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Recommendations for the Use of Intraosseous Vascular Access for Emergent and Nonemergent Situations in Various Health Care Settings: A Consensus Paper

The Consortium on Intraosseous Vascular Access in Healthcare Practice

In recognition of the value of intraosseous vascular access in resuscitation and stabilization of patients, leading national and international organizations have published position papers that have served to change the standard of care for emergency vascular access. Among these organizations are the American Heart Association (AHA), addressing vascular access in cardiac

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arrest patients,¹ the International Committee on Resuscitation,² the European Resuscitation Council,³ the Infusion Nurses Society,⁴ the National Association of EMS Physicians,⁵ with the Emergency Nurses Association and the American Association of Critical-Care Nurses (AACN) endorsing the position paper of the Infusion Nurses Society.^{6,7} These professional societies recognized that intraosseous access may provide significant time savings that could benefit patients in emergent situations by decreasing the time required to achieve access and the time required to administer necessary fluids and medications. The AHA concluded that intravenous and intraosseous administration have equal, predictable drug delivery and pharmacological effects. Guidelines from both the AHA and the European Resuscitation Council state that intraosseous access should be the first alternative to failed intravenous access.^{1,2}

Given the well-established use of intraosseous vascular access in

the emergency setting, the Consortium on Intraosseous Vascular Access in Healthcare Practice chose to go beyond its use in resuscitative settings to explore the evidence supporting use of intraosseous access wherever vascular access is medically necessary or difficult to achieve in all settings. Such settings include, but are not limited to, patients in intensive care units, on high acuity/progressive care units, on the general medical units, in pre-procedure surgical settings where lack of vascular access can delay surgery, and in chronic care and long-term care settings.

Definitions

For purposes of this article, an emergent patient situation is defined as a sudden unforeseen event that demands immediate action without which the patient is in danger of increasing morbidity or mortality.

A nonemergent patient situation refers to the potential of an eventual increase in patient morbidity or mortality if action is not taken.

Overview of Intraosseous Vascular Access

Intraosseous vascular access has received considerable attention as an effective first alternative to failed or delayed peripheral or central intravenous access in emergent situations. The technique involves the placement of a vascular device with the tip of the intraosseous catheter in the bone matrix with a dwell time of 24 hours. Crystalloids, colloids, or medications delivered through this catheter immediately infuse into the systemic circulation via the bone marrow cavity.

Background

Using the bone marrow space (described as a “noncollapsible vein”) for emergency purposes has a long history of research dating back to the 1920s, when Drinker et al⁸ described the sternum as a potential site for transfusions. Not long afterward, Papper⁹ described access to the marrow space for the use of intravenous fluids. Investigators since then have verified that fluids and drugs administered through the intraosseous space reach the central circulation as quickly as fluids and drugs administered via central catheters and faster than fluids and drugs administered via peripheral catheters^{10,11} and that, in many cases, intraosseous administration was life saving.

The use of the intraosseous space to resuscitate and stabilize patients reached a peak during World War II, when intraosseous venous access was used by medics to resuscitate soldiers dying of hemorrhagic shock. Following the war, the technique fell out of favor because those who used it in the military setting were returned to the civilian population, and since

there was no organized emergency medical system at the time, their skills were not transferred. Intraosseous placement fell out of use for a considerable time in many countries.

This situation changed in the early 1980s, when a pediatrician from the Cleveland Clinic, visiting India during a cholera epidemic, observed many dehydrated children being resuscitated by using intraosseous devices. His famous editorial, “My Kingdom for an Intravenous Line,”¹² led to intraosseous access becoming a standard in pediatric advanced life support in 1988, where it remains a standard to the present.¹³

The use of intraosseous access in adults had lagged behind that in children until recently. Its use in adults has increased in the past several years. Such use has increased for several reasons, among them an evolution in technology that has made intraosseous insertion possible in the dense bone cortex of adults, as well as intraosseous vascular access being a technique that is easily learned and a skill that is easily retained.¹⁴ Data have shown that rapid absorption of fluids by intraosseous infusion into the central circulation is equivalent to or better than the absorption resulting from peripheral intravenous access.¹⁵ The Joint Commission’s discouragement of the use of femoral catheters for vascular access¹⁶ and national initiatives that curb the unnecessary use of central catheters¹⁷ lend credence to use of intraosseous access as an alternative for adult patients in emergent situations. These initiatives result from an increasing focus on costly and life-threatening catheter-associated infections, notably those caused by central

catheters. The Centers for Disease Control and Prevention¹⁸ (CDC) report that 248 000 bloodstream infections occur per year, costing between \$2 billion and \$9 billion, with 31 000 deaths occurring per year. The necessary expertise for placing central catheters may not be available at all times, in all settings, making an alternative such as intraosseous access especially valuable.

