CARJ 2021: Year in Review

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Abstract
The past year has been one of unprecedented challenge for the modern world and especially the medical profession. This review explores some of the most impactful topics published in the CARJ during the COVID-19 pandemic including physician wellbeing and burnout, patient safety, and technological innovations including dual energy CT, quantitative imaging and ultra-high frequency ultrasound. The impact of the COVID-19 pandemic on trainee education is discussed and evidence-based tips for providing value-added care are reviewed. Patient privacy considerations relevant to the development of artificial intelligence applications for medical imaging are explored. These publications in the CARJ demonstrate that although this year has brought adversity, it has also been a harbinger for new and exciting areas of focus in our field.

Résumé
Cette année a été une année de défis sans précédent pour le monde moderne et plus particulièrement pour la profession médicale. Cette analyse explore quelques-uns des sujets publiés dans le CARJ et ayant eu la plus grande répercussion au cours de la pandémie de COVID-19, y compris le bien-être et l’épuisement professionnel des médecins, la sécurité des patients, les innovations technologiques (dont la TDM à double énergie), l’imagerie quantitative et l’échographie à ultra-haute fréquence. Les effets de la pandémie de COVID-19 sur l’enseignement des stagiaires sont abordés et des conseils reposant sur des données probantes visant à ajouter de la valeur aux soins font l’objet d’une analyse. Les questions pertinentes sur la protection de la confidentialité des patients face au développement des applications d’intelligence artificielle pour l’imagerie médicale sont explorées. Ces publications dans le CARJ démontrent qu’en dépit de l’adversité, cette année a laissé présager de nouveaux domaines d’intérêt enthousiasmants dans notre spécialité.

Keywords
review, artificial intelligence, patient safety, burnout, professional, imaging genomics

Introduction
The past year has been one of change and of overcoming adversity for many people as we lived through a time of uncertainty not seen in our country during most of our lifetimes. It was, and continues to be, a time of struggle and hardship that many had only previously read about in history books and could not fathom experiencing. And yet we persist, we evolve, and we grow. Paralleling the human journey over the past 1.5 years, medicine and radiology have also had to adapt to our ever-changing world. This year’s Canadian Association of Radiologists Journal “Year in Review” looks back on those topics which address the changing medical environment and embrace the future of radiology. We present 10 of the most interesting and impactful articles published by our journal over the past year.

Wellbeing
Physician wellbeing is a topic that we all recognize as being crucial to both our personal and professional lives and have for many years. The adage “physician heal thyself” first appeared millennia ago. We must heal ourselves before we are able to heal others. And yet, we continue to leave physician wellbeing on the back burner, at a personal level for many, but also at a systemic level.

Zha et al had an in depth survey-based look at the causes of burnout in radiology in a follow up to their previous study on the prevalence of burnout in radiologists and trainees, which concluded that up to 72% of respondents experienced at least 1 symptom of burnout.1 The greatest stressors for burnout among both staff radiologists and trainees in various types of practice were workload (volumes for staff and call for trainees) and career uncertainty/insecurity. However, radiologists felt that

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their concerns were not being heard at a systemic level. This study was in agreement with a previous study that also reported high levels of burnout in Canadian radiology residents (51%) and identified poor work-life balance and harassment or intimidation as major stressors. This work was performed before the COVID-19 pandemic hit. Anecdotally, many of us have likely felt these stressors and burnout more acutely during the pandemic without our usual sources of support available. This was our first topic for review so that as we embrace change, hopefully one of those changes will be that physician wellbeing is not left in the dust but rather brought to the forefront.

**Safety**

As physicians, we have all taken the oath to “Do no harm.” Therefore, continued evaluation and restructuring of techniques and safety protocols is vital. A survey-based study which assessed computed tomography (CT) dose and protocols for chest and abdominal pelvic CTs at several sites in developing countries demonstrated that many studies were performed using much higher dose than was necessary. The most common reason being inappropriate protocoling of multiphase studies. In fact, all multiphase routine chest CTs and 63% of multiphase routine abdomen and pelvis CTs were deemed inappropriate. An additional factor contributing to the overall increased dose of multiphase scans was the use of static scan parameters for all phases rather than tailoring scan length or potential. These data serve as an important reminder for all to apply the ALARA principle (As Low As Reasonably Achievable). Appropriateness criteria including the Canadian Association of Radiologists (CAR) diagnostic imaging referral guidelines provide a resource that can be applied to carefully protocol exams. The CAR plans to further develop this topic with the newly launched initiative with the Canadian Medical Association (CMA) to integrate electronic Clinical Decision Support tools.

