Orthopedic Management of Complications of Using Intraosseous Catheters

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Abstract

Intraosseous (IO) catheters have been used for vascular access in trauma and critically ill patients with increasing frequency in emergency departments and critical care units across the United States. Their use has long been accepted as a reliable method of obtaining vascular access in pediatric patients with difficult intravascular access. Articles about the complications of using IO catheters are scarce. Although orthopedic surgeons are not likely to place an IO catheter in an emergency situation, they often become involved when complications of IO catheter use arise.

In a literature search, we identified 5,759 patients treated with IO catheters. The overall complication rate was 2.1%. In this article, we discuss the literature on IO catheter complications and report 2 cases of orthopedic management of IO catheter complications.

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In a literature search, we identified 5,759 patients treated with IO catheters. The overall complication rate was 2.1%. In this article, we discuss the literature on IO catheter complications and report 2 cases of orthopedic management of IO catheter complications. The patients provided written informed consent for print and electronic publication of these case reports.

Historical Perspective

Drinker and colleagues[1] described the initial use of IO catheters in the sternum in 1922. IO catheter use was a popular method of administering fluids and drugs up until the advent of plastic intravenous (IV) catheters in the 1950s.[2] Recently, there has been renewed interest in the use of IO catheters, particularly in trauma or critically ill patients for whom time to access can literally determine their survival.

Rate of Insertion Success

The most common site for IO catheter insertion is the proximal tibial metaphysis, because of the large medullary canal, subcutaneous location, absence of important neurovascular structures in the interposing soft tissues, and relatively thin cortical shell. Other common sites are the femur (particularly in pediatric patients), the proximal humerus, the iliac crest, and the sternum. The rate of successful insertion is 80% to 95% in most series[2-8] and is 96% according to our literature review. IO catheters are most often placed by physicians in the ED (> 50%). The second most common scenario is placement by emergency medical technicians in critically ill or hemodynamically unstable patients in the field.[3]

Complications

Complication rates have been reported for many large series involving IO catheter use, but there have been no studies conducted to determine the actual rate. A rate of less than 5% is cited in the majority of reports in the literature.[2,3] The most commonly cited complications, apart from failed insertion, include osteomyelitis, compartment syndrome, and fracture.[4] Although fractured or incarcerated catheter and intra-articular insertion have not been reported, we believe these complications may also occur with some regularity.

A nonobvious potential complication of IO catheter use is extravasation of fluid into a soft-tissue compartment. If initial insertion is unsuccessful, another attempt should not be made in the same bone, as the infused fluid can extravasate through the original hole and into surrounding soft tissues. If not diagnosed early, fluid extravasation can lead to compartment syndrome and complicate resuscitation efforts. Similarly, bone fracture contraindicates IO access, and radiographs of the proposed insertion site should be obtained in obtunded or unresponsive patients.[4] Other contraindications are limbs with extensive soft-tissue injury,

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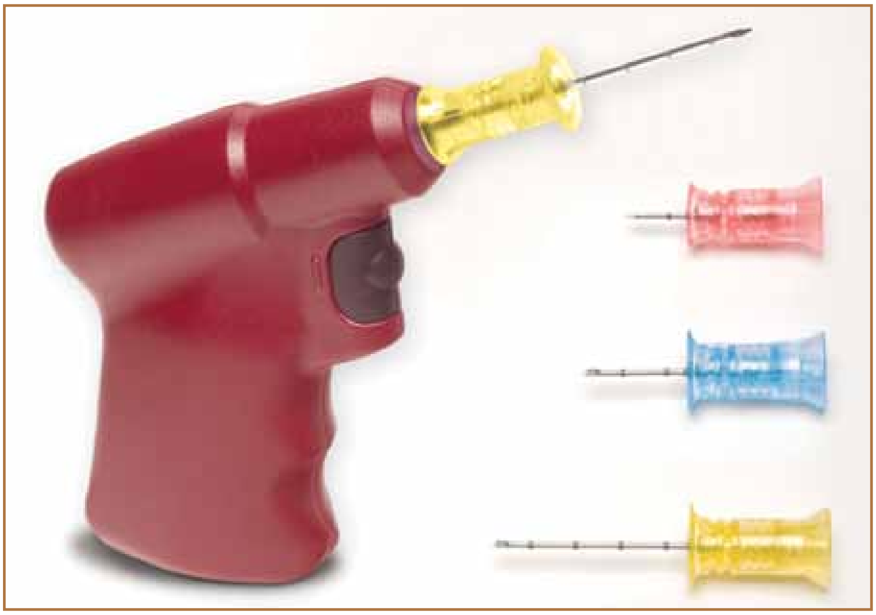

