Resuscitation 83 (2012) 20–26

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Mini-review

Current advances in intraosseous infusion – A systematic review☆

Giora Weiser[a], Yoav Hoffmann[b], Roger Galbraith[c], Itai Shavit[a,*]

[a] Emergency Department, Meyer Children's Hospital, Rambam Health Care Campus, Haifa, Israel
[b] Department of Pediatric Critical Care, Safra Children's Hospital, Chaim Sheba Medical Center, Tel Hashomer, Israel
[c] Emergency Department, Alberta Children's Hospital, Calgary, Alberta, Canada

ARTICLE INFO

Article history:
Received 4 April 2011
Received in revised form 11 July 2011
Accepted 14 July 2011

Keywords:
Intraosseous
Infusion
Needle
Device
Success rate
Cardiac arrest

ABSTRACT

Objectives: To describe the advancement of Intraosseous (IO) infusion in the spectrum of resuscitative protocols and to provide a systematic review on currently used semi-automatic IO infusion devices. The specific question addressed was: "In patients undergoing resuscitation, does the use of semi-automatic IO infusion devices compared to manual needles influence IO placement success rate, time for IO placement, and ease-of-use and user preference?"
Methods: The electronic databases PubMed and Embase were searched for articles published from 1997 to 2010 using the search terms ("intraosseous") AND ("needle" or "device" or "technique") AND ("infusion" or "injection" or "access"). The Internet search engine Google Scholar was searched using the search term "intraosseous infusion device" to identify articles published in electronic journals, books, and scientific websites. Articles were included only if they compared at least two types of semi-automatic devices, or compared one or more semi-automatic device with one or more manual needles. Reviews, editorials, surveys, and case reports were excluded.
Results: The search strategy yielded 179 papers. Ten studies met full criteria for further review. Of these, two were LOE 1 (randomized controlled trials), one was LOE 2 (non-randomized, concurrent controls), one was LOE 3 (retrospective controls), and six were LOE 5 (simulation-based study). One of the six LOE 5 studies was a non-peer reviewed article.
Conclusions: Only a few studies compared the performance of different types of IO infusion devices, most of them have a low level of evidence. These studies suggested a superiority of the battery-powered IO driver over manual needles, and other semi-automatic IO infuson devices.

1. Introduction

Intraosseous (IO) infusion as a means of vascular access has been recognized for close to a century. The use of IO access in paediatric medical or trauma resuscitation is endorsed by the American Heart Association (AHA), the European Resuscitation Council (ERC), the American College of Emergency Physicians (ACEP), the American Academy of Paediatrics (AAP), the American College of Surgeons (ACS), the American College of Critical Care Medicine (ACCM), the U.S. National Association for Emergency Medical Service Physicians (NAEMSP), and the U.S. Army Committee on Tactical Combat Casualty Care (TCCC). These organizations recommend IO access as the immediate alternative route if intravenous (IV) access cannot be rapidly obtained.[1–6] Currently, there is sufficient evidence to recommend that this method of administering fluids and medications should also be used in any adult who is undergoing cardiac arrest, when rapid vascular access cannot be immediately achieved.[3] As an accepted standard of care treatment modality, IO infusion has now claimed its place as an important form of vascular access in trauma resuscitation in adults as well.[4–6] A large-caliber peripheral IV catheter is the preferable vascular route in trauma resuscitation in adults because they sometimes need a large volume of fluids.[4] However, IV access can be challenging, especially in the prehospital setting or in the setting of combat casualty resuscitation, where early IO infusion is currently recommended.[5,6]

2. Historical background and current recommendations for using IO access

IO infusion was first used in the 1920s when Drinker and colleagues demonstrated in an animal model that fluids administered into the marrow cavity did reach intravascular circulation.[7] The introduction of IO access for use in humans was reported in 1934 by Josefson.[8]

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at doi:10.1016/j.resuscitation.2011.07.020.

* Corresponding author. Tel.: +972 48542522/1; fax: +972 48543109; mobile: +972 502063239.
E-mail addresses: i_shavit@rambam.health.gov.il, itai@pem-database.org (I. Shavit).

0300-9572/$ – see front matter © 2011 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.resuscitation.2011.07.020

2.1. IO infusion in children

In the 1940s, two reports showed IO infusion to be an effective method of fluid and medication delivery in the paediatric population.[9,10] However, with the introduction of the plastic IV catheter, the IO route stopped being used as an important source for vascular access. This was due both to the ease and availability of IV cannulation as well as several reports of IO complications.[11] In the early 1980s, the first paediatric advanced life support (PALS) course was introduced, followed shortly by the original advanced paediatric life support (APLS) course.[12] These courses, based on the AHA, AAP, and ACEP recommendations were the first to reintroduce the option of IO access in children younger than 6 years of age, but only when IV access has failed.[12] The 1993 updated versions of the PALS courses recommended that the IO access be used after three attempts or 90 s, but still only in the younger population.[13] The 2005 AHA guidelines recommended that a more "liberal" approach could be used by allowing the PALS provider to decide how quickly the IO access should be performed ("if you cannot achieve reliable IV access quickly – establish IO access").[14] This recommendation is emphasized by the latest (2010) AHA guidelines.[1,2] IO infusion is also recommended in the out-of-hospital setting. In its 2007 statement, the NAEMSP published a formal recommendation to treat critically ill children with IO infusion.[5]

