MEDICATION SAFETY: BEHAVIORS AND PERCEPTIONS AMONG PARENTS AND GUARDIANS. Kelly Matson,[1,2] Jayne Pawasauskas,[1] Courtney Barnas,[1] and Megan Leary.[2]
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INTRODUCTION: Prescription drug abuse is a growing health concern, as first-time, non-medical use was 2.3 million in adolescents aged 12 years and older in 2011. National survey data report 71.2% of persons who used prescription medications non-medically obtained the drugs from friends or family by buying them, receiving them, or stealing them. We hypothesized that caregivers of children are not adequately informed or educated about proper medication use and thus demonstrate unsafe use, storage, or disposal of prescription medications. The purpose of this study was to collect information about behaviors and perceptions of handling and storage of prescription medications of parents or guardians.
METHODS: Parents or guardians of a pediatric patient admitted to the hospitalist service at our academic medical center from October 2013 to February 2014 were evaluated through a prospective, observational study. Parents or guardians who were >18 years of age were offered an anonymous survey to assess their knowledge, behaviors, and perceptions of proper prescription medication use, storage, and disposal. Demographic data were collected, including age and sex of parent, number of children, age of children, and whether there were prescription medications in the home. Parents were ineligible if they were <18 years old, unable to complete survey of their own accord, or their children were admitted to pediatric subspecialty or intensive care services. The hospital's institutional review board approved this study.
RESULTS: A total of 213 parents met inclusion criteria, with 80 surveys completed. The average age of parents was 35.5 ± 9.07 years, and 83.8% were female. Average age and number of children in the household were 9.3 years and 2.35, respectively. Prescription medications were present in 83% of homes, and of those, 37% were controlled substances. Many parents reported never locking (54%) or monitoring (28%) medications. More than 20% reported sharing medications, and 29% reported doing so because another person asked them. Seventy-one percent stated they disposed of unused medications by flushing them down the toilet, the most common method. Only 53% of parents said they had talked to their children about prescription drug abuse. Parents with prescription medications in the home ($p=0.044$), and those in the age group over 35 years old ($p=0.003$) were more likely to discuss prescription drug abuse with their children. Parents under the age of 25 were more likely to monitor storage of prescription medications in the home than older age groups ($p=0.041$).
CONCLUSIONS: A significant proportion of parents report unsafe behaviors regarding prescription medication use, storage, and disposal. Additional findings show that parents are comfortable sharing medications and perhaps setting an example of drug diversion for their children. Pharmacists have a role in educating parents about proper medication use and dangers of misuse.

AMINOGLYCOSIDE PHARMACOKINETIC PARAMETERS IN INFANTS WITH CYSTIC FIBROSIS. Nathan Walleser, Lindsay Langrave, Lindsay Schray, Kimberly Novak.
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INTRODUCTION: Patients with cystic fibrosis have known alterations in aminoglycoside pharmacokinetics; however, many of the studies that describe these changes excluded neonates and infants. The purposes of this study were to describe aminoglycoside pharmacokinetic parameters and to determine the optimal empiric dose of intravenous aminoglycoside antibiotics in infants less than 12 months of age with cystic fibrosis.
METHODS: This was a retrospective chart review of infants with cystic fibrosis treated with intravenous aminoglycosides between October 2008 and September 2013. The study was approved through an expedited institutional review board review. Patients were included if they were less than 12 months of age, had a diagnosis of cystic fibrosis, and had two aminoglycoside levels drawn in relation to the same dose. Data evaluated for the outcomes of the study included age, sex, dosage weight, baseline serum creatinine level, maximum serum creatinine level during the course of therapy, cystic fibrosis genetic profile, initial dose of the aminoglycoside antibiotic in milligrams per kilogram, time of dose associated with therapeutic drug monitoring, and aminoglycoside levels (value and time laboratory data collected). The following pharmacokinetic parameters were calculated based on data obtained: elimination half-life, elimination constant, calculated peak and trough, volume of distribution, clearance, area under the curve (in 24 hours), and drug-free interval. Descriptive statistics were used to report population and subgroup pharmacokinetic

parameters. These pharmacokinetic parameters were used to determine optimal empiric dosage guidelines in this age group.
RESULTS: Thirty-one sets of aminoglycoside levels in 28 patients were evaluated. The mean age of patients in the study was 6±2.7 months. Although all patients achieved goal trough concentrations, only 3 patients achieved goal peak concentrations. No patients experienced nephrotoxicity during aminoglycoside therapy. Based on the pharmacokinetic parameters calculated, the number of patients achieving therapeutic peak and trough concentrations was predicted for several dosage regimens. Twice-daily dosage of 10 mg/kg was predicted to result in supratherapeutic troughs in 9 patients, whereas no patients were predicted to achieve supratherapeutic troughs with once-daily dosage. Seventeen of 31 patients were predicted to achieve therapeutic peak and trough concentrations if started on tobramycin, 15 mg/kg every 24 hours. Seventeen of 31 patients were predicted to have area under the curve values >120 $mg \cdot hr \cdot L^{-1}$ if administered a dosage of 20 mg/kg every 24 hours.
CONCLUSIONS: In infants less than 12 months of age, tobramycin at 15 mg/kg every 24 hours was the empiric regimen most likely to produce a therapeutic peak and trough while maintaining AUC of <120 $mg \cdot hr \cdot L^{-1}$.

CLINICAL PHARMACIST IMPACT ON MEDICATION-RELATED OUTCOMES IN A PEDIATRIC MEDICAL HOME. Sandra Benavides,[1,2] Danielle Padgett,[1] Isabelle Thony.[1]
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INTRODUCTION: The patient-centered medical home (PCMH) is a common delivery model for special needs children and lends itself to the incorporation of a pharmacist to manage medication use and improve medication related outcomes. The purpose of this study was to develop and implement clinical pharmacy services in a pediatric PCHM.
METHODS: A clinical pharmacist initiated services at Children's Medical Services. All medical charts were reviewed by a pharmacist prior to clinic visits and evaluated for improved medication use. During the visit, the clinical pharmacist completed a medication history to reconcile the medication records.
RESULTS: In 7 months, a total of 166 medical charts were reviewed. The average age was 11.6±5.2 years (range, 0.8-21.4). The average number of medications per patient at time of review was 4±4 (range, 0-18 medications). Overall, the total number of interventions made was 102 in 60 patients (36%). Intervention included 31 omitted medications (53% of all interventions), 28 medications discontinued (47%), 18 incorrect doses (17%), 1 incorrect route (2%), 14 incorrect frequencies (23%), 1 missing a PRN indication (2%), 4 missing allergy information (7%), and 5 other (8%, including incorrect concentrations of medication).
CONCLUSIONS: The number of interventions in a short time frame illustrates the necessity of a pharmacist to assist in coordinating medication use in this population. Accurate medication records can prevent medication errors upon hospital admission, visits to specialty practitioners in which sedation may be required (e.g., dental procedures), and referral of the patient to another specialty physician.

IMPLEMENTATION OF A PEDIATRIC CODE CARD WITHIN AN ELECTRONIC HEALTH RECORD. Monica Bogenschutz, Julie Pawola, Heather Van Ningen.
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INTRODUCTION: The electronic health record (EHR) has the potential to improve efficiency and safety of patient care, especially in a pediatric setting. Current systems used to provide instant dosage information in a pediatric code situation have led to multiple patient safety events as a result of the inability to locate a computer-based (e.g., Excel software; Microsoft, Redmond, WA) pediatric code card document within our hospital's intranet site. Subsequent system-wide computer updates have resulted in loss of access to the computer program for some users, causing further delays in access to necessary information. In addition, the computer-based document (Microsoft Excel) relied on nursing staff or unit coordinators to manually enter patient name and correct dosage weight upon patient admission and to update weight when a change occurred.
METHODS: A pediatric code card report was built within the EHR, using customized Smart Text and Smart Links software (Epic). This report includes medication dose and volume calculations based on available drug concentrations in the pediatric code tray and documented patient weight. When a patient's weight is entered in the EHR, the report is automatically updated. The report also accurately provides maximum dose information for large patients. The report was made available to pediatric pharmacists for review and testing for a 1-year trial period. After pharmacists provided feedback, the report was enhanced to include additional neonatal dosage information (in preparation for the opening of a new level-IV neonatal intensive care unit) as well as instructions for emergent drip preparation at bedside (consistent with institution standard concentrations).
RESULTS: After review by the hospital-wide resuscitation committee, the report will be made available

to staff members. Previously described patient safety events will be avoided because access will be granted to all authorized users of the electronic medical record. All patient rooms are equipped with computers, which will allow all staff to have immediate access to the report. This will eliminate the need to use the Microsoft Excel document outside of the EHR to obtain necessary information in a code situation. Inconsistencies in patient weights resulting from manual entry into the previous code card document will be prevented because all providers will now use the new report that contains the most accurate and up-to-date weight.
CONCLUSIONS: This project aimed to provide critical dosage information directly within the EHR based on the patient's most recently documented weight, to eliminate the use of an alternative system to obtain this information, to avoid the manual entry of patient weight on the pediatric code card, and to prevent future patient safety events related to the ability to access this critical information. The knowledge and skills gained from the creation of this report will be used to design and build a rapid sequence intubation report for emergency department providers.

PATIENT MOVE DAY: PHARMACISTS' ROLE IN MOVING A CHILDREN'S HOSPITAL. Lisa Hanlon-Wilhelm, Gretchen Brummel, Kimberly Cimarelli, Kevin Mulieri, Lindsay Trout, Han Lee-Hain.
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INTRODUCTION: Penn State Hershey Medical Center is the only level-1 pediatric trauma center in central Pennsylvania. On February 10, 2012, the hospital transitioned from a 120-bed children's hospital within an adult hospital to a 72-bed free-standing hospital. The neonatal intensive care unit (ICU) remained in the main hospital to provide continuity for maternal health.
METHODS: A patient move group was formed several months prior to the move and included multiple pharmacy representatives. Due to lower patient census and activity, Sunday was chosen as the moving day. Usual pediatric pharmacy staffing continued, and 6 extra pharmacists were deployed: 2 roving pharmacists and 4 extra unit-based pharmacists (EUP). EUPs reviewed medication profiles, assisted in patient triage, and implemented a predetermined plan to ensure medication availability. A staggered Pyxis (Carefusion, San Diego, CA) machine move was implemented. The pediatric ICU (PICU) EUP carried emergency medications. Three stations with crash carts and pediatric advanced life support-certified nurses were available along the transport route. A dedicated pharmacy technician runner was assigned. Due to acuity and a defined plan of care, the hematology/oncology/stem cell transplant patients were moved first, and PICU patients were moved last. After each unit was cleared, the pharmacy team swept for remaining medications. PICU admissions were directed to the new hospital, where standard medication drips were available.
RESULTS: 1) Units within the new Children's Hospital were prestocked with floor stock medications; however, floor stock medications remained in the old units; 2) Additional intubation medications were needed during the move for intubated patients; 3) EUP numbers were excessive; however, technician resources were inadequate; 4) A communication breakdown occurred when the technician was pulled to help with staffing elsewhere; 5) The patient move list was not available to the pharmacy in advance; 6) The Pyxis medical station move went well because jacks were activated in advance and rollout was staggered; 7) One patient transferred from the floor to the PICU prior to the move. Communication between the pharmacy team worked well in some areas, but overall, communication could have been better; not all EUPs had wireless phones; and 8) Transportation of patient-specific medication refrigerators was not assigned and necessitated last-minute planning.
CONCLUSIONS: Overall, the move was successful due to extensive multidisciplinary planning. Positive feedback was received from all disciplines. For the pharmacist**s,** patient ratio was higher than necessary, whereas technician support was limited. Improved considerations for floor stock medications and patient-specific medication refrigerators were warranted.

STANDARD START TIME PILOT FOR PEDIATRIC CHEMOTHERAPY IN AN INPATIENT SETTING. Sarah Castelo, Virginia Spickler, Daniel Favre.
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Inpatient bed availability, intravenous (IV) line access, and obtaining laboratory values contribute to delays in chemotherapy administration in the pediatric population that lead to necessary adjustments to the scheduled chemotherapy start time. Manipulation of the chemotherapy scheduled start times often leads to bypassing safety features, such as bar code scanning of the chemotherapy label. A multidisciplinary group at Monroe Carell Jr. Children's Hospital at Vanderbilt (Nashville, TN) met to discuss possible solutions to prevent bypassing safety features related to chemotherapy scheduling. The group agreed to introduce a standard start time pilot protocol for all pediatric chemotherapy to decrease the need to change scheduled chemotherapy start times. In preparation for the pilot, an assessment of the current chemotherapy start times was performed to determine an appropriate standard start time. A standard start time of 9:00 PM was initiated, with exceptions allowed for transplantation patients and current inpatients continuing therapy. For

6 months, 283 patients were started on chemotherapy. Of those 283 patients, 220 (78%) were scheduled to start at 9:00 PM. Within 2 hours of the scheduled start time was considered "on time," after which schedule changes would not be made by the pharmacy. Of the 220 patients scheduled to start at 9:00 pm, 171 (78%) were started "on time," and no adjustments to the schedules were made. Of the 63 patients scheduled to start chemotherapy at a time other than the standard of 9:00 pm, 42 (67%) were started "on time," or within 2 hours of the scheduled start time. Our goal was to create a standard start time for pediatric chemotherapy in order to reduce the necessity of making computer time changes that would cause safety measures to be bypassed and lead to errors.

A SURVEY EVALUATING PHARMACIST SIGN-OUT PROCESSES AND FUTURE DIRECTIONS.

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INTRODUCTION: This quality improvement project evaluated pharmacist sign-out (or handoff) processes at Children's Hospital Colorado (CHCO) and nationwide. This information was then used to develop future interventions in sign-out processes at CHCO. For the purposes of this abstract, pharmacist sign-out is defined as patient information passed on at shift change from pharmacist to pharmacist regarding patient condition, therapeutic monitoring, and other clinical information.
METHODS: A survey was sent to pharmacists at CHCO to evaluate the current, hand-written pharmacist sign-out process. A survey was also sent to American College of Clinical Pharmacy and American Society of Health-Systems Pharmacists list serves to assess pharmacist sign-out processes nationwide. Results of these surveys served as points of reference for further quality work. Questions for both surveys included the presence of a standardized pharmacist sign-out process, time spent on sign-out, pharmacist training for preparing and delivering sign-out, and the perception of a complete sign-out from colleagues both on weekdays and weekends. Pharmacist sign-out documentation at CHCO was created within the Epic (Verona, WI) electronic medical record (EMR). Sign-out was then transitioned from a hand-written process to electronic documentation. Following this transition, a postimplementation survey was distributed to CHCO pharmacists.
RESULTS: There were 89 responses to the nationwide survey and 22 responses to the CHCO survey. It was found that nationwide, 56% and 57% of institutions do not have a standardized procedure for preparing and delivering sign-out, respectively. At CHCO, 64% of pharmacists did not believe there was a standardized procedure for preparing and delivering sign-out. Sixty-eight percent of CHCO pharmacists felt they had not received adequate training in the preparation and delivery of sign-out, whereas 47% of institutions on the national level responded they had never had training on sign-out. The postimplementation survey addressing electronic sign out has been drafted and is awaiting distribution.
CONCLUSIONS: It has been identified both nationally and at the institutional level, that a standardized procedure for preparing and delivering sign-out is necessary. Additionally, training related to sign-out at CHCO and nationally are lacking or are non-existent. Using the EMR may be the first step in improving standardization and training of pharmacist sign-out. Survey results will direct further quality improvement projects, which may include directed sign-out training and unit-specific pharmacist sign-out bundles.

THE EFFECT OF PHARMACY INTERNS ON HCAHPS SCORES

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INTRODUCTION: Medicare reimbursement to hospitals across the nation is now affected by how well hospitals adhere to clinical performance guidelines as well as how patients perceive the care that was given to them. Patients' perception of the quality of care is assessed using the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey. Reimbursement to hospitals is based on how well the hospitals compare to other hospitals in adhering to clinical guidelines and on patients' perception of the quality of care. The Children's Hospital at Saint Francis began using student interns to counsel patients on a nursing unit in an effort to improve HCAHPS scores. The purpose of this study was to evaluate the impact of the student counselors on HCAHPS scores and to analyze the subsequent interventions in patient care.
METHODS: From September 2012 to December 2013, patients admitted to the selected nursing unit were counseled by student interns on medications. The interns also assessed patients' pain control and made pharmacotherapy interventions when identified. Investigators conducted a retrospective analysis of HCAHPS scores, analyzed intern intervention data provided by the hospital, and evaluated trends in the data that would be consistent with pharmacy student interventions.
RESULTS: There was a consistent increase in HCAHPS scores over the time period that was analyzed,

specifically after the pharmacy interventions were implemented. Interns counseled 36.4% of the patients in the nursing unit during the study period, resulting in 3067 counseling sessions. Although not the primary focus of the study, the interns identified 117 additional pharmacotherapy interventions including but not limited to pain management, drug addition/drug discontinuation, and medication administration recommendations. From July 2011 through December 2013, the pain management scores, medication explanation scores, and medication side effect scores increased from 65.63 to 84.72 with a slope change from -0.51 before interventions to 3.12 after interventions, from 86.21 to 89.99 with a slope change from -0.64 before interventions to 6.33 after interventions, and from 55.17 to 65.52 with a slope change from -1.13 before interventions to 4.5 after interventions. Upon implementation of the intern counseling sessions, HCAHPS scores continually increased in all areas analyzed. There was a trend toward decreasing the number of scores below achievement and a correlating increase in number of scores above benchmark beginning after October of 2012, with the intern-led counseling.

CONCLUSIONS: Pharmacy interns may have a positive impact on HCAHPS scores, specifically in the areas of pain management, medication explanation, and medication side effects. This study showed improvement in scores in all of these areas. Also, interns can play an important role in patient care as shown by the 117 interventions and 3067 counseling sessions.

DEVELOPMENT AND IMPLEMENTATION OF A COMPUTERIZED PRESCRIBER ORDER ENTRY PROCESS FOR SODIUM PHENYLACETATE/SODIUM BENZOATE AND ARGININE HCL FOR THE MANAGEMENT OF UREA CYCLE DISORDERS.

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INTRODUCTION: Patients with urea cycle disorders (UCDs) carry genetic defects in the metabolism of nitrogen generated by protein breakdown. Sodium phenylacetate/sodium benzoate (Ammonul) and arginine HCl regimens are initiated in these patients emergently to provide an alternative pathway for excretion of excess nitrogen. Prompt initiation is essential as prolonged hyperammonemia can result in permanent neurological damage and death. The medication process for Ammonul and arginine HCl is complex, especially in infants and children. In 2009, the US Food and Drug Administration released a review of 6 cases of arginine HCl overdose in pediatric patients, including 4 fatal errors. These medications prove cumbersome to order for many reasons. UCDs require defect-specific dosage strategies. Dosage regimens (mg/kg, mL/kg, g/m^2, and mL/m^2) also vary according to weight and drug reference. Ammonul contains 2 salt forms, which makes transcribing doses challenging. Finally, these medications are packaged in adult-sized containers, further confusing their administration to pediatric patients. Although computerized prescriber order entry (CPOE) has been available in our hospital for some time, there was limited ordering support prior to implementation of the Ammonul/arginine HCl order pages. In the past, these orders were completed through a pharmacy miscellaneous process or written on blank order forms.

METHODS/RESULTS: CPOE pages for Ammonul/arginine HCl were developed for patients who weighed ≤20 kg and >20 kg. Patients are automatically routed according to dosage weight. Each page outlines indications that populate defect-specific loading and maintenance doses. A free-text option is available if needed for individualized dosage of arginine. Doses are provided as mg/kg (mL/kg) or g/m^2 (mL/m^2) based on medication and weight. Infusion times, rates, and start times for loading and maintenance doses are calculated and conveyed to nurses via the electronic medication administration record/barcoding system and medication label. "Call-for medication" reminders and compatibility information are provided for nurses. Preparation instructions, including standard dilution and diluent, final total volume, and a filter reminder for Ammonul are communicated to the pharmacy computer system from CPOE. Standardized drug files and order processing formats are in place within the pharmacy system. Also, medication guardrails were updated/added to smart pumps. Prior to final implementation, hospital staff were trained about the use of the new CPOE ordering pages and how they interact with other hospital systems. Since their implementation from the end of January 2010 through February 2014, the CPOE pages have been used in the management of 18 patients with UCDs during 25 separate hospital admissions.

CONCLUSIONS: Implementation of the CPOE pages has provided a safe, standardized, and user-friendly medication ordering process for Ammonul and arginine HCl for the management of UCDs within our institution.

IMPROVING ADHERENCE TO COMMUNITY-ACQUIRED PNEUMONIA CLINICAL CARE GUIDELINES WITHIN THE CHILDREN'S HOSPITAL COLORADO NETWORKS OF CARE.

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INTRODUCTION: Community-acquired pneumonia (CAP) is an infection of the airways and lung tissue

caused by multiple organisms including viral and bacterial causes acquired outside the hospital. The preferred antibiotic for bacterial CAP is amoxicillin, 90 mg/kg/day in 3 divided doses, when suspicion for *Streptococcus pneumoniae* is high, to achieve adequate time above the minimum inhibitory concentration (MIC) for non-susceptible strains. Pharmacokinetic models strongly support use of amoxicillin over cephalosporins. Although twice-daily dosage in cases of otitis media is sufficient to maintain time above MIC due to extended drug half-life in the middle ear, the same cannot be said of twice-daily dosage for CAP. Because amoxicillin is cleared quickly from the lungs, a dosage of 3 times daily is necessary to achieve appropriate time above MIC, particularly in the case of penicillin-resistant pneumococcus (MIC >2 mcg/mL). Underdosage of amoxicillin in CAP remains a potential mechanism for development of *Streptococcus* sp resistance. The Children's Hospital Colorado (CHCO) Antimicrobial Stewardship Committee approved a Clinical Care Guideline (CCG) to steer appropriateness and dosage of antibiotics indicated for CAP. Although this guideline was approved in 2012, observed medication ordering patterns indicated that many of the providers in the urgent care setting were unaware of the dosage recommendations or the reasoning behind them.

METHODS: A survey was conducted to determine baseline knowledge of the providers throughout the urgent care locations. The goal was to improve the use of the CAP CCG and improve dosage appropriateness among providers in the outpatient setting. Currently, outpatient dosage is not monitored according to our CAP CCG, and it is unknown whether physicians are prescribing consistently across the acute care setting. The goal was to improve awareness and determine compliance with our standards of care.

RESULTS: Of the 33 providers who responded to the survey, 100% knew the meaning of "high-dose" amoxicillin. However, only 82% of responders knew which pathogen was being targeted. All of the responding providers were aware of CHCO's CCG for CAP, whereas 94% knew the appropriate dosage in accordance with the CCG. Approximately 18% of responders admitted they prescribed amoxicillin in accordance with the CCG less that 90% of the time. After reviewing prescribing patterns in 215 patients with CAP diagnosis over a 4-month period, it was determined that 20% of the doses were inappropriate.

CONCLUSIONS: Although survey results indicated nearly universal understanding of the CCG, prescribing patterns suggested a lack of compliance. An educational newsletter will be distributed to the urgent care providers to provide information regarding the CAP CCG. We will then re-evaluate dosage from November 1, 2014, through March 1, 2015, to determine improvement in dosage adherence. Results will be presented at the Pediatric Pharmacy Advocacy Group conference. With pharmacist intervention in the form of education, we hope to reduce inappropriate prescribing by 50%.

DEVELOPMENT OF CLINICAL PHARMACY METRICS FOR PRODUCTIVITY AND QUALITY PERFORMANCE IN A PEDIATRIC HOSPITAL.

