |
| Average mobilisation per ICU Mobilisation Scale (IMS) | 2                | 3.4               |
| 1: active movement in bed (percentage) | 193 (59.7%)      | 161 (29.8%)       |
| 2: mobilised passively out of bed (percentage) | 68 (21.1%)       | 44 (8.1%)         |
| 3 to 5: sitting on side of bed, stepping to chair, standing (percentage) | 54 (16.7%)       | 269 (49.8%)       |
| 6 to 10: marching, walking with and without support (percentage) | 8 (2.5%)         | 66 (12.2%)        |

**Table 2:** IMS Score by Ventilation Mode

|                                      | Pre-intervention | Post-intervention |
|--------------------------------------|------------------|-------------------|
| **Endotracheal tube**                |                  |                   |
| Number of Days with Endotracheal tube (percentage) | 480 (46.47%)    | 406 (43.6%)       |
| Number of days mobilised             | 80               | 110               |
| IMS 1 (percentage)                   | 78 (97.5%)       | 80 (72.7%)        |
| IMS 2 (percentage)                   | 1 (1.25%)        | 7 (6.4%)          |
| IMS 3 to 5 (percentage)              | 1 (1.25%)        | 20 (18.2%)        |
| IMS 6 to 10 (percentage)             | 0                | 3 (2.7%)          |
| **Tracheostomy**                     |                  |                   |
| Number of days with tracheostomy     | 193 (18.68%)     | 61 (6.5%)         |
| Number of days mobilised             | 69               | 45                |
| IMS 1 (percentage)                   | 22 (31.9%)       | 19 (42.2%)        |
| IMS 2 (percentage)                   | 42 (60.9%)       | 0                 |
| IMS 3 to 5 (percentage)              | 5 (7.2%)         | 26 (57.8%)        |
| IMS 6 to 10 (percentage)             | 0                | 0                 |
Introducing High School Students to Critical Care: 2nd Annual Interactive Workshop

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Introduction: Ontario high schools offer specialized courses for students interested in health and wellness. Our team previously conducted a highly-rated interactive intensive care unit (ICU) workshop for these students in 2018. However, participants identified opportunities for improvement. The purpose of this project was to study and address participant feedback in the planning and delivery of a second workshop in 2019.

Objectives: 1) Revise workshop curricula in response to 2018 participant feedback; 2) Evaluate participants’ 2019 workshop ratings; 3) Sustain high overall workshop rating from 2018; 4) Identify future opportunities for improvement.

Methods: The workshop objectives were to introduce students to: 1) the ICU environment, 2) ICU acquired weakness and rehabilitation treatment interventions, including in-bed cycling, and 3) healthcare and research career opportunities. Previous feedback suggested more time for activities, more exposure to healthcare careers, and further focus on research. We consulted with a multidisciplinary team (physiotherapists, research coordinators, graduate students) for ideas and revised the workshop agenda.

We invited students from 2 Hamilton high schools to participate. Three physiotherapists, 2 graduate students and 1 research assistant led the workshop. After the workshop, participants provided feedback with a self-administered questionnaire (8 participant enjoyment, learning and comprehension items assessed on a 7-point Likert scale, 7 demographic items, and 5 open-ended questions). We calculated summary statistics for numerical data and used the Wilcoxon Rank Sum Test to compare 2018 and 2019 activity ratings (alpha = 0.05). We analyzed open-ended questions using thematic content analysis.

Results: Twenty students (90% female, mean (SD) age 16.7 (0.8) years) participated, accompanied by three female teachers. We incorporated a randomized controlled trial simulation within an existing station and included a panel discussion with ICU healthcare and research professionals. The revised 2019 workshop agenda is described and contrasted to 2018 in Table 1. We received feedback from 22 participants (95.7%). The overall 2019 workshop rating was median (IQR) 7.0(1.0), which was not significantly different from 2018 (p>0.05). All activities received an overall median rating of 6.7 or greater (Table 2). New activities received the highest median ratings (> 6.8). All respondents (n=22) reported they would recommend the workshop to future students.

In both years, participants said they would recommend the workshop because they had the opportunity to learn, and the majority of participants most enjoyed station 1 (introduction to ICU technology; 2018=39%, 2019=27%) (Table 3). In this year’s workshop, participants equally enjoyed the newly introduced professional panel (27%). Some participants (29%) suggested more time for activities or more than one workshop annually.

Conclusion: In the second delivery of an educational ICU workshop, we addressed participant feedback and maintained a high level of overall and activity-level participant satisfaction. The professional panel was a new activity favored by participants. In similar educational initiatives, we recommend the inclusion of interactive stations and panel discussions. Results from this study can inform the design of future workshops to introduce other critical care concepts to high school students.
Grant Acknowledgment: This project was supported by the Ontario Ministry of Health Early Researcher Award.

Table 1: Comparison of 2018 and 2019 workshop activities and description of medications

| Activity | 2018 Description (Duration) | 2019 Description (Duration) | Activity revised? (Y/N) |
|----------|-----------------------------|-----------------------------|------------------------|
| Pre-Workshop | An introductory handout was sent to students prior to the workshop introducing ICU terminology, technology and research. | | N |
| Introductory Lecture | Students were introduced to physiotherapy, critical care, ICUAW and the role of physiotherapy in mitigating ICUAW. (25 minutes) | | N |
| *Station 1: Intro to ICU Technology | Students learned how to take their SpO2 and BP. Students were also introduced to common ICU technologies through a scavenger hunt activity in a simulated patient room with a “manakin” patient. (35 minutes) | | N |
| Break | All students had free time for a break. (20 minutes) | N/A | Y – Break was eliminated and combined with Station 3. |
| *Station 2: ICU Patient Simulation & Intro to RCTs | Students learned about ICUAW and physical function outcome measures. Students experienced what it like to have ICUAW by completing outcome measures with simulation equipment intended to restrict physical and respiratory abilities. (35 minutes) | ICU patient simulation as outlined in 2018 and students learned about five key RCT concepts: randomization, intervention and control groups, independent and dependent variables, blinding, and average treatment effect. (35 minutes) | Y – An additional component was added to teach students about RCTs and clinical research. |
| *Station 3: Introduction to In-Bed Cycling & Break | Students learned about in-bed cycling as a novel ICU therapy. Students learned how to use the bike and were given the opportunity to try in-bed cycling. (35 minutes) | Introduction to in-bed cycling as outlined in 2018. When students were not cycling, they were given time to ask questions and take a break. (35 minutes) | Y – Students were given an informal break to allow more time to participate in interactive stations. |
| Large Group Discussion: Career Opportunities in Health Care, Wrap Up | Following the interactive stations, students discussed associated health care and research career opportunities with local ICU clinicians and researchers from SJHH. Students were given the opportunity to ask questions to workshop facilitators. (15 minutes) | We invited 8 research and clinical professionals working in the SJHH ICU to discuss their professional role, educational pathway and challenges/rewards of their job. Students were given the opportunity to ask questions to any of the 8 panelists. The professionals included: a RC, RN, RT, Dietician, Pharmacist, Physician, Medical Student and a Graduate Student. (45 minutes) | Y – We introduced this activity to provide students with additional exposure to healthcare professionals. This activity was 30 minutes longer than 2018. |
| Feedback | Participants completed self-administered feedback questionnaires. (5 minutes) | Participants completed self-administered feedback questionnaires. (5 minutes) | N |

* Students were divided into groups of 6-8 to rotate through the interactive stations.

Abbreviations: ICUAW – ICU Acquired Weakness, RCTs – Randomized Control Trials, RC – Research Coordinator, RN – Registered Nurse, RT – Respiratory Therapist
Abstracts S79

Table 2: Overall activity from participant self-administered questionnaire results

| Activity | n Total | 2018 Median (IQR) | 2019 Median (IQR) | Wilcoxon Rank Sum Test, P value |
|----------|---------|-------------------|-------------------|---------------------------------|
| 1. Pre-workshop Handout | 40 | 7.0 (0.7) | 6.7 (1.0) | p=0.16 |
| 2. Introductory Lecture | 41 | 7.0 (0.7) | 6.7 (1.0) | p=0.08 |
| 3. Station 1: Intro to ICU Technology | 41 | 7.0 (0.75) | 6.75 (0.75) | p=0.04*** |
| 4. Station 2: ICU Patient Simulation & Intro to RCTs | 22 | N/A | 6.9 (0.5) | N/A |
| 5. Station 3: Introduction to In-Bed Cycling & Break | 22 | N/A | 7.0 (0.75) | N/A |
| 6. Large Group Discussion: Career Opportunities in Health Care | 20 | N/A | 6.8 (0.8) | N/A |
| 7. Overall Workshop** | 39 | 7.0 (1.0) | 7.0 (1.0) | p=0.60 |

n=22 (includes responses 20 students and 2 teachers). The scale was measured from 1 (strongly disagree) to 7 (strongly agree). N/A indicates activities that could not be compared as they were new/modified from 2018 workshop.

* Denominators vary as a result of missing data – activity 1 (2018, n=18), activity 6 (2019, n=20), activity 7 (2018, n=18; 2019, n=21)

** The overall workshop was measured from 1 (needs improvement) to 7 (outstanding)

*** Statistically significant difference (p<0.05), although a mean difference of 0.3 on a seven-point Likert scale is not considered to be meaningful.

Table 3: Summary of open-ended questions on feedback questionnaire

| Question | 2018 (n=19) | 2019 (n=22) |
|----------|-------------|-------------|
| Would you recommend this workshop to future students? (Y/N) | Yes (100%) | Yes (100%) |
| Why would you recommend this workshop? | n=19 | n=20 |
| I learned about different careers (58%) | I learned about different careers (50%) |
| I learned something new (26%) | I learned about the hospital/ICU (20%) |
| It was fun (16%) | I learned new things (20%) |
| I learned about the ICU (16%) | It was a fun/ good experience (25%) |
| I learned about research (11%) | It was hands-on (5%) |
| It was hands-on (11%) | |
| I learned about the role of PT (5%) | |
| I learned about new technologies (5%) | |
| Real life scenarios (5%) | |
| Simulation of ICUAW (5%) | |
| What was your favourite part about today’s workshop? | n=18 | n=22 |
| Station 1 (39%) | Professional Panel (27%) |
| Station 2 (33%) | Station 1 (27%) |
| Station 3 (28%) | Station 2 (18%) |
| | Station 3 (14%) |
| | All Stations (9%) |
| | Everything (5%) |
| What would you recommend changing about today’s workshop? | N/A | n=17 |
| Nothing (53%) | |
| More time/activities/workshops (29%) | More information on schooling (6%) |
| A brief break (6%) | |
| | Observe actual ICU patients (6%) |
Introduction and Evaluation of a Novel Clinical Decision Support Tool to Improve Extubation Decision-Making in the ICU

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Introduction: Timely and successful extubation is critical to care in the intensive care unit yet remains unsuccessful in ~15% of patients1,2. A variety of methods to assess extubation readiness have been developed, including the spontaneous breathing trial (SBT)3, the Rapid Shallow Breathing Index (RSBI)4, respiratory rate variability (RRV)5,6, cough strength and more4,7,8; however, no standardized clinical decision support tool has ever been implemented to assist in extubation readiness assessment.

Objectives: In this observational Phase I study, we aimed to evaluate feasibility of implementation of a clinical decision support tool, Extubation AdvisorTM (EA), which combines an RRV-derived model to predict the risk of extubation failure, RSBI, clinical impression of extubation failure risk, and a standardized extubation readiness checklist.

Methods: All patients underwent capnography waveform capture (Excel Bedmaster), with calculation of RRV. Patients were included if they were being considered for extubation and assessed with an SBT. RTs entered salient SBT information including a checklist, and their perception of extubation failure risk into the EA on a tablet. RTs were consented for email surveys and interviews on data entry. RT interviews were audio-recorded, transcribed verbatim and analyzed by a team of researchers with expertise in qualitative research. Themes emerged iteratively from the coded data. MDs and RTs were sent EA report 72 hours post extubation and asked to evaluate it.

Results: 117 patients were enrolled June 2017-October 2018, and 153 SBTs were included. 9 SBTs were excluded for protocol violations (i.e. one-way extubations, direct to tracheostomy), and 43 for inadequate waveform or clinical data. Of the remaining patients, 80 underwent extubation, of which 71 (89%) had complete EA reports. Of 9 unsuccessful reports, 6 had missing information and 3 had software issues. In total, 68 (85%) extubations were successful and 12 (15%) extubations failed. Based on the RRV-predictive model, the incidence of extubation failure in below-average risk patients was 11% compared to 21% in above-average risk patients. Response rates to surveys were low overall (21% from 245 data entry questionnaires and 33% from 48 EA report questionnaires). On average, 75% of RT respondents reported excellent or very good data entry process, clarity, time to complete and completeness, but rated workflow integration lower (56%). On average, 73% of MDs and RTs reported excellent or above average on clarity, accuracy, and completeness, but rated potential impact and usefulness lower (56%). Several themes emerged from RT interviews (n=15) including: EA was found to be clear and easy to use, with few technological issues, and interestingly we observed RT concerns that the EA may be threatening to their job security.

Conclusions: In this mixed-methods evaluation of the first implementation of a waveform-derived predictive model within a bedside tool, the EA was found to be feasibly implemented, and perceived by most RTs and MDs to be a clear, efficient, accurate and complete tool with the potential to aid in extubation decision-making, although lower scores were found for RT workflow integration and perception of utility and impact. Although the tool was designed to empower RT expression of extubation risk, this proved threatening to some. This study helps refine EA design and with planning of future interventional studies.
Grant Acknowledgment: This project is supported by The Ottawa Hospital Academic Medical Organization (TOHAMO) Innovation Fund 2016-2017, awarded March 2017.

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Figure 1: Flow of study enrolment and SBTs by SBT outcomes. \(^a\) N=114 unique patients. The last SBT prior to extubation is the only validated by the WAVE study to predict extubation risk. \(^b\) Protocol violations include tracheostomies or one-way extubations. \(^c\) Failed extubation was defined as the need for re-intubation or death within 48 hours of extubation.

Figure 2: (a) Respiratory therapist feedback on data entry for the Extubation Advisor\(^TM\) on categories including technical problems, time to complete, workflow integration, completeness, clarity and data entry process. (b) Clinician (RT and MD) feedback on the Extubation Advisor\(^TM\) reports on categories including usefulness, potential impact, accuracy, completeness and clarity. AP is the rating for the "average patient".
Liberation from PICU-Acquired Complications – A Bi-Center Implementation Study

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Introduction/Background: The rate of Pediatric Intensive Care Unit (PICU)-acquired complications (PACs) such as delirium, iatrogenic withdrawal and weakness is rising in critically ill children (1-10). This is a result of a practice paradigm of excessive sedation and immobilization, and the lack of pediatric evidence-based guidelines for managing and preventing PACs in this population.

Objective: To implement an early rehabilitation bundle to prevent PACs at 2 tertiary care PICUs at McMaster Children’s Hospital and London Health Sciences.

Methods: We used Pronovost’s 4 E’s Framework (Engage, Educate, Execute and Evaluate) to implement the "PICULiber8 Bundle". The Bundle consists of evidence-based practices to reduce sedatives, prevent withdrawal, manage delirium, optimize sleep, implement early mobilization, and engage families in the process. Engagement consisted of a pre-implementation survey to understand knowledge and practice preferences, followed by focus groups interviews with key inter-professional bedside stakeholder groups. Two inter-professional teams were developed – a Bundle Development and Bundle Implementation. The Bundle team was tasked with developing evidence-based sedation, weaning and delirium practice guidelines tailored to the needs and population of each center’s PICU. The Implementation team responsibility was to review these guidelines and the quantitative and qualitative feedback, and develop a systematic plan for the education and execution phase of bundle implementation. Both teams are responsible for reviewing incorporating the feedback from the engagement phase in their recommendations, and evaluation data on an ongoing basis. A Delphi process was used by each team to develop consensus on bundle content, implementation, educational roll out and sustainability plan. Evaluation will consist of assessing the impact of the bundle on the process of care, family satisfaction, clinical and patient-centered outcomes, and the cost of implementation using mixed methods and run chart analyses.

Results: Engagement was conducted in 3-months. Key knowledge gaps were identified: awareness of delirium, under appreciation of PACs, lack of consistency in measurement and practice variations with respect to sedation and goals in intubated children – site 1 allowed wakefulness, while site 2 preferred light to moderate sedation. Engagement data demonstrated the need for goal directed, evidence based and user-friendly guidelines, more consistency in approach to sedation amongst attending staff, and better team communication. Evidence-based Bundles were developed over a 4-month period, and an educational roll out plan and materials were developed over the subsequent 3 months. A combination of paper, electronic, and video educational resources and implementation tools
were developed, and sequential roll-out of sedation, withdrawal, delirium and revised early mobilization guidelines were implemented over 2-months through small and large group sessions and self-directed learning.

**Conclusion:** It is feasible to implement an early rehabilitation bundle over a 10-month period in 2 sites using a clear implementation framework. Ongoing evaluation will measure the uptake of the bundle and its impact on process of care and patient important outcomes.

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**Figure 1:** PICU Liber8 Bundle Implementation Plan (Pronovost’s 4 E’s Framework)
**Figure 2:** PICU Liber8 Bundle

**Figure 3:** Delphi Process
Long-Term Clinical Outcomes and Health Care Costs of Canadian Adults with Sepsis: A Population-based, Retrospective Cohort Study

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Background: Although the short-term mortality and healthcare costs for sepsis patients are known to be high, the long-term attributable mortality and costs of sepsis in Canada are unclear.

Objectives: To determine the attributable all-cause mortality and healthcare costs of sepsis patients compared to non-sepsis patients residing in Ontario.

Methods: We conducted a population-based retrospective cohort study and included a cohort of adult patients with sepsis (infection with organ dysfunction), infection alone (no organ dysfunction) and non-sepsis controls aged 18 years or older who were admitted to a hospital in Ontario between April 1, 2012 and March 31, 2016, with follow up to 31 March 2017. We used a validated Canadian method to define sepsis from health administrative data. Sepsis cases and hospitalized controls were matched 1:1 based on the propensity score, age, sex, type of admission, and date of admission. We used a conditional time to event analysis and generalized linear models to adjust for remaining confounders and to compare all-cause mortality, hospital readmissions, and health system costs associated with sepsis and non-sepsis patients.

Results: After matching, 248,612 pairs of cases and controls were included in the analysis, of which 82,211 had sepsis and 166,401 had infection alone. Over the 1-year follow-up period, sepsis and infection alone were associated with a higher risk of mortality compared to matched controls (HR 2.07, 95% CI:2.04-2.11 and HR 1.12, 95%CI: 1.11-1.14 respectively). Patients with both sepsis and infection alone had a higher risk of rehospitalization within 1-year of index admission discharge compared to matched controls, with odd ratios of 1.80 (95 %CI: 1.77-1.83) and 1.53 (95% CI: 1.52-1.54), respectively. Compared to matched controls, the incremental one-year health system costs for patients with sepsis and infection alone were $30,974 and $11,409, respectively.

Conclusions: Compared to hospitalized controls, patients with sepsis were more likely to experience higher risks of death and hospital readmission and incur the greater health system costs. The annual 1-year attributable costs to the Ontario health system were estimated to be $637 million for sepsis patients and $475 million for patients with infection alone.

Grant Acknowledgment: This project is funded by The Ottawa Hospital Academic Medical Organization (TOHAMO).

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Mechanical Ventilation in ARDS Patients Managed With and Without VV-ECMO

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Introduction: By completely taking over gas exchange, venovenous extracorporeal membrane oxygenation (VV-ECMO) can facilitate “ultra”-protective ventilation in patients with respiratory failure, thereby potentially preventing further injury. There are, however, limited data available to guide mechanical ventilation (MV) during VV-ECMO.

