A brief review on Intraosseous (IO) cannulation and outcome analysis of patients managed by Intraosseous (IO) route .

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Abstract

Objective: To review the application of IO infusion and come up with recommendations.
Methods: All patients on whom IO cannulation was done after attempted and failed to secure conventional intravenous route were recorded, cases followed and outcomes analyzed.
Results: IO infusion was done in 78 children aged one month to eight years during the period of 12 years. The peak age group with more than 75% was in age less than 24 months with a male to female ratio of 1:1.2. The proximal tibia was the site of insertion in all the patients. A spinal needle was used in 76% patients, IO and bone marrow aspiration needles were used in12.8% and 5.3% patients respectively and hypodermic needles were used in 5.13% patients. Fluid, blood, antibiotics, glucose, diazepam, and furosemide were given successfully with resultant effect. One child developed cellulites and osteomylitis following extravasations. Two children died after 48 hours stay in the hospital. The cause of death was not related to the procedure.
Conclusion: IO infusion has broad applicability in life threatening situations with few contraindications, minimal to no side effects and complications. All drugs and fluids given via intravenous route were safely given through IO route with superior to similar effect.

Introduction

Venous access in children particularly in emergency situations like shock and cardiac arrest is often very difficult, time consuming, challenging, frustrating and emotionally draining. Immediate venous access is required in situations of shock following blood loss, gastroenteritis with severe dehydration, burn child in shock and/or when there is a need of administering emergency drugs for correction of hypoglycemia, control of status epilepticus, and resuscitation of pulse less children. Prolonged attempt to obtain venous access may delay life saving therapy. However, fluid and drugs that are infused to the medullary cavity of long bones quickly enter the venous circulation [1, 2, 3, 4,5, 6].

Historically in 1922 the bone marrow route was proposed for injection fluids and drugs into circulation. In 1940 the first clinical studies of IO were published and up to 1950 gained wide acceptance[3]. It was used widely during the Korean War. In 1950-1960 Intravenous technique improved and IO technique fell in to obscurity, it was largely forgotten. In 1980s physicians began carefully to examine the timeliness of resuscitation process in children. In 1984 Rosetti and co-workers reported a three year retrospective study regarding intravenous access in children presenting in cardiac arrest; result showed in more than 6% intravenous was never attained even when resuscitation effort was stopped after more than 45 minutes. Mean time to access intravenous was 7.8 minutes but almost one quarter required 10 minutes or more [3, 7]. In 1985 Rosetti et al presented a review of 30 IO studies in the world literature involving 4359 attempts with a 2.1% failure rate [8].

In this article a brief review and analysis of cases managed by IO route is presented.

Methods

All patients who had life threatening conditions on whom intra-vascular access failed and as an alternative IO infusion used during the period of 1993-2005 at Massawa Hospital, Hazhaz Hospital and Orotta Pediatric National Referral Hospital were recorded, followed and analyzed.

This data does not include cases that did not come to the attention of the investigator.

Results

Intraosseous (IO) infusion was done in 78 patients with different life threatening clinical spectrum on whom attempted intravascular access was unsuccessful during a 12 years period (1993-2005). Forty eight of the cases were from Massawa Hospital in a 5 year time, 7 cases from Hazhaz Hospital in 2 years period and the rest 23 cases from Orotta Pediatric National Referral Hospital in 5 years period. The age and sex distribution as seen on table 1-1 showed more than 75% of the cases were children aged less than 24 months. The youngest patient was a 1 month old who came with circulatory collapse following profuse post circumcision bleeding who was finally diagnosed as a case of hemophilia (factor VIII deficiency). The oldest one was 8 years old child came with gastroenteritis in sever dehydration, shock and unconscious. The male to female ratio was 1:1.2.

Table 1 Age and sex distribution of children managed via IO route.

Age in months	Sex		Total	%	Cumulative %
	M	F			
0-5	6	5	11	14.2	14.2
6-11	10	12	22	28.2	42.4
12-23	12	14	26	33.3	75.7
23-59	7	9	16	20.5	96.2
> 60	2	1	3	3.8	100
Total	37	41	78	100	100