Clinical Considerations

Options for Vascular Access

It is recognized that lack of immediate vascular access can lead to unnecessary morbidity or mortality. To achieve access when peripheral intravenous access is delayed or impossible, the choices are few for patients with limited vascular access, which may result in difficult access or no access at all. Options include external jugular and peripherally inserted central catheters and nontunneled percutaneous central catheters. Although radiographic confirmation of tip placement is not required for intraosseous devices, it is a requirement for central catheters, which adds time and expense to the initiation of care. External jugular sites have high malposition rates¹⁹ and are particularly difficult to insert in obese patients and in infants because of their extremely short necks. They are also associated with several serious complications, including laceration of the deeper internal jugular vein and infection.²⁰

For both older adult patients and pediatric patients who are dehydrated, hypodermoclysis, or clysis, is a possible substitute for conventional intravenous access, but it has

some limitations, among them a tendency to enhance adverse events associated with coadministered drug products.²¹ Thus clysis may have limited use in patients in whom the administration of both fluid and drugs may be required.

The CDC²² recommends selecting intravenous catheters and insertion sites with the lowest risk of complications (infectious and noninfectious) appropriate for the therapeutic goal. Given the historical low complication rates of intraosseous vascular access (see “Complications of Intraosseous Access”), it is a practical alternative for patients with difficult vascular access who are in need of medication and fluids over the short term but for whom immediate administration of these products would reduce morbidity and mortality, and for whom peripheral intravenous access is not available. It should also be noted that intraosseous devices provide the added benefits of allowing bone marrow samples to be collected for laboratory analysis for blood sampling^{23,24} and for the delivery of radiologic contrast dyes.²⁵ Most medications that can be infused safely through peripheral intravenous catheters can also be safely infused through intraosseous devices.

Clinical Situations in Which Intraosseous Access May Be Considered

The following clinical situations represent patient groups in whom vascular access is notably difficult or who need access repeatedly but characteristically have limited vascular access. Intraosseous access can be considered clinically appropriate on the basis of a short-term need for patients

- with chronic disease who have been admitted to the hospital for treatment of a medical event, for example, the patient in deteriorating condition with chronic obstructive pulmonary disease.
- with limited vascular access because of aggressive treatment modalities (eg, fistulas, grafts, shunts, mastectomies, or multiple central catheter placements).
- for whom rapid response teams are called in order to prevent an emergent situation and in whom obtaining peripheral or central intravenous access is difficult.
- who experience an unexpected medical event that causes their peripheral or central intravenous device to become non-functional (eg, infiltration or occlusion) and difficult to reestablish.
- who have limited peripheral access due to morbid obesity.
- who suffer from intractable pain.
- who are in the early stages of sepsis.
- who are receiving palliative or hospice care.
- who are undergoing anesthesia and experience prolonged, difficult, or failed intravenous access.^{26,27}

Types of Devices

The technological evolution of intraosseous devices through which intraosseous vascular access can be obtained has been dramatic in the past several years, making the procedure relatively easy to perform with appropriate education and training.

Several devices have been cleared by the US Food and Drug Administration for intraosseous vascular access for 24-hour use. Three different methods of needle placement can be used for intraosseous access: manual, impact driven, and drill powered.

Manual

Manually inserted needles have been available in the United States since the 1940s. These manual needles are hollow steel needles with removable trocars that prevent bone fragments from plugging the needles during insertion. The steel manual needles are limited by the difficulty accessing dense adult bone.

Impact Driven

Two types of devices are impact-driven. One of these devices, originally designed for sternal access, has several needle probes to accurately locate the depth of the sternum. When pressure is applied, the central needle extends into the sternal medullary cavity. A possible limitation of this form of device is lack of access to the sternum in resuscitation situations. A second type uses a spring-loaded injector mechanism that fires the intraosseous needle into the medullary space of the tibia. Both of these devices must be appropriately stabilized to prevent injury to the patient or the clinician.