It can be unclear which patients with implantable cardiac devices are eligible for Magnetic Resonance Imaging (MRI). In 2020 we were provided with a guideline and performance recommendations. This update explained that MRI in the presence of implantable cardiac devices is much safer than historically thought and can be implemented into routine practice with a few considerations. First, the type of device must be considered as a few devices including permanent epicardial leads, temporary pacemakers, ventricular assist devices, and pulmonary artery monitoring devices remain contraindicated due to the potential for adverse events. Second, assessment of the manufacturer-provided MRI compatibility category and recommendations for protocol, including specific absorption rate (SAR), scan duration and sequences are instrumental to safely performing MRI in these patients. Third, institutional guidelines and protocols are vital. For example, pre-procedural chest radiographs may demonstrate abandoned or fractured leads, a contraindication to MRI, of which the patient may not be aware. Pre-and post-procedural assessment by an electrophysiologist for appropriate device programming, interrogation and reprogramming ensure optimal device functioning. Having the appropriate personnel and equipment available before, during, and after an MRI can be life saving. Attention to these items allows MRI in patients with implantable cardiac devices to be performed safely with relative ease on a routine basis.

**Innovation**

As dual energy CT (DECT) becomes more common in clinical practice, there is an opportunity to study its efficacy on a wider scale. In 2020, the CARJ published a systematic review and meta-analysis on the diagnostic accuracy of DECT for the detection of pulmonary embolism (PE). The authors included 7 studies in their meta-analysis after rigorous interrogation of the literature. In a combined 108 patients with PE, pooled analysis demonstrated overall excellent performance of DECT for detection of pulmonary embolism (PE). The reported sensitivity, specificity and area under the curve were 88.9%, 94.6% and 0.935, respectively. This high level of performance was attributed to the use of perfusion iodine maps improving sensitivity for detection of PE in subsegmental pulmonary arteries. However, despite the overall excellent performance, there was a poor negative likelihood ratio of 0.159 indicating that DECT cannot be used to exclude PE. This study demonstrated that DECT is a valuable tool in the radiologist’s arsenal. Other articles this year have also illustrated the versatility of DECT in trauma and neuroradiology imaging due to post-processing techniques that capitalize on the k-edge of iodine. DECT allows the identification of small bleeds and assessment of organ perfusion, differentiation of hemorrhage and luxury perfusion in post stroke imaging, and artifact reduction.

An emerging area of imaging which is not yet widely used is ultra-high frequency ultrasound (UHFUS). A review of UHFUS usage and statistical efficacy was published this year in the CARJ. This is an exciting new area of radiology which shows excellent performance in areas where more traditional cross-sectional imaging methods have been deficient. In this review, the authors defined UHFUS as > 30 MHz probe frequency, with the reminder that most clinical ultrasound probes have frequencies less than 15 or 20 MHz. UHFUS allows accurate and detailed assessment of structures less than 1 mm in size with the trade-off of decreased depth of penetration which is limited to 10–20 mm (given the inverse relationship between spatial resolution and depth of penetration).

Four areas highlighted in this review where UHFUS exhibits the most promise are dermatological, small vascular, small parts musculoskeletal, and intraoral imaging. Dermatology has historically been a relatively sparse topic in radiology with our assessments often limited to edema, abscesses, cysts and soft tissue nodules. However, this review illustrates the ability of UHFUS to play a role in the assessment of skin tumors and local staging including for oropharyngeal tumors. UHFUS may also be revolutionary in the field of rheumatology with its superior assessment of small structures and lesions in the skin, vasculature and musculoskeletal system. This is an exciting...
prospect for an area which historically has relied on the presence of relatively advanced disease for detection on imaging.