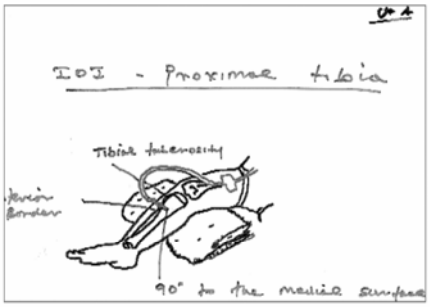
87.2% patients with gastroenteritis in severe dehydration were successfully resuscitated with the calculated fluid timely. 11.5% of children with clinical evidence of severe anemia in congestive heart failure as well as one child who was in shock following acute blood loss were transfused whole blood via the IO route. In 70% of those who received blood, the transfusion was carried out by conventional gravity on the specified time (4-6 hours) while in the rest it was given by direct push to the marrow cavity using syringe. Furosemide was given via the same rout upon completion of the blood transfusion. Concentrated 10% glucose was given to 8 children with clinical and laboratory evidence of hypoglycemic and diazepam to 4 convulsing children on whom immediate effect was seen in both situations.

Antibiotic (penicillin, ampicillin, gentamycin and or ceftriaxone) were given via the same route to manage the associated illness and/or as a prophylaxis until conventional line is in place.

In this series the site for insertion was the proximal tibia in all the patients using a spinal needle in 76.9% of the patients, IO needle in 12.8%, bone marrow aspiration needles in 5.1%, and hypodermic needles in the remaining patients all done under aseptic technique.

The needle is forwarded perpendicular at 90° and slightly down words to avoid damaging the growing end plate, simply by forwarding and twisting until entry to marrow cavity is felt by lack of resistance, marrow easily aspirated, fluid easily flashed with no resistance, no sign of extravasations and needle stand upright with out support. One has to avoid advancing the needle to the other end of the bone which may block the needle or by pass the marrow cavity (Figure 1).

Figure1 IO needle in place in the proximal anterior medial part of the tibia



Local anesthesia was not used at all. In 94.9% the procedure was successful in the first attempt with the second trial on the other site successful in the remainder of patients.

The duration of IO infusion in place ranged from 6-24 hours depending on the subsequent placement of conventional intravenous line. In the majority, it was removed out with in 8 hours.

Extravasations occurred in 2 children after receiving the required fluid following dislodgement of the needle in one it resolved and in the other patient was complicated by osteomyelitis. There was no other evidence record of cellulites or osteomyelitis on subsequent follow up. Two patients though received the required calculated fluid died after 48 hours stay in the hospital. The possible cause of death was sepsis with clinical evidence of disseminated intravascular coagulopathy and established renal failure.

Discussion

In emergency situations when there is a need to secure vascular access, one can keep on attempting to find an intravenous access peripheral or central provided the patient is ventilating well. In life threatening situations it is recommended to use an alternative route that is intraosseous (IO). The American Heart Association recommends doing IO cannulation if 90 seconds or 3 attempts were unsuccessful to secure vascular access. Others recommend doing IO cannulation if 2.5 minutes have passed without success. If IO failed and 3.5 minutes without success passed give lipid soluble drugs via endotracheal tube. However administration via endotracheal is not without limitation; such as the technique of intubations and availability of lipid soluble drugs at all facilities [3, 6, 9].

IO infusion is cannulation of the intraosseous and infusion of the required fluid and drugs to marrow cavity or infusion via the intra-medullary blood vessel which is described as infusion via none-collapsible vessels [2, 3, 4, 5, 6].

The marrow cavity is full of marrow sinusoids, medullary venous channels with venous plexus rich with sinusoids. Nutrient and emissary veins drain to systemic venous system. Moreover several studies of IO infusions have verified the return of fluids from the long bones medullary sinusoids through the nutrient and emissary veins to the venacava [3, 6]. The long bones in young children are full of red marrow which is more vascular less fibrous tissue as compared to older children and adults which is less vascular and more fibrous tissue. The iliac and sternum bones are more of red marrow in older children and adults. The advantage of marrow cavity is the non collapsible veins composed of red marrow with fast absorption of what is infused. Any drug and fluid that is given via the intravenous during resuscitation can be delivered safely and effectively via the IO route if intravenous access is not available. Samples may be aspirated and sent for analysis; chemistry analysis, complete blood count, blood group and Rh- factor determination and for culture if required [2,3,6].

The long bone preferably the proximal tibia is the convenient site, 1-2 cm distal to the tibial tuberosity or at the junction of the upper and middle third of the tibia, on the flat medial side of the anterior tibia. Other sites like the distal end of femur, 2 cm above the lateral condyles or the distal tibia proximal to the medial malleolus can be used safely too, if for any reason the proximal tibia is not convenient. The sternum and the iliac crest can be used in older children and adults. The sternum is not used in children requiring cardiopulmonary resuscitation (CPR)[3]. One has to

use aseptic technique during the procedure to avoid contaminating the marrow cavity. Local anesthesia can be given in to the skin and peristeum in alert and wakeful victims to avoid pain. In this series no local anesthesia was used.

