Insights From a Tertiary Care Intraosseous Insertion Practice Improvement Registry: A 2-Year Descriptive Analysis

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Contribution to Emergency Nursing Practice

- The current state of scientific knowledge on intraosseous (IO) access success in emergency departments by RNs is incomplete. Registry-based research into this procedure may be valuable to assess whether practice standards and guidelines for IO insertion and use by ED RNs are appropriate.
- This quality improvement IO insertion registry recorded and monitored IO insertions in a tertiary care emergency department. The registry captured whether the IO procedure was successful or unsuccessful and possible patient and clinician factors that may have influenced the outcomes.
- Key implications for emergency nursing practice from this quality review include that the use of 15-mm IO needles appear to be most associated with failure in pediatric patients, especially in infants younger than 12 months of age. Compared with adults, pediatric patients incurred more IV attempts prior to IO access. Consider earlier IO insertion in pediatric patients when indications for IO placement are present.

Abstract

Introduction: Few practice improvement registries exist that describe opportunities to improve intraosseous (IO) use. The goal of this project was to assess the success rate of the procedure by emergency nurses and identify opportunities to improvement. Secondary goals were to assess success rates based on clinician type, age of patient, and procedural factors.

Methods: Emergency nurses assigned to the resuscitation area of a tertiary care emergency department completed an education module and skill lab on IO placement. Tracking forms were completed whenever IO access was attempted, and the clinical nurse educator collated the forms.

Results: Over 2 years, quality improvement forms were submitted for 17 pediatric patients (receiving 23 IO insertions) and 35 adult patients (receiving 40 intraosseous insertions). Prior to an IO attempt, the average number of IV attempts for pediatric and adult patients was 4 (range 0 to 10) and 2 (0 to 5), respectively. Successful pediatric IO insertion rate was 6/15 (40%) for physicians (both residents and attending physicians) and 6/7 (86%) for emergency nurses. Physicians were more likely to perform IO insertions in children <12 months of age and emergency nurses in patients >12 months of age. The leading cause of failed insertions in pediatrics was selecting a needle that was too short: either not reaching the intramedullary canal or quickly becoming dislodged, especially with flushing the IO cannula after insertion. For adult patients, IO insertion success rates for physicians were 13/14 (93%) and 18/20 (90%) for emergency nurses.

Discussion: The registry identified opportunities to improve clinical practice on the clinical threshold for IO use in pediatric patients and the appropriate selection of IO cannula.

Key words: Intraosseous (IO); Resuscitation; Quality improvement registry; Vascular access

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Introduction

Obtaining vascular access in adult and pediatric patients during resuscitation can be challenging. Peripheral IV access may not be readily attainable, and an alternate method for vascular access may be required. Current guidelines for both adult and pediatric advanced cardiac life support (ACLS) and trauma care and neonatal resuscitation recommend initiating intraosseous (IO) access when peripheral IV access is not achievable.[1-5] During resuscitation, if peripheral IV access is not successful, accomplishing vascular access with IO insertion is important, as delays may increase morbidity or mortality in patients.[6] IO access is an intervention that can be performed quickly by trained ED health professionals. Few practice improvement registries exist that describe opportunities to improve success of IO insertion and decrease complications associated with IO insertions. It is recommended that data be collected on emergency nurse use of IO for vascular access so research can continue to inform the standards and guidelines for its use.[7]

A quality project was developed to follow the success of IO insertion by emergency department personnel and specifically emergency RNs. This quality project reports on the creation of an emergency clinical nurse educator (CNE)-led registry that tracked IO insertions in adult and pediatric patients over a 2-year period. The primary purpose of this project was to assess the success rate of the procedure by emergency nurses and identify opportunities for improvement. A secondary goal was to capture the health discipline of the IO inserter and determine discipline specific rates of success and complications.

