Adult IO Arrives
The solution to difficult vascular access

An Editorial Supplement
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Intraosseous Infusion: Bibliography
The Rebirth of Adult IO

A first-hand account of recent advances in intraosseous infusion for adults, drawn from a scientific workshop & practical lab experience

In March 2004, as I was walking around the exhibit hall at EMS Today in Salt Lake City, my cell phone rang. It was Jeff Lindsey, JEMS product reviewer and author of the monthly Hands On column. He told me to meet him at the VidaCare booth to see an exciting new clinical product.

When I walked up, Jeff handed me what first appeared to be a compact Makita drill. He told me it was, in fact, a newly FDA-approved medical drill specifically designed to insert a precision-tooled intraosseous needle, quickly, neatly and securely into adult patients, like a fine drill bit through a piece of fine wood.

Medical drill? Precision-tooled IO needle? Adult IO? Before I fully realized the implications of what I was witnessing, Jeff handed me an EZ-IO drill and a training bone with simulated skin and told me to try it. In less than three seconds I had positioned, drilled and inserted the IO snugly into the bone.

It was amazing. I had complete control over the insertion, placing it exactly where I wanted it to go. I could also feel the change in pressure (drill effort) as the IO needle drilled through solid bone and penetrated the soft intraosseous space. It was much easier (and less stressful) to use than the Jamshidi needles I’ve used on pediatric patients in the past. (I never did feel comfortable taking out what appeared to be a small ice pick and proceeding to twist it into the leg of a small child with their parents present. It always seemed a primitive and barbaric way to access the IO space. It also never penetrated in a truly precise manner because of the twisting motion required. This often resulted in extravasation [leakage].)

I walked away impressed and anxious to hear what the rest of the JEMS product reviewers felt about the EZ-IO. I wasn’t surprised to learn they all ranked it as one of the most innovative new clinical products being introduced to the prehospital arena. We selected it as one of the hottest products at EMS Today 2004 (see June 2004 JEMS, p. 44).

After that, I didn’t hear much about the EZ-IO until I attended the February 2005 Gathering of Eagles Conference in Dallas. The annual conference, the gathering of major metropolitan medical directors from throughout the United States, includes discussion and exhibition of some of the most significant, new medical procedures and equipment. Most importantly, the medical directors rely on research and proven field use before adopting new procedures or equipment in their EMS systems.

At the 2005 conference, Jullette Saussy, M D, EMS director of the New Orleans EMS system, reported on the successful implementation of the EZ-IO in their system. She said the New Orleans crews were using the device with great success for adult patients in whom IVs could not be established and the administration of fluids or drugs was critical to stabilization or resuscitation.

Physicians from San Antonio, Dallas, Austin and Montgomery County, Texas, systems, as well as Tampa/St. Petersburg, Emory/Atlanta and Acadian Ambulance Service echoed the New Orleans results and reported increased resuscitation success since the implementation of adult IO infusion. With these respected EMS systems already using EZ-IO, I knew I needed to learn more about it.

This Jamshidi IO needle requires a forceful, twisting motion for insertion, which can result in extravasation. New technology allows for more precise positioning and insertion of IO needles.
MY INITIATION

I spoke with Larry Miller, M.D., VidaCare’s chairman, chief medical officer and principle designer, and he impressed me with the amount of research behind the EZ-IO. His passion for the use of the intraosseous space as a “non-collapsible” vein was contagious.

He sent me training manuals and CDs, research, field trial results and an EZ-IO drill to work with. He also invited me to attend the company-sponsored Scientific IO Seminar (SIOS) at the University of Texas Health Science Center at San Antonio.

As a paramedic with 30 years of field experience, I was eager to attend the SIOS. Dr. Miller was the principle SIOS instructor. Although intimately involved in the development of the EZ-IO drill, he approached the subject and review of IO research and delivery devices in an unbiased manner, fully disclosing his involvement.

Dr. Miller explained that he became intensely interested in developing a better approach to IO insertion after the death of a friend, a fire captain/paramedic, who died as a result of injuries sustained in an auto collision despite valiant, but unsuccessful, efforts by EMS personnel to gain IV access. He pointed out that most paramedics have experienced similar situations and been frustrated by EMS calls in which they’ve been unable to gain IV access or administer fluids or medications to patients in extremis. It was something I could personally relate to.

He referenced the frustration experienced by crews unable to visualize or palpate veins in morbidly obese patients, a growing epidemic in the United States. He also noted the difficulty EMS personnel had in gaining IV access to administer fluids and medication to pro football player Cory Stringer who collapsed and died during football camp in 2004, pointing out that adult IO would have offered a solution in these difficult patient encounters.

Dr. Miller reviewed the application procedure for several IO infusion devices, including Pyng Medical’s FAST-1 sternal device and Waismed’s B.I.G. (bone injection gun), which we would use later in the day at the workshop’s animal and cadaver labs.

As previously noted, he helped the University of Texas Health Science Center at San Antonio design the EZ-IO. Drawing on the observation that orthopedists routinely use special drills in working with bones, the EZ-IO was designed to penetrate to the IO space by gently, but rapidly drilling through the bone with a hollow needle and integrated stylet that doubles as the forward cutting bit, thus securing its correct placement.

The device features a high degree of control for the provider and utilizes a needle that powers into the IO space with precision by rotating a sterile, hollow drill bit to a preset depth. It burrows in so cleanly that there’s no extravasation around the needle, and it’s nearly impossible to accidentally dislodge without purposefully twisting it—a plus for the active prehospital environment.

Dr. Miller explained the history of IO access in the United States, pointing out examples of successful use by military medics during World War II. Despite great success in WWII, adult IO use took a nearly 60-year hiatus from emergency medical care after the war because civilian EMS was virtually non-existent until the 1970s, when such physicians as Gene Nagel and Norman McSwain pointed out the expertise that the Vietnam military medics could transfer to the streets of America.

Data were presented from studies and clinical trials conducted on placement and use of the EZ-IO device, most of which are referenced later in this document (see “Bibliography,” p. 34). I found one study particularly interesting:

Research and field practice have shown the importance of a 10 mL saline flush post-needle insertion to improve IO flow rate and performance.
because it involved 250 patients in a prospective multi-center trial conducted to assess the ability of paramedics, nurses and physicians to use the EZ-IO for emergency vascular access (see “Clinical Evaluation of a Novel Intraosseous Device for Adults,” p. 20).

The study, conducted in 16 physician-directed EMS agencies throughout the United States, measured the success rate of their personnel in inserting the EZ-IO and administering fluids and drugs. The study also examined methods of IO needle placement confirmation, pain experienced by the patients, the estimated total time of insertion, fluids and drugs administered, flow rates, ease of use, and the control and function of the EZ-IO device.

What was most impressive to me was that the 97% success rate for insertion and subsequent ability to give fluids or drugs via the EZ-IO and that 23 different drugs and fluids were administered through it. Also, in 94% of the cases, insertion time (from start of IO drill to flow of IV fluids) averaged less than 10 seconds.

I was interested in how well conscious patients tolerate the pain associated with infusion, particularly because I know there are a lot of pain receptors in the IO space. Conscious patients (Glasgow Coma Scale above 8) rated their infusion pain on a modified VAS scale of 1 to 10 and averaged a 5 without the benefit of lidocaine given in advance of fluid or medication push. However, the use of lidocaine reduced that initial pain in 100% of those cases.

To prove that the procedure is easily tolerated by the conscious patient with a 20–50 mg dose of 2% lidocaine, Miller showed film clips of himself and Scotty Bolleter—an experienced flight paramedic, respected, national EMS educator and VidaCare’s director of education—placing needles in each other with the EZ-IO drill and administering fluids under pressure.

One important finding by this study, backed up by comments from field personnel, is that the EZ-IO catheter, similar to other IO catheters, must be flushed prior to use. Flushing with 10 cc of fluid greatly improves IO flow rate and performance. And, although EZ-IO tibial flow rates are generally slower than those achieved through an equivalent size IV catheter, from 20 mL to more than 3,000 mL per hour of fluid can flow through the IO space with the IV bag under pressure.

THE LAB EXPERIENCE

If I had any doubts about the effectiveness of the EZ-IO drill, they were all eliminated after my participation in the afternoon animal and cadaver lab. Our hands-on experience took place in the same prestigious lab where the cardiac stent was invented.

Before going into the lab, participants received an in-depth orientation on the proper treatment of laboratory animals and the processes involved in animal lab operations. The orientation ensured that all participants approached the animal and cadaver lab in a professional manner and made me feel comfortable that no live animals would be harmed or feel any pain during the IO procedures we would be performing. As an animal lover, I also found it reassuring to know that a veterinarian and anesthetist would be at each IO station to make sure each subject was well monitored and maintained.

After a standard orientation on IO insertion devices and techniques, I was given the opportunity to use the B.I.G. and the EZ-IO to insert IO needles in the tibias of live, anesthetized goats. I had used the B.I.G. in training situations...
many times and felt I would master its use in the lab. But I was surprised by the significant "kickback" of the spring-loaded device. Because it recoiled and moved my hand backward when I fired it, the needle did not fully penetrate into the medullary cavity.

When I was handed an EZ-IO drill, I found my spot on the tibial surface, held the drill perpendicular to the spot like I would hold my own battery-operated drill while penetrating the stud in a wall, and quickly and easily inserted the EZ-IO needle.

Dr. Miller then suited us up in special gear and injected radiopaque dye into a humeral head to show us how quickly IO-infused fluids can reach the heart. (Note: VidaCare has applied to the FDA for approval to allow use of the EZ-IO in the humeral head.) The fluid flow was shown on a C-Arm cinematoscope. It was amazing. Fluid flowed almost as fast as it would though a central line, but via a much less complicated insertion procedure.

By the time I moved over to the human cadaver lab, I was convinced that the EZ-IO device was the easiest and most precise IO placement device I had used. Insertion in the human cadavers was amazingly simple.

My personal experience, coupled with the research outcomes and the successful experience of major metropolitan EMS system use of the EZ-IO, made me realize that EMS systems were being introduced to a tool that would revolutionize emergency medical treatment as powerfully as the introduction of CPR, IV catheters, defibrillation and AEDs.

Witnessing the rebirth of adult intraosseous infusion and being aware that adult IO use was recommended by the 2003 ACLS guidelines, I approached VidaCare to help develop this special editorial supplement. In the following pages, you’ll find the answers to the following questions—and more:

- Why wasn’t adult IO access in the field introduced sooner?
- Can 50% dextrose and other critical medications be pushed via the IO route?
- How long does it take for fluids and medications to reach target areas in the body?
- What are the contraindications, if any, for its use?
- What post-insertion complications (e.g., infection or osteomyelitis) can result?

As the industry leader in the education of EMS personnel on clinical advancements, JEMS is proud to present this comprehensive look at the history, research and advances in intraosseous infusion that will now allow you to resuscitate patients in extremis though an ever-present, non-collapsible vein. IO

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Rescue Access Made Easy

Intraosseous infusion, once limited to use on children, is now becoming a reliable access site for adults.