Objectives:
1. To describe the MV parameters used in patients on VV-ECMO in our institution and to assess the association between MV parameters and patient outcomes.
2. To assess whether patients placed on VV-ECMO, as compared to conventional MV, are exposed to less injurious ventilation, as measured by mechanical power.
3. To assess whether any differences in mechanical power between the two groups is associated with patient outcomes, including mortality and organ dysfunction/injury.

Methods: We conducted a retrospective cohort study of all consecutive adult patients supported with VV-ECMO at the Toronto General Hospital between January 1, 2014 and January 30, 2019, and propensity score matched controls receiving conventional MV. Data was obtained from the Toronto Intensive Care Observational Registry (iCORE) and supplemented with data extracted from electronic patient records. MV parameters on the first and last day of ECMO, and outcomes were described using median (interquartile range). Wilcoxon signed-rank tests were used to compare the MV parameters of the first and last day of ECMO support, and the MV parameters of survivors and non-survivors. A Spearman correlation was used to assess the relationship between compliance and ECMO-free days at 28 days. A multivariable logistic regression analysis will be used to calculate the propensity score, which will be used to match ARDS patients managed with VV-ECMO and those managed without VV-ECMO using a 1:1 matching procedure without replacement and a caliper width of 0.2. Comparisons of mechanical power and mortality between VV-ECMO managed patients and their propensity score matched counterparts will be done using Wilcoxon signed-rank tests and multivariate logistic regression analysis, respectively.

Preliminary Results: Of the 74 patients included, 61% survived to ICU discharge, with a median of 6 (0-18) ECMO-free days. The median (IQR) MV parameters on Day 1 of ECMO were as follows: peak inspiratory pressure 21 (20-25) cmH₂O, positive end-expiratory pressures (PEEP) 10 (10-10) cmH₂O, driving pressure 11 (10-14) cmH₂O, respiratory rate 13 (10-18), tidal volume 2.8 (1.8-4.1) mL/kg, FiO₂ 0.5 (0.4-0.5), dynamic compliance 14 (8-22) mL/cmH₂O. On the last day of ECMO, there were significant increases in respiratory rate to 18 (15-26), tidal volume to 5.4 (4.2-7.6) mL/kg, and the compliance to 24 (16-36) mL/cmH₂O. There were no significant differences in Day 1 parameters between survivors and non-survivors. However, tidal volume and compliance increased significantly over time in the survivors (p=0.001). The change in compliance correlated significantly with ECMO-free days (rho=0.6; p=0.001).

Conclusions: In our institution, “ultra”-protective MV parameters were commonly initiated with VV-ECMO and no Day 1 MV parameter differed significantly between survivors and non-survivors. The propensity score analysis will provide additional insight on whether VV-ECMO allows a reduction in mechanical power and if this results in improved clinical outcomes.
Methicillin-Resistant Staphylococcus Aureus (MRSA) Isolation in the Hospital Setting, a Necessity or Double Whammy?

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Introduction: Methicillin Resistant Staphylococcus Aureus (MRSA) is among the most common and the most serious pathogen requiring prolonged isolation and contact precautions in a hospital setting. Nevertheless, MRSA single room isolation, may lead to negative consequences on patient care, jeopardizing patient safety and increasing dissatisfaction. Moreover, this contributes to substantial economic burden and shunting of limited infection control resources.

Objectives: Our main research question focused on exploring the necessity of single room isolation, supported by scientific evidence based data, and finding gaps in basic infection control practices in a hospital setting.

Materials and Methods: A literature search was performed through PubMed, Mesh and Medline between 2009 and 2019 to explore MRSA transmission rates in single vs shared rooms, in all types of hospital settings including ICU, wards, emergency, and rehabs. The search focused on potential merits and demerits of isolation, and the potential role of non-critical shared medical equipment (NCSME) in nosocomial MRSA transmission.

Results: There was no significant increase in MRSA transmission rates found in shared rooms settings while adhering to contact precautions and infection control measures. In fact, one article supported a rise in MRSA transmission rates during a respiratory outbreak, although the patients were in single room isolation. There is further evidence highlighting MRSA contamination of NCMSE and in existence of significant gaps in disinfection practices.

Conclusion: Overall, there is no clear scientific evidence supporting single room isolation for MRSA in a hospital setting. However, due to the limitations of this research, further evidence based studies need to be undertaken to evaluate the current isolation practices. It seems that NCSME can be a significant source of MRSA transmission and is currently overlooked. Written policies and procedures on NCSME disinfection and documentation of adherence and audits needs to be implemented.

A multidimensional patient-centered approach, targeting the hospital staff, environmental hygiene and patients was proposed. Utilization of this strategy would highlight some vital, but overlooked infection control measures, implementation of which could potentially modify patient isolation practices while reducing nosocomial infection transmission rates.

This abstract is prepared based on preliminary data.

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Mir-187 Regulation in Primary Cardiomyocyte and Murine Model of Experimental Sepsis-Induced Myocardial Dysfunction

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Background: Multiple microRNAs (miRs) are dysregulated during myocardial dysfunction in sepsis. Systemic administration of mesenchymal stromal/stem cells (MSCs) mitigates sepsis induced myocardial dysfunction and alters the expression of both miRs and their target mRNAs in the septic heart. In an experimental model, we have identified miR-187 as a putative host-derived MSC-regulated miR. Here we investigate, in vitro and in vivo, the in-silico hypothesis that miR-187 plays a critical role in the pathogenesis and therapeutics of sepsis-induced myocardial dysfunction.

Methods: Male wild-type mice (C57Bl/6J, 10 - 14 weeks) were randomized to sham or cecum ligation and puncture (CLP) and further randomized to receive MSCs (2 x 10^5 cells, tail vein) or placebo, 6 hours post surgery. Mice were sacrificed at 28hrs and hearts collected for protein, histology and RNA analysis. Transthoracic echocardiograms were performed at 48 hrs in a separate group of mice. Primary cardiomyocytes were harvested from 1-2 days old neonates and exposed to endotoxin (lipopolysaccharide, 2μg/mL) or IL-10 (10 ng/ml) ± MSCs (1x10^4 cells/ well). Cells were lysed, RNA isolated 24 hours post-treatment, and analyzed using qRT-PCR.

Results: MSC administration mitigated CLP-induced left ventricular dilatation and decreased ejection fraction. Quantitative real-time PCR confirmed differential expression of pre-identified in-silico targets in-vivo and IL-10, an anti-inflammatory cytokine, in murine septic hearts treated with MSCs. In vitro, miR-187 expression levels were significantly lower in primary neonatal cardiomyocytes, exposed to endotoxin while the expressions of its putative target genes were increased. Similarly, IL-10 expression was decreased in LPS treated cells; this was mitigated by MSC administration.

Conclusion: MSC administration results in the regulation of host-derived miRNAs involved in protecting cardiomyocytes from sepsis-induced inflammation.

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New-Onset Atrial Fibrillation and Associated Outcomes and Resource Utilization Among Critically Ill Adults

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Introduction: New-onset atrial fibrillation (NOAF) is commonly encountered in critically ill adults. Evidence surrounding the association between NOAF and outcomes of critically ill patients is conflicting. Furthermore, little is known regarding the association between NOAF and resource utilization and hospital costs.

Objectives: We sought to evaluate the association between NOAF and outcomes and costs of adult ICU patients.

Methods: We performed a retrospective analysis (2011-2016) of a prospectively collected registry from two hospitals of consecutive ICU patients ≥ 18 years of age. Atrial fibrillation (AF) detection was prospectively recorded by bedside nurses. NOAF was defined as either: 1) The observation of AF for more than one hour continuously on telemetry; or 2) The documentation of shorter AF as noted on 12-lead electrocardiogram; or 3) AF initiating either pharmacologic treatment or electrical cardioversion. Patients with a known history of AF prior to hospital admission were excluded. The primary outcome was hospital mortality. Secondary outcomes included resource utilization (mechanical ventilation, vasoactive medications, renal replacement therapy), and total costs. We used multivariable logistic regression to adjust for relevant confounders. To evaluate contributors to total cost, we utilized a generalized linear model with gamma distribution and log link.

Results: We included 15,014 patients, and 1,541 (10.3%) had NOAF. Following adjustment for known confounders, NOAF was not associated with increased odds of hospital death (adjusted odds ratio [aOR]: 1.02 [95% confidence interval [CI]: 0.97-1.08]) or discharge to long-term care (aOR 1.05 [95% CI: 0.92-1.14]). Among patients with NOAF, failure of cardioversion to sinus rhythm after 24 hours was associated with increased odds of hospital death (aOR 1.44 [95% CI: 1.18-1.74], as was a known history of heart failure (aOR 1.18
Patients with NOAF had prolonged median ICU length of stay (7 days vs. 6 days, \( P < 0.001 \)), and NOAF was associated with higher total costs (cost ratio [CR]: 1.09 [95% CI: 1.02-1.20]). Among patients with NOAF, treatment with a rhythm control strategy was associated with higher costs (CR 1.24 [95% CI: 1.07-1.40]).

**Conclusions:** In our cohort of critically ill patients, NOAF was not associated with in-hospital death or discharge to long-term care. However, incidence of NOAF was associated with higher total costs. Among patients with NOAF, higher odds of mortality were seen among those who were unable to achieve cardioversion to sinus rhythm after 24 hours, and those with an existing diagnosis of heart failure. A rhythm control strategy among patients with NOAF was associated with higher costs. Taken together, this work provides novel insight related to NOAF in critically ill adult patients.
Optimal Strategy and Timing of Left Ventricular Venting During Veno-Arterial Extracorporeal Life Support for Adults in Cardiogenic Shock - A Systematic Review and Meta-Analysis

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Introduction and Objective: Veno-arterial extracorporeal life support (VA-ECLS) is widely used to treat refractory cardiogenic shock. However, increased left ventricular (LV) afterload in VA-ECLS can lead to LV distension and stasis, which in turn may exacerbate myocardial ischemia, arrhythmias, pulmonary edema, thrombo-embolic phenomenon and timely myocardial recovery. The purpose of this meta-analysis was to explore the efficacy, safety, and optimal timing of adjunctive LV unloading strategies.

Methods: A systematic search was performed of Medline, EMBASE, PubMed, CDSR, CCRCT, CINAHL, ClinicalTrials.Gov, and WHO ICTRP from inception until January 2019 for all relevant studies including LV venting in accordance PRISMA protocols. Data were analysed for mortality and wean from VA-ECLS on the basis of timing of LV venting (<12hrs or >12hrs). All eligible studies were assessed for methodological quality using the ROBINS-I tool. Statistical heterogeneity for the outcomes among studies was assessed using the $I^2$-test and reporting biases using funnel plots of the treatment effect against study precision. Inverse variance, random effects model was used to account for between-study heterogeneity and assess the overall risk ratio. Pooled data were summarized using either means or medians (and interquartile range) for continuous parametric and non-parametric variables, respectively and categorical variables were reported as counts and percentages. P values < 0.05 by chi-squared test for difference in proportions or two-sided t-test for continuous variables, were considered statistically significant.

Results: A total of 7,995 patients were included from 62 observational studies, wherein 3,458 patients had LV venting during VA-ECLS. LV venting significantly improved wean from VA-ECLS (OR 0.62; 95% CI 0.47-0.83; p=0.001) and reduced short-term 30-day (RR 0.86; 95% CI 0.77-0.96; p=0.008) but not in-hospital (RR 0.92; 95% CI 0.83-1.01; p=0.09) or long-term up to 6 months (RR 0.96; 95% CI 0.90-1.03; p=0.27) mortality (Figure 1). Early (<12h, RR 0.86; 95% CI 0.75-0.99; p=0.03) but not late (>12h, RR 0.99; 95% CI 0.71-1.38; p=0.93) LV venting significantly reduced short-term mortality. Moreover, a significant improvement in wean from VA-ECLS overall (OR 0.62; 95% CI 0.47-0.83; p=0.001) and with early (OR 0.68; 95% CI 0.50-0.91; p=0.005), but not late (OR 1.21; 95% CI 0.19-7.57; p=0.84) LV venting. Patients with LV venting spent more time on VA-ECLS (3.6 vs. 2.8 days, p<0.001), and mechanical ventilation (7.1 vs. 4.6 days, p=0.013) (Table 1).

Conclusions: LV venting, especially if done early (<12h), appears to improve wean from ECLS and reduce short-term but not in-hospital or long-term mortality. Future studies are required to explore the full impact of any or early LV adjuncts on mortality and morbidity.
outcomes.

**Table 1:** Baseline Characteristics, Destination Therapy, and Mortality in Patients on VA-ECLS with or without LV Venting

|                           | Studies reporting on venting only (n. 25) | Studies reporting on venting vs. non- venting (n. 36) | P value*   |
|---------------------------|-----------------------------------------|------------------------------------------------------|------------|
| Number of patients, n (%) | 666/1523 (44%)                          | 6472/2792 (43%)                                      | 3680/6472 (57%) |
| Gender (male), n (%)      | 392/526 (74.5%)                         | 2874/4071 (70.6%)                                    | 1256/1684 (74.6%) | 1618/2387 (67.8%) | <0.01     |
| Age, mean years (n)       | 54.3 (550)                              | 55.6 (1892)                                         | 56.1 (715) | 55.1 (1177) | 0.001     |
| Weaned from VA-ECLS, n (%)| 208/408 (51%)                           | 2091/3753 (55.7%)                                   | 1068/1562 (68.4%) | 1023/2191 (46.7%) | <0.01     |
| Duration of VA-ECLS, mean days (n) | 6.0 (480) | 3.2 (4052) | 3.6 (1758) | 2.8 (2294) | <0.01     |
| Duration of MV, mean days (n) | 8.4 (97) | 5.8 (594) | 7.1 (264) | 4.6 (330) | 0.01     |
| ICU Length of Stay, mean days (n) | 15 (221) | 12.6 (1124) | 13 (574) | 12.3 (550) | NS        |
| Bridge to, n (%)          |                                        |                                                     | Recovery VAD | Transplant | NS        |
| All-cause mortality, n (%) |                                        |                                                     | 172/393 (43.8%) | 56/424 (13.2%) | 0.001     |
| Short-term                | 163/298 (54.7%)                         | 2157/3825 (56.4%)                                   | 797/1565 (50.9%) | 1360/2260 (60.2%) | <0.01     |
| In-hospital               | 229/377 (60.7%)                         | 3409/5424 (62.9%)                                   | 1308/2173 (60.2%) | 2101/3251 (64.6%) | 0.001     |
| Long-term                 | 90/142 (63.4%)                          | 416/510 (81.6%)                                     | 416/510 (81.6%) | 2101/3251 (64.6%) | NS        |

*chi-squared test for difference in proportions, two-sided t test for continuous variables

VA-ECLS = veno-arterial extracorporeal life support, LV = left ventricle, VAD = ventricular assist device, MV = mechanical ventilation, ICU = intensive care unit.
Figures 1a-c illustrate the all-cause mortality outcomes in relation to LV venting during VA-ECLS

**Figure 1a: Short-Term (up to 30 days) Mortality**

| Study or Subgroup | VA-ECLS + LV vent | VA-ECLS alone | Start of VA-ECLS | Risk Ratio | IV, Random, 95% CI |
|-------------------|-------------------|---------------|------------------|------------|-------------------|
| **1.5.1 IABP**    |                   |               |                  |            |                   |
| Acmis 2005        | 2                 | 5             | 1                | 8          | 0.3%              |
| Brecher 2013      | 24                | 64            | 33               | 42         | 7.6%              |
| Lm 2016           | 257               | 533           | 110              | 533        | 12.2%             |
| Overburn 2018     | 27                | 41            | 45               | 55         | 8.3%              |
| Park 2014         | 14                | 44            | 13               | 42         | 7.6%              |
| Fontanier 2017    | 34                | 55            | 62               | 108        | 9.0%              |
| Santis 2014       | 5                 | 13            | 5                | 6          | 1.7%              |
| Tepper 2019       | 15                | 30            | 22               | 30         | 4.7%              |
| Usecara 2013      | 26                | 55            | 5                | 8          | 2.8%              |
| **Subtotal (95% CI)** | 1145             | 1080          | 63.2%            | 0.82       | [0.75, 0.91]      |
| Total events      | 568               | 645           |                  |            |                   |

Heterogeneity: Tau² = 0.00, Ch² = 11.29, df = 9 (p = 0.26%; I² = 20%)
Test for overall effect: Z = 3.92 (p < 0.0001)

| Study or Subgroup | VA-ECLS + LV vent | VA-ECLS alone | Start of VA-ECLS | Risk Ratio | IV, Random, 95% CI |
|-------------------|-------------------|---------------|------------------|------------|-------------------|
| **1.5.2 Impella** |                   |               |                  |            |                   |
| Acmis 2018        | 16                | 29            | 87               | 196        | 5.6%              |
| Maurit 2017       | 4                 | 11            | 4                | 16         | 0.8%              |
| **Subtotal (95% CI)** | 40               | 212           | 63.5%            | 1.26       | [0.89, 1.78]      |
| Total events      | 20                | 91            |                  |            |                   |

Heterogeneity: Tau² = 0.00, Ch² = 0.06, df = 1 (p = 0.80%; I² = 0%)
Test for overall effect: Z = 1.31 (p = 0.19)

| Study or Subgroup | VA-ECLS + LV vent | VA-ECLS alone | Start of VA-ECLS | Risk Ratio | IV, Random, 95% CI |
|-------------------|-------------------|---------------|------------------|------------|-------------------|
| **1.5.3 Surgical vent** |                  |               |                  |            |                   |
| Schmack 2017      | 7                 | 14            | 10               | 13         | 2.7%              |
| **Subtotal (95% CI)** | 14               | 13            | 2.7%             | 0.65       | [0.36, 1.19]      |
| Total events      | 7                 | 10            |                  |            |                   |

Heterogeneity: Not applicable
Test for overall effect: Z = 1.40 (p = 0.16)

| Study or Subgroup | VA-ECLS + LV vent | VA-ECLS alone | Start of VA-ECLS | Risk Ratio | IV, Random, 95% CI |
|-------------------|-------------------|---------------|------------------|------------|-------------------|
| **1.5.4 Mixed**   |                   |               |                  |            |                   |
| Doll 2004         | 92                | 144           | 37               | 75         | 8.1%              |
| Perez 2018        | 9                 | 20            | 26               | 36         | 5.7%              |
| Re 2014           | 42                | 60            | 139              | 193        | 10.5%             |
| Schmack 2017      | 9                 | 20            | 21               | 28         | 3.3%              |
| **Subtotal (95% CI)** | 254              | 332           | 27.7%            | 0.91       | [0.69, 1.21]      |
| Total events      | 160               | 225           |                  |            |                   |

Heterogeneity: Tau² = 0.06; Ch² = 10.34; df = 3 (p = 0.02%; I² = 71%)
Test for overall effect: Z = 2.94 (p = 0.003)

Total (95% CI) 1453 1637 100.0% 0.86 [0.77, 0.96]

Total events 755 971

Heterogeneity: Tau² = 0.02; Ch² = 31.22; df = 16 (p = 0.011; I² = 49%)
Test for overall effect: Z = 2.67 (p = 0.008)

Test for subgroup differences: Ch² = 6.42, df = 3 (p = 0.099; I² = 53.2%)

