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A life-saving line in resuscitation and shock management of the critically ill child: intraosseous infusion

Kritik olarak hasta olan çocuğun canlandırılması ve şok tedavisinde yaşam kurtarıcı bir yol: kemik içi infüzyon

Tanıl Kendirli, Zahide Yalaki, Burcu Öztürk Hişmi, Aslı Kavaz, Emel Derelli, Erdal İnce

Intensive Care Unit, Department of Pediatrics, Ankara University Faculty of Medicine, Ankara

Aim: Intraosseous infusion (IOI) is an alternative method of vascular access which is considered when peripheral intravenous line cannot be achieved rapidly. Epinephrine, adenosine, crystalloids, colloids and blood products can be administered effectively using this route during resuscitation and shock management.
Material and Methods: We retrospectively evaluated the medical records of Pediatric Intensive Care Unit (PICU) patients who had required IOI administration, and the complications of this method are searched.
Results: Medical records of 332 patients who had been followed in our PICU were examined and 13 patients (3.9%) were detected to have IOI administered. Our patients' median age was 8 months, and male:female ratio was 2,5. The primary diagnoses of our IOI administered patients were septic shock (6), cardiogenic shock (2), acute gastroenteritis (1), hemorrhagic shock and encephalopathy syndrome (4). IOI were performed 2 of 13 patients during resuscitation. We performed IOI by spinal needle in 10 (76.9%) patients and by bone marrow aspiration needle in three patients. Eight (61.64%) patients were inpatient. The sites for placement of IO line were right proximal tibia in 12 patients, left proximal tibia in 2 patients, and right distal femur in one patient. The median time of IOI was 20 hours (3 hours-9 days) , and 11 patients survived in the first 24 hours. The only complication was extravasation, seen in a patient.
Conclusion: IOI is indicated in life-threatening situations in which vascular access is essential for treatment, and should be kept in mind for being an easily achieved vascular access.

Key words: ***intraosseous infusion, shock, resuscitation, emergency treatment***

Amaç: Kemik içi (Kİ) infüzyon acil durumlarda damaryolu açılamadığında ilâç ve sıvı tedavisi için alternatif bir yoldur. Bu yolla canlandırma sırasında ve şokta epinefrin, adenozin, kristaloid, kolloid ve kan ürünleri etkin bir şekilde uygulanabilir.
Gereç ve Yöntem: Yoğun bakım ünitesinde yatmış ve Kİ infüzyon tedavisi uygulanmış olan hastaların dosyaları retrospektif olarak incelenerek, bu tedavinin yapıldığı hastalar ve komplikasyonlar değerlendirildi.
Bulgular: Yoğun bakım ünitemizde yatan 332 hastadan 13 (3.9%)'üne Kİ infüzyon tedavisi uygulandı. Hastalarımızda median yaş 8 ay, erkek kız oranı 2.5 bulundu. Kİ infüzyon tedavisi uygulanan hastaların tanıları septik şok (6), kardiyojenik şok (2), akut gastroenterit (1), hemorajik şok ve ensefalopati sendromu (4) idi. Kİ infüzyonu 13 hastadan 2'sine canlandırma sırasında uygulandı. On (76.9%) hastaya spinal iğne, 3 hastaya ise kemik iliği aspirasyon iğnesi ile Kİ infüzyonu yapıldı. Sekiz (61.64%) hasta daha önceden hastanede yatmaktaydı. Kemik içi infüzyon tedavisi 12 hastada sağ proksimal tibia, 2 hastada sol proksimal tibia ve bir hastada sağ distal femurdan uygulandı. Kemik içi uygulanan iğneler ortalama 20 saat (3 saat-9 gün) kaldı ve 11 hasta 24 saatten uzun süre yaşadı. Hastalardan sadece birisinde 1 kez görülen ilâç ekstravazasyonu, tek komplikasyon idi.
Sonuç: Kemik içi infüzyon tedavisi hayatı tehdit eden ve damar yolu açılmasının gerekli olduğu durumlarda, kolay ve etkin bir yöntem olarak akılda tutulmalıdır.