Figure 1. EZ-IO (Vidacare, San Antonio, Texas).

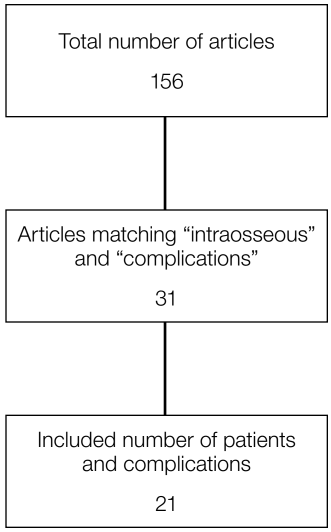

Figure 4. Systematic review methodology.

Figure 2. Bone Injection Gun (WaisMed, Migdal Tefen, Israel).

active compartment syndrome, active local infection, septicemia, and leukemia or another hematologic condition.[3,9]

Common Insertion Techniques

The commonly used IO catheter systems use either a battery-powered small drill, the EZ-IO (Vidacare, San Antonio, Texas) (**Figure 1**), or a spring-loaded IO insertion device, the Bone Injection Gun (WaisMed, Migdal Tefen, Israel) (**Figure 2**).[5] Each instrument provides a quick, easy, and reproducible IO insertion. The common manual IO catheter device is the Jamshidi needle (CareFusion, San Diego, CA) (**Figure 3**). There is less risk of IO catheter loss with a powered device because of the lack of toggle associated with manual insertion.[5]

Figure 3. Jamshidi needle (CareFusion, San Diego, CA).

Literature Review

For our systematic review of the literature for complication rates for IO access, we used Pubmed and Google Scholar and searched for the key terms *intraosseous catheter* and *complications*. Only those series that reported number of patients and number of complications were included in our study (**Figure 4**). Complications, defined as adverse outcomes that required further intervention or posed threats of lasting harm, included local infection, osteomyelitis, fracture, compartment syndrome, retained catheter, venous thromboembolic disease, fluid extravasation or infiltration, and iatrogenic injury to joints, nerves, or blood vessels. Failure to obtain access was not considered a major complication.

Overall, we included 21 different case series representing 5,759 patients, and the overall rate of successful insertion was 96%. Insertion devices varied and included manual needles, spring-loaded devices, and powered drill devices. There were 116 reported complications for an overall rate of 2.0%. There was no difference in the rate between manual and mechanical IO catheters. Complications of IO catheters are rare, and none of the series identified common risk factors. A review of the literature is displayed in chart format (**Table**).

Case Reports

Institutional Review Board (IRB) approval: Permissions were sought and obtained from all patients involved in this study. No identifying information was included. The study was submitted to the public affairs office of Naval Medical

