Resuscitation 83 (2012) 40–45

Contents lists available at SciVerse ScienceDirect

Resuscitation

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

Clinical paper

Comparison of intraosseous versus central venous vascular access in adults under resuscitation in the emergency department with inaccessible peripheral veins☆

Bernd A. Leidel[a,c,*], Chlodwig Kirchhoff[b], Viktoria Bogner[b], Volker Braunstein[b], Peter Biberthaler[b], Karl-Georg Kanz[b]

[a] Department of Emergency Medicine, Campus Benjamin Franklin, Charité – University Medical Centre, Berlin, Germany
[b] Department of Trauma, Medical Centre of the University of Munich, Germany
[c] Helicopter Emergency Medical Service Christoph 31, ADAC-Luftrettung Air Rescue Services, Campus Benjamin Franklin, Charité – University Medical Centre, Berlin, Germany

ARTICLE INFO

Article history:
Received 10 May 2011
Received in revised form 11 July 2011
Accepted 15 August 2011

Keywords:
Intraosseous
Intraosseous infusion
Central venous
Resuscitation
Emergency treatment

ABSTRACT

Introduction: Current European Resuscitation Council (ERC) guidelines recommend intraosseous (IO) vascular access, if intravenous (IV) access is not readily available. Because central venous catheterisation (CVC) is an established alternative for in-hospital resuscitation, we compared IO access versus landmark-based CVC in adults with difficult peripheral veins.
Methods: In this prospective observational study we investigated success rates on first attempt and procedure times of IO access versus central venous catheterisation (CVC) in adults (≥18 years of age) with inaccessible peripheral veins under trauma or medical resuscitation in a level I trauma centre emergency department.
Results: Forty consecutive adults under resuscitation were analysed, each receiving IO access and CVC simultaneously. Success rates on first attempt were significantly higher for IO cannulation than CVC (85% versus 60%, $p = 0.024$) and procedure times were significantly lower for IO access compared to CVC (2.0 versus 8.0 min, $p < 0.001$). As for complications, failure of IO access was observed in 6 patients, while 2 or more attempts of CVC were necessary in 16 patients. No other relevant complications like infection, bleeding or pneumothorax were observed.
Conclusions: IO vascular access is a reliable bridging method to gain vascular access for in-hospital adult patients under resuscitation with difficult peripheral veins. Moreover, IO access is more efficacious with a higher success rate on first attempt and a lower procedure time compared to landmark-based CVC.

1. Introduction

Current European Resuscitation Council guidelines for resuscitation recommend intraosseous (IO) route for delivery of drugs, if intravenous access cannot be achieved.[1] Peripheral intravenous (IV) access might be difficult, especially in dehydrated patients, those in shock, following chemotherapy, obese, with oedema or IV drug users. Failure rates of IV access in the emergency setting are described around 10–40% and average time needed for peripheral IV catheterisation is reported between 2.5 and 16 min in patients with difficult IV access.[2,3,4,5] Delays in establishing vascular access in the field might be followed by additional delay in the emergency department, when reattempting vascular access suspend necessary diagnostic and treatment procedures.

Alternative routes of drug and fluid administration are sublingual, endotracheal, subcutaneous and intramuscular. However, these options are not reasonable in most cases of emergencies and controversial due to unpredictable plasma concentrations along with unknown optimal dose of most drugs.[1] Central venous catheterisation (CVC) is an alternative, but it requires the interruption of CPR in the majority of cases and may be associated with risks for the patient, especially in the emergency setting.[1,5–10]

Consequently, a different vascular access technique may be reasonable, at least as a bridging option during ongoing resuscitation efforts. In this context, intraosseous (IO) vascular access of the non-collapsible and highly vasculated intramedullary venous plexus of concellous bone marrow can provide a rapid, safe and easy vascular access to administer drugs, fluids and blood products.[11] In infants and children IO approach for emergency vascular access has been widespread adopted for decades already.[1] However the role of IO access in adults is much less propagated.[12] Only few studies specifically investigate IO access in adults, and most of them were

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at doi:10.1016/j.resuscitation.2011.08.017.

* Corresponding author at: Charité – Universitätsmedizin Berlin, Campus Benjamin Franklin, Interdisziplinäre Rettungsstelle/Notfallaufnahme, Hindenburgdamm 30, D-12200 Berlin, Germany.
Tel.: +49 30 8445 2181; fax: +49 30 8445 773029.
E-mail address: bernd.a.leidel@charite.de (B.A. Leidel).

0300-9572/$ – see front matter © 2011 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.resuscitation.2011.08.017

restricted to the prehospital setting or training studies in animal or cadaver models. Own preliminary data of 10 adult patients in the emergency department showed potential benefits of IO access compared to conventional CVC regarding higher success rates and shorter procedure times on first attempt.[7]

Therefore our goal was to compare the time required to establish IO access versus CVC in adult patients undergoing resuscitation who initially had unsuccessful attempts at peripheral IV access, as well as report on their complication rates.