Footnotes
(1) Propensity matched
(2) Propensity matched
(3) Predominantly IABP + LA in 3 patients
(4) Predominantly Impella + surgical vent in 17 patients (LV, PA, IABP in 15 patients)
(5) Predominantly IABP + LV vent in 6 patients (at RUPV or atrial septostomy)
(6) Predominantly LV surgical vent + IABP in 17 patients
### Figure 1b: In-Hospital Mortality

| Study or Subgroup | VA-ECMO + LV vent | VA-ECMO alone | Total | Weight | Risk Ratio IV, Random, 95% CI |
|-------------------|-------------------|---------------|-------|--------|-------------------------------|
| 1.4.1 IABP       |                   |               |       |        |                               |
| Ayama 2014        | 22                | 35            | 2     | 3      | 1.2% 0.94 [0.41, 2.18]         |
| Ao 2016 (1)       | 298               | 533           | 344   | 531    | 6.1% 0.87 [0.79, 0.96]         |
| Beurmerler 2013   | 17                | 27            | 38    | 60     | 3.7% 0.99 [0.70, 1.41]         |
| Brechot 2018 (2)  | 28                | 63            | 35    | 63     | 3.6% 0.80 [0.56, 1.14]         |
| Chen 2019         | 40                | 77            | 39    | 75     | 4.2% 1.00 [0.74, 1.36]         |
| Chung 2011        | 7                 | 14            | 3     | 6      | 1.0% 1.00 [0.88, 1.30]         |
| Dangers 2017      | 35                | 66            | 35    | 39     | 4.6% 0.59 [0.46, 0.76]         |
| Elsharkawy 2010   | 15                | 22            | 134   | 211    | 4.1% 1.07 [0.79, 1.45]         |
| Gass 2014         | 18                | 56            | 39    | 79     | 2.9% 0.65 [0.42, 1.01]         |
| Kagawa 2012       | 46                | 71            | 15    | 15     | 5.3% 0.67 [0.55, 0.81]         |
| Nage 2016         | 5                 | 9             | 3     | 6      | 0.9% 1.12 [0.41, 2.99]         |
| Papadopoulos 2015 | 90                | 112           | 162   | 248    | 5.9% 1.23 [1.08, 1.40]         |
| Park 2014         | 21                | 41            | 30    | 55     | 5.4% 0.94 [0.64, 1.38]         |
| Rasam 2010        | 275               | 371           | 114   | 147    | 6.1% 0.88 [0.62, 1.09]         |
| Sakanoto 2012     | 62                | 94            | 4     | 4      | 3.9% 0.73 [0.53, 1.01]         |
| Sande 2014        | 6                 | 13            | 4     | 6      | 1.2% 0.69 [0.31, 1.54]         |
| Shin 2009         | 26                | 39            | 53    | 53     | 4.2% 1.01 [0.75, 1.35]         |
| Slomchik 2013     | 50                | 72            | 4     | 5      | 2.2% 0.87 [0.55, 1.38]         |
| Stepper 2014      | 18                | 30            | 23    | 30     | 3.6% 0.78 [0.55, 1.11]         |
| Unosawa 2013      | 27                | 39            | 6     | 8      | 2.8% 0.92 [0.59, 1.45]         |
| Wang 2013         | 12                | 41            | 31    | 46     | 2.6% 0.47 [0.29, 0.77]         |
| Wu 2012           | 20                | 44            | 8     | 16     | 2.0% 0.91 [0.51, 1.64]         |
| **Subtotal (95% CI)** | 1139            | 1108          |       |        |                               |
| **Total events**  | 1139             | 1108          |       |        |                               |
| Heterogeneity: Tau^2 = 0.03, Q^2 = 59.22, df = 21 (p = 0.00001), I^2 = 65% |
| Test for overall effect: Z = 2.82 (p = 0.005) |

| 1.4.2 Impella     |                   |               |       |        |                               |
| Arami 2018        | 18                | 29            | 112   | 186    | 4.0% 1.00 [0.79, 1.94]         |
| Mourad 2017       | 7                 | 11            | 7     | 16     | 1.5% 1.45 [0.71, 2.97]         |
| **Subtotal (95% CI)** | 25               | 120           |       |        |                               |
| **Total events**  | 25                | 120           |       |        |                               |
| Heterogeneity: Tau^2 = 0.00, Q^2 = 0.58, df = 1 (p = 0.45), I^2 = 0% |
| Test for overall effect: Z = 0.84 (p = 0.40) |

| 1.4.3 Surgical Vent |                   |               |       |        |                               |
| Biancari 2017      | 2                 | 5             | 93    | 143    | 0.8% 0.62 [0.21, 1.81]         |
| **Subtotal (95% CI)** | 2             | 93            |       |        |                               |
| **Total events**  | 2                 | 93            |       |        |                               |
| Heterogeneity: Not applicable |
| Test for overall effect: Z = 0.88 (p = 0.38) |

| 1.4.4 Mixed        |                   |               |       |        |                               |
| Biancari 2017 (3)  | 27                | 38            | 68    | 110    | 4.6% 1.15 [0.89, 1.48]         |
| Lorussi 2016 (4)   | 5                 | 14            | 12    | 43     | 1.2% 1.28 [0.55, 2.00]         |
| Pappalardo 2015 (5)| 10                | 21            | 31    | 42     | 2.6% 0.65 [0.40, 1.05]         |
| Ro 2014 (6)        | 41                | 60            | 139   | 193    | 5.2% 0.95 [0.78, 1.15]         |
| Tricci 2017 (7)    | 9                 | 10            | 45    | 102    | 4.1% 1.04 [1.51, 2.76]         |
| **Subtotal (95% CI)** | 143            | 490           |       |        |                               |
| **Total events**  | 92                | 295           |       |        |                               |
| Heterogeneity: Tau^2 = 0.12, Q^2 = 23.23, df = 4 (p = 0.0001), I^2 = 83% |
| Test for overall effect: Z = 0.71 (p = 0.48) |

| 95% CI            | 2057             | 2553          | 100.0% | 0.92 [0.83, 1.01] |
| **Total events**  | 1158             | 1616          |       |                  |
| Heterogeneity: Tau^2 = 0.04, Q^2 = 94.90, df = 29 (p < 0.00001), I^2 = 69% |
| Test for overall effect: Z = 1.70 (p = 0.09) |
| Test for subgroup differences: Chi^2 = 5.32, df = 3 (p = 0.15), I^2 = 43.6% |

**Footnotes:**

1. Propensity matched
2. Propensity matched
3. Predominantly IABP + Surgical vents in 5 patients – 3 in RUPV, 1 in LV apex, and 1 in PA
4. Predominantly IABP + LV vent in 13 patients (2 in PA, 4 in RUPV, 4 in LV, 4 not reported)
5. Propensity matched / Predominantly Impella + with a proportion of both groups having concurrent IABP
6. Predominantly IABP + LV vent in 6 patients (3 RUPV or atrial septostomy)
7. Predominantly IABP + Impella in 5 patients and surgical LV vent in another 5 patients (1 direct LV vent, 1 atrial septostomy, 3 ST-VAD)
Figure 1c: Long-term (up to 6 months) mortality
Introduction: Extracorporeal membrane oxygenation (ECMO) is used as temporary cardiorespiratory support in critically ill patients refractory to medical management. Little is known about population-level short- and long-term outcomes following ECMO, including healthcare use and health system cost across a wide range of sectors.

Objectives: To examine short- and long-term outcomes and health system costs among critically ill adults receiving ECMO for cardiorespiratory support.

Methods: Population-based, retrospective cohort study of adult patients (≥18 years) receiving ECMO between October 1, 2009, and March 31, 2017 in Ontario, Canada. We identified ECMO use through procedural codes for cannulation, as well as relevant billing codes. We captured outcomes through linkage to health administrative databases. The primary outcome was mortality during hospitalization, as well as at 7-days, 30-days, 1-year, 2-years, and 5-years following ECMO initiation. We secondarily evaluated disposition at hospital discharge (home vs. continuing care) in survivors, as well as incidence of lung and/or heart transplantation during hospitalization. Finally, we analyzed health system costs (in Canadian dollars) in the 1-year following the date of the index admission.

Results: A total of 692 patients were included in the study cohort. Mean (standard deviation [SD]) age was 51.3 (16.0) years, and 62.0% of patients were male. Median (interquartile range [IQR]) time to ECMO initiation from date of hospital admission was 2 (0-9) days. In-hospital mortality was 40.0%. Mortality at 1-year, 2-years, and 5-years was
45.1%, 49.0%, and 57.4%, respectively. Among survivors, 78.4% were discharged home, while 21.2% were discharged to continuing care. 193 patients (27.9%) received lung transplant, and 46 patients (6.6%) received heart transplant during the index hospitalization. Median (IQR) total cost in the 1-year following admission among all patients was $130,157 ($58,645-$240,763), of which $91,192 ($38,507-$184,728) were attributed to inpatient care. **Conclusions:** Hospital mortality among critically ill adults receiving ECMO for advanced cardiopulmonary support is relatively high, but does not markedly increase in the years following discharge. Survivors are more likely to be discharged home than to continuing care. Median costs are high, but largely reflect inpatient hospital costs, and not costs incurred following discharge.
Outcomes and Costs Following Extracorporeal Membrane Oxygenation in Critically Ill Pediatric Patients – A Population-Based Cohort Study

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Introduction: Extracorporeal membrane oxygenation (ECMO) provides temporary cardiorespiratory support in critically ill children whose heart or lung failure becomes refractory to medical management. Little is known about population-level health outcomes and costs following ECMO in pediatric patients.

Objectives: Determine the short- and long-term outcomes and costs of pediatric patients receiving ECMO for cardiorespiratory support.

Methods: Population-based, retrospective cohort study of pediatric patients (<18 years) receiving ECMO between October 1, 2009, and March 31, 2017 in Ontario, Canada. We identified ECMO use through procedural codes for cannulation, as well as relevant billing codes. We captured outcomes through linkage to health administrative databases. The primary outcome was mortality during hospitalization, as well as at 7-days, 30-days, 1-year, 2-years, and 5-years following ECMO initiation. We secondarily evaluated disposition at hospital discharge (home vs. continuing care) in survivors, as well as incidence of lung and/or heart transplantation during hospitalization. Finally, we analyzed health system costs (in Canadian dollars) in the 1-year following the date of the index admission.

Results: We captured 256 patients. Mean age at ECMO initiation was 3.6 years (standard deviation [SD] = 5.3), 53.9% were male, and 26.2% lived in the lowest income quintile, compared with 14.1% in the highest. Median time from hospital admission to ECMO initiation was 5 days (interquartile range [IQR] = 1-13 days). Overall survival to hospital
discharge was 55.5%. Survival at 1-year, 2-years, and 5-years was 50.0%, 48.8%, and 44.1%, respectively. During hospitalization, 40 patients (15.6%) received a VAD, 10 patients (3.9%) received lung transplant, and 11 patients (4.3%) received heart transplant. Among survivors, 99.3% were discharged home. Median total costs among all patients in the year following hospital admission were $143,053 (IQR: $67,175-$293,692). Of these costs, the large proportion were attributable to the inpatient cost from the index admission (Median $115,117, IQR: $55,840-$252,489).

Conclusions: While patients requiring ECMO have significant in-hospital mortality, there is little decrease in long-term survival at 1-year. Nearly all patients surviving to discharge were able to be discharged home. Few patients received heart or lung transplant following ECMO. Median costs among all patients were substantial, but largely reflect inpatient hospital costs, rather than post-discharge outpatient costs.
Outcomes and Costs of Patients with Cirrhosis Admitted to Intensive Care Unit

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Background: Cirrhosis comprises a significant burden on the healthcare care system in North America, both in the acute care setting and as a chronic disease. Commonly, acute deterioration of patients with cirrhosis manifests as multi-organ failure requiring admission to the Intensive Care Unit (ICU). These patients admitted to the ICU have a high mortality and have poor outcomes when compared to hospital patients with cirrhosis who do not require ICU admission. Due to the advancement of the standard of care, mortality rates for patients with cirrhosis has improved in the past 20 years; however, much of the mortality rate is still comprised of cirrhosis patients admitted to the ICU. There is a paucity of evidence about the factors that lead to increased mortality and cost in patients with cirrhosis who are admitted to the ICU.

Objectives: To identify the prognostic risk factors and outcomes for patients with cirrhosis admitted to the ICU and to evaluate cost patterns.

Methods: We conducted a retrospective cohort analysis of a health administrative database, consisting of patient data from two ICUs within a single hospital system. The sample consisted of 8,447 patients admitted to ICU from 2011 to 2014, of whom 332 had a diagnosis of cirrhosis. Control patients were defined as randomly selected age, sex, and comorbidity index–matched ICU patients without cirrhosis (1:4 matching ratio).

Results: Mean age of cirrhosis patients in the ICU was 59.6 years, and 131 (39.5%) died prior to discharge. As compared to cirrhotics who lived, patients with cirrhosis who died were more likely to have a high average bilirubin (65.5 vs. 106.5; p<0.001), lactate (3.8 vs. 6.5; p<0.001), INR (1.72 vs. 2.19; p<0.001), and an increased need for red blood cells transfusions (54.7% vs. 72.8%; p<0.001) during their hospital stay. The cirrhosis-related complications that most frequently brought cirrhosis patients to the ICU were ascites (31.1%), encephalopathy (18.9%), and peritonitis (14.4%). Cirrhosis patients with peritonitis (8.8% vs. 21.2%; p<0.001) and hepatorenal syndrome (2.8% vs. 13.9%; p<0.001) were more likely to die in the ICU compared to cirrhosis patients admitted with other diagnoses. Results from further analysis of prognostic markers comparing cirrhosis patients and controls, as well as cost analyses will be reported with the final abstract presentation.

Conclusion: Our findings illustrate that cirrhosis patients admitted to the ICU have a high mortality rate and are more likely to die in the ICU if their admission diagnosis is peritonitis and hepatorenal syndrome. Poor prognostic markers for cirrhosis patients admitted to the ICU are elevated bilirubin, high lactate, increased INR, and increased need for blood transfusions.
PEDIATRIC VIRTUAL CRITICAL CARE Pilot Study: A Qualitative Assessment Survey

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Introduction: Telemedicine is the use of telecommunication and technology to deliver health care remotely. Pediatric critical care expertise is concentrated within tertiary care centers. In Ontario, remote health care centers seek pediatric critical care consultation through a centralized system by telephone. The call would connect the health care physician with the consulting physician. Discussion of the case details occurs and advice is given. This may result in transporting the patient to the consulted critical care unit. Critical Care Response Teams (CCRT) comprised of MD’s, Respiratory Therapists (RT’s) and Registered Nurses (RN’s) bring specialized multidisciplinary knowledge to the bedside when critical care service is consulted. As an adjunct to the traditional extramural consultation service, we conducted a pilot quality improvement initiative using telemedicine or Pediatric Virtual Critical Care (PVCC) to connect a remote center (North Bay Regional Health Centre (NBRHC)) with the pediatric CCRT at the Children’s Hospital of Eastern Ontario (CHEO) as an extra resource to supplement the traditional telephone MD-only consultation. We conducted a qualitative survey of the teams at NBRHC and CHEO to assess this novel initiative.

Method: The project team developed the project documentation: project charter & work plan, guidelines, teaching materials and posters. A survey was developed by the PVCC team. Upon completion of each consultation, the survey was distributed to all participants from both sides in either paper or electronic forms. Free text space for comments was allowed. Respondents were anonymous.

Results: Prior to the initiation of the PVCC trial, our quality team implemented the project charter which included educating teams on the work plan and algorithm as well as the use of technology. Multiple mock PVCC codes were conducted by the nursing educators on both sites to assess the quality of the process and troubleshoot issues prior to implementation.

Between December 2016 and May 2019, a total of 41 PVCC calls were completed involving 27 primary activations and 14 follow up visits.

A total of 83 survey responses were received with 60 from CHEO and 23 from NBRHC. 51.5% of the surveys were completed by MD’s, 40% by RN’s and 8.5% by RT’s. In assessing the ease of the PVCC process, all participants at NBRHC and 88% of participants at CHEO thought that it was easy.

All the teams felt that the multidisciplinary resources were valuable. 90% of people at both sites thought that the educational benefit was better than a phone consultation. 88-95% of participants agreed that the ability to involve family in the consultation was valuable and felt that this was a huge asset to the program.

90% of the participants thought that the educational benefit was better than a phone consultation and felt more comfortable treating pediatric patients with PVCC vs phone consultation. 95 % felt that the PVCC improves the quality of care compared with a telephone.

After PVCC, 14/27 patients remained at their hospital with the support of CHEO’s CCRT.

Conclusion: PVCC presents a valuable resource in supporting remote teams caring for critically ill pediatric patients by providing multidisciplinary advice and family involvement in consultations. PVCC increases clinician comfort when caring for pediatric patients. Preventing transfer can add significant savings to the health care system. This model is easy to implement using current resources.
Survey on the Pediatric Virtual Critical Care program - Click here to view

**Figure 1: PVCC Program Model**

| Inputs | Outputs | Outcomes - Impact |
|--------|---------|-------------------|
| Resources<br>1. People - Referring and consulting sites’ Critical Care physicians, RTs, RNs, educators, OTN support<br>2. Technology – OTN, NEODIN | Activities<br>1. Referring and consulting sites to be: 1) Informed 2) Trained 3) Get access to PVCC<br>2. Critical Care physicians, SPOT RTs and SPOT RNs | Short Term<br>1. Share pediatric expertise<br>2. Increase interdisciplinary collaboration<br>3. Improve educational opportunities and knowledge translation | Medium Term<br>Future opportunity to expand services to other sites within LHIN, Baffin Island and Quebec | Long Term<br>1. Improve Morbidity and Mortality<br>2. Improve patient outcomes<br>3. Potential for child to receive care closer to home |

| Assumptions | External Factors that may influence the outcomes |
|-------------|-----------------------------------------------|
| 1. Access to PVCC service 24/7<br>2. Staff have access to OTN, NEODIN, and training is completed<br>3. Technology works without interruption | 1. Staff may perceive increased workload and time<br>2. The initial process may be complicated for some staff<br>3. Technology and advice may delay transfer time |
**Figure 2:** Process for Acute Pediatric OTN Consultation (PVCC) with CHEO for Non Life or Limb Patients

- North Bay Regional Health Centre Requests Pediatric Virtual Critical Care Consult through CHEO Switchboard (813) 737-7600 ext 0
- CHEO Switchboard Pages SPOT Nurse to 51XX
- CHEO SPOT Nurse Establishes: Presumptive Diagnosis Requested Time of Consult Location of Consult: ER or CCU
- SPOT Nurse Pages CHEO Intensivist and RT
- SPOT Nurse Establishes 2 or 3 way Videoconference with NBRHC (ER or CCU) and CHEO ICU MD
- Is Video Consult Possible at Proposed Time?
- CHEO Intensivist Calls NBRHC MD to Consult through Criticalcall 1-800-668-4357

**Consultation occurs**
- Documentation on PVCC forms and faxed to NBRHC

**Collaborative decision on disposition of patient**

- **Consult Only**
  - No Followup Required
- **Arrange followup**
  - VCC as needed minimum daily within the next 48 hrs if no patient transfer
- **Admit to CHEO**
  - arrange Ornge/EMS transfer and continue to support on route
  - North Bay Physician to call Criticalcall 1-800-668-4357 to page CHEO Intensivist
  - Some details of the case will have to be repeated for Criticalcall/Ornge

**Complete VCC Evaluation Forms for both CHEO and NBRHC**
Peri-Operative Hypertensive Urgencies; Etiologic Factors and Therapeutic Modalities Used

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Introduction: Perioperative hypertension is seen commonly in up to 20% of patients undergoing surgery (1). Hypotension and hypertension have been reported to be associated with postoperative complications and mortality (2-4). Occasionally patients can have a hypertensive urgency or emergency during perioperative period due to hemodynamic changes in response to anesthesia and surgery. Such severe hypertension in operative patients usually occurs in chronic hypertension and other comorbidities. Identifying the underlying condition and factors responsible for acute severe rise in blood pressure in the unique intra/postoperative time is fundamental to effective treatment and prevention of perioperative hypertensive urgency and its complications. Hypertensive urgencies are situations associated with severe BP elevation in patients without acute or impending target organ damage.

