Title: Paramedic ultrasound guided intravenous cannulation- A critically appraised topic

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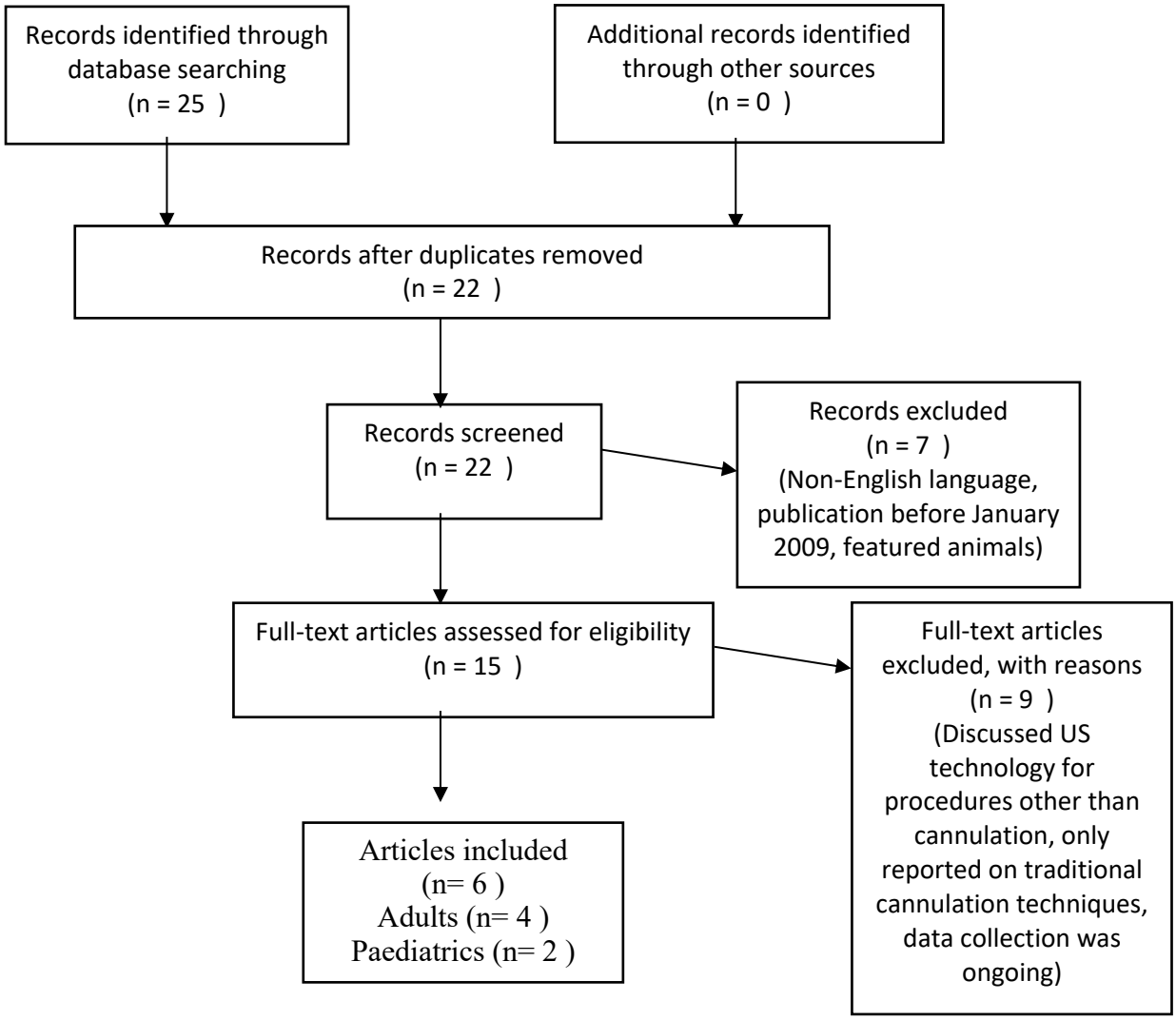
Clinical Scenario: You are working for a rural ambulance station in Western Queensland. You are dispatched Code One B to a 66-year-old female in respiratory distress with colour changes. The patient meets sepsis criteria and has signs and symptoms of pneumonia. She is hypoxic, with an SpO_2 reading of 88%, tachycardic with a heart rate of 110, and hypotensive, with a systolic blood pressure of 80. The patient has a history of breast cancer, which she suffered from ten years ago and received chemotherapy for. You are 30 minutes from the nearest hospital. You and your partner have both attempted twice to insert an intravenous (IV) catheter into the antecubital fossa and dorsal side of the hands, with no success.

