CriticalCareNurse
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Crit Care Nurse 2011;31:76-90 doi: 10.4037/ccn2011615

Published online http://www.cconline.org

Critical Care Nurse is the official peer-reviewed clinical journal of the American Association of Critical-Care Nurses, published bi-monthly by The InnoVision Group 101 Columbia, Aliso Viejo, CA 92656. Telephone: (800) 899-1712, (949) 362-2050, ext. 532. Fax: (949) 362-2049.

AMERICAN ASSOCIATION of CRITICAL-CARE NURSES

Intraosseous Devices for Intravascular Access in Adult Trauma Patients

Michael W. Day, RN, MSN, CCRN

Three intraosseous devices have been approved by the Food and Drug Administration for use in adult trauma patients when intravenous access cannot be obtained. Sites of insertion are the sternum (FAST1), proximal tibia and humerus (Big Injection Gun), and proximal and distal tibia and humerus (EZ-IO). Insertion generally requires less than 1 minute, and flow rates up to 125 mL/min can be achieved. The devices are used for emergency resuscitation and should be removed within 24 hours of insertion or as soon as practical after peripheral or central intravenous access has been achieved. Contraindications include fractures or other trauma at the insertion site, prosthetic joints near the site, previous attempts to insert an intraosseous device at the same site, osteoporosis or other bone abnormalities, infections at the proposed site, and inability to identify pertinent insertion landmarks. Primary complications are extravasation of medications and fluids into the soft tissue, fractures caused by the insertion, and osteomyelitis. (*Critical Care Nurse.* 2011;31:76-90)

Adults with life-threatening traumatic injuries often need immediate intravenous access for the delivery of medications and for fluid replacement, including crystalloids, blood, and blood products. Although nurses who care for adult trauma patients in critical and acute care and emergency settings often have highly advanced skills in inserting intravenous devices, occasionally, obtaining intravenous access is a prolonged process requiring more than several minutes or is altogether impossible because of hypovolemia and collapsed peripheral blood vessels. Reliance on a physician, advanced practice nurse, or physician assistant may be problematic because these health care providers may not be available, not have the necessary skill level for establishing central intravenous access, or be engaged in other lifesaving activities. In addition, establishing central intravenous access is time-consuming and may interfere with other resuscitation activities, especially when the internal jugular or subclavian site is the potential access site.

CE Continuing Education

This article has been designated for CE credit. A closed-book, multiple-choice examination follows this article, which tests your knowledge of the following objectives:

1. Identify 3 intraosseous insertion devices
2. Describe the indications and contraindications of inserting an intraosseous device
3. Discuss the steps needed before implementing a program for inserting intraosseous devices in an institution

 doi: 10.4037/ccn2011615

Historical Perspective

The theoretical use of intraosseous devices was first discussed in the medical literature in 1922, when Drinker et al[1] described the circulation of the sternum and suggested that this bone be used for transfusions. Research and case studies[2-4] in the 1940s showed the usefulness of using the intraosseous route for administration of blood, fluids, and medications and the effectiveness of intraosseous devices. An intraosseous device to access the sternum was used during World War II.[5] However, the advent of plastic intravenous catheters made peripheral intravenous access much more practical and simple, and research on and use of intraosseous devices

decreased. Subsequently, reports on the devices essentially vanished from medical literature until 1977.[6]

Intraosseous Anatomy

The medullary canal of bone contains a vascular plexus that communicates directly with the vascular system of the limb involved[7] or, in the case of the sternum, directly into the azygous and internal mammary veins.[2] The anatomy (Figure 1) of target bones (sternum, tibia, and humerus) for intraosseous devices is similar. The bones are composed of soft, spongelike cancellous bone (also known as trabeculae, a loose bone lattice filled with bone marrow and commonly referred to as the medullary canal) and hard compact bone, which provides the structural strength of the bone. The compact bone is composed of multiple layers of bone cells, arranged in circular groups (haversian groups or osteons) that run parallel to the long axis of the bone and are arranged around an individual blood vessel (haversian canal). In turn, the haversian canals are connected to one another via the many Volkmann canals throughout the compact bone. The Volkmann canals connect with both the trabeculae (medullary canal) and the blood vessels of the periosteum,[8] providing a direct path from the medullary canal to the central circulation.

When fluids and medications

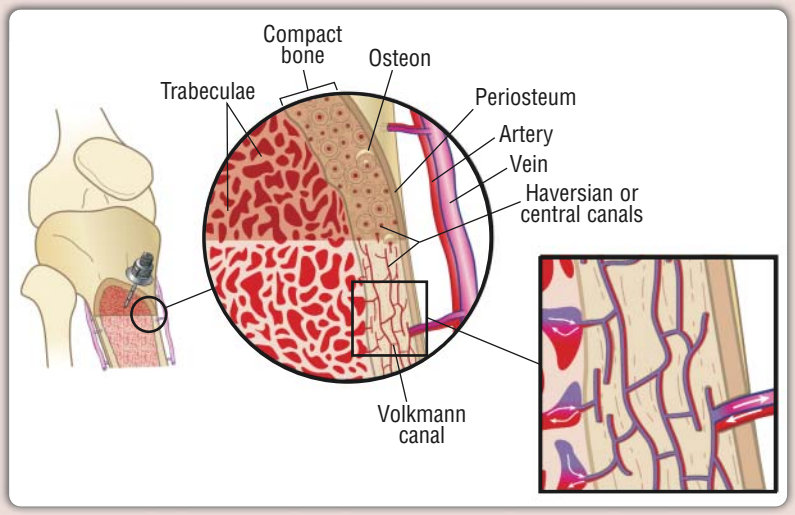

Figure 1 Bone anatomy.
Drawing courtesy of Vidacare Corp, San Antonio, Texas.

are introduced into the medullary canal, they flow through this vascular plexus directly into the vascular system. The overlying bony cortex of bone provides a rigid outer structure, creating a noncompressible space that can be easily accessed with intraosseous devices when peripheral veins are collapsed (as in profound shock) and no health care provider is available to place a central intravenous catheter. The bony cortex also provides a stable base and support for the intraosseous device once the device is placed.[7,9]

In 2007, Buck et al[9] published a review article on intraosseous administration of medication during cardiopulmonary arrest in children and adults. Buck et al reported that all resuscitation medications could be effectively given via the intraosseous route, but they also found that serum concentrations of some antibiotics and phenytoin given via this route were lower than when given intravenously. Moreover,

> The IO [intraosseous] route has consistently been found to be a fast, reliable means of obtaining vascular access. While the clinical studies and case series describing the use of the IO route have been relatively small and limited in scope, the successful resuscitations achieved in patients described in these reports, as well as the comparable serum concentrations and outcome measures achieved with intravenous and IO drug administration in animal models, support the efficacy of this route for drug and fluid delivery.[9(p1684)]

Intraosseous Devices in Children

Research on intraosseous access was stimulated by the knowledge that establishing peripheral access

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in children was difficult and often unsuccessful because of the collapse of identifiable veins when a child goes into shock. Even if intravenous access was established, the small lumen of the catheters inhibited the rapid flow of intravenous fluid, medications, and blood. Multiple reviews,[7,10,11] reports, and studies in the 1980s and early 1990s indicated the effectiveness of intraosseous devices in animal models,[12-14] in children and adults in the prehospital setting,[15,16] and in adults in the hospital.[6] On the basis of these studies, in 1985 the American Heart Association[17] endorsed the use of intraosseous devices in children; the current guidelines[18] continue that endorsement. The guidelines are clear about the usefulness of intraosseous devices in infants and children. Multiple studies on use of the devices are cited, and the guidelines state that health care professionals should limit the time attempting to obtain an intravenous access and use an intraosseous device if an intravenous access cannot be obtained quickly. In addition, the guidelines specify using an intraosseous device in cardiac arrest if an intravenous access has not already been established.