GLOSSARY

Cancellous bone (spongy bone): Lattice-like tissue normally present in the interior of many bones where spaces are usually filled with marrow.

Compact bone: Hard, dense bone that is usually found at the surface of skeletal structures.

Epiphyseal plate: The site of bone growth.

Extravasation: Blood or fluid leaking into tissues.

Red marrow: Specialized marrow found in some bones that is essential to the production of red blood cells.

Yellow marrow: Specialized tissue found in the compact bone of most adult epiphyses.

In the past few years, there has been a renewed interest in the old technique of intraosseous (IO) vascular access for adults when standard IV access is difficult or impossible. It has proven to be an invaluable tool for treating seriously ill or injured patients. It is safe, easy, fast and effective. It takes away some of the stress of treating patients in shock by providing a reliable back up for vascular access for nearly every emergency. The 2003 ACLS guidelines cite IO as a valuable alternative for adults. The FDA has recently approved three new devices for adult IO access: the F.A.S.T.1, the B.I.G. and the EZ-IO. With this renewed interest, it is time to take an in-depth look at adult IO access and how it is changing the way paramedics, nurses and doctors deal with difficult IV access.

BACKGROUND

The use of the IO route to administer drugs and fluids in the adult emergency patient is still relatively new in the modern EMS world, but IO access enjoys a long and colorful history.

Early experience: Anecdotal evidence indicates that IO access was used in the late 1800s, but the first scientific study of IO access was conducted in 1922, when C.K. Drinker, M.D., of Harvard University examined the circulation of the sternum and proposed that intraosseous space be considered a non-collapsible vein. In experiments, he confirmed that substances infused into the bone marrow were quickly absorbed into the central circulation.

The next two decades saw a flurry of research into IO access. An early clinical champion of IO infusion was Dr. Leandro Tocantins of Philadelphia. In 1940, Tocantins and his colleague, J.F. O’Neill, confirmed that the marrow cavities of the long bones, as well as the sternum, could be used for vascular access. They demonstrated that red dye injected into the tibial IO space of rabbits appeared in the heart within 10 seconds of administration. Tocantins also published several case studies on the use of IO infusion, developed practical techniques for the clinical use of IO and designed special needles for IO access.

In 1942, E.M. Papper, M.D., Ph.D., established that the circulation times for fluids administered by IO and IV routes were nearly identical. In 1944, British physician Hamilton Bailey, M.D., commented on the utility of sternal IO access during the blackout conditions of wartime London. Noting the potential danger of the IO needle accidentally perforating through the sternum and hitting the heart, Bailey designed a special IO trocar and guard to protect the heart.

A JEMS CONTINUING EDUCATION FEATURE

The JEMS continuing education program is coordinated by the Center for Emergency Medicine, Pittsburgh, and the University of Pittsburgh, School of Health and Rehabilitation Sciences.

By Larry Miller, MD,
George C. Kramer, PhD, &
Scotty Bolleter, EMT-P
The Olathe (Kan.) Fire Department, an ALS-capable first response agency, has been using intraosseous infusion for adults and finds it a safe, effective route for the administration of fluids and drugs for patients in extremis.
During the 1940s and 1950s, IO infusion was a popular method for administering medications and for blood transusions in both children and adults. The technique appeared often in medical journals. Hand-driven needles were used to access the IO space.

World War II experience: intraosseous infusion was widely used by military medics during World War II to save the lives of injured soldiers. More than 4,000 cases of IO use during the war are documented. The U.S. military considered IO infusion a standard practice in the treatment of seriously wounded soldiers. Prior to the use of IO access, many soldiers hemorrhaged to death because medics could not establish IV access in shock patients. The first documented life saved by IO administration was that of a 19-year-old B-29 crew member who was critically wounded while flying over Japan.

A lost art: Unfortunately, the successful practice of IO infusion did not carry over from military to civilian use after the war. This was mainly because there were no paramedics during the 1940s through the 1960s. Before the 1968 establishment of the first EMS organizations in Chicago by David R. Boyd, MD, and others, patients were usually transported to the hospital by hearse or station wagon ambulances with no treatment rendered either on scene or during transport. Another factor cited in the decline of IO use was the introduction and popularity of plastic IV catheters.

Why wasn’t IO reintroduced in 1968 with the advent of the first paramedics? Because EMS was created from the trauma centers, like the one at Cook County Hospital in Chicago. It was not born from the military. Most trauma surgeons at the time did not know about IO and, therefore, did not teach it. They were happy if paramedics could start IVs some of the time.

IO access rediscovered: An American pediatrician, James Orlowski, MD, of the Cleveland Clinic, is credited with the rediscovery of IO access as an alternative to IV vascular access. Visiting India during a cholera epidemic, he observed medics using IO access to deliver fluids and medications to save patients who otherwise would have died from the disease. After this experience, he published a 1984 editorial, “My Kingdom for an Intravenous Line,” which advocated the use of IO in pediatrics. This sparked renewed interest and research into IO vascular access, which was rapidly adopted by the pediatric community and became established as the standard of care in the Pediatric Advanced Life Support (PALS) guidelines in the 1980s.

During the past three decades, a number of studies investigated the pharmacokinetics (distribution of drugs in the circulation) of IO-introduced drugs in a variety of animal models. A 1990 literature review published in the New England Journal of Medicine concluded that any medication that could be administered intravenously could also be administered via the IO route and rapidly absorbed into the central circulation. Research is ongoing to explore further intraosseous infusions of drugs. (See the sidebar on p. 16 for a synopsis of research currently underway.)

IO ANATOMY & PHYSIOLOGY

The intraosseous space is often referred to as a non-collapsible vein. Although peripheral veins often collapse in cases of
Physiology: The unique structure of the IO space is the reason for its ability to quickly absorb infused fluids and medications and to transport them to the central circulation. The IO space contains thousands of tiny non-collapsible intertwined blood vessels, acting like a sponge that immediately absorbs any fluid coming in contact with it. Such substances are then rapidly transported to the central veins in the body.

Blood flow through the IO space is relatively constant, even in most cases of shock. Blood pressure in the IO space is approximately 35/25 mmHg, roughly one-third of systemic arterial pressure.

Anatomy: All long bones of the skeleton have two ends (epiphyses) and a long shaft (diaphysis). The epiphyses are composed of a thick, hard cortex (compact bone) with a hollow interior space (the medullary cavity). The epiphyseal plate is the junction between the epiphysis and the diaphysis where bone growth occurs during childhood. (See Figure 1, opposite, and Figure 2, p. 12.)

The term intraosseous space refers to the spongy cancellous bone of the epiphysis and the medullary cavity of the diaphysis, which are connected. The vessels of the IO space connect to the central circulation by a series of longitudinal canals (Haversian canals) that contain a tiny artery and vein. The Haversian canals are cross-connected by a series of Volkmann canals (also containing tiny arteries and veins), which penetrate through the hard cortex of the bone to connect the intraosseous vasculature with the major arteries and veins of the central circulation.

Bone marrow: The intraosseous space is filled with bone marrow, which comprises blood, a network of blood-producing cells and connective tissue. Red marrow is found in cancellous bone and contains a high concentration of blood. Yellow marrow is found in the medullary cavity of the long bones of adults. Infants and children have only red marrow in their bones. With age, some red marrow is replaced with fat and becomes yellow marrow. Fluids and medications infused into either the red or yellow marrow quickly reach the central circulation.

Microanatomy: The intraosseous space is lined with endosteum, which is composed of specialized squamous cells. Some cells of the endosteum, the hematocytoblasts, produce blood components, such as red blood cells, white blood cells and platelets. Other cells in the endosteum produce stem cells, which can be transformed into almost any tissue in the body.

IO DEVICES

Manually inserted IO devices (Cook, Jamshidi, Illinois Sternal and others; see p. 17): These devices have been available for years and are used primarily in pediatrics, because children's bones are softer than adults. They are all modified steel needles with removable trocars to prevent plugging with bone fragments during insertion. They have special handles to allow the operator to push into the bone while rotating. The difficulty with this method is that the resulting hole in the bone is often asymmetrical due to the non-axial rotation provided by the manual insertion technique, resulting in leakage.

Despite the popularity of pediatric IO access in emergency medicine, until recently there were few options for IO access in the adult patient. The hard bones of the adult prohibited easy, rapid IO access with manually inserted needles. This changed with the introduction of medical devices designed to facilitate insertion of the IO needle through the cortex into the marrow of adult bones.

The F.A.S.T.1 (see p. 16): In 1997, the FDA approved the use of the F.A.S.T.1, the first medical device for adult IO access in the United States, designed for use on the sternum. The F.A.S.T.1, manufactured by Pyng Medical in Vancouver, Canada, uses several needle probes to accurately locate the depth of the sternum. Then, as pressure is applied on the device, a central penetrating needle extends precisely into the sternum medullary space. The procedure is assisted by an internal spring that propels the needle into the sternum. This multiple needle design prevents the operator from accidentally penetrating through the sternum. After use, the IO needle is extracted from the sternum with a specially designed removal tool. The device...
is self-contained and disposable. It has been widely used in the military as well as the civilian population.

The B.I.G. (see p. 15): Another impact-driven device, the Bone Injection Gun (B.I.G.), was approved by the FDA in 2000 for use in the tibia. The B.I.G. was developed by Marc Waisman, M.D., in Israel and has been used by the Israeli military for more than a decade. It is a small, light-weight, self-contained device. After removal of the safety pin, the operator squeezes the trigger and a powerful spring shoots the pencil-tip needle into the medullary space of the tibia. Although approved for use only in the tibia in the United States, in Israel it is also used in the medial malleolus, the distal radius and the humeral head.

The EZ-IO (see p. 14): In 2004, the FDA approved the EZ-IO, the first battery-powered IO access device. The EZ-IO differs from its predecessors in that it uses a specially designed drill-tipped needle to enter the IO space. A battery-powered motor drives the drill-tipped needle into the bone, in contrast to the spring-loaded mechanism of other devices. The importance of this approach is that the resulting match between the needle and the hole in the bone is precise and tight, preventing most extravasation.

VASCULAR ACCESS—AN ESSENTIAL EMERGENCY MEDICAL SKILL

IV access is required to treat most cases of shock, altered mental status, respiratory distress, CPR and trauma. Paramedics and nurses are generally skilled in starting IVs in the field and in the emergency department (ED). Most EMS organizations report a peripheral IV success rate of 90–95%. However, when further analyzing the situation, patients in extremis conditions often go into shock as the body conserves the available circulating blood by shutting down the peripheral vasculature. Veins collapse and disappear. Unfortunately, in many cases the more urgently a patient needs IV access the harder it is to establish one.

Extent of the problem: The CES manager of a large private EMS system in Northern California told the authors that she didn’t think she had a problem. Her division reported a better than 90% IV success rate. However, when she examined IV success rates in cardiac arrest patients, she discovered to her amazement that IV access was not established in 25–32% of the 300-plus cardiac arrest patients transported to the ED during the previous year. Paramedics were spending prolonged periods attempting to establish IV access prior to transporting the patient to the ED.

