The Journal of Emergency Medicine, Vol. 66, No. 2, pp. 57–63, 2024

https://doi.org/10.1016/j.jemermed.2023.10.008
0736-4679/$ - see front matter

Original Contributions

Spiced RCT: Success and Pain Associated with Intravenous Cannulation in the Emergency Department Randomized Controlled Trial

Tatum Priyambada Mitra, MD, MSC,[*,†,‡] Sarah Coulter-Nile, MD,[§,‖] Thuvarahan Jegathees, MD,[§,¶] Jason Luong, MD,[§] Amith Shetty, MBBS, FACEM, PHD,[*,#] and Kevin Lai, MBBS, FACEM[*,**]

*Emergency Department, Westmead Hospital, Sydney, New South Wales, Australia, †Emergency Department, Westmead Children's Hospital, Sydney, New South Wales, Australia, ‡Wollongong Hospital, Wollongong, New South Wales, Australia, §Westmead Hospital, Sydney, New South Wales, Australia, ‖Royal Hospital for Women, Prince of Wales Hospital, Sydney, New South Wales, Australia, ¶Westmead Children's Hospital, Sydney, New South Wales, Australia, #New South Wales Ministry of Health, New South Wales, Australia, and **University of Sydney, Sydney, New South Wales, Australia

Reprint Address: Kevin Lai, MBBS, FACEM, Emergency Department Westmead Hospital, Westmead, NSW 2145, Australia.

□ **Abstract—Background: Peripheral venous cannulation is one of the most common procedures in medicine. A larger cannula allows higher rates of fluid to be provided if needed in a deteriorating patient; however, it is also perceived that larger-gauge cannula placement is associated with increased pain and procedural difficulty. Objective: This study aimed to compare the pain and procedural difficulty experienced during insertion between 18-gauge (18G) and 20-gauge (20G) cannulas. Methods: We conducted a single-blinded, randomized controlled trial on adult patients who required peripheral IV cannulation within a tertiary hospital emergency department between April and October 2018. Patients were randomized to either the 18G or 20G cannula group. The primary outcomes of the study—pain experienced by patients and procedural difficulties experienced by clinical staff—were recorded on two separate 10-cm visual analog scales. Other outcomes include first-attempt success rate, operator designation, complications, and the intent and actual use of the IV cannula were documented on preformatted questionnaires. Results: Data from 178 patients were included in the analysis. Eighty-nine patients were allocated to each cannula group. There were no statistically or clinically significant differences between mean pain score (0.23; 95% CI 0.56–1.02; $p = 0.5662$) and mean procedural difficulty score (0.12; 95% CI 0.66–0.93; $p = 0.7396$). between the two groups. There was no difference in first-attempt success rate (73 of 89 vs. 75 of 89; $p = 0.1288$), complications (2 of 89 vs. 1 of 89) between the 20G group and 18G group, respectively. Conclusions: There was no significant difference between the 18G or 20G cannula for either pain experienced by patients or procedural difficulty experienced by clinicians.**

□ **Keywords—cannulation; randomized controlled trial; cannula size; pain; procedural skills difficulty**

Introduction

Cannula insertion to establish peripheral venous access is a common procedure for obtaining blood samples and providing treatments in the emergency department (ED), where patients may deteriorate rapidly (1,2). Swift IV fluid resuscitation is fundamental for unstable patients (1–3). According to Poiseuille's law, a much faster rate of fluid delivery can be delivered through a larger-gauge cannula. The 18-gauge (18G) cannula may be preferred in patients who may require rapid fluid infusion or adequate rate of IV contrast delivery. Despite this, the larger

Received: 15 April 2023; Final submission received: 3 September 2023;
Accepted: 1 October 2023

cannula is used less frequently than the smaller-gauge cannula, mainly due to perceptions of increased pain or procedural difficulty associated with the larger-sized cannula (4). However, many patients presenting to the ED have already been experiencing considerable pain and anxiety. Previous studies have found no difference in pain score between the smaller- and larger-gauge needles (5,6). Similarly, IV cannula success rate has mostly not been found to differ among gauge sizes (7). Another common perception is that IV cannulas placed in the ED are not used and, therefore, not required in ED patients (8). We would argue, however, due to the unpredictable nature of ED presentations, insertion of a larger IV cannula can potentially benefit patients who deteriorate unexpectedly, especially if a larger IV cannula is not more painful or more difficult to insert compared with a smaller cannula.

