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Analiza porównawcza wybranych technik dostępów doszpikowych w warunkach medycyny ratunkowej

Rozprawa na stopień doktora nauk medycznych i nauk o zdrowiu w dyscyplinie nauki medyczne

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COMPARATIVE ANALYSIS OF SELECTED INTRAOSSEOUS ACCESS TECHNIQUES IN EMERGENCY MEDICINE CONDITIONS

Introduction

The ability to obtain intravascular access in emergency medicine is one of the obligatory critical competences of medical personnel. In emergencies, such as cardiac arrest or shock, the vascular bed is collapsed, proving intravenous access challenging or even impossible to obtain. In such cases, an alternative is intraosseous access, which warrants comparable effectiveness in terms of fluid and pharmacotherapy provision in life-threatening conditions.

Amidst the COVID-19 pandemic when medical personnel, especially emergency medicine teams, should treat each patient as potentially infected with the SARS-CoV-2 virus, medical procedures should be carried out wearing personal protective equipment (PPE). Studies on endotracheal intubation, however, show that the quality of CPR, obtaining intravenous access and performing procedures while wearing PPE may reduce the effectiveness of the performed procedure. It is, therefore, essential to pinpoint alternative methods of obtaining intravascular access, which, despite the use of PPE, will be more effective than intravenous line access.

Objectives

The aim of the research included in the thematically coherent series of publications was to compare various techniques of obtaining intraosseous access in the emergency medicine setting, both in the aspect of adult and pediatric patient populations.

Materials and Methods

The first study was a review paper that introduced a series of research on intraosseous lines. This work introduced the reader to the indications, contraindications, and potential complications of the intraosseous line access - using intraosseous lines in adults and pediatric patients.

The second study was a prospective, randomized, cross-simulation study comparing intraosseous (IO) access (including NIO-P, EZ-IO, and Jamshidi needles) to intravenous access using a standard intravenous cannula. The study included 65 nurses who obtained intravascular access to a simulated COVID-19 pediatric patient. Consequently, all procedures were performed by participants wearing full PPE. The following parameters were analyzed: the effectiveness of obtaining intravascular access, the duration of the procedure, and the ease of

its execution. Nurses' subjective preferences regarding the optimal method of obtaining the intravascular access in a COVID-19 pediatric patient were additionally assessed.

The third study was designed as a prospective, randomized, observational, crossover simulation study. 40 paramedics obtained intravascular access via IO access using B.I.G and NIO using simulated CPR on an adult patient. The order of participants and the mode of obtaining IO access were random. Time parameters related to the insertion of the needle into the intraosseous cavity, its stabilization, and the time to connect the infusion set were assessed. Additionally, the knowledge of potential complications of intra-IOs was assessed, and the overall effectiveness of obtaining IO.

The fourth study was also designed as a randomized crossover study. This study included 40 paramedics who performed IO using B.I.G and Jamshidi needles with and without CBRN protective wear. The test was performed under simulation conditions. PPE impact on the procedure's duration using each mode of IO access was assessed; the order of participants and mode of IO access was random.

The fifth study was designed as a systematic review and meta-analysis and was conducted under PRISMA guidelines. The study compared the effectiveness and safety of using intraosseous and intravenous lines by medical personnel wearing PPE. During the systematic review electronic databases were searched, including PubMed, Scopus, EMBASE, Web of Science, and the CENTRAL database. Predefined keywords were used to search the databases mentioned above. A search of databases based on keywords revealed 947 bibliographic records. After removing duplicate articles, preliminary analysis of papers based on titles and abstracts, followed by a comprehensive review of full texts of articles, 8 studies were qualified for meta-analysis. The last database search took place on April 10, 2020.

Results

In the study assessing intraosseous access in pediatric patients (NIO-P, EZ-IO, Jamshidi) with intravenous access performed by nurses wearing a full protective suit, the effectiveness of the procedure was 100% for NIO-P and EZ-IO, respectively, 80% for the Jamshidi needle and 69.2% for intravenous access. The duration of the procedure per each mode varied and amounted to 33 ± 3s, 37 ± 6.7s, 43 ± 7s, and 98.5 ± 10s, respectively. Ease of intubation on a 10-point scale where "1" meant an easy-to-perform procedure while "10" equaled a complicated procedure to perform - NIO-P and EZ-IO were scored 2 ± 1 point, obtaining an intra-IO with a Jamshidi needle at 5 ± 3 points, and intravenous access at 7 ± 2 points. The study participants

indicated the most preferred method of gaining access to the vascular system as the NIO-P device (78.5%).

In a study comparing NIO and B.I.G during simulated CPR, the IO access efficacy was 100% and 95%, respectively, for NIO and B.I.G. The time from the intraosseous device in hand to inserting the needle into the medullary canal was 5.4 ± 3.5 s for B.I.G. and 3.5 ± 2.5s for NIO puncture ($p = 0.014$). On the other hand, the time from taking the IO device to the participant's hand to the connection of the infusion set to the IO device was varied and amounted to 25 ± 5.5s and 11.5 ± 5.2s, respectively for B.I.G and NIO ($p <0.001$).

In the study comparing the obtaining of the intraosseous access, it was shown that the use of the CBRN suit significantly prolonged the duration of the procedure in the case of the Jamshidi needle (69.5 ± 34.2 and 35 ± 8s; $p <0.001$). However, this relationship was not observed in the case of the B.I.G (29.5 ± 13.2s and 22 ± 7s, with and without the CBRN suit, respectively; $p = 0.063$).

The meta-analysis comparing the effectiveness of IO access and IV access with full protective suits showed that the use of full protective clothing was associated with an increase in the duration of the IO access procedure (MD = 11.69; 95% CI: 6.47 - 16.92; $p <0.001$) as well as a decrease in the effectiveness of the intra-IOs access by 0.8% and the intravenous access by 10.1%. Under the conditions of performing the procedure in a protective suit, the duration of the procedure was significantly shorter in the case of the intraosseous puncture compared to the intravenous puncture (MD = -41.43; 95% CI: -62.36 - -24.47; $p <0.001$).

Conclusions

The conducted research allows for the following conclusions:

- Obtaining intravascular access by medical personnel wearing PPE, IO access compared to intravenous access is associated with a shorter duration of the procedure and an increase in the effectiveness.
- There are statistically significant differences between the semi-automatic IO access, the EZIO, and the Jamshidi needle.
- The use of full protective gear prolongs the duration of obtaining vascular access as well as reduces the first attempt at its execution.