Spring 5-8-2020

A Difficult Vascular Access Algorithm Using Intraosseous Devices in the Elective Pediatric Surgical Population

Cory R. Austin
Southern Illinois University Edwardsville

Executive Summary

Introduction of the Problem

In pediatric patients undergoing elective surgery, the most common technique utilized to induce anesthesia is a mask inhalational technique using inhaled nitrous oxide and sevoflurane followed by placement of a peripheral intravenous (IV) catheter for continued medication and fluid delivery (Lerman, 2013). However, even for the most experienced anesthesia providers and operating room personnel, peripheral IV access may be extremely unpredictable and difficult to obtain in this patient population, with reported success between 35% and 73.9% (Cuper et al., 2010; Nafiu et al., 2010; Parker, Benzies, & Hayden, 2017). During futile attempts at IV catheterization, prolonged mask ventilation of the child may lead to dangerous clinical sequelae such as insufficient oxygenation and ventilation, atelectasis, gastric insufflation, vomiting and aspiration, ecchymosis, hematoma, and significant hemodynamic alterations amid limited routes for intervention and medication delivery (Neuhaus, 2014).

Approaches to difficult IV access in the pediatric patient may include numerous peripheral IV catheter insertion attempts by multiple providers and adjuncts such as nitroglycerin ointment, transilluminator devices, near-infrared devices, and ultrasound devices, all with variable success (Heinrichs, Fritze, Klassen, & Curtis, 2013; Parker, Benzies, & Hayden, 2017). In current practice, inability to attain IV access by these means may progress to central venous catheter (CVC) placement, or the child may need to emerge from anesthesia and the procedure canceled (Crowley et al., 2012). Therefore, there is an expressed need for an evidence-based, systematic approach to difficult vascular access in elective pediatric surgical patients utilizing the most effective, least invasive means for the individual clinical situation.

Literature Review

A joint statement by the Infusion Nurses Society, Emergency Nurses Association, American Association of Critical Care Nursing, Society of Pediatric Nurses, and the Air and Transport Nurses Association recommends that IO devices be considered as an alternative to peripheral IVs or CVCs, including pre-procedure surgical settings (Phillips et al., 2010). Compared to IV catheters, IO access has a high rate of success and can be placed rapidly in pediatric patients by a trained provider, boasting a success rate of 70% to 100% and placement in under 90 seconds (El-Nawawy et al., 2018; Frascone et al., 2009; Horton & Beamer, 2008; Myers et al., 2011; Pifko et al., 2018; Schalk et al., 2011; Schwindt, Hoffmann, Deindl, Waldhoer, & Schwindt, 2018).

Intraosseous devices can be used in children weighing greater than 3kg for up to 24 hours, are generally more cost-effective, require less training, and are quicker to place than CVCs. Anesthetic medications delivered via the IO route exhibit similar overall drug exposure and onset times when compared to the intravenous route of administration. Therefore, IO devices may provide an effective alternative for rapid, successful vascular access when traditional methods fail. However, severe complications such as compartment syndrome can occur secondary to extravasation of hypertonic and caustic medications when delivered via IO. Therefore, if long-term access or infusion of such medications is planned, placement of a CVC is likely a safer option for the patient.

Project Methods

The difficult vascular access algorithm was developed based on the best available evidence from an exhaustive literature review as well as existing relevant algorithms in the literature. Twenty of the top ranked children's hospitals across the nation were also contacted by the primary investigator to request facility policies or algorithms used for pediatric difficult

vascular access. The twenty hospitals were chosen according to The U.S. News and World Report's "Best Children's Hospitals Honor Roll and Overview" as ranked using the combined clinical data from a survey of 200 hospitals and a reputational survey of 15,000 pediatric specialists (Olmstead et al., 2019). Unfortunately, no meaningful responses were obtained from emailing the publicly available contacts within each of the twenty hospitals.

Approaches to vascular access included in the algorithm were thus individualized based on the available evidence, in conjunction with the technology and the needs of the site of implementation. The stakeholders provided input regarding facility current practices, culture, and desired practice changes to individualize the algorithm to the facility needs.

Purpose and goals. The goals of project implementation were to develop and introduce a difficult vascular access algorithm using intraosseous (IO) devices in the elective pediatric surgical population at a tertiary care center in central Illinois, as well as to encourage adoption of evidence-based practice through staff education.

Setting. This project was implemented within a tertiary hospital in central Illinois. In the year prior to this project's implementation, the hospital's anesthesia department performed 39 neonatal cases, 674 cases on patients less than two years old, and 1328 cases on patients between the ages of two and twelve (R. Collier, personal communication, January 16, 2020).