Drill Powered

This device is a battery-operated, drill-based technology designed to access the intraosseous space to an appropriate depth. It consists of a driver and a needle set designed for insertion into the intraosseous space. Different needle sizes are used

depending on the patient's age, weight in kilograms, and tissue depth over the landmarks. The precise needle-to-bone ratio allows efficient insertion and is designed to minimize trauma to the bone during insertion.

Results of head-to-head comparisons of specific intraosseous devices have been reported.^{28,29}

Contraindications to Intraosseous Access

Intraosseous access should be avoided in the following situations:

- Fractures in the same extremity as the targeted bone
- Previous surgery involving hardware in the bone targeted for intraosseous access
- Infection at the insertion site or within the targeted bone
- Local vascular compromise
- Previous failed intraosseous access within 24 hours in the targeted bone
- Inability to locate the landmarks^{1,27,30}

Bone disease such as osteogenesis imperfecta, osteopetrosis, and severe osteoporosis may be contraindications depending on the device.³¹

Complications of Intraosseous Access

Few complications are reported in connection with intraosseous access. Most complications are avoidable with proper education and training. Others are related to the technique used to insert the device.²⁸ Complications associated with intraosseous access include extravasation from dislodgment, iatrogenic fracture, growth plate injury, infection, fat emboli, compartment syndrome, and osteomyelitis.²⁸

In early case reports, osteomyelitis was identified as a complication of intraosseous access. Although osteomyelitis is a serious adverse event, the incidence of osteomyelitis after intraosseous placement is rare. The largest study examining this complication—a meta-analysis of the literature of 30 intraosseous studies that included 4230 patients—revealed an incidence of osteomyelitis of only 0.6%; complications were more likely to occur with prolonged infusion or if bacteremia was present during the time of insertion.³² Since that 1985 study, only single case studies have been reported, all in pediatric patients.³³⁻³⁷ The most commonly reported complication is extravasation,³⁸ which is generally the result of poor insertion technique, inadequate device stabilization, or device design.

Although the historical risk of introducing infection into the soft tissue during intraosseous insertion is small, the incidence may increase if the procedure is practiced by a wider spectrum of clinicians and if the needles are purposely left in place for longer than 24 hours.¹ In the absence of evidence, the Consortium therefore advises that when the intraosseous needle is inserted in this unique group of patients, the clinician follow standard precautions and aseptic technique as established in organizational policies and procedures and follow AHA guidelines for dwell times.¹

Other Considerations

Pain in Conscious Patients

Pain is often discussed as a concern either upon entering the intraosseous space or during infu-

sion of fluids and medications under pressure. Most patients in need of emergency vascular access are unconscious or have severely altered mental states. However, several studies have been conducted to include conscious patients in order to assess pain associated with the procedure both during insertion and infusion. Insertion pain has been reported by several investigators to have a mean score on the Visual Analog Scale, or VAS, between 2.5 and 3.5, similar to scores associated with placement of peripheral and central devices.³⁹⁻⁴¹

Infusion pain has also been addressed. In a large, 1128-case series³⁰ that used the powered drill device, the investigators found that, in most cases, patients' pain level upon infusion of fluids could be substantially reduced by injecting 0.5 mg/kg of preservative-free lidocaine through the intraosseous port before infusion. In another study⁴² of 24 patients receiving tibial insertion, investigators recommended using a prior flush of 20 mg to 50 mg of 2% preservative-free lidocaine through the intraosseous device. When infused properly, the lidocaine acts as a local anesthetic, thus blocking the pain sensation. As with all procedures, pain is individualized, and additional dosing may be required. No data are available regarding pain in connection with manual or spring-loaded devices.

Education and Training

To insert and maintain an intraosseous device in a patient, the clinician must demonstrate adequate knowledge and psychomotor skill competency in the procedure.

This competency should include aseptic technique and appropriate insertion, care and maintenance, and replacement and removal procedures. In order for intraosseous vascular access to become a standard of care within clinical practice in all practice settings, education and training should be integrated into core competency curricula.