Objectives: We hypothesized that finding the patients characteristics and etiologies of perioperative hypertensive urgency and assessing the treatments used can affect our evaluation in the future and prevent postoperative complications.

Methods: We performed an observational study using data from University Health Network hospitals between 2015 and 2019 for noncardiac surgery to find patients with perioperative hypertensive urgency (defined as SBP>180 or DBP>120 or MAP>140 and >20% rise from the baseline BP) during or within 2 hours after surgery for whom all the required data was available. Patients with an acute intracranial event were excluded. Finally 300 patients were enrolled and the EPRs were reviewed to analyze the etiology of hypertension urgency and assess the treatment methods used. The research proposal was approved by the Research Ethics Board at UHN.

Results: Based on our preliminary result, of all cases 38% had poorly controlled HTN before the surgery. Volume overload was the main reason in 16% of cases. Alcohol withdrawal detected in 8%. ESRD patients on hemo/peritoneal dialysis and other CKD patients comprised of 35% of cases, many of them received liberal fluid therapy and later needed aggressive diuretic therapy to lower BP. Withdrawal of antihypertensive medication was seen in 2% of all subjects. Renovascular HTN was detected in 6%, half of which diagnosed after surgery, primary aldosteronism and pheochromocytoma each were 1% of subjects. 29% had 3 or more etiologic factors. 31% of patients with hypertensive urgency had an episode of intraoperative hypotension requiring treatment and in 34% of them treatment including vasopressors led to severe HTN.

Conclusion: Volume overload in general and specially in ESRD patients during operation can cause hypertensive urgency in a relatively significant number of patients. So adequate treatment of HTN and hypervolemia before surgery is crucial in preventing HTN crises. We suggest performing prolonged and more frequent hemodialysis in ESRD individuals and more stringent fluid management during surgery for such patients. The percentage of patients with post-op HTN crisis due to alcohol withdrawal was more than expected, they may remain unrecognized possibly due to incomplete history or refusal/denial of patients. Labile BP was seen in a significant number of perioperative HTN urgencies which requires more cautious management. In this study we found that a significant portion of patients have noticeable causes for Perioperative hypertensive urgency which are quite preventable.
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Predicting Delirium in ICU Patients Using Time Series Physiological Data and Convolutional Neural Networks

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Introduction: Delirium is a preventable yet highly common complication of critical illness, affecting up to 80% of patients who require invasive life sustaining therapies (Barr, Fraser, Puntillo, Ely, Gélinas, Dasta et al., 2013). To predict whether the patient will experience delirium, nurses can apply the PRE-DELIRIC model (Wassenaar, Schoonhoven, Devlin, van Haren, Slooter, Jorens et al., 2018) when a patient is admitted into the ICU. The PRE-DELIRIC model achieves a sensitivity and specificity of 60% and 65% respectively, leaving much room for improvement. Auto-DelRAS (Moon, Y. Jin, T. Jin, and Lee, 2018) is another approach, it uses electronic health records and logistic regression to achieve a sensitivity of 63% and a specificity of 90%. To the best of our knowledge, no previous research has used high fidelity time series data to predict delirium.

Objectives: Develop a machine learning model to predict whether a patient will experience delirium at any point during their stay in the ICU given derived regional cerebral oxygenation (rSO2), peripheral oxygen saturation (SpO2), heart rate (HR), and mean arterial pressure (MAP) time series data.

Methods: We derived our data from the Cerebral Oxygenation and Neurological outcomes FOllowing CriticAL illness (CONFOCAL, NCT02344043 www.clinicaltrials.gov) study, a single centre observational study assessing the link between near-infrared spectroscopy, rSO2, and delirium in patients admitted with respiratory failure and/or shock to a tertiary ICU. Participants were divided into training (n=37), cross validation (n=37), and withheld test (n=6) sets. The training and cross validation sets contained the same 37 subjects. For each subject trained on, the initial 80% of the collected data went in the training set and the remaining 20% went in the cross-validation set. We normalized rSO2, SpO2, HR, and MAP for the whole data set, regardless of what subject contributed each value. Then, we augmented each of the time series into Gramian Angular Summation/Difference Fields and Markov Transition Fields (Wang and Oates, 2015), producing a 128x128x3 volume for every 128-minute rolling window of subject data. The volumes for the four-time series were stacked together into 128x128x12 volumes. A convolutional neural network trained on the volumes and predicted whether the data was from a patient who experienced delirium at any point in the study. The model architecture was made up of a 2D convolutional layer followed by batch normalization, global average pooling, and a densely connected layer.

Results: The cross-validation set achieved a sensitivity of 82.609% and a specificity of 71.429%. Similarly, the test set achieved a sensitivity of 100% and a specificity of 66%, verifying variance was minimized. Most notably, 84% of the patients in the cross validation set and 67% of patients in the test set were accurately classified 100% of the time even when using data from days prior to a patient entering delirium.

Conclusion: High fidelity physiological time series data can be used to predict delirium with higher sensitivity and specificity than attempts with other data sources. Our predictions were consistently accurate regardless of the length of time before the onset of delirium. We propose the consistency is evidence the interactions between rSO2, SpO2, HR, and MAP put patients at risk of delirium. Further analysis into the patterns our model learned may shed insight into the pathophysiology of delirium.

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**Figure 1:** Fields Generated for a Window of Heart Rate data
Predicting Safe Liberation from Venovenous Extracorporeal Life Support in Patients with Severe Acute Respiratory Distress Syndrome

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Introduction and Objective: Venovenous extracorporeal life support (VV-ECLS) for patients with severe ARDS is spreading worldwide, nonetheless, uncertainty regarding its use and management exist. Well defined criteria for both initiation and liberation are lacking. Expert opinion suggests discontinuing VV-ECLS when the patient can tolerate non-injurious mechanical ventilation (MV) settings during reduction of blood flow rate, fraction of delivered oxygen, or a sweep gas flow off trial (SGOT). We sought to describe patient conditions and MV practices at the time of VV-ECLS liberation and the potential development of respiratory and hemodynamic complications in the ensuing 48 hours.

Methods: We studied adult patients receiving VV-ECLS for severe ARDS over 5 years (2012 – 2016) at the Toronto General Hospital. Failure of safe liberation from VV-ECLS was defined as development of respiratory or hemodynamic complication within 48 hours from decannulation as follows: 1) escalation of MV after decannulation (i.e., change from support modality to control modality, and/or driving pressure16 and delta driving pressure >5); 2) need for rescue therapies after decannulation (i.e., new use of neuromuscular blockers and deep sedation, and/or use of pulmonary vasodilators, and/or HFOV); or 3) new worsening hemodynamics after decannulation requiring addition of vasoactive agents. Data on patients’ demographics, VV-ECLS settings and MV parameters, and outcomes are expressed as proportions or median and interquartile range (IQR), as appropriate. P values < 0.05 by chi-squared test for difference in proportions, were considered statistically significant.

Results: A total of 55/75 patients were liberated from VV-ECLS after improvement in respiratory function. The strategy for weaning VV-ECLS was SGOT for a duration of 22 hours (15 – 25), maintaining an ECMO blood flow of 3.6 L/min (3.2 – 4.2). Baseline characteristics, MV settings during last hour of SGOT and outcomes are reported in Table 1. After VV-ECLS liberation, 14/55 (25%) patients developed respiratory or hemodynamic complications within 48 hours from decannulation. 12/14 (85%) required escalation of MV settings, 7/14 (50%) required a form of rescue therapy, and 7/14 (50%) required treatment with the new addition of vasoactive agents. In a univariate analysis, the only MV setting at the end of SGOT that is significantly associated with unsafe liberation from ECLS was tidal volume per predicted body weight (VT/PBW), which was 9.2 ml/kg in patients developing complications vs 7.1 ml/kg in patients not meeting our pre-defined criteria of post decannulation complications (Table 1 and Figure 1). There was no significant difference in the VT/PBW at the first hour of SGOT between the two groups. In a multivariate analysis, VT/PBW and heart rate were the only two variables that were independently predictive of unsafe liberation (table 2). Although not statistically significant in our small cohort, patients developing complications had longer duration of MV, ICU and hospital length of stay.

Conclusions: In our ECLS center, a significant proportion of patients with severe ARDS liberated from VV-ECLS required an unplanned escalation of MV settings or hemodynamic support within 48 hours of decannulation. The only MV parameter during ECLS weaning that could predict safe ECLS liberation was a tidal volume per PBW. Further studies are needed to verify if these findings improve patient-centered outcomes.
Table 1: Baseline clinical characteristics of 55 consecutive patients with severe ARDS supported with and liberated from VV-ECLS, whom developed or not respiratory and hemodynamic complications

|                                      | All patients  | Patients with complications | Patients without complications |
|--------------------------------------|---------------|-----------------------------|-------------------------------|
|                                      | (n. 55)       | (n. 14)                     | (n. 41)                       |
| **Age, years**                       | 45 (33 – 52)  | 47 (39 – 52)                | 41 (33 – 52)                  |
| **Gender, male**                     | 41 (74%)      | 11 (78%)                    | 30 (73%)                      |
| **BMI**                              | 27.2 (23.2 – 33) | 28.4 (23.9 – 34.3) | 26.5 (23 – 33)               |
| **Charlson comorbidity index**       | 0 (0 – 1)     | 0 (0 – 1)                   | 0 (0 – 0)                     |
| **APACHE II**                        | 29 (28 – 33)  | 30 (27 – 33)                | 29 (28 – 33)                  |
| **SOFA score**                       | 12 (10 – 13)  | 10 (8 – 12)                 | 12.5 (11 – 14)                |
| **Cause of ARDS**                    |               |                             |                               |
| Pulmonary                            | 50 (92%)      | 13 (93%)                    | 37 (90%)                      |
| Extra-pulmonary*                     | 7 (12%)       | 3 (22%)                     | 4 (10%)                       |
| **MV prior to ECLS, days**           | 3 (2 – 7)     | 2 (1.5 – 8)                 | 4 (2 – 7)                     |
| **Sweep gas off trial (SGOT), hours**| 22 (15 – 25) | 24 (23 – 27)                | 20 (12 – 25)                  |
| **ECLS blood flow during SGOT, L**  | 3.6 (3.2 – 4.2) | 3.6 (3.2 – 4.0) | 3.7 (3.2 – 4.3)               |
| **Mode of MV**                       |               |                             |                               |
| PSV 34 (62%)                         |               |                             |                               |
| PCV 14 (25%)                         |               |                             |                               |
| CPAP 4 (7%)                          |               |                             |                               |
| APRV 1/2%                            |               |                             |                               |
| NP 1 (2%)                            |               |                             |                               |
| **Tidal volume, ml/kg PBW**          | 7.1 (6.0 – 9.2) | 9.2 (6.1 – 9.8) | 7.1 (6.0 – 8.4)               |
| **Respiratory rate, min**            | 24 (18 – 28)  | 26 (18 – 30)                | 24 (19 – 26)                  |
| **Minute ventilation, L/min**        | 11 (9 – 13)   | 12.5 (9.5 – 14)             | 10.5 (6 – 13)                 |
| **Corr Min Vent, L/min**             | 13.3 (11 – 16) | 14.3 (13 – 16.9) | 12.2 (9.2 – 15.4)             |
| **Ventilatory ratio**                | 2.4 (2.2 – 2.9) | 2.4 (2.2 – 2.9) | 2.0 (1.4 – 2.7)               |
| **Mechanical power, J/min**          | 19.7 (13 – 22) | 21 (14 – 23)                | 16.7 (13 – 20)                |
| **PEEP, cmH2O**                      | 10 (10 – 10)  | 10 (10 – 11)                | 10 (10 – 10)                  |
| **Peak Pressure, cmH2O**             | 23 (20 – 27)  | 25 (21.5 – 26)              | 23 (19.5 – 27)                |
| **Driving pressure, cmH2O**          | 11 (10 – 15)  | 12 (11 – 14.5)              | 11 (9.5 – 15)                 |
| **PaO2/FiO2 ratio, mmHg**            | 183 (154 – 238) | 185 (139 – 201) | 183 (162 – 242)               |
| **SOFA score**                       | 7 (6 – 8)     | 7 (5 – 9)                   | 7 (6 – 8)                     |
| **MAP**                              | 78 (70 – 90)  | 75 (70 – 80)                | 83 (70 – 91)                  |
| **HR**                               | **100 (90 – 105)** | **105 (100 – 120)** | **95 (90 – 100)**             |
| **Weaned from MV**                   | 30 (54%)      | 6 (43%)                     | 24 (58%)                      |
| **Duration of ECLS, days**           | 12 (1 – 18)   | 12 (10 – 22.8)              | 12 (10 – 18)                  |
| **Duration of MV, days**             | 18 (14 – 28)  | 19 (13 – 36)                | 18 (14 – 27)                  |
| **ICU length of stay, days**         | 21 (15 – 31)  | 28 (14 – 36)                | 21 (16 – 30)                  |
| **Hospital length of stay**          | 27 (17 – 41)  | 31 (16 – 45)                | 25 (17 – 38)                  |
| **Mortality**                        | 1 (6%)        | 1 (6%)                      | 0 (0%)                        |

†chi-squared test for difference in proportions, two-sided t test for continuous variables
*Trauma, pancreatitis, intra-abdominal sepsis, subarachnoid hemorrhage
*parameters from last hour on SGOT prior to decannulation from VV-ECLS
**Figure 1:** Tidal volume per predicted body weight (Vt PBW ml/kg) during Sweep gas off trial – 1 hour prior to decannulation from VV-ECLS

![Box plot showing tidal volume per predicted body weight (Vt PBW ml/kg) during Sweep gas off trial – 1 hour prior to decannulation from VV-ECLS.](image)

**Table 2:** Tidal volume per predicted body weight (adjusted for ventilator ratio and heart rate)

|                     | Odds ratio | 95% CI      | P value |
|---------------------|------------|-------------|---------|
| Tidal volume PBW    | 1.50       | (1.04 – 2.17) | 0.031   |
| Ventilatory ratio   | 1.37       | (0.58 – 3.21) | 0.467   |
| Heart rate          | 1.05       | (1.00 – 1.11) | 0.023   |
Preliminary Results of the Incidence, Predictors, and Recovery of Post-Extubation Dysphagia in Critically Ill Patients

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Introduction/Background: The Intensive Care Unit (ICU) at Hôpital Montfort has seen an increase in patients requiring prolonged endotracheal intubation (≥48 hours), a known risk factor for post-extubation dysphagia, aspiration, and associated complications. While the literature has sought to determine factors associated with post-extubation dysphagia, there is a paucity of literature demonstrating its incidence (3% to 63%), timing and resolution. This clinical uncertainty results in prolonged duration of non-oral intake (NPO), and incorrect dietary prescriptions resulting in aspirations or inadequate intake. In order to address care gaps and improve clinical practice, an interdisciplinary team consisting of medicine, speech-language pathology (SLP), pharmacy, and nursing, has undertaken a longitudinal project with the aim to complete, collect, and review the results of all swallowing assessments post intubation to identify dysphagia.

Objectives: Our main objective was to identify the incidence of dysphagia after prolonged endotracheal intubation. Secondary objectives were to determine (1) Predictors of post-extubation dysphagia; (2) duration of dysphagia (3) predictors of recovery and (4) time to recovery.

Methods: This is an ongoing quality improvement, combined retrospective and prospective cohort study of patients with prolonged endotracheal intubation at Hôpital Montfort between July 2017 to December 2018. One hundred and ninety-two patient medical charts were reviewed. Data extracted by a trained medical student included medical history and demographic variables, lengths of stay, ICU readmissions, death, results of SLP assessments and their follow-ups. SLP follow-ups of patients post-ICU discharge were used to assess the incidence of recovery from post-extubation dysphagia as well as time from extubation to recovery. Basic descriptive and frequency statistics were computed for all primary and secondary outcome variables. Associations were determined using T-tests, Mann-Whitney U tests, and chi-square tests to examine possible differences between outcome variables. The incidence rate of dysphagia was expressed as the number of patients with dysphagia over the total number of patients intubated for longer than 48 hours. The risk factors (predictors) of dysphagia were examined using binary logistic regression analysis, presented as Odds Ratios (OR) with 95% Confidence Intervals (CI). Ethics approval was obtained from Hôpital Montfort Research Ethics Board.

Results: Preliminary results indicate that our population was 56.3% male, a mean age of 64 years old, hospital length of stay of 21.8 days, ICU length of stay of 12.1 days, a total of 62.5% had an SLP follow-up, and 34.4% died. The prevalence of post-extubation dysphagia was 47.9% with a recovery rate of 82% as per SLP assessment. Using binary logistic regression only baseline functional status was found to predict dysphagia with an odds ratio (OR) of 1.48; 95% CI (2.07-9.39) P=.000.

Conclusion: The incidence of dysphagia after prolonged endotracheal intubation of 47.9% found in our study is similar to published results for those who undergo proper assessment by a trained speech language pathologist. We also found a recovery rate of 82% in those who had dysphagia, excluding deaths. Based on these findings, all patients intubated for longer than 48 hours should be assessed prior to initiation or oral intake by a trained SLP practitioner.
Grant Acknowledgment: This study is funded by the Alternate Funding Plan (AFP) – Association Médicale Universitaire Hôpital Montfort (AMUHM) Medicine Department.

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Prone Position Enhances Regional Homogeneity at High and Low Peep Assessed by Direct Pleural Pressure Measurement

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Introduction and Objective: Prone position (PP) is a cornerstone in the treatment of acute respiratory distress syndrome (ARDS), improves oxygenation and protects the lung against ventilator induced lung injury (VILI). The precise mechanism of lung protection, interaction with PEEP and its impact on regional respiratory mechanics during prone positioning are still unknown.

To assess the changes in pleural pressure gradient, ventilation homogeneity and regional respiratory mechanics at different PEEP levels, during Supine position (SP) and PP.

Methods: Ten pigs (weight 35.9 ± 2.1 Kg) were anesthetized and mechanically ventilated. Cooper Catheters were inserted into the dorsal and ventral pleural spaces to obtain a direct measurement of regional pleural pressure (Ppl), an esophageal balloon and an EIT belt were added. Lung injury was modelled by repeated saline lavages (to obtain a PaO2 < 100 mmHg) followed by injurious ventilation (until a decrease in respiratory system compliance by 20%). Animal’s lungs were recruited with PEEP 25 cmH2O and starting at 20 cmH2O the PEEP was reduced by 1 cmH2O every 5 to 6 breaths to 3 cmH2O. This was a crossover trial and was done in supine and prone position. At every level of PEEP, Airway pressure (Plateau pressure and total PEEP), Pes, regional Ppl (dorsal & ventral) and EIT were recorded at inspiratory and expiratory hold. Vertical gradient of Ppl (Ppl dependent – non-dependent), distribution of ventilation, Regional transpulmonary Pressure (PL), Compliance (respiratory system, lung and chest wall; total & regional) were calculated.

Results: Prone maintains lung homogeneity by creating a uniform vertical Ppl gradient in both inspiration and expiration, which is PEEP independent. Whereas, in SP vertical gradient of Ppl is PEEP dependent (Fig 1). PL in Prone were always lower than Supine at Inspiratory and Expiratory in dependent and non-dependent. Prone had more uniformity in regional tidal volume especially at lower PEEP (Fig 2). Levels of PEEP required to achieve the best lung compliance (Optimal PEEP) in dependent vs non-dependent lung was congruent in Prone (13 and 12cmH2O respectively) compared to Supine (15 and 10 cmH2O respectively) (Fig 3).