Methods

An academic tertiary care emergency department with approximately 50,000 pediatric visits and 66,000 adult visits annually was selected as the site for the project. There were no previous data available to assess successes, failures, or complications of IO insertions for this emergency department. Initially, the health care providers performing IO insertion were emergency physicians (adult or pediatric specialists), residents, fellows, or emergency medical technician paramedics (EMT-Ps) who worked in emergency departments. Emergency nurses had some education on IO care and maintenance, typically through ACLS and pediatric advanced life support (PALS) courses. However, no formal education package existed before the implementation of this project for emergency nurse staff.

An education module on IO insertion, care, and maintenance was developed by the CNE. Emergency nurses assigned to the resuscitation area of the emergency department completed the education module and a skill lab session. The education plan for the RN group included completing a written examination on IO insertion, care, and maintenance and attending a simulation skill workshop on IO insertion of approximately 60 minutes. Twenty emergency nurses initially received the training (about 25% of the RN staff who are assigned to the resuscitation area of the emergency department), followed by increasing the number of RNs trained for IO insertion over the 2-year period. The CNE implemented simulated case studies and a standardized skill checklist to assess skills and knowledge on the IO-insertion procedure. Ongoing IO skill and maintenance education included an IO skill lab during the implementation period by an IO master trainer. Over the 2-year study period, IO training became a part of the resuscitation education in the emergency department as a unit standard.

INTERVENTION

The intervention tool was a paper-based data collection form that was implemented to collate IO-insertion characteristics. Emergency nurses were requested (voluntarily) to complete the tracking form whenever a patient had an IO inserted by any health care professional in the emergency department. The tracking form was made available widely throughout the emergency department in the IO kits, in the trauma bays, on desktop computers, and e-mailed to the emergency nurses to encourage completion of the forms. The CNE did unit rounds weekly to educate staff on the project, use of the tracking tool, and where the tool was located in the emergency department. The completed forms and information were abstracted into a database (Excel, Microsoft, Redmond, Washington). A second researcher independently double abstracted the data to ensure accuracy. If any differences were found, the 2 researchers would reassess that form with a third researcher to reach a consensus (see Appendix for example of a tracking form; available at www.jenonline.org). Completed forms were assessed by the CNE on a weekly basis to consider any opportunities or strategies for practice improvement education.

Results were tabulated after year 1, and all data were collated after year 2. The implementation period was from July 1, 2015, to June 30, 2017. Results of the IO registry were shared with ED leadership, nursing and physician staff,

TABLE 1
Intraosseous (IO) registry data

	Adult patients			Pediatric patients		
Number of tracking forms completed by IO placement clinician type	ED physician	14		ED physician	11	
	ED nurse	15		ED nurse	6	
	ED paramedic	5		**Total**	**17**	
	Unknown	1				
	Total	**35**				
Reason for IO insertion n (%)	Nontraumatic cardiac arrest	14 (40)		Precardiac arrest	7 (40)	
	Traumatic cardiac arrest	10 (29)		Cardiac arrest	2 (12)	
	Sepsis	10 (29)		Diabetic ketoacidosis	2 (12)	
	Gastrointestinal bleeding	1 (2)		Shock	2 (12)	
				Trauma patients	2 (12)	
				Sepsis	1 (6)	
				Seizure	1 (6)	
Age in months: mean/median (standard deviation [SD])	59.9/49 (SD 17.7) (no differences between clinician groups)			ED physician	8.8/7 [12.5]	
				ED nurse	36 /12.5 [59]	
Placement location by clinician type n (%)	ED physician	Proximal humerus	3 (21)	ED physician	Distal tibia	2 (18)
		Proximal tibia	7 (50)		Proximal tibia	8 (73)
		Distal tibia	4 (29)		Unreported	1 (9)
	ED nurse	Proximal humerus	4 (27)	ED nurse	Proximal tibia	5 (83)
		Proximal tibia	10 (67)		Unreported	1 (17)
		Distal tibia	1 (6)			
	ED paramedic	Proximal tibia	5 (100)			
Average number of IV attempts prior to IO insertion by clinician type: mean (SD) (range)	ED physician	2.3 [1.8] (0-8)		ED physician	4.5 [2.2] (0-10)	
	ED nurse	1.6 [0.9] (1-5)		ED nurse	3.5 [1.7] (1-6)	
	ED paramedic	1.2 [0.8] (0-2)				
IO success rate (defined as a functioning IO till ED transfer or planned removal in the ED)	ED physician	93%		ED physician	40%	
	ED nurse	90%		ED nurse	86%	
	ED paramedic	100%				
Overall disposition status n (%)	Died:	15 (43%)		Critical care:	14 (82%)	
	Critical care:	13 (37%)		Inpatient ward:	3 (18%)	
	Cardiac catheterization lab:	3 (9%)				
	Operating room:	3 (9%)				
	Not disclosed:	1 (1%)				
Lidocaine use with IO insertion on noncardiac arrest patients	6 of 26 noncardiac arrest adult and pediatric patients received lidocaine anesthetic before IO infusion					

