Development of Two Pediatric Intraperitoneal Antibiotic Dosing and Delivery Tools

Purpose: Distance and lack of local pediatric facilities often require our physicians to initiate antibiotic therapy for peritonitis via phone calls to parents or health care providers. Calculation of correct concentrations and doses of these antibiotics (especially after midnight) can be complex. Our purpose was to develop user-friendly antibiotic dosing tools to reduce the risk of medication error, and to ensure the rapid and accurate mixing and administration of our current empiric antibiotics.

Approach: During a recent redevelopment of PD Policies & Procedures, and along with development and standardization of current best evidence-based peritonitis guidelines, we developed a number of tools to allow for more consistent application of our guidelines. Two of these tools for the prescribing physicians were an antibiotic dosing worksheet, and antibiotic mixing instructions.

Results: Each antibiotic worksheet (will be available at poster session) allows for simple and sequential dosing calculations with clearly designated and “letter labeled” outcomes at each step. Each step builds on those preceding it and feeds results into subsequent calculations. Each sheet also has clear suggestions for making modifications as required due to patient size, the need for calculating loading vs. maintenance doses, any anticipated change in dwell volume, a choice as to Cycler vs. CAPD, and/or the presence of residual urine output. The final steps on each worksheet also suggest the form and format for the “outpatient prescription” of that antibiotic. The antibiotic mixing instructions provided to the physicians as part of their peritonitis treatment algorithm are identical to those provided to the families in their take-home peritonitis kits.

Discussion: Peritonitis remains a major cause of PD failure, and prompt delivery of appropriately dosed antibiotics is paramount to successful preservation of the peritoneal membrane. Failure to adhere to best evidence-based dosing guidelines and/or improper calculations of drug doses lead to either suboptimal or potentially super therapeutic doses, neither of which are acceptable outcomes.

Conclusions: Antibiotic drug dosing and delivery in peritonitis protocols can be effectively and efficiently translated into dosing and mixing work sheets that minimize risk of drug errors and assist the physician in following best practices for prescription of antibiotics, even in complex situations where drug doses require significant modification. Mirroring of physician and patient instruction sheets allow for more clarity and certainty during phone calls, as both sides have the same information in front of them at all times. Future directions would be to incorporate automated calculations to further minimize risk calculation error, and move from paper-based to an electronic set of work sheets.

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Short-term Use of Renal Cal to Provide Sufficient Nutrition in a Pediatric Patient When Dialysis is Suspended

Objective: To study the short-term use of RENALCAL (Needle, Foxham Park, NJ), a low electrolyte, calorically dense formula, as the total source of nutrition in children with end-stage renal disease (ESRD) whose peritoneal dialysis (PD) was temporarily discontinued.

Problem Statement: Children may have times where PD is interrupted and hemodialysis (HD) is not possible, limiting options for ongoing nutritional delivery. We report two small children whose PD was stopped but were given adequate nutrition without side effects of fluid overload, nor electrolyte disturbances.

Approach/Procedure: Child 1: A 2-year-old black male patient with ESRD on PD was admitted for a herniorrhaphy repair surgery. During the 3 days of recovery, PD was discontinued. He was started on 1% strength RENALCAL at 25 ml/s per hour continuous feed over 20 hours daily. Based on the patient’s actual weight, this provided 375 ml/s of formula (29 ml/kg), 750 calories (58 kcal) 60% of caloric needs, 13 g protein (1ªg/kg), 390 ml free water (30 ml/kg). Blood work and anthropometrics were taken prior to, during, and postadmission. Over the 3 days off dialysis, the weight was unchanged, and electrolyte changes were Na from 142 to 135 mmol/l, K from 4 to 3.6 mmol/l, Ca from 8.5 to 8.5 mmol/l, SUn from 71 to 84 mg/dl, phos from 5.7 to 6.5 mg/dl and the creatinine increased from 4.8 to 6.3 mg/dl. The toddler had no gastrointestinal side effects from the 1% strength RENALCAL. Child 2: A 3.5 kg, 1-month-old anuric infant had PD discontinued for 5 days. Full strength RENALCAL at 7 ml/hour was given via a nasal jejunal tube. This provided 168 ml/s of formula (46 ml/kg), 336 calories (83 kcal) 88% of caloric needs, 5.6 g protein (1.5 g/kg). Over the 5 days off PD, the weight went from 3.5 to 3.9 kg without hypotension nor oxygen requirements, while the electrolyte changes were Na from 142 to 135 mmol/l, K from 4 to 2.9 mmol/l, Ca from 10.1 to 8.7 mg/dl, SUn from 44 to 69 mg/dl, phos from 5.4 to 2.3 mmol/l, and the creatinine increased from 3.1 to 6.7 mg/dl. Supplemental K and Phos were given on day 4 while off PD. The infant had no gastrointestinal side effects from the full strength RENALCAL.

