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Title: Strategies to improve IV start success by paramedics in paediatric trauma patients
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Clinical Scenario

A paramedic crew is dispatched code 1 to pedestrian vs. car, located one hour from a major trauma hospital. On arrival your patient is a four-year-old boy who is hypotensive, tachycardic and distressed. Your primary concerns are traumatic brain injury, internal bleeding and spinal injury. You attempt to gain intravenous (IV) access to administer fluids in order to increase blood pressure and maintain cerebral perfusion. You cannot gain IV access peripherally and as you are located rurally a more advanced paramedic is not available to initiate intraosseous (IO) access.

PICO Question

In paediatric trauma patients with suspected difficult peripheral intravenous access (PIVA), can paramedics implement techniques to improve the success of IV access, compared to the traditional palpation technique?

Research rationale

In trauma patients, vascular access is essential for patient outcome to prevent and/or manage deterioration through the provision of medication and fluid resuscitation (Verhoeff et al., 2018). There is a renowned increased difficulty cannulating a paediatric as they have smaller blood vessels that are often poorly visible or palpable. Intravenous cannulation of a paediatric often requires multiple attempts, with a first attempt success rate of 44-53% (Gümüş & Başbakkal, 2021). This inability to gain access may delay treatment and causes significant distress due to pain associated with reattempts or more invasive access such as IO (Steege et al., 2021).

Search Strategy

Three databases; Medline OVID, EMBASE and CINAHL, were used to search the literature from their commencement date to September 2021. The MeSH headings and keywords in Table 1 were combined with Boolean search commands to search for relevant articles.

Table 1: *MeSH headings and keywords used in search*

	Combined with: 'AND' & 'OR'	
"paed*"	"peripheral* IV"	prehospital*
"ped*"	"peripheral* intravenous"	paramed*
"child*"	"peripheral* venous access"	pre-hospital*
	"peripheral* vascular access"	"out of hospital*"
	"difficult IV access"	out-of-hospital
	"difficult intravenous access"	ambulance*
	"difficult venous access"	"emergency*"
	"difficult vascular access"	EMS

An English language limitation was placed on the search. Initially articles included were those that discussed strategies to improve PIVA in paediatric trauma patients treated prehospitally, however this yielded zero results and therefore it was modified. The modified inclusion criteria included paediatric patients within the prehospital, emergency department (ED) or intensive care unit (ICU) setting. Articles were excluded if they were published more than five years ago, full text article inaccessible, editorials and systematic/meta-analysis/literature reviews. Articles were assessed using the Oxford Centre of Evidence

Based Medicine, Level of Evidence (OCEBM, LOE) as seen in the appendix, and excluded if they had a score of four or greater.

Search Results & Analysis

From the initial search, 515 articles were located. Upon further review, 39 articles met the inclusion criteria and of these, five were considered suitable for critical appraisal. The article selection process can be seen in Figure 1 and a summary of the five articles seen in Table 2.