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INTRODUCTION: It is important to continuously evaluate and identify ways to incorporate innovative practice and technology and to improve safety and quality with associated cost savings as a result of clinical pharmacy services especially as they relate to health care reform and the refocus on efficiency consistent with the Pharmacy Practice Model Initiative (PPMI) sponsored by the American Society of Health-System Pharmacists. Monroe Carell Jr Vanderbilt Children's Hospital (MCJVCH) has an established clinical specialist model which has integrated decentralized pharmacy services to enhance patient care and support high quality clinical pharmacy practice in a more consistent manner for all patients. In an effort to reduce medication waste, MCJVCH transitioned to an every-3-hours-batch-production of intravenous and oral batches in October 2012. The use of clinical pharmacy metrics has been described for adult pharmacy practice, but there are no defined metrics for pediatrics. MCJVCH developed internal clinical pharmacy metrics for productivity and quality performance to support implementation of an integrated pharmacy model.

METHODS: From January 2013, to Feburary 2014, members of the pharmacy team at MCJVCH evaluated departmental pharmacy metrics data from a collection of internal databases. A workgroup was established, made up of key pharmacy stakeholders and informatics, which worked collaboratively to identify useful metrics to target integrated clinical pharmacy services to highlight productivity, quality, and efficiency, to drive practice changes and workload balance. Specific metrics included orders processed, doses missed, and clinical interventions.

RESULTS: The average number of missing doses per month for the entire time was 1633. The number of missing doses per month decreased 14.5% after starting decentralized pharmacy services during the months of July 2013 through October 2013. Starting in November 2013, the number of missing doses trended upward. The average number of orders processed per month by pharmacy residents after decentralized services were established increased 2212.5%. In January 2014, clinical pharmacists began processing orders while on rounds. A 51% increase in the average number of orders processed per month by clinical pharmacists was seen after this change. The average number of

interventions entered in Quantifi per month increased 14%, and the average number of adverse drug events reported increased 35.5% after establishing decentralized services.
CONCLUSIONS: Clinical productivity and quality metrics were established for trending and performance improvement. Decentralized services had a positive impact on the amount of missing doses, interventions reported, and ADE's reported. It was recognized that the amount of orders being processed by the decentralized pharmacist were disproportionally high, and workflow was adjusted to allow for more balanced and consistent clinical pharmacy services.

INDIVIDUALIZED PRESCRIBER ORDER ENTRY TRAINING TO REDUCE PATIENT-CONTROLLED ANALGESIA PRESCRIBING ERRORS.

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INTRODUCTION: Opioids administered via patient-controlled analgesia (PCA) are commonly used in hematology and oncology patients for pain that is uncontrolled by intermittent dosage. Opioids are a category of medications that have a high risk for causing significant harm to patients when used in error. We hypothesized that standardized individualized prescriber order entry training would reduce the number of patient-controlled analgesia prescribing errors.
METHODS: This single-center retrospective study evaluated all hematology and oncology patients who received PCA for treatment of pain from June 1, 2012, through September 30, 2013. The primary objective of this study was to compare the number of PCA prescribing errors before and after implementing pharmacist-directed individualized prescriber order entry training. Secondary objectives were to compare severity of medication error events and number of patients harmed and to evaluate other types of PCA errors. The focus of the training was to demonstrate the correct process of ordering a PCA, educate prescribers on appropriate initial PCA settings and dosage, and review all required PCA safety orders.
RESULTS: Of the 21 PCA errors, 7 prescribing errors were identified. There were 4 prescribing errors prior to and 3 prescribing errors after implementing individualized training. The average severity score of prescribing errors decreased, and the number of patients harmed was reduced from 1 to zero after implementation of training. Other PCA-related errors including administration, documentation, and pump programming errors were decreased. There was an increase in process errors relating to safe handling of PCAs. Overall, the total number of PCA-related errors was decreased.
CONCLUSIONS: Individualized prescriber order entry training decreased PCA prescribing errors in this retrospective study. Further data collection and analysis will be ongoing.

RETROSPECTIVE EVALUATION OF VITAMIN K USE IN THE PEDIATRIC AND NEONATAL POPULATIONS.

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INTRODUCTION: Use of vitamin K therapy outside of indications of vitamin K deficiency bleeding prophylaxis, reversal of vitamin K antagonist-associated bleeding, and vitamin K deficiency has been observed in the pediatric and neonatal populations. Efficacy and safety, as well as optimal route and dosage, of other uses of vitamin K have not been clearly established in published reports. Our retrospective study described vitamin K use outside of common indications and routes in order to determine safety and efficacy of these uses. Through analysis of current practices and published reports, a guideline was established to recommend safe dosage and routes of administration for the various appropriate uses of vitamin K.
METHODS: The study was approved by the Institutional Review Board. Pediatric patients given at least 1 dose of vitamin K by any route were identified over 1 year. Patients receiving the standard 1 mg of intramuscular birth dose or with fat malabsorptive conditions were excluded. Data collected included age, weight, international normalized ratio (INR), dose and route of vitamin K administration, duration of therapy, concomitant products affecting INR (such as fresh frozen plasma [FFP]), indication for therapy, and any possible adverse reaction to vitamin K therapy. The primary outcome of this study was the safety of vitamin K administration between various routes. A secondary analysis was performed to analyze efficacy of vitamin K therapy.
RESULTS: Of 295 patient doses included, 67.8% were subcutaneous, 24.4% intravenous, 6.8% enteral, and 1% intramuscular. Excluding intravenous birth doses, 82.3% of doses were given subcutaneously and 4.1% intravenously. Of 50 intravenous birth doses, 90% were administered to neonates weighing less than 1.5 kg at birth. Of 200 subcutaneous doses, 20% were administered to patients taking enteral medications. Sixty percent of vitamin K courses (excluding birth doses) were initiated with INR less than 1.4, and the median course of therapy was 3 days. Reactions to any route of administration were not described in patient charts or progress notes, although only 10 doses were given intravenously to patients for reasons other than the birth dose. Fifty-four percent of courses, excluding birth

doses, were initiated along with FFP, thereby making efficacy of vitamin K usage difficult to elucidate.
CONCLUSIONS: The described use of vitamin K is beyond that established in published reports. This study contributed to evidence describing the safety of intravenous administration of vitamin K birth doses for low-birth-weight neonates and aided in establishing an institutional guideline for uses outside of common indications.

IMPACT ON STUDENT KNOWLEDGE OF PEDIATRIC PHARMACOTHERAPY FOLLOWING IMPLEMENTATION OF A CORE CURRICULUM DURING A GENERALIST ADVANCED PHARMACY PRACTICE EXPERIENCE (APPE).

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INTRODUCTION: At our institution, the pharmacy practice model includes both clinical specialist and generalist pharmacists. Although P4 students may elect to take an APPE with a pediatric clinical specialist, all students are required to complete a 5-week rotation with a generalist pharmacist, distinct from the institutional (i.e., hospital pharmacy) experience. Thirty-six students (~40% of each PharmD class) are assigned to complete a pediatric-specific generalist rotation, a unique opportunity for students at our institution. During this APPE, students complete a core pediatric curriculum, which includes 5 topics: 1) general pediatrics review, 2) palatability and medication dosage and administration, 3) pediatric emergencies, 4) pharmacokinetics, and 5) parenteral nutrition. The objective of this study was to assess the impact of the core curriculum on student knowledge of pediatric pharmacotherapy.
METHODS: For the 2013 to 2014 academic year, a competency examination was developed to assess student knowledge of the 5 topics in the core curriculum. All students completing the pediatric generalist APPE take the examination during the first 3 days of the rotation (pretest). The 5 core topics are then covered through a series of lectures and topic discussions, which are reinforced through hands-on practical experience throughout the rotation. Students retake the examination during the last 3 days of the rotation (post-test). A comparison of student performance on the pre- and post-test was evaluated using Student's *t*-test, with significance level set at a p value of <0.05.
RESULTS: Interim results from the first 6 rotations (n=24 students) demonstrate that students performed significantly better on the post-test than on the pretest (p<0.0001), with a mean improvement of 3.3 points (13.2%). The mean improvement did not significantly differ among the 6 rotations. Student knowledge improved in 4 of 5 core topics as a result of the core curriculum. The most significant improvements were seen in pharmacokinetics and parenteral nutrition. Seven students had previous pediatric experience (completion of a previous pediatric IPPE/APPE or the pediatric elective and/or pediatric-related work experience). Pretest scores for students with previous pediatric experience were significantly higher than scores for those without previous experience (18.4 vs. 16.1, p<0.0001). Post-test scores were not significantly different between those with and those without previous pediatrics experience.
CONCLUSIONS: The core curriculum within the pediatric generalist APPE is a unique learning opportunity for our students that significantly improved student knowledge of pediatric pharmacotherapy. Students' prior knowledge of general pediatrics was revealed by high pre- and post-test scores, which reflects previous exposure to this topic during the didactic PharmD curriculum. The highly significant improvements seen in pharmacokinetics and parenteral nutrition may be due to minimal previous exposure to these topics, an emphasis on these as priority initiatives within our hospital's pharmacy department, as well as the core curriculum.

IMPROVING INFUSION PUMP DRUG LIBRARY COMPLIANCE USING REAL TIME WIRELESS REPORTING.

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In November 2012, our children's hospital replaced the existing syringe pumps with new "smart" pumps that included a drug library with error reduction software. The Medfusion 4000 (Smiths Medical, Keene, NH) pumps are able to check the programmed dose based on the weight of the patient relative to a custom-built drug library. The use of smart pumps introduced a new safety step in our medication use process that could prevent administration errors in pediatric patients. The smart pump can prevent errors only when the drug library is used, so our initial goal was for nurses to use the drug library for greater than 97% of syringe pump administrations. Three months after implementation, use of the drug library for some units was below 80%. Efforts to improve use of the drug library through soliciting feedback from unit-based nursing practice councils and voluntary reporting via e-mail did not have a measurable impact. To engage nursing staff, we began regular surveillance of drug library compliance, using real- time wireless reporting from the infusion pumps. Pump data were matched with the medication administration record (MAR) in our electronic health record and used to identify medications involved with

non-library drug use. Interviews with each nurse identified from the MAR during the surveillance period provided essential information about the barriers to drug library compliance. Feedback from nursing staff led to quarterly wireless updates of the drug library. By improving the drug library and addressing nursing concerns, the overall use increased from 89% in January 2013 to 97% in December 2013. Use of the drug library software has prevented several pump programing errors including weight in grams instead of kilograms, low- and high-dose misprogramming, and medication programmed to run too slowly (over hours instead of minutes).

COLLABORATIVE CLINICAL PHARMACY PRACTICE: "CLEAN"ING PATIENT CARE.

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INTRODUCTION: Our institution has developed a collaborative clinical pharmacy practice (CCPP) which has led to an innovative and effective approach to implementing LEAN in clinical pharmacy ("CLEAN"). Instead of approaching patient care issues in a patient-, dose-, or unit-specific manner, issues are now recognized as universal concerns that could benefit from a collaborative, standardized institution-wide approach. LEAN principles are applied to create solutions which decrease waste with respect to time and consequences of inadequate/inappropriate medical care.
PROCESS: Multidisciplinary groups often require the expertise of clinically trained pharmacists to strategically manage complex issues. A leader and core group was selected from the CCPP to establish a CLEAN plan. A draft was then brought to CCPP for discussion, each specialist tested and refined the product, and then the group reconvened to finalize the solution. This was followed by development of a standard operating procedure, metrics, quality assurance measures, and staff education. Finally, the group published the results for the advancement of pharmacy practice.
EXAMPLES: Informed consent (IC) acts as an educational tool for families and practitioners to understand off-label use in situations with limited data. A validated grid was developed by the CCPP that standardized the requirement of IC for formulary medications, streamlining the review process and improving quality of care. 1) Alert fatigue: the CCPP responded to concerns of clinically irrelevant computerized prescriber order entry alerts by reviewing 947 drug-drug interactions in the system and keeping only 4.8% of these. This led to a 75% reduction in alert firing frequency, a 10% reduction in alert override rates, and a 300% increase in the perception of number of alerts improving practice. 2) Partial dose administration: to reduce confusion and the risk of preparation/medication errors, an algorithm was developed to guide the selection of the appropriate dosage forms for every patient. This included considerations such as physiochemical properties like water solubility when crushing and dissolving tablets for partial doses. 3) Medication absorption site: there was lack of consideration of the importance of intestinal absorption site when administering medications via alternate enteral routes. Medication-tube interactions and alterations in or lack of absorption when bypassing the stomach can directly impact patient care. CCPP developed both an algorithm to identify information for each medication and a living resource.
CONCLUSIONS: Investment in a CCPP paid off in terms of significantly improved quality of patient care, education of practitioners and families, and standardization throughout the hospital that reduced the risk of errors and adverse events. Our clinical specialist group continues to achieve these objectives regularly and fills a need that is often unmet and even unrecognized at many institutions. This "CLEAN" approach to the resolution of such issues should be considered by other large, academic institutions, as well as institutions which care for specialty populations.

COMPUTERIZED ADVERSE DRUG EVENT SURVEILLANCE IN A PEDIATRIC HOSPITAL.

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INTRODUCTION: Monroe Carell Jr. Children's Hospital at Vanderbilt (MCJCHV) is well known for its innovation and use of technology to support patient care and quality. MCJCHV has a sophisticated and customizable electronic medical record (EMR) and computerized physician order entry system (CPOE). To maximize safety and efficacy of drug therapy, the systems include specific needs and challenges associated with pediatric pharmacy practice. In 2012, MCJCHV began development and implementation of an electronic adverse drug event (ADE) surveillance tool based on the Institute for Healthcare Improvement (IHI) Global Trigger Tool methodology to identify pediatric patients at high risk for a potential adverse event.
METHODS: The electronic ADE surveillance tool uses customized rules built into Pharmacy OneSource software. The rules allow for a higher capture rate in real time and are easily modified to expert opinion. Each trigger is retrospectively reviewed daily by a pharmacy resident. Resulting adverse event reports

are reconciled with Quality and Patient Safety (QPS) event information, including voluntary incident reports, to severity and classified based on NCC MERP. Additionally, electronic surveillance quality assurance measures are taken to modify rules that are missing reported capturable events. Reconciled results are presented monthly to a multidisciplinary committee focusing on medication safety and quality for pediatrics. This work is done in collaboration with the clinical pharmacy specialists to enhance the level of clinical pharmacy services provided for patients, as part of an integrated model. In addition to identifying potential adverse events, this tool is used in combination with our current clinical intervention tool and antimicrobial stewardship program to monitor P&T initiatives and reduce costs.

RESULTS: In 2013, 462 ADEs were documented in the electronic database. 254 (55%) were classified as severity level D (error required monitoring/treatment to prevent harm); 201 (44%) were classified as severity level E (error caused temporary harm/required intervention); 3 (0.6%) were classified as severity level F (error caused prolonged hospitalization). Hypokalemia, potassium less than 2.5, is an active trigger. For this trigger, the positive predictive value for 6 months (July-December 2013) was 81% with 132 rule matches and 106 documented events. By utilizing this electronic tool, focus has also turned to medication reconciliation, especially for patients admitted on high-risk medications. In 2013, 1906 quick and 62 extensive medication reconciliations were documented totaling $301,104 in cost avoidance. This task is completed by decentralized or resident pharmacists, who complete an average of 15 to 20 reconciliations per day.

CONCLUSIONS: An evidenced-based electronic trigger tool has been designed to focus on specific drug related ADEs in high-risk pediatric patients. This tool has allowed workflow to be prioritized in order to create an efficient process to identify potential adverse events without an exhaustive retrospective chart review.

IMPROVING THE SAFETY OF TRANSDERMAL PATCH DISPENSING FOR PEDIATRIC PATIENTS.

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INTRODUCTION: Our project involved a complete redesign of dispensing "partial" patches, which we defined as patches prescribed at doses that were a portion of the commercially available transdermal patch size.

METHODS: There are a general lack of commercially available dosage forms and concentrations appropriate for administration to neonates, infants, and children. This problem is a particular nuisance in the use of some transdermal patches. There are published reports for the pediatric population supporting the use of both clonidine and oxybutynin partial patch doses. Dispensing a partial patch in the inpatient setting is a challenge because there is no published report to support cutting these patches in advance of application. For years we dispensed the intact patch with instructions for the nurse to cut the patch to the appropriate size prior to administration. Numerous actual and potential adverse drug events were reported in our pediatric population that were a direct result of our failure to dispense these partial patch orders in the exact dose ordered by the provider. Upon investigation, we found mostly overdoses, resulting from nurses applying the entire patch, which is not surprising, given that all other medications are dispensed as patient-specific unit-doses from our pharmacy. We set out to eliminate errors associated with partial patch orders and to provide these doses to our nursing units in the patient-specific, unit-dose form that nurses are accustomed to in our institution.

RESULTS: We investigated the drug delivery system for both clonidine and oxybutynin, which are microreservoir and drug-in-adhesive, respectively. We determined that the risk of drug loss resulting from cutting these patches in advance of dispensing was minimal and felt that the risk of overdose from not providing a patient-specific unit-dose form was of greater concern. We determined computerized physician order entry and pharmacy computer system changes were needed to support the desired dispensing change. We added standardized comments to the pharmacy-generated dose labels and electronic medication administration record to make it clear that the dose was dispensed in a ready-to-use form. We developed a standardized process for preparing and labeling the dose in the pharmacy. The new dispensing process was implemented in November 2012. Prior to implementation, we received, on average, 3 medication error reports involving partial patch orders per month via our voluntary error reporting system; however, since implementation, we have received only 1 report in 4 months.

CONCLUSIONS: We have developed a robust new dispensing process for partial patches that allows us to provide a patient-specific unit-dose ordered by the provider. The new process is safer than the alternative of dispensing partial patches intact and requiring nurses to cut them prior to administration.

MINIMIZING MEDICATION ALERT FATIGUE: A QUALITY IMPROVEMENT PROJECT.

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INTRODUCTION: The benefits of the electronic

health record with clinical decision support must be balanced with the potential hazards of over-alerting clinicians to the point that alerts are ignored.
METHODS: Customization of pediatric dose ranges and filtration of low-risk drug-drug interaction alerts were used to decrease the medication alert appearance rate. A total of 149 dose ranges were customized, and 131 drug-drug interactions were filtered. The number of adverse drug events involving an override of a clinical medication alert was measured between 2012 and 2013. Pre- and postimplementation medication alert override rates were measured.
RESULTS: A 33% reduction in adverse drug events involving a medication alert override was achieved between 2012 and 2013. The mean medication alert appearance rate per medication order decreased from 23.5% ± 3.89% to 13.2% ± 1.48% (43% reduction, $p<0.001$). The mean alert override rate was 92.6% ± 5.2%. There were no harm-causing adverse drug events involving a medication alert override in 2013.
CONCLUSIONS: Although the mean medication alert override rate in the electronic health record remains high, customization of pediatric dose ranges and filtration of low-risk drug-drug interactions successfully decreased the medication alert appearance rate without compromising patient safety.

EFFECT OF AN INPATIENT FORMULARY BAN ON CODEINE-CONTAINING MEDICATIONS ON INPATIENT AND OUTPATIENT PRESCRIBING.
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INTRODUCTION: Codeine is a pro-drug metabolized to its active form, morphine, via the CYP450 enzyme 2D6 (CYP2D6). Genetic polymorphisms of CYP2D6 can lead to patients being ultrarapid metabolizers of codeine, leading to increased morphine levels. Higher levels of morphine can lead to life-threatening respiratory depression or even death. Prevalence of ultrarapid metabolization CYP2D6 polymorphisms vary by ethnic group and have been reported in up to 29% of those with African ancestry, particularly Ethiopian. Conversely, up to 30% of individuals may be poor codeine metabolizers and achieve little or no pain relief. In August 2012, the US Food and Drug Administration (FDA) released a safety announcement advising caution when prescribing codeine to children. In February 2013, the FDA added a boxed warning to codeine labeling, stating a contraindication for use as postsurgical pain management for tonsillectomy and/or adenoidectomy procedures. In light of these emerging concerns, codeine-containing medications were removed from the hospital formulary in October 2012. Removal from formulary began with a 6-month planned phase-out which included education of prescribers, multidisciplinary discussion with various hospital departments, replacement of codeine-containing order sets with therapeutic alternatives, and creation of electronic medical record (EMR) alerts with alternative recommendations for codeine-containing medications. The ban went into full effect in April 2013. An audit was performed in September 2013 to determine the impact of this inpatient formulary ban on prescribing practices.
METHODS: Inpatient EMR dispensing records were queried for codeine-containing medications between April 1 and August 1, 2013, to evaluate adherence to the hospital formulary ban. Outpatient codeine prescription data from the EMR were queried between April 1 and August 1, 2012 and 2013, to evaluate influence of the inpatient formulary ban on outpatient prescribing practices.
RESULTS: No inpatient orders for codeine-containing medications were issued in the 4 months after implementation of the ban. Outpatient prescriptions for codeine-containing medications declined from 527 prescriptions in the 2012 audit period to 128 prescriptions in the 2013 audit period, a 75.7% reduction. In the 2013 audit period, no outpatient prescriptions for codeine-containing medications were issued from inpatient or outpatient ear, nose, and throat prescribers.
CONCLUSIONS: An inpatient formulary ban was effective in eliminating inpatient use of codeine-containing medications and dramatically reduced outpatient prescribing.

THE IMPLEMENTATION AND IMPACT OF GUIDELINE—CONCORDANT CARE FOR SEPSIS IN A PEDIATRIC EMERGENCY DEPARTMENT.
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INTRODUCTION: In the United States, sepsis is fatal in 4% to 12% of pediatric patients. In medically complex patients, the mortality rate increases to 20%. Over a 1-year period, sepsis accounted for a 7.1% increase in 30-day mortality in patients at our institution. It has been shown that guideline-driven treatment for these patients has led to lower rates of mortality. Specifically, these guidelines include earlier recognition, diagnosis, and treatment.

METHODS: A sepsis treatment and recognition program was designed for phased implementation throughout Children's Hospital Colorado and surrounding networks of care. The program included a 2-tiered approach consisting of sepsis code yellow and sepsis code stat, along with algorithms outlining the responsibilities of team members and appropriate antibi-

otic choices. An order set was created to assist in proper medication and laboratory ordering. Sepsis yellow was activated for patients presenting with fever and a central venous catheter, an immunocompromised state and/or neutropenia, or for patients deemed to be septic based on the provider's clinical evaluation. Sepsis stat was activated for critically ill septic patients with fever and hypotension, lactate level greater than 4, and/or a condition upgraded from sepsis yellow. The goal of this program was to improve outcomes in pediatric patients with sepsis through enhanced treatment and diagnosis. Goal process measures included time to antibiotics less than 1 hour from triage and time to first fluid bolus less than 30 minutes from triage and the outcome measure was mortality. Training was provided in person, via email, and through computer-based courses outlining the roles specific to providers, nursing, and pharmacy staff.

RESULTS: The program began in the emergency department (ED) in October 2012. More than 1440 nurses completed the computer-based training course. All pharmacists completed sepsis activation competency, and all pharmacy staff was educated about the process. From the time of initiation to December 2013, 604 patients in the ED were included. A total of 124 patients (20.5%) were designated sepsis stat patients, whereas 480 (79.5%) were designated sepsis yellow patients. The number of sepsis yellow activations increased from 2 in October 2012 to 68 in December 2013. In the sepsis yellow patients, median time to bolus decreased from 140 minutes to 50 minutes. Also in these patients, median time to antibiotic administration decreased from 200 minutes to 60 minutes. Median time to antibiotics decreased from 80 minutes to 30 minutes, and median time to fluid bolus decreased from 154 to 26 minutes in sepsis stat patients. Finally, there were no changes in mortality. The institution ranked 4 of 5 in the final assessment tool, according to the Champions for Children's Health.