Anahtar sözcükler: ***kemik içi infüzyon, şok, canlandırma, acil tedavi***

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Corresponding author
Tanıl Kendirli
Kazım Orbay Mahallesi, 28. sokak 31/9, Akdere 06100, Mamak, Ankara
Tel : (312) 3623030
Fax : (312) 3620581
E-mail adress : tanilkendirli@hotmail.com

Providing a good functioning vascular access in a child is a real success in certain conditions like shock. In 1922, Drinker first described the anatomy of the bone marrow and suggested that, it could be used for infusion of blood products and other fluids. Thereafter intraosseous (IO) infusions are

indicated in life-threatening situations in which vascular access is essential for treatment and routine intravenous infusion is not readily available (1). Common clinical indications for IO infusion include cardiopulmonary arrest, shock, major trauma, extensive burns, status epilepticus and overhelming sepsis (2-6).

Pediatric applications of IOI have been widely used, perhaps because of difficulty in establishing intravenous line in small children with correspondingly small veins. The procedure is used also in adults, both historically and currently; however, the increased density of adult bone makes the procedure technically more difficult (1,7-9). In this study, we retrospectively examined the medical records of the children who had 10 infusion administered in our pediatric intensive care unit (PICU).

Methods

We retrospectively examined the medical files of children admitted to our PICU, for IOI administiration during shock or resuscitation. We performed IO infusion, when the patient with severe shock or cardiopulmonary arrest has no intravenous line and attempts for achieving central venous catheter or sufficient intravenous line fail (1-3). Intraosseous infusion was performed on proximal tibia, distal tibia or distal femur. The technique of intraosseous infusion was as follows: Under sterile conditions, the tibial tuberosity is identified and a needle (an 18-gauge spinal needle or bone marrow aspiration needle) is placed some distance, usually referred to as one fingerbreadth, distal to the tibial tuberosity. The needle is advanced in a caudal direction through the bone cortex and into the bone marrow (6).

Various drugs (epinephrine, atropine, sodium bicarbonate, lidocain, e.g) and fluids (0.9% NaCl, albumin, all blood products) were administered via IO line and IO infusion needle was pulled out when sufficient intravenous line or central venous catheter is provided.

We examined the IOI performed patients, for infusion time, outcome from shock or cardiopulmonary arrest (recovery or death), mortality rate, procedure related complications.

Results

We examined 332 patients with supplied files. Intraosseous infusion was performed in 13 patients (3.9%), and male:female ratio was 2.5. The patients' median age was 8 months (2-168), and their average ages were 28.6±48.3 months. Their primary diseases were cerebral palsy (5 patients), congenital heart disease (3 patients), Prader Willi syndrome (1 patient) and acute lymphoblastic leukemia (1 patient), while 3 patients were previously healthy. The etiologies of shock in these IOI administered patients were septic shock (6), cardiogenic shock (2), acute gastroenteritis (1), hemorrhagic shock and encephalopathy syndrome (4).

Our attempts to put on a central catheter failed in 4 (30%) patients and one patient had an intravenous line insufficient for the emergency treatment, so we had to perform IO access. We performed IO infusion by spinal needle in 10 (76.9%) patients, and by bone marrow aspiration needle in 3 (23.1%) patients. Eight (61.64%) patients were inpatient. The sites for placement of IO line were right proximal tibia in 12 patients, left proximal tibia in 2 patients, and right distal femur in one patient. In one patient IO infusion was performed on two different sites during resuscitation, for administration of huge volumes of fluids, inotropics, and blood products. The median IO infusion time was 20 hours (3 hours-9 days) and 11 patients survived in the first 24 hours. Also, after an average 2 hours of IO infusion, sufficient intravenous line or central venous catheter was supplied. There was only one complication as extravasation seen in a patient. Previously reported complications like bone fracture, osteomyelitis and compartment syndrome were not seen in our patients. Intraosseous infusion helped 11 (84.6%) patients to recover from shock and saved their lives in the first 24 hours, but 7 (53.8%) patients died afterwards. The patients' specified features are shown on Table 1.