2. Methods

2.1. Study design and setting

This prospective, clinical trial was conducted between November 2007 and May 2009 at the emergency department of an urban level I trauma centre and teaching hospital with approximately 35,000 presentations a year. Our institutional review committee approved this study.

2.2. Selection of participants

Based on physiological criteria we approached consecutively all severely injured or critically ill adult patients under resuscitation admitted to our emergency department without at least 1 efficient 18-gauge peripheral IV access. A senior attending physician, consultant in surgery directed resuscitative efforts as team leader following protocols of advanced trauma life support for severely injured and advanced cardiac life support for critically ill patients. Indications for vascular access included blood drawing for serum analysis, delivery of drugs, antibiotics, fluids or blood products when no other access was available. Exclusion criteria were age under 18 years, pregnancy and prisoners. Informed consent was obtained delayed from each patient when returning to full consciousness or from legal representative as surrogate after enrolment. Each patient received both, IO access and CVC to compare success rate on first attempt and necessary procedure time. To compare 2 different IO access devices we prospectively randomised and assigned them to patients prior to the beginning of this trial. Patients were randomised to one of two IO access devices by computer-generated block randomisation. Allocation assignments were concealed in serially numbered opaque sealed envelopes. The operator and patient became aware of the access device only after enrolment.

2.3. Interventions

During initial resuscitation in accordance with present standards of care, peripheral IV access was attempted for a maximum of 3 efforts or a maximum of 2 min. If unsuccessful, IO access and CVC were performed in a standardised course of action by 2 independent operators.

2.4. Operators of IO and CVC

Operators were trained specialists and well experienced in resuscitation. Anaesthesiologists experienced of at least 25 successful traditional landmark CVC procedures without supervision performed CVC while surgeons provided the IO access. Before commencement of the study, surgeons participated in a 2-h education program outlining the use of the IO device with instructional videos and consecutive hands-on training.

2.5. Central venous catheterisation

CVC was performed in a standardised procedure using traditional landmark orientated Seldinger technique.[13,14] For haemodynamic monitoring option, internal jugular or subclavian vein was preferred to femoral access. According to our protocol, insertion site was primarily subclavian vein for CVC, but a different insertion site was chosen appropriate to injury pattern or disease. For CVC a standard triple- or quad-lumen 7-French (2.3 mm), 20 cm in length catheter (Arrow International Inc., 155 South Limerick Road, Limerick, PA 19468-1699, USA) was used, depending on patients' need. A chest radiograph was obtained in each patient following CVC to confirm placement and assess for complications.

2.6. Intraosseous vascular access

IO access was performed in a standardised course of action. According to our protocol, insertion site was primarily the proximal humerus. Different insertion sites were chosen appropriate to injury pattern or patients' condition. For example, if there was an obvious or suspected injury of both upper limbs, the tibial insertion site was used. Lower limbs were also preferred if anatomical landmarks of proximal humerus insertion site were unable to identify due to excessive soft tissue. After IO cannulation the prepared extension tubing was attached before drug and fluid administration. Each IO cannula was used only once and removed within 24 h of insertion according to manufacturers' recommendations. IO access was established with 2 different FDA-approved devices: the battery driven EZ-IO system (Vidacare Corporation, 722 Isom Road, San Antonio, TX, USA) and the spring load driven Adult BIG Bone Injection Gun (WaisMed Ltd., 2 Hamada Street, Yokneam, Israel). Technical specifications and procedure details of both devices have been published elsewhere.[15]

2.7. Methods of measurement, data collection and processing

Success rate of the procedure on first attempt was defined as successful administration of drugs or fluids via the newly established vascular IO access or CVC on first effort. Failure in CVC was defined as impossible insertion or advancing the guide wire. However, more than one (the first) attempt to puncture a central vein was not distinct as failure. The measured time of each procedure was defined as the duration of picking up the prepared set of IO access device or CVC set from the shelf, preparation of the access set and patients' insertion site including sterilisation and draping, insertion procedure of IO access or CVC itself, assembling of the access set and first successful administration of drugs or fluids through the newly established vascular access. An independent observer with 2 stopwatches took the time of each procedure. The patient's baseline characteristics such as age, gender, injury or cause of vital organ disorder were retrieved subsequently from the hospital record, if not available on admission. All treatment data and variables were collected prospectively in a structured form for each patient.

2.8. Outcome measures

Main outcome measures were success rate and procedure time of IO cannulation and CVC on first attempt. Secondary outcome measures included the prior determined possible complications according to literature, including failure of vascular access, malposition, dislodgment, bleeding, compartment syndrome, arterial puncture, haematothorax, pneumothorax and vascular access