CONCLUSIONS: Due to the successful education of staff and appropriate activation of the sepsis treatment and recognition program, our institution experienced significant improvement in the management of pediatric sepsis.

INFLUENZA ASSESSMENT TOOL COMPLIANCE AT PEYTON MANNING CHILDREN'S HOSPITAL AT ST. VINCENT.

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INTRODUCTION: Influenza immunization was a clinical quality measure newly proposed for 2014 from Centers for Medicare and Medicaid Services. The measure, IMM-2, addressed acute care-hospitalized inpatients 6 months of age and older and assessed if patients were screened for the seasonal influenza immunization and were vaccinated if indicated. This study was intended to determine whether the use of an electronic medical record and electronic medication administration record improved influenza vaccine assessment completion and influenza vaccination administration rates.

METHODS: This was a retrospective chart review of patients admitted to Peyton Manning Children's Hospital (PMCH) between October 15 and November 15 of 2011 thru 2013. These time frames were chosen in order to capture patients the year before, the year during, and the year after our institution's transition to an electronic medical record system. Patients were included in the study if they were between the ages of 6 months and 18 years at the time of discharge from PMCH. Patients' medical records were reviewed for completion of an influenza assessment and administration of influenza vaccine.

RESULTS: During the 2013 influenza season, 86% of patients admitted to PMCH had an influenza assessment completed, compared to 72% and 34% in 2011 and 2012, respectively. The low percentage of completion in 2012 could have been the result of transitioning from paper to electronic medical record and medication administration record. Overall, more patients were identified as eligible for the influenza vaccine in 2013 than in previous years. However, the vaccination rate was lower than that in previous years, with only 59% of eligible patients receiving an influenza vaccine prior to discharge in 2013, compared with 70% in 2012 and 69% in 2011.

CONCLUSIONS: Completion of the influenza nursing assessment and number of vaccines administered to eligible patients has increased since the implementation of an electronic medical record and medication administration record. However, the percentage of eligible patients who received the vaccine has decreased. In order to maintain our high influenza assessment completion rate and to improve our vaccination completion rate in eligible patients, there will be a continued focus on staff education prior to and during influenza season along with modifications to our electronic medical record to support best practice.

DEVELOPMENT AND IMPLEMENTATION OF A NURSE-DRIVEN ELECTROLYTE REPLACEMENT PROTOCOL IN A PEDIATRIC CRITICAL CARE UNIT.

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Electrolyte replacement is a standard of care in pediatric critical care units. The diuretic therapy required by this patient population often leads to low electrolyte

levels that require repletion. Factors such as current electrolyte level, dose, and type of diuretic, type of intravenous (IV access, concentration of the replacement electrolyte and renal function must be considered when replacing electrolytes. Although computerized prescriber order entry (CPOE) and decision support for electrolyte therapy had been in place at our institution for several years, electrolyte replacement was non-standardized and time consuming. Prior to implementation, electrolyte replacement was often initiated by the bedside nurse, who notified the prescriber of a low electrolyte level. The prescriber would assess the patient, determine the need for replacement therapy, and enter electrolyte doses and laboratory orders at his/her discretion. Large amounts of time were spent managing electrolyte imbalances with a process that was highly variable. Our goal was to empower the bedside nurse, save prescriber time, and improve patient safety by standardizing doses and subsequent laboratory orders. The most commonly used electrolytes, potassium chloride, calcium gluconate, calcium chloride, and magnesium sulfate, were included in the protocol. A CPOE electrolyte ordering page was created for each electrolyte in the protocol. Each electrolyte page provided information on which patients could be included in the protocol and excluded patients with poor renal function. The order pages were designed with several features which included the most recent trend in electrolyte values, standardized doses of each electrolyte, and standardized future laboratory orders. Because the appropriate dose may be dependent on the electrolyte value, only the dose appropriate for the current electrolyte value could be ordered. Repeat laboratory orders were also automatically ordered based on the prereplacement electrolyte level and the replacement dose given. Prior to implementation of the new CPOE ordering pages, nursing education about the new process was provided. With the new process, each patient is assessed daily to determine if they meet criteria and would benefit from the protocol. The prescriber then enters an order for the "Pediatric Electrolyte Replacement Protocol." The prescriber selects which electrolytes may be replaced in this initial ordering. The order stays active for only 24 hours to force daily re-evaluation of each patient. If a patient has an active electrolyte replacement protocol order, the bedside nurse may enter the CPOE system to request replacement electrolytes in preset standardized doses based on current laboratory values. The prescriber does not have to be contacted to request doses. The protocol has been well received by prescribers, bedside nurses, and pharmacists. It has allowed for safe electrolyte replacement and appropriate monitoring without delays in care.

REDUCTION OF LENGTH OF STAY FOR INFANTS WITH NEONATAL ABSTINENCE SYNDROME.

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INTRODUCTION: The number of infants with diagnosis of neonatal abstinence syndrome (NAS) has risen over the last decade as reported by the Agency for Healthcare Research and Quality. Treatments with nonpharmacologic and pharmacologic therapy can vary greatly among providers. West Virginia University Children's Hospital established a multidisciplinary team led by the clinical pharmacy specialist and a neonatology fellow to review current practices. The aim of this quality improvement initiative was to reduce the median length of stay (LOS) by standardizing processes.
METHODS: A key driver diagram was completed, and the following drivers were selected to be addressed: standardized nursing education for use of the modified Finnegan NAS scoring tool, development and implementation of a standardized treatment algorithm, and development of a policy related to the use of breast milk. The quality improvement methodology used was Plan, Do, Study, Act (PDSA) cycles, which were completed around each key driver. Education was conducted by a core group of educators. Compliance with the treatment algorithm was monitored by a single observer. The following data were collected the year after implementation: gestational age, birth weight, birth location, toxicology screening, morphine initiation dose and maintenance dose, duration of therapy, use of phenobarbital, length of stay, number of steps in weaning process, percentage of compliant weans, days between weans, discharge location, discharged on medication, and 30-day readmission.
RESULTS: At baseline, 61 term infants received pharmacologic treatment for NAS between January 2009 and December 2011. The LOS of these infants ranged from 5 to 61 days (median of 20 days). During the year after implementation of standardization (January-December 2013), 38 term infants received morphine for the treatment of NAS. The median LOS decreased from 20 days to 18 days (range, 8-36 days). The number of infants requiring a hospitalization longer than 21 days was decreased by 37%. All nurses in the neonatal intensive care and maternal infant care units were formally educated. Compliance with the treatment algorithm improved from 29.3% in the first quarter of the year to 84.4% in the fourth quarter. The breast feeding policy was amended to include guidance for substance use and abuse. No readmissions occurred during the year following implementation.
CONCLUSIONS: Standardization of scoring and pharmacologic treatment led to a reduction in LOS

for infants with NAS. The next steps for this quality improvement initiative are to develop a toolkit and education related to non-pharmacologic care.

RETROSPECTIVE EVALUATION OF TWO ENOXAPARIN DOSING PROTOCOLS IN PEDIATRIC PATIENTS.

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INTRODUCTION: Enoxaparin is recommended by American College of Chest Physicians' *Chest Journal* guidelines as an option when treating thromboembolism in pediatric patients. Current guideline recommendations for infants <2 months old and those >2 months old are 1.5 mg/kg/dose and 1 mg/kg/dose subcutaneously every 12 hours, respectively. Previous research suggests these doses may be too low to achieve therapeutic anti-factor Xa levels. Therefore, in March 2012, new dosage protocols were implemented at our institution with increased doses for all pediatric patients. This study evaluated and compared these enoxaparin dosage recommendations and their ability to achieve therapeutic anti-factor Xa levels.
METHODS: A retrospective review of all children <18 years old receiving treatment dose enoxaparin was performed. Patients receiving enoxaparin from January 1, 2010, to March 1, 2012, received the *Chest* guideline dosage, and those receiving enoxaparin from April 1, 2012, to September 30, 2013, received the institutional guideline dosage. Subjects were excluded if their calculated glomerular filtration rate was <30 mL/min/1.73 m^2 or if no anti-factor Xa monitoring was performed. The institutional guideline dosage was 1.7 mg/kg/dose for infants <3 month old, 1.5 mg/kg/dose for children 3 to 12 months old, 1.2 mg/kg/dose for 1 to 5 year olds, and 1.1 mg/kg/dose for children >5 years old. The primary outcome assessed the percentage of patients with therapeutic anti-factor Xa concentrations (0.5-1 units/mL) after initial dosage between protocols. Secondary outcomes included the percentage of patients achieving sub- or supratherapeutic anti-factor Xa levels after initial dosage, the number of dosage changes required to achieve therapeutic anti-factor Xa levels, and the average therapeutic dose by age group. Continuous data were analyzed using the *t*-test and discrete data analyzed using the chi-square test.
RESULTS: A total of 401 patients received enoxaparin, with 245 patients meeting inclusion criteria. The *Chest* guideline group included 165 patients, and the institutional guideline group included 117 patients. There was, however, a non-significant numeric difference in the percentage of patients achieving therapeutic anti-factor Xa levels between groups (37.6% *Chest* guideline versus 46.2% institutional guideline, p=0.178). The institutional guideline required fewer dose changes on average (2.3 dose changes for *Chest* guidelines versus 1.7 institution changes, p=0.040). The percentages of patients with sub- and supratherapeutic anti-factor Xa levels were 56.7% and 5.7%, respectively, for *Chest* guideline versus 40.4% and 13.5%, respectively, for our institutional guideline, p=0.005. The average ±SD therapeutic enoxaparin doses of both groups was 1.9±0.56 mg/kg/dose for infants <3 months old, 1.6±0.37 mg/kg/dose for children 3 to 12 months old, 1.2±0.27 mg/kg/dose for 1 to 5 year olds, and 1.0±0.21) mg/kg/dose for children >5 years old.
CONCLUSIONS: Therapeutic anti-factor Xa concentrations were achieved in less than half of pediatric patients after initial dosage for both dosage guidelines. Our institutional guideline achieved therapeutic anti-factor Xa levels more often than dosage recommended by the *Chest* guideline; however, the study was underpowered to determine statistical significance; approximately 800 patients were needed for a 10% difference between groups.

EFFECT OF DOPAMINE INFUSION ON LYMPHOCYTE COUNT IN PICU PATIENTS: A RETROSPECTIVE REVIEW.

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INTRODUCTION: There are reports that suggest that dopamine, which is frequently used in hemodynamically unstable children, may act as an immunosuppressant through its effects on lymphocytes. This study was conducted to determine the effect of dopamine infusion lasting more than 12 hours on the lymphocyte count in patients in the pediatric intensive care unit (PICU).
METHODS: Children who received dopamine for 12 hours or longer in the PICU at Children's of Alabama from October 1, 2012, to September 30, 2013, were identified from an electronic database. University institutional review board approval was obtained. Dopamine dose, duration of infusion, and absolute lymphocyte counts at baseline, during infusion, and after infusion were collected in addition to other demographic data and severity of illness scores. Mann-Whitney *U* test was used to compare the absolute lymphocyte count at baseline to the count during and after infusion, and after infusion was discontinued. Analysis of variance was used to assess correlation between the peak dose of dopamine and duration of infusion and the absolute lymphocyte count after the infusion was discontinued.
RESULTS: A total of 29 of the 740 patients who were

admitted to the PICU during the study period received dopamine. Twelve patients (n=10 males) met the inclusion criteria; the mean patient age was 71.25 months, mean weight was 24.4 kg, and mean pediatric risk of morality version 3 (PRISM3) score was 23. Dopamine dose ranged from 1 to 20 mcg/kg/min, with a mean of 7.19 mcg/kg/min; the mean length of infusion was 55 hours. There were no significant differences between the baseline absolute lymphocyte counts (median, 1630 cells/mm^3) and the counts obtained either during infusion (median, 1250 cells/mm3) or after infusion had been discontinued (median, 1145 cells/mm^3; p=0.15 and p=0.12, respectively). There was no correlation between the peak dose of dopamine infused or the duration of exposure to dopamine and the absolute lymphocyte count. Six of the patients had no underlying conditions, whereas 8 patients had no apparent reason for immunosuppression, 4 of the 8 patients were receiving concurrent steroids.
CONCLUSIONS: In this cohort of critically ill children, the absolute lymphocyte count decreased during dopamine infusion and after the infusion had been discontinued, but this was not statistically significant. The small sample size may have precluded detection of a statistically significant difference. More research is needed to determine the immunologic effects of dopamine on critically ill children.

PHARMACOKINETICS OF CONTINUOUS INFUSION MEROPENEM WITH EXTRA-CORPOREAL MEMBRANE OXYGENATION.

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INTRODUCTION: Meropenem, a broad spectrum carbapenem, is commonly used in the pediatric population for empirical and definitive therapy for pediatric patients admitted to an intensive care unit. Pharmacokinetic (PK) data to guide dosages in children, however, are limited to healthy volunteers or non-intensive care unit patients. Adult data demonstrate that PK parameters such as volume of distribution (Vd) and clearance (CL) can be significantly altered for individuals receiving extra-corporeal membrane oxygenation (ECMO). Alterations in Vd and CL of antimicrobial agents in patients with sepsis and septic shock have also been documented and demonstrate lower-than-expected serum levels based on standard dosage regimens. Impaired antibiotic distribution into tissue is a major concern for clinicians and may explain the high morbidity and mortality resulting from infections in this patient population. The PK alterations associated with sepsis can be further exacerbated by the cumulative PK changes with ECMO. Therefore, an understanding of the PK changes in critically ill children receiving ECMO is crucial to determining the most appropriate dose and interval selection for any antimicrobial therapy. The purpose of this case report was to describe the pharmacokinetics of continuous infusion meropenem in a single patient on ECMO therapy.
METHODS: Retrospective single-patient chart review.
RESULTS: An 8-month-old male with heterotaxy, dextrocardia, mitral atresia, double-outlet right ventricle, pulmonary stenosis underwent a Glenn procedure and pulmonary artery reconstruction in January 2014. Postoperatively, he became hypoxemic due to pulmonary artery stenosis, viral bronchiolitis, and pulmonary hypertension, requiring ECMO support. The total ECMO run was 21 days. On day 11 of ECMO, a bronchoalveolar lavage was performed and cultures grew *Pseudomonas aeruginosa*. Blood cultures from days 11 and 12 of ECMO also grew *P aeruginosa* with a minimum inhibitory concentration (MIC) to meropenem of 0.5 mcg/mL. On ECMO day 13, meropenem was initiated with a loading dose of 40 mg/kg and was infused over 30 minutes. After the bolus, a continuous infusion of 200 mg/kg/day was started. A meropenem serum concentration was obtained 8 hours after the start of infusion, which was 46 mcg/mL. Repeat levels were obtained on days 3 and 9 of meropenem therapy and were 39 and 42 mcg/mL, respectively. Blood cultures drawn from ECMO days 13 to 21 were all negative. Blood cultures drawn for 1 week after ECMO decannulation remained negative. Repeat respiratory cultures from ECMO day 20 and day 6 after decannulation were negative.
CONCLUSIONS: A meropenem regimen consisting of a 40 mg/kg bolus followed by a continuous infusion of 200 mg/kg/day was successful in providing a target attainment of 100% for serum and lung concentrations above MIC for at least 40% of the dosage interval and was associated with a successful clinical outcome in this complex patient.

ONCE-WEEKLY INTRAVENOUS HIGH-DOSE LIPOSOMAL AMPHOTERICIN B FOR FUNGAL PROPHYLAXIS IN PEDIATRIC HIGH-RISK LEUKEMIA AND STEM CELL TRANSPLANT PATIENTS: A RETROSPECTIVE EVALUATION OF SAFETY AND TOLERABILITY.

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INTRODUCTION: Invasive fungal infections (IFI) are a major cause of morbidity and mortality in children

receiving intensive chemotherapy for hematologic malignancies. In an attempt to decrease rates of IFI in patients being treated for high-risk hematologic malignancies, an institutional standard of care using once-weekly high-dose (10 mg/kg) liposomal amphotericin B prophylaxis (LAMB) during intensive phases of chemotherapy, including stem cell transplantation (SCT), was initiated on December 5, 2011, and continued through October 16, 2013. The purpose of this study was to evaluate safety and tolerability of once-weekly LAMB prophylaxis and to report the incidence of breakthrough IFI in patients who received this therapy.

METHODS: Approval was obtained through the University of Texas Southwestern Institutional Review Board for this retrospective chart review. Patients treated at Children's Medical Center Dallas for high-risk leukemia or SCT who received at least one dose of LAMB between December 5, 2011 and October 16, 2013 were identified. Medical records were reviewed, and the following data were collected: age, ethnicity, sex, weight, white blood cell count at diagnosis, indication for prophylaxis, medical history of a fungal infection, breakthrough fungal infection while receiving LAMB prophylaxis, phase of chemotherapy, administration dates of LAMB, electrolyte supplementation, laboratory values including serum creatinine, potassium, magnesium and phosphorus concentrations, and adverse events. Acute kidney injury (AKI) was defined as an elevation of serum creatinine level above the normal limit based on age.

RESULTS: A total of 125 patients received at least 1 high dose of LAMB in the study period. Of these, 103 (82%), 90 (72%), and 76 patients (60.8%) experienced hypokalemia, hypomagnesemia, and hypophosphatemia, respectively. AKI occurred in 43 of 125 patients (34.4%); 12 incidences were attributable to high-dose LAMB. Of these, 11 patients recovered within 1 week, and 1 patient with a history of renal insufficiency experienced a rise in serum creatinine to 1.2 that persisted for 1.5 months. Twenty-five patients developed infusion-related reactions. There were 12 documented breakthrough fungal infections (9.6%).

CONCLUSIONS: Weekly high-dose LAMB delivery was tolerable, although not without toxicity. The frequency of electrolyte abnormalities, infusion-related reactions, AKI, and lack of evidence to suggest efficacy contributed to the decision to discontinue the use of high-dose LAMB in high-risk leukemia patients. Efficacy is difficult to determine and will require continued documentation of fungal infections that occur after the cessation of standard weekly prophylaxis. SCT patients continue to receive high-dose LAMB as an option for prophylaxis against fungal infection as a standard of care.

MEROPENEM PHARMACOKINETICS IN CRITICALLY ILL CHILDREN.

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INTRODUCTION: Meropenem is a frequently prescribed antibiotic in pediatric intensive care units (PICU), but pharmacokinetic (PK) data to justify the optimal dosage regimen are sparse in critically ill children. Current data suggest that to provide for optimal efficacy, meropenem dosage regimens should provide a free drug concentration above minimum inhibitory concentration (MIC) of the infecting organism for at least 40% of the dosage interval.

METHODS: This was a retrospective chart review of patients treated from January 1, 2009, to December 31, 2012. Patients admitted to the PICU who received meropenem for empirical or definitive therapy with an expected duration of >48 hours were eligible for inclusion. Patients who had cystic fibrosis, acute or chronic renal failure, or who were receiving extra-corporeal membrane oxygenation were excluded from the PK analyses. Blood samples (2-3 per child) were collected from patients admitted to the PICU who were receiving standard meropenem dosage regimens to treat infections. Meropenem concentrations were measured by a bioassay and the patient specific meropenem serum concentrations were plotted against time, and individual PK parameters were determined by a one-compartmental analysis.

RESULTS: Eleven children were included in the analysis, with an age range of 3 months to 9 years. The mean meropenem dose was 29 mg//kg/dose, and the most common dosage interval was every 8 hours. Mean±SD estimates for clearance (CL), volume of distribution (Vd), and elimination rate constant were 6.4±5.1 mL/kg/min, 0.65±0.4 L/kg, and 0.55±0.22 · hr^{-1}. This resulted in a mean±SD elimination half-life of 1.4±0.68 hours. Using the mean PK estimates above, currently available dosage recommendations provided a free-drug concentration above MIC for only ~20% of the dosage interval.

CONCLUSIONS: These are the first PK data of meropenem in critically ill pediatric patients (3 months to 9 years of age). Based on these data, a regimen of 40 mg/kg/dose administered as a 0.5-hour infusion does not provide optimal exposure up to the meropenem MIC cutoff of 4 mcg/mL. These PK data suggest unique dosages, such as every 4 to 6 hours, extended or continuous infusion regimens, and serum drug level monitoring are needed to provide an optimal exposure up to the breakpoint of 4 mcg/mL in critically ill children.

ANTIMICROBIAL NEPHROTOXICITY IN THE PEDIATRIC ICU: β-LACTAMS VERSUS VANCOMYCIN.

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INTRODUCTION: Serum vancomycin trough (Vt) concentrations of 15 to 20 mg/L have been associated with an increased rate of vancomycin-induced nephrotoxicity in adults. Current data in pediatrics suggest Vts of 15 to 20 mg/L do not increase the incidence of nephrotoxicity in children admitted to a pediatric intensive care unit (PICU). Comparing the incidence of nephrotoxicity in PICU patients receiving a β-lactam agent with that of vancomycin could provide insight regarding whether targeting a Vt of 15 to 20 mg/L had an effect on nephrotoxicity in a PICU cohort.
METHODS: The medical records of all children admitted to the PICU between November 2008 and June 2009 who received vancomycin for at least 48 hours, targeting higher Vt concentrations of 15 to 20 mg/L for pneumonia, bacteremia, and meningitis, were reviewed. This high-trough concentration cohort (V group) was compared to children admitted from July 2009 through July 2013 who received either cefepime (CEF) or piperacillin/tazobactam (TZP) for ≥72 hours (C and P groups, respectively). Serum creatinine (SCr) values were collected from 48 hours before the start of therapy, when available, until 48 hours after the discontinuation of therapy. Nephrotoxicity was categorized according to pediatric risk, injury, failure and loss, and end-stage (pRIFLE) criteria.
RESULTS: A total of 57, 86, and 29 patients met inclusion criteria and were included in the V, C, and P groups, respectively. Data are presented as mean±SD. The median (range) age was 2 (0.08-18), 1 (0.02-20), and 2.5 (0.07-17) years in the V, C, and P groups, respectively. The therapeutic dose of vancomycin was 63.5±17 mg/kg/day, and the trough concentration was 17.8±3.1. The dose of CEF was 51±26 mg/kg/dose, and the most common interval was 8 hours. The dose of TZP was 76±22 mg/kg/dose, and the most common interval was 6 hours; 5 of 57, 7 of 86, and 3 of 29 patients in the V, C, and P groups, respectively, were classified in the injury classification of the pRIFLE nomogram, yielding an incidence of nephrotoxicity of 8.8%, 8.1%, and 10.3 % in the V, C, and P groups, respectively.
CONCLUSIONS: Our observations suggest that maintaining Vt concentrations of 15 mcg/mL or greater is not associated with an increased rate of nephrotoxicity compared with β-lactam monotherapy in a PICU population.

USE OF ETOMIDATE FOR RAPID SEQUENCE INTUBATION IN PEDIATRIC TRAUMA PATIENTS: A NATIONAL SURVEY.