Alternative routes to give medications if IV access can’t be established include the ET tube, IM, rectal, subcutaneous, nasal, percutaneous, sublingual and inhalation. All of these routes can be effective in controlled situations; however, in life-threatening emergencies many of these approaches are ineffective.

Central lines vs IO: Most emergency physicians will say, “If I have a problem with getting an IV, I’ll just slip in a central line.” Several air medical services also place central lines, but ground EMS organizations rarely have this option.

Central lines are not a quick procedure. Placing central lines as an alternative approach to difficult IV access is fraught with high risk, high costs...
and excessive throughput time. Complications of central lines include sepsis, local infection, punctured lung, arterial puncture, large hematoma, perforation of the heart, hemothorax, hydrothorax and brachial nerve injury. The FDA reported that up to 400,000 patients each year are hospitalized for complications from central line and other intravenous catheters. Further, the mortality rate attributable to these complications is reported to be 10 to 20%. Adult IO is a preferable method of vascular access for the patient in extremis.

Myth 1: IO is only for children. Actually, IO was used on adults long before children. During World War II in the 1940s, adult IO was the standard of care for military medics treating casualties in shock. IO was also routinely used in children at that time. The re-emergence of pediatric IO occurred during the 1980s.

Myth 2: Epiphyseal plate injury is a significant risk. In theory, there is danger of the IO needle penetrating the epiphyseal growth plate in infants and children; however, in clinical practice and experimental models, the insertion of IO needles through the growth plate does not result in impaired growth or bone deformity.

Myth 3: Fat embolism is a serious risk. Clinically significant fat embolism resulting from IO administration has never been reported in the medical literature or in actual practice, although animal trials have shown microscopic fat emboli in the lungs after high pressure IO infusion.

Myth 4: Osteomyelitis is a significant risk. In practice, IO infusions have resulted in a very low rate of infection. According to several studies, osteomyelitis occurs in less than 0.6% of IO insertions, or about one in 200 cases. To date, there are no cases in the literature of osteomyelitis from IO catheters causing death or prolonged incurable infections.

Myth 5: IO pain is unbearable. Admittedly, the IO procedure looks painful. In reality, it is no more painful than inserting an 18-gauge catheter in a vein. In conscious patients, pain levels with IO insertion are rated at 2–3 on a scale of 1–10, with IO being the worst possible pain. However, most patients who need IO access are unconscious. On the other hand, there may be significant pain upon high-pressure IO infusion in conscious patients (a visceral pain) due to stimulation of pressure sensors in the medullary space of the bone. This pain can be controlled by injecting 2 cc of 2% preservative-free lidocaine into the IO catheter prior to infusion. Only about 15% of the patients requiring IO are conscious. [Author’s note: See “Clinical Evaluation of a Novel Intraosseous Device for Adults” in this supplement, p. 20.]

Myth 6: IO is a difficult procedure to master. Although children have relatively soft bones, insertion of manual IO needles can be difficult. However, all of the new FDA-approved adult IO devices greatly facilitate IO insertion, making IO access easier and faster than starting an IV.

Myth 7: There’s no support for IO from medical opinion leaders. Many medical opinion leaders do support IO. ACLS and PALS guidelines recommend IO in cases of difficult vascular access. The Eagles now recommend that cardiac drugs be given via IO rather than via the ET tube in cases of cardiac arrest with no IV access. Many large EMS systems and EDs are using adult IO access. Because of their long successful history of using this technology, military medics enthusiastically endorse IO access for treating battlefield casualties.

Myth 8: In cases of cardiac arrest, IO infusion below the diaphragm is ineffective. Recent studies in animal models of cardiac arrest indicate that medications injected into the bone marrow of the tibia during CPR reach the heart in therapeutic concentrations within 51 seconds compared with 25 seconds via the sternum.

Myth 9: IO infusions can be given only in the “red” marrow. Research in several animal models has shown that medications enter the central circulation when infused into either the red or yellow marrow, although a slight delay is associated with infusion into the yellow marrow.

Myth 10: IO infusion rates are just as fast as infusion rates through central lines. Drugs injected into the IO space of the tibia, sternum and humeral head all reach the central venous circulation within one second. Therefore, cardiac drugs given via IO infusion are just as fast as drugs given through central lines. However, if large volumes are required in a short time, the IO route has limitations. IO infusion rates (liters per hour) for fluids are generally slower than through a central line. Practically speaking, drug boluses of up to 5 cc given IO by syringe reach the heart just as fast as when given via a central line. However, the volume of fluid given per unit time is similar to the rate infused through a 21-gauge catheter.
THE EZ-IO™

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FDA cleared: 2004

Placement method:
Battery-powered drill

Product support:
24-hour, toll-free emergency hotline;
Detailed Web site and e-mail access;
Product evaluation survey with medical oversight;
Toll-free business number;
Clinical representative (experienced paramedics and nurses);
Direct physician developer access;
Distributors;
Implementation start-up guide for first-time users; and
Image Quick Reference Card for “assured retention under fire.”

Training materials: Comprehensive training program included in purchase with complete product training video;
training manual (printed or digital) covering IO history, anatomy, physiology, step-by-step insertion process, scenarios, outlines, study guide, skills assessment, written test, specifications and a bibliography; all-inclusive instructor manual (digital or printed); PowerPoint demonstration for auto tutorial or instructor guided programs; training driver and needle sets (actual driver with colored needle sets created specifically for non-sterile realistic hands on training); and anatomically correct (inexpensive and disposable) manikins in multiple weight ranges.

invasive procedure (central lines with high complication rates) with a less invasive procedure (adult IO with low complication rates). With adult IO quickly established, the emergency professional can concentrate on the more important aspects of airway management, arrhythmias, fluid resuscitation, wound management and scene time, and not worry about time-consuming and often exasperating IV access. The ability to immediately establish vascular access should significantly improve the quality of care. In several services, including Montgomery County Hospital District EMS, IV attempts are eliminated in cases of cardiac arrest and their paramedics go straight for the IO, which saves an average of eight minutes.

DRUGS ADMINISTERED THROUGH THE ET TUBE
For many years, the standard of care has been to administer cardiac medications into the endotracheal (ET) tube in the case of cardiac arrest, when IV access cannot be established. ACLS guidelines recommended this approach as recently as 2003, with suggested doses of ET medications at two to four times the IV dose. Several research studies examined the utility of this administration route. A recent study found a significant difference in survival between patients who received medication via the ET tube vs. the IV route, with no survivors to discharge in the ET-mediated group and 5% survivors in the IV group. Granted, patients who received ET medications may be those in whom IV access was more difficult, which might represent a sicker population.

VidaCare Corp. conducted its own study of ET medication administration in 10 large animals with normal circulation. Epinephrine administered in the recommended doses via the ET tube rarely caused any measurable increase in the heart rate or blood pressure, even after five minutes. The animals often became hypoxic because of the extra pulmonary fluid. Conversely, epinephrine administered via IO caused the heart rate and blood pressure to more than double in less than 15 seconds in every instance. [Editor’s note: VidaCare manufactures the EZ-IO.]

“Why do we continue pouring drugs down the ET tube during cardiac arrest when we know it doesn’t work?” This question was posed during the February 2005 Gathering of Eagles Conference in Dallas. The Eagles are a group of EMS medical directors of the 25 largest U.S. cities. The answer was that until now it was the only alternative available to failed IV access. The Eagles now recommend that paramedics use adult IO
instead of the ET tube for administering cardiac drugs during CPR in patients with no IV access.

“Over time the trend was developed to put drugs down the endotracheal tube,” says Eagles member Ray Fowler, M.D., “but those of us involved in EMS critical care have come to understand that this is an ineffective way of delivering medication to people who are critically ill. So now with development of an adult intraosseous device we are able to get an intravenous line (that for ALS drugs is equivalent to a central line) in virtually any patient every time. So just as large needles on epinephrine for ACLS went away because we don’t do intra-cardiac injections anymore, drugs down the ET tube will go away as well because of the advent of the adult intraosseous alternative.”

**IS THE USE OF ADULT IO INFUSION COST-EFFECTIVE?**

As with any new product or procedure, one must always consider the economic impact of the device on their organization and EMS in general. Because adult IO catheters range in price from $65–160 each, in contrast to IV catheters that range from $3–5 each, one must ask the question, “Is the added cost justified?” Do the economic as well as the medical benefits translate into overall cost savings and improved quality of care? The answer? The IO route presents numerous direct and indirect economic benefits to both patients and paramedics.

IO saves time. Adult IO devices take less than a minute to insert. It frees the emergency professional to focus on managing more urgent problems, such as airway, arrhythmias, medication, fluid administration and transport. Each minute saved translates into dollars saved for the EMS organization. It helps get the unit back into service quicker. It allows one provider to treat multiple patients. It allows for the administration of fewer drugs. With IO access, the correct dose of medication can be given right the first time, every time. Paramedics no longer need to risk overloading their patients’ lungs by giving them multiple doses of drugs down the ET tube, an ineffective method of medication delivery. The use of fewer drugs translates into cost savings.

Reduces need for backup: With adult IO, the paramedic can almost always administer fluids and medications to the patient with difficult vascular access. Therefore, in these cases they are less likely to need backup from other EMS units or air transport assistance.

It reduces stress. Giving paramedics the tools and procedures to do their job well significantly reduces their stress levels and improves their job satisfaction. When paramedics can quickly establish venous access, it allows them to say they did their best with every patient and even improves their image with the receiving hospital team.

It reduces liability: As adult IO becomes the standard of care, paramedics will no longer be excused for not being able to administer lifesaving medications and fluids. Taking patients to the ED without first establishing vascular access will not be accepted. Being able to give ALS drugs every time will significantly reduce the risk of mistakes and bad outcomes.

It improves patient care. Improved quality of care nearly always translates into cost savings. The more urgently a patient needs an IV, the more difficult it may be to start. For these patients in extremis, the difference between life and death often depends on establishing venous access. Using the IO route allows the paramedic to establish vascular access quickly and reliably, in a safe and effective manner.

Blood pressure in the IO space is approximately one-third of systemic arterial pressure and remains relatively constant even in most cases of shock.
easy manner with fewer risks and side effects than a central line. Faster administration of ALS drugs would be expected to improve outcome.

DOES IO REPLACE IV?
A cornerstone principle in IO access is that it is not a replacement for routine IV therapy. IO is the most appropriate option for vascular access when conventional IV access is difficult or impossible and when patients exhibit altered levels of consciousness, respiratory compromise and/or hemodynamic instability. Delays in the treatment of these life-threatening conditions may result in death or permanent morbidity and should never be acceptable to any EMS provider.

EMS providers know that IV access falls primarily into two categories: establish IV access for immediate treatment or place an IV line prophylactically (to provide a lifeline in case drugs or fluids are needed in the near future). IO access is not recommended for prophylactic use. Prophylactic IV placement is considered prudent treatment, provided it does not affect transport time. No doubt, many patients have benefited from prophylactic IV placement.