Intraosseous Devices in Adults

The use of intraosseous devices in adults has lagged behind the use in children. The lag is due to, among other things, the hardness of adult bone, compared with that of children, and the lack of devices to effectively establish intraosseous access in patients.[9] However, on the basis of continued research on the use of intraosseous devices in adults, in 2005 in the Advanced Cardiac Life Support course, the American Heart Association[19] began advocating the use of intraosseous devices for adults as an effective and equivalent alternative to intravenous access. In addition, the group noted that intraosseous devices are more appropriate than an endotracheal tube for delivery of medications if no intravenous access is available, because intraosseous devices provide a more predictable drug delivery and pharmacological effect.[19] Use of an intraosseous device for trauma patients is also advocated in the Advanced Trauma Life Support course sponsored by the American College of Surgeons, Committee on Trauma.[20]

Intraosseous Devices

Intraosseous devices are quickly inserted; most are successfully placed in less than 1 minute from the time of opening the package to use of the device for administration of fluids and medications. Correct placement is verified by flow of intravenous fluid into the device without extravasation of the fluid around the insertion site. Some manufacturers recommend aspiration of bone marrow as another way to confirm placement. If extravasation does occur, the intraosseous device is removed to prevent development of compartment syndrome. Once the device is placed, flow rates up to 125 mL/min can be obtained by using a pressure bag. Because infusion of large volumes may cause discomfort in an awake patient, 2 to 4 mL of 1% lidocaine is instilled before a large volume is administered.

Although intravenous pumps may be effective in delivering fluid through an intraosseous device, many of the pumps are restricted by a backflow pressure sensor that may continually trigger an alarm because of the necessary pressure generated within the intravenous tubing to push the fluid into the intraosseous device. In addition, depending on the type, many devices may have advantages in certain situations. For example, Suyama et al[21] compared a specific intraosseous device, the EZ-IO, and intravenous access in a simulated hazardous materials (hazmat) scenario in which both the health care providers and the patient mannequins were in hazmat personal protective equipment. In comparison with intravenous access, the greatest benefit of intraosseous access was lack of exposure of health care workers to a hazardous environment in a hazmat situation.

Complications

The primary complications associated with intraosseous devices are extravasation of medications and fluids into the soft tissue, fractures caused by the intraosseous insertion, and osetomyelitis.[5] Extravasation of fluid and medications into the surrounding soft tissue from a misplaced intraosseous device can lead to compartment syndrome. Although fractures related to intraosseous devices have been reported, they are rare.[5] Osteomyelitis is uncommon and has not been associated with marked morbidity or mortality.[8] Osteomyelitis is generally associated with poor aseptic technique, leaving the intraosseous device in place for more than 24 hours, and multiple intraosseous attempts at the same site.[5,8] Fat embolus is a theoretical risk of intraosseous devices but has not been reported in humans.[8]

Table Comparison of intraosseous devices in adult trauma patients

	Device		
Feature	**BIG, Big Injection Gun**	**EZ-IO**	**FAST1**
Insertion sites	Proximal tibia Proximal humerus	Proximal tibia Distal tibia Proximal humerus	Sternum
Insertion process	Activated by manual pressure	Battery-operated power driver	Activated by manual pressure
Advantages	Small Color coded (blue, adults; red, children) Lightweight Multiple insertion sites (4 total)	Color coded, weight-based needle sets (PD, 3-39 kg; AD, >40 kg; LD, "excess tissue" over insertion site) Multiple insertion sites (6 total)	Small Lightweight Single insertion site (less training required)
Disadvantages	May cause scatter artifact on computed tomography scans of chest or cervical spine when placed in humerus May be overlooked during transport or transition from one level of care to another	Large device and packaging Requires visualization of needle skin depth before insertion in bone May cause scatter artifact on computed tomography scans of chest or cervical spine when placed in humerus May be overlooked during transport or transition from one level of care to another	No alternative insertion site May require 2 hands to exert 4.14×10^5 Pa (60 lb/sq in) of pressure needed to activate device May preclude use of a cervical collar (towel rolls and taping the patient's head to a backboard may be substituted)
Contraindications	Insertion in limbs with fractures Insertion in limbs with prosthetic joints near insertion site Insertion at sites of previous attempts to place an intraosseous device Severe osteoporosis or other bone abnormality Infection over insertion site Inability to identify pertinent insertion landmarks	Insertion in limbs with fractures Insertion in limbs with prosthetic joints near insertion site Insertion at sites of previous attempts to place an intraosseous device Severe osteoporosis or other bone abnormality Infection over insertion site Inability to identify pertinent insertion landmarks	Severe osteoporosis or other bone abnormality Inability to secure target patch to skin over sternum (eg, burns, wounds, infection)
Removal	Grasp needle hub with safety latch Pull and twist	Attach syringe Pull and twist clockwise (if hub separates, grasp needle with large forceps and withdraw using twisting motion)	Grasp and pull out perpendicular to sternum

The Food and Drug Administration currently has approved 3 intraosseous devices for use in the United States: FAST1 (Pyng Medical Corp, Richmond, British Columbia, Canada), Bone Injection Gun (BIG; WaisMed, Houston, Texas), and EZ-IO (Vidacare Corp, San Antonio, Texas). All 3 devices have some common characteristics and concerns (see Table), and use of any of the 3 is contraindicated when a patient has severe osteoporosis or an infection at the selected insertion site. If insertion of an intraosseous device at a specific site has been unsuccessful, no other intraosseous insertions should be attempted at that site. Intraosseous devices are used for emergency resuscitation and should be removed as soon as practical after peripheral or central intravenous access has been achieved, but no more than 24 hours from time of insertion of the intraosseous device.[5,11]

FAST1

The FAST1 is the only currently approved intraosseous device that is placed in the sternum. Specifically, the device is placed into the manubrium (superior one-third) of the sternum. Blood flows from the sternum directly into the central circulation via the internal mammary and azygos veins.[2] The FAST1 consists of a delivery device, which houses stabilizer points, and the infusion tube[22] (Figures 2 and 3).