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INTRODUCTION: Etomidate is an imidazole-derived, ultrashort-acting nonbarbiturate hypnotic and has been commonly used as an induction agent in trauma and non-trauma patients. However, etomidate has been shown to inhibit 11-beta-hydroxylase, which catalyzes the conversion of deoxycortisol to cortisol in the adrenal gland, leading to decreased concentrations of cortisol for up to 48 hours after its administration. The use of etomidate has been associated with an increased morbidity and mortality rate in many different settings, including pediatrics. The purpose of this study was to use a questionnaire to determine the following factors among pediatric trauma programs: a) how common the use of etomidate is for rapid sequence intubation (RSI), b) how pediatric trauma centers are using etomidate, and c) why pediatric trauma programs are using etomidate for RSI.
METHODS: A 25-question survey was created using Survey Monkey (SurveyMonkey.com), an online survey tool. A link to the survey was emailed to each of the pediatric and adult trauma programs that care for pediatric patients. Two additional emails were sent at 3 and 5.5 months with reminders to complete the online survey. After 6 months, the survey link was deactivated, and the information was removed from the website for analysis. The survey was open for 2 months. The answers to the questions were analyzed using nonparametric methodology. The significance level, determined a priori, was set at an α level of 0.05.
RESULTS: A total of 36 responses were received. Most centers that responded were urban, academic, teaching level 1 pediatric trauma centers that provided care for >200 pediatric trauma patients annually. The trauma program directors were the most likely to respond to the survey (16 of 36). A total of 30 of 34 respondents stated they use etomidate in their RSI protocol but it is not used in all pediatric trauma patients; 24 of 34 respondents believe that etomidate is associated with adrenal suppression, and 22 of 33 believe it exacerbates adrenal suppression in pediatric trauma patients, yet 24 of 33 respondents did not believe it is clinically relevant.
CONCLUSIONS: Despite an association with adrenal suppression and effects on morbidity and mortality, the use of etomidate in pediatric trauma patients is common among urban, academic, teaching level 1 pediatric trauma centers.

CONTINUOUS ACYCLOVIR FOR NEONATAL DISSEMINATED HSV WITH CONCURRENT ECMO AND CVVH CIRCUITS.

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INTRODUCTION: Disseminated herpes simplex virus (HSV) infection in neonates represents a devastating entity which yields high mortality despite treatment with high-dose acyclovir. We present the pharmacokinetics (PK) of acyclovir in an infant with disseminated HSV-1 infection progressing to fulminant hepatic and renal failure necessitating the use of extracorporeal membrane oxygenation (ECMO) for hemodynamic support and then to facilitation of continuous venovenous hemofiltration (CVVH) as a treatment modality for hepatic and renal failure. Current reports demonstrate increased survival and decreased long-term morbidity in patients treated with high-dose acyclovir, 60 mg/kg/day divided every 8 hours. Currently, no data exist regarding the PK of acyclovir in ECMO or in the setting of CVVH coupled with ECMO for intermittent or continuous infusion (CI) dosage modality.

METHODS: This is a single-case report describing the PK of acyclovir on ECMO with concurrent CVVH. Acyclovir was initially started at 30 mg/kg/dose intravenous (IV) every 8 hours, to account for the extra volume of distribution (Vd) of the ECMO circuit and the efficiency of the CCVH circuit. After 24 hours of therapy, blood samples were collected at 0.25, 2, and 4 hours from the end of a 0.5-hour acyclovir infusion. Patient-specific acyclovir serum concentrations were plotted against time, and individual PK parameters were determined by a one-compartment analysis. After obtaining an elevated quantitative HSV viral load, the patient was transitioned to a continuous infusion of acyclovir via the replacement solution for CVVH, at a concentration of 5.5 mg/L. Acyclovir serum concentration was obtained on day 3 of CI acyclovir.

RESULTS: Initial acyclovir levels were 17 and 16 mcg/mL, respectively, representing a Vd of 1.4 L/kg, a half-life, t1/2, of 11.4 hours, and a peak of 19.8 mcg/mL, which was below the target peak of ~45 mg/L and a trough of 12.1 mg/L. After the CI was started, the levels on day 3 were 8.8 mg/L, which was within the target range for CI acyclovir.

CONCLUSIONS: These are the first acyclovir PK data on ECMO with or without CVVH. These data suggest that adding acyclovir to the replacement fluid during CVVH is effective in achieving therapeutic drug levels despite the complications of adding ECMO and CVVH circuits to a small patient.

DEXMEDETOMIDINE AS AN ADJUNCTIVE AGENT FOR SEDATION AND ANALGESIA IN A PEDIATRIC CRITICAL CARE UNIT.

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INTRODUCTION: Dexmedetomidine is approved by US Food and Drug Administration for sedation in adults undergoing mechanical ventilation or in non-intubated patients undergoing a procedure, at doses of 0.2 to 0.7 mcg/kg/hr for <24 hours' duration. Pediatric studies are limited but suggest that higher doses and longer duration may be required, especially in patients with analgesic or sedative tolerance or certain genetic disorders (e.g., trisomy 21). Prolonged infusions, however, may be associated with a withdrawal syndrome. The objectives of this study were to evaluate compliance with FDA-approved dose and duration, to determine factors associated with higher dose and longer duration, and to determine whether patients were managed for potential withdrawal syndrome.

METHODS: This retrospective study included randomly selected, mechanically ventilated patients who received dexmedetomidine infusion during the study period. Patient demographics, comorbidities, history of exposure to analgesics and sedatives, dexmedetomidine information (indication, dose, and duration), concomitant analgesics and sedatives, and time to extubation or tapering of other analgesics and sedatives were collected. Descriptive statistics were used to assess dexmedetomidine usage in combination with other analgesics and sedatives. Patients receiving >0.7 mcg/kg/hr or duration of ≥24 hours were compared to patients receiving ≤0.7 mcg/kg/hr or duration of <24 hours by using chi-square, Fisher exact, and Student *t* tests as appropriate. A p value of <0.05 was statistically significant.

RESULTS: Ninety-nine patients were evaluated (57.6% male; median age, 1.1 years; median weight, 10.2 kg). Most patients were admitted for cardiovascular surgery (49.5%), had 1 to 2 comorbidities (47.5%), and received dexmedetomidine for primary or adjunctive sedation (43.4% and 42.4%, respectively). Only 20% of patients' doses exceeded 0.7 mcg/kg/hr, whereas more than 50% of patients' infusions exceeded 24 hours in duration. Average maximum dose was 0.6±0.29 mcg/kg/hr, and median duration was 22 (range, 1.5-176) hours. Patients with infusions ≥24 hours received dexmedetomidine more often for adjunct sedation (55.8% vs. 32.1%, respectively; p=0.0242) and had a greater requirement for other sedatives

used in conjunction with dexmedetomidine (83.5% vs. 62.5%, respectively; p=0.025) than patients on shorter infusions. Presence of tolerance or genetic disorders predisposing to difficulty with sedation were not associated with longer infusion duration (p=NS). No factors were associated with patients receiving doses >0.7 mcg/kg/hr or ≤0.7 mcg/kg/hr (p=NS). None of the patients who received dexmedetomidine for >24 hours had infusions tapered prior to discontinuation, and clonidine was initiated to prevent withdrawal in only 3 of 41 patients (7.3%).
CONCLUSIONS: Duration of dexmedetomidine infusion often exceeded manufacturer recommendations. Longer duration should be anticipated in patients who receive dexmedetomidine for adjunct sedation and who initially require more supplemental sedatives. Tapering of dexmedetomidine dose or initiation of clonidine to prevent withdrawal syndrome should be considered for these patients.

ACCURACY OF MEDICATION FORMULARIES IN A PEDIATRIC CLINIC ELECTRONIC HEALTH RECORD AND EPOCRATES MOBILE APPLICATION.
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INTRODUCTION: Physicians commonly use formulary drug coverage information generated by electronic health records (EHR), a mobile application (Epocrates, Inc., San Mateo, CA) for medication selection, and non-formulary selections could lead to non-adherence to prescribed regimens. However, the accuracy of these selection tools have not been systematically verified in our population. This study's purpose was to assess the accuracy of formulary status icons generated by the EHR and a mobile application for patients with Medicaid and Blue Cross Blue Shield (BCBS), the primary insurance providers in our state.
METHODS: Patients of all ages who had a chart review performed by pharmacy students at the outpatient pediatric clinic at our institution from May to October of 2013 were included in the analysis. Patients who were uninsured or were insured by third party payers other than Medicaid or BCBS were excluded. Data were collected retrospectively from the EHR and from published online formularies for Medicaid, BCBS, and the mobile application. For each patient reviewed, prescription and over-the-counter (OTC) medication information, date seen in clinic, third party payer, and coverage status in the EHR and mobile application were collected. Coverage status was defined as covered, prior authorization required, or not covered. The status provided in the EHR and the mobile application was compared to that of the actual Medicaid and BCBS formularies published online, and the accuracy of the two databases was determined. This study received Institutional Review Board approval.
RESULTS: There were 936 medications reviewed for formulary accuracy. The EHR and mobile application provided accurate formulary information for 84.8% of medications. Most discrepancies among the formularies, EHR, and mobile application were for OTC medications. Formulary information generated by the EHR was 96.9% accurate (94.7% for OTCs) for Medicaid patients and 83.5% accurate (88.9% for OTCs) for BCBS patients. Mobile application data were 86.6% accurate (34.7% for OTCs) for Medicaid patients and 92.7% accurate (22.2% for OTCs) for BCBS patients.
CONCLUSIONS: For patients with Medicaid, the formulary information from the EHR was more accurate for all medication than that found in the mobile application. However, for patients with BCBS, the formulary information found in the mobile application was more accurate than that in the EHR for prescription medications only. Information generated by the EHR and mobile application is a useful tool for physicians when prescribing medications, but it is important to consider that neither source has completely accurate formulary information.

EVALUATION OF INTRAVENOUS PENTAMIDINE FOR PNEUMOCYSTIS PNEUMONIA PROPHYLAXIS IN PEDIATRIC ALLOGENEIC STEM CELL TRANSPLANT RECIPIENTS.
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INTRODUCTION: Pneumocystis pneumonia (PCP) is a life-threatening complication in immunocompromised pediatric patients undergoing allogeneic stem cell transplantation. The preferred regimen for PCP prophylaxis is trimethoprim-sulfamethoxazole (TMP-SMX) taken twice daily, 3 days every week. The standard of care for initial PCP prophylaxis at Riley Hospital for Children for patients undergoing allogeneic stem cell transplantation is intravenous pentamidine. Intravenous pentamidine, 4 mg/kg monthly, is used initially after allogeneic transplantation in order to avoid possible myelosuppression resulting from TMP-SMX use and patients' inability to consistently take medications by mouth. The aim of this study was to retrospectively review intravenous pentamidine usage in a dedicated academic pediatric stem cell transplantation center with the intent of characterizing its use and identifying PCP breakthrough rates in patients who received intravenous pentamidine.
METHODS: Patients who received intravenous pentamidine at Riley Hospital for Children from January 1, 2007, through December 31, 2011, were identified. Patients eligible for study inclusion were

≤18 years old who had undergone allogeneic stem cell transplantation and had received at least 1 dose of intravenous pentamidine during their admission. The following data were collected: patient demographics, pentamidine dosage information, premedications received prior to pentamidine dosage, reported adverse effects of pentamidine, microbiology data confirming the diagnosis of pneumocystis pneumonia, and any alternative PCP prophylactic therapies the patient received during the study time period.

RESULTS: A total of 83 patients received intravenous pentamidine during the study period. The most common diagnoses resulting in allogeneic stem cell transplantations were acute lymphoblastic leukemia, acute myeloid leukemia, immunodeficiency, and hemophagocytic lymphohistiocytosis. These 4 diagnoses resulted in 79% of allogeneic stem cell transplantations at Riley Hospital for Children over the 5-year period. Myeloablative regimens were used as the preparative regimen in 74% of cases. Bone marrow served as the stem cell source in 46% of patients, compared to 51% of patients who received cord blood transplants. In 73% of cases, patients received transplants from a matched unrelated donor. All 83 patients received 4 mg/kg monthly doses of intravenous pentamidine immediately after transplantation. In total, the study population received 249 doses of intravenous pentamidine during the study period. No patients developed PCP pneumonia, and there were no noted intolerances to intravenous pentamidine.

CONCLUSIONS: Our results confirm that the use of intravenous pentamidine is an effective and safe alternative PCP prophylaxis strategy in patients immediately following allogeneic stem cell transplant. Over a 5-year period, no patients receiving intravenous pentamidine at our institution developed breakthrough PCP. This strategy allowed patients to avoid the myelosuppressive effects of TMP-SMX in the critical engrafting period. Once patients were fully engrafted, they were able to transition to the oral, preferred PCP prophylactic therapy TMP-SMX.

FACTORS ASSOCIATED WITH USE OF INTERMITTENT INTRAVENOUS POTASSIUM REPLACEMENT IN A PEDIATRIC INTENSIVE CARE UNIT.

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INTRODUCTION: Critical illness increases the likelihood of significant hypokalemia, requiring intravenous (IV) supplemental potassium (K+). IV K+ is a high-alert medication that ranks among the top 5 most alerted medications. To determine the risk associated with the use of this medication, this study aimed to identify the reasons for use of intermittent IV K+ in pediatric intensive care patients and to assess the relationship between the underlying causes of hypokalemia and the number of intermittent intravenous K+ doses given.

METHODS: The study was conducted at Children's Hospital of Los Angeles (CHLA), a 347-bed nonprofit academic and specialty pediatric care facility. A retrospective analysis of all orders for intravenous potassium replacements in the pediatric intensive care unit between May 1, 2012, and June 30, 2012, was conducted. The primary outcome to be measured was the identification of contributing factors for hypokalemia. Each order was designated as a surrogate for a hypokalemic episode. Data obtained included patient demographics, renal function parameters, identifiable causes of hypokalemia, and serum K+ levels pre- and postinfusion and doses (mEq/kg). In addition, we noted any presence of supplemental potassium and occurrence of adverse events postinfusion. Descriptive statistical analysis was used to interpret the results.

RESULTS: Thirty-five patients received a total of 164 intermittent IV potassium replacements. Analysis of causative factors showed that 140 orders (85%) were used to correct medication-related hypokalemia due primarily to loop diuretics and liposomal amphotericin B (Ambisome). Of these 140 orders, 115 (82%) were for 23 patients receiving loop diuretics, 22 (15%) were for 2 patients (1.5%) taking liposomal amphotericin B, and 3 orders (1.5%) were to correct insulin-related hypokalemia. Hypokalemia due to decreased oral intake accounted for 23 orders (14%). Four patients had hypokalemia due to mixed origins. Furthermore, 19 prescription orders (12%) were for mild hypokalemia, 89 (54%) for moderate hypokalemia, and 53 (32%) for severe hypokalemia. Among the 35 patients, 7 patients (22.2%) required >5 correctional doses. These included 2 patients receiving liposomal amphotericin B and 5 patients taking loop diuretics. One patient receiving liposomal amphotericin B required 14 doses over 7 days, whereas the other received 8 doses over 5 days. Five of the 23 patients taking loop diuretics received between 6 and 16 doses. No incidence of hyperkalemia resulted in any of the patients in whom intermittent IV potassium replacement was used.

CONCLUSIONS: Loop diuretics and amphotericin B were the most common contributing factors to hypokalemia requiring intermittent intravenous potassium K+ doses in the pediatric intensive care unit, despite being given potassium supplements. Further research may clarify whether patients taking these two medications could benefit from earlier use of potassium supplementation or anticipatory increases in supplemental doses as a standard of care.

RETROSPECTIVE EVALUATION OF RASBURI-

CASE USE FOR THE MANAGEMENT OF TUMOR LYSIS SYNDROME AT A SINGLE PEDIATRIC INSTITUTION.

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An expert panel of the American Society of Clinical Oncology (ASCO) published its most recent guidelines in 2008 on the management of tumor lysis syndrome (TLS) in adults and children. This paper addresses the use and dosage of rasburicase, a recombinant urate oxidase enzyme, in patients at low, intermediate, and high risk for developing TLS. The medication review evaluated compliance with these guidelines regarding rasburicase use at a pediatric institution. Data collected from computerized records of patients between January 1, 2004, and September 30, 2013, served as the primary source for analysis. Patients included in the review were between 0 and 18 years of age and received at least 1 dose of rasburicase for the management of hyperuricemia secondary to TLS. A total of 41 patients (mean age, 8.6 ± 5.3 years) were categorized for review according to risk: low (50%), intermediate (7%), and high (43%). They received a total of 58 doses of rasburicase. Eighty-four percent (84%) of rasburicase doses were warranted based on ASCO guidelines, however dosage calculations that would be based on patient weight and would consider vial size were appropriate in only 66% of administrations. In order to ensure compliance with ASCO guidelines, an institution-specific protocol and associated order-set were proposed to assist prescribers with dosage at the time of patient presentation.

GRAM-POSITIVE CENTRAL NERVOUS SYSTEM INFECTION AND CONTINUOUS INFUSION PENICILLIN: A NOVEL METHOD OF DRUG ADMINISTRATION.

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INTRODUCTION: Continuously infusing beta-lactam antibiotics increases the amount of time the concentration of free drug is above minimum inhibitory concentration (MIC). By optimizing this pharmacodynamic target, it is theorized that patients receiving a beta-lactam by continuous infusion could have improved outcomes, especially for infections caused by organisms with high MICs. Most pediatric reports involve treating Gram-negative infections outside the central nervous system. Additionally, most of the available reports use beta-lactams such as piperacillin/tazobactam or ceftazidime. Reports supporting the use of continuous infusion penicillin for the treatment of Gram-positive infections are lacking. Also, reports supporting its use for the treatment of central nervous system infections are limited to a single case. We report the use of continuous infusion penicillin in a 13-year-old whose diagnosis of Pott's puffy tumor was complicated by orbital cellulitis and abscesses caused by *Staphylococcus aureus* infection.
CASE: A 13-year-old, 64-kg male had a diagnosis of sinusitis and was started on amoxicillin. Despite treatment, the patient developed swelling of his left eye and forehead. This prompted a visit to an emergency room, where a computed tomography (CT) scan revealed frontal sinusitis with frontal bone osteomyelitis. Secondary to these findings, the patient was transferred to a children's hospital. Initial laboratory values were remarkable for an elevated white blood cell count, C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR). Following magnetic resonance imaging (MRI) results demonstrating a frontal epidural abscess, extraconal abscess, frontal bone osteomyelitis, and a subperiosteal abscess were diagnosed with Pott's puffy tumor complicated by orbital cellulitis and multiple abscesses. He was presumptively started on vancomycin, cefotaxime, and metronidazole. Blood, sinus, and abscess cultures grew *S aureus* sensitive to penicillin. Based on these findings, vancomycin, cefotaxime, and metronidazole were discontinued, and penicillin G potassium, 20,000,000 units per day via continuous infusion, was started. On day 17 of hospitalization, the patient underwent his last sinus debridement. At that time, his white blood cell count, CRP, and ESR had normalized. Follow-up imaging showed resolution of the epidural abscess and improvement of the extraconal abscess. He was discharged to complete a 42-day course of continuously infused penicillin G.
CONCLUSIONS: Continuous infusion penicillin G appears to be effective for treatment of central nervous system infections caused by Gram-positive microorganisms.

INFLIXIMAB, REPEAT IMMUNE GLOBULIN (IVIG), OR BOTH FOR REFRACTORY KAWASAKI DISEASE: A 14-MONTH REVIEW AT AN ACADEMIC TERTIARY CARE CENTER.

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INTRODUCTION: A single dose of intravenous immunoglobulin (IVIG) along with high-dose aspirin remains the standard of care for Kawasaki disease (KD). There is, however, a subset of children for whom this therapy fails and who require further treatment. To date, the best second-line regimen remains unclear. We compared clinical outcomes of children with refractory

KD who were subsequently treated with 3 different regimens: additional IVIG (group 1); infliximab (group 2); or additional IVIG plus infliximab (group 3).

METHODS: This was a retrospective review of patients with refractory KD (defined as failure of the primary therapy, with rising c-reactive protein (CRP), development of coronary artery abnormalities on echocardiogram, or recurrence of fever (temperature, ≥38°C), diagnosed between January 1, 2013, and February 18, 2014, at our institution. Duration of fever (on presentation and posthospitalization), CRP (on presentation), length of hospital stay, and coronary artery dimensions using Boston Z-scores (at baseline and 6-week follow-up) were recorded and compared among treatment groups.

RESULTS: Seventy-one patients were diagnosed with KD during the study period, and 26 cases (37%) were considered refractory (n=11, group 1; n=8, group 2; n=7, group 3). Baseline demographics were similar among groups, except patients in group 2 were younger (group 1, 66±45 months; group 2, 27±35 months; group 3, 53±30 months). One patient in group 2 presented with an echocardiogram-confirmed coronary aneurysm, which resolved at 6 weeks. Boston Z-scores for each of the 3 coronary arteries (LCA, LAD, and RCA) were evaluated at 6 weeks and were compared to baseline values. These values were 0.33, 0.61, −0.71 (group 1); 2.14, 1.87, 2.02 (group 2); and 0.36, 0.72, 0.05 (group 3), respectively. Time to normal temperature was 4.1±2.2 days (group 1); 1.4 ± 0.7 days (group 2); and 4.9±3.0 days (group 3); and hospital stay was 7.2±3.5 days (group 1); 3.9±0.6 days (group 2); and 9.7±3.6 days (group 3). Hospital readmission rates secondary to fever recurrence were 9%, 13%, and 29% for groups 1, 2, and 3, respectively.

CONCLUSIONS: Children with refractory KD experienced greater improvement in coronary artery measurements, faster resolution of fever, and shorter hospital stay with infliximab alone than those treated with additional IVIG or additional IVIG plus infliximab. Readmission rates were lowest in the additional IVIG group. These results could serve as a platform for further clinical and pharmacoeconomic research surrounding secondary treatment options for KD.

EVALUATION OF THE INCIDENCE OF DELIRIUM IN A PEDIATRIC INTENSIVE CARE UNIT AND THE MEDICATIONS ADMINISTERED ON DELIRIUM POSITIVE DAYS.

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INTRODUCTION: Delirium is a fluctuating, acute disturbance of cognition and consciousness. It can be difficult to detect and affects patients of all ages. Delirium in critically ill hospitalized adult patients is associated with poor outcomes, including a longer length of hospital stay and increased mortality. It may be associated with the use of central nervous system-altering medications such as opioids and benzodiazepines or the withdrawal from these medications. Delirium is divided into 3 subtypes: hyperactive, hypoactive, or mixed. Patients with hyperactive delirium are usually agitated and restless and more commonly have a diagnosis of delirium because of the higher level of disturbance to hospital staff. Hypoactive and mixed delirium are more common than hyperactive type and are also associated with the same poorer outcomes. Reports of occurrence, treatment, and associated outcomes of delirium in critically ill children are lacking. The purpose of this study was to determine the incidence of delirium in critically ill children and to review the medications these patients received while positive for delirium.

METHODS: This study was a retrospective, descriptive study of patients who were admitted to the pediatric intensive care unit (PICU) at an inner city teaching hospital between December 1, 2013, and December 31, 2013. Patients were assessed for delirium using the Cornell-Pediatric Assessment for Delirium (CAP-D) tool. Intubated patients were evaluated using this tool at minimum every 4 hours, and non-intubated patients were evaluated every 12 hours. Patients were considered to have delirium on a given day if any score was 10 or greater according to the CAP-D tool. On days the patients were positive for delirium, the medications that were administered were examined, and medications that have been associated with causing delirium in other studies or that have central nervous system effects were tallied and reported.

RESULTS: A total of 15 patients were positive for delirium during the month-long study period. The patients ranged from less than 6 months of age to 21 years. The estimated census on these days was 20, and the total number of patients with delirium ranged from 0 to 5 each day, giving a daily incidence of 0% to 25%. Among all patients, there were a total of 56 delirium-positive patient days. Benzodiazepines were administered on 43 of the 56 days, whereas opioids were administered for 47 days. Dexmedetomidine was administered a total of 31 days, whereas clonidine was administered 19 days. Other medications that were administered included antiepileptics, barbiturates, ketamine, and others.

CONCLUSIONS: The incidence of delirium in the PICU varied from 0% to 25%. Most patients experiencing delirium were receiving at least 1 centrally acting agent that could contribute to mental status changes. Further study is needed to determine what role, if any, these agents play in the development of delirium.