Conclusion: At times when PD is discontinued and HD is not an option, the short-term use of RENALCAL can be used to deliver nearly full caloric needs to these small children without risk of volume overload or significant electrolyte disturbances.

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**Navigation**

- **Kidney Care Day**
  - Background: Dialysis and kidney transplant patients have complex medical needs. CMS requires that dialysis patients receive annual education regarding these medical needs.
  - Project Aim: To provide pediatric dialysis and transplant patients a day of education to help satisfy the annual education requirements from CMS, while bringing together patients and families to offer support, form friendships, and learn important information about kidney disease.
  - Methods/Results: Each year, the Section of Nephrology at Children’s Mercy Hospital hosts an education day titled “Kidney Care Day.” During this day, patients have the opportunity to meet representatives from a variety of service providers including support groups, vocational rehabilitation, nutrition, financial counselors, Make A Wish, United States Transplant Games, Children’s Mercy Infection Control (for proper hand-washing technique), and a variety of others who are invited to set up “booths” in the dialysis unit. The patients and their caregivers also attend a modality specific education session. In the afternoon, all patients and caregivers attend lectures and activities on various topics which are relevant to our patient population. Past lectures have included phosphorus control, anemia, hypertension, coping strategies, organizational tips for home supplies, adherence, and disaster preparedness. Patient/family survey results regularly reflect the benefits aspect of the experience.

- **Conclusion:** Kidney Care Day provides the patients and families the opportunity to learn from dialysis faculty and staff, as well as from one another. The group setting is particularly beneficial because of the similarity of patient/family concerns. We will continue to offer this education day as a creative solution to the CMS required annual patient education requirement. Future initiatives will include an assessment of the impact of attendance on patient outcomes.

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**Serum 25-hydroxyvitamin D3 Deficiency in a Pediatric Dialysis Population Depsite Adequate Tropical UV-B Sunlight Exposure**

- Background: Dyregulated vitamin D metabolism is a hallmark feature of end-stage renal disease (ESRD), with implications on mineral bone disease, immune function, and cardiovascular health. Low vitamin D levels amongst patients in temperate countries have widely been attributed to lack of sunlight exposure. Ultraviolet sunlight with wavelength between 290-310 nm (UV-B) is required for the conversion of 7-dehydrocholesterol to cholecalciferol in the skin. It is widely thought that tropical countries like Singapore (latitude 1°22’) should have sufficient UV-B to provide adequate vitamin D levels in the population. This study aimed to profile serum 25-hydroxyvitamin D3 (25(OH)D) levels in a pediatric dialysis population in tropical Singapore, in order to test the hypothesis that high cumulative doses of administered activated vitamin D suppressed 25(OH)D levels via negative feedback.

- Methods: The study population consisted of 27 ESRD patients (16 male and 11 female; median age 18 years, age range 6–24 years old). Twenty-four patients were on peritoneal dialysis and 3 were on hemodialysis. Serum 25(OH)D levels were measured using a standard electrochemiluminescence assay. Associations of 25(OH)D levels with risk factors such as age, gender, ethnic group, dialysis duration, cumulative doses of calcitriol (1,25-dihydroxyvitaminD3), and intact parathyroid hormone (iPTH) suppression were evaluated statistically using Wilcoxon Signed Rank Test and linear regression methods.