On the other hand, IO access has several advantages over IV access when patients have an immediate need for fluids or medications:

- IO vessels don’t collapse in shock; thus, IO is extremely reliable;
- IO access is unquestionably quicker than IV access for patients in shock or trauma;
- IO requires less skill and training;
- IO competency remains high even after periods of non-use (minimal skill decline);
- IO access has a low complication rate; and
- There are few contraindications to IO.

IO access disadvantages for prophylactic use include:

- IO placement appears uncomfortable to those unfamiliar with the process;
- IO bolus (required to clear the pathway for treatment) can be painful in the alert patient;
- IO competency remains high even after periods of non-use (minimal skill decline); and
- There are few contraindications to IO.

F.A.S.T.1™ ADULT INTRAOSSEOUS INFUSION SYSTEM
Pyng Medical Corp. #7-13511 Crestwood Place Richmond, BC V6V 2E9 Canada 604/303-PYNG (7964); Fax: 604/303-7987 www.pyng.com/pym FDA cleared: 1997 Placement method: Impact/force Product support: Detailed Web site and e-mail access; Distributors; and Toll-free business number.
Training materials: Training system with lesson plan, Demo Introducers, SimSterns and SimIO System; training manual; online instructions and troubleshooting; PowerPoint demonstration for auto tutorial or instructor guided programs; and video and Training F.A.S.T.1 (designed to approximate the motion without risk) training available by trained distributors.

DIRECTION OF IO RESEARCH
To date, more than 400 articles on IO use have been published in the medical literature. Current research is concentrating on the use of IO in the EMS and emergency medicine communities, military use of IO for battlefield injuries, and IO use in response to chemical and biological attacks. Studies are underway to examine the clinical outcomes of patients who receive fluids and medications via IO compared with traditional IV access, as well as the relative speed and safety of using IO instead of central lines. Other studies are documenting the time saved using adult IO and its effect on patient outcome.

George Kramer, PhD, is one of the nation’s foremost researchers on the basic science of IO. He has a special interest in the military applications of adult IO. Here he outlines current research:

The American Heart Association is supporting several studies to better define how IO use and technologies may or may not impact future care of cardiac arrest and life-threatening arrhythmias. One concept is that first responders could use IO auto-injectors preloaded with drugs. Further, such drugs could be administered under the direction of modified AEDs.

Recent laboratory and clinical reports suggest that blood sampled from the IO space can be used for certain critical chemistry measurements when vascular access via catheters is delayed.

The recent introduction of several adult IO devices, Pyng Medical’s F.A.S.T.1, Waismed’s Bone Injection Gun and VidaCare’s EZ-10, is impacting emergency medical care in both civilian and military prehospital settings. In accordance with the American Heart Association’s recent recommendations, there is a need for industry-independent, randomized, controlled trials of IO access to provide an evidence base for its continuing and growing use.
IO catheters are more expensive than traditional IV catheters; IO is perceived to carry a higher risk of complications than peripheral IV access (there is no evidence that this is true); and IV catheters (established under the correct conditions) can be left in place longer.

“We consider IO for anybody in extremis,” says Roy Yamada, MD, medical director of six Texas EMS services and EMS Medical Director of the Year 2002. “The trauma center asks, ‘Why don’t you do a peripheral line first?’ I say, ‘Why?’ When you go looking for a vein that may not be there, why not just go for where the money is, which is a non-collapsible bone marrow. Get the IO, put the patient down, intubate, then do a central line or a peripheral line if you want. If the patient is in extremis, you don’t have the luxury of two, three, four or five minutes to mess around looking for a vein, that may not be there. I say, ‘Why?’

Not only that, if you delay you compromise the patient. You’ve got acidosis that you have to look after. When before you had bradycardia that you could treat, if you delay, the patient goes into cardiac arrest. When we have a patient in extremis, quicker is better. Do IO first, and go from there to get a secondary IV.”

THE FUTURE OF IO ACCESS
IO access has been widely used in children for difficult vascular access for the past 15 years. We are now experiencing a paradigm shift in the practice of emergency medicine in which IO access may soon become the standard of care for adults as well, especially in cases where vascular access is difficult or impossible for the patient in extremis. New devices and new understanding of the benefits of IO access are driving this change. The ability to establish vascular access has always been an expected skill of paramedics. But between 10 and 30% of patients in extremis are delivered to the ED without a functioning IV. This failure rate has not improved in 25 years and has become an accepted deficiency. With the advent of three new FDA-approved adult IO devices, this dismal IV success rate may no longer be tolerated.

The future state-of-the-art for adult IO access is based on the current need for a better solution to difficult IV access and the power this new capability gives to every emergency professional. Our predictions:

• New guidelines will direct every patient in extremis to have vascular access via either IV or IO.
• All ALS drugs will be given in less than five minutes.
• Studies will prove that IO is not only faster, but will improve

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Training materials:
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outcomes (ROSC and discharge intact from the hospital) because everyone will be able to give all appropriate drugs nearly every time. The rationale is that if any ALS drugs work at all toward improving outcome, giving them sooner is better than later.

- Other anatomical sites will be approved for placing IO needles. These will likely include the humeral head, the clavicle, radius, calcaneus, olecranon and the medial malleolus. In fact, just as IV needles are approved for any vein, IO needles will be approved for any bone.

- Adult IO access will replace the majority of central lines we are now placing in the prehospital setting and in the ED. This is because IO access is faster, safer and less costly.

- IO capabilities will extend to first responders, who until now could not be expected to establish vascular access.

- AEDs will be programmed to suggest IO medications in certain circumstances. Such a device is currently under development for first responders. An example is where the AED detects bradycardia that might respond to atropine or where the patient may need epinephrine, as in PEA. First responders cannot be expected to start an IV, but they can easily start an IO.

- IO auto-injectors will be being developed for the military and first responders, providing advanced ability to treat the effects of weapons of mass destruction.

- IO myths will be replaced with the truth as new evidence and experience are gained.

Simply stated, IO access should be considered a “rescue” vascular access route. EMS providers should take comfort in knowing that the IO choice is always there for them, ready to work in seconds, when the conditions are difficult and the patient is in extremis. IO auto-injectors are being developed for the military and first responders, providing advanced ability to treat the effects of weapons of mass destruction.

The average insertion time for the EZ-IO is less than 10 seconds. With adult IO quickly established, the more important aspects of airway management, arrhythmias, etc. can be addressed.

Larry Miller, MD, has researched IO infusion technologies for more than 20 years in collaboration with the University of Texas Health Science Center at San Antonio. A board-certified emergency physician who serves as the medical director for six Texas EMS organizations, Dr. Miller also practiced emergency medicine for 30 years treating more than 120,000 patients in his career. He recently served as the chair of Emergency M edicine for five Baptist Health Systems Hospitals in San Antonio. He earned his MD at the University of Michigan and took his internship and residency at Cook County Hospital in Chicago.

Larry Miller, MD, is the chairman and chief medical officer of VidaCare. He holds more than 20 intraosseous patents. George C. Kramer, PhD, is an inventor of 16 issued and pending patents for treatment of hemorrhage, trauma and cardiac arrest.

This continuing education activity is approved by the Center for Emergency Medicine, an organization accredited by the Continuing Education Board for Emergency Medical Services (CECBEMS), for 1.5 hours credit for First Responder, Basic and Advanced providers. If you have any comments regarding the quality of this program and/or your satisfaction with it, please contact CECB EMS by mail at CECB EMS, 5111 Mill Run Road, Dallas, TX 75244; by phone at 972/387-2862; by fax at 972/716-2007; or by e-mail at lbsley@cecbems.org.

Editor’s note Larry Miller, MD, is the chairman and chief medical officer of VidaCare. He holds more than 20 intraosseous patents. George C. Kramer, PhD, is an inventor of 16 issued and pending patents for treatment of hemorrhage, trauma and cardiac arrest. George C. Kramer, PhD, is a professor of anesthesiology and physiology, and director of the Resuscitation Research Laboratory, UTM B, Galveston. His college degrees are in physics (BS, U.S. Air Force Academy), bioengineering (M.S., University of California, San Diego) and physiology (PhD, University of Texas Medical Branch). He has a 25-year record of research into resuscitation of circulatory shock and resuscitation strategies for treatment of hemorrhage, burns, trauma and cardiac arrest.

REFERENCES


1. IO access is especially helpful in patients in extremis because:
   a. the IO space acts as a non-collapsible vein
   b. more types of medications can be delivered through IO than through IV
   c. fluids flow faster through an IO than through an IV
   d. medications delivered through an IO reach central circulation faster than those delivered through a central line

2. Historically, use of the IO route has been:
   a. popular for use in both adults and children
   b. a fairly recent discovery, dating to the 1970s
   c. only tested in hospital settings with little field data
   d. restricted to children

3. IO vascular access in pediatric patients is:
   a. difficult and not commonly attempted
   b. not recommended for children under eight years of age
   c. established as the standard of care through PALS guidelines
   d. rarely beneficial to the child, even to those in extremis

4. Medications delivered through the IV route:
   a. must be delivered with double dosage through the IO route
   b. can't commonly be delivered via the IO route
   c. are absorbed into central circulation much more quickly than medications delivered via the IO route
   d. can be safely delivered via the IO route

5. Which of these situations would make IO access unsuccessful?
   a. burns to skin over the intended IO site
   b. shock with constricted blood vessels in the periphery
   c. trauma to the bony structure of the intended site
   d. inability to properly visualize the intended IO site

6. Fluids delivered into the IO space are:
   a. transported through the long bone, exiting through the epiphysis
   b. rapidly absorbed into the tiny blood vessels in the space
   c. slowly transported into central circulation
   d. not rapidly absorbed if the patient is in shock

7. Blood flow through the IO space is:
   a. normal only if the patient has a normal blood pressure
   b. relatively constant, even in most cases of shock
   c. extremely slow once the blood pressure falls below 90 mmHg systolic
   d. much faster in children than in adults

8. The average blood pressure in the IO space is:
   a. 35/25 mmHg
   b. 55/35 mmHg
   c. 75/45 mmHg
   d. 95/65 mmHg

9. The epiphyses of a long bone is filled with:
   a. cancellous bone
   b. thick, hard bone
   c. compact bone
   d. cortex bone

10. The medullary cavity of long bones is the:
    a. mass of small blood vessels inside the bone
    b. hard bone case
    c. compact bone
    d. hollow interior space

11. The epiphyseal plate is the site of:
    a. fluid absorption
    b. blood cell production
    c. bone growth
    d. bone-to-tendon connection

12. Where is yellow marrow found?
    a. cancellous bone
    b. medullary cavity of adult long bones
    c. long bones of children
    d. epiphysial plate of children

13. Fluids infuse easily into:
    a. red marrow, but not yellow marrow
    b. yellow marrow, but not red marrow
    c. red and yellow marrow
    d. red marrow, but absorb quickly into only yellow marrow

