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Simulation and education

Comparison of intravenous and intraosseous access by pre-hospital medical emergency personnel with and without CBRN protective equipment☆

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ABSTRACT

Introduction: Rapid intravascular access is a prerequisite component of emergency care and resuscitation. Peripheral intravenous (IV) access is the first-choice for most of the medical or trauma patients, but may be delayed in emergency conditions because of various difficulties. Elsewhere, intraosseous (IO) access may now be easily performed with a new semi-automatic battery-powered IO-insertion device (EZ-IO®). The aim of this study was to compare the overall time to establish IO infusion with the EZ-IO® device and the equivalent time for peripheral IV infusion, performed by emergency personnel in standard (No-CBRN) and in chemical, biological, radiological, and nuclear (CBRN) protective equipment.

Methods: Nine nurses and 16 physicians randomly performed 4 procedures on a training manikin: IV and IO access under No-CBRN conditions and IV and IO under CBRN conditions. The time for each infusion attempt included all the steps essential for a simulated safe clinical use of infusion.

Results: Under No-CBRN conditions, the time to establish IO infusion was shorter than the equivalent IV time (50 ± 9 *vs* 70 ± 30 s). Similarly, under CBRN conditions, the time for IO infusion was shorter than for IV infusion (65 ± 17 *vs* 104 ± 30 s). The mean time saved by IO infusion over IV infusion was respectively 20 ± 24 s ($P < 0.001$) and 39 ± 20 s ($P < 0.001$) under No-CBRN and CBRN conditions.

Conclusion: The time to establish IO infusion was significantly shorter than that for peripheral IV infusion, under both No-CBRN and CBRN conditions. Further clinical studies are required to confirm that IO access would effectively save time over IV access in real pre-hospital emergency settings.

1. Introduction

Rapid intravascular access is an essential component of emergency care and resuscitation, allowing administration of fluids, pressor agents, or other drugs such as anesthetic agents. Generally, peripheral intravenous (IV) access is the first-choice for most of the medical or trauma patients, whereas other potential routes for vascular access, such as central venous access, are time-consuming to establish and consequently are rarely attempted. Nevertheless, in emergency conditions, there may be many causes of difficulty and subsequent delay in inserting a peripheral IV cannula. Firstly, the pathophysiological condition of the patient may be unfavorable, because of a poor venous network or multiple previous punctures.[1] Secondly, the condition requiring intravascular access may be itself responsible for difficulties, of which the more frequent reason is shock.[2] Thirdly, the pre-hospital setting may increase difficulties for IV access, whether peripheral or central, especially in an unlighted small room, or for an entrapped patient.[3] Finally, in special circumstances such as wearing chemical, biological, radiological, and nuclear (CBRN) protective equipment, with a facial filtration respirator and butyl gloves, IV access may be much more difficult.[4]

Intraosseous (IO) access was first described as an alternative to conventional intravenous access during the 1930s and 1940s, and was thereafter extensively used in emergency cases during World War II.[5] Afterwards, IO access was not largely used in adults, and was essentially limited to paediatric emergencies, mainly because for fear of complications such as osteomyelitis or fat or bone marrow embolism.[6,7] Currently, IO access is the first recommended vascular access in paediatric emergencies such as cardiac arrest.[8–10] Conversely, for adult cardiac arrest, according to the most recent international guidelines, an attempt at peripheral venous access is the first-choice, whereas IO access is the first alternative when intravenous access is delayed or impossible.[11,12]

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Although several IO-insertion manual devices have been available for a long time, a new semi-automatic battery-powered IO-insertion device has recently been marketed (EZ-IO®, Vidacare™) for both paediatric and adult use. In a comparison between the EZ-IO® device and a classical manual infusion device, the EZ-IO® device was reported as more effective, mainly because of a higher rate of success at the first attempt and a lower rate of complications.[13] Therefore, the aim of this study was to compare the overall time to establish IO infusion with the EZ-IO® device with the overall time for peripheral IV infusion, performed by experienced physicians and nurses, first wearing standard pre-hospital emergency care equipment, and then when wearing CBRN protective equipment.

2. Materials and methods

This study was conducted in accordance with the French legislation and ethical committee recommendations, and no patient was involved. The procedures were performed in the pre-hospital emergency department of a university teaching hospital. All the professionals participating in this study were voluntary physicians and nurses regularly practicing in the department, who were all experienced in pre-hospital emergency medicine. However, none of them had been previously trained in IO access, either manual or using the EZ-IO© device.

Prior to the study, all participants received guidelines and training regarding the study, and were enrolled in a workshop. This 1-h workshop included a theoretical presentation by an expert and hands-on practice of IO-insertion in a training manikin (Vidacare™ training kit). After the workshop, each participant successively performed 4 procedures in an individual randomly assigned order, which had been computer-generated prior to the beginning of the study. The 4 procedures were (1) IV infusion while wearing standard pre-hospital equipment (IV No-CBRN), (2) IV infusion while wearing CBRN equipment including a filtration respirator and butyl gloves (IV CBRN), (3) IO infusion while wearing standard pre-hospital equipment (IO No-CBRN) and (4) IO infusion while wearing CBRN equipment (IO CBRN).