Conclusion: The vertical Ppl gradient across the lung is stable during PP i.e. not affected by both high (overdistension) or low (collapse) PEEP. Thus, lung homogeneity is maintained as reflected by homogenous regional ventilation, stable gradient of ventilation and more uniform best PEEP for regionals CL. This implies that prone positioning confers protection by better regional homogeneity and is PEEP independent, whereas similar lung protection can be achieved by high PEEP in supine.

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**Figure 1:** Vertical Pleural Pressure Gradient

**SUPINE**

**PRONE**

Fig 1. Prone maintains lung homogeneity by creating a uniform Ppl gradient in both inspiration and expiration, which is PEEP independent. # p < 0.05 inspiration is significantly different to expiration.

**Figure 2:** Regional Tidal ventilation

**SUPINE**

**PRONE**

Fig 2. Prone had more uniformity in regional tidal volume especially at lower PEEP. p < 0.05 dependent is significantly different to non dependent.
Figure 3: Regional Lung Compliance

Fig 3. Levels of PEEP required to achieve the best lung compliance (Optimal PEEP) in Dependent vs Non Dependent lung was congruent in Prone compared to Supine. * p < 0.05 dependent is significantly different to non dependent.
**REACT: A Pre-Clerkship Bootcamp to Improve Student Knowledge and Interest in Critical Care Specialties**

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**Background:** Given the increasingly competitive process of entering a Canadian residency program in critical care specialties and limited exposure to these disciplines in the pre-clerkship curriculum, a one-week critical care career exploration boot camp for pre-clerkship students was implemented. The program was modeled on similar, well-established career exploration programs for surgical and internal medicine specialties.

**Objectives:**
1. Increase pre-clerkship students' self-perceived knowledge and interest in critical care specialties.
2. Assess confidence in career planning and self-development in program participants.
3. Increase self-perceived knowledge and confidence in performing skills tailored to individual critical care specialties in a simulation environment.

**Methods:** Pre-clerkship students at the University of Ottawa were selected to participate in a five-day career exploration camp for specialties related to critical care, which included radiology, emergency medicine, anesthesiology, critical (intensive) care and trauma surgery (REACT). REACT is a pilot program providing a combination of observerships, informal career discussions, and hands-on simulation across the selected acute care specialties. Skills were tailored to individual specialties and included ACLS, central line insertion, airway management, point of care ultrasound (PoCUS) and chest tube insertion.

This prospective cohort study evaluated the effectiveness of the REACT program in improving critical care knowledge and facilitating career decision making when compared with a control group that did not participate in the program. At baseline and completion, students completed a survey assessing interest and self-perceived knowledge of each specialty as well as critical care overall, and self-perceived knowledge and confidence of the simulated skills. Chi-square tests were performed to identify the demographic differences. Equality of variances were measured, which showed most measures were parametric. Of the measures which were not, the means were corrected in the results via nonparametric analyses. Independent samples t-tests compared differences in means between control and REACT groups. Paired sample t-tests were used to compare differences between pre-test and post-test means for both control and REACT groups.

**Results:** 29 pre-clerkship students were recruited as part of our study, 15 of which participated in the REACT program, and 14 were the control group. There were no significant differences in baseline demographic parameters. No significant differences in baseline study outcomes were noted between the study arms, with the exception of confidence in performing a chest tube insertion which was higher in the REACT group (p=0.046). Interest in critical care, self-perceived knowledge of each individual specialty, as well as self-perceived knowledge and confidence in performing simulated skills were significantly higher following the REACT program amongst students who participated in the program (p<0.05). No statistically significant difference between the pre- and post-program survey results were noted for the control group.

**Conclusion:** The REACT program was effective in increasing interest in critical care specialties, as well as self-perceived knowledge of careers and skills related to critical care. This program can be expanded to other medical schools in order to expose medical students earlier to critical care and inform them of these increasingly competitive specialties.
**Figure 1:** Overview of the REACT Career-Exploration Program, Including Clinical Observerships, Informal Career Discussions and Hands-On Skill Sessions

**Table 1:** REACT Participants Report an Increase in Self-Perceived Knowledge of Critical Care Specialties

| Self-Perceived Knowledge of REACT Careers | Control Group (n=14) | REACT Program Group (n=15) |
|-----------------------------------------|----------------------|---------------------------|
| Group                                   | Pre-Test Mean Rank   | Post-Test Mean Rank (α=0.05) | Pre-Test Mean Rank | Post-Test Mean Rank |
| Knowledge of Radiology                   | 5.500                | 5.571                      | 4.200              | 6.600               | <0.001 |
| Knowledge of Emergency Medicine          | 5.857                | 6.214                      | 5.800              | 7.200               | 0.002 |
| Knowledge of Anesthesiology              | 4.643                | 5.071                      | 4.333              | 7.533               | <0.001 |
| Knowledge of Critical (Intensive) Care Medicine | 3.857             | 4.929                      | 4.400              | 7.067               | <0.001 |
| Knowledge of Trauma and Acute Care Surgery | 3.071              | 3.286                      | 3.400              | 6.733               | <0.001 |
Table 2: REACT Participants Report an Increase in Self-Perceived Knowledge and Confidence Towards Performing Common Acute Care Procedures

| Variable                      | Control Group (n=14) | REACT Program Group (n=15) |
|-------------------------------|----------------------|-----------------------------|
|                               | Pre-Test Mean Rank   | Post-Test Mean Rank         | p-value (α=0.05) | Pre-Test Mean Rank   | Post-Test Mean Rank         | p-value (α=0.05) |
| Knowledge of PoCUS            | 4.357                | 5.071                       | 0.393             | 4.000                | 7.200                       | <0.001               |
| Knowledge of ACLS             | 4.286                | 4.000                       | 0.763             | 4.467                | 6.800                       | <0.001               |
| Knowledge of Airways          | 5.000                | 5.071                       | 0.911             | 4.067                | 7.267                       | <0.001               |
| Knowledge of Line Insertion   | 2.643                | 3.286                       | 0.380             | 3.533                | 6.933                       | <0.001               |
| Knowledge of Chest Tube Insertion | 2.500            | 3.429                       | 0.251             | 3.667                | 6.533                       | <0.001               |
| Confidence with PoCUS         | 4.071                | 4.714                       | 0.359             | 3.600                | 6.600                       | <0.001               |
| Confidence with ACLS          | 3.571                | 4.071                       | 0.561             | 3.200                | 6.067                       | <0.001               |
| Confidence with Airways       | 4.214                | 4.286                       | 0.885             | 3.400                | 6.800                       | <0.001               |
| Confidence with Line Insertion | 2.571               | 3.071                       | 0.530             | 3.067                | 6.200                       | <0.001               |
| Confidence with Chest Tube Insertion | 1.786        | 2.500                       | 0.303             | 3.200                | 6.400                       | <0.001               |
Reducing Hyperoxia in the Critical Care Unit: A Quality Improvement Initiative

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Introduction/Background: Providing supra-physiologic supplemental oxygen can induce hyperoxia, which is associated with increased mortality in critically ill patients.1,2 Despite literature supporting conservative oxygen therapy to target normoxia,3 patients are hyperoxic 63% of the time in the Sunnybrook Critical Care Unit (CrCU).

Objectives: The project aim was to reduce the percentage of CrCU patients with hyperoxemia (blood oxygen saturation greater than 97% on supplemental oxygen) by 25% between November 30, 2018 and April 30, 2019. The primary outcome was percentage of CrCU patient days with blood oxygen saturation (SpO2) > 97% on supplemental oxygen.

Methods: The interprofessional ICU team, including respiratory therapists, nurses, staff physicians, fellows and residents was engaged as part of this project. An Ishikawa diagram identified primary drivers for hyperoxia such as lack of clinician awareness of the potential patient harms, and miss-understanding the relationship between arterial oxygen tension, SpO2, and systemic oxygen delivery. Process mapping identified existing CrCU order sets as a target for improvement, including current SpO2 targets which did not have an upper limit. Interventions included a CrCU unit educational campaign and revision of existing CrCU admission order sets to adjust SpO2 targets. Five PDSA cycles were performed. Cycles one and two included quality “walk arounds” and bedside pilot testing of an upper limit SpO2 alarm. Feedback from the ICU staff prompted our third PDSA cycle utilizing a structured educational handout tool to improve knowledge about hyperoxia. PDSA cycles four and five consisted of implementing changes to existing order sets to alter SpO2 targets (changing from SpO2 > 92% for all patients to SpO2 88-95%). We used an interrupted time-series method to analyze the changes in hyperoxia rates. Interrupted time-series control for secular trends that are a common threat to validity in before-after studies, and also provides information on the sustainability of the intervention. We coded intervention as beta1, secular trend as beta 2 and post-intervention trend as beta3.

Results: The interrupted time-series shows an immediate effect of the intervention that led to a decrease of 8% in hyperoxia rates (beta 1 = -0.08, 95% CI: -0.16 to -0.01, p = 0.03), a constant decrease in hyperoxia rates of 3% per month after the intervention (beta 3 = -0.03, 95% CI: -0.06 to -0.00, p = 0.04), and no evidence of a secular trend (beta 2 = -0.00, 95% CI: -0.02 to 0.01, p = 0.57). Mean hyperoxia rate (SpO2 > 97% on supplemental oxygen) during the intervention was 33% vs 53% baseline (p<0.02 for Special Cause Variation using chi-square statistics for the dichotomized outcome). The Run Chart in Figure 1 summarizes our findings.

Conclusion: Hyperoxia among critically ill patients is preventable, and the incidence can be reduced through a systematic multifaceted intervention that leads to an immediate change of 8% in rates and a constant improvement of 3% per month afterwards. Given the harms of hyperoxia extend beyond critically ill patients; future work should focus on other departments such as the Emergency Room and General Wards, as well as regional dissemination to other health care institutions.

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Figure 1: Reducing hyperoxia in the Critical Care Unit – Findings
Resumption of Diaphragmatic Activity After Intubation Often Occurs with a Pattern Consistent with Reverse Triggering

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Background: Reverse triggering occurs when patients’ respiratory muscle contraction follows and is entrained by controlled mechanical insufflation (i.e. effort is triggered by the ventilator). Physiological mechanisms and clinical impact remain unclear. Entrainment of the respiratory rhythm to cyclic lung inflation contributes to the phenomenon. It was first described in patients that appeared heavily sedated and susceptibility to entrainment is higher with low brain activity and respiratory drive. Therefore, we hypothesized that in intubated patients, the first recognizable pattern of inspiratory effort after intubation may often be consistent with reverse triggering.

Objective: Determine the proportion of critically ill patients in whom resumption of diaphragmatic electrical activity (EAdi) after intubation occurs with a pattern consistent with reverse triggering.

Methods: Ancillary analysis of the DIVIP Study, a prospective observational cohort study (NCT02434016) in which adult patients admitted to the ICU and intubated had a feeding tube containing an array of electrodes to measure EAdi (EAdi monitoring). Data acquisition and analysis: Ventilator trends were acquired from the day of endotracheal intubation until resumption of stable continuous EAdi (presence of a median EAdi peak > 5 μV for 24hr) or 5 days after study enrollment. Additionally, 1 hr-recording of real-time ventilator tracings (Paw, flow, volume, and EAdi) was performed daily, every 24h. The 1hr-recording corresponding to the day of EAdi resumption was analyzed offline. Patients without resumption of EAdi within 5 days were excluded from this analysis. Each tracing (one per patient) was visually classified as 1) Absence of EAdi: machine-trigger breaths defined by a cyclic increase in flow and pressure without an increase in EAdi; or 2) Presence of EAdi: increase in EAdi tracing during the breath cycle. Tracings with EAdi were classified into Spontaneous efforts: all breaths being patient-triggered breath, presence of a negative inflection in Paw or subtle change in flow before insufflation concurrent with an increase of EAdi signal starting prior to insufflation; or Reverse Triggering (RT): breathing efforts in which the increase in EAdi starts after the beginning of machine-trigger breaths (Fig 1). In patients in whom EAdi activity was classified as “Spontaneous effort”, the tracing corresponding to the day prior was analyzed to explore if the first recognizable pattern of EAdi was RT.

Results: From June 2015 to August 2018, 70 patients were included, 10 of which were excluded from this analysis. In the remaining 60, 5 patients were classified as Absence of EAdi and 55 patients as Presence of EAdi. 47 patients (85%) had spontaneous efforts during the day of EAdi resumption and were mainly ventilated in pressure support (34/47, 71%). 8 patients (15%) were classified as having RT activity (Table 1). Median EAdi peak was 6.1 μV (IQR 5.2-15.1). RT was only detected during assist-control modes. When considering only patients under assist-control modes during the day of EAdi resumption the prevalence of RT increased to 47% (8/9). Three additional patients classified as spontaneous efforts exhibited RT the day before of EAdi resumption, all occurring during volume assist-control ventilation.

Conclusion: Reverse Triggering is present in more than half of the patients who resume diaphragmatic activity after intubation in assist-control mode.
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Table 1: Description of patients with Presence of EAdi during 1hr-recording during Day of EAdi resumption

| Day of EAdi resumption since intubation, nro (%) | Type of Effort |
|------------------------------------------------|---------------|
|                                                 | Spontaneous Effort n = 47 | Reverse Triggering n = 8 |
| Day 1                                           | 34 (72)        | 3 (37)          |
| Day 2                                           | 8 (17)         | 4 (50)          |
| Day 3                                           | 4 (9)          | 1 (13)          |
| Day 4                                           | 1 (2)          | 0               |
| Day 5                                           | 0              | 0               |

| Ventilation Mode, nro (%) | Spontaneous Effort n = 47 | Reverse Triggering n = 8 |
|---------------------------|---------------------------|--------------------------|
| Volume control            | 4 (9)                     | 4 (50)                   |
| Pressure control          | 4 (9)                     | 3 (37)                   |
| PRVC                      | 0                         | 1 (13)                   |
| Pressure Support          | 34 (72)                   | 0                        |
| NAVA                      | 5 (10)                    | 0                        |

Definition of abbreviations: EAdi, diaphragmatic electrical activity; PRVC, Pressure Regulated Volume Control; NAVA, Neurally Adjusted Ventilatory Assist.
**Figure 1**: Definition of EAdi classification based in Paw (red), Flow (blue) and EAdi (green) tracings. A) Absence of EAdi during pressure-control ventilation. B) Spontaneous effort, increase in EAdi signal concurrent with negative inflection in Paw (first solid line) that triggers mechanical insufflation during pressure assist-control ventilation. C) Reverse triggering (RT) in pressure assist-control ventilation. Ventilator triggered insufflation is followed by a RT (green arrow) starting after machine insufflation (dP), leading to a negative deflection of the Paw (red arrow) and deformation on flow slope during insufflation phase (blue arrow). Dotted green lines in B) and C) indicate the 5uV threshold. Paw, airway pressure; EAdi, diaphragmatic electrical activity; T\text{tot\textsubscript{mech}}, ventilator cycle duration; dP, phase difference.
Reverse Triggering, A Missed Phenomenon in the Literature

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Background: Reverse triggering (RT) is a type of asynchrony that can occur during mechanical ventilation (MV). RT is defined by the presence of patient’s inspiratory effort after mechanical insufflation (i.e. triggered by the ventilator)\textsuperscript{1}. The presence of RT was recently described in deeply sedated patients with acute respiratory distress syndrome (ARDS) but this asynchrony is thought to have existed previously\textsuperscript{3}. Asynchronies have been associated with poor outcomes\textsuperscript{5}. RT in particular might be injurious for the lung and the diaphragm. However, little clinical relevance is known on the effects of RT probably because of longstanding omission. Accurate recognition of RT at the bedside is necessary in order to further understand the phenomenon and to study its clinical effects.

Objectives: A systematic review to identify the frequency of RT present in respiratory waveforms but not described in papers describing asynchronies up until 2017.

Methods: Medline and EMBASE databases were searched utilizing key words related to asynchrony and MV. Included manuscripts were those containing respiratory waveforms that are used to detect RT (airway pressure (Paw) and flow with or without esophageal pressure (Peso) or electrical activity of the diaphragm (EAdi)). Excluded manuscripts were studies involving animals, non-invasive ventilation, neonate (only), infant (only), lack of availability, conference abstracts, high frequency oscillation ventilation, cardiac synchronization, thoraco-abdominal synchrony, negative pressure ventilation and spontaneous modes of ventilation. Each tracing from the included manuscripts was analyzed for the presence of RT (definite or possible) using predefined criteria by two experts and assessing if it was missed by the original authors. Possible RT was defined as figures that only contain flow and Paw tracings but display an abnormality in the waveform that may indicate patient effort following a machine-triggered breath. Definite RT was defined as having flow and Paw with Peso or EAdi tracings that indicate a patient effort (i.e. negative deflection in Peso or positive deflection in EAdi) following a machine-triggered breath. RT was missed when no reference to the phenomenon was found in the paper (“reverse triggering” or “entrainment”).

Results: 2700 citations were screened; 963 manuscripts were eligible for full-text screening. A total of 963 full text articles were retrieved, 711 manuscripts have been excluded for the lack of appropriate tracings. For the final analysis, 163 manuscripts published between 1965 - 2017 were included. From this, 721 figures have been analyzed, with 41 (5.7\%) of them accounting for possible (n=22) or definite (n=19) RT. RT was incorrectly described in 26 (63\%) of them. Manuscripts published before RT was described had 100\% of the waveforms with missed RT, whereas manuscripts published after RT was described had 25\% of waveforms with missed RT.

Conclusions: Final results indicate that RT is a frequent phenomenon and has been missed commonly in previously published papers.

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**Figure 1:** Example of Possible RT²

![Figure 1: Example of Possible RT²](image)

**Figure 2:** Example of Definite RT⁴

![Figure 2: Example of Definite RT⁴](image)
Sedative, Analgesic and Neuromuscular Blocker Use in TBI Patients Admitted to Canadian ICUs: A Multicenter, Observational Study

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Introduction: TBI represents a significant health burden and is associated with a wide range of short- and long-term deficits. Analgesics, sedatives and neuromuscular blockers are commonly required to manage pain, sedation, anxiety, agitation, and intracranial hypertension. Pain, Agitation, Delirium (PAD) guidelines¹ do not provide specific recommendations for TBI patients and it is unknown if strategies promoted by the SCCM for critically ill patients are used for TBI patients in the ICU or what clinical benefits these strategies provide. Thus, significant heterogeneity likely exists in the prescribing of sedation/analgesia strategies for Canadian TBI patients.

Objectives: The objective was to describe sedation, analgesia, and neuromuscular blockers practices in critically ill TBI patients.

Methods: A retrospective observational study of 9 adult trauma ICUs in Canada was conducted to describe the utilization of sedation/analgesia strategies during hospitalization. We included consecutive adult (18 years or older) patients with moderate (Glasgow Coma Score 9-12) to severe (Glasgow Coma Score of 8 or less) TBI admitted to ICU between Jan 2015 and Dec 2016. Data were collected using standardized forms for up to a maximum of 21 days in ICU or until transfer out of ICU or death. The primary outcome was the proportion of patients receiving propofol.

Results: We included 332 patients (3029 patient days) with a moderate (43.7%) or severe (56.3%) TBI. Etiologies included falls (47.6%), MVA (33.7%) and assaults (7.8%). The majority were male (71%), mean age was 53.6 (SD 21.9) and median SOFA score was 6 (IQR 4). A total of 32.7% of patients required invasive ICP monitoring. Sedation and pain scales were used in 86.8% and 39.3% of patients-days, respectively. Protocolized sedation, daily awakenings and interruptions for neurological evaluation for were used in 39.9%, 6.9% and 7.9% of patient-days, respectively. Propofol (42.1% of patient-days) was the most frequently used sedative followed by benzodiazepines (30.4% patient-days) and dexmedetomidine (3.9% of patient-days). Pentobarbital was used for 0.1% of patient-days. Analgesics were used 73.0% of patient-days whereas neuromuscular blockers were used 7.3% of patient-days.