Table. **Summary of Literature Review**

Author	Number of Patients	Success on First Attempt	Success Rate	Complications
Gazin et al[8]	39	33/39	84%	1 local infection
Frascone et al[6]	19	18/19	95%	2 infiltration 2 slow flow 1 dislodgement
Paxton et al[11]	30	27/30	90%	11 dislodgment
Nijssen-Jordan et al[7]	42	36/42	86%	2 fractures
Gerritse et al[12]	40	29/40	73%	None
Leidel et al[5]	40	34/40	85%	None
Wampler et al[13]	244	222/244	91%	None
Hartholt et al[8]	87	71/87	82%	14 adverse events: 2 extravasation 1 excess bleeding 1 incarcerated catheter 5 bicortical perforation 1 dislodgment 2 bent needle 2 inability to penetrate
Bowley et al[14]	1	1/1	100%	1 fracture
Siegler et al[15]	17	16/17	94%	None
Smith R et al[16]	15	12/15	80%	3 extravasation 1 dislodgment 1 slow flow
Horton et al[2]	95	78/95	82%	2 bicortical perforation 1 dislodgement 2 device failure 1 extravasation
Fiorto et al[17]	47	37/47	78%	7 infiltration
Davidoff et al[18]	250	242/250	97%	None
Rosetti et al[19]	4,359	4,270/4,359	98%	27 osteomyelitis 2 sternal peforation 1 arterial thrombus 2 mediastinitis 4 subcutaneous abscess 1 subcutaneous skin slough
Ngo et al[4]	35	31/35	100%	2 incarcerated catheter
Sunde et al[20]	70	59/70	84%	1 fracture 1 extravasation
Claudet et al[21]	78	64/78	82%	20 subcutaneous infusions 1 osteomyelitis 1 articular perforation
Schwartz et al[3]	189	172/189	91%	1 dislodgement
Guy et al[22]	27	27/32	84%	None
Ong et al[23]	35	35/35	100%	None
Totals	**5,759**	**5,514/5,759**	**96%**	**116 complications**
Complication Rate	**116/5,759**	**2.0%**		

Figure 5. Initial radiograph shows retained IO catheter after attempted removal and subsequent fracture of hollow-bore needle. Note thick diaphyseal bone in which IO catheter was placed.

Figure 6. Postoperative radiograph shows retained IO catheter recessed below outer cortex of tibia after trephine was used to remove core of bone surrounding needle to provide adequate space to break needle below tibial surface.

Center San Diego and was submitted to the Naval Medical Center San Diego IRB as a reviewed case report in August 2012.

Case 1

A 14-year-old adolescent presented with diabetic ketoacidosis to the ED. Given the patient's severe dehydration and the difficulty encountered in obtaining IV access, the patient was treated with an IO catheter device in the ED. An EZ-IO was placed into the diaphysis of the tibia and became lodged there (**Figure 5**). Pliers were used to try to remove the hollow-bore needle, but the result was needle collapse and fracture. The needle could not be removed from the hard bone of the tibial diaphysis, and the orthopedic service was consulted. Manual traction with a Luer-Lok syringe (Becton-Dickson, Franklin Lakes, New Jersey) was unsuccessful. The patient was taken to the operating room, where again manual attempts to remove the needle were unsuccessful. Ultimately, a trephine was used to core around the needle so that the retained needle could be broken off below the level of the outer cortex of the tibia (**Figure 6**).

Case 2

A young active-duty US Marine sustained a dismounted improvised explosive device (IED) blast injury—a traumatic below-knee amputation and extensive soft-tissue injury of the contralateral lower extremity. A proximal humerus IO catheter was placed to assist with resuscitation on the battlefield. The patient was eventually transferred to a stateside military tertiary-care center. On arrival, he complained of right shoulder pain, which worsened with abduction or rotation of the shoulder. He also had reduced supraspinatus strength. **Figures 7 through 9** show the retained tip of the IO catheter embedded in the humeral metaphysis just proximal to the insertion of the rotator-cuff tendons.

Diagnostic arthroscopy was performed. During surgery, the protruding metal tip from the broken IO catheter was seen exiting the humeral cartilage near the superoposterior margin (**Figure 10**). In addition, partial-thickness tearing of the posterior labrum and significant glenoid chondromalacia were noted corresponding to the intra-articular protruding loose body (**Figure 11**). The supraspinatus tendon had an 8-mm full-thickness tear about 1 cm medial to the insertion, also corresponding to the sharp end of the broken, protruding IO catheter (**Figure 12**). No fatty infiltration was noted, and both tendon edges appeared healthy. The tear was exploited to identify the protruding fragment of the IO catheter, and the fragment was removed (**Figure 12**). The posterior labral tear was debrided, and the stability of the labrum was verified. Then, the supraspinatus tear was repaired with a mini-open technique.

The patient was treated with immobilization in a sling with gentle Codman exercises beginning on postoperative day 1.