Economics

In an era of increasing focus on cost, economic evaluation of new technologies is an essential part of technology assessment. The cost of intraosseous devices and needles should be compared with the cost of central catheter kits, ultrasound evaluation, and human resources required for their insertion. Risk management and patient safety are additional aspects of economic considerations. Central catheters are associated with infection and increased length of hospital stays.⁴³ Hospital-acquired infections have been placed on a list of “never events” by the Centers for Medicare and Medicaid Services (CMS), and both CMS and large private insurers will not fully reimburse hospitals for catheter-related infections.⁴⁴ When economic factors are being weighed, the potential complications of therapeutic strategies should be considered.

Risk Management and Patient Safety

In an era when liability concerns continue to drive many clinical decisions, it is worth noting that delays in treatment are often cited as the proximate cause of injury leading to malpractice claims. In patients who arrive at a medical facility or provider

in need of immediate fluid resuscitation or drug administration and for whom vascular access cannot be readily or safely obtained, intraosseous access may provide a safe and practical alternative and treatment defense. With existing evidence of the clinical efficacy of intraosseous access and the ease and speed of insertion,^{14,28,29,31,39} clinicians should consider using this method of infusion delivery. Clinicians will have to assess the patient’s condition carefully; determine if the patient’s condition requires immediate intervention including fluids, medications, or both; and then determine whether intraosseous access provides the safest and most effective treatment option.

Data

The literature on the use of intraosseous vascular access is abundant. More than 20 pharmacokinetic studies indicate that intraosseous access delivers fluids and medications as quickly as intravenous administration.¹⁵ The rapidity of absorption of medications and fluids via the intraosseous route in humans is well established. Equally well established is the relative lack of complications compared with the complications associated with alternative methods of vascular access. Data gathering will continue as the intraosseous approach becomes more established in a variety of health care settings. Currently more data are available on emergent patient scenarios than on alternative intraosseous access of inpatients. Clinical studies of intraosseous access that focus on deployment in nonemergent clinical situations are encouraged. In addition, the estab-

lishment of national criteria (CDC/National Healthcare Safety Network) for defining an intraosseous hospital-associated infection is encouraged, and organizations should develop methods to capture data related to intraosseous access and report use of intraosseous access to facility administrators and nationally to the CDC. However, the current lack of data should not be regarded as a barrier to use of a proven technique in achieving vascular access in a timely way.

Constituency Education

It is important that groups such as the Agency for Health Care Research and Quality and The Joint Commission, as well as professional associations representing clinicians whose patients have vascular access issues, actively support intraosseous vascular access in their practice recommendations. Such consideration could encourage use of intraosseous devices in appropriate situations.

Summary of Recommendations

The Consortium on Intraosseous Vascular Access in Healthcare Practice has reached a consensus on the following:

1. Intraosseous vascular access should be considered as an alternative to peripheral or central intravenous access in a variety of health care settings, including intensive care units, high acuity/progressive care units, general medical units, preprocedure surgical settings where lack of vascular access can delay surgery, and chronic care and long-term care settings, when an increase in patient morbidity or mortality is possible.

2. Intraosseous vascular access should be considered as part of an algorithm for patients treated by rapid response teams in whom vascular access is difficult or delayed.

3. A new algorithm that includes the intraosseous route should be developed for assessing the appropriate route of vascular access.

4. For patients not requiring placement of central catheters either for long-term vascular access or hemodynamic monitoring, intraosseous access should be considered as the first alternative to failed peripheral intravenous access.

5. Techniques of intraosseous catheter placement and infusion administration should be a standard part of the medical school and nursing school curriculum.

6. In evaluating the economic implications of adopting intraosseous technology, the following should be considered: the expense of diagnostic tools to guide and confirm placement, the cost of human resources, the known and unknown risks to patient safety, and the cost of complications related to delayed treatment.

7. Organizational policies, procedures, and protocols that establish the responsibility of insertion, maintenance, and removal of intraosseous access devices should be developed.

8. Further research should be conducted on, but not limited to, the safety and efficacy of use of intraosseous access in all practice settings, its economic impact on patient care, and to support the use of intraosseous access in all health care settings.

The Consortium recognizes that support of this practice change requires a practice shift in all clinical

settings. However, the change could result in an appropriate vascular access solution for a growing population of patients with difficult vascular access. The Consortium believes that embracing patient-centered care is a vital step in improving safety and quality. This goal is shared by all those involved in health care. **CCN**

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