- Results: Suboptimal serum 25(OH)D levels were common in our pediatric ESRD population in tropical Singapore, with 24/27 (88%) of patients having 25(OH)D levels <30ng/ml. Of these, 15/27 (56%) had moderately severe deficiency with 25(OH)D levels <15 ng/ml. There was no correlation between 25(OH)D levels and cumulative calcitriol doses (r = 0.15, p>0.05) or iPTH levels (0.042, p>0.05). Gender, ethnicity or dialysis duration also did not influence 25(OH)D levels. Young age was significantly associated with higher serum 25(OH)D levels: the median age of patients with serum 25(OH)D >35 ng/ml was 19.0 years (range 14–24 years), while the median age of patients with serum 25(OH)D D <25 ug/l was 7.0 years (range 6–18 years) (p=0.001). We postulate that this may be related to higher milk intake in the younger patient group, while the older 18-year-old patient reported high daily milk intake.

- Conclusion: Suboptimal serum 25(OH)D levels were prevalent amongst pediatric dialysis patients in Singapore, despite adequate UVB exposure from tropical sunlight. This phenomenon was not related to the cumulative dose of calcitriol, but appeared to be multifactorial in etiology, with dietary milk intake playing a contributory role.

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**Home Sweet Home: a Take-home Peritonitis Kit**

**Purpose:** We provide PD to ~10–15 children spread over a landmass 6 times that of California. Sixty percent of these children come from small towns and may require 12–15 hours of travel to reach us. Distance and lack of local pediatric facilities often lead to delay in initiation of peritonitis therapy. Our purpose was to develop a “take-home” kit to enable immediate initiation of an empiric antibiotic protocol and standardize its delivery in the home and local health-care setting.

**Approach:** Combined with recent review of all peritonitis episodes, organisms, and sensitivities we revised all our PD and Peritonitis Policies & Procedures based on current best available evidence. With input from a professional design firm, we then developed our “Take-home” peritonitis kit (pictures and mock-up available at poster).

**Results:** Based on our reviews, we chose cetazolin, tobramycin, and vancomycin for the kit. All kits have expiry dates and lot numbers (recorded in a log book), are assembled by a PD nurse and renal pharmacist, and are replaced regularly. Each kit has sufficient antibiotics to ensure 72 hours of coverage for the size of the child, presuming use of cycler. Each kit contains heparin vials, sample bags, sterile contain- ers, reconstitution fluids, needles, and syringes along with a transfer set, clamp and povonide-iodine cap to allow for replacement in the case of a transfer set contamination or disconnect. The kit also includes a professionally-designed booklet for parents or health-care workers with step-by-step instructions for reconstitution and proper delivery of each antibiotic and replacement of the transfer set if required.

**Discussion:** Peritonitis is a major cause of PD failure. Promptly delivered and appropriately dosed antibiotics are paramount for effective treatment and salvage of membrane lifespan. Inability to deliver antibiotics to distant patients in a timely fashion and/or lack of access to health-care facilities able to perform rapid sampling and antibiotic intuitions often lead to poor outcomes and increase the severity of the child’s illness. Middle-of-the-night episodes often lead to haphazard application of protocols, inefficient or insufficient dosing of antibiotics, and/or situations where families forget how to use the antibiotics. As well, obtaining local supplies, costing, payment, and delivery at the time of a peritonitis episode remains difficult.

**Conclusion:** Distribution of these kits with clear instructions for families or health-care workers allows our program to ensure prompt and best evidence-based delivery of empiric antibiotics in the shortest possible time to our many distant patients. Future work on measuring the cost and effectiveness of these kits is planned.

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**Creative Strategies: Educating the Pediatric Peritoneal Dialysis Patient and Family**

- Background: It has been documented that patients who are knowledgeable about their health-care needs have better outcomes. A primary function of the nursing role is to provide the education necessary to create knowledgeable patients. The pediatric peritoneal dialysis nurse is in an ideal position to provide ongoing education to patient and families due to the frequency of patient encoun- ters. Since the majority of learning theories suggest a multi-step approach to education and the literature recommends standardization of patient education materials, our institution has developed a variety of materials to educate pediatric dialysis patients. One example of our efforts is The Peritoneal Dialysis Continuing Education Monthly Newsletter.