The sternal notch is identified, and the manubrium is cleansed. A target patch, which is included in the kit and conforms to the sternal notch, is applied to the patient's chest, providing a target hole for the stabilizer points (Figure 4). The delivery device is then positioned

Figure 2 FAST1 kit.

Photo courtesy of Pyng Medical Corp, Richmond, British Columbia, Canada.

Figure 3 FAST1 delivery device.

Photo courtesy of Pyng Medical Corp, Richmond, British Columbia, Canada.

over the target patch with the stabilizer points surrounding the hole in the target patch (Figure 5). When applied perpendicular (90°) to the manubrium with a pressure of approximately 4.14×10^5 Pa (60 lb/sq in), the stabilizer points penetrate the skin, mark the depth of the manubrium, and deliver the FAST1 infusion tube into the bone (Figure 6).[23] The delivery device is then removed, leaving the intraosseous catheter embedded in the manubrium; the catheter is then connected to tubing affixed to the target patch. A plastic dome is fastened to the target patch to secure the device in place and protect it (Figure 7). The target patch tubing is flushed with 5 to 10 mL of isotonic saline[9] and attached to intravenous tubing. The insertion site of the FAST1 is the same for all sizes of adult patients, and the device can be quickly inserted (usually <60 seconds).[22]

For removal of the FAST1, the intravenous tubing is disconnected and the dome is removed. The FAST1 is removed by simply grasping the intraosseous catheter and pulling up, perpendicular to the manubrium (Figure 8). The insertion site is then covered with a sterile dressing.

In adult trauma patients, the FAST1 provides an effective intraosseous delivery system. The insertion site is out of the way of many of the critical lifesaving interventions required during a trauma resuscitation, including intubation and insertion of a chest tube. The device comes in a small, self-contained package that is easily transported and stored. However, placement of the FAST1 in the manubrium may make placement of a cervical immobilization collar difficult, if not impossible. If necessary, the cervical spine can be immobilized by placing towel rolls on either side of the head and taping the head to the backboard. A previous sternotomy, a patient's small size, or traumatic injury (including sternal fractures) over the insertion site may affect the integrity and/or vascularity of the manubrium and make the FAST1 ineffective. In addition, safe use of the FAST1 in patients with severe osteoporosis or other bone abnormalities has not been adequately studied and currently is not recommended.[22]

Other considerations in using the FAST1 include the required positioning of the delivery device directly perpendicular to the manubrium, rather than perpendicular to the patient's body. When a patient is supine, the manubrium is at an upward angle, toward the feet, compared with the horizontal plane of the patient's body. If the delivery device is not positioned directly perpendicular to the manubrium, the infusion tube may not penetrate the manubrium and establish an effective intraosseous access.[22] A 2-handed technique may be required to apply the pressure needed to activate the FAST1. Also, if the infusion tube is not removed in a

A **B** **C**

Figure 4 **A**, Opening FAST1 target patch. **B**, Applying target patch. **C**, Confirming target patch placement.

Photos courtesy of Pyng Medical Corp, Richmond, British Columbia, Canada.

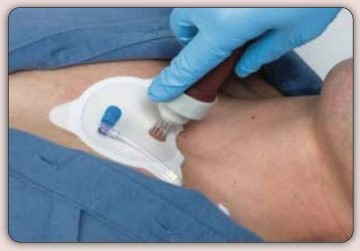

Figure 5 Positioning FAST1 delivery device.

Photo courtesy of Pyng Medical Corp, Richmond, British Columbia, Canada.

Figure 6 Inserting the FAST1.

Photo courtesy of Pyng Medical Corp, Richmond, British Columbia, Canada.

Figure 7 Fastening FAST1 dome to the target patch.

Photo courtesy of Pyng Medical Corp, Richmond, British Columbia, Canada.

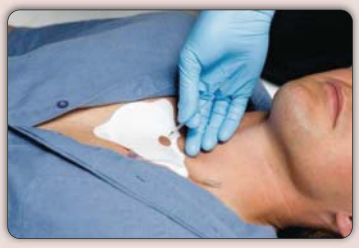

Figure 8 Removing the FAST1.

Photo courtesy of Pyng Medical Corp, Richmond, British Columbia, Canada.

movement directly perpendicular to the manubrium, the removal may be unsuccessful.[22]

Figure 9 BIG, Big Injection Gun (adult).

Photo courtesy of WaisMed, Ltd, Houston, Texas.

Bone Injection Gun

The BIG was developed in Israel by WaisMed, Ltd, in the 1990s (Figure 9). The BIG is a spring-loaded device, which resembles a large, felt-tipped marker, that delivers a trocar and needle directly into the bone (Figure 10). The trocar is removed, leaving the needle in the bone. The BIG is color coded: the device for use in adults has a blue cap (a red cap indicates the BIG for children; a green cap, the device for use by veterinarians). The BIG is approved for insertion at both the proximal tibia and the humerus (as an alternative site), where a flat surface and relatively shallow medullary canals are accessible.[24]

The tibial insertion site is identified by locating the tibial tuberosity, just below the patella, and then moving 2 cm medially and 1 cm proximally[25] (Figure 11). The humeral insertion site is identified by first placing the patient supine, with arms next to the body and the hands over the umbilicus. The acromion and coracoid processes of the scapula are located, establishing the points for placement of the operator's thumb and index finger. An imaginary line is then drawn

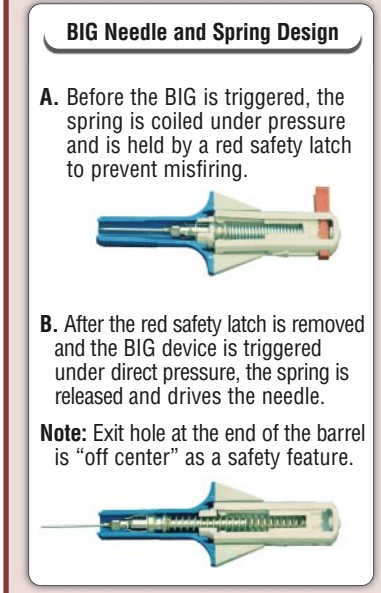

Figure 10 Design of BIG, Big Injection Gun.

Drawing courtesy of Waismed, Ltd, Houston, Texas.