INTRAMUSCULAR LORAZEPAM FOR BREAKTHROUGH SEIZURES IN CHILDREN WITH COMPLEX MEDICAL AND PHYSICAL DISABILITIES.
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INTRODUCTION: Status epilepticus (SE) is a medical emergency associated with prolonged seizures or recurrent seizures, without regaining complete consciousness. Many children admitted to The Children's Center (TCC) experience SE, and none of these children has intravenous access, making treatment challenging. A treatment protocol was developed that included intramuscular (IM) lorazepam followed by a repeated dose as needed and rectal diazepam if seizures persisted for >15 minutes. There is a paucity of data for IM lorazepam in children. The purpose of this study was to evaluate IM lorazepam's effectiveness in managing seizures lasting longer than 5 minutes.
METHODS: This was an institutional review board-approved, retrospective, descriptive study of children, 0 to 19 years old with complex medical and physical disabilities, from June 1, 2007, through May 1, 2012, at TCC, who received at least 1 IM dose of lorazepam for SE. Data collection included demographics, data pertaining to SE treatment (IM lorazepam and rectal diazepam regimen), baseline seizure types, and pertinent baseline antiepileptic regimens. As many patients at TCC have frequent seizures, only the first 5 SE episodes were included for analysis. The primary objective was to identify the number of IM lorazepam doses required to achieve cessation of SE. Secondary objectives included determining the mean IM lorazepam dose per episode and number of patients who required rectal diazepam. Descriptive and inferential statistics were performed. A multiple logistic regression was used to the asses the relationship between SE resolution and independent variables. Data analyses were conducted using Stata version 13.1 software (Stata, College Station, TX), with a p value of <0.05.
RESULTS: Sixty-two patients were included for analysis, representing 194 separate SE episodes. The median age of patients was 6.5 years old (range, 0.6-19 years) with a median weight of 19.2 kg (range, 2.6-58.5 kg). The mean number of episodes per patient was 3.1±1.6. The mean number of lorazepam doses administered per episode was 1.2±0.05. The mean IM lorazepam dose administered was 1.4±0.8 mg or 0.07±0.05 mg/kg/dose. Rectal diazepam was administered in 9 SE episodes (4.6%). Seizure resolution was noted in 86 episodes (44.3%). Children given more than 1 dose of IM lorazepam had a 79.5% decrease in the odds of seizure resolution (odds ratio, 0.205; 95% confidence interval, 0.046-0.909; p=0.037).
CONCLUSIONS: This is one of the first studies to evaluate the use of IM lorazepam for SE treatment in this pediatric subpopulation. The number of seizure episodes in this cohort was noticeable. SE resolution was noted in fewer than half of the episodes. These results highlighted the need to make changes to the existing protocol.

INITIAL ENOXAPARIN DOSE REGIMENS IN PEDIATRIC CARDIAC INTENSIVE CARE PATIENTS: A RETROSPECTIVE COHORT STUDY.
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PURPOSE: The objective of this study was to determine whether the current enoxaparin dose regimen used in the pediatric cardiac intensive care unit (PCICU) at a large academic medical center was more effective at achieving therapeutic anti-factor Xa activities without a significant increase in bleeding events than the national guideline-recommended dose regimen.
METHODS: This was a single-center, retrospective, review of PCICU patients younger than 12 months of age who were started on a treatment regimen of enoxaparin. The treatment regimen was defined as at least 4 doses of enoxaparin, between 1 and 2 mg/kg every 12 hours. Exclusion criteria included patients with anti-factor Xa activities that were not monitored or were not drawn 4 to 6 hours after the fourth or greater dose of enoxaparin, patients who had been prescribed other anticoagulants which affect anti-factor Xa activities within 48 hours, or those who had a known history of a clotting disorder.
RESULTS: Seventeen patients received the guideline-recommended dose regimen, and 29 patients received the University of Rochester Medical Center (URMC) dose regimen. The URMC dose regimen group achieved initial therapeutic anti-factor Xa activities significantly more often than the American College of Chest Physicians *Chest* guideline group (65% vs. 35%, respectively, p=0.0348). The patients in the guideline group had significantly more subtherapeutic initial anti-factor Xa activities than the URMC dose regimen group (43% vs. 11.5%, respectively, p=0.044). The URMC dose regimen did not result in significantly more supratherapeutic initial anti-factor Xa activities (23% vs.14%, respectively, p=0.69).
CONCLUSIONS: The URMC dose regimen resulted in more initial anti-factor Xa activities in the therapeutic range than the dosage recommendations from national expert guideline without resulting in a significant increase in supratherapeutic activities or occurrence of bleeding events.

EVALUATION OF THERAPEUTIC ENOXAPARIN DOSE REGIMENS AND ANTI-FACTOR XA LEVELS IN ADULT PATIENTS WITH CYSTIC FIBROSIS.

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INTRODUCTION: Cystic fibrosis (CF) patients have risk factors for venous thromboembolism (VTE) formation secondary to vitamin K deficiency and hepatic dysfunction, chronic inflammation, hyper-reactive platelet function, and chronic use of central venous catheters. They also have a high concomitant bleeding risk and increased hemoptysis risk secondary to vitamin K deficiency and pulmonary inflammation. All adult patients with CF treated for a VTE with enoxaparin at Nationwide Children's Hospital have anti-factor Xa levels monitored to follow the safety and efficacy of the anticoagulation. The initial dose regimen is 1 mg/kg every 12 hours with the goal anti-factor Xa level of 0.5 to 1 U/mL. This study investigated whether the current empiric enoxaparin dose regimen used in adult CF patients at a children's hospital was effective at achieving therapeutic anti-factor Xa levels.
METHODS: Retrospective analysis of 46 adult CF patients receiving enoxaparin was carred out between January 2008 and October 2013. This study was approved through an expedited institutional review board review. The patients' electronic medical records were reviewed from the time of administration of the first dose until completion of therapy. Patients in whom anti-factor Xa levels were not monitored or drawn 4 to 6 hours postdose and patients who received prophylactic doses of enoxaparin were excluded. Data evaluated for the outcomes of the study included the initial dose of enoxaparin (mg/kg) and incidence of initial subtherapeutic and supratherapeutic anti-factor Xa levels, number of dose changes needed until anti-factor Xa levels became therapeutic, time to first therapeutic anti-factor Xa level, and dose (mg/kg) that achieved a therapeutic anti-factor Xa level, anti-factor Xa levels throughout the treatment course, duration of anticoagulation therapy, thrombus resolution, need for central line removal, bleeding incidence, and progression or recurrence of the clot. Outcomes were analyzed using descriptive statistics.
RESULTS: Seven patients received the current standard adult enoxaparin dose regimen of 1 mg/kg every 12 hours. The median initial anti-factor Xa level achieved was 0.6 U/mL. The median number of days until therapeutic was 2, and the median dose required to achieve therapeutic levels was 1 mg/kg every 12 hours. Four of 7 patients experienced minor non-pulmonary bleeding. Two patients experienced hemoptysis; however, only 1 episode could be described as clinically relevant.
CONCLUSIONS: The current empiric enoxaparin dose regimen used in adult CF patients at a children's hospital is effective at achieving therapeutic initial anti-factor Xa levels of 0.5 to 1 U/mL without an increase in incidence of clinically relevant bleeding events. The altered pharmacokinetic profiles associated with CF patients do not seem to have an effect on anti-factor Xa levels.

THERAPEUTIC DRUG MONITORING OF ITRACONAZOLE IN PEDIATRIC PATIENTS.

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INTRODUCTION: Itraconazole is an oral triazole antifungal agent used for the prevention and treatment of fungal infections. A plasma itraconazole concentration of ≥0.5 mcg/mL when used prophylactically has shown to result in a decreased incidence of invasive fungal infections (IFIs) and mortality in adult patients. Pharmacokinetic variability and significant drug interactions cause interpatient variability warranting therapeutic drug monitoring. This project was designed to evaluate standard itraconazole dosage (5-10 mg/kg/day divided twice daily) and achievement of therapeutic plasma concentrations in pediatric patients.
METHODS: Washington University Institutional Review Board approved a retrospective chart review that identified patients in the medical data base who were receiving itraconazole and had plasma concentrations drawn. Patients were included between January 1, 2011, and June 30, 2013. Patients with allergic bronchpulmonary *Aspergillus* infection were excluded. The primary outcome examined achievement of therapeutic itraconazole concentration in correlation with standard dosage. Secondary outcomes included the correlation of itraconazole dose with target level attainment as well as any additional factors that might have affected reaching the target level. These factors included underlying medical conditions, indication for itraconazole, and concomitant medications. Descriptive statistics were used for patient and dosage characteristics; Student *t*-test and analysis of variance were used to compare continuous variables, and chi-square test was used to compare nominal variables.
RESULTS: Standard dosage of itraconazole resulted in poor target level attainment (53%) in our population of pediatric patients. Initial itraconazole dosage had poor linear correlation with plasma itraconazole concentrations (r = 0.051). Acid suppression, patients with hematologic malignancies or previous stem cell transplantation, and formulation had significant effects on plasma concentration levels. Concomitant used of

CYP 3A4 inducers or inhibitors did not significantly affect plasma concentrations.
CONCLUSIONS: Pediatric patients receiving standard dosage of itraconazole (5-10 mg/kg/day) had poor target level achievement. Factors that may influence this are dose, acid suppression, patients with hematologic malignancies or previous stem cell transplantation, and formulation.

VANCOMYCIN AUC/MIC AND CORRESPONDING TROUGHS IN A PEDIATRIC POPULATION.
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INTRODUCTION: Guidelines for adult dosage recommend an area under the curve/minimum inhibitory concentration (AUC/MIC) >400, corresponding to a trough of 15 to 20 mg/dL for vancomycin for a severe *Staphylococcus aureus* infections but obtaining these troughs in children is difficult. The primary objective of this study was to assess the likelihood that at least 15 mg/kg every 6 hours (60 mg/kg/day) in a child would achieve an AUC/MIC >400 for *S aureus* infection. Secondary objectives included comparison of the different methods used to calculate AUC, using only a trough concentration, and an assessment of clinical outcomes with an AUC/MIC >400.
METHODS: This retrospective chart review included any pediatric patient between >2 months and <18 years of age at an inner city teaching hospital from July 1, 2007, to August 30, 2013, with an *S aureus*-positive blood culture and a documented MIC that received at least 2 doses of vancomycin with a corresponding trough level. Those patients undergoing dialysis or with an abnormal serum creatinine level for their age were excluded. Patients were divided into 2 groups. Group 1 included any patient receiving ≥15 mg/kg every 6 hours, and group 2 included all other dosage ranges and intervals. AUCs were calculated using 2 methods, and lengths of stay, intensive care unit (ICU) stay, and time to negative blood cultures were compared.
RESULTS: A total of 45 patients with 99 vancomycin troughs were assessed. There were 58 isolates positive for methicillin-resistant *S aureus* (MRSA) infection (58.59%), with an average MIC of 1.3. Baseline characteristics were similar for the groups, except more patients in group 2 (n = 4) were admitted to shock trauma than in group 1 (n = 0). For the troughs evaluated in group 1 (n = 71), the probability of achieving an AUC/MIC >400 ranged from 14% to 61% with an average trough of 14.27, whereas in group 2, the probability of achieving the AUC/MIC >400 ranged from 21% to 57% with an average trough of 12.53 mg/dL. The AUC/MIC ratios differed between the 2 methods used to calculate the AUC/MIC; the method using the patient's creatinine clearance yielded the lowest probability in groups 1 (14%) and 2 (21%). Average hospital length of stay was shorter for those with AUC/MIC >400 than for those with AUC/MIC <400, 27.0 versus 43.13 days, respectively (p=0.05), as was the ICU lengths of stay of 14.28 compared to 35.31 days, respectively (p=0.04). Times to first negative blood cultures were similar between these groups, 2.21 versus 1.95 days, respectively (p=0.36).
CONCLUSIONS: The probability of achieving an AUC/MIC >400 using only a trough with patients receiving 15 mg/kg every 6 hours is variable based on the method used to calculate the AUC/MIC ratio and ranged from 14% to 61%. The calculated AUC/MIC ratios were not similar between the methods. A decrease in length of stay and ICU days was seen in patients with AUC/MIC >400.

CONTINUED ACUTE KIDNEY INJURY IN CHILDREN AFTER 7 DAYS OF VANCOMYCIN THERAPY.
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INTRODUCTION: Vancomycin is a commonly used antibacterial agent that has been associated with acute kidney injury (AKI) in adults and children. An association between elevated trough concentrations and AKI in both adults and children has been demonstrated. The objective of this study was to determine the incidence and factors associated with continued AKI in a cohort of children categorized as having AKI within the first 7 days of vancomycin therapy.
METHODS: Children ages 1 through 18 years at a free-standing pediatric hospital, who experienced AKI within the first 7 days of their vancomycin course (from January through December of 2007 and 2010) were previously identified and evaluated. This follow-up study specifically examined those patients with AKI to evaluate continued AKI in patients receiving at least 8 days of vancomycin therapy. Patients were included if they received intravenous (IV) vancomycin for at least 72 hours for suspected or proven Gram-positive infection. Serum creatinine and trough concentrations were collected from day 8 of vancomycin therapy through 10 days following vancomycin discontinuation. AKI was defined as an increase in serum creatinine concentration by ≥50% from baseline values. Continued AKI was defined as any AKI identified beyond the first 7 days of treatment.
RESULTS: At total of 164 patients at a median (interquartile [IQR]) age of 2 (1-9) years with AKI identified

within the first 7 days of vancomycin therapy were evaluated. Patients received a mean±SD empiric vancomycin dose of 43.3±15.5 mg/kg/day. Fifty patients (30%) received vancomycin for at least 8 days, and 12 patients (24%) met criteria for long-term AKI. Trough serum concentrations were obtained in 36 patients (72%) after at least 8 days of vancomycin therapy, with a median (IQR) vancomycin trough serum concentration of 11.3 (8-13.9) mg/L. In patients receiving at least 8 days of vancomycin therapy, continued AKI developed in 33.3% versus 25% (p=0.599) of patients with and without any serum trough concentration ≥15 mg/L, respectively. There were no differences in median (IQR) vancomycin trough concentrations between those with and without continued AKI (10.9 [IQR, 10.2-13.9] and 11.6 [IQR, 7.4-14]), respectively; p=0.855]. Rates of intensive care unit admission did not differ between patients with and those without continued AKI (22.9% vs. 26.7%, respectively; p=0.773).
CONCLUSIONS: Continued AKI occurred in 24% of children who were initially identified as having AKI within the first 7 days of vancomycin therapy and also received vancomycin therapy for at least 8 days. These findings raise additional questions about the indicative value of changes in serum creatinine concentration observed early in the vancomycin course for predicting continued AKI.

TRENDS IN PHARMACY COSTS BY DIAGNOSTIC CATEGORIES AT A PEDIATRIC HOSPITAL.
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OBJECTIVE: Health care cost continues to increase unsustainably. In order to develop a practical solution to controlling health care cost, it is beneficial to evaluate areas of highest consumption where interventions can decrease cost and add value. Our objective was to describe the trends of drug cost by diagnostic categories tracked by a pharmacy database at a pediatric hospital.
METHODS: A comprehensive report of drug costs over the last 5 years was generated for various diagnostic classifications by using records of inpatient admissions retrieved from an electronic data warehouse within Intermountain Healthcare. Diagnostic classifications were based on either All Patient Defined Diagnosis-Related Group (APR-DRG) or International Classification of Diseases, ninth revision (ICD-9), codes. Pharmacy utilization was tabulated according to the diagnostic category in which the admission was billed at the time, such that end users could compare aggregate utilization trends from one time period to another for the same diagnostic category. Tabulated information included number of cases by diagnostic category, average length of stay, total drug cost, drug cost per case, drug cost per day, and percentage of drug cost compared to overall admission cost. Elements are introduced into the database in real time, and end users are able to access and view the interactive report at any time.
RESULTS: Over the last 5 years, pharmacy utilization has risen more than 15% but has slowly stabilized in recent years at an average cost per case of $1653 ($1514-$1822) and $317 ($277-$342) per day. The percentage of pharmacy utilization compared to overall admission cost has remained relatively unchanged at approximately 9.8%. The top 5 APR-DRG groupers are neonates with perinatal conditions, myleoproliferative diseases, and diseases and disorders of the digestive, respiratory, and circulatory system. The top 5 ICD-9 groupers are maintenance chemotherapy, cardiac congenital anomalies, perinatal conditions, congenital conditions, and leukemias. Diagnoses with a significant increase in cost per case over 5 years are leukemia and neonates with perinatal conditions, at rates of 83% and 92%, respectively. The highest total drug cost for both APR-DRG and ICD-9 codes is chemotherapy. The APR-DRG with highest drug cost per case is bone marrow transplantation at $46,692, accounting for 29.1% of total admission cost, and the highest drug cost per day is male reproductive malignancy at $2422, accounting for 69%. The ICD-9 with the highest drug cost per case is disorders of lipid metabolism at $45,378, accounting for 13.7%, and the highest drug cost per day is poisoning by non-medicinal substances at $2773, accounting for 52.7%.
CONCLUSIONS: With initiatives to lower health care cost and utilization, hospital systems will need to implement tools for evaluating progress toward meeting quality indicators. Development of a report analyzing drug cost and utilization allows the user to target specific diagnoses associated with larger expenditures and develop cost-saving initiatives.

EVALUATION OF INFUSION-RELATED REACTIONS AND ADVERSE EVENTS ASSOCIATED WITH AMPHOTERICIN B LIPID COMPLEX (ABELCET) IN CHILDREN COMPARED TO ADULTS.
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INTRODUCTION: Since 1959, conventional deoxycholate amphotericin B has been the gold standard of antifungal treatment. However, the high incidence of adverse events resulted in the more frequent use of less toxic lipid formulations such as amphotericin B lipid complex (ABLC). Although the incidence of adverse events is lower with the lipid formulations, adverse events are still a concern. One study noted a difference in nephrotoxicity incidence between adults over 60

years old and children less than 13 years, but no studies directly compare the incidence of infusion-related reactions and adverse events in children versus those in adults. The purpose of this study was to characterize and compare the incidence of infusion-related reactions (IRR), hypokalemia, hypomagnesemia, and nephrotoxicity associated with ABLC in children versus that in adults.

METHODS: This study was a retrospective, descriptive study of patients who received ABLC during their admission to University of Maryland Medical Center between September 1, 2009, and August 31, 2011. Patients were excluded from nephrotoxicity analysis if they received renal replacement therapy at the time of ABLC treatment. Demographic data were collected to characterize the nature of ABLC use. Data collected to characterize the incidence of adverse events included use of medications to treat infusion-related reactions, documentation of IRR, baseline and nadir concentrations of potassium and magnesium, use of potassium and magnesium supplements, and maximum serum creatinine concentration. Incidence of IRR and adverse events in children were compared to those in adults. Nephrotoxicity was defined according to risk, injury, failure and loss, and end-stage (RIFLE) and pediatric RIFLE (pRIFLE) criteria guidelines. Chi-square and Mann-Whitney *U* tests were used to analyze data collected.

RESULTS: ABLC therapy was ordered for 126 patients during the 2-year study period, but 11 patients were excluded due to discontinuation of the order. Of the 115 included patients, 92 were adults and 23 were children. The incidence of IRR after ABLC in adults was 28% (26 of 92) compared to 21% (5 of 23) for pediatric patients (p=0.71). The incidence of nephrotoxicity associated with ABLC in adults was 13% (12 or 92) compared to 0% (0 of 23) in children (p= 0.06). The incidence of clinically significant hypokalemia associated with ABLC therapy in adults was 25% (23 of 92) and 9% (2 of 23) in children (p=0.07). The incidence of clinically significant hypomagnesemia in adults was 9% (8 of 92) and 4% (1 of 23) in children (p=0.43).

CONCLUSIONS: The incidence rates of IRR were not significantly different between adults and children receiving ABLC. There were no differences between associated nephrotoxicity or electrolyte abnormalities in children and those in adults.

ACETAMINOPHEN EXPOSURE IN PEDIATRIC PATIENTS.

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INTRODUCTION: There have been several case reports and studies elucidating the fact that chronic exposure to acetaminophen, even at therapeutic doses, may pose a higher risk of severe toxicity than an acute one-time overdose. In pediatrics, acetaminophen dosage is 10 to 15 mg/kg/dose every 4 to 6 hours, with a maximum dose of 75 mg/kg/day or the adult maximum of 4 g/day. In accordance with the risk of toxicity from chronic exposure, some practitioners may recommend limiting the total dose of acetaminophen to 175 mg/kg over 2 to 4 days. A previous quality improvement project was performed within the institution's adult patient population to determine the number of patients who received more than 4 g/day. Two months of data revealed 0.73% of 10,419 patients received more than 4 g/day. The primary focus of the current study was to investigate acetaminophen use and risk of toxicity in pediatric patients admitted to an inpatient care facility. Additionally, the study determined the need for an electronic calculator to track the patient's total daily exposure to acetaminophen or for an automatic discontinuation of acetaminophen orders after 72 hours.

METHODS: A retrospective chart review of patients aged 0 to 18 years old who received acetaminophen during their admission between January and March of 2012 and 2013 was performed. Participating children were identified by doses charted in the electronic medical record for any acetaminophen-containing products during their stay. Patient age, weight, administered doses, administration dates and times, total number of doses received, and the number of acetaminophen-containing products administered to the patient were included in the data collected. Patients were excluded if they had an order for an acetaminophen-containing product but never received a dose. The total daily dose of acetaminophen was calculated for rolling 24- and 96-hour periods.

RESULTS: A total of 2591 patients were identified as having received acetaminophen during the study period and were included in the analysis. Thirty-nine patients (1.5%) received total daily doses greater than 75 mg/kg/day, with 17 (0.7%) receiving greater than 90 mg/kg/day. Of the patients who received more than 75 mg/kg/day, 40.9% received a cumulative dose greater than 175 mg/kg in 4 days. Additionally, 41.2% of patients who received more than 90mg/kg/day had also received a cumulative dose greater than 175 mg/kg in 4 days. Of the patients who received more than 175 mg/kg in 4 days, 88.9% had been receiving doses greater than 75 mg/kg/day.

CONCLUSIONS: In pediatric patients to whom acetaminophen was administered, 1.5% had received a total daily dose greater than 75 mg/kg/day. Of these patients, 41% exceeded the concerning 175 mg/kg over 4 days. The creation of a cumulative electronic calculator, which was reported to be successful in other institutions, could alert staff and prevent future excessive acetaminophen exposure.

PROTEIN AND ENERGY INTAKE DURING THE FIRST WEEK OF LIFE AND BRAIN GROWTH AND DEVELOPMENT IN PRETERM NEONATES.

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INTRODUCTION: Preterm neonates are at high risk for postnatal growth failure. Inadequate nutrition may result in anthropometric growth failure and decreased brain growth, contributing to neurodevelopmental impairment. Early aggressive provision of protein and calories has been postulated to influence brain growth and maturation. The purpose of this study was to determine the association between early protein and energy intake in preterm neonates and brain growth and development at term-equivalent age.
METHODS: A retrospective chart review was performed to collect clinical data from a cohort of preterm neonates. This cohort was originally enrolled in a single-center, longitudinal cohort study evaluating brain magnetic resonance imaging (MRI) at term-equivalent age. Data collected for each patient included nutrition source and daily protein, fat, carbohydrate, and energy intake for the first week of life. Brain images were analyzed for both macrostructural growth (brain metrics and volumes) and microstructural development (diffusion and anisotropy). A linear regression analysis was performed to describe the relationship between nutritional variables and MRI measures, controlling for appropriate covariates.
RESULTS: An interim analysis of 40 patients (25 males, 15 females) was used to explore preliminary results. Thirty-seven patients underwent MRI at term-equivalent age, and 9 images were processed for volumetric analysis (to date). The mean gestational age and birth weight values were 26.6±2.0 weeks and 937±238 g, respectively. Increased average protein intake was significantly associated with increased bifrontal ($p=0.003$) and biparietal diameter ($p=0.039$). The correlation between protein intake and biparietal diameter persisted after controlling for gestational age and severity of early illness ($p=0.024$). Increased average protein intake was also associated with increased white matter volume ($p=0.047$), although the significance of this association did not persist after correction for covariates. Increased average energy intake was significantly associated with increased bifrontal diameter ($p=0.028$), transverse cerebellar diameter ($p=0.002$), and transverse cerebellar volume ($p=0.028$). The correlation between energy intake and transverse cerebellar diameter persisted after controlling for gestational age and severity of early illness ($p=0.029$). Neither average protein intake nor average energy intake was associated with differences in white matter microstructure (diffusion or anisotropy) at term-equivalent age.
CONCLUSIONS: Increased protein and energy intake in the first week of life was associated with macrostructural brain growth, primarily in the frontal lobes and cerebellum. Collection of additional patient data is warranted to further explore these findings.