Figure 7. Anteroposterior shoulder radiograph shows retained foreign body with suggestion of hollow bore.

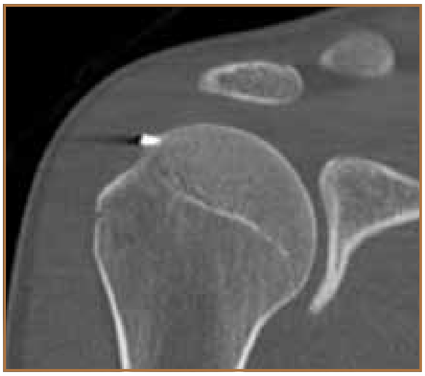

Figure 8. Coronal computed tomography image shows metal fragment protruding from articular margin.

Figure 9. Axial computed tomography image shows metal fragment protruding from articular margin.

After 6 weeks of immobilization, a standard rotator-cuff therapy protocol was instituted. At most recent (3-month) follow-up, the patient was pain-free and had achieved full strength and range of motion of the affected shoulder.

Conclusion

IO catheter devices are excellent tools for delivering fluid and drugs to critically ill patients. These devices are very

Figure 10. Extruded tip of IO catheter with resultant complete supraspinatus rotator-cuff tear.

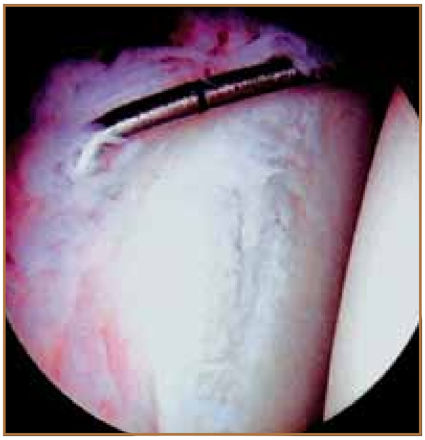

Figure 11. Damage to posterosuperior glenoid surface and labrum caused by protruding remnant of IO catheter.

reliable (> 90% insertion success rate) in the hands of experienced operators. The time it takes to insert an IO device is often less than 20 seconds. According to our literature review, IO catheters have low complication rates. However, the evidence in most of the series included was of low quality, and therefore these rates may be overestimated.

Insertion complications can be serious, leading many providers to use IO catheters under only the most dire of circumstances. This reluctance may not be warranted, given the low rate of complications. Although many orthopedic surgeons never place IO catheters, they may have to manage the complications.

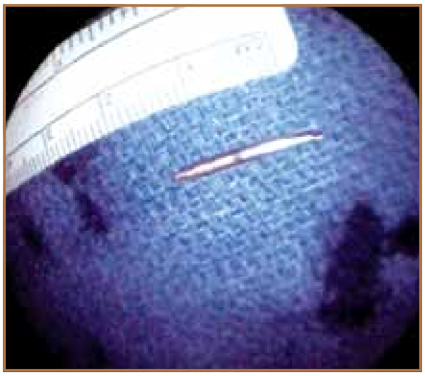

Figure 12. Length of retained IO catheter tip removed from humeral head is about 15 mm.

This article has described the possible complications of IO catheter use and has provided simple tips that can help in managing them.