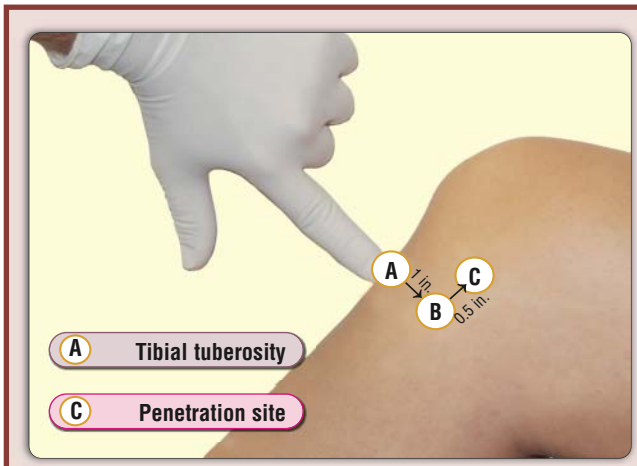

Figure 11 Tibia insertion site for BIG, Big Injection Gun.

Photo courtesy of Waismed, Ltd, Houston, Texas.

from the operator's thumb to his or her index finger. The humeral insertion site is 2 finger-widths distal from the midpoint of that line, which is the head of the humerus. In some patients, such as those with large muscle mass, the insertion site is an additional 1 finger-width medially.[24]

Once the appropriate insertion site is identified and cleansed, the cap of the BIG is removed and the barrel is placed on the skin perpendicular (90°) to the identified insertion site (Figure 12). The hand used to identify the insertion site then grasps the barrel of the device and stabilizes it at the insertion site during the entire insertion procedure. The opposite hand is used to squeeze and remove the red safety latch, which is saved for later use (Figure 13). The "shoulders" of the BIG are firmly grasped with the fingers of the other hand while the palm is firmly pressed into the top of the BIG. With the barrel of the BIG stabilized on the insertion site with one hand, the palm and the 2 fingers grasping the shoulders of the device are squeezed together to deploy the needle and trocar (Figure 14). Once the needle and trocar are deployed (as indicated by an audible and palpable click), the BIG is slowly removed from the needle and trocar. The trocar is removed (Figure 15), and the needle is secured to the skin at the insertion site by taping the red safety latch around it (Figure 16). A prefilled intravenous extension set is attached to the needle, flushed with 5 to 10 mL of isotonic saline[9] (Figure 17), and attached to intravenous tubing.

The intraosseous device is removed by grasping the needle hub and withdrawing and rotating at the same time. If needed, the safety latch can be used to grasp the hub of the needle during removal. The insertion site is then covered with a sterile dressing.

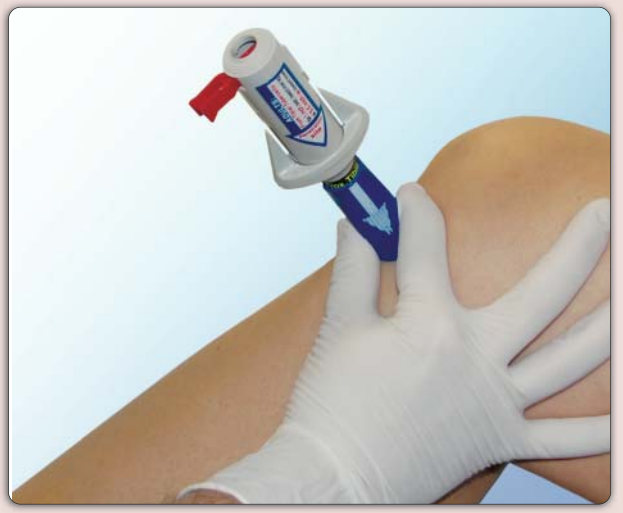

Figure 12 Placing BIG, Big Injection Gun, on insertion site.
Photo courtesy of Waismed, Ltd, Houston, Texas.

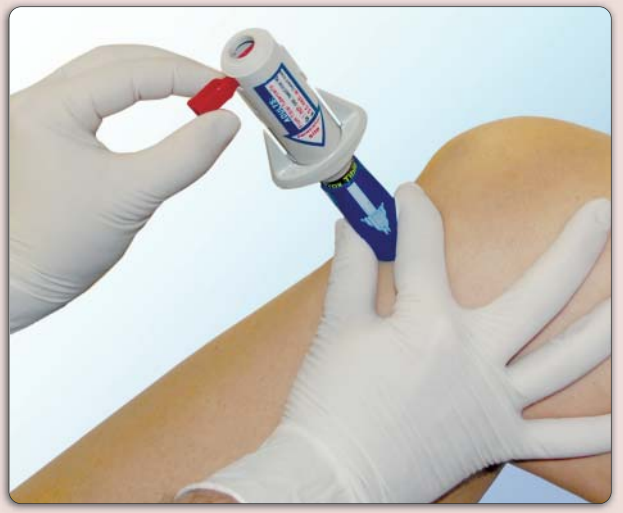

Figure 13 Removing BIG, Big Injection Gun, safety latch.
Photo courtesy of Waismed, Ltd, Houston, Texas.

In adult trauma patients, the BIG is an effective tool, as proven by field use.[26] Like the FAST1, the BIG is compact and easily transported and stowed. It can be quickly inserted in the tibial insertion site; insertion in the humeral site is somewhat more problematic because of the potential difficulty in identifying the appropriate anatomical landmarks, particularly in a heavily muscled patient or one with excess adipose tissue at the insertion site. Use of the BIG has several contraindications, including fractures at the insertion site, previous orthopedic procedures near the insertion site, skin infection, osteogenesis imperfecta, osteopenia, and previous attempts at an intraosseous insertion at the same site during the same incident.[25]

Trauma patients often have bilateral lower extremity fractures, which would make tibial insertion impossible, but in that case the BIG could possibly be used in the humerus if the anatomical landmarks were identifiable. Because the BIG is rather small once it is inserted, it may be overlooked during resuscitation. The tibial inser-

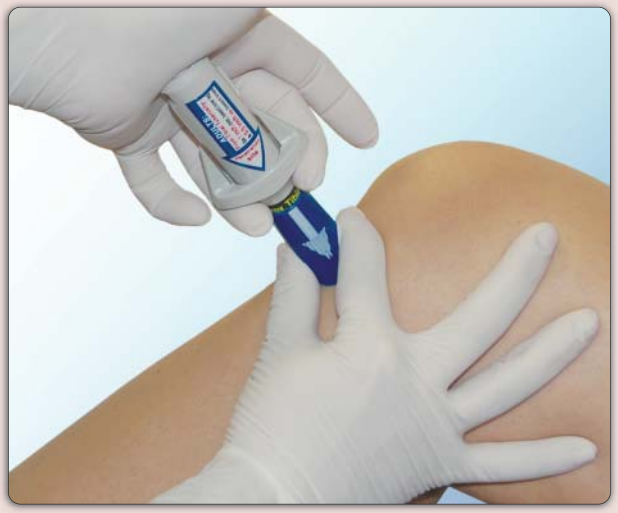

Figure 14 Inserting BIG, Big Injection Gun, needle and trocar.
Photo courtesy of Waismed, Ltd, Houston, Texas.