In recent years, tailored medical treatments have been attempted based on the genomics or molecular subtype of a person or disease. For these patients, the role of radiology has been mostly limited to staging and providing guidance for tissue sampling. With advancing imaging quantitative techniques, there may be a role for cross-sectional imaging to narrow the differential diagnosis of disease to a particular molecular subtype using radiogenomics. The application of quantitative imaging to identify epidermal growth factor receptor mutation status was assessed for non-small cell lung cancer.11 This study found that CT texture analysis could be used to differentiate wild type and mutant epidermal growth factor receptor (EGFR) variants. Both CT texture analysis and FDG-PET texture analysis could be used to differentiate EGFR wild type and mutant, with entropy and kurtosis being the most important texture analysis features. However, FDG-PET texture analysis showed superior performance for differentiating between types of EGFR mutations.11 Tumors with EGFR mutations are more likely to respond to tyrosine kinase inhibitor therapy and obtaining this information pre-surgery could accelerate initiation of systemic treatment.

**Practice Changes**

The COVID-19 pandemic has changed the way many academic activities are approached and delivered. This includes trainee education. Radiology education of medical students can be challenging given the limited roles available to medical students in radiology practice. Physical distancing measures have further exacerbated this issue.

Darras et al evaluated the importance of radiology training for undergraduate medical education and provided several tools and approaches.12 This includes using a combination of synchronous and asynchronous teaching with student response systems. Deductive learning (lecture first, problem later) was noted to be more effective than inductive learning (problem first, lecture later), although students preferred case-based learning. Particularly in early learners such as medical students, exposure to abnormal cases and pathologies was most important for developing sensitivity, whereas later in training, normal cases were required to develop specificity. The use of a “flipped classroom” combines synchronous and asynchronous learning with virtual online modules followed by virtual small group sessions. The authors noted that radiology education at the undergraduate level was important for vertical integration of learning, or integrating different biochemical or systems-based topics, and its continued delivery is therefore crucial.12

An important topic for all fields of medicine including radiology is providing “value-added care.” Listening to our patients and physician colleagues may help radiologists produce more user-friendly reports. A survey was performed of emergency department staff, including physicians, trainees, and allied health professionals, to assess perception of radiology interpretations.13 Ten recommendations were provided to improve the reception of radiology reports. The top recommendation was the use of standardized reporting structure and lexicon. Standardized reporting has several benefits including completeness of reporting (by providing an inherent checklist) and amenability to data mining. Standardized lexicons exist in some areas of radiology such as for breast and chest imaging, and adoption in other areas may also be beneficial. Items listed as “disliked” by clinicians included clinical recommendations for management and the use of “hedge” terms (although paradoxically end-users did prefer to know the radiologist’s certainty of a diagnosis). Importantly, 34% of users stated they only read the impression, therefore it seems prudent to ensure that findings requiring the attention of the end-user are stated in the impression.13

**Privacy**

With new technologies come new challenges. We are currently in an era of rapid growth in the application of artificial intelligence. Most machine learning models require massive datasets of images and other clinical parameters. Inter-institutional sharing is crucial for the development of new tools using machine learning. Measures taken to de-identify clinical and imaging data to safe-guard patient privacy must not be overly restrictive to the point that machine learning research becomes impractical. Machine learning could greatly benefit the delivery of many elements of healthcare and further research in this realm should be embraced.

This past year the CARJ published a 2-part white paper for the de-identification of patient data in artificial intelligence. Part 1 focused on the general principles of de-identification and part 2 on practical considerations.14,15 In total, 8 recommendations were made for the de-identification of data in artificial intelligence research. The first 4 address background considerations and the last 4 are considerations for the specific application of de-identification. The 8 recommendations are summarized as follows: 1) Any custodian of patient data should be comfortable with a small inherent risk of data reidentification; 2) Public data sets should be encouraged if the data can be de-identified to low reidentification risk; 3) Medical AI algorithm validation is important prior to their use in an institution; 4) Commercialization of AI adds complexity, although is important, in developing AI applications; 5) Reidentification competitions have value highlighting vulnerabilities in de-identification and encryption processes; 6) Analogous to the ALARA principle, de-identification should aim to have “as little retained medical data as reasonably acceptable” ; 7) Up-to-date storage and encryption help maintain confidentiality in the event of a data breach; and 8) De-identification is a right.14,15

The use of these recommendations as well as educating ourselves on the background and methods of de-identification can allow us to safely perform research and advance our field further into the 21st century while ensuring a safe and respectful environment for our patients.
Conclusion

The past year has been tumultuous and uncertain. This brief review of some of the most interesting recent topics published in the CARJ demonstrates that although this year has been challenging, it has also been a harbinger for new and exciting areas of focus in our field.

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