EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 6
Issue: 6
116-120
Year: 2019

EVALUATION OF MEDICATION ERRORS AND THEIR REDUCTION IN PEDIATRIC ANESTHESIA SETTING

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Article Received on 11/04/2019 **Article Revised on 02/05/2019** **Article Accepted on 23/05/2019**

ABSTRACT
Aim of study: The study aimed to characterize the frequency, type and outcome of anesthetic medication errors among children during 8-year period. **Patients:** Patients of this study were children selected from Department of anesthesiology at Ibn Al-Haytham Eye Hospital/ Baghdad-Iraq during the period from 2008 to 2016. **Results:** Results showed that 26 medication errors were identified out of the 10,968 cases evaluated during the study period. The rate of incorrect dose was (61.5%), while the rate of incorrect medication was (27%) and the rate of errors due to known allergens was (4%). **Conclusions:** Although medication errors persisted, there was a statistically significant reduction in errors during the study period. Formalized medication safety should be adopted by hospitals.

KEYWORDS: Medication errors, Medication safety, Quality improvement.

1. INTRODUCTION
Medical errors constitute the third leading cause of mortality in Iraq[1], and medication complications are implicated most commonly in adverse medical events.[2] Combatting anesthetic medication errors poses distinct challenges, especially in the pediatric population e.g diagnosing the problem, deciding the appropriate therapy, selecting the drug, dose, time and route of administration, procuring the medication and ultimately administering the medication.[3] These decisions need to be made rapidly by clinicians that are often multi-tasking, stressed and sometimes fatigued.[4,5]

Pediatric patients increase the risks for, and consequences of, anesthesia medication errors. Pediatric doses are weight-based and require careful calculation. Additionally, patient maturity may affect medication clearance and, thus, amplify the effect of inappropriate dosing.[6] Despite considerable advances in technology and patient safety initiatives, accurately assessing the frequency of medication errors remains difficult.[7] This report was able to examine the patterns of medication errors during the perioperative period and to suggest targeted interventions that might address the identified patterns of medication errors.

2. AIMS OF THE STUDY
(1) to identify the type, severity and frequency of medication errors from 2008 to 2016 (2) to assess the etiologies of medication errors.

3. METHODS
3.1. Study Design
In 2008, the department of anesthesiology at Ibn Al-Haytham Eyes Hospital in Baghdad/Iraq implemented a systematic data collection database to capture reported medication errors: self-reported, the questionnaire utilized a basis for the root cause analysis conducted for every medication error. Medication route, outcome (Table 1), intervention, time of error and of the staff responsible for the error were also recorded.

Table. 1: Definitions of medication error outcomes.

Term	Definitions
Outcome 1	Recovered without intervention or sequelae
Outcome 2	Recovered with intervention, without sequelae
Outcome 3	Recovered with transient sequelae

In addition to data collection, all medication errors were reviewed and categorized by the hospital Committee based on error type, severity, preventability, accountability, and potential systems-level issues.

Using the root cause analysis tool, each incident was independently reviewed. The case for discussion and final categorization. Recommendations for process changes, if any, were made at this time. Event ratings were then averaged and input into the Department's

clinical adverse events tracking database. These entries were the basis of this analysis.

The data were analyzed based on the personnel involved in the errors, classified as either "primary anesthesia provider" or "trainee". Primary anesthesia providers were defined as attending anesthesiologists. Trainees included fellows, residents, and Nurses.

During the study timeframe, a number of specific interventions were devised and implemented by the Department of anesthesiology, and consequently, reviewed and analyzed in this study.

These interventions include

- **2009:** Implementation of the Medication Safety Program to promote reporting and reduction of medication errors with an emphasis of medication errors, staff meetings.
- **2010:** Installation of a custom-built pediatric anesthesia drug library for medication. Forcing functions to double check the patient's weight and appropriate dosages. The anesthesiologist needs to confirm that the dosage is as intended.
- **2010:** Increased pharmacy support with standardization of drug dilutions, premixed antibiotics, and prefilled syringes of commonly used medications introduced successively during the study period.
- **2011:** Initiation of Medical Administration for Anesthesia Providers Policy, which requires anesthesia providers drawing up or administering medications to have a second clinical provider, an MD, CRNA, RN, or NP, perform an independent confirmation of the patient, medication, dose, time and route. Table 2 includes the frequently used anesthesia medications that are exempt from this policy to preserve anesthesia workflow.

Table. 2: Drugs exempt for Policy by category.

Narcotics	Neuromuscular blocking agents	Reversal agents	Hypnotic agents	Antiarrythmics	Antiemetics	Other
Fentanyl, sufentanyl, remifentanil, morphine	Pancuronium, atracurium, cisatracurium, rocuronium, vecuronium, succinylcholine	Neostigmine	Midazolam, propofol, etomidate	Lidocaine (for IV administration)	Ondansetron, dexamethasone	Atropine, glycopyrrolate

- **2013:** Implementation of Zero-tolerance philosophy for all medication errors; this was deemed necessary to help enforce the Department's philosophy that "production pressure" will not be tolerated as an excuse for not taking the time to "do it right".