- **Purpose:** To develop a comprehensive, population-specific patient education tool.

- **Strategies:** As part of our ongoing education initiatives, we create a monthly educational pamphlet promoting one topic essential to the care of the pediatric peritoneal dialysis patient. Taking into consideration adult learning principles and health-care literacy initiatives, we keep information brief and relevant to the patient and family, and the language simple. Fun photos and images that support messages are incorporated into the pamphlet. The documents are then distributed at each monthly clinic visit, and are reviewed with patients and families. Learning needs are identified by peritoneal dialysis nurses and other members of the health-care team who recognize patient knowledge deficits through conversations, physical exam or complications. Recent topics have included infection control, dietary information, and emergency preparedness.

- **Outcomes:** To date, we have distributed 7 monthly continuing education pamphlets to every peritoneal dialysis patient family and have received positive feedback. Nurses and other members of the health-care team report that the newsletters have been helpful in guiding the verbal education provide to families, as well. The utilization of brief single-topic monthly newsletters has been an ef- fective educational strategy for the pediatric peritoneal dialysis patient.

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Transition: Navigating the Journey from Pediatric to Adult Care

Background: Transition and transfer of care from pediatric to adult renal providers is not well researched, and best practice methods are not well defined. This has the potential of resulting in less-than-ideal outcomes for patients with chronic kidney disease who reach this developmental milestone.

Project Aim: To prepare pediatric dialysis and kidney transplant patients for transfer to adult care, and to develop a successful transition of care program through a formal, comprehensive collaboration with adult renal care providers.

Methods: The KEYS (Kidney Education for Your Success) transition program is a 4-phase program for dialysis/transplant patients aged 12–21 years, which culminates in the transfer of care to an adult renal provider. The phased educational curriculum is age-related and features age-appropriate language and activities to help children understand the complexities of their kidney disease and how it relates to their overall well being and life activities. The program includes information on the medical components of living with kidney disease, as well as psychosocial and nutritional information. In addition to the KEYS program, a multidisciplinary, city-wide collaborative group was formed involving pediatric providers, adult renal care providers from multiple adult dialysis/transplant programs, and former transitioned patients. This group meets annually to discuss the impact of chronic illness on development, transition strategies based on research and literature, the components of the education program, and the needs and expectations of the pediatric and adult care providers, in order to identify barriers to an effective transition of young adults to adult care and to discuss potential solutions to promote effective transition to adult care. Subcommittees and a steering committee ensure progress is made on the group’s goals. Current work with recently-transitioned patients is being conducted to assess the quality of the transition program.

Conclusions: In theory, this transition program, consisting of an education program and a multi-institutional initiative, will increase patient and provider knowledge and create a more successful transfer of care of adolescents/young adults to adult renal providers. Long-term follow-up and critical assessment of the experience are crucial, and will likely result in beneficial modifications.

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Cardiac Calcifications (CC) Are More Prevalent in Hemodialysis (HD) when Compared to Peritoneal Dialysis (PD) Pediatric (ped) End-stage Renal Disease (ESRD) Patients (pts)*

Background: CC portends high mortality in adult ESRD pts. We and others have shown high prevalence in children with ESRD. No pediatric study has examined modality differences in CC prevalence.

Aim: Our previous cross-sectional study demonstrated high CC prevalence (31%) in ped HD pts. Current study: to determine difference in CC prevalence between HD and PD in children with ESRD.

Method: 2 centers; Houston and Cincinnati (18 female, 19 male; median age 17±4 yrs) receiving dialysis (21 HD, 16 PD). CC assessed by ultrafast CT and quantified by APD.

Results: CC (+) 46.5(19.9) 19.1(2.2) 7.6(1.6) 2695(2130.9) 48.2(67.6) 1.9(2.1)
CC (-) 21.5(15.5) 14.2(3.8) 6.3(1.5) 1419(1382.6) 25.1(18.5) 0.96(1.5)

Conclusion: 1) HD ped pts have higher CC prevalence than PD (pts), and 2) high serum P and FGF 23 contribute to this CC.