Figure 1. *PRISMA flow chart of selection process*

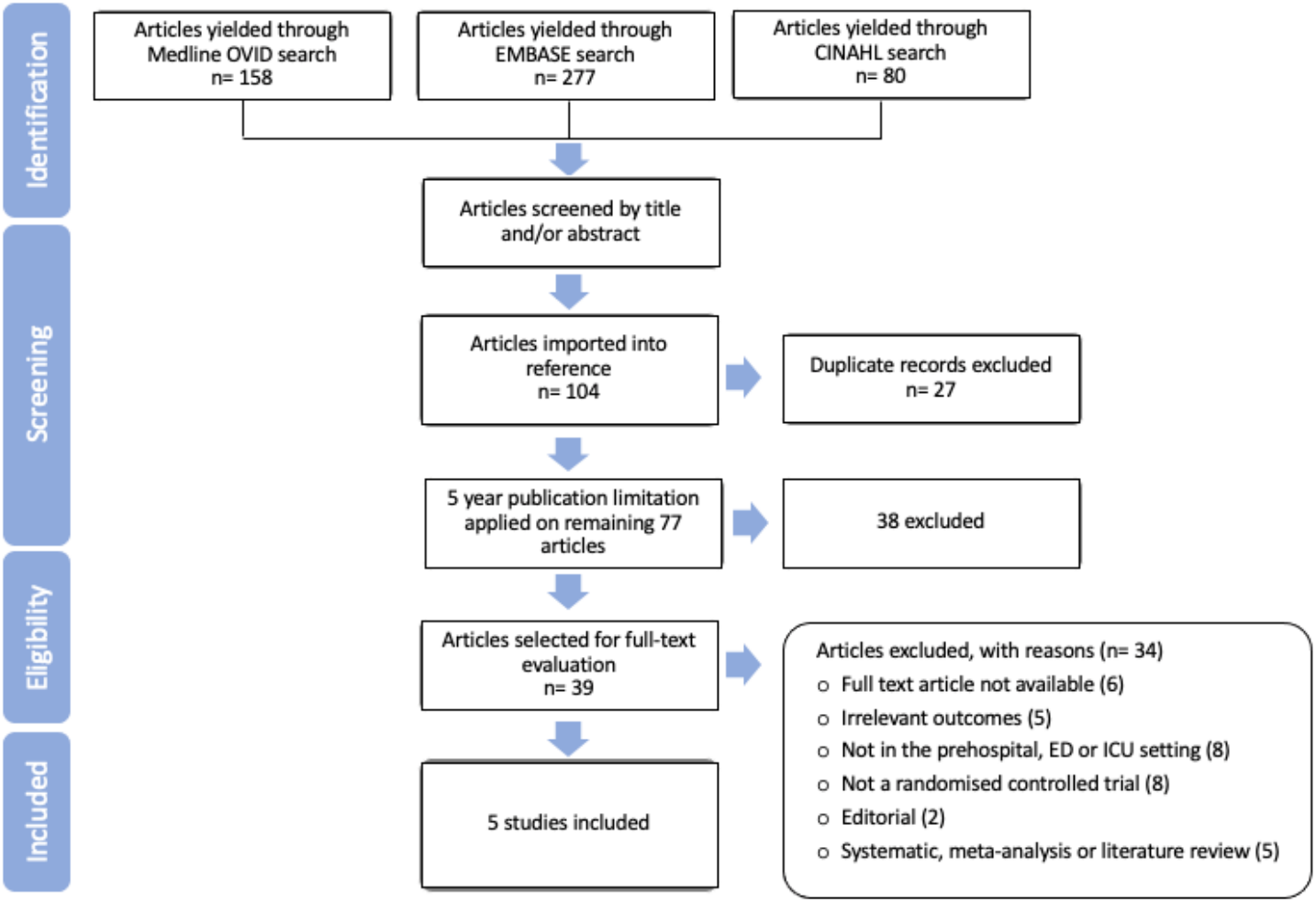

Table 2: *Included Studies*

Author (Year)	**Population**	**Study Design**	**Results**	**Strengths & Limitations**	**OCEBM LOE**
Blick et al. (2021)	Patients in the paediatric ED between November 2013 – April 2019, that were placed with an USGPIV by the 83 trained nurses	Retrospective study Data collected from saved reports on ultrasound machines and patient EMR	• 86.7% success on first attempt after the training program • Positive correlation between successful USGPIV placement and nurse experience. Success rate was 67% immediately after training and 83% after 10 encounters	Strengths: • Data over 5.5 years • Large sample size (3,646 encounters) Limitations: • No control • Non-randomised • Data was based on self-reporting and results may have been influenced by bias and/or memory	2c
Gümüş and Başbakkal (2021)	Children aged 1-10 years treated in the paediatric ED who required PIC between November 2015 – February 2016	Prospective randomised controlled study Intervention: Receive PIC with the aid of a transilluminator (Veinlite PEDI) Control group: Receive PIC via standard technique	• First attempt success rate was significantly higher in intervention group (92.9%) vs control (72.2%) ($p < 0.004$). • Intervention group required less attempts vs control (mean 1.07 vs 1.31, $p < 0.04$) • Successful insertion was achieved quicker in the intervention vs control group (49.98 secs vs 59.68 secs, $p<0.01$)	Strengths: • Protocol randomisation • Sample size Limitations: • Low level of criticality in the population limits validity in a trauma setting • "Standard technique" used in the control group not specified +/-: • One nurse performed PIC on all participants. This eliminated confounding effects of different skill levels between nurses. However, poor internal validity.	2b
Otani et al. (2018)	Children <16 years in the ED with	Prospective comparative trial	• Success rate was significantly lower with ultrasound	Strengths:	2b