A CASE STUDY OF GRANULOCYTE-STIMULATING FACTOR CAUSING ANAPHYLAXIS IN A YOUNG ADULT.

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INTRODUCTION: Approved uses for recombinant human granulocyte colony-stimulating factor (GCSF) include accelerating neutrophil recovery after myelosuppressive therapy and mobilization of hematopoietic progenitor cells for peripheral blood stem cell collection. Filgrastim is a nonglycosylated *Escherichia coli*-derived 175-amino-acid glycoprotein with an extra N-terminal methionine group, although the pegfilgrastim chemical structure includes a polyethylene glycol modified form of filgrastim. The most common side effects are bone pain, myalgias, and headache. Anaphylactic reactions are rare, but a few cases have been reported.
CASE: Patient was a 19-year-old female with localized osteosarcoma of the right distal femur. She received cisplatin and doxorubicin therapy and was discharged home to self-administer pegfilgrastim subcutaneously 24 hours after chemotherapy. Concurrently, she administered leuprolide injection for fertility preservation. Thirty minutes after giving injections of pegfilgrastim and leuprolide, patient became nauseous and "passed out and turned blue." After aggressive hydration, her sensorium and blood pressure improved. Confounding effects of multiple concomitant drugs made attribution of causality uncertain. Patient received the next cycle in the hospital and was observed having an anaphylactic reaction to pegfilgrastim. Due to the rarity of anaphylaxis to GCSF encountered in published reports and the benefits of its administration in patients receiving chemotherapy, it was decided to keep patient admitted after the third cycle to receive filgrastim. It was not clear if patient was actually allergic to the polyethylene glycol or to an additive in pegfilgrastim. Thirty minutes after receiving filgrastim, patient complained of nausea and became diaphoretic, hypotensive, and cyanotic. A code blue was called, and she was observed in the intensive care unit overnight. After these repeated episodes, patient was declared allergic to filgrastim and pegfilgrastim. Alternative options to prevent serious infections dur-

ing neutropenia include desensitization to filgrastim or use of bacterial prophylaxis. These were presented to the patient, and she opted for the latter. The patient had episodes of prolonged neutropenia, as she was unable to use GCSF, but did not incur severe infections with the use of ciprofloxacin prophylaxis.

DISCUSSION: Anaphylactic reactions to GCSF are rare. Case reports do not state what was used instead of GCSF or if it was omitted from the supportive regimen. It is important to report this case as it adds to the scarce reports about GCSF hypersensitivity. Symptoms suggestive of allergic reaction should prompt inpatient administration of GCSF with close monitoring for anaphylaxis.

CONCLUSIONS: This case serves as a reminder that GCSF administration may be associated with severe hypersensitivity reactions mimicking anaphylaxis. Pharmacists should be familiar with this rare side effect and the options that can be used to reinitiate GCSF or what can be used instead of GCSF.

EVALUATING THE USE INTRAVENOUS PALIVIZUMAB FOR THE TREATMENT OF RESPIRATORY SYNCYTIAL VIRUS INFECTION IN THE PEDIATRIC POPULATION.

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INTRODUCTION: Respiratory syncytial virus (RSV) is a major cause of morbidity and mortality in the pediatric population. Standard management includes supportive care measures. Pharmacologic treatment should be considered in patients who develop severe RSV infection; however, therapy approved by the US Food and Drug Administration (FDA) is limited to ribavirin. Current evidence suggests palivizumab may be beneficial for the treatment of RSV infection, although it is only approved by the FDA for RSV prophylaxis. The purpose of this study was to further describe the use of intravenous palivizumab in the treatment of RSV infection in pediatric patients by comparing patients with RSV infection who were treated with intravenous palivizumab to those who received standard of care (e.g., ribavirin, intravenous fluids, and respiratory support) alone.

METHODS: This was a retrospective, matched cohort study. Patients ≤25 years old with RSV infection treated with intravenous palivizumab after initiation of mechanical ventilation, between November 2003 and October 2013, were matched 1:1 to a control selected from patients who received the standard of care. Patients were matched by sex, age, and admission date. Patients were excluded if they received intramuscular palivizumab for the treatment of RSV infection. RSV was defined by positive rapid antigen test, direct fluorescence antibody test, and/or polymerase chain reaction assay. The primary endpoint evaluated the duration of mechanical ventilation of patients in the treatment versus those in the control group. Secondary endpoints included hospital length of stay (LOS), intensive care unit (ICU) LOS, duration of respiratory support over baseline, time to RSV microbiologic cure, and mortality.

RESULTS: Twenty-two patients were included in the study. Sixty-four percent of patients were male, and the median age was 3 months. All patients received bronchodilators and corticosteroids with the exception of 1 patient in the control group. No patients received ribavirin. High-frequency oscillatory ventilation was used in 64% of treatment patients versus 46% of the control; 1 patient in the treatment group required extracorporeal membrane oxygenation. The average dose of palivizumab was 14.2 mg/kg, and the median number of doses per patient was 2. There were no differences in primary endpoints between patients who received intravenous palivizumab and those who received standard of care (18.9±9.5 vs. 14.3±9.3 days, respectively). Hospital LOS, ICU LOS, and duration of respiratory support were longer for the treatment group; however, time to RSV microbiologic cure was shorter, although not significant. There were no differences in mortality.

CONCLUSIONS: In this pediatric population, patients receiving intravenous palivizumab for treatment of active RSV infection experienced outcomes similar to those who received the standard of care. Unlike previous studies, no patients in this study received ribavirin, therefore intravenous palivizumab was compared to supportive care alone. Additional studies are necessary to further evaluate the potential benefit of palivizumab over supportive and/or the standard of care.

OBESE PEDIATRIC ADMISSIONS AND MEDICATION USE: A MULTICENTER ASSESSMENT.

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INTRODUCTION: Approximately 17% of children 2 to 19 years of age (YOA) in the United States are considered obese. Obesity has been shown to alter the pharmacokinetics (PK) of medications, resulting in supratherapeutic or subtherapeutic dosage. Currently, there are a limited number of reports evaluating PK and dosages of medications in obese children. There is a need to identify which medications are most commonly used in obese children. The purpose of this study was to determine the percentage of admissions involving obese children and to identify the most

commonly used medications in this population at two southwest children's hospitals.
METHODS: This descriptive, retrospective, institution review board-approved study included children 2 to 17 years of age admitted on or after January 1, 2011, and discharged before December 31, 2011, from Texas Children's Hospital (TCH) and The Children's Hospital at OU Medical Center (CHO). Patients were included in the analysis if they were obese, defined by the Centers for Disease Control and Prevention (CDC) as a body mass index (BMI) greater than the 95th percentile for age and sex. Patients were excluded if they were missing data for the admission. BMI percentile was calculated using the CDC pediatric BMI calculator. Demographic data were collected as well as all medication regimens that the patients received during their admission. The primary objective of this study was to determine the percentage of admissions involving obese children. The secondary objective was to identify the top 25 medications used in this population. An in-depth search of reports was performed for each of these medications to determine available evidence to guide dosages in obese children. Descriptive statistics were used for continuous data and percentages for categorical data.
RESULTS: A total of 15,119 admissions occurred during 2011. Obese patients comprised 2,844 (18.8%) of all admissions. There were no statistically significant differences between the percentages of obese admissions in the 2 institutions (18.8% at TCH vs. 18.9% at CHO; p=NS). The admissions were 51% male patients with a mean age of 9.8±4.7 years and BMI percentile of 98.0±1.4. The majority (71%) of admissions of obese patients were from TCH. A total of 28,234 medications were recorded during these admissions. The medication classes in the combined top 25 list included analgesics, antibiotics, and steroids, and benzodiazepines. The top 5 medications prescribed were acetaminophen, morphine, ondansetron, hydrocodone/acetaminophen, and ibuprofen. An in-depth search of reports of the top 25 medications prescribed in this study revealed only 7 publications evaluating dosage or PK in obese children.
CONCLUSIONS: The percentage of obese admissions is slightly higher than previously reported epidemiologic data in the US population. There is limited published evidence of PK and medication dosage for the top 25 medications prescribed in this study. This study highlights the need for future exploration.

ASSESSMENT OF THE UNDERSTANDING OF PEDIATRIC ORIENTED MEDICATION EDUCATION MATERIALS VERSUS STANDARD AVAILABLE EDUCATION MATERIALS.

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INTRODUCTION: Many children require medications to treat chronic illnesses, and adherence is based largely on a patient's understanding of their therapy and disease. Children want to become more involved in their care and develop independence. However, patient medication leaflets and educational materials are typically created for adults. The objective of this study was to determine whether educational material targeting children would improve their understanding of how to take their medication and common side effects.
METHODS: This was a cross-sectional pilot study and was approved by the Institutional Review Board. Seventy children, 7 to 11 years old, were selected from an elementary school. After randomization, children looked at a medication leaflet about levetiracetam that was written at a first grade level or at a medication guide produced by the US Food and Drug Administration for adults. Participants were read the leaflet and then asked standardized survey questions to assess their knowledge about levetiracetam. The survey included questions about the indications, side effects, administration, and their overall impression of the information they received. Demographic data were collected which included age, sex, race, medication history, medical conditions, and the presence of medical providers in the home. Patients with developmental disabilities who were taking the medication described in the leaflet and those who did not speak English were excluded from the study. Data were compared by leaflet group for correct answers. Data were analyzed using the Fisher exact test, chi-square test, and Mann-Whitney *U* test.
RESULTS: Seventy children were screened, and 58 were included in the study. Fifty-six percent of the children were male, 80% were Caucasian, and the average age was 9 years old. There were no statistical differences between demographics in the adult leaflet and those in the pediatric leaflet group. Children were able to correctly state the indication for the medication in 9 of 30 participants (30%) in the adult group and 22 of 28 participants (79%) in the pediatric leaflet group (p=0.002). The question about administration frequency in the pediatric leaflet group (26 of 28) was significantly different from that in the adult leaflet group (22 of 30; p=0.05). For questions about side effects and administration, there were no differences between the groups. The readability and understanding of the leaflets were significantly different in the pediatric group (p=0.001 and p≤0.001, repectively).
DISCUSSION: Leaflets developed for children improved knowledge regarding indication of the medication and administration frequency. There were no differences in knowledge about side effects and how to take the medication, which could be due to those open-ended questions used in the survey. Overwhelm-

ingly, study participants thought the pediatric leaflet was easy to read and understand. Limitations for this study include the fact that the leaflet was read to participants and the results are from one site.
CONCLUSIONS: Medication leaflets designed for children improve the understanding of the indication and the frequency of administration.

ASSESSING CAREGIVER KNOWLEDGE OF THE AMERICAN ACADEMY OF PEDIATRICS VITAMIN D GUIDELINES.

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INTRODUCTION: Despite an increase in media coverage, many caregivers remain unaware of the benefits and recommended daily intake of vitamin D for their child's health. As trusted health care providers, pharmacists are in a position to improve patients' health by providing current information to patients. The primary objective of this study was to determine the percentage of caregivers from an inner city clinic that were knowledgeable about the American Academy of Pediatrics (AAP) recommended daily intake of vitamin D. Secondary objectives were to determine the public perception about various health care providers and how information about vitamin D from these health care providers would be received by the community. We hypothesized that 25% of caregivers are knowledgeable about the AAP recommendations.
METHODS: This study was granted an exemption by the Institutional Review Board. An 11- question survey was administered verbally to caregivers of children ages 0 to 17 years at a single inner city pediatric clinic to assess caregivers' familiarity with the health risks, recommended daily intake, and sources of vitamin D. The questions also asked about trusting information from various providers and determining if any of the providers had provided vitamin D information. The survey was written at a sixth-grade level with multiple choice, Likert scale, and open-ended questions. Upon completion of the survey, participants were given an educational handout about vitamin D. To confirm our hypothesis with 95% confidence, we needed 204 caregivers to complete the survey. Data were collected over 6 months and analyzed using chi-square test.
RESULTS: A total of 224 caregivers completed the survey. Most caregivers perceived vitamin D to be very important for their child's health, but only 22% were able to identify the AAP-recommended daily intake. Ninety-three percent of caregivers said they would trust information from pharmacists, and 85.7% said they would very likely or absolutely read an informational sheet on vitamin D provided by pharmacists. Study limitations include possible recall bias, a single-site study, and pressure to answer positively about pharmacists, as the surveyors identified themselves as student pharmacists.
CONCLUSIONS: These findings suggest that caregivers have inadequate knowledge of vitamin D supplementation. Pharmacists can potentially improve health outcomes in children by providing accurate, current health information on vitamin D to caregivers of children, but this would need further investigation to determine the impact.

DOES TRUST IN THE PHARMACIST CORRELATE WITH IMPROVED ASTHMA OUTCOMES? A PILOT STUDY.

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INTRODUCTION: Pharmacists are trusted health care professionals who have an important role in assisting children in properly using their medications. Patients who trust their physician have improved health outcomes, but this has not been documented with pharmacists and asthma patients. The purpose of this pilot study was to determine whether parents of children with asthma who trust their pharmacist regarding inhaler information have improved asthma control.
METHODS: Data for this study were obtained between May 25, 2010, and September 12, 2011, from a pilot study of inhaler use in urban, under-served children with poorly controlled asthma. Caregivers of children with asthma were orally administered a piloted survey asking about whom they trusted on obtaining asthma information and how they perceived the role of pharmacists in their asthma care. Additional survey questions related to asthma control including the number of oral corticosteroid courses over the last 6 months; number of day and night time symptoms over last 4 weeks; number of days with limited activities in the last 4 weeks; and how often the child used a quick relief medication in the last 4 weeks. Participants were divided into 2 groups, those who were willing to receive information about inhalers from the pharmacist (group B) and those who were not (group A). Reported asthma control was compared between groups.
RESULTS: Thirteen caregivers of 19 children completed the survey. Forty-seven percent of the children were male and 95% were black. Thirteen (68.4%) of the participants had Medicaid for insurance, and 78.6% had a household income of <$40,000. Only 5.3% had previously been intubated. In the last year, 64.3% used 1 pharmacy, and 35.7% used 2 pharmacies. Eleven

caregivers (84.6%) were willing to receive information from a pharmacist (group B), and 2 were not (group A). There were no differences between demographics of group A and those of group B. No hospitalizations were reported in group A and an average of 0.82 in group B (p = 0.50). Children in group A had a median of 5 emergency department visits in the last year compared to 3 visits in group B (p = 0.84). The average number of oral corticosteroid courses in group A was 1 versus 0.8 in group B (p = 0.91). There were no differences between the numbers of symptom days or nights per group and no differences in quick relief use or limited activity days. One patient in group 1 reported daily use of a quick reliever, and another reported limited activities on 4 to 10 days per month.
CONCLUSIONS: There were no differences in asthma outcomes based on caregivers who trusted their pharmacist, likely due to the small sample size. It was interesting to note that some caregivers were not able to determine control of their child's asthma and would likely benefit from a pharmacists interaction and education.

EVALUATION OF THE IMPLEMENTATION OF CONTINUOUS RECOMBINANT ANTITHROMBIN IN PEDIATRIC EXTRACORPOREAL MEMBRANE OXYGENATION PATIENTS.

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INTRODUCTION: In patients receiving extracorporeal membrane oxygenation (ECMO) support, anticoagulation is necessary to prevent thrombosis formation on the artificial surfaces of the circuit. The prevention of thrombosis must be weighed against the risk of bleeding, and the consequences of this balance are the major complications of ECMO therapy. Heparin is the anticoagulant most commonly used in patients receiving ECMO. Heparin therapy is often complicated by acquired antithrombin deficiency related to patient age, history of cardiopulmonary bypass, presence of sepsis, and the heparin therapy itself. According to a recent study, 84% of institutions use some form of antithrombin concentrate in their replacement strategy, although the product, dose, and frequency varied significantly. We hypothesized that continuous replacement of antithrombin may present an advantage for ECMO management by improving anticoagulation through consistent antithrombin activity, resulting in increased time spent with therapeutically activated clotting times (ACTs).
METHODS: A new continuous infusion antithrombin protocol was developed and implemented in all pediatric ECMO patients. Prior to implementation, there was no protocol for targeting antithrombin activity levels; antithrombin replacement was administered intermittently, and the dose was left to the discretion of the pediatric intensivist. Patients receiving the new continuous protocol (n = 5) were compared to historical controls (n = 7). The primary objective of the study was to compare fraction of time spent at goal ACT. Secondary outcomes included determining frequency of heparin dose changes per 24 hours, heparin dosage range (measured as differences in heparin doses over 24 hours), average daily antithrombin activity, and achievement of therapeutic antithrombin activity as defined in the protocol.
RESULTS: Patients who received continuous infusion antithrombin spent significantly more time in the goal ACT range, with the study group spending 63% of time in range versus 54% in control (p<0.0001). A nonsignificant difference in average daily antithrombin activity was seen in patients receiving continuous infusion antithrombin (76.3% versus 68.6%, respectively, p=0.11). No statistical differences in heparin dose changes per day (3 versus 3.22, respectively, p=0.90) or change in daily heparin dosage (7.59 units/kg/hr versus 7.66 units/kg/hr, respectively, p=0.79) were present between the 2 groups. Only 28% of control patients achieved normal antithrombin activity compared with 80% of study patients (p=0.242).
CONCLUSIONS: Use of a continuous antithrombin infusion protocol improves consistency of anticoagulation during ECMO, as measured by ACTs. The continuous antithrombin infusion group also had a higher average antithrombin activity level. Results seen with respect to heparin dosage are consistent with those in previous studies evaluating protocol-driven antithrombin replacements compared with placebo; although no previous studies have compared continuous antithrombin replacement with intermittent replacement. Results of this analysis suggest that larger studies comparing these therapies are warranted to evaluate overall patient outcomes and assess the potential for decreased bleeding and thrombosis with optimization of anticoagulation.

A NATIONAL SURVEY OF ANTIMICROBIAL DOSING STRATEGIES AT PEDIATRIC INSTITUTIONS.

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INTRODUCTION: Extended-interval aminoglycoside (EIAG) and extended-infusion beta-lactam (EIBL) dosages are examples of dosage strategies that can optimize antibiotics' pharmacokinetic and pharmacodynamic properties. Optimizing the way in which

antimicrobial doses are given is consistent with the general goals of antimicrobial stewardship programs and could further positively impact patient care. The widespread adoption of these dosage strategies in children has lagged behind that in adults, and the current prevalence of these dosage strategies in pediatric patients is unknown. The objective of this study was to describe the use of EIAG and EIBL dosages in national pediatric hospitals.
METHODS: A national survey of children's hospitals was conducted using SurveyMonkey (SurveyMonkey.com). A single practitioner from each target hospital was identified through the Children's Hospital Association. Following initial survey administration, the survey remained open for 6 weeks, and follow-up reminders were sent at weeks 2 and 4. Demographic questions queried presence of an antimicrobial stewardship program, infectious diseases physician specialists, institution size, and geographic location. Practice-based survey questions identified whether institutions were utilizing EIAG, EIBL, and/or continuous infusion penicillin dosage. Reasons cited for not using these dosage strategies were also questioned.
RESULTS: The survey was administered to 215 identified practitioners with 77 participating, for a 36% response rate. The majority of respondents were clinical pharmacists (79.2%), and the hospital being considered was a teaching hospital (93.5%). EIBL and continuous infusion penicillin antibiotics were used by 61% (n = 47), 21% (n = 16), and 10% (n = 8) of responding institutions, respectively. The most common reasons for not using EIA were concern regarding lack of efficacy data (56%) and concern for the duration of drug-free period (41%). Respondents who responded they did not use EIBL indicated concern due to lack of pediatric EIBL efficacy data (54%), need for more intravenous (IV) access (54%), IV medication compatibility issues (39%), time patient is attached to an IV infusion (30%), and lack of resistance at the individual's institutions (25%). The most common reason for not using continuous penicillin, including nafcillin, was the prolonged time a patient would be attached to the IV infusion (55%).
CONCLUSIONS: This national survey of children's hospitals indicated that the optimized dosage strategy of EIAG is used in over 50% of institutions but that the EIBL and continuous infusion penicillin dosage strategies are used in less than 25%. Documented concerns for their use suggest that there are opportunities for further education and clarification of the available clinical evidence supporting the use of these strategies. Additional studies regarding EIBL and continuous penicillin administration may result in increased adoption of these strategies.

EVALUATION OF INTRAVENOUS ACETAMINOPHEN USE IN A FREE-STANDING CHILDREN'S HOSPITAL.

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INTRODUCTION: Intravenous (IV) acetaminophen offers a safe and effective route of analgesic and/or antipyretic administration for patients unable to tolerate enteral or rectal acetaminophen dosage forms. As IV acetaminophen is substantially more expensive, appropriate patient selection is key to balancing both cost and benefits of use. IV acetaminophen was initially added to formulary in 2011 for use by anesthesiologists in the operating room (OR) and postanesthesia care unit (PACU) setting, as patients are usually unable to take enteral medications and appropriate rectal administration technique may be difficult to perform. Formulary approval was subsequently expanded to inpatient use with restriction to the pain management service. Widespread prescribing was subsequently noticed across a variety of patient care services, as well as an increase in pain management consults specifically requesting prescription of IV acetaminophen. The primary objectives of this review were to characterize and evaluate appropriateness of current IV acetaminophen prescribing practices.
METHODS: Retrospective chart review of all inpatient IV acetaminophen doses administered outside of the OR/PACU setting during 2012 was carried out. Institutional Review Board expedited review was submitted; however, IRB review designated the project as a quality improvement audit. Data evaluated included patient demographics, indication for use, concurrent analgesic agents, IV acetaminophen dose and frequency, number of administered doses, adjustment for renal and hepatic dysfunction, managing service and unit, adherence to pain management consultation, re-evaluation of continued need upon transfer of service, and ability of a staff pharmacist to determine appropriateness of use with routine chart review.
RESULTS: A total of 1699 doses were administered during 260 treatment courses in 2012 (range, 1-213 doses per course), with the majority of these courses (88.5%) occurring in patients admitted to critical care and surgical services. Collectively, 51 courses (19.6%) were deemed to have an inappropriate indication, 31 (11.9%) an inappropriate dose and/or frequency, and 22 (8.5%) an inappropriate duration of therapy. Of note, 13 treatment courses met criteria for renal adjustment, but only 6 (46.2%) of these included an appropriate dose for renal dysfunction. Similarly, 5 courses met criteria for hepatic dose adjustment, but only 2 (40%) included an appropriate dose for hepatic dysfunction. The pain management service was consulted in 241 (92.7%) treatment courses, 12 of these for the specific purpose of requesting IV acetaminophen by

the primary team. Of the 19 courses in which no pain management consultation was placed, 15 (79%) were deemed to be fully appropriate in dose, frequency, duration, and indication.
CONCLUSIONS: IV acetaminophen use is prevalent across all hospital services. Opportunity exists to optimize dosage in organ dysfunction and to use or convert to enteral or rectal dosage forms earlier in the course of therapy. Further restriction should be explored.