We postulate that insertion of a slightly larger cannula of 18G would not be associated with significantly more pain experienced by the patients or procedural difficulty experienced by the clinicians than insertion of a smaller cannula of 20G.

Materials and Methods

Study Design and Setting

We conducted a single-blinded, comparative, randomized controlled trial at an urban, university-affiliated tertiary center with a prepandemic census of more than 79,000 ED presentations annually. This study was approved by the local health district human research ethics committee. Data were collected using questionnaires self-reported by patients and clinicians. The primary metrics, encompassing pain experienced by the patient and procedural difficulty experienced by the clinician, were assessed using two separate 10-cm visual analog scales (VAS).

Participants

Between April 16, 2018 and October 9, 2018, we enrolled a convenience sample of patients 16 years and older who, according to clinical judgment, required a cannula. Written informed consent was obtained. Patients who were unable to communicate pain severity effectively due to cognitive impairment, altered mental state, or visual or language difficulties, or those who required a specific cannula size for a compelling reason, were excluded. Compelling reasons for specific cannula size included patients who needed a 18G cannula for computed tomography or a procedure, unstable patients, or clinical judgment of the ED clinicians.

Intervention

We used computerized block randomization in blocks of four to allocate the assigned cannula size. After enrollment and obtaining informed consent, the clinicians received an opaque envelope containing the assigned cannula (18G or 20G). The clinicians were required to use the assigned cannula and to persist with the same cannula at least twice if there was a failure of the initial attempt. The clinicians were allowed to choose a cannula of their preference only after two failed attempts with the assigned cannula. The patients were blinded to the cannula used by wearing blackout glasses; however, the clinicians could not be blinded due to visualizing needs of the procedure. The pool of clinicians performing cannulation encompassed senior medical students, interns, resident medical officers (RMOs), trainee registrars, consultants, and trained nurses. The clinicians followed standard procedures in terms of aseptic technique, flushing, and securing the cannula. Collecting blood from or delivering fluids and medications into the cannula was determined by the treating clinicians as required. Local anesthetic agents were not used for cannula insertion.

A preformatted questionnaire was used to collect relevant information. The severity of pain experienced by the patient and the procedural difficulty experienced by the clinician were documented on two separate 10-cm VASs. The patients and clinicians were asked to place a vertical line across the 10-cm horizontal VAS to indicate the pain severity or procedural difficulty experienced. Pain severity and procedural difficulty were recorded for each attempt if there was more than one attempt. Demographic data for patients and clinicians, use of the cannula, and complications of the cannula insertion were recorded on the same questionnaire.

The cannula was defined as being "used" if it had been used to draw blood samples more than twice, or the patients were given IV fluids or medications during their stay in the ED.

Equipment

For this study, we used the Smiths Medical's Jelco® cannulas, which were available hospital-wide. The two cannula sizes used were the larger 18G (green-colored flushback chamber, width = 1.3 mm; length = 32 mm; flow rate = 6.6L/h) and the smaller 20G (pink-colored flushback chamber, width = 1.1 mm; length = 25 mm; flow rate = 3.9 L/h). In general, patients are not able to see the flushback chamber once it has been covered by securing tape and, therefore, not be able to identify the size of cannula inserted.

Data Analysis

We used basic descriptive statistics methods, including calculation of proportions, means, and SDs. Demographic data between the two different cannula gauge groups were compared using unpaired *t*-tests. Unpaired *t*-tests were also used to determine differences between the two groups for successful attempts, pain, and difficulty. Spearman's ρ values were calculated for correlations between difficulty and pain by designation. All analysis of the data was completed using Stata 14 software (9). The biostatisticians were blinded to the groups to ensure that no perceptional bias was present.