IO infusion may be gradually expanding into other conditions in paediatric emergencies in which urgent vascular access is needed. In paediatric septic shock, early aggressive fluids management is crucial to improve survival. In 2009, the ACCM updated their guidelines on haemodynamic support of paediatric and neonatal septic shock. The old guidelines (from 2002) recommended aggressive fluids treatment via peripheral line or central vein catheter (CVC) in critically ill infants or children. The ACCM currently recommends that aggressive fluids management should be provided via the IO route if peripheral IV access cannot be rapidly obtained.[15]

2.2. IO infusion in adults with cardiac arrest

In 2005, the AHA and the ERC revised their guidelines to include recommending IO access in adults with cardiac arrest when IV access is not available.[16] These recommendations were re-emphasized in the AHA 2010 guidelines which recommended that only an appropriately trained provider should place a CVC (internal jugular or subclavian).[3]

2.3. IO infusion in trauma

The American College of Surgeons Committee on Trauma, in its 2008 Advanced Trauma Life Support (ATLS) course, discouraged using IO access in adults. However, it recommended using IO infusion in children in whom venous access was impossible or difficult (when two attempts for placing intravenous cannula failed).[4] In the military field, establishing IV access for resuscitation of critically injured casualties remains a persistent challenge. During the military engagements of the U.S. and the U.K. armies in Iraq and Afghanistan, and the Israeli army in the Second Lebanon War, IO access emerged as a viable alternative to IV.[17–19] The U.S. Army Committee on the TCCC guidelines currently (2010) recommends using IO infusion in any resuscitation scenario in which IV access is not obtainable.[6]

3. IO infusion devices

3.1. Manual needles

The first devices to be introduced were the manual needles which are still widely used by many practitioners. There are currently several different manual IO needles commercially available. These are all basically modified steel needles with central removable trocars that prevent plugging during insertion. The Jamshidi/Illinois (Cardinal Health, McGaw Park, IL), the threaded Sur-Fast needle, and the Dieckman modified needle (both from Cook Critical Care, Bloomington, IN) are the most commonly used manual IO needles. These needles are all relatively similar, and their success rate, time for insertion, and ease-of-use seem to be comparable.[20–22] Previous studies and case reports showed that manual needles can be easily used in young paediatric patients, but are considered technically more difficult in older patients.[23,24]

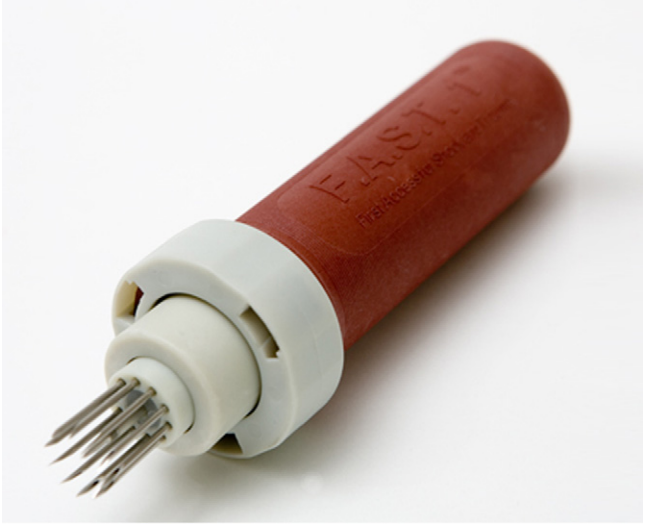

Fig. 1. The FAST 1. Pyng Medical Corporation, Vancouver, Canada.

Over the last 14 years, three mechanical semi-automatic IO devices designed for use both in children and adults were approved by the Food and Drug Administration (FDA). The IO device, the FAST 1 (Pyng Medical Corporation, Vancouver, Canada), was approved by the FDA in 1997. The spring-loaded IO device (bone injection gun – BIG, Waismed Ltd., New York, NY, USA), was approved in 2000, and the battery-powered IO drill (EZ-IO, Vidacare, San Antonio TX, USA) was approved in 2004.[25–28] The development of these IO devices has increased the options available for IO access.

3.2. The FAST 1

The FAST 1 (Fig. 1) is a sternal IO infusion device that creates a port through which fluids can be introduced via the sternum. The FAST 1 is a sterile disposable system which uses a probe composed of multiple needles that properly align the device with the patient's sternum. A guide is placed on the upper part of the sternum to mark placement, and the device uses a bed of needles to control the depth. With manual pressure, the IO device is inserted into the sternum and the infusion tube is left in place. The device requires the use of a specialized tool to remove it from the sternum.[25] Although the FAST 1 can be used in older children and adolescents, current literature indicates that this device has been used almost exclusively in adult patients.[23] A new generation of the device, the FAST X (Fig. 2) was approved by the FDA in September 2010. The device has been re-engineered and, according to the manufacturer, is faster and easier to use than the FAST 1. In this latest version, a removal tool is no longer needed.[26]

3.3. The bone injection gun (BIG)

The BIG is a small automatic plastic disposable IO injector. It includes a spring-loaded device with a trigger. Once the safety pin is