Conclusion: Propofol remains the most frequently used sedative in TBI patients but benzodiazepines use remains significant. Sedation scales are commonly used whereas protocolized sedation is much less common and pain is less well documented.
Grant Acknowledgment: This study was supported by the Pettit Respirology Block Term Grant, Respiratory division, University of Toronto.

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Sex-Specific Prevalence, Correlates and Outcomes of Frailty in Critically Ill Patients

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Introduction: Frailty is increasingly being recognized as an important risk factor for worse short and long-term outcomes in hospitalized patients, and for greater health care service use.\textsuperscript{1-3} A recent study examining population-level screening of frailty in critically ill adults found differences in the prevalence of frailty by sex.\textsuperscript{4}

Objectives: To determine if the prevalence of frailty in critically ill adults differs by sex, and if mortality and organ support rates differ in males living with frailty compared to females living with frailty. We hypothesized that the prevalence of frailty would differ by sex and that mortality and organ support rates would differ by sex stratified by frailty.

Methods: This is a retrospective multi-centre population-based cohort study. All adult patients (aged ≥18 years) admitted to 17 intensive care units (ICUs) in Alberta between January 1, 2016 - June 30, 2017 were eligible. Patients missing a frailty score or who died within 24 hours of ICU admission were excluded. The primary source of data was eCritical Alberta, a bedside clinical information system and data repository. Frailty was defined as Clinical Frailty Scale (CFS) score ≥5. The primary outcome was sex-stratified prevalence and severity of frailty. The secondary outcomes were ICU and hospital mortality, and receipt of organ support (i.e. invasive mechanical ventilation, vasoactive support, renal replacement therapy). The association between sex and frailty was evaluated using multivariable logistic regression. The association between sex, frailty and mortality was assessed using Chi\textsuperscript{2} tests and by multivariable Cox regression. The association between sex, frailty and organ support was assessed using Chi\textsuperscript{2} tests and by multivariable logistic regression.

Results: A total of 15,238 patients were included (mean age [standard deviation] 58 [17] years, 39% female). Twenty-eight percent (n=4,199) had a CFS score ≥5 at admission. Females had a higher prevalence of frailty compared to males (1,917/5,984 [32\%] vs. 2,282/9,254 [25\%], p<0.001) and in multivariable logistic regression were more likely to have a CFS score ≥5 (odds ratio 1.44 [1.33 – 1.56], p<0.001). APACHE II scores were similar (21.9 [8.1] for males vs. 21.9 [8.1] for females, p=0.61). Differences between females and males living with frailty are shown in Table 1. Differences in ICU and hospital mortality were not significant. Females received less invasive mechanical ventilation and vasoactive support compared to their male counterparts. In multivariable analysis females were significantly less likely to receive vasoactive support compared to males.

Conclusions: Females admitted to the ICU have higher frailty scores and a larger proportion are frail (CFS score ≥5), compared to males. Females living with frailty received less intensive support compared to their male counterparts, despite similar illness acuity.
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Table 1: Comparisons in outcome in males vs. females living with frailty

|                              | Males with Frailty (n=2,282) | Females with Frailty (n=1,917) | Univariable       | Multivariable<sup>a</sup> |
|------------------------------|-------------------------------|--------------------------------|-------------------|---------------------------|
| ICU mortality, HR [95% CI]   | 287 (12.6%)                   | 236 (12.3%)                   | 1.00 [0.84 – 1.19] | 1.03 [0.86 – 1.22]       |
| Hospital Mortality, HR [95% CI] | 556 (24.4%)                   | 432 (22.5%)                   | 1.01 [0.89 – 1.14] | 0.98 [0.86 – 1.11]       |
| Invasive Mechanical Ventilation, OR [95% CI] | 1,471 (64.5%)                  | 1,126 (58.7%)*               | 0.83 [0.73 – 0.93]* | 0.88 [0.76 – 1.01]       |
| Vasoactive support, OR [95% CI] | 1,272 (55.7%)                  | 977 (51.0%)*                  | 0.78 [0.69 – 0.89]* | 0.81 [0.70 – 0.92]*      |
| Renal Replacement Therapy, OR [95% CI] | 179 (7.8%)                     | 128 (6.7%)                    | 0.84 [0.66 – 1.06] | 0.87 [0.67 – 1.13]       |

<sup>a</sup> p<0.05 - Comparison of males with frailty (reference) to females with frailty.
<sup>a</sup> Controlled for age, diagnostic category, pre-ICU duration of hospitalization and APACHE II score. Male with frailty is the reference variable.
Single-Centre Evaluation of Differential Leukocyte Ratios as Biomarkers of Mortality in Patients with Acute-On-Chronic Liver Failure Admitted to the Intensive Care Unit

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Introduction: Acute-on-chronic liver failure (ACLF) is characterized by rapid deterioration of hepatic function along with multiorgan failures following an acute insult in patients with cirrhosis and often necessitates intensive care unit (ICU) admission. ACLF is associated with significant morbidity and mortality. In recent years, differential leukocyte ratios including neutrophil-to-lymphocyte ratio (NLR) and monocyte-to-lymphocyte ratio (MLR) have been evaluated in different ICU populations as predictors of mortality.

Objectives: Our aim is to assess NLR and MLR in ACLF patients admitted to the ICU as biomarkers of mortality.

Methods: Retrospective cohort study of 599 cirrhotic patients admitted to the Liver Intensive Therapy Unit at King's College Hospital from 2009 until 2016. Grade of ACLF was determined at the time of ICU admission. Hematological data including neutrophil count, lymphocyte count, and monocyte count was obtained at the time of ICU admission. Primary outcome was in-hospital mortality. NLR and MLR were correlated with the primary outcome. Subgroups of patients including those with alcohol liver disease and sepsis were also evaluated regarding NLR and MLR and in-hospital mortality.

Results: Overall 599 cirrhotic patients were evaluated with 375 (62.6%) being male and median age of 52 years (15-78). 181 (30.2%) patients had ACLF grade 0, 67 (11.2%) had ACLF grade 1, 127 (21.2%) had ACLF grade 2, and 224 (37.4%) had ACLF grade 3. Alcohol was the etiology of chronic liver disease in 296 (49.4%) of patients. Sepsis was present in 277 (46.2%) of patients. In-hospital mortality occurred in 249 (41.6%) patients. Both NLR and MLR were higher in patients with ACLF grades 2 and 3 compared with no ACLF (p<0.0001 for both). Both NLR and MLR were higher in patients with in-hospital mortality (p<0.0001 for both). NLR predicted outcome with an area under the receiver operating characteristic (AUROC) of 0.684 (95%CI 0.641-0.727, p<0.0001) and MLR predicted outcome with AUROC of 0.630 (0.590-0.669, not significant). In the alcohol liver disease group, NLR and MLR both were higher in patients with in-hospital mortality (not significant and p<0.0001 respectively). NLR predicted outcome in this group with AUROC of 0.685 (0.62-0.72, p<0.0001) while MLR predicted outcome with AUROC of 0.635 (0.570-0.700, p<0.0001). In the sepsis group, both NLR and MLR were higher in patients with in-hospital mortality (p<0.01 for both). NLR predicted outcome in this group with AUROC of 0.662(0.598-0.726, p<0.0001) and MLR predicted outcome with AUROC of 0.614(0.546-0.681, p=0.001).

Conclusions: ACLF is associated with high neutrophil and monocyte counts along with low lymphocyte counts. NLR and MLR are associated with higher grades of ACLF and in-hospital mortality. However, NLR and MLR were not highly accurate predictors of in-hospital mortality even in subgroups of alcohol liver disease and patients with sepsis suggesting this is a pan-ACLF phenomenon unrelated to etiology or bacterial infection.

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**Figure 1**

![NLR and MLR comparisons for No ACLF, ACLF 1, ACLF 2, and ACLF 3](image1)

**Figure 2**

![NLR and MLR comparisons for Died and Survived](image2)

**Figure 3:** ROC of Survive vs Died NLR

![ROC curve for NLR](image3)

**Figure 4:** ROC of Survive vs Died MLR

![ROC curve for MLR](image4)
Skeletal Troponin I In Serum and Diaphragmatic Ultrasound in Mechanically Ventilated Intensive Care Unit Patients: A Prospective Observational Study

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Introduction: Prolonged mechanical ventilation can cause muscle atrophy and adversely affect diaphragmatic force-generating function [1]. Diaphragmatic ultrasound has been proposed as a bedside daily monitoring of diaphragm function [2]; however, to date there are no specific serum biomarkers for muscular damage and dysfunction. Foster et al. [3] suggested that skeletal troponin I (sTnI) could be a sensitive marker to detect early signs of muscle injury.

Objectives: Firstly, to evaluate the trend of traditional and novel biomarkers of muscular damage in mechanically ventilated intensive care unit (ICU) patients; secondly, to determine whether this trend was associated with a consistent change in diaphragmatic function indices assessed by ultrasound.

Methods: In this prospective, single centre, observational study serum samples were obtained from 102 mechanically ventilated ICU patients at 24 (T0), 48 (T1) and 72 (T3) hours after admission. Patients were not considered for inclusion if they had a history of neuromuscular disease or a previously documented diaphragm paralysis. Specimens were analysed and traditional muscular damage markers (CPK, aldolase and myoglobin) and specific isoforms for sTnI (slow (ssTnI) and fast (fsTnI)) were assayed. Simultaneously, in a subset of 69 patients’ diaphragmatic displacement (DD) and thickening fraction (TF) were measured with ultrasound. Values were compared using Friedman’s analysis for repeated measures; Spearman test was used to test for bivariate correlations; p < 0.05 was considered statistically significant.

Results: Among the serum markers analyzed, CPK and myoglobin decreased significantly between T0 and T2 (p < 0.0001). fsTnI showed a decreasing trend (p = 0.112), while there was no change in ssTnI values during the first 72 hours of ICU stay. Both DD and TF decreased significantly over time (p < 0.0001). fsTnI levels at the baseline was correlated both with TF (r = 0.339, p = 0.005) and DD (r = 0.427, p < 0.001).

Conclusion: Our results showed that both traditional muscular damage markers and sfTnI decreased over time in mechanically ventilated ICU patients possibly indicating muscle atrophy. Diaphragmatic ultrasound showed a decrease in diaphragmatic function over time. The correlation between ultrasound indices and sfTnI at the baseline might indicate the use of this novel biomarker to detect early signs of muscle injury.

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Spirituality and End-of-life Wishes in the ICU: A Multicenter Quantitative Analysis of the 3 Wishes Project

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Introduction: Death can be experienced as a highly spiritual event by many patients, families and healthcare workers, who often struggle to cope with the acuity and devastation of critical illness. Spirituality, a belief in something beyond oneself, is a human experience that may facilitate coping for those who bear witness to the transition from life-support interventions to end-of-life care. The 3 Wishes Project (3WP) is a multicenter, prospective study in which clinicians elicit and implement patient-centered wishes for dying critically ill patients in the ICU. Wishes can be articulated by patients, families, or members of the healthcare team.

Objectives: The purpose of this analysis was to characterize wishes of a spiritual nature that occurred at the end-of-life in the ICU as captured in the 3WP.

Methods: We conducted a quantitative analysis of the 3WP database to identify the proportion of patients who were spiritual and the prevalence of spiritual wishes at the end of life. We identified patients as “spiritual” if they had any listed spiritual beliefs (including “spiritual”), and “non-spiritual” if they self-reported as “agnostic” or “none indicated.” Patients without documented spiritual preferences were classified as “unknown” and excluded from analysis.

Results: Overall, 873 patients were included in the database over a six-year study period (November 2012 to May 2019) across six North American sites. A majority (60.7%) of patients were identified as spiritual (530/873), 23.6% as non-spiritual (206/873), and 15.7% as unknown (137/873). A minority (13.3%) of total wishes in the 3WP database were classified as spiritual (522/3921). However, for 35.6% of all dying patients, there was at least one spiritual wish at the end-of-life. During the dying process, spiritual patients, compared to others, more frequently had spiritual wishes elicited and implemented (56.5% vs 19.0%, p<0.0001), as well as spiritual care consultation (85.6% vs 46.4%, p=0.01). Spiritual wishes were most commonly requested by families for both spiritual and non-spiritual patients (89.3% vs 79.5%, p=0.02), followed by patients themselves (4.5% vs 9.6%, p>0.05). Prayer was the most commonly elicited wish (19.9%), followed by a ceremony or ritual (16.5%), and request for spiritual support at the bedside (7.9%).

Conclusions: In a diverse patient population across multiple North American institutions, patients and their families frequently invoke spirituality during the dying process. In the context of our increasingly pluralistic society, the 3 Wishes Program fostered an environment that empowers patients and families — whether identified as spiritual or not — to address this important
Survival Outcomes of Cancer Patients Who Experience a Code Blue

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Introduction: In patients with cancer, goals of care (GOC) conversations including code status and life-sustaining interventions such as cardiopulmonary resuscitation (CPR) often do not occur at all or occur late in the illness trajectory (1). Cancer patients have a poor prognosis after CPR, and GOC discussions play a large role in educating patients and their family members on options at the end of life (EOL) and suitability of resuscitation (2). To our knowledge, no study has focused on “code blue” events in cancer patients. This study aims to describe the population of cancer patients experiencing a code blue and their outcomes at a large Canadian cancer centre. Despite medical advances, outcomes after CPR in cancer patients have not improved over the past decade (3). This lack of improvement emphasizes the profound impact GOC discussions may have in eliminating futile efforts.

Objectives: To describe survival outcomes of cancer patients who experienced a code blue.

Methods: We conducted a retrospective chart review of cancer patients at Princess Margaret Hospital who had a “code blue” initiated between January 2007 to December 2017. Variables were collected from the patient record using a standardized case report form.

Results: There were 183 patients who met the study criteria; median age was 60.5 years (range 18-91 years), 52% male, 51% hematological cancers, 49% had solid cancers, and of the solid cancers 63% had metastatic disease. Reasons for code blue being called was cardiac/arrhythmia (N=56, 36%), respiratory arrest/failure (N=39, 26%), and other (N=57, 38%). Of the 174 cases with documentation 97 (56%) had CPR, and overall 44 (24%) died at the code. Of 139 (76%) patients who survived, 129 (93%) were admitted to the ICU; and 3 remained at PMH. Of the 129 patients admitted to ICU, 75% received mechanical ventilation, 69% vasopressors, 6% CRRT, 8% therapeutic hypothermia, and 8% had a tracheostomy; 34% had withdrawal of care, and 47% died in the ICU. Of the 68 patients who were discharged alive from ICU, 24% were DNR at ICU discharge. Of the 183 patients, resuscitation was considered to be “inappropriate” in 92 (50%), with 21 (23%) having a DNR recommended, 12 (13%) with GOC documenting wishes for no CPR/resuscitation, 17 (18%) with no further therapeutic options for cancer treatment, 2 (2%) with no therapeutic options for ICU care, 30 (33%) having palliative medicine involved for EOL care, and 10 (11%) with other reasons.

When comparing characteristics of the appropriate and inappropriate resuscitation groups, the inappropriate group was more likely to have a solid cancer (70% vs 29%) and metastatic disease (78% vs 27%). The inappropriate resuscitation group was also more likely to have a code status discussion before the code (47% vs 2%). In terms of code blue outcomes they were also more likely to die in ICU (64 vs 32%) or in hospital (88 vs 60%), and be dead 12 (99% vs 74%) months.

Conclusion: Of cancer patients who experienced a code blue, 26% survived to hospital discharge. 50% of patients were deemed to be inappropriate resuscitation candidates because they were palliative or had no treatment options; these patients had worse outcomes compared to appropriate resuscitations. The poor prognosis was recognized by physicians, as GOC discussions had occurred more frequently in cases of inappropriate resuscitations. Our study highlights the need for more GOC discussions in patients with no treatment options.
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Targeting the NO-sGC Axis to Monitor and Treat Vascular Dysfunction and Vasoplegia in Sepsis

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Introduction: Sepsis is a life-threatening condition caused by a dysregulated host response to infection. If unimpeded, sepsis can progress to septic shock, characterized by refractory hypotension and unresponsive vasculature (i.e. vasoplegia) resulting in tissue hypoperfusion and eventually organ failure. The overall mortality rate of septic shock is more than 30%. The vascular dysfunction and refractory hypotension in septic shock are caused, at least in part, by excess reactive oxygen species (ROS) generation and dysregulated nitric oxide (NO) production (via inducible NO synthase upregulation and increased scavenging by excess ROS). Moreover, excess ROS oxidizes and hence damages soluble guanylate cyclase (sGC), the downstream mediator of NO, resulting in the impaired organ blood flow. We believe the loss of sGC-mediated vasodilation is a critical determinant of reduced organ blood flow in sepsis.

Objectives: To assess the state of vascular dysfunction and altered blood flow patterns as sepsis progresses to septic shock. We hypothesized restoring defective sGC in sepsis using cinaciguat would improve survival in a murine model of sepsis.

Methods: Studies were in accordance with Canadian Council on Animal Care guidelines and the Animal Care and Use Committee at the University of Alberta. Male C57Bl/6 mice (10-12 weeks of age) were instrumented with fibre-optic pressure sensors for direct blood pressure monitoring under anesthesia. Flow probes were placed around the left common carotid, superior mesenteric, and right renal arteries to monitor blood flow to the brain, gut, and kidney, respectively. After baseline recordings, sepsis was induced by an intraperitoneal injection of fecal slurry (FS, 1.3mg/g) or equivalent volume of vehicle. In a separate series of experiments, mice were treated with cinaciguat (15μg/kg IV) 30 minutes after FS injection and survival time was monitored.

Results: Blood pressure decreased steadily over time after FS administration (44%±4% after 4h) compared to control mice (p<0.01), but no changes in heart rate were noted (p>0.05). Blood flow in the carotid, superior mesenteric, and renal arteries reduced at 47±4%, 71±8%, and 57±13% respectively, 4h after FS injection. Vessel reactivity, assessed by monitoring constrictor and relaxation responses to bolus doses of phenylephrine (10μg/kg body weight) and sodium nitroprusside (5μg/kg body weight) was reduced by 36±9% and 53±7% respectively, in mice administered FS compared to controls, suggesting impaired regional vascular function. These data suggest certain organs are more susceptible to vascular dysfunction and hypoperfusion with the progression of sepsis. Administration of cinaciguat 30 minutes after FS injection improved survival (3.3h vs 4.8h; p<0.001). While sGC activity was impaired in septic mice, cinaciguat administration restored its activity by 87±2% (p<0.05).

Conclusion: Vascular dysfunction occurs as sepsis progresses to septic shock. Sepsis impairs sGC activity and regional blood flow while cinaciguat administration restores defective sGC, hence improving survival in septic mice.

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The Cerebral Perfusion Index: Developing a Novel Model of Cerebral Perfusion in the Intensive Care Unit

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Introduction: There is increasing evidence that poor cerebral perfusion may contribute to delirium in the critically ill. Real-time monitoring of cerebral perfusion presents challenges, however, as no non-invasive method exists to directly measure cerebral perfusion. Researchers have used alternative measures to approximate cerebral perfusion, including near-infrared spectroscopy (NIRS) to capture regional cerebral oxygenation (rSO2), as well as vital sign analysis to capture disturbances in cerebral autoregulation, a mechanism that regulates perfusion to the brain. Results from studies of reduced cerebral perfusion using alternative measures in critically ill patients have shown that while reduced cerebral perfusion predicted delirium development, there was substantial variation within delirious and non-delirious groups, suggesting that individual metrics approximating cerebral perfusion may not provide an adequate representation of the global changes occurring in the brain.