and within the health authority ED CNE council. Data and trends from the registry were used to reinforce staff education in IO insertions to promote greater procedural success. Ongoing data from the registry will identify whether these education efforts improve practice.

ANALYSIS

Basic descriptive statistical analyses were calculated on data obtained through the registry. Results were reviewed by local medical and nursing experts to assess the variations seen in practice between clinician and patient groups.

A Research Ethics Community Consensus Initiative Screening Tool was used, and it was determined that this study involved quality improvement and program evaluation and was of minimal risk to patients (http://www.aihealthsolutions.ca/).

Results

Between July 1, 2015, and June 30, 2017, 52 IO tracking forms were completed for 17 pediatric patients and 35 adult patients. Double data abstraction resulted in an initial percentage of agreement between reviewers of 82.5%. Initial disagreement was found in the interpretation of free text comments and whether to include or exclude these specific findings. Consensus was achieved in discussion among the 3 reviewers. See Table 1 for the clinical description for pediatric and adult patients, respectively, who required IO insertions.

NUMBER OF INTRAVENOUS ATTEMPTS PRIOR TO IO INSERTIONS

Prior to IO attempts, pediatric patients had, on average, 4 attempts at IV access (range: 0 to 10) whereas adult patients had, on average, 2 attempts at IV access before IO attempts (range: 0 to 5).

IO INSERTION SUCCESS RATE

Successful rates of pediatric IO insertion by physicians were 6/15 (40%), whereas the emergency nurse rate of success was 6/7 (86%). One additional IO placement was captured that an EMT-P placed within the department that was not successful. ED physicians were more likely to place IO insertions in children <12 months of age. Emergency nurses were more likely to place IO insertions in children >12 months of age. The leading reason attributed to failed insertions was selecting a needle that was too short (15-mm size), either not reaching the intramedullary canal, or quickly becoming dislodged following flushing the IO cannula.

For adult patients, physicians were successful in 13/14 (93%) IO insertions, whereas the rate of success for emergency nurses was 18/20 (90%). For IO placements by EMT-P in adults within the department, 5/5 (100%) were successful. One placement did not have a clinician type noted.

LIDOCAINE USE WITH IO INSERTION

Only 6 of 26 noncardiac arrest adult and pediatric patients received lidocaine anesthetic prior to intraosseous infusion.

DISPOSITION STATUS

There was a difference in discharge destination of pediatric and adult patients from the emergency department. The destinations of pediatric patients were described as critical care units in 14/17 cases (77.7%) or inpatient ward (unknown type) 3/17 (16.6%). Destinations for adult patients were 15/35 (43%) morgue, 13/35 critical care (37%), 3/35 (9%) cardiac catheterization lab, 3/35 (9%) operating room, and 1/35 (2%) to an unreported location.

Discussion

The registry review supports the anecdotal reports of emergency nurses' comfort with IO use post-training. Our reported first insertion and overall success for adult insertions by both physicians and emergency nurses and for pediatric insertions by emergency nurses are similar to previous research ranges: from 83% to 96% in adults[8,9] and 90% in pediatics.[10] The registry also identified a number of areas to review and opportunities to provide ongoing education.

