Resuscitation 127 (2018) 79–82

Contents lists available at ScienceDirect

Resuscitation

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

Clinical paper

Anatomical investigations on intraosseous access in stillborns – Comparison of different devices and techniques☆

Zeynep Fuchs[a], Martin Scaal[b], Heinz Haverkamp[c], Friederike Koerber[d], Thorsten Persigehl[d], Frank Eifinger[a,*]

[a] Department of Pediatric Critical Care Medicine and Neonatology, University Children's Hospital, Kerpener Str. 62, 50937 Cologne, Germany
[b] Institute of Anatomy II, University of Cologne, Kerpener Str. 62, 50937 Cologne, Germany
[c] Institute of Medical Statistics and Computational Biology, University of Cologne, Kerpener Str. 62, 50937 Cologne, Germany
[d] Department of Radiology, University of Cologne, Kerpener Str. 62, 50937 Cologne, Germany

ARTICLE INFO

Keywords:
Resuscitation
Intraosseous
Neonatal
Newborn
Access
Anatomy

ABSTRACT

Aim: Intraosseous (IO)-access plays an alternative route during resuscitation. Our study was performed to investigate the successful rate of IO-access in preterm and term stillborns using different devices and techniques.
Methods: The cadavers used were legal donations. 16 stillborns, median: 29.2 weeks (IQR 27.2–38.4) were investigated. Two different needles (a: Butterfly needle, 21G, Venofix® Fa.Braun; b: Arrow®EZ-IO®15G, Teleflex, Dublin, Ireland) were used. Needles were inserted i: manually, using a Butterfly needle; ii: manually, using EZ-IO® needle or iii: using a battery-powered semi-automatic drill (Arrow®EZ-IO®). Spectral-CT's were performed. The diameter of the corticalis was determined from the CT-images. Successful hit rates with 95% confidence intervals (CI) and odds ratios between the three methods were estimated using a generalised linear mixed model (GLMM).
Results: Estimated success rate was 61.1% (95%CI:39.7%–78.9%) for the Butterfly needle, 43.0% (95%CI:23.4%–65.0%) for hand-twisted EZ-IO® screwing and 39.7% (95%CI:24.1–57.7%) for the semi-automatic drill (Arrow®EZ-IO®), all referring to an average diameter of the corticalis of 1.2 mm. The odds of a correct position were 2.4 times higher (95%CI:0.8–7.6) when using the Butterfly needle than with the drill. In contrast, the odds of correct positioning when inserting the needle by hand were not significantly different from using the drill (odds ratio 1.1, 95%CI: 0.4–3.3). Neither of these effects nor the diameter of the corticalis with an odds ratio near one were significant in the model. Median diameter of the bone marrow cavity was 4.0 mm [IQR 3.3–4.7].
Conclusion: Intraosseous access for premature and neonatal infants could be best achieved by using a manually twisted Butterfly needle.

Introduction

In the emergency setting, rapid vascular access is recommended for drug and fluid administration. Peripheral venous cannulation can be difficult or impossible in children, especially newborns, as success rates are significantly associated with patient age [1]. Therefore, intraosseous (IO)-access is used as an alternative route if intra-venous access has failed and medication for resuscitation must be given immediately. Resuscitation in pre- and term newborns is problematic due to the fragility and small size of peripheral venous vessels. According to the European Resuscitation Council Guidelines 2015 [2] drugs are best given via a centrally positioned umbilical venous catheter. IO-access is sometimes performed in serious cases independently of umbilical catheterisation [3]. Circumstances in which intraosseous access may be preferred over umbilical venous catheterization remain unclear [4–6].

Complications (e.g. compartment syndrome, dislodgement, dysfunction, needle break, fracture etc.) of intraosseous access in neonates and infants are often serious and well described [7–10] and it is evident, that complication, as well as unsuccessful placement rate, will proportionally arise in younger patients [11]. Intraosseous access can be performed via a battery-powered semi-automatic drill (Arrow®EZ-IO®) or using alternative needles (e.g. Butterfly needle, bone marrow needle) with manual insertion, e.g. hand-twisted. Both techniques are used during neonatal resuscitation. The Arrow®EZ-IO® (Teleflex, Dublin, Ireland) is a reusable battery-powered semi-automatic drill that comes with single-use specialised sterile IO-needles to be attached to the drill

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at https://doi.org/10.1016/j.resuscitation.2018.04.003.