Objectives: To determine whether creation of a composite measure of cerebral perfusion, the cerebral perfusion index (CPI), is feasible in a multi-centre prospective observational study. The CPI will capture multiple components of cerebral perfusion, combining rSO2, duration of cerebral autoregulation dysfunction, and time outside of optimal mean arterial pressure (MAPopt) in order to provide a more comprehensive view of cerebral perfusion in ICU patients. Feasibility was defined by data capture and the ability to acquire/calculate the components of CPI.

Methods: This study was part of a larger feasibility trial, the Cerebral Oxygenation and Neurological Outcomes FOllowing CriticAL Illness-2 (CONFOCAL-2), examining the influence of cerebral perfusion on delirium development and long-term impairment in the intensive care unit (ICU). Briefly, critically ill adults in the ICU were enrolled if they had shock and/or respiratory failure requiring invasive mechanical ventilation for >24hrs. For the first 72hrs, patients’ vital signs, blood gases, and regional cerebral oxygenation (rSO2) levels were monitored. rSO2 was captured using near-infrared spectroscopy (NIRS). Patients were monitored for delirium on the ICU and ward for up to 30 days of their stay.

Results: The capture rate of rSO2 data was 82.7%. Vital sign was lower, at 43.6% for mean arterial pressure (MAP) monitoring. Of the 59 patients enrolled over a one-year period, 30 had sufficient rSO2 and MAP data to be used to calculate CPI. Mean physiological (± SD) values of the cohort were: rSO2 (70.3 ±7.0%), mean arterial pressure (76.5 ±12.9 mmHg), duration of disturbed autoregulation (291± 276 minutes) and time outside MAPopt (1202±723 minutes).

Conclusions: Feasibility was determined through enrolment, and data acquisition and analysis. Calculating the constituents of the CPI was challenging across multiple sites, as MAP data capture was low. Strategies will be implemented to improve data acquisition rates across sites. A composite measure of cerebral perfusion is a potentially useful tool in providing a comprehensive view of perfusion changes that occur in the brain. Future use of CPI will be aimed toward understanding the impact of low regional cerebral oxygenation (rSO2) on delirium development and long-term cognitive outcomes in critically ill patients.
Grant Acknowledgment: This study was supported by the Physician Services Incorporated (PSI) and the Southeastern Ontario Academic Medical Organization (SEAMO) New Clinician Scientist Program.

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Abstracts S141

The ICU Family Education on Delirium (iFAM-ED) Study: Educating Family Caregivers of Critically Ill Patients to Prevent, Detect and Manage Delirium

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Background: Delirium is a common, under recognized condition in critically ill patients, affecting nearly half of all patients admitted to an ICU. Family caregivers of critically ill patients may act as an extension of the ICU care team by acting as partners in the prevention, detection and management of delirium by using nonpharmacological strategies. However, not all family caregivers have sufficient knowledge about delirium to be effective partners.

Objectives: The objective of the iFAM-ED study was to create, validate and refine an ICU delirium education intervention that prepares family caregivers to detect delirium symptoms and prevent and manage delirium using nonpharmacological strategies.

Methods: A multidisciplinary team comprised of past-ICU patients and family caregivers and members of the ICU care team were involved as research partners throughout this pre-post quasi-experimental study, which was conducted in Calgary, Canada. Family caregivers watched a six minute video on ICU delirium developed by the study team, which reviewed delirium risk factors, how they can prevent and manage delirium and how to communicate changes in cognition to the ICU care team. To complete the intervention, participants were asked to review two case vignettes of hypothetical ICU patients to determine whether the patients had delirium using the previously validated family-administered delirium detection questionnaires, the Family Confusion Assessment Method (FAM-CAM) and the Sour Seven. The participants’ delirium knowledge was measured before, immediately after and two-weeks following the intervention using the Caregiver ICU Delirium Knowledge Questionnaire (CIDKQ).

Results: Between January 14 and May 15, 2019, 43 family caregivers were recruited, with a participation rate of 54% (43/79). Out of the 43 family caregivers recruited, 33 completed the intervention (33/43, 76.7%). As of May 15, 21 family caregivers had completed all follow-up questionnaires (21/25, 84%). Family caregivers were 49.5 years of age and the majority female (71.4%, 15/21) adult children of the patient (11/21, 52.4%). Family caregivers’ knowledge of ICU delirium prevention and management strategies and symptoms of delirium improved significantly following the intervention (CIDKQ pre: 14.4 ± 2.9 [95% CI 13.0-15.7]; CIDKQ post: 16.9 ± 3.7 [95% CI 15.2-18.6], p=0.019) and was retained 2 weeks after the intervention [CIDKQ 2 weeks: 16.3 ± 3.0 [95% CI 14.9-17.7], p=0.047]. Family caregivers correctly classified delirium in 84.5% (95% CI: 72.6-92.7%) of the provided case vignettes using the FAM-CAM or Sour Seven.

Conclusions: A video-based ICU delirium intervention is effective in educating family caregivers of critically ill patients on delirium prevention and management and detection of delirium symptoms in case vignettes of hypothetical ICU patients. Furthermore, this ICU delirium knowledge was maintained for up to two weeks. This study supports future research evaluating if family caregivers can use the information provided in the education video to prevent, detect and manage delirium in their loved one during their ICU stay.
Grant Acknowledgment: This study was supported by the Canadian Institutes of Health Research.
The PROMIZING Study Enrolment Algorithm May Be a Useful Clinical Tool for Early Identification of Patients Ready to Liberate from Mechanical Ventilation

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Introduction: Liberating critically ill patients from invasive mechanical ventilation (MV) at the earliest opportunity is essential for avoiding the morbidity and mortality associated with prolonged MV. Daily screening for readiness to wean from MV once patients have improved from the acute phase is recommended best practice to aid early liberation. Criteria exist for assessing readiness to wean but there are no guidelines for determining when a patient in the acute phase of illness can enter the "recovery" phase prior to weaning. Often clinicians switch first from a controlled mode to an assisted mode of ventilation, which may be the first step in recognizing readiness to wean.

Objectives: We created a standardized approach for assessing patient's readiness to move from the "acute phase" to the "recovery phase" and diirectly to the "weaning phase" of MV for the purpose of identifying potential clinical research participants for a randomized controlled trial (RCT) comparing two spontaneous modes of MV (the PROMIZING Study). Our purpose here is to describe how the application of this RCT enrolment algorithm led to the identification of patients who, previously unsuspected by their clinical team, were actually ready for weaning and passed their first SBT.

Methods: We created a 5 stage screening /enrolment /randomization algorithm including criteria for each stage. This algorithm was used for screening, enrolling, and randomizing participants in 10 centres. Patients were enrolled in the study with a priori or deferred consent from the patient /substitute decision maker if they passed the screening and enrolment criteria, had not yet been on pressure support ventilation >24 consecutive hours, and the treating physician anticipated an ongoing need for MV >24 hours. The standardized tests and criteria included the "Pressure Support Trial", assessing "Weaning Criteria", the 2 minute "CPAP Trial" and a spontaneous breathing trial (SBT). Each stage was performed only if the preceding was passed successfully. This process allowed us to
identify 4 groups of patients: Group 1 – did not meet Weaning Criteria; Group 2 – met Weaning Criteria but failed CPAP Trial; Group 3 – Passed CPAP Trial but failed SBT; and Group 4 – passed SBT. Group 4 patients were deemed ineligible for randomization (Enrolled Not Randomized, ENR) and while Groups 1, 2, 3 were randomized in the study.

**Results:** From September 2016 to September 2018, 200 patients were enrolled in the study, of whom 134 were randomized and 66 (33%) were ENR. Data is available for 190 patients, of whom 67 (35%) were not ready to try weaning, 47 (25%) were not ready for an SBT, and 76 (40%) underwent an SBT. Of the 76 undergoing an SBT, 18 failed and 58 (76%) passed their SBT; those passing SBT were extubated within a median time (IQR) of 0.09 (0.03, 1.05) days. Table 1 shows the ventilator settings for the 4 groups at the end of the Pressure Support Trial, and prior to assessment for weaning readiness.

**Conclusion:** This algorithm efficiently and rapidly categorized patients into 4 groups according to their level of weaning readiness. Furthermore, it effectively identified that 40% of enrolled patients were eligible for an SBT; and that 76% of those eligible can successfully pass this SBT and be extubated within 24 hours. This algorithm could be utilized as a clinical tool to aid in early identification of patients ready for liberation from MV.

**Grant Acknowledgment:** This study was supported by 2014 CIHR- industry-partner operating grant, and 2018 CIHR operating grant.

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**Table 1:** Ventilator settings for the 4 groups at the end of the Pressure Support Trial, and prior to assessment for weaning readiness.

|                  | Group 1 | Group 2 | Group 3 | Group 4 | P value |
|------------------|---------|---------|---------|---------|---------|
| N                | 67      | 47      | 18      | 58      |         |
| Pressure Support (cmH2O) | 11.4 (3.8) | 10.9 (3.3) | 10.6 (2.9) | 9.0 (2.7) | <0.001  |
| PEEP (cmH2O)    | 9.9 (2.2) | 7.5 (1.7) | 6.8 (1.5) | 6.3 (1.5) | <0.001  |
| FiO2             | 0.45 (0.09) | 0.37 (0.06) | 0.37 (0.05) | 0.35 (0.06) | <0.001  |
| Vt (mL)          | 858 (170) | 479 (138) | 526 (135) | 540 (154) | 0.006   |
| RR (breaths/min) | 21 (7)   | 22 (7)   | 21 (6)   | 17 (3)   | <0.001  |
| VE (L/min)       | 11.9 (3.6) | 9.8 (2.9) | 10.1 (2.5) | 8.6 (2.6) | <0.001  |
Through the Video Lens: Art as Healing for Grieving Family Members

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Introduction: Under the auspices of the ICCCare Program (Improving Compassion in Critical Care) at St Joseph’s Healthcare, we supported a resident-led project involving the creation of personalized paintings for grieving family members of patients enrolled in the 3 Wishes Project (3WP). The 3WP is an end-of-life intervention to provide compassionate care for dying patients and their families in the Intensive Care Unit (ICU).

Objective: ARTICU (Personalized Artwork to Ease Bereavement in the ICU) involved approaching families for consideration of receiving an individualized painting commemorating their deceased loved one. In this project, we used videography to complement other qualitative data collection techniques. The purpose of this method was to visually capture the artist’s rationale for image selection for the painting as explained to family recipients, and to capture the family’s initial responses to this personalized artwork.

Methods: This arts-based research initiative applying a multiple forms approach was completed in a 21 bed, university-affiliated ICU in Hamilton, Ontario\textsuperscript{1}. After obtaining verbal family consent for the creation of a personalized painting, we provided the artist with patient data, including values, interests and wishes in the 3WP. Clinicians shared with the artist patient stories from the family. If one was available, a “Word Cloud” (a visual representation of words collated by families to represent who the patient was, and reflect “what mattered most” to them) was shared with the artist. Lastly, the artist contacted family members to describe her vision for the painting, and gathered input from family members as a final step in the co-creation process. Upon painting completion and framing, the family was invited to the hospital to receive the gift and to create an opportunity for the artist to present and describe the images in the painting. We obtained verbal consent to video record this encounter. Two investigators reviewed and interpreted these videos, synthesizing findings from the perspectives of the family members, clinicians and the artist.

Results: Approximately 2-6 months post-mortem, a total of 20 family members of 9 deceased patients received a personalized painting in honour of their loved one. The descriptive features of the paintings were thoughtfully presented to the family by the artist during the encounter, revealing symbolism and messages purposefully placed within the art. In turn, families identified features of the painting which prompted the recounting of stories related to the imagery - for example, a passion for gardening, links to a country of origin, love of fishing, and connection to First Nations roots. Visual imagery through these videos captured emotional interactions between the artist and families; families were deeply moved that their loved one would be honoured this way and occasionally shared where this painting would be displayed.

Conclusions: Personalized paintings had a powerful impact on family members in grief as interpreted by verbal and nonverbal communication. Videography captured the artist’s stories behind personalized paintings, which in turn prompted narratives by families, and evoked emotional moments between families and the artist and clinical team. Videography can be an effective adjunct to capture and create lasting impressions of personalized post-mortem artistic interventions that are both long-lasting and deeply meaningful.

Grant Acknowledgment: This project was supported by the Regional Medical Associates of Hamilton Scholarship Award, Walmart Canada Community Grant, and Ontario Art Council: Artists in Communities and Schools Projects.
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Trainee Conceptual Understanding of Cardiac Physical Examination

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Background: Cardiac examination of critically ill patients is considered challenging for both medical trainees and practitioners, as it requires integration of the physiology and anatomy of the heart, as well as inspection, palpation and auditory skills to discern normal and abnormal heart sounds. Cardiac examination skills do not significantly improve after undergraduate training and may decline after years of clinical practice [1], which may be a major factor hindering diagnostic abilities, future clinical practice, and patient safety. Although we have made advances in our diagnostic tools and technologies, bedside diagnosis, including but not limited to the physical examination, is a cornerstone of patient evaluation in setting of critical illness and is a core competency in both medical school and at the postgraduate level. One of the biggest challenges is acquiring adequate exposure to patients with good physical exam findings during training, and lack of experienced instructors who provide comprehensive teaching at bedside. Many students and residents rely on currently available audiovisual “eLearning” materials; however, evidence-based, concise and easily accessible resources are not readily available.

Aim: Our aim in this study is to establish a baseline level of cardiac examination knowledge among medical trainees, and their current use of audiovisual material.

Methods: A survey consisting of multiple-choice structured questions were developed by expert clinicians using current evidence-based information. The survey was distributed in electronic and paper-based formats between medical students and Internal medicine residents with the goal of collecting 150 responses. The questionnaire included an initial consent form indicating anonymous response collection. Data were analyzed using Microsoft Excel in three main categories; 1) Basic cardiac physiology knowledge, 2) Evidence-based physical examination knowledge, 3) Audiovisual material usage, its significance in learning, and its accessibility.

Results: Preliminary results had a 45% (N:61) response rate. On average, trainees answered only 47% of physiology-based questions correctly. In each main category of questions, we calculated the correct response rate for individual respondents, and took the mean and standard deviation of these results. Incomplete responses were counted as incorrect. In comparison, 55% of evidence-based physical examination questions were answered correctly. Approximately 81% of trainees have tried web-based resources but less than 50% of those trainees found them useful. A majority of participants believed that trustful, concise, easily accessible, interactive and practical multimedia resources are lacking.

We compared the correct response rate of trainees based on their frequency of web-based resource usage. Participants were grouped as using these resources often (rating of 1-2), occasionally (rating of 3), or seldom (rating of 4-5). For each group, mean correct response rate for all questions was calculated and compared by single factor ANOVA. There was no statistically significant difference in correct responses between trainees that used web-based resources often, occasionally, and seldom (P=0.074). Participants were also grouped based on their level of training: pre-clerkship (undergraduate years 1 and 2), clerkship (undergraduate years 3 and 4), junior residents (postgraduate years 1 and 2), senior residents (postgraduate years 3+), and staff physicians. Mean correct response rate for each group was compared by single factor ANOVA. There was no statistically significant difference in correct response rates between different levels of medical training (P=0.155).

Conclusion: There is a considerable lack of knowledge among trainees in performing cardiac physical exams, which could compromise patient’s safety specially in urgent situations requiring rapid diagnosis and management. This could be a result of deficiencies in understanding and integrating basic cardiac physiology and clinical skills. A large proportion of the Medical trainees rely on online multimedia for study, yet suffer from lack of trustworthy sources that combine teaching clinical skills and basic physiology. Our
preliminary analysis suggests that current web-based resources do not significantly improve the user’s knowledge. There is a need for developing a well structured, concise, and evidence-based web resource that is readily available to trainees.

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Trends in Opioid Use Before Critical Illness Among Elderly Patients in Ontario

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Introduction: Opioid consumption in some developed countries has risen to epidemic proportions (1). It is also associated with increased risk of cardiovascular events and death especially in the elderly population (2, 3). The prevalence of prior opioid exposure among patients admitted intensive care units (ICU) and its impact on outcomes remain unknown.

Objectives: To assess temporal trends in pre-existing opioid exposure prior to hospitalization among elderly patients with critical illness and to determine whether prior opioid exposure is associated with adverse outcomes during hospitalization.

Methods: We performed a population-based cohort study using health administrative datasets from Ontario, Canada. We included all hospitalizations among Ontario residents aged > 65 years that involved an ICU admission between 2002 and 2014. The exposure was opioid use before admission, categorized as chronic use, intermittent use, and non-use. Chronic use is defined as having filled at least one opioid prescription with a duration overlapping the day of hospital admission and to have filled at least 10 opioid prescriptions and/or any number of opioid prescriptions having at least 120 cumulative days of supply during the 1-year look-back period. Intermittent use is defined as having filled at least one opioid prescription in the year before hospitalization but not meeting criteria for chronic use. Non-use is defined as not filling any opioid prescriptions in the year prior to hospitalization.

Primary outcome was hospital mortality. The association between opioid exposure and hospital mortality was assessed using generalized estimating equations. A secondary outcome was time to hospital discharge, evaluated using Fine and Gray regression model, accounting for the competing risk of death.

Results: The cohort included 711,312 elderly patient admissions to an ICU during the study period. Of these admissions, 6.8% (n=48,363) were chronic opioid users, 28.1% (n=200,149) intermittent users, and 65.0% (n=462,800) non-users. The prevalence of chronic users increased from 5.3% (95% CI, 5.1%-5.5%) in 2002 to 8.1% (95% CI, 7.9%-8.3%; p-value for trend <0.0001) in 2014 (figure 1). Compared with non-users, chronic opioid users and intermittent users had higher in-hospital mortality (adjusted odds ratio: 1.12, 95% CI, 1.09-1.15, p<0.0001 for chronic users; adjusted odds ratio: 1.09, 95% CI, 1.07-1.11, p<0.0001 for intermittent users), and a lower subdistribution hazard of time to hospital discharge, translating to a longer hospital length of stay (adjusted subdistribution hazard ratio: 0.87, 95% CI, 0.85-0.88, p<0.0001 for chronic users; 0.93, 95% CI, 0.92-0.94, p<0.0001 for intermittent users) (table 1).

Conclusion: The prevalence of chronic opioid use has increased among elderly patients who required ICU admission and is associated with worse hospital outcomes. While prior opioid use may not be easily modifiable, future studies should explore in-hospital and in-ICU interventions that can decrease opioid use in these chronic users, and to evaluate the impact of chronic use on subsequent clinical outcomes.
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Table 1: Association between opioid exposure and mortality and hospital length of stay in elderly patients admitted to ICU in Ontario from 2002 to 2014

| Opioid exposure | Hospital mortality, N (%) | Odds ratio for mortalitya | 95% CI | p-value |
|-----------------|---------------------------|---------------------------|--------|--------|
| Non-users       | 73,668 (15.9)             | Ref                       |        |        |
| Intermittent users | 35,091 (17.5)           | 1.09                      | 1.07–1.11 | <0.0001 |
| Chronic users   | 9,002 (18.6)              | 1.12                      | 1.09–1.15 | <0.0001 |

| Opioid exposure | Hospital length of stay, median (IQR)b | Subdistribution hazard ratio for length of stayc | 95% CI | p-value |
|-----------------|----------------------------------------|-----------------------------------------------|--------|--------|
| Non-users       | 8.0 (4.0–15.0)                         | Ref                                           |        |        |
| Intermittent users | 8.0 (5.0–16.0)                       | 0.93                                          | 0.92–0.94 | <0.0001 |
| Chronic users   | 9.0 (5.0–17.0)                         | 0.87                                          | 0.85–0.88 | <0.0001 |

CI: Confidence interval, IQR: interquartile range
aAdjusted model. For complete model see Supplement eTable 2. Adjusted for age, sex, selected Charlson comorbidities, patient type (medical or surgical), mechanical ventilation, year and hospital type (teaching or community).
bHospital length of stay in days for survivors
cAdjusted model. For complete model see Supplement eTable 3. Adjusted for age, sex, selected Charlson comorbidities, patient type (medical or surgical), mechanical ventilation, year and hospital type (teaching or community).
**Figure 1:** Prevalence of chronic opioid use, intermittent use and non-use prior to hospital admission among elderly ICU patients admitted in Ontario from 2002 to 2014, with 95% confidence intervals.