Discussion

Intraosseous infusion has been proposed as the route of choice if intravenous infusion is not available within a few minutes during the resuscitation in children. The simplicity of the technique and high success rate suggests that it is feasible with infants (3,7). Recent guidelines from the European Resuscitation Council state that an intraosseous cannula provides infusion to a noncollapsible marrow venous plexus, which serves as a rapid safe and reliable route for administration of drugs, crystalloids, colloids and blood during resuscitation (7). We performed IO infusion in 3.9% of patients in our PICU, and generally there was not any problem about IOI application technique. Especially, IO infusion affected the mortality rate in the first day of PICU admission. Most patients died from the resulting multiple organ dysfunction after severe shock or resuscitation in the following days.

One of the fundamental elements of resuscitating critically ill patients is providing vascular access for the administration of fluids and drugs. As a result of the body's compensatory mechanisms against shock, there is often

Table 1. Patients' features who had intraosseous infusion performed

Patients	*Diagnosis*	*Needle type*	*Place of IO infusion*	*Drugs*	*Death in first day*	*Result*	*Follow time*
1	*HSES	Bone marrow	Right tibia proximal	Fluid, epinephrine, dopamine, dobutamine, midazolam, vecuronium, blood products	-	Death	9 days
2	Septic shock	Spinal	Right tibia proximal	Fluid, epinephrine, atropine, sodium bicarbonate	Yes	Death	1 hour
3	Cadiogenic shock	Spinal	Right tibia proximal	Fluid, epinephrine, dopamine, dobutamine,	-	Death	3 days
4	Acute gastroenteritis	Spinal	Right femur distal	Fluid, dopamine	-	Death	6 hours
5	Septic shock	Spinal	Right tibia proximal	Fluid, dopamine, blood products	-	Death	3 days
6	HSES	Bone marrow	Right tibia proximal	Fluid, dopamine, blood products	-	Alive	4 days
7	Septic shock	Spinal	Right tibia proximal	Fluid, dopamine, dobutamine,	-	Alive	5 days
8	HSES	Spinal	First right tibia proximal/ after left tibia proximal	Fluid, dopamine, blood products	-	Alive	4 days
9	Septic shock	Spinal	Right tibia proximal	Fluid, dopamine, dobutamine,	-	Alive	4 days
10	Cardiogenic shock	Spinal	Right tibia proximal	Fluid, dopamine,	-	Death	2 days
11	Septic shock	Spinal	Right tibia proximal	Fluid, epinephrine, sodium bicarbonate	-	Alive	6 days
12	HSES	Spinal	Right tibia proximal	Fluid, epinephrine, dopamine, dobutamine, sodium bicarbonate	-	Alive	4 days
13	Septic shock	Bone marrow	Right and left tibia proximal	Fluid, epinephrine, dopamine, dobutamine, sodium bicarbonate, blood products	Yes	Death	30 minutes

***HSES:** Hemorrhagic shock and encephalopathy syndrome

peripheral vascular collapse and gaining venous infusion may not be possible. Intraosseous infusion, in children under the age of 6 years, is recommended when attempts at intravenous infusion fail (1,6,10-13). Our patients' average age was 2.4 years. High percentage of our patients had septic shock and HSES, also IO infusion were put on 2 patients. IOI is administered easily without any serious complications, in severe shock and cardiopulmonary arrest of critically illl children in our PICU, if intravenous line or central venous catheter cannot be provided in 90 seconds. We pull out IO infusion needle when we supply sufficient and safe intravenous line or central venous catheter.