	difficult PIVA (unsuccessful first attempt) between August 2014 – February 2016	Control: first 100 participants. Reattempts with conventional technique (visual and palpation +/- transilluminator) Intervention: second 100 participants. Reattempts with ultrasound	guidance (65%) compared to the conventional technique (84%) (p value, 0.002) • Number of attempts greater in the ultrasound group vs the control (mean 3.27 vs 2.75, respectively) (p value, 0.010) • Procedure time was a mean of 4 minutes longer in the ultrasound group (p value, 0.012)	• Adequate sample size (200) for statistical significance • Patient presentation generalisable to the prehospital setting <u>Limitations:</u> • Single centre, non-randomised • Unrefined control group • Poor internal validity	
Takeshita et al. (2019)	Patients <2 years in the paediatric ICU requiring a PIC between November 2017 – September 2018	Prospective, randomised, un-blinded, controlled trial DNTP (dynamic needle tip positioning) group: the ultrasound transducer was moved to visualise the needle tip in real time Static group: vein was visualised with the ultrasound, however transducer remained stationary during	• Success rate of first attempt was 86.7% in the DNTP group and 60% in the static group (p= 0.039) • Overall success within ten minutes was greater in the DNTP vs static group (90% vs. 63.3%, p=0.03) • Number of attempts was significantly lower in the DNTP group • Median time to insertion was reduced in the DNTP group at 51.5 secs vs 71.5 secs in the static group	<u>Strengths:</u> • Randomised, controlled trial • Clear and structured methods <u>Limitations:</u> • Small sample size (60) • Differentiating patient alertness may have had confounding effects on ease and success of cannulation • Low internal validity as operators were two experts and results may not reflect those with less experience • Study was limited to the cephalic vein and cannot conclude that DNTP is useful for other peripheral veins	2b

		advancement of cannula			
Vinograd et al. (2019)	Children 0-18 presenting to the ED and required IV access with a DIVA score equal to or > 3	Randomised controlled trial Control: visual and palpation with the ability to use transilluminators and/or hot packs Intervention: ultrasound guided IV placement	• First attempt success was 45.8% in the control and 85.4% in the ultrasound group, with 89.2% and 97.6% success at third attempt, respectively. • 71% of IVs in the control were placed in the dorsum of the hand, while 93% of the ultrasound were placed in the forearm • Fewer attempts were required in the intervention group compared to the control, and a reduced procedure time of 14 mins vs 28 mins was noted. • Parents reported being more satisfied with the ultrasound technique	<u>Strengths:</u> • Sample size (167) • High internal validity: Researchers included attendings, fellows and nurses • Ultrasound and cannulation operated by a single researcher, relatable to prehospital setting • Randomised <u>Limitations:</u> • IV gauge and length were non-standardised • Single centre • Potential selection bias • Non-blinded treatment may have altered satisfaction survey	1b

Abbreviations: ultrasound guided peripheral intravenous catheter (USGPIV); emergency department (ED); emergency medical records (EMR); peripheral intravenous cannula (PIC); intravenous (IV); Clinical Dehydration Score (CDS); Difficult Intravenous Access Score (DIVA)

Comments

Among the literature reviewed, transillumination and ultrasound were the strategies investigated to improve IV access in paediatrics. Evidence suggests that ultrasound, particularly the DNTP technique (Takeshita et al., 2019), yields a significantly higher first attempt success rate, reduced attempts and procedure time reduction (Blick et al., 2021; Vinograd et al., 2019). Similarly, transilluminator devices compared to the standard palpation technique results in faster cannulation time and increased first attempt success (Gümüş & Başbakkal, 2021). One study suggests that transilluminators may be superior to ultrasound, however the control group was not standardised appropriately in order to confidently make these conclusions (Otani et al., 2018).

Considerations

The populations used in these studies predominately included paediatric patients of a non-trauma aetiology, that were stable and non-critical. Therefore, the results extrapolated from the literature appraised may be inappropriate to apply to a time critical, unstable trauma patient, particularly if IO access is available. Furthermore, all studies were conducted in a hospital setting which is highly controlled compared to the prehospital environment. There has been a significant gap in research identified through this critically appraised topic. Research is required to determine the efficacy of transilluminator and/or ultrasound use by paramedics, for paediatric trauma patients that require PIVA.

Clinical Bottom Line

Transilluminators and ultrasound do improve success of PIVA in paediatric patients who are stable. Their use in paediatric trauma patients may be applicable in those who are stable or when IO access is not available.

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Appendix

Oxford Centre for Evidence-Based Medicine: Levels of Evidence for Therapy/ Prevention, Aetiology/ Harm

Level	Therapy / Prevention, Aetiology / Harm
1a	SR (with homogeneity*) of RCTs
1b	Individual RCT (with narrow Confidence Interval"¡)
1c	All or none§
2a	SR (with homogeneity*) of cohort studies
2b	Individual cohort study (including low quality RCT; e.g., <80% follow-up)
2c	"Outcomes" Research; Ecological studies
3a	SR (with homogeneity*) of case-control studies
3b	Individual Case-Control Study
4	Case-series (and poor quality cohort and case-control studies§§)
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research or "first principles"

University of Oxford (2021). *Oxford Centre for Evidence-Based Medicine: Levels of Evidence (March 2009)*. Centre for Evidence-Based Medicine. Retrieved September 14, 2021 from https://www.cebm.ox.ac.uk/resources/levels-of-evidence/oxford-centre-for-evidence-based-medicine-levels-of-evidence-march-2009