Figure showing the proportion of elderly ICU admissions exposed to opioid prior to admission. The trend of change in prevalence of chronic users, intermittent users and non-users over time was assessed using a negative binomial model. Between 2002 and 2014, chronic users admitted to the ICU increased (p<0.0001) while intermittent users decreased (p=0.0002). The trend for non-users did not change over time (p=0.5).
Understanding Decision Making in Organ Donation - A National Study: Progress Update

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Introduction: Despite the central role of the substitute decision-makers (SDMs) in the process leading to organ donation, very little is known about their decision-making process. Previous studies have explored SDMs characteristics and predictors of providing consent; the consent process itself; and the effect of the decision on subsequent care and on family well-being. Our understanding of factors, especially modifiable ones, influencing the decision around posthumous organ donation is restricted to few studies that are limited by inappropriate sampling (retrospective design) or lack of appropriate theoretical assumptions (non-structured and validated models). Our study seeks to fill these gaps by proposing an innovative sampling solution that will directly and prospectively identify SDMs who: a) were and were not approached for organ donation; and b) among those who were approached, those who consent or decline organ donation.
Objective: The study’s primary objective is to explore the experiences and perspectives of patients’ SDMs involved in decisions about organ donation consent. The objective of the current publication is to inform the development phase of the interview guide.

Methods: We will conduct a national multicenter prospective cohort study of SDMs of potential organ donors (Clinical Trials NCT03850847) in two steps. In step 1 (qualitative phase), semi-structured telephone interviews will be conducted with SDMs of 60 patients 6-8 weeks after the patient’s death. The study will include adult SDMs of patients aged ≥18 yrs admitted to one of the 10 participating ICUs with either catastrophic brain injury or for whom an evaluation for deceased organ donation was considered or could have been considered. Interviews will be balanced across different subsample groups: SDMs who were or were not approached for organ donation and provided or declined consent for organ donation. Step 2 (SDMs of 232 patients) will be informed by the results of step 1 and will include a national survey with SDMs (quantitative phase). Our team includes experts in health psychology, medical sociology, qualitative methodology, questionnaire design and survey administration, patient research partner, organ donation and transplantation and critical care research. The collaboration with large Canadian research networks will ensure future knowledge transfer and dissemination to the population.

Results: From November 2018 to July 2019, our research team developed a template interview guide in both English and French. The interview guide was informed by two complementary theoretical frameworks: 1) the Leventhal’s Common-Sense Self-Regulation Model (CSSRM) of health and illness that aims to explore how SDMs understand and conceptualize the illness/injury/brain death; 2) the Theoretical Domains Framework that aims to explore views about what may have impacted the decision to consent to organ donation or not. The interview guide was subsequently pilot tested and revised in collaboration with our patient partner knowledge users for clarity, brevity, and sensitivity. Recruitment and Step 1 data collection will take place between August 2019 to January 2020.

Conclusion: Our study seeks to understand the SDM’s beliefs and views surrounding organ donation and identify potential reasons for organ donation refusal and potential barriers to obtaining consent so that we may better support SDMs in the future.

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Updates from the Canada-DONATE Data Link Survey: National Efforts to Link Donor and Recipient Data for Research in Canada

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Introduction: Canadian research to improve the medical care of deceased organ donors and transplant recipients is challenged by the regionalization of donation and transplant services across provinces, and inconsistent research access to individual transplant recipient data.

Objective: In order to support clinical research that will improve organ outcomes by establishing best care for deceased organ donors, we endeavored to build a live compendium of provincial and national databases of organ transplant outcome data.

Methods: We developed a 23-item online survey to assess the content, quality, and accessibility of the databases. In two focus group interviews, donation researchers helped to generate and refine survey items. Three donation researcher/administrators pre-tested the content and completion time. We contacted representatives from 10 provincial and national organizations housing organ recipient data to respond to our online survey, providing telephone support as necessary.

Results: Each organization responded and six have completed the survey. Five databases record organ recipient vital status (e.g. mortality); four track biochemical and mechanical support data; three track pathology; and two track physiologic function (Table 1). The period of post-transplant data varies from one to 10 years, with three organizations recording data at regular intervals. Data entry is immediate for provincial organizations, and requires up to one year for national databases. All databases have data integrity processes in place, though data validation procedures vary. For clinical research applications, provincial organizations occasionally require direct recipient consent; national databases do not. Estimates of the median time to research access varied from 1-4 months depending on data complexity. The Canadian Blood Services Canadian Transplant Registry (CBS-CTR) was the only fully linked database from the time of allocation to the time of irreversible organ failure or death (Tables 1-3).

Limitations: The survey response rate is 60%. Some items (e.g. time to access) are highly variable, so the compendium is limited to listing the most common result for each organization. The CBS-CTR database is currently limited to highly sensitized kidney patients (HSP-Kidney). The Institute for the Clinical Evaluative Sciences database (ICES) is limited to Ontario. The Transplant Québec database is French language.

Conclusion: The CBS-CTR database has the most robust data, but is limited to HSP-Kidney patients. All databases have unique purposes, and vary in content, timeliness, and time to access; the most suitable database will vary according to the specific needs of a study. Completion of this work will result in a living compendium of organ recipient data sources available to Canadian researchers on-line. Next steps will extend this work to individual transplant programs across Canada.
### Table 1: Database Procurement Methodologies

| Databases                                                                 | Data Source                  | Timeliness of Data Entry | Recipient Data Consent | Data Integrity Processes | Instances of Data Collection                      |
|---------------------------------------------------------------------------|------------------------------|--------------------------|------------------------|-------------------------|--------------------------------------------------|
| Canadian Blood Services – Canadian Transplant Registry (CBS-CTR) [HSP Kidney Only] | Paper Records External Registry | Variable up to several months | Clinical Use Research Use | Track Missing Data       | Prior to Transplant                                |
|                                                                           |                              |                          |                        |                         | Time of Transplant                                 |
|                                                                           |                              |                          |                        |                         | Post-Transplant in Hospital                        |
|                                                                           |                              |                          |                        |                         | Post-Discharge                                     |
|                                                                           |                              |                          |                        |                         | Irreversible Organ Failure/Death                   |
| Canadian Organ Replacement Registry (CORR)                                  | External Registries          | Variable from 3-12 months | N/A                    | Database Cross-Referencing Track Missing Data     | Time ofIrreversible Organ Failure Time of Death   |
|                                                                           |                              |                          |                        |                         | Pre-Transplant                                    |
|                                                                           |                              |                          |                        |                         | Post-Transplant in Hospital                        |
|                                                                           |                              |                          |                        |                         | Post-Discharge                                     |
|                                                                           |                              |                          |                        |                         | Irreversible Organ Failure/Death                   |
| Institute for Clinical Evaluative Sciences (ICES) [Ontario Only]           | External Registries          | Variable up to 1 year    | Clinical Use           | Duplicate Data Entry | Duplicate Entry Source Document Check Database Cross-Referencing Track Missing Data |
|                                                                           |                              |                          |                        |                         | Pre-Transplant                                    |
|                                                                           |                              |                          |                        |                         | Time ofTransplant                                  |
|                                                                           |                              |                          |                        |                         | Post-Discharge                                     |
|                                                                           |                              |                          |                        |                         | Irreversible Organ Failure/Death                   |
| British Columbia Patient Records and Outcome Management Information System (BC PROMIS) | Paper Records Immediate      | Clinical Use Research Use | Database Cross-Referencing | Duplicate Entry Source Document Check Database Cross-Referencing Track Missing Data |
|                                                                           |                              |                          |                        |                         | Pre-Transplant                                    |
|                                                                           |                              |                          |                        |                         | Time of Transplant                                  |
|                                                                           |                              |                          |                        |                         | Post-Discharge                                     |
|                                                                           |                              |                          |                        |                         | Irreversible Organ Failure/Death                   |
| Ontario Trillium Gift of Life Network (TGLN)                               | Paper Records Electronic Medical Record | Variable up to 6 months | No                     | Duplicate Entry Source Document Check Database Cross-Referencing Track Missing Data |
|                                                                           |                              |                          |                        |                         | Prior to Transplant                                |
|                                                                           |                              |                          |                        |                         | Time of Transplant                                  |
|                                                                           |                              |                          |                        |                         | Post-Discharge                                     |
|                                                                           |                              |                          |                        |                         | Irreversible Organ Failure/Death                   |
| Transplant Quebec [French Language]                                         | Paper Records Immediate      | Research Use              | Duplicate Data Entry Source Document Check Database Cross-Referencing Track Missing Data | Prior to Transplant                                |
|                                                                           |                              |                          |                        |                         | Time of Transplant                                  |
|                                                                           |                              |                          |                        |                         | Post-Discharge                                     |
|                                                                           |                              |                          |                        |                         | Irreversible Organ Failure/Death                   |

### Table 2: Database Contents and Characteristics

| Databases | Transplant Data | Recipient Data | Ex-Vivo Thripsies | Post-Transplant Data |
|-----------|----------------|----------------|-------------------|----------------------|
| CBS-CTR   | Date Transplant Program Discharge Date | Date of Birth Medical Record Number Health Card Number | No | Biochemical Pathology Mechanical Support Vital Status |
| CORR      | Transplant Date Transplant Program Procedural Notes | Date of Birth ODO Number Health Card Number | No | Vital Status |
| ICES      | Date Transplant Program Date of Discharge Procedure Notes | Date of Birth Health Card Number | Yes | Biochemical Mechanical Support Vital Status |
| BC PROMIS | Date Transplant Program Procedure Notes Date of Discharge | Date of Birth Medical Record Number ODO Number Health Card Number | Yes | Biochemical Physiological Pathology Diagnostic Imaging Pathology Mechanical Support Vital Status |
| TGLN      | Transplant Date Transplant Program Procedure Notes | Date of Birth Medical Record Number ODO Number Health Card Number | Yes | Biochemical Physiological Pathology Mechanical Support Vital Status |
| Transplant Quebec | Transplant Program | Date of Birth Medical Record Number ODO Number Health Card Number | No | N/A |

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**Abbreviations:**
- CBS-CTR: Canadian Blood Services – Canadian Transplant Registry
- CORR: Canadian Organ Replacement Registry
- ICES: Institute for Clinical Evaluative Sciences
- BC PROMIS: British Columbia Patient Records and Outcome Management Information System
- TGLN: Ontario Trillium Gift of Life Network
- HSP: Hematopoietic Stem Cell Transplant
- ODO: Organ Donor Number
- N/A: Not Applicable
### Table 3: Database Research Access

| Databases          | Individual Data | Patient Consent | Regulatory                                           | Cost                | Access Time     |
|--------------------|-----------------|-----------------|-----------------------------------------------------|---------------------|-----------------|
| CBS-CTR            | Yes             | No              | Research Ethics Board Data Sharing Agreement        | None                | 1-3 Months      |
| CORR               | Yes             | No              | Research Ethics Board                                | Cost-Recovery       | Variable        |
| ICES               | Yes             | No              | Research Ethics Board Privacy Office Institutional Review Data Sharing Agreement | Variable            | Variable        |
| BC PROMIS          | Yes             | Variable        | Research Ethics Board Privacy Office Institutional Review Data Sharing Agreement | Cost-Recovery       | 1-3 Months      |
| TGIN               | Yes             | No              | Research Ethics Board Privacy Office Institutional Review Data Sharing Agreement | Variable            | Variable        |
| Transplant Québec  | Yes             | Variable        | Research Ethics Board Privacy Officer Approval Institutional Review Data Sharing Agreement | Variable            | 3-12 Months     |
Urinary Biomarkers of Acute Kidney Injury in the Ovation-65 Trial: A Nested Analysis of the Urinary Proteome

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Introduction: OVATION65 is a randomized controlled trial comparing permissive hypotension vs. usual care on organ injury biomarkers. Our overarching objective is to select a biomarker reflecting acute kidney injury (AKI). Herein, we report preliminary results of a proteomics study of candidate biomarkers of AKI in OVATION65.

Objectives:
1) Quantify peptides and proteins expressed in the urine of OVATION65 participants using the proposed methodology;
2) Determine whether these proteins include 6 prespecified candidate biomarkers of kidney injury;
3) Describe renal outcomes that will ultimately be associated with proteomics clusters.

Methods: This analysis includes 65 OVATION65 participants from 7 Canadian hospitals. Patients were ≥65 years old with vasodilatory hypotension, ≤12 hours since vasopressor initiation and anticipated to remain on vasopressors for ≥6 more hours. Exclusion criteria included acute spinal cord or brain injury; acute hemorrhage, ventricular failure or post-cardiopulmonary bypass vasoplegia; <1 year since solid organ transplantation; extracorporeal life support at baseline; lacking commitment to life-sustaining therapies; previous enrollment in OVATION65; and lack of physician equipoise. Patients were randomized to permissive hypotension (mean arterial pressure [MAP] target 60-65 mmHg) or usual care. Prespecified renal outcomes are incident KDIGO stage 3 AKI, incident renal replacement therapy (RRT), and renal SOFA score of 4. SOFA scores are measured on days 1 (baseline), 2, 3, 7, 14 and 28 while in ICU; other renal outcomes are screened daily. Fresh urine samples were collected on study days 1, 3, and 7. Following centrifugation, supernatants were stored at -80°C. After thawing, trypsin digestion of urinary proteins, peptides were quantified using a TimsTOF Pro mass spectrometer coupled to high-performance liquid chromatography (HPLC). Analyses were performed in duplicate and blinded to group allocation and renal outcomes. We ascertained if 6 candidate biomarkers (NGAL, FABPL, CYTC, KIM-1, combination of TIMP2 and IGFBP7) could be detected. Hierarchical clustering of urinary proteins was performed using complete-linkage methodology.

Results: The mean age of OVATION65 participants was 75 (standard deviation [SD] 7) years, and 24 (37%) were women. The mean APACHE II score was 24 (SD 6), 23 participants (35.6%) had chronic kidney disease, and 4 (6%) received chronic dialysis at
baseline. Stage 3 AKI occurred in 12 (18.5%) participants at a median 0.5 (interquartile range 0-2) days after randomization. Six (9.2%) participants received new RRT and 22 (33.9%) participants achieved renal SOFA score of 4. Urine samples were collected from 62 (92%), 58 (89%), and 45 (69%) participants on days 1, 3, and 7, respectively. Following analysis of these 165 urine samples, over 2,600 hydrosoluble proteins were quantified (average of four peptides per proteins, Figure 1), and grouped in 3 distinct clusters. The 6 prespecified candidate biomarkers were among the proteins expressed in detectable levels. **Conclusion:** Using mass spectrometer coupled to HPLC, we quantified over 2,600 hydrosoluble proteins in urine samples from OVATION-65 participants. While we remained blinded to their quantity, prespecified candidate biomarkers were expressed in detectable amounts and will be included in subsequent hierarchical clustering analyses linking urinary proteins to renal outcomes.

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Vein of Galen Malformations Presenting as Neonatal Heart Failure

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Introduction: Vein of Galen malformation (VGM), a fistulous connection between cerebral arteries and the vein of Galen, is an uncommon congenital vascular malformation. It is a rare cause of neonatal heart failure. Cardiac dysfunction severity is related to the degree of shunting though this malformation. Historically, the prognosis was guarded and the mortality, if untreated, high. Endovascular embolization has improved outcomes significantly.

Objective: describe features, evaluation, management and outcomes of VGMs.

Method: case review

Case description: an 8-day-old girl with unremarkable perinatal history was referred to cardiology for murmur evaluation. She had feeding intolerance, tachypnea and lethargy. Examination revealed respiratory distress, weak pulses, a hyperdynamic precordium, a gallop, a continuous murmur heard throughout the precordium and maximally upon auscultation of the anterior fontanel, and hepatomegaly. Echocardiography revealed dilatation of the superior caval vein, severe biventricular dysfunction, severe right ventricular dilation, supra-systemic pulmonary pressure and abnormal diastolic flow reversal in the descending aorta. Brain MRI confirmed a large VGM. Instability led to intubation and the initiation of milrinone, epinephrine and inhaled nitric oxide. The patient underwent trans-arterial embolization of the main feeding arteries. Intervention led to immediate normalization in heart rate and blood pressure. Pulmonary hypertension and ventricular dysfunction resolved over 24 hours. At 18 months, neurodevelopment was normal.

Discussion: VGM is a rare cause of high-output heart failure and pulmonary hypertension and is associated with high mortality and morbidity1. Pulmonary hypertension is a complication in newborns with VGM2. The large left-to-right shunt results in increased venous return, high pulmonary flow and pulmonary congestion3. These disturbances lead to abnormal post-natal transition and prevent the expected drop in pulmonary vascular resistance.

Pre-intervention priorities include minimizing myocardial demand with appropriate ventilation, sedation and optimization of fluid status. Inhaled nitric oxide may reduce pulmonary vasoconstriction but may exacerbate pulmonary vascular congestion. Prostaglandin may be considered in RV failure, to ensure that the ductus arteriosus remains patent, and in LV failure, to improve systemic output. Milrinone may improve systolic and diastolic function, and induce systemic and pulmonary vasodilation. Beta-adrenergic agents are not recommended.

The natural progression of VGM is characterized by high morbidity and mortality. Neonates are at particular risk4. Historically, neonates with cardiac failure were untreated due to concern for VGM-associated cerebral infarction and poor neurodevelopmental outcome. With improved management, pre-operative death rates have declined (33 to 5%)4. Embolization interrupts the high-output state and results in normalization of cardiac function. With neuro-intervention and cardiac failure management, neonates can survive without neurological impairment3. Embolized patients had a reduction in mortality, good outcomes increased by more than 20% and complications decreased significantly5.

Conclusion: Neonates with cardiac failure secondary to VGMs require prompt diagnosis and management. Clinicians must maintain a high index of suspicion because survival and neurodevelopmental outcomes significantly improve with endovascular neuro-intervention.
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Figure 1
What is Known About Parental Attitudes Towards Participation in Pediatric Critical Care Research? A Scoping Review

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Introduction: Prospective informed consent, most often from parents or legal guardians, is the standard and ethically accepted practice in pediatric clinical research. In critically ill children, obtaining timely and fully informed consent is especially difficult.

Objective: To review published studies exploring parental attitudes toward participation in pediatric clinical research.

Methods: This scoping review includes original research of any design including parents of children admitted to an intensive care unit (ICU) or hospitalized with severe or acute illness. We excluded studies focusing on neonates and studies failing to include parental attitudes. We searched MEDLINE and EMBASE (January 2019) and two reviewers screened and assessed publications independently for eligibility.

Results: We included 19 studies reporting on 2424 parents. Ten (53%) studies asked parents about hypothetical research and sixteen (84%) studies were qualitative in design. The median number of parents in each study was 68, the median percentage of fathers included was 22% and seven (37%) studies included bereaved parents. Included studies focused mostly on parental reasons for consent refusal (68%) and general attitudes towards research participation (63%). Parents were mostly approached in the ICU or emergency room (42%) and more than one year after hospital discharge (21%).

Conclusions: This review demonstrates that parents are more accepting of certain consent processes depending on their child’s illness severity. However, most studies failed to obtain parental suggestions on potential improvements of these processes. The limited literature including fathers and bereaved parents, supports the need for developing a more holistic understanding of parental attitudes towards research.