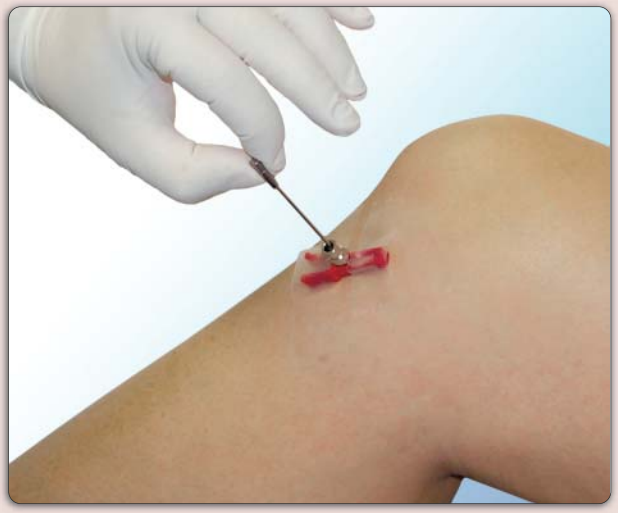

Figure 15 Removing BIG, Big Injection Gun, trocar.
Photo courtesy of Waismed, Ltd, Houston, Texas.

tion site is relatively protected by the patient's anatomy (medially, just below the knee). However, the humeral site is exposed, and care must be taken to protect the device (such as making all providers aware of its presence), because it can be dislodged or broken during transport, during movement of the patient from one gurney to another, or during procedures.

The BIG also requires good 2-handed dexterity on the part of the operator to identify the correct insertion site and successfully use the device. Because 2 different BIGs are available for use in humans (blue cap for adults, red cap for infants and children), the wrong device could be selected if both sizes are stored in the same place, a situation that could delay the establishment of a patent intraosseous device. If a BIG is placed in the humerus, the metal needle may cause radiographic scatter during computed tomography of the cervical spine or chest. Such scatter could potentially interfere with ready detection of injuries of the lower part of the cervical spine or the upper part of the chest.

EZ-IO Devices

The EZ-IO was developed by Vidacare Corp, in conjunction with the University of Texas Health Science Center, San Antonio. The EZ-IO system consists of a power driver (Figure 18) and a needle set, which includes an appropriately sized needle and stylet[27] (Figure 19). A total of 3 different sizes of needle sets are available; the size used depends on the weight and/or size of the patient. The PD needle set is for patients who weigh 3 to 39 kg; the AD needle set, for patients who weigh 40 kg or more; and the LD needle set, for patients with "excess" tissue over the insertion site.[28]

The insertion sites for the EZ-IO are similar to those for the BIG: the proximal tibia and the humerus. However, the Food and Drug Administration has approved a third insertion site for the EZ-IO: the distal tibia. The proximal tibia insertion site is identified by locating the tibial tuberosity and then moving 2 cm medially and 1 cm proximally (Figure 20). The distal tibia insertion site is located by identifying the medial malleolus and then moving 2 finger-widths proximally, at the midline of the medial aspect of the leg (Figure 21). The humeral head insertion site is used if neither of the tibial sites, on either leg, is available. Before the humeral head is located, the patient is placed supine with the arm across the abdomen and the hand at the umbilicus. The preferred method of locating the humeral head insertion site is palpating the midshaft of the humerus and then palpating up the arm until the greater tubercle is located. The insertion site is 1 finger-width lateral from the greater tubercle. An alternative method for identifying the humeral head insertion site is palpating the end of the clavicle and

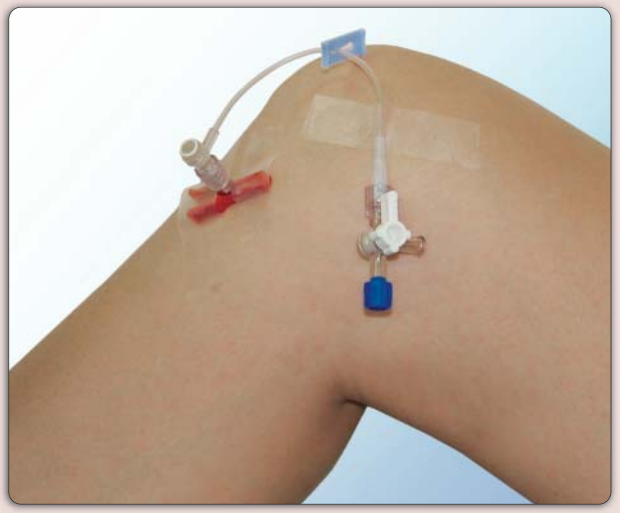

Figure 16 BIG, Big Injection Gun, safety latch taped in place and intravenous extension attached to needle.

Photo courtesy of Waismed, Ltd, Houston, Texas.

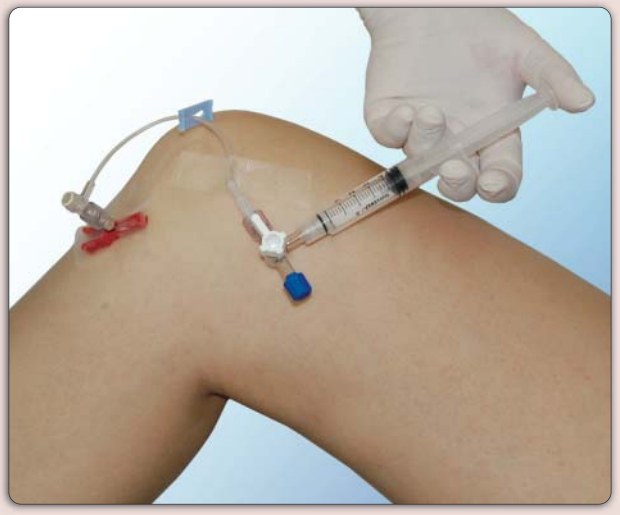

Figure 17 Needle and extension set of BIG, Big Injection Gun, flushed.

Photo courtesy of Waismed, Ltd, Houston, Texas.

then moving 2 finger-widths toward the elbow (Figure 22).

Once the insertion site is located and cleansed, the appropriate-sized needle set is attached to the power driver. The limb is stabilized from behind, and the needle is advanced into the insertion site, at 90°, until contact with the bone is felt. The device is then evaluated to determine if the 5-mm mark on the needle (the mark closest to the needle hub) is visible (Figure 23). If the 5-mm mark is not visible, the needle is withdrawn and a larger size (AD or LD) needle is attached and advanced into the same insertion site. The needle is again evaluated to determine if the 5-mm mark on the needle is visible. If the 5-mm mark is visible, steady firm pressure is applied and the power driver is activated, until the needle hub contacts the skin or a sudden decrease in resistance is noted (Figure 24). The needle hub is then stabilized with the fingers of the free hand, and the power driver is removed. While the hub remains stabilized, the free hand is used to turn the stylet counterclockwise and withdraw it (Figure 25). An intravenous extension set is attached, the needle is flushed with 5 to 10 mL of isotonic saline[9] (Figure 26), and the intravenous tubing is attached.