We precalculated that a sample size of 200 was required to achieve 80% power, data collection was constrained to 181 patients due to time limitations. An SD of 2.7 for the VAS score within the two cannula sizes yielded a 73% power to detect a difference of 1.3 or more, which has been clinically established as significant in literature. Furthermore, 97% power was attained to detect a difference of two or more, based on previous studies by Yee et al. and Kelly (6,10).

Results

We recruited 181 patients into the study between April and October 2018. Of the 181, three were withdrawn due to incomplete data (2 had no difficulty scores and 1 had no pain scores). Of the 178 patients with all available data, there were 89 participants in each group. The median age of participants was 49.8 years. There was no significant difference in gender or age between the groups; 100 patients (56.2%) were female (Table 1).

Most of the cannula insertions were successful on the first attempt (n = 148 [90.8%]; 95% CI 1.42–1.57). The overall success rate for cannula insertion within three attempts was not significantly different between the 18G and 20G cannulas (89.9% for 18G and 93.3% for 20G; $p = 0.10$). The success rate for the 20G cannula was 93.3% and success rate for the 18G cannula was 89.9%. The rate of successful insertion did not differ significantly between the two cannula sizes ($p = 0.60$). The preferred site for insertion was the cubital fossa (70.8%), and this preference was similar in both cannula groups ($p = 0.09$). Complication rates were low (n = 18); cannulation failure was the most common complication (n = 15) (Table 1).

Mean (SD) pain scores were 3.61 (2.68) for the 20G cannula and 3.84 (2.64) for the 18G cannula (Table 2). Mean difference between pain scores was 0.23 (95% CI 0.56–1.02; $p = 0.57$). The difference in pain experienced by the patient was neither clinically nor statistically significant. Similarly, for procedural difficulty, mean (SD) scores were 2.58 (2.73) for the 20G cannula group and 2.72 (2.63) for the 18G cannula group; mean difference was 0.13 (95% CI 0.66–0.93; $p = 0.74$). There was no significant difference between the experience of the clinician and pain score for either the 18G cannula group or the 20G cannula group ($p = 0.72$). Blood samples were taken one time for 109 patients, 2 times for 29 patients, and more than 3 times for 23 patients. In total, 62 patients (38.8%) received an unused cannula, there was no difference between the 2 groups (n = 62 [38.8%]; $p = 0.80$).

Spearman's ρ analysis showed a significant correlation between clinician-perceived procedural difficulty and patient-reported pain for the 18G cannula (n = 89, $\rho = 0.25$, $p = 0.02$), but not for the 20G cannula (n = 89, $\rho = 0.001$, $p = 0.99$). Notably, for medical students and interns, a Spearman's ρ correlation of –0.41 ($p < 0.001$, not independent) was observed between first pain and first difficulty in the 18G group, as opposed to a correlation of 0.99 ($p = 0.0156$, independent) in the 20G group. This correlation was exclusive to the medical student and intern group, who used 18G cannulas only (Table 3). In addition, the medical student and intern group had the highest rate of complications. Among 18 post-cannulation complications, 8 were attributed to the medical student and intern group, 5 to the senior resident medical officer (SRMO) and senior medical officer group, 4 to the senior consultant and registrar group, and 1 to the nursing group.

Discussion

Peripheral IV cannula insertion, although painful, is a crucial procedure in the ED (11,12). The presumption of more pain and technical difficulty associated with the insertion of a larger cannula has led to the avoidance of using large cannulas, which may be more appropriate for the unpredictable resuscitation requirement in ED patients. Our study found no significant difference in pain or procedural difficulty between the insertion of 18G and 20G cannulas, aligning with some previous research findings (5,13). This suggests that the choice between 18G and 20G cannulas can be made based on clinical requirement rather than on concerns about pain or procedural difficulty.