IMPACT OF A HOME INTRAVENOUS ANTIBIOTIC PROGRAM IN PEDIATRIC CYSTIC FIBROSIS.
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INTRODUCTION: Patients with cystic fibrosis (CF) are frequently admitted to the hospital for pulmonary infections requiring extended lengths of intravenous (IV) antibiotic therapy. A home IV antibiotic program was developed to ensure patients received appropriate therapy, monitoring, and education during the course of home IV antibiotic therapy. This program involves pharmacist interventions in patient care, including antibiotic regimen, monitoring, and patient education for those being discharged with IV antibiotic therapy. The objective of this study was to determine the outcomes of the implemented program, including changes in lung function tests and time to next hospitalization.
METHODS: This retrospective study was approved by the Institutional Review Board. The electronic medical record was used to identify CF patients treated with home IV antibiotic therapy within 1 year prior to and 1 year after program implementation. The following data were collected: demographics, length of hospitalization, length of home IV antibiotic therapy, antibiotics used, respiratory culture data, pulmonary function test, comorbidities, adverse effects, documentation of counseling by a pharmacist, time to next hospital admission, and time to next home IV antibiotic course. Student's *t*-test was used to evaluate continuous data including length of hospitalization and time to readmission. Chi-square test was used to evaluate nominal data.
RESULTS: Patient baseline characteristics of the preprogram group (n=58) were similar to those of the program group (n=73). Patients in the program group had lower pulmonary function test results at the start of home IV antibiotics, including Forced expiratory volume in 1 second (FEV1; preprogram, 72.3%; program, 63.2%; p=0.068), forced vital capacity (FVC; preprogram, 85.1%; program, 76.1%; p=0.037), and forced expiratory flow (FEF_{25-75}; preprogram, 53.9%; program, 45.7%; p=0.201). Lengths of hospitalization (6.2 days in both groups; p=0.998) and home IV therapy were similar in both groups (preprogram, 13.9 days; program, 17.8 days; p=0.357). Changes in pulmonary function test resultss during home IV therapy did not differ between the 2 groups: FEV1, preprogram, 3.7%; program, 4.7% (p=0.747); FVC, preprogram, 0.8%; program, 2.8% (p=0.509); and FEF_{25-75}, preprogram, 10.9%; program, 7.1% (p=0.565). Time to next hospitalization (preprogram, 211 days; program, 131 days; p=0.005) or home IV antibiotics was greater in the preprogram group (preprogram, 253 days; program, 148 days; p=0.015). Two adverse effects occurred in the preprogram group, rhabdomyolysis and abdominal pain, but none in the program group. Pharmacist counseling was provided in the program group to 75.3% of the patients, a significant increase from that in preprogram group (p<0.0001).
CONCLUSIONS: The home IV antibiotic program dramatically increased the number of patients and families that received counseling prior to discharge. This intervention did not change time to next hospitalization or home IV antibiotic course in this sicker patient population. The program may influence patient satisfaction with the home IV antibiotic experience, which is an area of future study.

KNOWLEDGE OF AND ATTITUDES ON CHILDHOOD VACCINATION: A SURVEY AMONG SAUDI PARENTS IN TAIF REGION, SAUDI ARABIA. Abubaker Elbur, MA Yousif, Ahmed Albarraq, and Mustafa Abdallah**.**
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INTRODUCTION: Parents' knowledge of and attitudes toward immunization are likely influence uptake. The objective of this study was to assess parental knowledge of and attitudes toward childhood immunization among Saudi parents.
METHODS: A cross-sectional survey was conducted during April 2013 in Taif, Saudi Arabia. A convenient method of sampling was adopted. Parents with children 0-12 years old were invited to participate. Data were collected during a face-to-face interview using a pretested structured questionnaire. Data were processed using SPPS software (version 21; IBM, Armonk, NY). Descriptive statistics were used to describe all variables. Association between dependent variables (knowledge and attitudes) and independent ones (parents' demographics) were tested using chi-square test. p values of <0.05 were considered statistically significant.
RESULTS: A total of 731 parents were recruited. Parents had good knowledge of aspects related to the general role of vaccination in prevention of some infectious diseases (672 [91.9%]) and timing of the first dose in vaccination schedule (635 [86.9%]). However, poor knowledge was documented among parents in other

aspects like the importance of administration of multiple doses of the same vaccine to child immunity (304 [41.6%]), the fact that administration of multiple vaccines at the same time have no negative impact on child immunity (271 [37.1%]), importance of vaccination of children against seasonal influenza (334 [45.7%]), and contraindications to vaccination (287 [39.3%]). Parents' attitudes toward immunization was positive, expect in some aspects related to vaccination side effects (316 [34.2%]), and the probability of occurrence of diseases against which the child was vaccinated (288 [39.4%]). Sex, residence, and educational level were found to be significantly associated with parents' knowledge and attitudes toward immunization.
CONCLUSIONS: Although parents had good knowledge and positive attitudes about some aspects related to childhood immunization, gaps in both studied domains were identified. Educational interventions are needed to upgrade parents' knowledge, with special emphasis on less educated and residents of rural areas.

EVALUATION AND RECOMMENDATIONS FOR 200+ COMMONLY PRESCRIBED PEDIATRIC DRUGS WHERE PRODUCT LABELING INFORMATION IS UNAVAILABLE.
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PURPOSE: To increase pediatric patient safety related to medication dose range screening for prescribing clinicians by creating new consensus-based guidelines for medications with no age specific US Food and Drug Administration (FDA)-approved labeling information.
METHODS: First Databank convened a panel of independent pediatric dosing experts to review and recommend clinically acceptable minimum/maximum dosage recommendations based upon age and clinical evidence, along with expert opinion. Commonly used medications, as determined by utilization history of 7 geographically diverse hospitals, were assigned to each expert based upon therapeutic class. Each panel member was responsible for reviewing clinical evidence supporting or refuting current dosage recommendations. Grades of clinical evidence were based upon previously published guidelines. Following the compilation of medication reviews, the panel met to discuss and finalize dosage recommendations and associated clinical evidence.
RESULTS: A total of 198 routed drugs representing 258 generic formulations (active ingredients, dosage form, and strength) in 924 pediatric dosage records were evaluated. A dosage record consisted of the generic formulation (e.g., oral acetaminophen, 160 mg/5 mL liquid), patient's age range, route of administration, dosage type (loading dose vs. maintenance dose), and dosage range and indication (when necessary). A total of 668 records were modified (72%) based on the panel's recommendations; 611 (66%) of the dosage records were extended into a lower age range of pediatric patients than previously recommended, whereas 57 (6%) of records resulted in the targeted pediatric age range being raised; and 256 (28%) resulted in no change to the current age-based dosage recommendations.
CONCLUSIONS: Pediatric medication use involves a multitude of challenges, including the immature organ systems of the premature neonate, administration challenges associated with product formulations, and lack of clinical trials determining appropriate dosage based upon pharmacokinetic and pharmacodynamic principles. Evidence, not label indication, remains the gold standard from which practitioners should draw when making therapeutic decisions for their patients. A panel of experts was able to quickly gather information not readily available in the product's license or standard reference books for incorporation into a clinical decision support module. Changes recommended by the panel should greatly enhance the effectiveness of pediatric computerized physician order entry and dose checking, decreasing alert fatigue while improving patient care.

IMPACT OF DISCHARGE PRESCRIPTION REVIEW BY EMERGENCY DEPARTMENT PHARMACISTS AT A PEDIATRIC TEACHING HOSPITAL.
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PURPOSE: To assess the frequency, type, and potential severity of errors intercepted by pharmacists upon review of discharge prescriptions in a pediatric emergency department.
METHODS: This was a retrospective observational study conducted in the emergency department of an urban pediatric teaching hospital. A daily report of prescriptions written in the previous 24 hours was reviewed by the pharmacist on duty for safety and efficacy. If an intervention was deemed necessary, the prescriber was contacted via email for clarification. In urgent situations where patient harm could occur, the physician assigned to follow-up was contacted by phone. Interventions were categorized by type as well as potential severity. The response rate from physicians and intervention acceptance rate were assessed.
RESULTS: An estimated total of 23,600 prescriptions were reviewed over the period of 1 year (October 2012 to October 2013), 60 of which required intervention. Of the 60 interventions, 48 (80%) were estimated to have minor, 7 (12%) moderate, and 3 (5%) major potential severity. The most common types of interventions were drug overdose, optimization of therapy, or dose omission (19 [32%], 20 [33%], and 8 [14%], respectively). A

total of 85% of physicians responded, of which 62% accepted the intervention proposed by the pharmacist, whereas 23% provided a rationale for their decision. More importantly, valuable information was gained from reviewing the prescription errors, allowing for implementation of system fixes to prevent the error from occurring again. On average, the pharmacist spent 45 minutes total per shift reviewing and clarifying the prescriptions.
CONCLUSIONS: Pharmacists in the emergency department can provide a valuable service by reviewing discharge prescriptions. A small amount of time dedicated to this service can make a significant impact toward reducing medication errors and optimizing prescription therapy.

COMPARING THE EFFECTS OF TWO FORMULATIONS OF SUPERSATURATED CALCIUM PHOSPHATE MOUTHWASHES ON PHARMACY WORKFLOW AND PERCEPTION OF PATIENT SATISFACTION IN PEDIATRIC ONCOLOGY PATIENTS.

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INTRODUCTION: Oral mucositis is a common complication of chemotherapy in pediatric oncology patients. Supersaturated calcium phosphate mouth rinses (SCPR) are used as adjuncts to standard oral care in preventing and treating oral mucositis. Two commonly used formulations of SCPR, Caphosol (Jazz Pharmaceuticals, Dublin, Ireland) and NeutraSal (Invado Pharmaceuticals, Pomona, NY) are not US Food and Drug Administration-approved for pediatric patients, but use has been described in published reports. Caphosol was the primary SCPR at our institution, but issues regarding product packaging and taste were identified as interfering with administration and compliance. The purpose of this study was to describe Caphosol from the pharmacy and nursing perspectives and subsequently compare them to the cost-effective alternative SPCR NeutraSal. The objective of this study was to evaluate the perceptions of registered nurses, pharmacists, and pharmacy technicians about patient preference, compliance, ease of preparation, efficacy, and timely and effective distribution of the products.
METHODS: The study was approved by the Institutional Review Board. Surveys were distributed to nurses in the pediatric oncology unit for Caphosol and then after the formulary change for NeutraSal. Survey points included SPCR indication, perceived SPCR efficacy, ability of SPCR to decrease the need for pain medications, patient compliance and satisfaction, SPCR palatability, and ease of preparation. Pharmacy staff were surveyed about the ease of packaging, verifying, product checking, storing, and distributing the medications on the patient units.
RESULTS: A total of 48 pharmacists completed the Caphosol survey, and 31 completed the NeutraSal survey. In terms of receiving requests to refill automated dispensing cabinets (ADC), 52% in the Caphosol group reported receiving requests more frequently than once a week above the regular refill schedule versus 26% in the NeutraSal group. In the Caphosol group, 28% rated product checking as easy compared to 58% in the NeutraSal group; 86% of the 43 pharmacy technicians (PT) surveyed identified Caphosol requiring additional ADC refills, as compared to 18% of the 23 PTs surveyed for NeutraSal. Ease of packaging the products was described as difficult by 42% of PT for Caphosol versus 0% for NeutraSal, where the ease of storing the products in the ADC was described as difficult by 48% of PT for Caphosol versus 0% for NeutraSal. All 20 nurses surveyed on Caphosol and 8 on NeutraSal were unable to assess or stated no change in pain medication requirements with either product. Perception of product taste was reported as tolerable by 30% versus 50% of nurses, and perception of patient satisfaction was 20% versus 50% of nurses, both on Caphosol versus NeutraSal, respectively.
CONCLUSIONS: The change of Caphosol to NeutraSal at our institution has demonstrated improved and efficient pharmacy workflow. NeutraSal provides a cost-saving alternative that has potential for better patient tolerability and satisfaction.

CONVENTIONAL VERSUS HIGH-DOSE STEROIDS IN SEVERE ASTHMA EXACERBATIONS REQUIRING CONTINUOUS ALBUTEROL.

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PURPOSE: To determine whether high-dose intravenous methylprednisolone reduces the number of patients transferred to the pediatric intensive care unit (PICU) compared to conventional dose methylprednisolone in patients with severe asthma exacerbations.
METHODS: This retrospective study was approved by the institutional review board. Asthma patients admitted to the general pediatric unit from 2008 through 2013 who received high-dose continuous albuterol nebulization (15-20 mg/hr) and were initially started on conventional dose intravenous methylprednisolone (~1-2 mg/kg/day) were included. Patients were

excluded if they did not receive intravenous methylprednisolone, received continuous albuterol without a diagnosis of asthma, or were admitted to the PICU. Patients who received high-dose methylprednisolone (>2 mg/kg/day) were compared to those receiving conventional methylprednisolone (1-2 mg/kg/day). The primary endpoint was the rate of transfer to the PICU; secondary endpoints included rate of intubation, length of PICU stay, and duration and dose of continuous albuterol and corticosteroids.
RESULTS: Of 135 subjects identified, 59 received high-dose and 76 received conventional dose methylprednisolone. In the high-dose group, 2 patients (3.4%) were transferred to the PICU, whereas 15 (19.7%) were transferred from the conventional dose group ($p = 0.01$). The rates of intubation were not significantly different between groups ($p > 0.05$). Both groups used a similar dose and duration of continuous albuterol ($p = 0.16$ and $p = 0.07$, respectively) and had similar lengths of stay in the PICU ($p = 0.15$). The high-dose group was exposed to a greater cumulative dose of corticosteroids throughout treatment than the conventional dose group (13.7 vs. 10.4 mg/kg, respectively; $p < 0.001$), while not requiring longer duration of therapy (7.2 vs. 6.6 days, respectively; $p=0.54$).
CONCLUSIONS: High-dose methylprednisolone appears to reduce the rate of transfer to the PICU compared to that with conventional dose methylprednisolone. Patients achieved this benefit with similar duration of corticosteroid treatment and a similar duration and dose of continuous albuterol nebulization.

IMPLEMENTATION OF AN ADOLESCENT VENOUS THROMBOEMBOLISM PROPHYLAXIS PROTOCOL IN A COMMUNITY PEDIATRIC HOSPITAL.

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INTRODUCTION: The purpose of this study was to assess whether a new standardized adolescent venous thromboembolism (VTE) protocol impacted the prescribing of mechanical and pharmacologic VTE prophylaxis among patients 18 to 21 years of age admitted to the general pediatrics floor and pediatric intensive care unit (PICU) of a community pediatric hospital.
METHODS: All patients 14 years of age and older admitted to the general pediatrics floor or PICU between January 1, 2013, and March 1, 2013, were included in the retrospective arm of the study. The concurrent arm included all patients 14 years of age and older admitted to the general pediatrics floor and PICU between January 1, 2014, and March 1, 2014. Data collected for both arms of the study included admission date and time, age, presence of orders for mechanical or pharmacologic VTE prophylaxis, and incidence of VTE during admission. Additional data collected for the concurrent arm included the presence of the adolescent VTE protocol on the chart within 24 hours of admission and prior to discharge, and the date and time the protocol was completed by a physician. Descriptive statistics were used to describe the retrospective and concurrent arms of the study.
RESULTS: Fifty-five patients with a mean age of 15.4 years (range, 14-19 years) were included in the retrospective arm of the study. Approximately 5% (n=3) of these patients had orders for VTE prophylaxis during admission, all of which were mechanical in nature. There was 1 case of VTE identified in a patient not receiving prophylaxis during the retrospective period. Eighty-seven patients with a mean age of 15.5 years (range, 14-19 years) were included in the concurrent arm. Approximately 13% (n=11) had orders for VTE prophylaxis during admission, all of which were mechanical in nature. Of the 87 patients included in the concurrent arm, 48% (n=42) had the protocol on the chart at the time of discharge, and 55% (n=23) had been completed at discharge. There were no documented VTEs identified during the concurrent phase of the study.
CONCLUSIONS: Although limited data are currently available regarding the benefits of a standardized VTE prophylaxis program for hospitalized adolescent patients, the small percentage of patients receiving VTE prophylaxis in the retrospective arm of the study supports the presumption that VTE prophylaxis was not often considered for these patients. The implementation of a standardized adolescent VTE prophylaxis protocol resulted in an increase in the number of patients receiving VTE prophylaxis; however, further education of staff is necessary to increase utilization of the protocol for all hospitalized adolescent patients.

ROLE OF TOBRAMYCIN ENDOTRACHEAL INSTILLATION ON CLINICAL OUTCOMES: A CASE SERIES.

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INTRODUCTION: Infection and colonization of endotracheal tubes often act as a barrier to a patient's clinical improvement and extubation. Systemic antibiotics may reach the site of infection but are often associated with systemic side effects. Local instillation of tobramycin may be a suitable alternative to systemic antibiotics, achieving high concentration at the site of infection and having little to no systemic adverse effects. The purpose of this study was to present the outcomes of 13 cases that highlight the use of tobramycin instilled into the endotracheal tubes of patients in the pediatric ICU.
METHODS: A retrospective chart review of children

under the age of 18 years who received instilled tobramycin (1 mg/kg/dose every 8 hours for 5 days) while admitted between January 1, 2008, and January 1, 2013. The primary outcomes of this study were resolution of sputum/endotracheal culture and clinical improvement. The secondary outcome was the return of positive cultures ≥5 days after treatment, which would presume recolonization. The use of concomitant antibiotics was also evaluated.
RESULTS: During the study period, 13 patients were identified as receiving tobramycin instillation. Ten patients had full resolution of culture, whereas 3 achieved partial resolution. Five of 10 patients who achieved full resolution had a return of positive culture (recolonization) ≥5 days after treatment. All 13 patients improved clinically, although 11 of these 13 patients received concomitant antibiotics during this time.
CONCLUSIONS: Instilled tobramycin appears to be a potential option for treating isolated endotracheal infection in complicated patients. Most of the patients reviewed were treated with concomitant systemic antibiotics, which limits the analysis of treatment. Further data in patients without concomitant antibiotics are needed to truly assess efficacy. This series did not address risk of adverse effects, such as systemic absorption or bronchospasm, which need to be addressed going forward.

COMPASSIONATE USE OF OMEGAVEN FOR THE TREATMENT OF PARENTERAL NUTRITION-ASSOCIATED LIVER DISEASE: A CASE REPORT OF 20 PRETERM INFANTS.

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INTRODUCTION: Pediatric patients, particularly infants, with intestinal failure require long-term total parenteral nutrition (TPN) to allow for intestinal growth and adaptation. Although traditional fat emulsion (Intralipid 20%; Fresenius Kabi, Homburg, Germany) provides calories and prevents essential fatty acid deficiency, they are composed of omega-6 fatty acids and phytosterols which may increase free radicals, reduce bile flow, and impair biliary secretion leading to cholestasis and liver injury. Although intravenous omega-3 fatty acids like Omegaven (Fresenius Kabi) are not approved in the United States for use, many intuitions have used Omegaven for parenteral nutrition-associated liver disease (PNALD) under a compassionate use protocol. Our institution reports the successful and safe use of Omegaven in 20 patients over the last 3 years. Our objectives were to determine whether Omegaven was effective in reducing hepatic inflammation and reversing hepatic dysfunction in infants admitted specifically to the neonatal intensive care unit and to demonstrate that Omegaven is well tolerated by infants and exhibits few adverse effects.
METHODS: A prospective, observational study of preterm infants who received Omegaven for PNALD was conducted from March 2011 to March 2014. Our protocol was modeled after the original protocol developed at Boston Children's Hospital. Infants who had a diagnosis of PNALD, defined as 2 consecutive direct bilirubin levels >2 mg/dL, failed to respond to standard therapies to prevent the progression of their liver disease, and were expected to be TPN-dependent for 30 additional days met inclusion criteria. Institutional review board and US Food and Drug Administration approvals and parent consent were obtained. Omegaven was given in place of conventional Intralipid. Candidates received 1 g/kg/day over 12 hours as their only source of fats until the patient achieved full enteral nutrition and was off TPN. Baseline laboratory values were obtained prior to the start of Omegaven therapy and were followed routinely for 2 months after the completion of Omegaven therapy.
RESULTS: Twenty infants, 12 males and 8 females, were enrolled. Nineteen infants were less than 6 monthws of age at enrollment, with a mean gestational age of 27.35 weeks (23-36 weeks) and mean birth weight of 1.14 kg (0.43-3.72 kg). Fifteen of the 20 enrolled patients completed the Omegaven study and follow-up, 1 patient was currently enrolled at the time of writing, 3 non-Omegaven-related deaths occurred, and 1 candidate withdrew due to transfer for transplantation evaluation. The infants tolerated Omegaven well, without significant changes in international normalized ratio, platelet count, essential fatty acid profile, or serum triglycerides concentration. There were no significant bloodstream infections related to Omegaven. Serum direct bilirubin decreased significantly (p=0.001).
CONCLUSIONS: Omegaven is beneficial and safe for treating liver injury associated with prolonged TPN exposure. Omegaven was well tolerated in 20 preterm neonates with PNALD at our institution. We strongly encourage the manufacturer to pursue FDA approval for use of Omegaven in the United States.

USE OF GASTROPROTECTION WITH THE USE OF HIGH-DOSE GLUCOCORTICOSTEROIDS FOR PROLONGED COURSES IN THE PEDIATRIC POPULATION.

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INTRODUCTION: The primary objective of this study was to compare and review the incidence of

bleeding gastrointestinal tract (BGIT) of the upper tract arising from prolonged courses (defined as ≥2 weeks) of high-dose oral prednisolone (defined as ≥40 mg/day or ≥1 mg/kg/day or ≥40 mg/m2/day) for the treatment of autoimmune diseases (AD) or nephrotic syndrome (NS) in patients ≤18 years old, with or without the use of gastroprotectants, between January 2012 and June 2012. Secondary objectives were to identify other gastrointestinal (GI) side effects arising from prolonged courses of high-dose oral prednisolone, the common gastroprotectants prescribed by physicians in KK Women's and Children's Hospital to prevent upper BGIT, and any side effects arising from use of the gastroprotectants.
METHODS: Patient-specific demographic characteristics, medication history, physician-reported signs, and patient-reported symptoms of upper BGIT, other GI side effects arising from prolonged courses of high-dose oral prednisolone, and side effects arising from use of the gastroprotectants were documented.
RESULTS: A total of 42 patients were recruited to this study. None of the patients could be confirmed to have experienced upper BGIT. Two patients (4.8%) experienced abdominal pain. The most common gastroprotectant prescribed was omeprazole (n=12 [28.6%]). There was no documentation of any side effects arising from use of gastroprotectants by the physicians in the patients' case notes.
CONCLUSIONS: The results of this study revealed no association between prolonged courses of high-dose oral prednisolone and the risk of upper BGIT.

MEDICATION USE EVALUATION OF INTRAVENOUS IMMUNE GLOBULIN THERAPY IN A CHILDREN'S HOSPITAL AFTER IMPLEMENTATION OF NEW GUIDELINES IN A TEACHING INSTITUTION.

