Intraosseous Infusion of Blood Products and Epinephrine in an Adult Patient in Hemorrhagic Shock

James M. Burgert, CRNA, MSNA

A 79-year-old woman presented in the postanesthesia care unit with hematemesis following replacement of a jejunostomy tube. Her medical history included recurrent stage IIIC ovarian cancer. The patient rapidly decompensated despite blood products administered through the patient’s implanted medication port. The anesthesia service was consulted for resuscitative support.

Examination revealed an alert, hypotensive elderly female in hemorrhagic shock. While peripheral intravenous (IV) access was sought, her condition further deteriorated. Attempts at peripheral access were determined futile and central venous access would be required. An intraosseous (IO) catheter was placed in the proximal medial aspect of the left tibia using the EZ-IO device (Vidacare Corp, San Antonio, Texas). Crystalloid and colloid fluids, blood products, and drugs were administered via the IO route, stabilizing the patient’s condition during the central access procedure. The IO route was used throughout the resuscitative effort. Hemostasis was achieved, and the patient was admitted to the intensive care unit.

Intraosseous infusion is a valuable and underutilized technique in managing patients in hemorrhagic shock with poor IV access. Anesthesia providers should seek education and training from those experienced in IO placement techniques and consider use of the IO route early in the resuscitative process.

Keywords: EZ-IO, hemorrhagic shock, intraosseous infusion, intraosseous transfusion.

A nesthesia providers are frequently confronted with patients in whom placement of vascular access may be difficult or impossible. Often overlooked in anesthesia practice is the use of the intraosseous (IO) route of infusion.

Historically, the potential use of the IO route of infusion can be traced to Drinker et al in 1922. Studies performed in the 1930s established IO infusion as a clinically useful technique. Intraosseous infusion was used in adults and children, mainly in Europe, through the 1940s and into the early 1950s. The development of plastic intravenous (IV) catheters replaced the IO technique, and it was all but abandoned until the 1980s. Resurgence of IO infusion occurred during the 1980s and 1990s when it became advocated for use in pediatric patients with difficult IV access or who were in shock. Further studies in the mid-1990s suggested that IO infusion may be useful in adults. Manufacturers developed new devices that ease the placement of IO catheters and greatly decrease procedural complications.

Emergency medical systems in the United States increased their use of the IO route, developing training programs and guidelines for use in the emergency department and the prehospital settings. The US military has shown renewed interest in IO infusion, as it has proved particularly useful for patients with injuries related to blast trauma such as burns or traumatic amputation of multiple extremities. The American Heart Association (AHA), in 2005, advocated the use of the IO route for administration of resuscitative drugs over administration through an endotracheal tube. According to the AHA, IO cannulation provides drug delivery similar to central venous access. The IO route has also been found to be effective for fluid administration, drug delivery, and blood sampling for laboratory evaluation. The IO delivery of resuscitative drugs results in higher blood concentrations than the same dose given by endotracheal tube. The AHA concluded that IV or IO administration is preferred because of more predictable drug delivery and pharmacologic effect. The review of past and current literature supports the use of the IO route. The case study reported here illustrates the utility of this technique to the clinical anesthesia provider.

Case Summary

A 79-year-old woman presented to the Gynecological Oncology Service, from a skilled nursing facility, with intractable hyperemesis secondary to an occluded jejunostomy tube. Her previous medical history included recurrent stage IIIC ovarian cancer, hypertension, hyperlipidemia, hypothyroidism, paroxysmal atrial tachycardia, and anemia of chronic disease. Her previous surgical history included total abdominal hysterectomy with bilateral salpingo-oophorectomy and staging, appendectomy, bilateral breast lumpectomy, bilateral prophylactic mastectomy,
knee arthroscopies, cataract extraction, implantation of a medication infusion port, and placement of a jejunostomy tube. Her outpatient medications included metoprolol, metoclopramide, levethyr oxine, pantoprazole, spironolactone, docusate, ondansetron, magnesium oxide, potassium chloride, and ferrous sulfate. The patient had received 8 cycles of chemotherapy, including taxol and carboplatin, with her last cycle of therapy 6 months earlier. She was allergic to salicylates.