Figure 18 EZ-IO power driver.

Photo courtesy of Vidacare Corp, San Antonio, Texas.

The EZ-IO is removed by attaching a 5- to 10-mL syringe to the hub of the needle, stabilizing the limb, and then simultaneously pulling and rotating the syringe clockwise (Figure 27). (If rotated counterclockwise, the syringe will be removed from the needle hub of the needle.) The needle should not be rocked during attempts to remove the device; rocking can cause the hub to separate from the needle. If the hub does separate from the needle, the needle can be grasped with a 20-cm (8-in) needle forceps and withdrawn by using a twisting motion. After removal of the EZ-IO, the insertion site is covered with a sterile dressing.

The EZ-IO has been successfully used in both civilian and military settings.[23,29] However, unlike the FAST1 and the BIG, which are small, self-contained, and compact, the EZ-IO is somewhat larger; it is packaged in a portfolio-sized case and requires multiple steps to assemble it before insertion. The EZ-IO can be quickly inserted in the tibial insertion site, but insertion in the humerus is somewhat more prob-

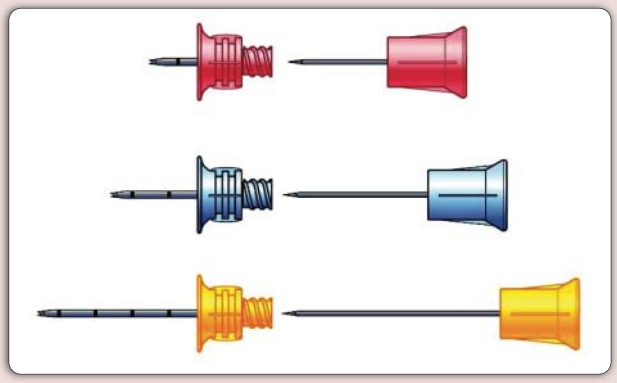

Figure 19 EZ-IO needle sets (top, PD for weight 3-39 kg; middle, AD for weight >40 kg; bottom, LD for "excess tissue" over insertion site).

Drawing courtesy of Vidacare Corp, San Antonio, Texas.

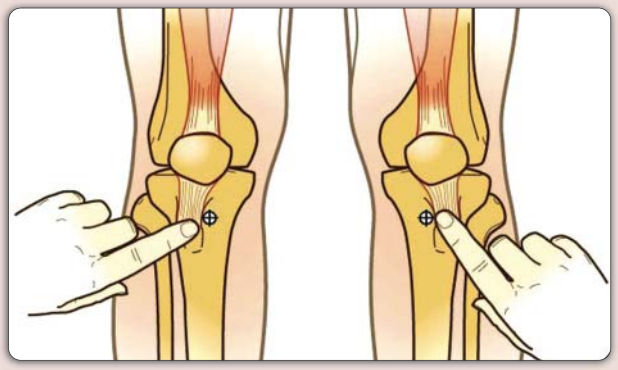

Figure 20 EZ-IO proximal tibia insertion site.

Drawing courtesy of Vidacare Corp, San Antonio, Texas.

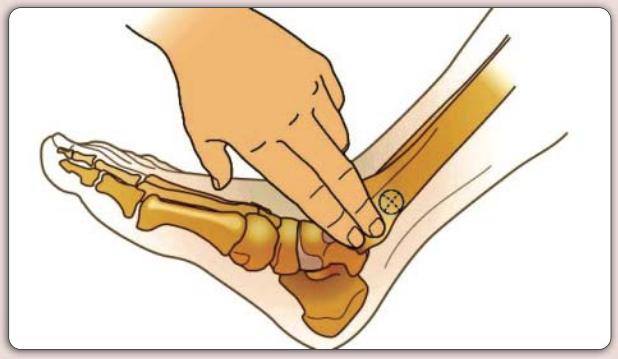

Figure 21 EZ-IO distal tibia insertion site.

Drawing courtesy of Vidacare Corp, San Antonio, Texas.

lematic because of the potential difficulty in identifying the appropriate anatomical landmarks, particularly in heavily muscled patients or patients with excess adipose tissue at the insertion site. Successful insertion of the EZ-IO requires good 2-handed dexterity. In addition, the required visualization of the 5-mm needle mark, after the needle is inserted into the tissue but before it is actually inserted into the bone, makes use of the device difficult in a low-light situation, a common occurrence in the prehospital setting. The EZ-IO should not be used in patients who have excess tissue at the possible insertion site, unidentifiable landmarks, fractures of or previous orthopedic procedures on the target bone, or infection over the insertion site.

As with the BIG, bilateral lower extremity fractures can make tibial insertion of the EZ-IO impossible. However, the EZ-IO could possibly be inserted in the humerus, if the anatomical landmarks are identifiable. The EZ-IO is rather small once it is inserted, and it may be overlooked during resuscitation. The tibial insertion site is relatively protected by the patient's anatomy (medially, just below the knee). However, the humeral site is exposed, and care must be taken to protect the device because it can be dislodged or broken during transport, movement of a patient from one gurney to another, or procedures. If an EZ-IO is placed in the humerus, the metal device may cause radiographic scatter during a computed tomography of the cervical spine or chest. Such scatter could potentially interfere with easy detection of injuries of the lower part of the cervical spine or the upper part of the chest.

Nursing Implications

The various intraosseous devices are important tools that can help nurses establish an intravascular route when standard intravenous access cannot be quickly achieved. The devices can be placed quickly and used for standard resuscitation therapies, such as fluids, medications, and blood products. Nurses must be aware of the potential for complications (eg, pain on instillation of fluids, extravasation of fluids and medications from the insertion site, and compartment syndrome) and be ready to address any that occur. If the patient is awake, instillation of 1% lidocaine immediately after the patency of the device is confirmed will decrease the patient's pain when fluid or medications are administered under pressure.

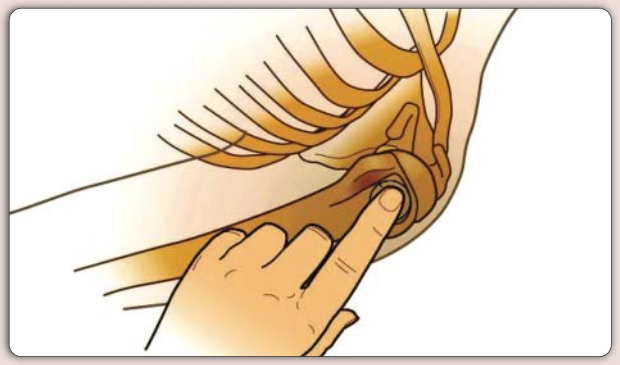

Figure 22 EZ-IO humeral insertion site.
Drawing courtesy of Vidacare Corp, San Antonio, Texas.