14. Manually inserted IO devices have been used primarily in children because:
    a. children's bones are softer than an adult's
    b. needles aren't long enough to reach the IO space of an adult
    c. only small amounts of fluids can be administered through them
    d. they can't be properly stabilized into an adult bone

15. The F.A.S.T. IO device is designed for insertion into the:
    a. humerus
    b. tibia
    c. femur
    d. sternum

16. The EZ-IO is placed with:
    a. a spring-loaded device
    b. a battery-operated drill
    c. manual pressure
    d. percussion impact

17. Central line placement is:
    a. faster than peripheral line placement
    b. a quick, easy alternative to IO access for those properly trained
    c. expensive with serious risks
    d. becoming more popular as a field technique for IV access

18. Osteomyelitis following IO insertion is:
    a. a rare complication
    b. a frequent complication
    c. generally associated with life-threatening sepsis
    d. often incurable, leading to death

19. Recommended management of pain associated with IO infusion includes:
    a. 5-10 mg valium IV
    b. inhaled nitrous oxide
    c. 2% lidocaine through the IO catheter
    d. topical anesthetics

20. Infusion through an IO catheter:
    a. leads to fast absorption into the central circulation for small volumes of fluid
    b. occurs at a similar rate of a 16 gauge IV catheter
    c. is very slow for patients in cardiac arrest
    d. does not reach the central circulation if administered below the diaphragm
Clinical Evaluation of a Novel Intraosseous Device for Adults
Prospective, 250-patient, multi-center trial

The intraosseous route has long been the standard of care for pediatric emergencies when conventional IV access is difficult or impossible. Until recently, alternatives for prehospital emergency vascular access in the adult were limited. EMS providers now have another option when IV access can’t be obtained. The EZ-IO is an FDA-approved device for adult intraosseous (IO) vascular access. The device is a reusable battery-powered driver with a disposable IO needle set that powers into the IO space by rotating a hollow, drill-tipped needle to a preset depth within the bone.

To assess the ability of paramedics, nurses, physicians and other EMS personnel to use the EZ-IO for emergency vascular access, a prospective trial was conducted in 16 physician-directed EMS agencies from July 16, 2004, to Feb. 1, 2005. The multi-center study included nine ground-based, four air-medical-based and three air- and ground-based combination departments throughout the United States.

METHODS
Prior to being placed in service, participating emergency medical professionals were trained in the use of the EZ-IO by completing the manufacturer’s training program and familiarizing themselves with the protocol for the device. After each use, reports on their experience with the device were faxed to the company or sent via its interactive Web site. The study measured the success rate of emergency medicine professionals in the insertion of the EZ-IO and their ability to administer fluid and drugs. The study population included 250 eligible patients (148 male and 102 female; see Exclusions sidebar, at right), who were classified as either medical (190 or 76%) or trauma (60 or 24%) patients.

The study also examined methods of IO needle placement confirmation, pain levels experienced by patients during insertion and infusion, estimated total time of insertion, fluids and drugs administered, flow rates, ease of use, and control and function of the EZ-IO device. Any complications were reported by the operator and supervisory personnel. The operator often included additional comments on the data-collection form. An identifying bracelet with a toll-free number was placed on the patient’s wrist so that emergency and hospital personnel could call to receive further assistance and information about the device.

RESULTS
The study results indicated a 97% success rate (242 of 250 patients) for device insertion into the intraosseous space and function to give fluids and/or drugs (see Tables 1 and 2, p. 22). The reported times for insertion of the needle set through the bone cortex and into the intraosseous space was less than 10 seconds in 94% of the patients and less than 20 seconds in all of the successful patients. Twenty-three different emergency drugs and fluids were administered successfully via the EZ-IO (see Table 3, p. 23).

For those patients with a Glasgow Coma Scale (GCS) score greater than 8 (36 patients), the reported average insertion pain was rated at 3.8 on a modified Visual Analog Scale (VAS) scale from 1 to 10. The average pain upon fluid infusion was rated at 5.0 (see Table 4, p. 23). The use of lidocaine was effective in reducing the pain in 100% (11 patients) of conscious patients.

Users (10 EMT-I’s, 140 EMT-Ps, 35 LPs, 61 RNs and four MDs) reported good control of the device and its function 100% of the time. They also reported return of spontaneous
Photos 1-4: Providers locate the site of insertion one centimeter inferior and medial to the anterior tibial tuberosity in the flat anterior medial surface of the tibia.

Photo 5: The site is prepped.

Photo 6: A sterile needle set is attached to the EZ-IO driver via a magnet.

Photo 7: The drill is positioned at a 90º angle to the bone, and the needle is inserted until either the hub of the EZ-IO needle set touches the skin or until the provider feels a sudden lack of resistance, indicating entry into the intraosseous space.

Photos 8 & 9: After insertion, the drill is disconnected, and the stylet is removed from the catheter.

Photo 10: Proper catheter position is confirmed by ascertaining one or more of the following: that the catheter is standing at a 90º angle and firmly seated in the tibia, by a small amount of aspiration, by observing blood at the tip of the stylet and/or by noting free flow of fluid through the catheter with no evidence of extravasation.

Photo 11: Before connecting the IV tubing, the catheter is flushed with 10 mL normal saline.

Photo 12: Conscious patients received 20–50 mg of 2% preservative-free lidocaine slowly through the catheter for local analgesia prior to infusion.
Clinical Evaluation of a Novel Intraosseous Device for Adults

**TABLE 1: PLACEMENT FAILURE CAUSES**
Case 1: Batteries were not replaced following extensive training.

Case 2: Attributed to patient’s prolonged down time prior to resuscitative efforts (neither IV nor IO would flow).

**TABLE 2: INFUSION FAILURE CAUSES**
Cases 1 & 2: Failure to attempt syringe flush or pressure infusion.

Case 3: EZ-IO was placed, but not used.

Case 4: Bilateral unsuccessful use—failure to syringe flush.

Case 5: Attributed to attempted placement in the incorrect anatomical location and associated patient discomfort.

Case 6: Attributed to significant obesity; catheter would not flush (suggesting the catheter was not in the intraosseous space).

Excessive tissue over the insertion site may be a contraindication to the EZ-IO. This can be determined if you have not yet hit bone at the 5 mm mark on the catheter.

Excessive tissue

Proper needle placement

Excessive tissue circulation (ROSC) in 22 cardiac arrest patients, although this information was not specifically requested on the evaluation form.

Comments by the end users were overwhelmingly positive. Some complications were noted, although none that affected the safety of the patient or the user. There were no observed cases of osteomyelitis, embolism, fracture, infection, extravasation, or compartment syndrome. The most frequent concern was a low flow rate, which was noted to improve significantly following a 10 cc rapid syringe flush of saline. (This is now recommended as standard practice.) The EZ-IO failed to deliver medications or fluids in eight (3%) cases. This complication was predominately associated with a failure to syringe flush following insertion.

Two catheter displacements were reported, one during treatment and one during transport. In each situation, the patient was moved without protection of the EZ-IO site. Neither event resulted in injury to the patient.

Two reports indicated no flow. Follow-up interviews determined that these patients had been pulseless for a prolonged period.

Three reports stated the device failed to function properly: One device remained in the “on” position after an insertion attempt (resulting in redesign of the trigger mechanism). Two reports indicated battery problems, including one case related to extensive use during training without changing the batteries before use in actual patients. (In this case, the needle set was successfully placed and used for treatment.) In another case, some of the batteries were placed backward in the device. This was thought to have occurred during maintenance.

Twelve reports indicated “poor flow,” and follow-up interviews determined the following suspected causes:

- Failure to syringe flush the catheter after insertion.
- Provider inexperience with intraosseous insertions and usage.
- Unrealistic flow expectations.
- Failure to use a pressure infusion device.
• Failure to follow the protocol for the device.

Immediately following the first three patients, the study protocol was modified to require syringe bolus after IO insertion. This modification, as well as adjustments to training methods, additional experience, more realistic flow expectations and adherence to protocol dramatically improved reported flow rates.

**CONCLUSIONS**

The results of the study indicated that emergency medicine personnel were able to use the EZ-IO to provide reliable and rapid vascular access in 97% of the patients. Participants considered the device to be safe and easy to use.

The study revealed one important caveat in the use of the device. After placing the device within the bone cavity, the EZ-IO catheter must be flushed with 10 mL saline prior to use. Flushing is paramount to improved IO flow rate and performance. The participants observed that the flow rates through the intraosseous space of the tibia were generally slower than those achieved through an equivalent size IV catheter. To date, no device and/or insertion-related adverse outcomes have been reported.

In short, the EZ-IO provides fast, safe, easy and reliable vascular access for emergency medicine personnel in the majority of patients.

Emergency medicine personnel were able to use the EZ-IO to provide reliable & rapid vascular access in 97% of patients. A 10 cc rapid syringe flush significantly improves flow rates.

**TABLE 3: MEDICATIONS & FLUIDS ADMINISTERED**

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<td>17. Promethazine</td>
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<td>18. Rocuronium</td>
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<td>7. Dopamine</td>
<td>19. Sodium bicarbonate</td>
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<td>8. Epinephrine</td>
<td>20. Succinylcholine</td>
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<td>10. Fentanyl</td>
<td>22. Vasopressin</td>
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<td>11. Lactated Ringer’s</td>
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<td>12. Lasix</td>
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**TABLE 4: AVERAGE INFUSION PAIN 5.0 (N=26)**

Patients with a GCS of 8 or higher on a modified VAS Scale of 1–10, where this field was completed.

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This article reports the experience of Montgomery County Hospital District (MCHD) EMS in its initial use of the EZ-IO infusion system in 125 patients.

METHODS
Located just north of Houston, the Montgomery County Hospital District (MCHD) EMS system provides prehospital services for a population of 362,000. MCHD EMS responds to more than 30,000 calls annually spread out over 1,100 square miles. It operates a fleet of 24 emergency vehicles. MCHD EMS paramedics and EMTs underwent a four-hour training session before using the EZ-IO infusion system. The program included lecture, viewing of a training videotape and a hands-on skills workshop. At the conclusion of training, all providers passed practical skills testing and a written test.

The treatment protocol for EZ-IO use was limited to adult patients in whom peripheral IV access could not be achieved after two attempts or 90 seconds. At least one of the following conditions was also satisfied: hemodynamic instability, respiratory compromise, the patient required emergent medical or fluid therapy or the patient presented with an altered mental status (defined as a Glasgow Coma Scale Score of <8). Prehospital providers were allowed to bypass the protocol and proceed directly to IO access for patients in cardiac arrest or those who were judged to be hypotensive from hypovolemic with concurrent altered mental status.