The jejunostomy tube had been placed the month before presentation secondary to her inability to tolerate oral nutrition, which ultimately led to development of aspiration pneumonia. She had been discharged to the skilled nursing facility following resolution of the aspiration pneumonitis. At the skilled nursing facility, she experienced repeated episodes of emesis secondary to occlusion of the jejunostomy tube. She was admitted to the hospital, and the Interventional Radiology Service was consulted for replacement of the jejunostomy tube and placement of a decompressive gastrostomy tube under ultrasound and fluoroscopic guidance.

The procedures were successfully completed in the interventional radiology suite using intravenous sedation administered by a conscious-sedation nurse. The patient was transferred to the postanesthesia care unit (PACU) in stable condition. One hour after arrival in the PACU, the patient vomited approximately 250 mL of bright red blood. The attending service was notified, and team members initiated transfusion of blood products through her implanted medication port while they continued their evaluation. The Anesthesia Service was consulted for resuscitative support.

Upon arrival at the bedside, the patient was alert but in mild distress. The heart rate was 100/min and blood pressure was 100/52 mm Hg. Respirations were 18/min and unlabored. Oxygen saturation (SaO2) was 99% with a 3-L/min nasal cannula. The patient’s “full code” status was confirmed with the attending service. The decision was made to obtain additional peripheral IV access in light of the patient’s symptomatic hemorrhage. The patient’s vital signs rapidly declined over a 5-minute time span. The heart rate increased to 136/min, and blood pressure declined to 66/20 mm Hg. At this point, it was determined that further attempts at peripheral access were futile and that the patient required central venous access. During preparations for the central venous procedure, the decision was made to attempt placement of an IO infusion device.

The EZ-IO device (Vidacare Corp, San Antonio, Texas), a device similar to a battery-powered screwdriver, and a 15-gauge, 25-mm IO needle were selected to achieve IO access. After skin preparation with chlorhexidine, the proximal medial surface of the left tibia was infiltrated with 1% lidocaine down to the periosteum. The tip of the IO needle attached to the powered device driver was driven through the overlying tissues until the tibial surface was contacted. The device driver was activated, and the IO needle was advanced until a distinct loss of resistance was noted indicating penetration into the medullary cavity. The inner stylet was removed and a 10-mL syringe was attached to the IO needle. Aspiration of bone marrow into the syringe confirmed correct placement. The IO needle was flushed with 10 mL of sterile saline, producing substantial discomfort in the patient. Five milliliters of 1% lidocaine was injected into the marrow space, giving the patient complete resolution of the infusion-related pain.

Blood tubing was attached to the IO needle. A 500-mL bag of hetastarch was pressurized to 300 mm Hg and infused over a 5-minute period, producing minimal clinical effect. No extravasation was noted.

The patient’s mental status declined despite aggressive resuscitative interventions, and the decision was made to secure the airway with an endotracheal tube. A rapid-sequence induction and endotracheal intubation with etomidate and succinylcholine was performed without difficulty, and she was placed on a ventilator. Additionally, a 20-gauge arterial line was placed in the dorsal artery of the right foot. Phenylephrine, administered in 100-µg IV boluses over the prior 2 to 3 minutes, failed to elicit any hemodynamic improvement. Epinephrine, administered in a 50-µg dose via the IO route, resulted in a rise of the patient’s systolic blood pressure to 90 mm Hg after approximately 30 seconds. Additional blood products arrived and were administered. One unit of packed red blood cells (RBCs) was pressurized with a pneumatic infusion bag to 300 mm Hg and administered to the patient through the IO device in approximately 6 minutes. An 8.5F × 10 cm central venous catheter (Arrow International, Inc, Reading, Pennsylvania) was placed, over a 10-minute period, with difficulty, in the right internal jugular vein using ultrasonic guidance. Two additional units of packed RBCs were given through the 8.5F catheter. An epinephrine drip was initiated and maintained at an infusion rate of 0.1 µg/kg per minute through the patient’s implanted medication port. Intermittent boluses of epinephrine were administered via the IO route to maintain the mean arterial pressure at a goal of 65 mm Hg. Two units of fresh frozen plasma were also administered through the IO device. Once the patient’s condition stabilized, the Interventional Radiology and Gastrointestinal Medicine teams were able to proceed with esophagogastroduodenoscopy (EGD) to identify and arrest the source of bleeding. Intermittent boluses of ketamine were given as tolerated for sedation.