3.2. STATISTICAL ANALYSIS

Analysis of findings included a descriptive summary of all medication error types with cross-sectional and longitudinal analysis of patient outcome variables, where the investigation team assessed whether the incidence of medication errors has changed over the time period from 2009 through 2016.[19]

In addition, a bivariate logit model with year as a continuous independent covariate was performed to estimate the year-to-year reduction in the odds of a medication error over the time period.

The Wald test was used to assess significance of changes in the incidence of medication errors over time and 95% confidence intervals for incidence of medication errors were derived using Wilson's method.[20]

Two-tailed $P < 0.05$ was considered statistically significant. Statistical analysis was performed using IBM SPSS Statistics (version 23.0, IBM Corporation, Armonk, NY).

4. RESULTS

Analysis of the medication error rates from 2008 through 2016 demonstrated a statistically significant reduction over time "Fig. 1".

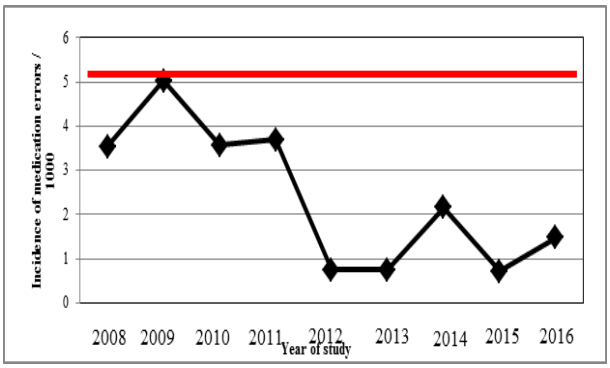

Figure. 1: Analyis of medication error rates illustrating a significant decrease in the incidence of medication errors after implementation of the protocol in 2009 ($P < 0.001$). The red line denotes the incidence in 2009 (5.025% errors). The solid black line represents the observed incidence percentage per 1000 cases each.

No statistically significant differences were detected between 2009 and 2011, although the incidence dropped from 5.025% in the reference year 2009 to 3.565% in 2010 (P = 0.33) and 3.69% in 2011 (P = 0.24). Each subsequent year, excluding 2014 (P = 0.15), showed a significant reduction in the event rate compared with 2009 (2012: 0.739%, Wald test = 11.96, P < 0.001; 2013: 0.738%, Wald test = 9.34, P = 0.002; 2015: 0.719%, Wald test = 9.41, P = 0.002; 2016: 1.48, Wald test = 8.85, P = 0.003).

Overall, since 2009, as well as for years in which a significant reduction was observed, the reductions per 1000 cases are significant even with a conservative Bonferroni adjustment of the P-value to account for the multiple comparisons. Compared to the reference year of 2009, when the protocol was implemented and the incidence of medication errors was 5.025 per 1000 cases.

Nearly 90% of the 26 medication errors that occurred during the entire study period involved either incorrect dosing (61.5%) or incorrect medications given (27%) with another 4% being errors due to known allergens "Fig. 2". “Known allergen” indicates that a patient with a previously documented allergy was still administered that medication. There was a variety of substances involved when incorrect doses were used, often opioids (14%), IV anesthetics (14%), analgesics (12%) or antibiotics (8%)

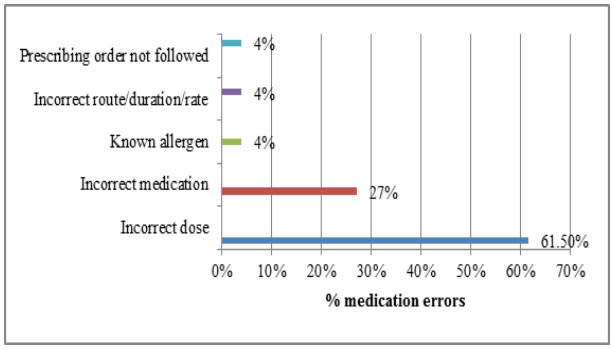

Figure. 2: Bars represent the percentage of types of medication errors which occurred throughout the study period with incorrect dose (61.5%) and incorrect medication (27%) being the most common types. The substances involved when incorrect doses were given are shown in the caption with opioids (14%), IV anesthetics (14%), and analgesics (12%) representing the most common.

Both Table 3 and Fig. 3 illustrate the outcomes of the medication errors included in this study, based on the definitions provided in Table 1. In the first 4 years of the study period, there were 19 errors, 10 of which were Outcome 1 (52%), 9 were Outcome 2 or Outcome 3 (48%). From 2012 through the end of the study, there were 7 errors, 6 of which were Outcome 1 (85%), one of which were classified as Outcome 2 or Outcome 3 (15%).