A standardized technique was used for IO placement. All rescue units carried an EZ-IO Driver, an EZ-IO Needle Set, betadine swabs, an IV setup and extension tubing, a 10-cc or 20-cc syringe and roller gauze. After prepping the skin, providers located the site of insertion one centimeter inferior and medial to the anterior tibial tuberosity in the flat anteromedial surface of the tibia. They then attached a sterile needle set to the EZ-IO driver. Approaching the skin at a 90° angle, they inserted the needle until either the hub of the EZ-IO needle set touched the skin or until they felt a sudden lack of resistance, indicating entry into the intraosseous space. The driver was disconnected from the needle set and the stylet was removed from the catheter.

Proper catheter position was confirmed by ascertaining one or more of the following: that the catheter was standing at a 90° angle and firmly seated in the tibia, by a small amount of aspiration, by observing blood at the tip of the stylet and/or by noting free flow of fluid through the catheter with no evidence of extravasation.

Before connecting the IV tubing, the catheter was flushed with 10 cc normal saline. At the paramedic’s discretion, the catheter site was dressed using roller gauze to prevent dislodgement during transit. Conscious patients received 50 mg of 2% preservative-free lidocaine slowly through the catheter for local analgesia prior to infusion.

Data were collected from patient usage reports filled out within 24 hours of device use.

RESULTS
From August 2004 to April 2005, 125 patients underwent EZ-IO insertion. Patients ranged in age from 19 to 96 years old with an average patient age of 61. The study included 70 males and 55 females (see Figure 1).
Ninety percent of patients were classified as having a medical etiology for distress with 10% classified as trauma-related origin (see Figure 2).

Eighty-two percent of patients presented with CPR in progress, the most common medical diagnosis (see Figure 3). Of the medical patients who did not have CPR in progress, the most common diagnoses included drug overdose (five), respiratory distress (four) and bradycardia (two).

Glasgow Coma Scale (GCS) was recorded as an indicator of mental status. One hundred and three patients with CPR in progress were classified as unconscious with a GCS of 3 (82%). Eleven patients (9%) were classified as unconscious with a GCS greater than 8. Only five patients (4%) were conscious for IO insertion (see Figure 4). Thirty-nine percent of patients survived to be admitted to the hospital. Fifty-nine percent did not survive to admission. This is attributable to the high percentage of cardiac arrest patients (73% of all patients) that were enrolled during the study trial.

Placement was successful in 118 of 125 attempts for a success rate of 94%. The average insertion time for an EZ-IO was 4.5 seconds from the time the procedure was started until access was achieved. On average, the EZ-IO catheter was placed within five minutes of arrival at a patient’s side versus 10 minutes after arrival for placement of a peripheral IV catheter. Flow rates were defined as follows: good flow = >100 mL, poor flow = <100 mL, and no flow. Good flow was achieved in 83% (104). Poor flow was achieved in 10% (12), and no flow was achieved in 7% (9). The maximum fluid administered during patient care was in excess of 1,500 mL. The average amount of fluids infused during patient contact was 350 mL.

Seventeen medications were infused through the EZ-IO catheter, including cardiac arrest medications, sedatives and paralytics. There were no complications reported in the study group. One catheter was dislodged while moving the patient. This was noted immediately, and the catheter was removed before soft tissue extravasation could occur.

Of the 103 patients in whom CPR was in progress (93 medical and 10 trauma-related), 30 (29%) had return of spontaneous circulation (ROSC) and survived to admission to a hospital emergency department (ED) with a stable pulse and blood pressure. An additional 10 patients had transient ROSC during treatment in the field, but did not survive to hospital admission.

Pain was rated on a five-point scale with 1 being the lowest amount of pain and 5 being the greatest. In conscious patients, the average pain recorded was 1.2. Lidocaine was infused in five patients for initial pain control.

DISCUSSION

When treating patients with life-threatening conditions, delays in obtaining vascular access can play a role in survival. Although intraosseous infusion has long been viewed as a safe and reliable alternative route of vascular access in treating pediatric patients, adult IO infusion is just now experiencing a resurgence in the prehospital and combat settings. Providers are finding that marrow space is a reliable source of intravascular access, particularly under circumstances in which conventional IV access is unavailable or difficult to obtain in the field.
POWERED INTRAOSSEOUS ACCESS IN THE PREHOSPITAL SETTING

Compared with pediatric IO infusion, placement of an adult IO catheter requires penetration of a thicker bony cortex. For this reason, a powered drill enhances insertion, allowing an operator to penetrate the cortex quickly and accurately. Manual catheter insertion, as reported in the pediatric literature, may take up to several minutes. Rossetti et al found that it took upward of 10 minutes to start an IV in 24%, could not gain access in 6% and had an average cut-down time of 24 minutes.

In this study, when a provider elected to attempt an IO line before a peripheral IV, the total mean time to access was significantly reduced by 50%. The literature supports the fact that IO access is faster than any other access technique, particularly during cardiac arrest resuscitation. Glaeser et al report the following:

- 30 seconds to one minute for IO insertion;
- 69% had access in less than five minutes, and 90% achieved access in less than 10 minutes;
- 20 of 21 IO insertions were without complication;
- Arrested patients had vascular access before non-arrested, perhaps due to a reluctance to insert the IO in non-arrested patients.

Glaeser concluded that if IO attempts are made with IV attempts, all children should have access in less than five minutes and that IO infusions are rapid, reliable and free of significant complications.

The EZ-IO intraosseous infusion device, which uses a powered drill to obtain access to the bone marrow, has even faster insertion times (five seconds on average) than that reported in the literature.

In this study, access using the EZ-IO was not only quick, it was effective—as evidenced by seven patients requiring intubation using a pharmacology intubation protocol, where the intraosseous site was the only medication route. The fact that 17 different medications were successfully infused in the field without complications demonstrates that emergent medications traditionally given via peripheral IV can be given safely through an IO catheter.

This study also demonstrated that patients can receive adequate resuscitation fluids through the EZ-IO catheter. On average, patients received approximately 350 cc. It was noted early in the study that it is important to flush the catheter before infusion in order to dislodge any tissue that may obstruct the catheter and impair flow. The Pediatric Advanced Life Support (PALS) guidelines from the American Heart Association literature recommends that all IO devices be flushed prior to administering medications.

Early clinical trials using this device demonstrated that flow rate difficulties were invariably linked to failure to flush the catheter after insertion and not to improper catheter placement. Flow rates ranged from 20 mL to 1,500 mL with an average flow of 350 mL. Although these rates are somewhat lower than what can be achieved via traditional large-bore IVs, they are more than satisfactory for the vast majority of emergency resuscitations. Use of a pressure bag does enhance infusion rates and is recommended by the manufacturer.

The EZ-IO was also shown to be a safe device to use in the field. Of the 125 patients in whom an IO was attempted, none sustained a complication as a result of attempt or placement of an IO catheter. These results are consistent with complication rates reported in the literature for the use of IO lines in pediatric patients in whom complication rates are uniformly less than 1%. When compared with the complication rates associated with central line insertions in the field (15%), the EZ-IO appears to offer a safer alternative (0% serious complications).

The EZ-IO infusion system is unique in that it uses a handheld drill to power the insertion of a specially designed bone-penetrating needle. Drilling into the bone allows a smooth circular opening in the bone just big enough to admit the catheter. This technique of insertion is designed to minimize trauma to the bone during insertion and the subsequent extravasation that may occur when the bone is entered by manual force.

CONCLUSIONS

Rapid intravascular access is a necessity when a patient is in hemodynamic, cardiac or respiratory compromise. It is in these very situations, however, that IV access may be difficult or even impossible due to the inadequacy of available veins. This study demonstrates that the EZ-IO infusion system is a fast, reliable, safe and effective means of obtaining vascular access in emergency situations. This access technique should, therefore, be considered as a first line measure in the field when treating patients in cardiac arrest or shock.

For more information about this study, contact Lee Gillum via e-mail at lgillum@mchd-tx.org.

REFERENCES

A young infantry soldier is brought into the emergency medical treatment section of a combat support hospital with wounds from an improvised explosive device (IED). He has traumatic injuries to both of his legs, with one fully amputated below the knee. CPR is performed. The staff quickly establishes vascular access to begin the resuscitation process.

The first access achieved is an intraosseous (IO) catheter inserted into the head of the patient’s humeral bone. The catheter is connected to fluids and a pressure bag to facilitate rapid fluid infusion. With this device in place, the patient is resuscitated effectively enough to be taken to the operating room for emergent surgery and later evacuated out of the combat theater.

BACKGROUND

The military in action is at great risk for massive trauma, moderate to massive hemorrhagic hypotension and exposure to toxic or lethal substances, agents, gases, etc., each requiring a time-critical response and, usually, immediate vascular access. Unfortunately, patients injured in the combat zone often have to wait varying lengths of time for definitive medical care. The care that soldiers receive from combat medics within their units is the best that can be imagined under very austere conditions; however, depending on the severity of injuries sustained on the battlefield, the combat medic may not possess the knowledge or necessary tools needed for effective care and resuscitation.

One fundamental tenet of good care in the traumatized or medically distressed patient is rapid access to the vascular system for the timely delivery of appropriate fluids, medications or blood products. This is especially true in the prehospital setting and in various military and battlefield environments, which may be subject to adverse light and weather conditions or awkward patient positions, and is stressful for lone healthcare providers in emergency situations.

The traditional peripheral IV access route can be difficult or time-consuming, leading to the need for other options for vascular access, many of which have higher complication rates. These alternatives to IV access are usually performed in emergency departments (EDs) or intensive care unit settings. (Can you remember an ICU patient who didn’t have a vascular access line, even if only as a precaution?) This is where IO technology would prove useful.

ENTER THE IO

The IO route is gaining wider acceptance due to its immediacy of access, and, after a hiatus, the medical profession is reconsidering use of the IO route as an alternative to IV access. Sometimes, IO is the preferred method of gaining safe, reliable and quick vascular access. It has been used for those who present with a variety of injuries, including multi-system trauma, traumatic amputation of extremities and cardiac arrest.

When we look at the anatomy and physiology of the various IO spaces throughout the body, we realize that many are relatively easily accessible and that they constitute multiple sources for a “non-collapsible vein” with rapid uptake into the central circulation. Indeed, with the right medical device, central-line-equivalent vascular access can be more readily available with IO than with the traditional peripheral IV.

Military medicine has historically encouraged medics to gain IO access at the sternum, given the limited number of FDA-approved IO medical devices. However, the military is now exploring newer IO options.

In recent conflicts, the military has turned from the long-accepted standard needles and trocars to newer technologies, such as the F.A.S.T.1 IO access system (which targets the sternum) from Pyng Medical in Canada, and the BIG (Bone Injection Gun), which targets the tibia, from Waismed in Israel. Neither technology is ideal for U.S. military use, according to several military physicians, surgeons, medics and corpsmen.

Although body armor protects the chest and upper abdomen like never before, blunt trauma may preclude use of the sternum. Extremities are at high risk of injury in battlefield conditions. Therefore, insertion of an IO device in an extremity may be impossible in many casualties. The development of a small
Adult IO in the Combat Zone

A new family of IO products (which includes IO auto-injectors preloaded with such drugs as nerve gas antidotes) to address the need for time-critical (less than a minute) drugs to reach the vascular space is approaching regulatory approval.