PICO (Population- Intervention- Comparison- Outcome) Question: In patients with known or suspected difficult veins for IV cannulation, will ultrasound guided IV cannulations (USGIVC), compared to traditional methods, provide higher success rates?

Search Strategy and Outcome: PubMed and Embase databases were utilised. The search terms 'Prehospital AND "IV cannulation" AND ultrasound' were used. This resulted in zero articles from both databases. The search terms were adjusted to '"IV cannulation" AND ultrasound' which yielded 10 articles from PubMed and 15 articles from Embase (see Diagram 1). Articles were included if they reported the use of USGIVC on adults, paediatrics or ultrasound phantoms, either in the hospital or simulated setting. Articles were also included if the procedure was performed by ED technicians, nurses or medical students. Articles were excluded if they were not written in English, featured animals in the study, were literature reviews or editorials, were published more than ten years ago or discussed only traditional methods of cannulation or uses of ultrasound technology for procedures other

than cannulation. Furthermore, three duplicate articles from Embase and one study which was ongoing at the time of submission were also exlcuded. The articles included in the appraisal can be found in Table 1.

Diagram 1. PRIMSA Flow Chart



Abbreviations: US, ultrasound

Search outcome: 25

Relevant papers: 6

Table 1. Summary of Included Articles

Title	Authors and Date	Method Design and Sample Characteristics	Main Findings	Main Limitations	Main Strengths
Perceived Difficulty and Success Rate of Standard Versus Ultrasound-Guided Peripheral Intravenous Cannulation in a Novice Study Group: A Randomized Crossover Trial.	Vitto, M.J., Myers, M., Vitto, C.M., & Evans, D. P. (2016).	Randomised, cross-over study of 61 medical students with limited IV access experience. A one-hour training period was provided. Results were collected 6 weeks apart.	100% of USGIVC were successful on the first attempt compared to 56% traditional IV cannulation. 6 weeks after the initial training, the USGIVC group had success rate of 86% compared to 62% for standard technique.	Follow-up data was limited due to the high drop-out rate. The inexperience of the population skewed the data, as in practice this procedure would be performed by experienced paramedics, thus this is not representative of the broader workforce.	The longitudinal design demonstrated that the skill of USGIVC is easily retained. This is applicable to clinical practice, where paramedics may have extended periods of time between performing this procedure.
Ultrasound guidance allows faster peripheral IV cannulation in children under 3 years of age with difficult venous access: a prospective randomized study.	Benkhadra, M., Collignon, M., Fournel, I., Oeuvrard, C., Rollin, P., Perrin, M., Volot, F., & Girard, C. (2012).	Prospective, randomised study. Population consisted of children under three with non-visible, non-palpable veins. Procedure was performed by surgical nurses with experience in USGIVC and traditional techniques.	Time to successful cannulation was significantly lower in US technique (63.5secs vs 420.5secs).	Results are specific to paediatrics under 3, therefore not generalisable to other age groups. Small sample size (n= 40).	Randomised design ensured demographics between the two groups were comparable.
Ultrasound-guided small vessel cannulation: long-axis approach is equivalent to short-axis in novice sonographers experienced with landmark-	Erickson, C.S., Liao, M., Haukoos, J.S., Douglass, E., DiGeronino M., Christensen, E., Hopkins, E., Bender, B., & Kendall, J. (2014).	Prospective, observational study. Emergency nurses, proficient in traditional cannulation but novice sonographers, performed USGIVC on US phantoms after	Novice sonographers are capable of performing USGIVC successfully with similar time to vessel penetration in long- and short-axis approaches. Both approaches had near-optimal median	US phantoms do not perfectly simulate human skin, therefore, the clinical complexity of USGIVC was not represented. Success rate was based on time to vessel penetration, which may not	Data was collected by emergency medicine residents who were blinded to the purpose of the study, eliminating bias. Large sample size of 100 USGIVCs.