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The Influence of Method of Peritoneal Dialysis (PD) on Residual Renal Function (RRF) in Children

Background: Adult studies show inconsistent data on influence of PD modality (CAPD vs. APD) on RRF.

Objective: To assess influence of method of PD on RRF in children.

Methods: In 101 children with ESRD and preserved RRF for whom PD was the first method of RRT (44 CAPD, 57 APD) every 12 months RRF (daily diuresis [mL/kg/24h], IL-8 [pg/mL]), GFR, cause of ESRD, presence of arterial hypertension (AH), biochemical parameters. Pts with ESRD (17 CAPD, 35 APD) were assessed. Follow-up period was 36 months.

Results: At onset, CAPD and APD groups did not differ significantly in age, ESRD causes, AH frequency, PET results, Hb, albumins, lipids, proteinuria, diuresis; GFR was higher (p<0.05) in APD. In CAPD group, volume of PD fluids was lower (<0.05), peritonitis, ESI frequency, use of aminoglycoside antibiotics higher (p<0.05). In both groups, twkSV and twCC were normal, higher in APD group. Diuresis and GFR decreased systematically in both groups; in the first year, rate of diuresis ([mL/min)/24h] and GFR decline was lower (p<0.05) in CAPD group without significant differences in next 2 years. During 36 months, 20 children preserved (10 CAPD, 10 APD), 22 lost diuresis (7 CAPD, 15 APD); best RRF preservation was found for hypoplasia/dysplasia (p<0.05), worst for HUS and peritoneal dialysis. Children who preserved RRF had higher (p<0.05) diuresis, GFR at onset, Hb and albumin lower (p<0.05) AH prevalence, volume of PD fluids, cholesterol, triglycerides, proteinuria than those who became anuric.

Risk of diuresis loss during 36 months did not differ significantly between CAPD and APD group (Kaplan-Meier analysis).

Conclusions: 1) In children on CAPD/APD, risk factors for RRF loss are HUS, hereditary nephropathy, low diuresis and GFR at onset of PD treatment, arterial hypertension, proteinuria, anemia, protein and lipid disturbances. 2) Children treated with CAPD show better RRF preservation during the first year compared to those treated with APD, although the risk of diuresis loss seems to be the same for both methods.

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An Alternative Treatment Option for Exit-site and Tunnel Infections in Pediatric PD Patients

Chronic peritoneal dialysis (PD) is, in most cases, the first choice dialysis modality for end-stage renal disease in children. Exit-site and tunnel infections (ESI/TI) are a clear risk factor for the development of peritonitis, and impose a 2-fold risk of access revision and an almost 3-fold risk of hospitalization for peritoneal access complications. International guidelines for management of ESI/TI recommend a 2–4 week course of systemic (oral or intraperitoneal) antibiotic therapy, in addition to local treatment with non-alcoholic disinfectants, with the potential drawback of increasing antibiotic resistance.

According to an ad-hoc protocol for the management of ESI/TI, since 2008 children on PD diagnosed for ESI with a low-medium score (according to Twardowski’s classification), who did not respond to topical treatment with antibiotic ointment, and those diagnosed for TI with a high score, were addressed to a course of local injections of antibiotic solution into the tunnel by means of a flexible 22-gauge cannula inserted between the peritoneal catheter and the tunnel wall.

We administered 80 mg of gentamicin diluted in 10 mL of saline once a day for a 1–2 week course, depending on the therapeutic response. In the period 1st January 2008–31st December 2010 (corresponding to 516 treatment months), we observed 39 infections, 33 of the ES and 6 of the tunnel (1 episode/13.2 treatment months – 0.07 ep/mos pts); the ES culture was positive in 22 cases (staphylococcus species 65%). Thirteen out of 39 infections had to be treated with the above-mentioned protocol. The median duration of the treatment was 7 days (range 7–10 days): a full recovery was obtained in 100% of the ESI/TI and no relapses occurred. No local complications related to the procedure were observed.

Notwithstanding the limits of the cohort study design, local intratunnel antibiotic injection represented in our experience a valid therapeutic option for ESI/TI management, with the advantage (compared to the international recommendations) of decreasing potential antibiotic resistance.

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