The military has started to employ an FDA-approved powered IO device (the EZ-IO) for insertion at the tibia and humeral head sites. The device has been used on the battlefields in Iraq and Afghanistan, from the medic at the point of injury to the battlefield trauma ED at combat hospitals. Reports from military users in the field have been positive.

Their training on the powered IO device has been easy and very intuitive, leading to high confidence levels with the device. In addition, the availability of a quick, safe and reliable IO site allows for immediate pain control and fluid therapy in challenging battlefield conditions where patient extraction may require an extended period of time.

Rapid IO access and patient stabilization allow the medic or health-care team to direct attention to other injured soldiers more quickly. Intraloesosal vascular access has an important role in the future for good patient care—in hospitals, in prehospital care and on battlefields. Newer medical devices are making IO safer and easier.

Another research effort is the automated delivery of medical therapy, with the goal of reducing the time and manpower needed for the delivery of resuscitative therapy. The recent development of partial or complete closed-loop resuscitation algorithms and support technology (sensors, pumps, vascular access devices, etc.) is aimed specifically at this need, although no system is yet ready for fielding.

Resuscitative technologies that provide minimally invasive monitoring of physiological variables before and during resuscitation will allow the provider to tailor care to the needs of the individual casualty. It is hypothesized that including such technology and procedures in the medical arsenal of the combat medic will ultimately save lives on the battlefield.

Research, Resuscitation Solutions Inc., where he is the PI on National Institutes of Health grants developing new IO technologies. A Vietnam veteran who served as a Navy corpsman in combat operations, Bruttig subsequently earned his college degrees, was commissioned in the Army and performed research into resuscitation strategies for combat casualty care, including evaluations of several IO vascular access devices at Letterman Army Institute of Research. He is the former director of the Combat Casualty Care Research Program, Medical Research and Materiel Command, Ft. Detrick, MD. He has served on numerous military, regulatory, strategic planning and research review boards and was an advisor to both the U.S. Military Joint Staff and the FDA on future trends in emergency medical technology development.

Matthew W. Ruemmler, CPT, AN, graduated from nursing school in 1998 and has five years’ experience in the emergency department and cath lab settings. A volunteer firefighter and an EMT, he joined the Army in 2004 and deployed with 86 CSH in December.

Note: The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or necessarily representing the position of the Department of the Army or the Department of Defense.
Profiles in Leadership
Conversations with Don Gordon, Jullette Saussy, R.J. Frascone, Ray Fowler & Ed Racht

EMS systems need strong leaders who stay on top of the science and are willing to introduce new tools that improve patient care. The five EMS medical directors profiled here are EMS advocates who lead large systems with reputations for delivering quality care. One thing they have in common is that they’ve already introduced their systems to the EZ-Io and incorporated adult intraosseous infusion into their ALS protocols.

DONALD GORDON, PHD, MD—EDUCATOR AT HEART

Donald Gordon, PhD, MD, serves as medical director for both the San Antonio EMS and Leon Valley (Texas) EMS systems. He got his EMS start in the Army, where he earned nine Air medals and a Bronze Star, did tours in Vietnam and served as an assistant professor in physical chemistry at the U.S. Military Academy at West Point. Ten years into his military career, he decided to become a physician. He completed a surgical internship and an Emergency Medicine Residency Program at Brooke Army Medical Center, where he served and retired after 20 years of Army service.

“I was in charge of the emergency room,” he says. “I was involved in EMS—without it being called EMS—even before I left the Army. I was actually responsible for the first paramedic in the Army; he did his training under me. When I left [Brooke], there were six paramedics and two ALS ambulances.”

In 1987, as a new civilian, Gordon accepted an appointment with San Antonio EMS, a large, urban system that covers 675 square miles and serves a population of 1.2 million, with an average transport time of between seven and nine minutes 90% of the time. The fleet size varies to meet demand, with 27 units on duty at all times and sometimes up to 35 deployed. “One of the nice things about San Antonio,” says Gordon, “is that it’s very supportive of EMS. The political climate here is that we want to help everybody.

“T here’s so much a medical director can do,” continues Gordon. “It depends on the environment.” He interfaces with politicians, educators and the media. In one day, he was interviewed by three TV stations and helped open a new emergency department (ED) at N.E. Baptist Hospital.

Gordon offers some sage advice for new medical directors: “Know your community,” he says. “Know the provider. Get a good feel for the folks you’re serving.”

He follows his own advice: “I’ve got 300 paramedics,” he says, “and I know them each by their first name.” When asked about the last time he did a ridealong, he replied, “Yesterday. ... It was a cardiac arrest, and I happened to be there.” He goes on ridealongs two or three times a month.

“Our paramedics are very patient-oriented,” says Gordon. “Every patient is a learning experience and should be approached with care as a first objective.”

A charter member of the National Association of EMS Educators (NAEMSE) and a tenured professor at the Department of Emergency Health Sciences, University of Texas Health Science Center at San Antonio, Gordon is an educator at heart. The program graduates more than 60 paramedics each year, and Gordon actively teaches and approves the curriculum for paramedic initial and refresher education. He also co-authored sections of the Orange Book (4th, 5th and 6th editions) and several other texts.

“I don’t want to discipline,” he says. “I’d rather educate. I’m involved in all aspects of EMS education, initial and continuing, but I’ve got a staff of seven nurses and senior paramedics who assist in training and quality assurance. It’s a team. We meet every Friday and as needed otherwise. The big push lately has been WMD training.”

The innovative, early introduction of technology to improve patient care has characterized Gordon’s career. “We were the first major department to put AEDs on fire trucks,” he says. “In 1989, we had [AEDs] on 90 pieces of fire apparatus.”
Profiles in Leadership

‘Every patient is a learning experience & should be approached with care as a first objective.’ — Don Gordon

In 1998, San Antonio served as a test site for the LifeLink System, a distributed mobile Local Area Network (LAN) designed to link ambulances on or near San Antonio’s freeway system with a hospital in the city. The system used the roadside fiber-optic network of the TransGuide Advanced Traffic Management System (ATMS) to establish a communication link between a mobile ambulance and a hospital, allowing for real-time videoconferencing between ambulances and hospital-based physicians. Although the initiative is no longer funded, Gordon says crews continue to keep the program alive.

“We have been using the EZ-IO since September 2004,” says Gordon. “I believe that we were the first large urban city ground-based system to have adopted this device. We find the device is quick, easy and without complication. We feel every use constitutes a success because it was a situation that required IV access, and that was not possible.”

Other innovations: “We used end-tidal CO₂ really early to make judgments on whether or not to call a cardiac arrest,” he says. “We were the first large system to introduce adult IO. We’re adding CPAP on every ambulance. We just installed a 15-tower comm system that I’ve been told is cutting edge for the country; I just care if it works.”

EMS delivery in San Antonio will likely look very different in five years. “We have a Cadillac system,” he says, “and that’s going to have to change.” He explains that the sheer demand for service will force change. “It’s a very expensive system to operate. EMS is headed toward relegating certain types of transports to the private sector—lower priority, non-emergency calls.”

Looking at the big picture, Gordon says, “EMS is so many things. It’s multifaceted. It’s important to interface with public safety, but I think EMS is public health. I think it is crucial that it be under the purview of public health. EMS needs to come out of the DOT. I think there needs to be cooperation with homeland security because there are a lot of common issues.”

On a personal note, Dr. Gordon has been married to Judith Lee for 42 years. They have two sons.

JULLETTE SAUSSY, MD—ACTIVE EMS ADVOCATE

Jullette Saussy, M.D., is not your typical medical director. Unlike many of her colleagues, she was a paramedic before studying to become an ED physician, and in addition to her responsibilities as the city of New Orleans medical director, Saussy is the EMS system director.

Saussy has been a medical director for as long as she has been a doctor, taking her first post the day she finished her residency in 1998. She served as the New Orleans medical director for several years before also becoming the director of EMS last December.

She admits tackling the dual role of medical director and director of EMS has been a learning experience. However, she credits her success to the team of people who surround her, including Deputy Director Mark Reis, who is also a former paramedic.

Reis's background in business management and extensive operational experience dovetails nicely with Saussy's medical expertise. According to Saussy, the two work so well together, the staff affectionately refers to them as “T hing One” and “T hing Two.”

While it's exciting to be in a position to effect change, Saussy says, “You have to work within the system you've been given.” Like many communities, New Orleans EMS is short-staffed.

“We run about half the ambulances as other cities our size,” she says. “Our guys were being run into the ground.”

Saussy sees her role as an active advocate for EMS, helping city government understand how important emergency services are to the city. Because New Orleans EMS is not funded directly by tax dollars, Saussy must fight for her budget.

She has convinced the city to hire an additional 30 paramedics, bringing the total to 145. She hopes to have 150 by the end of the year. Twelve-hour shifts are now being employed at different times of the day to more efficiently cover peak periods. New Orleans is also in the process of incorporating sprint vehicles.

“The pieces are all there for us in New Orleans,” she says. “It’s like a diamond in the rough.”

Her eventual goal is to move toward standing orders. To that end, she uses every opportunity as a teaching experience. As an ED physician, she is in the unique position of being able to provide ongoing and immediate feedback. “I’m the emergency room doc who receives their patients. They can’t hide from me,” she laughs.

Saussy likes that she is so accessible. “Nobody hesitates to pick up the phone and call me, and I love that,” she says.

If she could find more time in the day, Saussy would spend it on ridealongs. Her solution is to include paramedics on rounds with her at the hospital.

To help keep paramedics invigorated, Saussy has involved the system in several beta-testing projects, such as one for the EZ-IO by VidaCare. Given the rough-and-tumble nature of prehospital services in a party town like New Orleans, products that survive a beta-test in New Orleans are well suited for the real world. “If it can make it here, it will be good,” Saussy says.

During the testing process, Saussy became a big fan of the EZ-IO device, saying she finds it an effective vascular access technique. “The EZ-IO has done for vascular access what the CombiTube & LMA did for emergent airways,” she says. “I feel the EZ-IO device joins the cutting edge for the ABCs.”

‘The EZ-IO has done for vascular access what the CombiTube & LMA did for emergent airways.’ — J ullette Saussy
Frascone says EMS has leverage to change how hospitals interact with prehospital providers. ‘There are a lot of EMS systems that roll over,’ he says, but ‘EMS is the customer of the hospital, not the other way around.’

Local EMS and fire services contract with the hospital for medical direction. The hospital, in turn, hires the medical director. To avoid direct competition, the hospital doesn’t own an ambulance service. “All we do is medical direction,” Frascone says.

The results are significant. Regions Hospital EMS developed the state’s first trauma system and its first diversion system. Recently, it instituted a Level 1 heart system and within the next 12 months, will add both a stroke system and a resuscitation hospital system. The idea behind each system is to bring the right patient to the right hospital.

Regions Hospital EMS is also heavily involved in prehospital research, focusing primarily on airway, critical vascular access and cardiac arrest.