Table 3: Medication errors, need for intervention and presence of sequelae according to year of study.

Year of study	Anesthetics administered	Medication errors	Outcome 1	Outcome 2	Outcome 3
2008	1131	4	2	1	1
2009	1194	6	4	2	0
2010	1122	4	2	2	0
2011	1355	5	2	1	2
2012	1353	1	1	0	0
2013	1355	1	1	0	0
2014	1393	3	2	1	0
2015	1390	1	1	0	0
2016	675	1	1	0	0
Total	10968	26	16	7	3

Based on data between January 2008 and June 2016. Outcome 1= recovered without intervention or sequelae; Outcome 2 = recovered with intervention, without sequelae; Outcome 3 = recovered with transient sequelae.

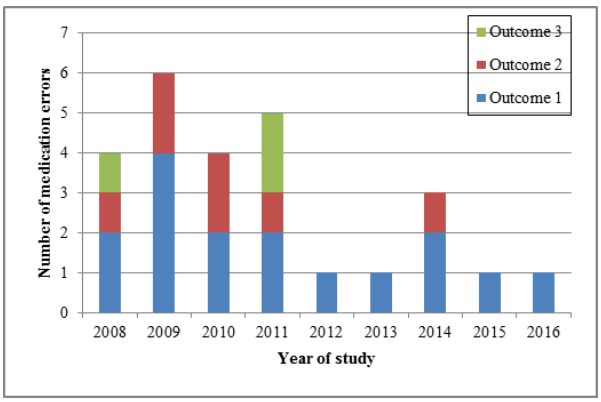

Figure. 3: Medication error outcome (2008-2016).

5. DISCUSSION

Since 2009, the Department has shifted its focus from simply reporting and reviewing medication errors to developing systems and processes that are aimed at proactive error prevention. Toward this goal, the results of this study demonstrate a statistically significant decline in the rate of medication errors, a trend that held from 2011 to 2016.[21]

An additional safeguard, the “Medication Administration for Anesthesia Providers Policy”, established the process of verifying another practitioner's work by independently performing calculations, visualizing the medication and verifying pump settings and doses without interference

or bias— a strategy proven efficacious in preventing drug administration errors.[22]

Additionally, for continuous infusions, the pump settings and the connection of the infusion to an appropriate carrier must be verified. While no documentation of compliance with this policy is necessary, in the case of a drug error, the Safety Event Report must reflect that this verification procedure was carried out along with the verifying clinicians' identity. A recent study suggests that multiple-practitioner involvement in medication administration is a contributing factor to medication error in approximately 20% of cases.[17]

It is hypothesized that this is the result of poor communication and non-standardized dilution practices.[17,23] This departmental policy is designed to eliminate these types of errors and leaves little room for communication shortfalls. To help ensure compliance in the future and to better analyze the policy's efficacy, mandatory documentation and accompanying periodic audits should be considered.

Since 2011, the majority of medication errors observed in this study were made by fellows, rotating residents, or SRNAs, a finding which differs from the recent WUS Report[18] where medication errors were most commonly attributed to attending anesthesiologists. Based on this, further emphasis has been placed on trainee medication error prevention, with the inclusion of error case studies in their orientation. Additionally, the Anesthesiologist-in-Chief now participates in trainee orientation to further stress the importance of medication safety and to highlight the Department's policies. While increased educational efforts to reinforce the importance of performing double-checks of nonstandard anesthetic drugs and pump programming could improve compliance, introducing system changes that incorporate these protocols into routine daily practice would likely prove more effective. Finally, though it may be tempting to give credit to enhanced training and educational efforts for the observed reduction in errors, without denominator information no such conclusions can be made.

This study has several limitations. The data come from a voluntary reporting system and manual chart review, making it difficult to determine the true rate of medication errors. It is important to acknowledge that reporting may vary by provider, regardless of institution, departmental culture or reporting infrastructure; some may report all events, including those that do not require intervention or result in patient sequelae, while others report only errors that cause harm or are discovered/prevented by a nurse or pharmacist.[24,25,26]

Additionally, studies have shown that physicians perceive that reporting an error is not part of their duties or they are reluctant to report for fear of reprisal.[25,26]

The Department of Anesthesiology, Critical Care and Pain Medicine's Medication Safety Policy was implemented to promote a culture of transparency and safety around event reporting and process improvement. Whether or not the rate of medication errors has improved because of, or in spite of, these initiatives, this paper does outline measures that have been used as part of a successful safety program that can be adopted by other departments.

6. CONCLUSION

This paper outlined measures that have been used as part of a successful safety program that can be adopted by other departments. Although medication errors persisted, there was a statistically significant reduction in errors during the study period, and formalized medication safety should be adopted by hospitals. Apparently previously healthy female without any immunosuppressive agents and the rash started as bruises-like around the eyes that became aggressive and rapidly spreading after periorbital PRP injection.

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