Commentary

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Barriers to utilisation of Intraosseous vascular access in Paediatric Emergencies.

Running Title: Intraosseous access in Paediatric Emergencies

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Capsule Summary:

What's already known? Intraosseous (IO) access has been shown to be of great significance when it comes to emergency resuscitation of critically ill children. Such utility adds up even more especially when the patient's condition demands immediate vascular access of which couldn't have been easily secured by traditional venous access.

What's new in this review? Despite possessing a great potential as a lifesaving option in most emergency settings, IO is still not widely utilized. This review aims at breaking down unraveling the barriers to its usage. Not only that, but also synthesizing the best possible evidence-based recommendations that will keep promoting it's frequent utilization successfully in specific paediatric emergency situations.

Administering life-saving fluids and medications during paediatric emergency resuscitation inevitably requires rapid vascular access. Traditional intravenous access often requires multiple attempts to be successfully obtained; therefore, securing vascular access can be time-consuming [1]. Anatomical variations, excess subcutaneous fat, small and mobile veins, along with a child's fearfulness, often exacerbate the difficulty and prolong the process, which can further jeopardise the patient's clinical outcomes [2, 3]. In situations where quick vascular access needs to be secured and/or both central and intravenous access cannot be achieved promptly, intraosseous (IO) vascular access comes into play [4, 5]. IO vascular access is an increasingly common procedure for quickly establishing vascular access in most paediatric emergency settings [6]. Familiarity with both indications and contraindications (Table 1) for IO access is crucial for emergency medical services (EMSs) providers [6, 7].

IO success rates have been documented to be higher than traditional methods, with very minimal complication rates. One study found that IO access was successful in 86% of paediatric patients, with a median time to successful IO placement being 8 minutes [8]. Moreover, a recent study by Ting et al. reported IO success rates of 96.7% in young children in a pre-hospital setting [9]. Another prospective study conducted in Germany found an overall IO success rate of 98.3%, with a first attempt success rate of 81.9%. Additionally, 63.6% of patients were successfully punctured within the first 3 minutes from the time of indication [10]. In a 5-year review of pre-hospital IO needle placement, success rates were reported to be higher in children under 3 years (85%) than in older children or adults (50%). The main causes of failure were errors in the identification of landmarks, attempting IO access when contraindications existed, and bending of the needles after being placed incorrectly [11]. Improved tools and techniques, such as better needle design and new devices, have helped overcome drawbacks related to bone penetration, facilitating easier and faster access.

Despite the higher success rates reported in a wide variety of clinical settings, IO access is still not widely utilised in most emergencies that require quick vascular access [12]. Recent studies have reported the barriers to fully utilising IO access, primarily in adult emergency situations. However, there is limited synergistic information on the factors contributing to the underutilisation of the IO approach in paediatric

emergency patients. In this section, the focus will be on unravelling the factors that hinder IO access usage.

Lack of an overall understanding of IO indications and usefulness

A proper understanding of the purpose, indications, and benefits of IO access is essential for healthcare providers, as well as members of the public. Some patients and/or relatives have been quoted denying IO access procedure. In a national web-based survey conducted in China, 1233 (38.9%) emergency medical providers reported rejection from individual patients and/or their relatives when attempting to perform IO access [13]. To help mitigate such behaviour, it has been proposed that providing education aimed at raising awareness about the life-saving benefits of IO access, particularly in emergency situations, is of vital significance [14]. Additionally, emphasis should also be placed on the indications and contraindications of IO access, so that patients could be on the safest side [15].

The use of IO access in paediatric emergencies has been endorsed by the American Heart Association (AHA), the American College of Emergency Physicians (ACEP), the American Academy of Pediatrics (AAP), and many other reputable international organisations [16]. Improper risk–benefit analysis has led to the misconception that IO access is a very risky procedure with more harm than good. Such impressions have significantly discouraged IO access utilisation. Awareness of the benefits that come with IO access needs to be strengthened, especially among EMSs providers [17].

Suboptimal level of knowledge and experience regarding IO access

IO access should always be performed by a trained, qualified and a competent professional to ensure the safest outcomes [18]. In situations where EMSs providers may possess sufficient information regarding IO access itself, their skills and experience may be lacking. Pfister CA et al. emphasised the importance of enhancing structured, standardised training in IO puncture. Standardised training was found to improve success rates more than relying solely on a trainee's previous experiences and occupation [19]. On the other hand, Lo TY et al. reported that in order to reduce the reluctance of trainee paediatricians to use IO

access during emergencies, nothing is more helpful than previous real-life experiences of IO needle insertion [20]. Following proper IO-focused training, knowledge and attitude towards IO access utilisation have been reported to increase [21]. Studies further encourage regular workshops focused on IO access to contribute to shaping the overall readiness to undertake this vital approach [22]. Moreover, rescuers are obligated to learn safe techniques for establishing IO access [23]. In one study, telesimulation was found to be an effective novel approach in teaching procedural skills, including IO insertion techniques. Following the telesimulation teaching session, there were significant improvements in physician knowledge, self-reported confidence, and comfort levels in inserting the IO needle [24]. Another survey in a prospective observational study reported high satisfaction rates and improved operability of the IO procedure among EMSs providers after intensive training [25]. In order for IO vascular access to become a standard of care in clinical practice, education and training should be incorporated into core competency curricula [26]. The introduction of the Just-In-Time Training (JITT) curriculum was found to significantly improve the comfort level of the trainees in performing IO needle insertion [27]. In addition, recent advancements have made it possible to develop cost-effective 3D-printed adult proximal IO tibia task trainers (simulators) as a practical tool for practicing IO techniques. It has been reported that simulation-based training using such 3D-printed trainers is effective in fulfilling IO training objectives [28, 29, 30].