Sepsis and cardiopulmonary arrest were two common states necessitating IOI administration in our study. It has been well described that early initiation and aggressive fluid resuscitation improve outcomes in sepsis (14). One final recommendation was that community physicians should intervene with early vascular access, either by peripheral, IO, or central venous route, and administer aggressive fluid resuscitation until resolution of shock symptoms. Out-of-hospital pediatric cardiac arrests generally have poor outcomes, but it is known that children arriving to the emergency department asystolic fare worse (12-14). The ability to more rapidly deliver resuscitation fluids and medicines via the IO route could possibly improve outcomes in these patients. There was any patient who had performed IOI at out-of-hospital.

While early descriptions of the technique required bones with a functioning medullary cavity, recent researches and case studies describe using the calcaneus, a bone without a functioning medullary cavity, as an effective site for intraosseous infusions. The calcaneus has also been used as a site for intraosseous infusions in adults. The following research was conducted to explore further whether intraosseous infusions via the calcaneus could infusion systemic veins and whether infusions via this site could be success-

ful in adults (9). We only performed IO infusion to bones with functioning medullary cavity. We have no experience on IO infusion to calcaneus in children with severe shock.

In conclusion, intraosseous infusion is indicated in life-threatening situations in which vascular access is essential for treatment and routine intravenous line is absent. Intraosseous infusion application is very easy that all pediatric intensivist,, pediatric residents, intensive care nurses can perform in severe shock or cardiopulmonary arrest states of children.

References

1. McDonald MJ, Wiebe RA. Intraosseous infusions. In: Levin DL, Morriss FC (eds): In Essentials of Pediatric Intensive Care (ed 1). Newyork, Churchill Livingstone, 1997; 1249-52.
2. Kentner R, Haas T, Gervais T, Hiller B, Dick W. Pharmacokinetics and phermacodynamics of hydroxyethyl starch in hypovolemic pigs; a comparison of peripheral and intraosseous infusion. Resuscitation 1999; 40:37-44.
3. Stoll E, Golej J, Burda G, Hermon M, Boigner H, Trittenwein G. Osteomyelitis at the injection of adrenalin through and intraosseous needle in a 3-month-old infant. Resuscitation 2002; 53:315-8.
4. Bowley DMG, Loveland J, Pitcher GJ. Tibial fracture as a complication of intraosseous infusion during pediatric resuscitation. J Trauma 2003; 55:786-787.
5. Korszun T, Raio CC, Theodoro D, Nelson MJ, Hormozdi S, Lee DC, Elliott D. Can emergency physicians utilize ultrasonography to accurately confirm intraosseous needle placement? Ann Emerg Med 2004; 44:S84.
6. Boon JM, Gorry DLA, Meiring JH. Finding an ideal site for intraosseous infusion of the tibia: an anatomical study. Clin Anat 2003; 16:15-18.
7. European Resuscitation Council. Guidelines 2000 for cardiopulmonary resuscitation and cardiovascular care-an international consensus on science. Resuscitation 2000; 46:359.
8. McCarthy G, O'Donnell C, O'Brien M. Successful intraosseous infusion in the critically ill patient does not require a medullary cavity. Resuscitation 2003; 56:183-186.
9. Clem M, Tierney P. Intraosseous infusions via the calcaneus. Resuscitation 2004; 62:107–12.
10. Foex BA. Discovery of the intraosseus route for fluid administration. J Accid Emerg Med 2000; 17:136-137.
11. Simmons CM, Johnson NE, Perkin RM, van Stralen D. Intraosseous extravasation complication reports. Ann Emerg Med 1994; 23:263-266.
12. Glaeser PW, Losek JD. Emergency intraosseous infusions in children. Am J Emerg Med 1986; 4:34-36.
13. Glaeser PW, Losek JW, Nelson DB. Pediatric intraosseous infusions: impact on vascular infusion time. Am J Emerg Med 1988; 6:330-332.
14. Fiorito BA, Mirza F, Doran TM, Oberle AN, Cruz ECV, Wendtland CL, Abd-Allah SA. Intraosseous access in the setting of pediatric critical care transport. Pediatr Crit Care Med 2005; 6:50-53.