based cannulation.		one hour of training.	counts for skin penetrations (1) and catheter redirections (0).	always represent appropriate placement, thus the success rate could have been inflated.	
Ultrasound-guided peripheral intravenous access placement for children in the emergency department.	Otani, T., Morikawa, Y., Hayakawa, I., Atsumi, Y., Tomari, K., Tomobe, Y., Uda, K., Funakoshi, Y., Sakaguchi, C., Nishimoto, S. & Hataya, H. (2018).	Prospective, comparative study. Population consisted of paediatrics in the emergency department. If IV access failed on the first attempt, then the participant was assigned to the USGIVC or traditional cannulation group for a second attempt.	Dual-operator USGIVC method had a lower success rate than the blind technique (65% vs 84%).	The findings do not corroborate with other studies. Hence, further research to determine if this result was due to the dual-operator technique used is required to validate the results. The article did not specify the type of US machine used, thus the results are not comparable to other studies.	Large sample size of 712 participants was used. Emergency setting is compatible with prehospital setting to an extent.
Ultrasound-guided peripheral intravenous catheter training results in physician-level success for emergency department technicians.	Duran-Gehring, P., Bryant, L., Reynolds, J.A., Aldridge, P., Kalynych, C.J. and Guirgis, F.W. (2016).	Retrospective review of prospective database. Patients who met difficult IV access criteria were included.	Overall success rate of USGIVC was 97.5%. 86.6% were placed on the first attempt.	Retrospective design has increased risk of incorrect data being included. Difficult IV access criteria was not explicitly stated, hence, the study was open to selection bias.	Many of the ED technicians enrolled in this study were also paramedics. Thus, the capability to perform the procedure is generalised to the paramedic industry.
Ultrasound-guided peripheral intravenous access in the intensive care unit.	Gregg, C., Murthi, S.B., Sisley, A.C., Stein, D.M. and Thomas, M. (2010).	Retrospective, cohort review of USGIVC in the intensive care unit between September 2007 and February 2008.	A high success rate was found (99%). The placement of an USGIV cannula also resulted in fewer central line days.	Lack of randomisation and physical observation may lead to confounding factors.	The data collected was over a 6-month period, which resulted in a large sample size and measured the longitude effects. Factors that impacted normal

					IV access and led to the decision to use US technology corroborates with those in the prehospital setting.

Abbreviations: US, ultrasound; USGIVC, ultrasound-guided intravenous cannulation; IV, intravenous; ED, emergency department.

Summary of Findings and Comments:

- Overall, USGIVC produced higher success rates than traditional techniques.
- However, there was no strong evidence base for patients in the prehospital setting. Thus, the benefit of this procedure cannot be generalised to this field without further research.

Clinical Practice Considerations:

From an isolated clinical perspective, the benefit of USGIVC is significant. However, the cost-effectiveness of this procedure greatly impacts the decision to include it into paramedics' scope of practice. Whilst ultrasound machines are fairly inexpensive, the cost of taking paramedics out of service to complete the appropriate training and hospital practice course to ensure they are reaching an 80-90% success rate is not reasonable. If the prehospital scope of practice was increased to include other ultrasound procedures, and this was taught from tertiary level training, then the cost-effectiveness of this procedure would be improved. Overall, the implementation of ultrasound machines into ambulances is unreasonable for the sole purpose of IV cannulation.

Clinical Bottom Line:

This review has demonstrated that USGIVC improves success rates and requires fewer attempts. These factors assist infection control as less skin punctures results in fewer entry

points for pathogens. The procedure is successful for both adults and paediatrics, and the long and short-axis techniques have both been found to have similar times to vessel penetration. As there are no current articles on this procedure and its effectiveness in the prehospital setting, the findings must be extrapolated to apply to paramedic practice. In the prehospital setting, this procedure would be beneficial for patients with veins that are not palpable or visible, or have a known history of difficult cannulation. The procedure would be particularly beneficial to rural services where patients who require medications or fluids immediately are a significant distance from back-up and hospitals. It would not be recommended for use in critical cases as other methods of access such as intraosseous (IO) are quicker. As the paramedic industry advances, it would be beneficial for new graduates and students to be aware of this technology and its uses as it may be implemented during their career.

References:

Benkhadra, M., Collignon, M., Fournel, I., Oeuvrard, C., Rollin, P., Perrin, M., Volot, F., & Girard, C. (2012). Ultrasound guidance allows faster peripheral IV cannulation in children under 3 years of age with difficult venous access: a prospective randomized study. *Paediatric Anaesthesia, 22,* 449-454. http://dx.doi.org/10.1111/j.1460-9592.2012.03830.x.

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