Psychological Barriers

The provision of EMSs is often associated with psychological challenges such as stress and anxiety [31]. EMSs providers often experience frustration when attempting to establish vascular access in critically ill patients, especially in children. Fear of failure and the potential to cause significant pain to the patient often make EMSs providers reluctant to place an IO needle [32]. For instance, Szarpak et al. highlighted how psychological factors influenced the underutilisation of IO access. In their study, 48% of participants reported that psychological barriers accounted for their decision to avoid the procedure, with fear being the most frequently reported barrier. Other factors included a lack of confidence in achieving IO access,

and stress while performing the procedure [33]. However, confidence in performing IO access increases with the number of learning modalities a trainee has been exposed to. That is, participants who had reported having previous hands-on workshops were less likely to have psychological concerns when inserting an IO device [34].

Lack of proper intraosseous access-focused protocols and guidelines

It is important for all EMS agencies to have the appropriate equipment, staff, protocols, and guidelines in order to ensure the provision of high-quality care to children [35]. Given the usefulness of IO techniques, IO-related protocols and guidelines are crucial in supporting clinical decision-making. Therefore, they should be developed, made available, and highly integrated into our daily emergency medical practice [36]. Several international organisations, including AHA, have established protocols and guidelines for emergency situations that have proven to be useful. However, the lack of specific national organisational guidelines regarding IO access in paediatric patients presents a significant challenge. Local guidelines are highly recommended to ensure that emergency medical teams can perform this procedure safely, effectively, and with full confidence [37].

Availability, Affordability, and User-friendliness of Intraosseous Devices

The evolution of medical technology has been instrumental in the development of a wide variety of IO devices [38]. A lack of proper IO equipment hinders the ability to perform the required procedure [39]. Despite groundbreaking and innovative efforts in developing suitable IO technologies, there are still disparities in accessibility. Recent studies have reported that one of the barriers faced by EMSs providers in performing IO procedures is the delayed acquisition of IO kit devices [40]. Despite numerous reasons to appreciate and support the development of new IO devices, several other issues have emerged. Among them is the cost of the devices, especially in resource-limited healthcare settings [41]. Cost is of great consideration when providing any aspect of patient care [42]. Additionally, there are concerns regarding user-friendliness that need to be addressed to provide a more robust healthcare service [43]. In a study

assessing IO device preference and satisfaction, it was found that EMSs providers preferred a powered IO system with passive needle-safety, easy-to-use features, and battery-powered enhancements that improve device reliability [44].

Awareness and understanding of IO usefulness in emergency situations is not enough if EMS providers lack crucial knowledge and expertise to perform the technique. Remote simulation-based training of IO techniques using recently developed 3D-printed simulators is recommended. This method has proven to be effective in equipping the EMS workforce with the crucial skills and confidence to perform IO procedures. Additionally, local health authorities should ensure the timely availability of IO-focused guidelines and user-friendly IO devices for EMS providers.

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Table 1. Detailed Indications, Absolute and Relative Contraindications of Intraosseous Access in Paediatric patients [45]

INDICATIONS:

- **Prompt Vascular access** required in life-threatening emergencies, but not immediately available via a peripheral vein[a)]
- **Diagnostic purposes**, including blood for laboratory analysis or point-of-care testing[b)]

CONTRAINDICATIONS:

Absolute Contraindications:

- Adequate venous access
- Fractured bone site
- Recent Orthopaedic Surgery with hardware at insertion sites
- Recent failed IO attempt in a target extremity (within 24 hours)
- Compartment syndrome in a target extremity
- Vascular injury at insertion site
- Inability to identify bony landmarks

Relative Contraindications:

- Burn Site
- Cellulitis, osteomyelitis, sepsis or bacteraemia
- Osseous abnormalities including Osteogenesis imperfecta, Osteoporosis, Osteopetrosis
- Right-to-left intracardiac shunt secondary to the risk of fat embolism
- Inferior vena cava injury
- Prosthesis in the target limb

*IO denotes Intraosseous access

*Footnotes: [a)] Life-threatening emergencies involving conditions such as shock, severe sepsis, cardiopulmonary arrest and status epileptus. [b)] Aspirate bone marrow from IO access is more suitable and preferred for inoculation of blood culture, bedside glucometer, pH, Hb, and lactate testing.