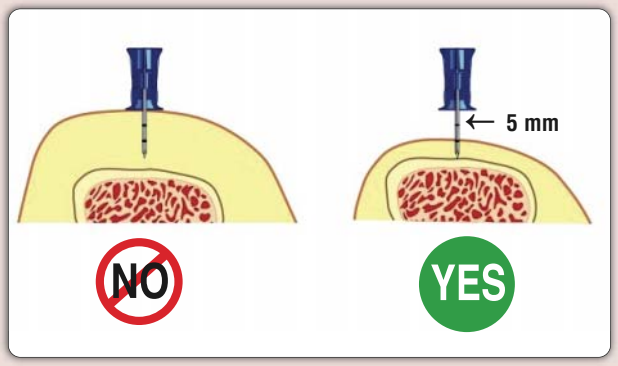

Figure 23 EZ-IO needle depth assessment.
Drawing courtesy of Vidacare Corp, San Antonio, Texas.

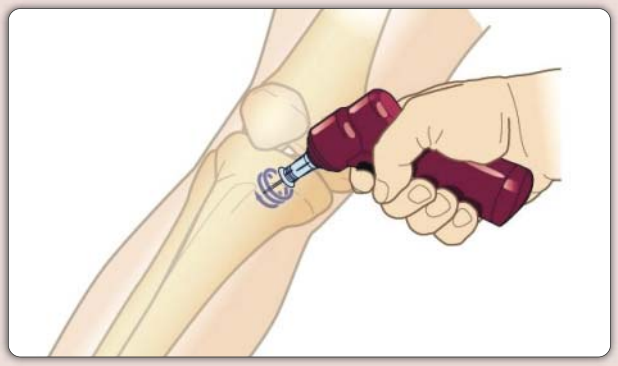

Figure 24 EZ-IO insertion.
Drawing courtesy of Vidacare Corp, San Antonio, Texas.

Continual and frequent reassessment of the intraosseous insertion site for extravasation is necessary. When extravasation is detected, the intraosseous device should be removed and other intraosseous or intravenous access obtained. If extravasation does occur, the limb in question must be frequently assessed for the development of compartment syndrome. The intraosseous devices are not designed to be used for more than 24 hours and should be removed as soon as effective standard intravenous access (either peripheral or central) has been obtained.

Before the use of intraosseous devices is implemented in an institution, several steps must be addressed to ensure the best patient outcomes. As with any new technology, implementation of the devices should be preceded by a thorough literature review of the advantages and disadvantages of each device. The literature review will guide the recommendations, which will need approval from the appropriate hospital committees (eg, emergency, critical care, surgery, code, pharmacy and therapeutics, nursing).

Once an intraosseous device has been selected, institutional policies and procedures related to the specific device, such as indications, contraindications, insertion and removal processes, and quality assessment, must be developed. In conjunction with the policies and procedures, an educational process must also be developed that provides practitioners both the didactic and hands-on experience necessary to become familiar with the intraosseous device and its use. The manufacturer of each device has multiple educational resources (print, video, and Web based) for the device. Many of these resources are free. Last, a quality assessment process for evaluating the use the intraosseous device and any associated complications in practice must be established. The quality assessment should include a feedback loop for reporting the results of the assessment to the group responsible for implementation of the intraosseous device, so that modifications of process can be based on data.

Conclusion

Intraosseous devices for intravascular access can have a marked impact on the successful resuscitation of adult trauma patients. The devices provide a rapid, effective, and safe alternative to both peripheral and central intravenous access. However, each of the intraosseous

dotmore

To learn more about intraosseous access, read "Recommendations for the Use of Intraosseous Vascular Access for Emergent and Nonemergent Situations in Various Health Care Settings: A Consensus Paper" in *Critical Care Nurse,* 2010;30:e1-e7. Available at **www.ccnonline.org**.

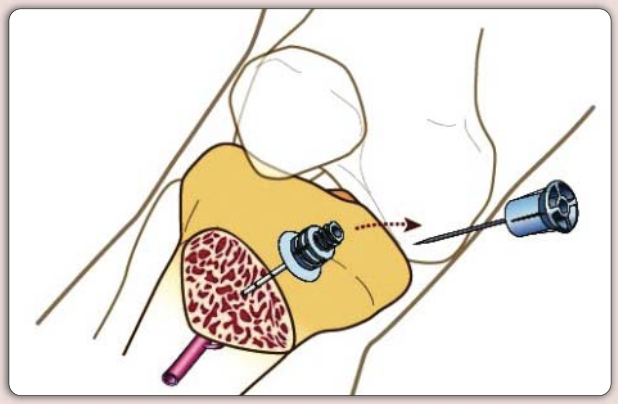

Figure 25 EZ-IO stylet removal.

Drawing courtesy of Vidacare Corp, San Antonio, Texas.

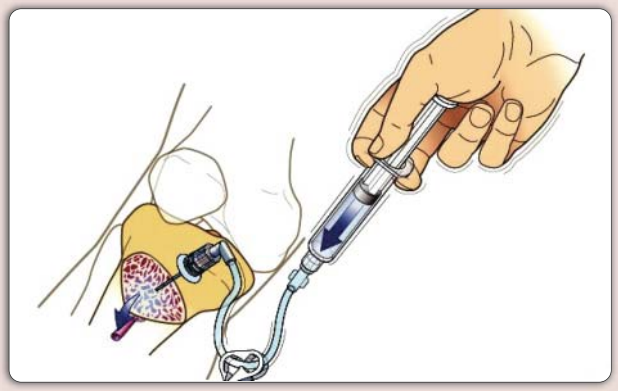

Figure 26 EZ-IO intravenous extension tubing attached and needle flushed.

Drawing courtesy of Vidacare Corp, San Antonio, Texas.

devices approved by the Food and Drug Administration for use in adults has specific limitations, especially related to trauma. Further research is needed to compare the efficacy of the devices to one another in adult trauma patients. CCN

eLetters

Now that you've read the article, create or contribute to an online discussion about this topic using eLetters. Just visit www.ccnonline.org and click "Respond to This Article" in either the full-text or PDF view of the article.

Financial Disclosures
None reported.

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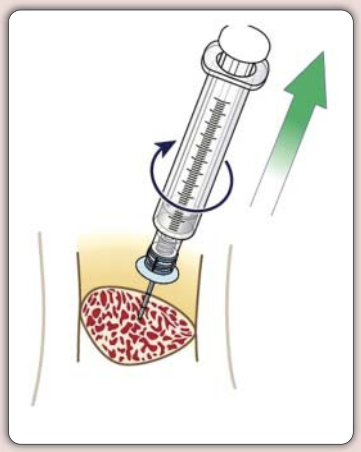

Figure 27 EZ-IO removal.

Drawing courtesy of Vidacare Corp, San Antonio, Texas.