Resuscitative efforts continued throughout the EGD to include additional units of packed RBCs, fresh frozen plasma, epinephrine, and calcium chloride, as guided by laboratory analysis of blood samples and vital signs. The 8.5F catheter and IO device were used primarily for resuscitation during this portion of the procedure. Urine output was monitored following placement of an in-
The patient experienced renewed hematemesis despite endoclips placement the previous evening. Embolization of the left gastric artery by the interventional radiology team yielded no improvement. The patient's family agreed to “do not resuscitate” status after being informed by the attending service that further treatment of the upper gastrointestinal bleeding superimposed on the patient's terminal disease would be futile. The patient's condition continued to decline throughout the night. The patient's family agreed to withdraw care the following day. The endotracheal tube was removed, and the patient died 2 hours later.

Discussion

Intraosseous infusion is not a common procedure used in clinical anesthesia practice. It is not readily considered even by anesthesia providers familiar with the procedure. When it is considered, it is usually with reluctance. The most likely reason that anesthesia providers do not use the IO route is a lack of familiarity, training, or skill with the procedure. Perhaps this is due to a misperception that IO access is a difficult procedure, undertaken in times of extreme desperation and as a method of last resort.

This case report demonstrates that a properly placed IO catheter was valuable in the resuscitation of a critically ill patient in hemorrhagic shock. Immediately on placement, the ability to administer crystalloid fluids, blood products, and resuscitative drugs increased dramatically compared with the implanted medication port already in use. The IO catheter economized time and personnel, allowing central venous access to proceed more quickly, rather than continuing a futile search for more peripheral access. The total time to prepare and place the IO device was less than 2 minutes. The procedure itself was less than 10 seconds. It is likely the probability of successful placement of central access was increased in this case, secondary to increased circulating volume contributed by the IO infusion and/or vasoactive drugs administered through the IO device.

The patient's greatest discomfort was when the IO catheter was flushed with 10 mL of sterile saline, but she had complete resolution of discomfort when 50 mg of lidocaine was injected into the medullary cavity. The IO device continued to be useful after central access placement as a secondary infusion site for crystalloid and colloid fluids and drugs. Under pressurized infusion, epinephrine boluses, administered through the IO device, consistently demonstrated therapeutic effect within 20 to 30 seconds. Additional drugs including phenylephrine, ketamine, and vecuronium administered through the IO route produced their desired effect in times comparable to the IV route. The patient suffered no complications from the IO device for the 12 to 14 hours it was in place or during removal the following morning.

Indications for IO infusion include the need for rapid access to the systemic circulation for the administration of drugs or fluids and sampling of blood for laboratory analysis. The procedure is appropriate in all ages, especially in cases of difficult IV access or cardiovascular collapse as in shock, cardiac arrest, burns, or morbidly obese patients. 14

Relative contraindications include cutaneous infection or burn at the entry site, osteomyelitis, osteopenia, osteoporosis, and osteogenesis imperfecta. Absolute contraindications include previous attempt at the same site or at another site on the same bone and fracture of the selected bone because of increased risk of extravasation or fracture. 15

Ideal anatomical sites for IO infusion are those with recognizable surface anatomy with thin layers of overlying tissue over a thin layer of compact cortical bone, allowing access to the medullary cavity. 19 Commonly used sites in adults are the proximal medial tibia, the humeral head, and the manubrium. McCarthy et al 16 suggested that IO infusion may be accomplished in bone without a medullary cavity such as the calcaneus.