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INTRODUCTION: Intravenous immunoglobulin (IVIG) is used for a variety of labeled and off-labeled indications. A new protocol and form with pharmacy and therapeutics committee-approved guidelines was implemented in 2012 to improve appropriate therapy and reduce IVIG waste in the children's hospital. IVIG prescribing is limited to designated pediatric neurology, hematology and oncology, infectious disease, immunology, and rheumatology attending physicians. The primary objective of this study was to review the use of IVIG at our institution over a 1-year period and to evaluate compliance with our institutional guidelines. Secondary objectives included development of dosage recommendations for certain obese patients, hence, decreasing product exposure, waste, and cost.
METHODS: This was a retrospective chart review of all pediatric patients who received IVIG products between January and December 2012. The data collected included sex, age, height, weight, serum creatinine, blood urea nitrogen concentration, indication for IVIG, treatment dates and duration, product name and dose(s) administered, outcome, and adverse events. All patient weight-based doses were calculated according to patient's actual body weight. The body mass index was determined for each patient. All patient data were de-identified and stored on an encrypted secure password-coded computer.
RESULTS: A total of 36 patients received 60 IVIG infusions in 2012. There were 26 males (74%) and 9 (26%) female patients ranging in age from 1 day to 9 years old. All were treated in accordance with institutional guidelines. The most common indications for IVIG use were immune thrombocytopenia (31%), Kawasaki disease (20%), and hyperbilirubinemia (14%). Some of the other indications included Guillain-Barré syndrome (9%), paraneoplastic neurologic syndromes (9%), hypogammaglobulinemia (9%), and other (8%). Of the patients 2 years old and older, 42% had healthy weights based on their BMI, 38% were obese, and 17% were overweight. Of the patients with Kawasaki's disease, 4 received a second infusion due to failure of the first treatment. Of these 4 patients, 1 developed acquired hemolytic anemia after the second IVIG dose and was transferred to a higher level of care.
CONCLUSIONS: This medication utilization review demonstrated that indications for IVIG therapy were appropriate based on institutional approved guidelines. Almost all patients tolerated IVIG infusions well, with the exception of 1 patient. A little more than half of the patients in this study population were overweight based on their BMI, however, dosage of IVIG was calculated based on actual body weight. These findings demonstrate the need for investigating the use of adjusted or ideal body weight to dose IVIG in those patients who are obese to decrease exposure to large product loads and reduce waste and cost. However correlation with clinical efficacy is warranted, and further research is needed before implementation of new dosage guidelines, especially in such a young patient population.

LEVETIRACETAM (KEPPRA) EFFICACY AND SAFETY FOR THE PREVENTION OF EARLY-ONSET SEIZURES FOLLOWING TRAUMATIC BRAIN INJURY IN PEDIATRIC PATIENTS.

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INTRODUCTION: Approximately half a million emergency department visits for traumatic brain injury

(TBI) in pediatric patients occur each year. One of the common complications of TBI is early onset seizure. Historically, phenytoin has been the agent of choice for seizure prophylaxis; however, administration reactions limit its use in practice. Fosphenytoin is a safer alternative but, at times, is unavailable in the intravenous formulation due to drug shortages. Despite studies demonstrating efficacy of levetiracetam in adult patients with TBI, the efficacy and safety of levetiracetam in children with TBI is unknown. The purpose of this study was to determine the efficacy and safety of levetiracetam for the prevention of early onset seizures in pediatric patients after TBI.

METHODS: After institutional review board approval, a retrospective study was conducted at a local level 2 trauma institute. Children and adolescents ages 0 to 17 years admitted to the hospital secondary to a non-penetrating TBI, who received levetiracetam for seizure prophylaxis for up to 7 days were included. Patients were excluded if they were taking antiepileptic medications prior to injury, were pregnant, or had sustained a devastating head injury with expected or confirmed brain death within 48 hours. Data collected included patient demographics, initial Glasgow coma scale , mechanism of injuries, diagnosis, history of cranial surgery upon admission, dose of levetiracetam, duration of therapy, concomitant receipt of antiepileptic medications, seizure activity, and adverse drug reactions while on levetiracetam. The primary outcome was the number of children who had a seizure within the first 7 days following a TBI, and secondary outcomes included the number of adverse drug reactions.

RESULTS: A total of 89 pediatrics patients with non-penetrating TBI were identified and included in the study. The average initial Glasgow coma scale of patients was 11 ± 4.67. Forty-six patients received a mean dose of 10 ± 4.22 mg/kg levetiracetam twice a day, and 43 patients received 500 mg twice per day (based on adult dosage). The average length of the therapy was 9 ± 10 days. Seizure activity was observed in 2 patients (2%) within the first 7 days following TBI. A total of 11 patients (12%) experienced anemia, agitation, and elevation of liver enzymes during levetiracetam therapy.

CONCLUSIONS: Levetiracetam appears to be an effective agent for early onset seizure prophylaxis status-post TBI in pediatric patients, as indicated by the low number of patients with seizures. The reported adverse reactions may have resulted from the trauma rather than the use of levetiracetam and, as such, appears to be a safe alternative to phenytoin and fosphenytoin.

MEDICATION USE FOR THE TREATMENT OF DIABETES IN PEDIATRICS.

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INTRODUCTION: Studies describing medication regimens for pediatric patients with type 2 diabetes mellitus (T2DM) are lacking. Metformin and insulin are the only US Food and Drug Administration (FDA)-approved medications for the treatment of T2DM in children and adolescents. Therefore, the goal of the study was to describe medication regimens used in overweight and obese pediatric subjects for the treatment of T2DM. A secondary outcome was to report the number of subjects achieving controlled hemoglobin A1C concentrations.

METHODS: The study was a secondary data analysis using National Health and Nutrition Examination Survey (NHANES) cohorts from 2003 through 2010. Subjects between the ages of 2 and 21 years old at the time of survey interview were included if they self-reported having been told by a provider that they had diabetes and a body mass index (BMI) over the 85th percentile for sex and age upon examination. Subjects who did not specify diabetes medication names at the time of the survey were excluded. Sex, age (in months), race/ethnicity, BMI, waist circumference, hemoglobin A1C concentration, insulin, and diabetes prescription medications used 30 days prior to the interview survey were extracted. Descriptive statistical analysis was conducted using SPSS software (IBM, Armonk, NY) for Windows (version 21.0; Microsoft, Redmond, WA).

RESULTS: A total of 30 subjects were identified as being overweight or obese and having been told they had diabetes, with 28 included in the analysis. Diabetes medication names were not reported by 2 subjects and therefore those subjects were excluded. Median age was 188 months (range, 34-245 months), and 32.1% were Hispanic, non-Hispanic white, and non-Hispanic black, respectively. Median age at diabetes diagnosis was 12 years (range, 2-18 years). Mean BMI was 30.9 kg/m^2 (range, 18.5-62.5±SD 9.03 kg/m^2). Mean waist circumference was 96.5 cm (range, 56.4-134.7±SD, 19.8 cm). Valid hemoglobin A1C and glucose concentrations were available for 18 and 10 subjects, respectively. Mean A1C concentration was 7.6±2.2%, and mean glucose serum concentration was 183.1±78.5 g/dL). Twenty (71.4%) patients were treated with antidiabetic medications: 13 (46%) were taking insulin monotherapy, 5 (18%) were taking metformin monotherapy, and 2 (7%) were taking both. Types of insulin included regular, aspart, glargine, isophane, and lispro. Among those with a reported hemoglobin concentration of A1C, 44% had a level less than 7%.

CONCLUSIONS: The pharmacologic management of T2DM in children and adolescents in an NHANES cohort remains limited to insulin and metformin, the currently approved medications. Based on the low number of patients with a measured hemoglobin A1C and achieving the desired goal of less than 7%, there is a need for more aggressive monitoring and adjustment of treatment regimens in the pediatric population.

VACCINATION FOR INFLUENZA IN CHILDREN AGES 6-18: AN ANALYSIS OF IMPLEMENTATION BY ARIZONA PHARMACISTS.

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INTRODUCTION: State legislation in Arizona changed in 2011, allowing pharmacists to immunize children ages 6 and older according to Statute R4-23-411. Time and money have been greatly invested by both the state and Arizona's Pharmacy Association (AzPA), and the concern is that pharmacists are not being used to the extent that the new statute allows.
METHODS: Five major chain pharmacies (labeled A, B, C, D, E) were selected and contacted in Tucson, Arizona. During the course of 2 months, phone calls were made to 93 chain pharmacies and 4 independent pharmacies. The primary outcome measured was whether a 6-year-old was able to receive the influenza vaccination. Determining the discrepancies in minimum influenza vaccination ages among retail chain pharmacies was a secondary factor. Documentation of referral sites was included. Yate's correction for continuity analysis was conducted to determine the primary and secondary outcomes for this descriptive, quality improvement study.
RESULTS: During the 2-month data collection period, only 10.75% (10 of 93 [$p<0.001$]) of respondents would vaccinate a 6-year-olds, reflecting Statute R4-23-411. Of those 10 pharmacies, 7 came from chain pharmacy D. Various reasons, ranging from liability to mistaking corporate for state policy, were factors for low rates of vaccination. Independent pharmacies showed no improved level of consistency, with 25% (1 of 4) of respondents choosing to immunize children 6 years and older.
CONCLUSIONS: Pharmacists are aware of legislative amendments regarding vaccination of people 6 years and older with assorted levels of comprehension within various chain pharmacies and independent pharmacies for Statute R4-23-411.

MEETING AMERICAN ACADEMY OF PEDIATRICS REQUIREMENTS FOR ELECTRONIC PRESCRIBING IN CHILDREN: A PILOT STUDY.

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PURPOSE: The objectives of this pilot study were to develop a process for assessing electronic health records (EHR) for the ability to meet American Academy of Pediatrics (AAP) requirements for safe and effective electronic prescribing and to determine whether prescribing errors could be decreased by meeting these requirements.
METHODS: A pilot clinic was chosen in which to participate, based on participants' interest in improving electronic (e)-prescribing practices. Investigators met with key personnel at the clinic to discuss the project, EHR specifics for the clinic, and methods for assessing the system's capabilities. Scenarios for prescription ordering were entered into the system to determine the presence or absence of each of the 19 requirements outlined by the AAP. The clinic generated a report of all prescriptions written in their pediatric clinic in June and July 2013. Each prescription was reviewed by a pharmacy student and 2 pediatric clinical pharmacists. Prescriptions categorized as containing an error were further classified as preventable or not preventable by inclusion of the AAP requirements.
RESULTS: The EHR used by the clinic met 4 of 19 criteria; date of birth and age in years and months, allergies, and medication intolerance can be documented, all available dosage forms are included and easily identifiable, and transmission of medication strength, dosage form, and dose volume in metric units to the pharmacy. Four criteria were rated as partially met, including weight (kg) and height (cm) because although these are present within the system, either could be entered by the staff and both displayed when entering a prescription. Weight-based dosage calculations were possible using the system calculator; however, not all calculations were accurate, and the calculator would not always provide a final dose in milliliters. The system included weight-based dosage calculations, but each provider had the capability to disable this feature, and some dosage ranges included by the system were incorrect. A total of 351 prescriptions were reviewed, 43 of which (12.3%) contained a prescribing error. If the system contained the AAP requirements of indication-based dosage, individual and daily dose recommendations, reliable dose range checking alerts, and medication-specific indications, 22 errors (51.1%) could have been avoided. If a customized medication list were created for use by the providers, 30 errors (70%) could have been avoided. The 2 combined could have prevented 38 (88%) of the prescribing errors.
CONCLUSIONS: A process for analyzing the EHR was developed. This process will be valuable in assessing additional clinic and EHR systems. Although inclusion of AAP requirements for prescribing could help avoid half of the errors seen, additional interventions will be needed to further reduce prescribing errors in pediatrics.

WITHAFERIN A INHIBITS STAT3 ACTIVATION AND INDUCES CELL DEATH OF NEUROBLASTOMA CELLS.

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PURPOSE: Neuroblastoma (NB) is the most common extracranial, solid tumor of the sympathetic nervous system in childhood. Withaferin A (WFA) is a withanolide derived from *Withania somnifera* that exhibits anti-inflammatory, proapoptotic, anti-invasive, and antiangiogenic effects that has not been studied in NB cells. STAT3 plays a key role in the survival and progression of cancer cells including NB. We hypothesize that WFA inhibits STAT3, thereby inducing cell death in NB.
METHODS: To examine the effect of WFA in NB, 7 NB cell lines were treated (0-10 μM) for 48 hours. Cell viability was determined by using an assay that distinguishes live from dead cells by staining with 0.5 μg/ml Hoechst 332558 dye (live cells) and 0.5 μM TOTO-3 iodide (dead cells). Stained cells were imaged and evaluated (Operetta imaging system, Volocity 3D, Harmony imaging software; PerkinElmer, Waltham, MA). Because WFA binds to STAT3 and prevents it from forming a dimer in silico, Western blot analysis was performed with WFA (5.0 μM) treated NB cells to examine the expression of STAT3 and its phosphorylation at Y705 and S727. STAT3 inhibitor S3I-201(100 μM) and dimethyl sulfoxide (DMSO) were used as controls.
RESULTS: WFA induced cell death in 7 NB cell lines in a dose-dependent manner, with inhibitory activity detected at concentrations as low as 0.625 μM in IMR-32 cells. At 10 μM, cell death was significant in all tested tumor cell lines and ranged from ~40% to 90%, depending on individual lines. We also examined whether WFA interfered with STAT3 phosphorylation at Y705 and S727 *in vivo* to verify the possible mechanism for the observed induction of cell death. In NB cells, the phosphorylation of STAT3 at Y705 was detected in IMR-32 control cells and was reduced in response to treatment with WFA and S3I-201. We examined STAT1 and STAT6 expression in response to WFA treatment and found that WFA down-regulated STAT1. STAT6 was not detected, and STAT1 was not phosphorylated at Y701 in control or treated cells.
CONCLUSIONS: WFA is a novel inhibitor that prevents activation of STAT3 and induces cell death in NB cells. WFA is a potential new therapeutic agent that warrants further investigation.

CLINICAL EFFECTIVENESS OF SODIUM ACETATE CATHETER INFUSATE FOR THE REDUCTION OF METABOLIC ACIDOSIS IN CRITICALLY ILL PREMATURE NEONATES.

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INTRODUCTION: Metabolic acidosis is a common occurrence in premature infants, given their physiologic renal immaturity and reduced ability to renally reabsorb sufficient bicarbonate to maintain an adequate acid-base balance. An unproven practice to manage this metabolic acidosis is the use of sodium acetate (NaAc) as a catheter infusate. The purpose of this study was to determine whether the use of NaAc was associated with a significant reduction in the degree of metabolic acidosis or the receipt of additional intravenous base therapy in premature neonates during the first week of life.
METHODS: This single-center historical cohort study consisted of 2 epochs. Infants born at less than 33 weeks gestation and surviving for at least 1 week of life and without renal or cardiac anomalies (other than patent ductus arteriosus) were included in this study. During the first epoch (January 1, 2008 to December 31, 2008), NaCl, 154 mEq/L or 77 mEq/L, was used as standard practice for catheter infusate. During the second epoch (October 1, 2011 to September 30, 2012), NaAc, 154 mEq/L or 77 mEq/L, was used as standard practice for premature neonates with metabolic acidosis. The daily amounts of base therapy administered to study subjects in the form of acetate, bicarbonate boluses, and THAM boluses during the first week of life were quantified. The degree of metabolic acidosis was qualified using serum sodium bicarbonate levels and blood gas base deficits. Descriptive statistics were calculated and *t*-tests and chi-square analyses were performed as appropriate with SPSS software (IBM Corp., Armonk, NY).
RESULTS: A total of 80 patients (40 per group) were included. Baseline demographics were similar between the groups, except for serum bicarbonate levels, which were lower in the NaAc group (21.3±2.2 vs. 24.2±1.9 mEq/L, respectively, $p<0.001$). There were no doses of THAM administered during the study period. The receipt of intravenous sodium bicarbonate boluses and supplemental sodium acetate in parenteral nutrition was similar between both groups for each day in the first week of life. Base deficit values were not significantly different between the two groups during the first week of life.
CONCLUSIONS: The findings of this study suggest that the use of sodium acetate catheter infusate does not reduce the degree of metabolic acidosis experi-

enced by premature neonates in the first week of life. The risk of adverse events such as medication errors associated with compounding this product may outweigh the theorized benefit. A randomized study of infants receiving NaAc versus NaCl to support the use of NaAc catheter infusate is warranted.

EVALUATING METHADONE AND MORPHINE TAPERS FOR IATROGENIC OPIOID DEPENDENCE IN THE PEDIATRIC INTENSIVE CARE UNIT.

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INTRODUCTION: Methadone has been widely used to prevent withdrawal in patients with iatrogenic opioid dependency. However, the prolonged half-life and variable hepatic metabolism of methadone elicits concern that it may accumulate in neonatal patients with reduced hepatic capacity. Morphine has a shorter half-life than methadone and has been described as an effective treatment for neonatal abstinence syndrome. The purpose of this study was to compare the need to adjust a predetermined taper schedule of either methadone or morphine in patients under the age of 6 months with iatrogenic opioid dependency.
METHODS: This study was reviewed by the Institutional Review Board and deemed exempt. The electronic medical record system was used to identify patients under the age of 6 months who received at least 1 dose of oral methadone or morphine in the pediatric or cardiac intensive care units from May 1, 2012 to April 30, 2013, for inclusion in the study. Patients were excluded if methadone or morphine was used for purposes other than iatrogenic opioid dependency, as determined by documentation. The initial taper plan for each patient was recorded and compared to the medication administration record to find any discrepancies. The primary outcome was alteration of the administered taper from the initial taper plan. Other data collected included history of continuous opioid infusions, administration of concomitant taper (e.g., benzodiazepine), and documented symptoms of withdrawal and/or oversedation. Secondary outcome was to assess if differences in the number of altered tapers in the two treatment groups were related specifically to withdrawal or oversedation.
RESULTS: A total of 63 patients were included in the primary analysis: 22 in the methadone group and 41 in the morphine group. It was determined that 68% of methadone tapers were altered and 41% of morphine tapers were altered ($p = 0.043$). Additionally, 54% of methadone tapers compared to 32% of morphine tapers were altered due to clinical symptoms of withdrawal. On the other hand, 23% of methadone tapers versus 9.8% of morphine tapers were altered due to clinical symptoms of oversedation. However, these results failed to yield a statistically significant difference ($p = 0.161$; $p = 0.077$, respectively).
CONCLUSIONS: Overall, morphine tapers are more often completed without alteration than methadone tapers because they produce fewer clinically relevant symptoms of withdrawal and/or oversedation in patients under the age of 6 months with iatrogenic opioid dependency. It cannot be determined which specific symptoms led to the differences in taper alteration between the 2 treatment groups. Further research is necessary to better address the high overall percentage of taper modifications in both treatment groups.

EFFECT OF A PHARMACIST-LED QUALITY IMPROVEMENT INITIATIVE IN A PEDIATRIC ONCOLOGY SETTING.

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INTRODUCTION: The initiation of two pharmacist-led committees at Kosair Children's Hospital originated at the end of 2012 to focus on continuous quality improvement measures for pediatric oncology patients. The initiation of the committees originated when the Division of Pediatric Oncology underwent a leadership change accompanied by a high rate of turnover. To maintain quality care during this transition, the pharmacy department sought engagement from key stakeholders and formed 2 pharmacist-led committees. The Children's Oncology Group (COG) committee was formed to provide oversight for active COG research protocols within our institution. The Chemotherapy Safety Committee was simultaneously formed to oversee safe and cost-effective care of patients receiving chemotherapy who are not on protocol.
PROGRAM DESCRIPTION: Both committees were a collaboration among pharmacists, physicians, nursing, and other staff from inpatient and outpatient settings. The focus for both groups was maximizing technology to improve medication safety, reduce chemotherapy errors through systematic review of error data, and financial stewardship. When creating each committee's mission and purpose, the initial areas of focus for data collection included barcode medication verification (BMV) compliance, medication errors rates, and cost containment.
DISCUSSION: At baseline, BMV compliance on the oncology unit was in the 50% range. Through regular education, improvements with connectivity and addition of barcodes to the database, we were able to improve BMV compliance rate to consistently above 90%.The second focus was reduction in medication errors, both actual and averted. This was achieved

through order set development and refinement of the chemotherapy verification process to assure orders had the highest probability of being correct and clinically appropriate for patients every time they were dispensed. Since implementation of the committees, error rates have decreased from approximately 50 errors per month to less than 10 errors per month. The final area of data collection examined cost containment, which was aided through rigorous revision of order sets. The refined order sets for 1 specific protocol resulted in a net savings of $52,079 per patient. To date, 8 chemotherapy protocols have been reviewed. Based on 2012 enrollment numbers for the 8 protocols, there is an expected annual savings of $446,189.

CONCLUSIONS: The initiation of 2 pharmacist-led committees as a quality improvement initiative in the pediatric oncology setting has proven vital in helping attain measurable outcomes that are improving quality of patient care, reducing medication errors, and providing significant savings.

REDUCTION OF BROAD-SPECTRUM ANTIMICROBIAL USE IN A TERTIARY CHILDREN'S HOSPITAL AFTER ANTIMICROBIAL STEWARDSHIP PROGRAM GUIDELINE IMPLEMENTATION.

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INTRODUCTION: The overall goal of an antimicrobial stewardship program (ASP) is to improve patient outcomes while decreasing the negative consequences of antimicrobial use. The 2 core strategies recommended for accomplishing this goal, formulary restriction with preauthorization and prospective audit and feedback, can be difficult to implement with limited resources; therefore, we took the approach of guideline development and education, with the goal of reducing overall antibiotic use and unwarranted use of broad-spectrum antimicrobials.

METHODS: Because antimicrobials are commonly initiated in our ICUs, we initially reviewed the electronic medical records in each ICU to determine baseline prescribing practices. This revealed excessive use of broad-spectrum antibiotics and inconsistencies in managing our most common infections. The ASP team met with physicians to discuss unit-specific use patterns and ways to improve prescribing. Empiric antibiotic guidelines were then developed for each intensive care unit, and cycles of education, retrospective audit, and feedback were used for implementation. Hospital-wide purchasing and antibiotic use data were obtained from our drug wholesaler and the Pediatric Health Information Systems database, respectively. Unit-specific antibiotic days were measured using periodic monthly chart audits. Lengths of stay and deaths >48 hours after admission were reviewed to ensure implementation of guidelines did not cause harm.

RESULTS: During the preimplementation year, our most common broad-spectrum antibiotics (meropenem, piperacillin-tazobactam, and cefepime) purchases totaled $230,059. After full implementation, the yearly purchase decreased 62% to $86,887. Median monthly purchases of these drugs preimplementation were $19,389 and $11,043 postimplementation ($p = 0.00003$). Hospital-wide broad-spectrum antibiotic days/1000 patient days during the preimplementation year averaged 105 per month and 70 per month for the postimplementation year, demonstrating a decrease of 33%. The cardiac intensive care unit's overall antibiotic days decreased 41%, whereas broad-spectrum antibiotic days decreased by 99% at 6 months after guideline implementation. The pediatric intensive care unit's total antibiotic days decreased by 21%, and broad-spectrum antibiotic days decreased by 75% at 6 months. The neonatal intensive care unit's total antibiotic days and broad-spectrum antibiotic days decreased by 18% and 61%, respectively, at 1 year after guideline implementation. Average monthly length of stay during the preimplementation year was 6.00 days and 6.13 during the postimplementation year. There were no difference in deaths at >48 hours postadmission during the postimplementation period versus that during the preimplementation year (69 vs. 49 deaths, respectively; $p = 0.273$).

CONCLUSIONS: Guideline implementation was successful in reducing broad-spectrum antibiotic use and acquisition cost in our hospital to the point where the core strategy of prospective audit and feedback has become feasible. Our ASP has now implemented hospital-wide prospective audit of patients receiving the most broad-spectrum antibiotics with immediate feedback to prescribers. Programs with limited resources may find guideline implementation improves antimicrobial prescribing without putting into practice one of the more resource intensive core strategies.