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References

1. Drinker CK, Drinker KR, Lund CC. The circulation in the mammalian bone marrow. *Am J Physiol*. 1922;62:1-92.
2. Horton MA, Beamer C. Powered intraosseous insertion provides safe and effective vascular access for pediatric emergency patients. *Pediatr Emerg Care*. 2008;24(6):347-350.
3. Schwartz D, Amir L, Dichter R, Figenberg Z. The use of a powered device for intraosseous drug and fluid administration in a national EMS: a 4-year experience. *J Trauma*. 2008;64(3):650-654; discussion 654-655.
4. Ngo AS, Oh JJ, Chen Y, Yong D, Ong ME. Intraosseous vascular access in adults using the EZ-IO in an emergency department. *Int J Emerg Med*. 2009;2(3):155-160.
5. Leidel BA, Kirchhoff C, Braunstein V, Bogner V, Biberthaler P, Kanz KG. Comparison of two intraosseous access devices in adult patients under resuscitation in the emergency department: A prospective, randomized study. *Resuscitation*. 2010;81(8):994-999.
6. Frascone RJ, Jensen J, Wewerka SS, Salzman JG. Use of the pediatric EZ-IO by emergency medical services providers. *Pediatr Emerg Care*. 2009;25(5):329-332.
7. Nijssen-Jordan C. Emergency department utilization and success rates for intraosseous infusion in pediatric resuscitations. *CJEM*. 2000;2(1):10-14.
8. Hartholt KA, van Lieshout EM, Thies WC, Patka P, Schipper IB. Intraosseous devices: a randomized controlled trial comparing three intraosseous devices. *Prehosp Emerg Care*. 2010;14(1):6-13.
9. Greaves I, Evans G, Boyle A. Intraosseous infusions in the adult. *Trauma*. 1999;1(4):291-299.
10. Gazin N, Auger H, Jabre P, et al. Efficacy and safety of the EZ-IO™ intraosseous device: Out-of-hospital implementation of a management algorithm for difficult vascular access. *Resuscitation*. 2011;82(1):126-129.
11. Paxton JH, Knuth TE, Klausner HA. Proximal humerus intraosseous infusion: a preferred emergency venous access. *J Trauma*. 2009;67(3):606-611.
12. Gerritse BM, Scheffer GJ, Draaisma JM. Prehospital intraosseous access with bone injection gun by a helicopter-transported emergency medical team. *J Trauma*. 2009;66(6):1739-1741.
13. Wampler D, Schwartz D, Shumaker J, Bolleter S, Beckett R, Manifold C. Paramedics successfully perform humeral EZ-IO intraosseous access in adult out-of-hospital cardiac arrest patients. *Am J Emerg Med*. 2012;30(7):1095-1099.
14. Bowley DM, Loveland J, Pitcher GJ. Tibial fracture as a complication of intraosseous infusion during pediatric resuscitation. *J Trauma*. 2003;55(4):786-787.
15. Siegler RS, Tecklenburg FW, Shealy R. Prehospital intraosseous infusion by emergency medical services personnel: a prospective study. *Pediatrics*. 1989;84(1):173-177.
16. Smith RJ, Keseg DP, Manley LK, Standeford T. Intraosseous infusions by prehospital personnel in critically ill pediatric patients. *Ann Emerg Med*. 1988;17(5):491-495.
17. Fiorito BA, Mirza F, Doran TM, et al. Intraosseous access in the setting of pediatric critical care transport. *Pediatr Crit Care Med*. 2005;6(1):50-53.
18. Davidoff J, Fowler R, Gordon D, et al. Clinical evaluation of a novel intraosseous device for adults: prospective, 250-patient, multi-center trial. *JEMS*. 2005;30(10):suppl 20-23.
19. Rosetti VA, Thompson BM, Miller J, Mateer JR, Aprahamian C. Intraosseous infusion: an alternative route of pediatric intravascular access. *Ann Emerg Med*. 1985;14(9):885-888.
20. Sunde GA, Heradstveit BE, Vikenes BH, Heltne JK. Emergency intraosseous access in a helicopter emergency medical service: a retrospective study. *Scand J Trauma Resusc Emerg Med*. 2010;18:52.
21. Claudet I, Baunin C, Laporte-Turpin E, Marcoux MO, Grouteau E, Cahuzac JP. Long-term effects on tibial growth after intraosseous infusion: a prospective, radiographic analysis. *Pediatr Emerg Care*. 2003;19(6):397-401.
22. Guy J, Haley K, Zuspan SJ. Use of intraosseous infusion in the pediatric trauma patient. *J Pediatr Surg*. 1993;28(2):158-161.
23. Ong ME, Chan YH, Oh JJ, Ngo AS. An observational, prospective study comparing tibial and humeral intraosseous access using the EZ-IO. *Am J Emerg Med*. 2009;27(1):8-15.

This paper will be judged for the Resident Writer's Award.