* Corresponding author.
E-mail address: Frank.Eifinger@uk-koeln.de (F. Eifinger).

https://doi.org/10.1016/j.resuscitation.2018.04.003
Received 5 January 2018; Received in revised form 24 February 2018; Accepted 3 April 2018

Table 1
Patient characteristic: Sixteen (8 female, 8 male) formaldehyde-fixed (10%) stillborns were investigated (median gestational age: 29.2weeks (IQR 27.2–38.4)). The investigation involved both legs. The needle for intraosseous access was manipulated manually (Butterfly needle and Arrow®EZ-IO® intraosseous needle) and by means of an automated puncture system (Arrow®EZ-IO® intraosseous drill, Teleflex, Dublin, Ireland). The exclusive position of the needle in the bone marrow was regarded as successful placement (+). The diameter of the corticalis was determined from the CT images. No. = preparation number, n/a = not applicable, GA = gestational age, i.o. = intraosseous, G = Gauge.

No.	GA [week]	Diameter of the corticalis [mm]		Catheter placement (±)					
				Butterfly needle [21G]		EZ-IO® needle manual		EZ-IO® needle drill	
		right	left	right	left	right	left	right	left
1. (75/37)	26 + 3	1.1	0.9	−	+	−	−	+	−
2. (76/37)	29 + 2	1.0	1.1	+	−	+	−	+	−
3. (74/35)	39 + 5	1.3	1.4	−	−	−	−	+	−
4. (1/87)	39 + 5	1.7	1.3	+	−	−	−	−	−
5. (11/1981)	29 + 1	1.2	1.1	+	+	−	−	−	−
6. (75/48)	32 + 0	1.2	1.0	+	−	+	+	−	−
7. (77/18)	25 + 0	1.3	1.1	−	−	−	−	−	−
8. (23/78)	29 + 1	1.3	1.3	+	+	+	+	+	+
9. (26/78)	43 + 2	1.2	1.2	−	−	−	−	+	+
10. (2/1985)	27 + 4	1.2	1.1	+	−	+	−	+	−
11. (587)	37 + 1	1.0	1.1	n/a	n/a	n/a	n/a	−	+
12. (23/79)	35 + 0	1.3	1.3	+	+	−	+	−	−
13. (7622)	29 + 1	1.2	1.4	+	+	+	−	−	+
14. (2878)	26 + 6	1.0	1.2	+	+	+	+	+	−
15. (788)	26 + 0	1.1	1.1	+	+	−	+	+	−
16. (1779)	39 + 4	1.3	1.1	−	+	+	+	−	+

with different needle lengths.

There are only limited studies about IO-infusion access in newborn patients [12,13] and mainly performed in patients more than one month of age [13–15]. Our study investigated the feasibility of performing intraosseous access in preterm and term stillborns using different devices and techniques.

Methods

The cadavers used for the investigations were legal donations to the Centre of Anatomy, University of Cologne, Germany. After ethical committee approval (No: 16-408), sixteen (8 female, 8 male) formaldehyde-fixed (10%) stillborns were investigated (median gestational age: 29.2weeks (IQR 27.2–38.4); Table 1). There was no morphological malformation in the bodies investigated. The age of gestation of the cadavers was compared to the documented gestational age by measuring the length of the clavicle according to Sherer et al. [16].

Two different needles (a: Butterfly needle, B.Braun Venofix® Safety, 0,8 × 19 mm, 21G, colour green; b: EZ-IO® intraosseous needle PD 15G for 3–39 kg body weight with a maximum depth of 15 mm, colour pink, Teleflex Medical, Dublin, Ireland) were applied to a total of 16 premature and term cadavers by an experienced investigator using a standard protocol. In detail, the tibial tuberosity was identified and approximately 15 mm distal and medial to the patella, the place of insertion was located. This location (Fig. 1) is in accordance with the official recommendation in placing IO-access in paediatric emergency care [2]. The investigation involved the tibial bone of both legs of each cadaver. The needle was first inserted manually (Butterfly needle or EZ-IO® intraosseous needle) and then by means of a battery-powered semi-automatic drill (Arrow®EZ-IO® intraosseous drill, Teleflex, Dublin, Ireland). In total, the investigation was performed 15 times using Butterfly needle, 15 times manually using an EZ-IO® intraosseous needle and 16 times using a battery-powered semi-automatic drill (Arrow®EZ-IO®). Due to an amputation just below the knee joint having been performed on one cadaver (No.587), the attachment of the intraosseous needle could only be achieved by using a battery-powered semi-automatic drill (Arrow®EZ-IO®). The correct position of the needle within the bone marrow cavity was analysed by spectral-CT (Table 1, Fig. 2).