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Intraosseous Devices for Intravascular Access in Adult Trauma Patients

Facts

The use of intraosseous devices in adults has lagged behind the use in children. However, on the basis of continued research on the use of intraosseous devices in adults, in 2005 in the Advanced Cardiac Life Support course, the American Heart Association began advocating the use of intraosseous devices for adults as an effective and equivalent alternative to intravenous access. In addition, the group noted that intraosseous devices are more appropriate than an endotracheal tube for delivery of medications if no intravenous access is available, because intraosseous devices provide a more predictable drug delivery and pharmacological effect.

The Food and Drug Administration currently has approved 3 intraosseous devices for use in the United States. All 3 devices have some common characteristics and concerns (see Table), and use of any of the 3 is contraindicated when a patient has severe osteoporosis or an infection at the selected insertion site.

Table Comparison of intraosseous devices in adult trauma patients

	Device		
Feature	**BIG, Big Injection Gun**	**EZ-IO**	**FAST1**
Insertion sites	Proximal tibia Proximal humerus	Proximal tibia Distal tibia Proximal humerus	Sternum
Insertion process	Activated by manual pressure	Battery-operated power driver	Activated by manual pressure
Advantages	Small Color coded (blue, adults; red, children) Lightweight Multiple insertion sites (4 total)	Color coded, weight-based needle sets (PD, 3-39 kg; AD, >40 kg; LD, "excess tissue" over insertion site) Multiple insertion sites (6 total)	Small Lightweight Single insertion site (less training required)
Disadvantages	May cause scatter artifact on computed tomography scans of chest or cervical spine when placed in humerus May be overlooked during transport or transition from one level of care to another	Large device and packaging Requires visualization of needle skin depth before insertion in bone May cause scatter artifact on computed tomography scans of chest or cervical spine when placed in humerus May be overlooked during transport or transition from one level of care to another	No alternative insertion site May require 2 hands to exert 4.14×10^5 Pa (60 lb/sq in) of pressure needed to activate device May preclude use of a cervical collar (towel rolls and taping the patient's head to a backboard may be substituted)
Contraindications	Insertion in limbs with fractures Insertion in limbs with prosthetic joints near insertion site Insertion at sites of previous attempts to place an intraosseous device Severe osteoporosis or other bone abnormality Infection over insertion site Inability to identify pertinent insertion landmarks	Insertion in limbs with fractures Insertion in limbs with prosthetic joints near insertion site Insertion at sites of previous attempts to place an intraosseous device Severe osteoporosis or other bone abnormality Infection over insertion site Inability to identify pertinent insertion landmarks	Severe osteoporosis or other bone abnormality Inability to secure target patch to skin over sternum (eg, burns, wounds, infection)
Removal	Grasp needle hub with safety latch Pull and twist	Attach syringe Pull and twist clockwise (if hub separates, grasp needle with large forceps and withdraw using twisting motion)	Grasp and pull out perpendicular to sternum

Day M. Intraosseous Devices for Intravascular Access in Adult Trauma Patients. *Crit Care Nurse.* 2011;31(2):76-90.

CE Test

Test ID C1122: Intraosseous Devices for Intravascular Access in Adult Trauma Patients

Learning objectives: 1. Identify 3 intraosseous insertion devices 2. Describe the indications and contraindications of inserting an intraosseous device 3. Discuss the steps needed before implementing a program for inserting intraosseous devices in an institution

1. When was an intraosseous device first suggested for use in transfusions?
a. 1922
b. During the 1930s
c. During World War II
d. 2005

2. Which of the following provides a direct path from the medullary canal to the central circulation?
a. Trabeculae
b. Volkmann canal
c. Haversian groups
d. Azygous

3. Which of the following describes why research on intraosseous devices was first conducted on children?
a. Children's bones are harder and easier to find.
b. The ratio of vessel to lumen size of the catheter made it easier to obtain intravenous access.
c. Intravenous access was harder to obtain in children because of vessel collapse.
d. Children's bones are similar to those in animal models.

4. Which of the following describes why intraosseous access has been found to be appropriate during cardiovascular collapse?
a. Drug delivery is more predictable with the endotracheal route of administration.
b. Intraosseous access should always be used without attempting standard intravenous access.
c. There is less pain associated with intraosseous administration of fluids.
d. An intraosseous device can be inserted in less than 1 minute when standard intravenous access may be unobtainable.

5. The incidence of which of the following intraosseous complications can be decreased by using aseptic technique and removal of the device within 24 hours?
a. Compartment syndrome
b. Osteomyelitis
c. Multiple insertion attempts to the same extremity
d. Pain at the insertion site

6. Which of the following intraosseous insertion devices is approved for use in the sternum?
a. FAST1
b. BIG
c. EZ-IO
d. All of the above

7. Which of the following intraosseous insertion devices has color-coded caps for adults, children, and animals?
a. FAST1
b. BIG
c. EZ-IO
d. All of the above

8. Which of the following intraosseous devices has approval to be used on the distal tibia?
a. FAST1
b. BIG
c. EZ-IO
d. All of the above

9. Which of the following intraosseous devices has multiple assembly steps before insertion?
a. FAST1
b. BIG
c. EZ-IO
d. All of the above

10. Which of the following should be included in the policy for use of intraosseous insertion devices for patient resuscitation?
a. Instructions on how to use all of the devices on the market
b. A test and check-off list on insertion technique
c. Indications and contraindications for insertion of an intraosseous device
d. The central supply code number for charging for the insertion kit

11. Which of the following interventions is appropriate to decrease a patient's pain at the intraosseous access site?
a. Applying heat to the site
b. Instilling 1% lidocaine following verification of patency
c. Checking for a pulse in the extremity
d. Removing the device with a rocking motion

12. Which of the following is a contraindication to using the FAST1 device?
a. Insertion in limbs with fractures
b. Insertion in patients with severe osteoporosis
c. Insertion in a prosthetic limb
d. Need for a cervical collar

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

1. ❑**a** ❑**b** ❑**c** ❑**d**	**2.** ❑**a** ❑**b** ❑**c** ❑**d**	**3.** ❑**a** ❑**b** ❑**c** ❑**d**	**4.** ❑**a** ❑**b** ❑**c** ❑**d**	**5.** ❑**a** ❑**b** ❑**c** ❑**d**	**6.** ❑**a** ❑**b** ❑**c** ❑**d**	**7.** ❑**a** ❑**b** ❑**c** ❑**d**	**8.** ❑**a** ❑**b** ❑**c** ❑**d**	**9.** ❑**a** ❑**b** ❑**c** ❑**d**	**10.** ❑**a** ❑**b** ❑**c** ❑**d**	**11.** ❑**a** ❑**b** ❑**c** ❑**d**	**12.** ❑**a** ❑**b** ❑**c** ❑**d**

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Content was relevant to my nursing practice	❑	❑
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