For the IV infusion, each participant used a single-use 18-gauge peripheral intravenous catheter (Vygon™), which was inserted in a Multi Venous IV Training Arm Kit (Laerdal™). For the IO infusion, each participant used the semi-automatic device EZ-IO®, which is a reusable battery-operated motor that drives a drill-tipped single-use 15-gauge needle into the bone (Vidacare™ training kit). For each infusion attempt, materials were presented to the participant in sterile pre-packaged kits containing the needle, dressings, infusion line and infusion bag. For the No-CBRN conditions attempts, each participant used non-sterile gloves, whereas for the attempts under CBRN conditions, each participant used butyl gloves. Manikins were placed on a table in a well-lit room of the pre-hospital emergency department. Each IV or IO infusion attempt was recorded on a videotape, and the time for each attempt was measured offline by an investigator with a stopwatch.

The period for each infusion attempt began when the participant has access to the manikin, and continued until starting a successful fluid infusion, including all the steps mandatory for a simulated clinical safe use of the infusion line. Therefore, the total measured time included all the following stages: putting on non-sterile gloves for No-CBRN conditions, skin disinfection, preparation of the infusion line, insertion of the IV or IO needle for the vascular access according to the infusion attempt, aspiration test and flush injection for IO access, connection of the infusion line to the IV or IO needle, secured fixation of the access on the skin, and starting the fluid infusion. In the case of failure of an IV or IO access attempt, including the case of absence of fluid infusion after connection of the infusion line to the vascular access, the participant immediately re-attempted IV or IO access, and the total measured time was still running until finally starting a successful fluid infusion.

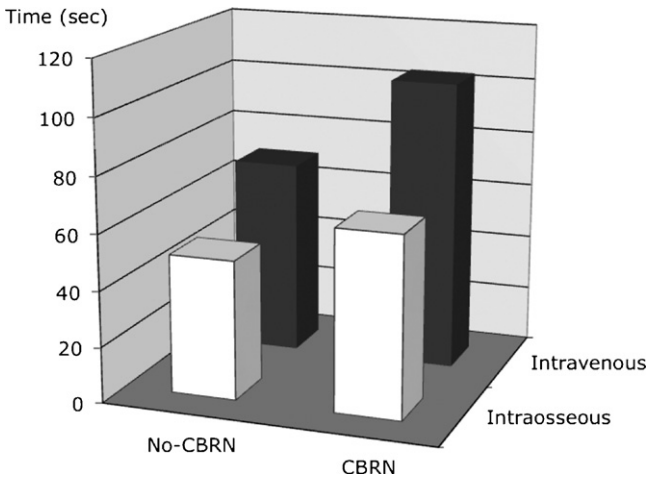

Figure 1. Time for intraosseous infusion and for intravenous infusion in No-CBRN and in CBRN conditions on a training manikin.

The time taken for each infusion attempt was measured offline while reviewing procedures by videotape, and subsequently entered into a computer spreadsheet. Times were measured in seconds, and results expressed as means ± SD. For each participant, the number of attempts until success was counted for each vascular access. Comparisons between groups were performed using the paired Student *t*-test with R© software (http://cran.r-project.org). All statistical tests were 2-sided and were considered to be statistically significant at $P < 0.05$.

3. Results

Twenty-five pre-hospital emergency professionals participated in this study. Nine were nurses or nurse–anesthetists and 16 were physicians. Each participant performed each of the 4 vascular access procedures at the first attempt. No complication was observed for any attempt.

Under No-CBRN conditions, the time to establish IO infusion was shorter than the equivalent IV time (50 ± 9 *vs* 70 ± 30 s) (Figure 1). Similarly, under CBRN conditions, the time for IO infusion was shorter than for IV infusion (65 ± 17 *vs* 104 ± 30 s). The time under CBRN conditions was significantly increased compared with No-CBRN conditions, both for IV (34 ± 35 s, $P < 0.001$) and IO infusion (15 ± 16 s, $P < 0.001$). Overall, irrespective of the conditions, the time for IO infusion was significantly reduced compared with IV infusion. Consecutively, the mean estimated time saved by IO infusion over IV infusion was 20 ± 24 s ($P < 0.001$) under No-CBRN conditions and 39 ± 20 s ($P < 0.001$) under CBRN conditions.

4. Discussion

In this study, we have reported that, while times to establish both IV and IO infusion were significantly increased while wearing CBRN equipment with a filtration respirator and butyl gloves, the time for IO infusion was significantly reduced as compared to time for IV infusion, whatever the No-CBRN or CBRN condition.

Several studies have shown that IO access, both in children and adult patients, is safe, simple and effective, and is associated with a low rate of complications provided proper technique and training are used.[14–17] Moreover, in opposite to peripheral veins, intramedullary blood vessels do not collapse during shock.[7] In a recent review of IO access for emergency vascular infusion in adults, Bruttig and Kramer concluded that IO device insertion is