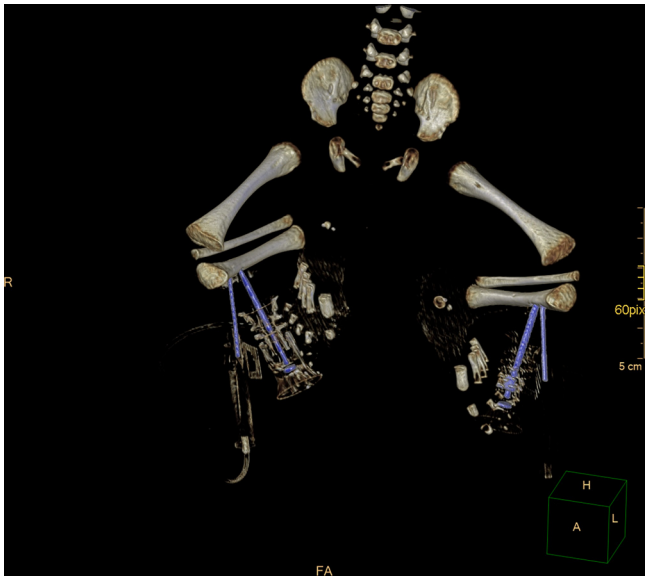

Fig. 1. Postmortem computed tomography (CT) of a preterm stillborn infant, age 29 + 1 gestational weeks showing the correct installation of both intraosseous needles on the tibia on both sides (proximal Butterfly needle and distally located hand-twisted EZ-IO® intraosseous needle).

Spectral-CT examination (iQon®, Dual-layer Spectral-CT, Philips™, The Netherland) were performed, row data were reconstructed using a soft kernel (soft tissue window) and an ultra hard kernel (bone window), saved in DICOM format and analysed on a clinical PACS workstation (IMPAX-EE® V.R20XVISU2, AGFA, Germany). In order to clarify the position of the intraosseous needle, 1 ml contrast medium (Imeron®, Fa.Bracco™, Konstanz, Germany) was injected and the distribution of the contrast agent was analysed whether there was contrast medium inside the bone marrow cavity (successful placement) or only outside the bone (unsuccessful placement, Fig. 3). Focus distance was kept constant in all investigations and positioned in order to reduce parallax to a minimum. Due to the special properties of iQon® Spectral-

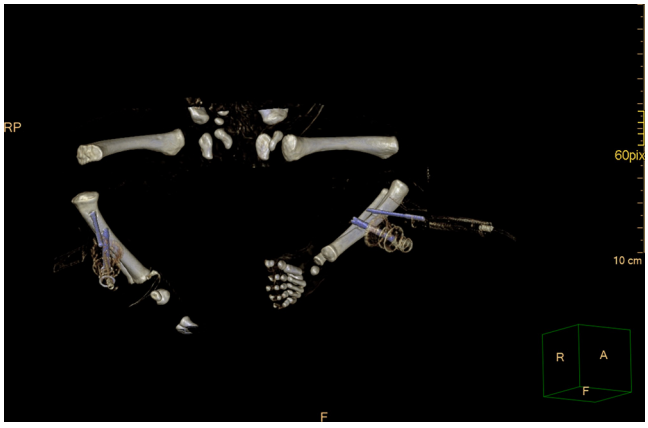

Fig. 2. Postmortem computed tomography (CT) of a preterm stillborn infant, age 27 + 4 gestational weeks demonstrating the dislocated installation of the intraosseous needles on the right tibia and correct installation on the left one (proximal Butterfly needle and distally located hand-twisted EZ-IO® intraosseous needle).