A rigid needle preferably specially designed IO needle or bone marrow needle with a protective sheath or alternatively in resource limited countries any needle with a stylet like spinal needle can be used. Hypodermic needle or butterfly can be used in a very young but the chance of being blocked by bone cortex fragments is very high[11].

Blockage of the needle or by passing the marrow cavity can be avoided by adjusting the size to penetrate with the protective sheath, which is not a problem when using an ideal IO needle[2, 3, 6]. In this series where spinal needles were used in the majority, a clamp (hemostat) or needle holder was used to adjust the size and no incidence of penetrating to the posterior occurred. In our case only 4 bone marrow aspiration needles used for transfusing blood were flashed with heparin treated saline before cannulation. Only one attempt at one site is recommended, if unsuccessful use the contra-lateral bone and do not attempt if there is fracture on the ipsi-lateral bone. The reason is whatever infused may leak via the hole created or via the fracture site. If needle is accidentally removed from its correct place an attempt can be made to reinsert on the already created hole, if unsuccessful use the other limp. IO can stay in place up to 24 hours; the more it stays the higher is the risk of infection.

There are some contraindications to the use IO such as ipsi-lateral fracture of the bone that may lead to extravasations of whatever infused, osteogenesis imperfecta which may be complicated by fracture, osteopetrosis as it is stony hard to penetrate; and if there is overlying infection, cellulites, abscess or wound at the preferred site due to the risk of carrying or seeding pathogen to the marrow cavity.

Studies on pharmacokinetics of emergency drugs, by comparing the different routes central intravenous, peripheral intravenous and IO were done to see if there is any difference on the time of onset of action, time of peak effect, duration of effect, and timely management of fluid replacement. IO was found to be equal to central and to peripheral intravenous routes. [3, 6, 10, 12]

Speed of intervention on the average is less than 2 minutes and with experience can be secured in less than 60 seconds. Failure rate was as high as 2.1 % in former studies improved with experience and the availability of ideal needles. The most possible cause of failure are failure to adhere, to the land mark, bent needle, dense marrow, blockage of needle specially if used with out a stylet and clotting of marrow within the needle[3, 6, 8, 10].

IO infusions have some complications that can be related to the technique like: incomplete penetration of the boney cortex, needle not well fixed and resulting into infiltration of fluid under the skin. Penetration of the posterior part of the cortex may lead to infiltrations resulting tense cuff muscle and compartment syndrome[13]. The needle will be well fixed if penetration to posterior cortex occurred. Necrosis and sloughing of the skin at the site of infusion may occur when drugs such as adrenaline, calcium chloride, sodium bicarbonate get into the tissue. Studies had shown that cellulites and subcutaneous abscess in IO occurred in 0.7% versus 3.4% when using indwelling cannulas[3, 10]. From the 1985 review data 0.6% developed osteomyelitis when needle remained for long period over 24 hours [12]. In this series, 1.3% of patients developed skin necrosis later complicated by osteomyelitis following dislodgment of the needle and extravasations of fluid. Although systematic data collection and analysis was not done from observations it is not unusual to see intravenous sites been infected and complicated by cellulites, abscess and osteomyelitis of the overlying bone. Pain may be resulted from intra-medullary pressure. Fat and/or marrow embolism if occur may be life threatening but is very rare [3, 6, 14]. There may be some effect of IO on the growing end plate and marrow cavity but has no lasting effect from both clinical and experimental observations [3 , 15]. Death if occurs is not associated to the technique but may result from the effect of the disease entity that cannot be avoided even other conventional routes were used. If sternum cannulation is used and if there is accidental penetration to the mediastinium, mediastinitis and death may result. In this series 2.6% of patients died after successful resuscitation with the calculated fluid management via IO route which was later shifted to conventional intravenous line. Both died after 48 hours of hospital stay. The death was not related to the technique. The possible cause of death was sepsis with clinical evidence of disseminated intravascular coagulopathy and established renal failure.

In conclusion, IO infusion was shown to be a very successful intervention to manage children with life threatening emergencies requiring infusion when access through conventional intravascular routes had failed. The results from this study strongly recommend that all health care providers for children should have this skill either through pre-service training or continuing in-service training in order to minimize childhood mortality.

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