Currently Regions Hospital EMS is involved in a research field trial comparing two adult IO devices—the EZ IO by VidaCare and the F.A.S.T.1 device by Pyng. The trial is assessing the overall success rates, speed of insertion and operator comfort of using the devices to establish vascular access in patients for whom it might otherwise be difficult or impossible in situations where it might take an exorbitant amount of time to establish access. “It allows us to treat patients rapidly with fluids and drugs. In fact, anything that can be infused into a peripheral IV, can be infused utilizing these devices,” Frascone says.

“Our medics are loving it and we are getting good results,” Frascone says.

So far, Frascone is impressed with the results. “The central circulation times are outstanding, as are the infusion rates,” he says. “We have performed two rapid sequence intubations using this technology. Recently, we have been using the EZ IO in patients with normal levels of consciousness, significantly increasing the applicability of this technology.”

According to Frascone, the most important research project he’s been involved with to date will begin in September when Regions Hospital EMS, together with Minneapolis, Royal Oaks, Mich., Bellingham, Wash., and Oshkosh, Wis., launches the first U.S. trial to study the effectiveness of using standard CPR vs. a combination of active compression-decompression (ACD) and Impedance Threshold Device (ITD) CPR. The goal of the multi-center trial is to develop a new kind of CPR that will help increase the long-term, neurologic survivability of patients who suffer cardiac arrest. The three-year trial will study up to 2,300 patients, following them for a year post arrest.

“[The trial] will be the high point of my career,” he says. “If I have one regret in my career, it’s that I didn’t get involved in research earlier.”

Frascone says he can’t take singular credit for the success of EMS in the East Metro area. “My abey the medical director can set the course, but the actual implementation of the plans are done by people who are better equipped than I am,” he says.

According to Frascone, the success of the medical director and, therefore, the EMS system depends on the efforts of a high-performing staff and forward-thinking colleagues. “Everything in this business is collegial,” he says.

In 1996, Frascone helped establish the EMS Regulatory Board, the lead state agency for EMS in Minnesota. It was designed “to give EMS the attention the fire service and police service get,” he says. The board comprises 17 official and two ex-official members who meet once a month. Frascone is a former chair. The standing members include a state senator and representative, plus members of both the Department of Health and Department of Public Safety. By law, physicians must fill three of the board positions. Frascone believes it is critical that physicians, not just administrators, have input in EMS decision-making.

Unlike some medical directors, Frascone believes in giving EMS providers lots of training and lots of...
Profiles in Leadership

RAYMOND L. FOWLER, MD—COMMITTED TO UNBRIDLED EXCELLENCE

When most people retire, they head for the links, take the opportunity to see the countryside or just sit back and reflect on a career well spent. But Raymond L. Fowler, M D, is not like most people. After more than 20 years of clinical practice and service as the medical director for Fulton County (Atlanta) Fire/EMS, Douglas County Fire/EMS and the Mid-Georgia Ambulance Service, plus a 20-year stint as the emergency department director at Parkway Medical Center in Atlanta, Fowler "retired" to Dallas, Texas, to become the deputy medical director of the BioTel EMS system, the ninth largest urban EMS system in the United States.

Even his method of finding employment was unique. In February 2001, after leaving his clinical practice and handing off the immediate and urgent care center he built and operated, Fowler ran into an old friend, Paul Pepe, M D, MPH, FCCM, FACEP. Pepe's work at the University of Texas Southwestern Medical Center intrigued Fowler enough to set up residence at a local hotel while he observed the Dallas EMS medical direction team. Finally, Fowler says, half in jest, Pepe told him that since he wouldn't go home, he might as well join them.

By June, Fowler was on the payroll, overseeing 1,210 paramedics, 14 fire/EMS agencies and one small private service. Together they run approximately 220,000 responses, transport 95,000 patients and work with 2,000 cardiac arrests per year.

Fowler is also an associate professor of emergency medicine and surgery at the University of Texas Southwestern School of Medicine and co-section chief of U T Southwestern's section on EMS, Disaster Medicine and Homeland Security.

Over the years, Fowler served as the second elected president of the National Association of EMS Physicians and was a co-founder of the National EMS Medical Director's Course. In Georgia, he is considered the "Father of Basic Trauma Life Support (BTLS)."

Not bad for a guy who began college as a pre-law student.

Fowler says he has seen an even mix of fire-based and private EMS systems and finds both can provide good, quality care. "It requires the commitment of the leadership to unbridled excellence in clinical care," he says.

Not surprisingly, Fowler is heavily involved in clinical research. He was one of the early adopters of adult intraosseous infusion and is an enthusiastic supporter of the EZ-IO. "I put the very first, second and fourth into a human," he says. "Progress in medicine has been marked by many important steps—anesthesia, blood products, antibiotics—this device approaches the magnitude of these important steps."

"All of us who do critical care, especially in the environment where we receive patients from the field, know the dangers," Fowler says, referring to unstable patients, those with airway problems and patients with impossible venous access. "The EZ-10 device finally gives us access into any adult," he states.

Currently BioTel medics are involved in two research projects. One is evaluating the use of glucose, insulin and potassium solution vs. a placebo for patients with acute coronary syndrome. The other is a clinical trial with the Resuscitation Outcomes Consortium in the area of cardiac arrest, traumatic brain injury and hemorrhagic shock due to trauma.

"We really have our work cut out for us as we venture into these very important areas of resuscitation research," Fowler says. His latest project is an online continuing education Web site (www.utsw.ws) developed through UT Southwestern. The site's dynamic format combined with audio is designed to appeal to adult learners. Online coursework includes actual lectures by instructors combined with graphics and full-screen animation. According to Fowler, one-third of all continuing education in the BioTel system is completed via the site.

One of the most exciting advancements in EMS, Fowler says, is the appearance of laptop computers in the field. Paramedics in the Dallas EMS system are using laptops and wireless technology to capture an enormous amount of data contemporaneously with a patient's event, providing running medical reports, quality assurance and the capture of real-time data for research purposes. More importantly, Fowler notes, it permits syndromic surveillance, permitting the capture of clinical issues that could suggest potential disasters or matters affecting homeland security.

Fowler says he appreciates the opportunities he's been given at BioTel. "Working with Paul Pepe lifts you to a very high level because that's where he operates," he says. "Once at that level, the winds blow very hard, and you have to squint to see clearly. But from that height, you can see columns of smoke on the distant horizon, and I say, 'I wonder what that is over there,' and Paul says, 'Why don't you go check it out?'

As he enters his 28th year in clinical practice, Fowler says he has a single and abiding goal: to practice emergency medicine for 50 years. Then maybe he'll retire.

'EMS requires the commitment of the leadership to unbridled excellence in clinical care.' —Ray Fowler

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JEMS • ADULT IO ARRIVES
ED RACHT, MD—EMS PHYSICIAN

It’s hard to imagine, but initially, Ed Racht, MD, was a reluctant medical director. When he finished his residency, the ED director “convinced” Racht to become the medical director for the local volunteer rescue squad. “He told me all I’d have to do is sign a piece of paper once a year,” Racht says.

Eventually, providers began asking him for medical advice. At one point, he told someone to use her best judgment regarding the use of a certain treatment. When the EMT reminded him she was “operating under his medical license,” Racht had an epiphany. “I realized I was a medical director fraud!” he says.

From that point forward, Racht set out to educate himself. He went on calls to learn about operations and logistics, asked questions and listened hard to the answers—EMS 101, he calls it. “My learning curve began that day and continues,” he says.

Today if you ask Racht what kind of doctor he is, he will tell you with pride, “I’m an EMS physician.”

Racht earned both his bachelor’s and medical degrees at Emory University in Atlanta. He was introduced to medicine in high school when his father helped get him a job cleaning respiratory therapy equipment at a local hospital. His interest in EMS began when he served as an observer on a volunteer ambulance in his home state of Florida. Ever the fashion trendsetter, it was the clothes that caught his attention. “I had the coolest polyester shirt that snapped down the side,” he recalls. “It was probably my beginning in EMS.”

Later Racht settled in Richmond, Va., splitting his professional life between the ED and his duties as the medical director of the Henrico Volunteer Rescue Squad. But 10 years ago, he chose to leave his beloved Virginia home to become a full-time medical director for the City of Austin (Texas) and Travis County EMS, providing medical oversight for approximately 1,700 providers in 38 agencies.

The promise of a full-time position as medical director was only part of the allure. “It was one of those opportunities to put my efforts where my passions were,” he says.

In Austin he made every effort to encourage the marriage between the practice of medicine and the operational delivery of that care in the field. “I honestly believe EMS is a practice of medicine,” he says. “I try to live and practice that concept.”

Racht maintains his street cred by spending one day a week in the field. Attending to calls in his own response vehicle is his clinical time, he says. He considers it a vital part of keeping his skills sharp and his focus directed on the day-to-day challenges of providing emergency medical services. “It forces me to walk the walk,” he says.

When Racht is on duty, he is a member of the team, going out on all calls, whether routine or high priority. On scene, he introduces himself as “Ed” not Dr. Racht.

For a medical director, Racht also has an unusual habit of referring to the paramedics in the Austin/Travis County system as “paramedic colleagues.” He says he is constantly in awe of them, especially their street smarts. “There have been many incidents in my career where my paramedic colleagues have handled a scene better [than me] because they understood the nuances,” he said. Those same people skills can have a direct effect on a patient’s outcome. “A bedside manner can impact how a patient responds to health-care providers and ultimately impacts the decisions they make for their own health care,” he maintains.

Racht says one of the biggest changes in the role of medical director is a dramatic reassessment of clinical care and a renewed focus on the basics. He believes medical directors can encourage the process by becoming an integral part of public health assessments and responses and getting more involved in setting standards and guidelines.

The secret is to be a teacher and a student. The best way to do that, he offers, is to develop a collegial environment between yourself and your medic colleagues. “Ask questions about the science and share. Share good ideas and good applications. It has to be part of your personality and desire,” he says.

The result will be a stronger bond between public health and EMS. “There are a host of new interventions that will be introduced and evaluated better than they have in the past,” he says. These innovations will be mutually implemented based on evidence rather than just random adoption. “I love the application of the science in the culture of the street,” he adds.

For example, medics on several Austin/Travis County EMS special operations units did the initial evaluation of the EZ-IO before it was adopted throughout the system. According to Racht, the paramedics have embraced it as an important tool for use in critical situations that are often time dependent.

Mostly Racht is hopeful for the future. If he sees EMS systems recognizing the importance of and the need for an involved and vital medical director. That’s more, medical directors are getting more interested in making this their career.

“There is no more fascinating field of medicine than EMS,” Racht says. “It’s this cool intersection between science, community, politics, relationships and unpredictability.”

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Editor’s note: JEMS spoke with Juliette Saussy again shortly after Hurricane Katrina struck the Gulf Coast. She and her colleagues were forced to evacuate to higher ground. Although she lost her home in the flood, she and her family are safe. She continues to lead her service during this difficult time.
Intraosseous Infusion: Bibliography

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