Institutional review board. This project was designated a quality improvement project by the Institutional Review Board at Southern Illinois University Edwardsville and subsequently approved by the implementation site project review committee. Participation in this project was voluntary.

Evaluation

The evidence from the literature review as well as the difficult vascular algorithm were

presented at the implementation site in a PowerPoint presentation followed by an open discussion session. Following the PowerPoint project presentation and discussion session, a ten-question survey consisting of eight Likert-scale questions and two open-ended comment questions was administered to all attendees for voluntary completion and anonymous collection. Seven anesthesia providers consisting of anesthesiologists and CRNAs attended the presentation and participated in the voluntary survey. Supplemental materials from the presentation including an "IO sizing guide" created by this author were requested by the implementation site and readily provided in laminated form.

After anonymous survey collection, an analysis of the completed survey deriving a mean score and standard deviation from the Likert-scale questions, and comments from questions nine and ten were analyzed. Results of the eight Likert-scale questions from all seven participants were generally positive. Each answer to the Likert-scale questions was assigned a point value on a scale of one to five, with one representing "strongly disagree" and five representing "strongly agree" respectively. Scores for Likert-Scale questions ranged from 4.29 to 5 with a standard deviation of 0 to 0.7. Results of the two comment questions were also generally positive.

Impact on Practice

Overall, the difficult vascular access algorithm made a positive impact on the anesthesia group. The attending providers noted that the presentation was thorough and improved their knowledge regarding IO access in elective pediatric surgery. With the knowledge gained from this presentation, the providers noted that they would be quicker to seek assistance from another provider, and to implement alternative measures such as ultrasound or IO to obtain rapid vascular access. Unfortunately, despite positive survey and discussion feedback, the anesthesia department did not choose to officially implement the difficult vascular access algorithm.

During the post-presentation discussion, the anesthesia department voiced concerns about the unknown frequency of IO use in elective pediatric surgery amongst other national leaders in pediatric anesthesia, due to lack of response from twenty contacted hospitals during the literature review phase. Ultimately, the barrier to implementation at this hospital was hesitation to implement a protocol viewed as an extreme change in practice. Since IO devices have a long and successful record of use in emergency and trauma medicine, their use is often associated with the stigma of extreme measures. Members of the anesthesia department feared that during the post-operative period, parents or guardians of pediatric IO recipients would be angered that providers "drilled into their kid's bone." In children as well as adults, there is significantly less provider and public comfort with the use of IO devices than IVs or CVCs, a dilemma which may be remedied by continuing education, as well as mounting evidence and individual case studies.

Conclusion

The implementation of this project made a positive effect on the anesthesia group at a tertiary hospital in central Illinois. Although they will not be officially implementing the algorithm at this time, the CRNAs and anesthesiologists in attendance provided positive feedback and indicated a gain in knowledge and comfort with IO devices following the presentation. Copies of supplemental presentation materials were requested and supplied by this author, and staff indicated a willingness to further discuss the project in future staff meetings.

Recommendations for future quality improvement projects would be to perform knowledge assessment, barrier assessment, and hands-on educational activities for IO use in elective anesthesia. Anesthesia providers may benefit from annual computerized training modules, as well as immersive manikin simulations where providers approach a decompensating child who is a difficult IV candidate and requires rapid vascular access. The EZ-IO

manufacturer has a training kit to educate providers on locating landmarks and inserting the IO appropriately, which may be helpful for such simulations. While this project targets IO use in the pediatric population, anesthesia providers may also benefit from a project that first promotes IO use in the adult elective surgical population, whose scope is then expanded to the pediatric population at a later date after initial professional and public buy-in.

The use of IO devices in elective pediatric anesthesia has the potential to improve speed of vascular access and improve patient outcomes. An evidence-based algorithm for vascular access utilizing the most effective, least invasive means for the individual clinical situation and in-line with the needs of the facility has the potential to improve patient outcomes and expedite workflow. Despite this project not being officially implemented at this time, IO devices still continue to be placed on occasion for anesthesia when the clinical situation and provider judgment deems their use necessary. Since the literature supporting IO use in elective anesthesia relies heavily on case studies, this author recommends readers who place an IO for elective anesthesia to expand the available literature via continued documentation of case studies.

Author Contact Information

Cory R. Austin

Southern Illinois University Edwardsville

caustin@siue.edu

craustin90@gmail.com