The most common reason for failed IO access in pediatric patients was selection of too short a needle (15 mm when a 25 mm needle is indicated) based on tissue depth over the site. In the pediatric population, there was an increased number of IV starts prior to an attempt at IO access compared with adults. One proposed rationale is that the adult patient cohort was sicker than the pediatric cohort, as many more adults were in cardiac arrest on arrival to emergency departments. Some pediatric patients were admitted to noncritical-care inpatient wards after stabilization. No adult patients were admitted to nonintensive-care settings.

These findings support continued educational programs that should focus on determination of appropriate IO needle length and threshold for indications for use. Other findings that were emphasized were the emergency

nurse's role to support, through coaching and mentoring, all health professionals in the IO insertion skill.

The variation seen between physician and emergency nursing success rates in pediatric IO placement (40% and 86%, respectively) helped focus the ED team on identifying areas for improvement. This difference in rates of complications might indicate that the physicians were attempting placement on the most challenging patients. Data reflected that ED physicians attempted most of the IO insertions in the <12 months of age group. The IO tracking form did not identify the physician level of training before the project—resident, fellow, or attending staff emergency physician—nor their experience and skill maintenance. We did not collect data on the total number of all physicians in the department, and it is not known if all physicians placing IO insertions received standardized training in IO insertion compared with their emergency nurse colleagues.

Modifications have been made to the data collection form to identify specific data on level of training of physician (resident, medical student, staff ED physician). An assessment of emergency physician and resident training in this area has occurred. This may represent an opportunity for improvement for pediatric insertion, as the reported rate of dislodgement was higher than previously reported rates of approximately 6%.[11,12] Didactic and practical training can be as short as 2 hours to improve IO successful placement to 97% after a maximum of 2 attempts.[13] Physician training is integral in increasing IO success and confidence and in the use of this skill. Research in adult trauma patients found that previous IO device training had the largest association with increasing the likelihood of physicians subsequently using IO placements.[14]

It is difficult to assess the appropriateness of the low reported use of lidocaine for noncardiac arrest patients. For example, patients might have been in periarrest states requiring immediate access or unconscious, and a painful stimulus of a flush might have been used as an assessment of Glasgow Coma Score (GCS). The tracking form has been further modified to attempt to assess appropriate use of lidocaine in conscious patients for management of pain after IO insertion.

Limitations

A significant limitation of this quality improvement initiative was that the exact response rate was not known and that not all IO insertions may have been captured in the database, as the completion of the tracking forms depended on the emergency nurse to complete and submit. Reassuringly, at least in pediatric patients, the total numbers of patients included were similar to previously published findings in a similar sized tertiary pediatric emergency department.[15] Other limitations include that specific training and experience of physicians was not known or available. Owing to the quality review nature of the study, it was not possible to identify if IO insertions were being placed by a small group of individuals or a wider group. Long-term follow-up of patients was not performed, so no long-term complications (those that occurred after leaving the emergency department) could be reported in this review, and it is possible that overall complication rates are underreported. Furthermore, all limitations associated with observational, single-center, nonexperimental research apply, so our findings should be considered hypothesis-generating only.

Implications for Emergency Nurses

A CNE-led IO registry can be implemented successfully in a busy tertiary care emergency department. Emergency nurses were able to place IO insertions with a high rate of success, which may free the ED physician to focus on the team lead role and overall patient care during resuscitations. Review of the IO registry identified educational opportunities to improve IO rates of success on adult and pediatric patients. Opportunities exist to provide continued educational programs focused on the clinical threshold for IO use, particularly in pediatric patients: the appropriate selection of IO needle based on tissue depth over the site and not based on the weight indicated on the IO packaging and the indications for use of lidocaine for management of pain after IO insertion.

Conclusion

The creation of a voluntary IO placement-reporting registry at a busy tertiary emergency department has provided our emergency department with vital information on IO use, rates of success for IO insertion, and patient factors that can affect success rates of the IO-insertion procedure. For both emergency nurses and physicians, there are ongoing opportunities to improve IO placement. Ongoing use of tracking and the registry will provide continuing evidence of increased success of IO placement by all ED health professionals.

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