There are several distinct advantages of IO access. Intraosseous infusion is relatively simple and quick to achieve—usually 1 to 2 minutes. It has a high success rate at greater than 80% and a low complication rate of less than 1%. 17,18 It may be used in all age groups. Fluids and drugs delivered via the IO route demonstrate similar bioequivalency compared with IV administration. 18,19 Bell et al 20 demonstrated that radiolabeled autologous porcine red blood cells, transfused via the IO route, readily enter the systemic circulation. Venous samples, measured for radiolabeling at 30 seconds and 1, 5, 15, 30, and 60 minutes after administration showed that the highest counts of radiolabeled cells were obtained between 30 and 60 seconds. 20 Van Hoff et al 21 noted no significant difference in plasma concentrations of morphine between IO and IV infusion groups when measured over time, suggesting there is no pharmacokinetic difference between the IO and IV routes. Tobias and Nichols 22 reported the successful administration of succinylcholine using the IO route. At 1 mg/kg, they were able to obtain adequate intubating conditions in 45 seconds. 22 An air rescue service in Germany reported repeated inductions of general anesthesia using the IO route, with dosage and onset of administered drugs being equivalent to a peripheral IV. 23
Placement of an IO device is relatively simple when using traditional IO needles such as the Cook, Jamshidi, and Illinois needles. Recently developed devices such as the EZ-IO power driver (Vidacare Corp), the First Access for Shock and Trauma system (FAST1, Pyng Medical Corp, Richmond, BC, Canada), and the spring-assisted Bone Injection Gun (B.I.G., Waismed Ltd, Herzlilya, Israel) greatly increase the simplicity and success of the procedure in adults by overcoming the difficulty presented in the penetration of fully developed adult bony cortex. The ability to train special operations medics to place various IO devices in cadaver models was evaluated in a study, which found that the technique was easy to teach and skill was easily acquired. First-time success in placement of all IO devices tested in the study was greater than 94%, in times ranging from 37 to 150 seconds.11

Potential complications of the IO access procedure include fracture of bone, penetration of opposite cortex, soft-tissue infection or osteomyelitis (0.6%),2 mediastinitis, growth plate injuries (none reported), fat embolism, and pain.24 Displacement of the device during treatment or transport may result in extravasation, up to 12% occurrence in 1 source, causing local edema, hematoma, or compartment syndrome.18 However, newer IO devices may decrease the incidence of complications associated with displacement of the device.

The risk of infection may be minimized by removal of the IO device within 24 hours of placement.25 There is one report of a cerebral artery air embolism after tibial IO infusion in a 7-month-old female infant.26 Plewa et al27 reported that infusion of autologous blood into a porcine model under manual pressure using a 30-mL syringe produced no incidence of hemolysis, fat embolism, or disseminated intravascular coagulation. Stoll et al18 noted that high concentrations of epinephrine in a 1:1,000 solution administered in a dose of 100 µg/kg, to a 3-month-old male infant, may increase the chance of osteomyelitis due to local vasoconstriction preventing an appropriate immune mobilization. They further state that this may occur alone or in combination with procedural contamination or underlying sepsis. They stress that these complications remain quite rare but propose that epinephrine should be given cautiously and in more dilute concentrations.18

Fiallos et al28 studied the incidence of fat embolism after cardiopulmonary resuscitation (CPR) and IO infusion and found no difference in the appearance or distribution of fat globules in pulmonary tissue in the study groups. It was their determination that the use of IO infusion of emergency drugs did not increase the magnitude of fat embolism over CPR alone. Safety of IO infusion with and without pressure is further supported by LaSpada et al,29 who reported no significant difference in extravasation rates among threaded and nonthreaded IO needles under gravity or pressurized infusion. They further stated that extravasation is more likely caused by penetration of the opposite bony cortex or when the procedure is performed under stressful conditions or by unskilled personnel.29

**Conclusion**

Intraosseous infusion is an underutilized but clinically useful procedure in emergent situations when IV access is difficult or too time-consuming to achieve. Rapidly achieved IO access can dramatically improve the patient outcome in critically ill patients. The most recent generation of IO devices are easy to use and increase both success in placement and safety of the procedure. Anesthesia providers should seek education and training from those experienced in IO placement techniques and consider use of the IO route early in the resuscitative process.

**REFERENCES**


**AUTHOR**

James M. Burgert, CRNA, MSNA, is a staff nurse anesthetist and a Phase II clinical instructor in the US Army Graduate Program of Anesthesia Nursing at Brooke Army Medical Center, Fort Sam Houston, Texas.

**ACKNOWLEDGMENTS**

My thanks and grateful appreciation to Arthur D. Johnson RN, PhD, and Brian T. Gell, CRNA, MSN, of the US Army Graduate Program in Anesthesia Nursing for their editorial guidance and support.

**DISCLAIMER**

The views expressed in this article are those of the author and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the US Government.