Prior research found that circumference, size, and status of veins may be important factors in the choice of cannula used and the success rate of the cannulation (14,15). The choice of cannulation sites, particularly the cubital fossa and dorsum of the hand, matched our findings; the cubital fossa was the preferred site (16–19). Prior literature has commented on cannulation of the dorsum of the hand resulting in more pain (19). Another important consideration for pain is the fact that multiple cannulations may result in more pain (20). Most clinicians needed only one attempt to cannulate the patient, so it was diffi-

Table 1. Demographic Characteristics of Participants, Site of Cannulation, and Level of Operator Experience According to Cannula Size Groups

Characteristics	Cannula Size		Total
	18 Gauge	20 Gauge	
No. of participants	89	89	178
Median age, y	45.8	53.7	49.7
Gender, n (%)			
Male	36 (40.5)	42 (47.2)	78 (43.8)
Female	53 (59.5)	47 (52.8)	100 (56.2)
Site, n (%)			
Dorsum of hand	11 (12.4)	15 (17.0)	26 (14.6)
Forearm	5 (5.6)	17 (19.1)	22 (12.4)
Cubital fossa	72 (80.9)	54 (60.7)	126 (70.8)
Other	1 (1.1)	3 (3.4)	4 (2.2)
Operator experience, n (%)			
Medical student/intern	24 (26.9)	21 (23.6)	45 (25.3)
Resident medical officer/senior resident medical officer	24 (26.9)	27 (30.3)	51 (28.7)
Registrar or consultant	26 (29.2)	24 (27.0)	50 (28.0)
Nurse	15 (16.8)	17 (19.1)	32 (18.0)

Table 2. 10-cm Visual Analog Scale (VAS) Scores of Pain and Procedural Difficulty, Attempts, Success of Cannulation, and Complications Between the Cannula Size Groups

Variable	Cannula Size		*p* Value
	18 Gauge (n = 89)	20 Gauge (n = 89)	
Pain VAS, first attempt, mean score	3.84	3.61	0.57
Difficulty VAS, first attempt, mean score	2.72	2.58	0.74
No. of attempts, n (%)			
1	75 (84.3)	73 (82.0)	0.13
2	5 (5.6)	8 (9.0)	*
> 3	9 (10.1)	8 (9.0)	*
Success, n (%)	80 (89.9)	83 (93.3)	0.10
Complications			
Hematoma	1 (1.1)	1 (1.1)	*
Thrombophlebitis	0 (0)	1 (1.1)	*
Failure of cannulation	10 (10.1)	5 (6.7)	*

* Could not be calculated due to small group numbers.

cult to assess whether there was more pain experienced on multiple attempts, as past qualitative studies have found (20). The multiple attempts for cannulation can be due to an array of factors, including but not limited to, difficult anatomy, poor lighting, patient hydration station, and human error; however, there was no indication that gauge size increases failure to cannulate based on our two groups.

There was no significant difference overall in procedural difficulty experienced by the clinician between 18G

Table 3. Designation and Procedural Difficulty Experienced According to Cannula Size

Variable	Difficulty			
	18-Gauge		20-Gauge	
	Mean	95% CI	Mean	95% CI
Medical student or intern	4.37	3.22–5.52	3.6	2.13–5.06
Resident medical officer/senior resident medical officer	2.93	1.84–4.02	2.63	1.79–3.46
Registrar or consultant	1.31	0.62–2.02	1.68	0.61–2.76
Nurse	2.2	0.87–3.57	2.52	0.98–4.06

and 20G. However, junior doctors, including medical students and interns, experienced more difficulty with the 18G cannulas compared with the 20G cannulas than the more senior clinicians. This is likely a reflection of lack of experience in the junior clinicians compared with their senior colleagues.

Complication rates in our study were low, contrary to literature suggesting higher failure rates among larger-gauge cannulas (21). Regardless of gauge of cannula, the medical student and intern group and the RMO and SRMO group were more likely to experience complications compared with registrars and consultants and nurses.

Contrary to Limm et al.'s study, of the 182 patients recruited, only 9 patients had cannulas that were inserted but not used for patient care; 62 patients (38.8%) in our study received an unused cannula (22). The most common reason for cannulating in our study was for collecting blood samples, whereas prior literature found antibiotic administration was the most common use of a cannula (23). The rationale for insertion of IV cannula rather than perform venepuncture alone in ED patients is often that the patients may need to have IV therapy as well as blood tests. Future study comparing pain experienced and complication rates between IV cannulation and venepuncture may help to inform decisions to perform IV cannulation or to perform venepuncture alone.

Factors such as age, sex, ethnic differences, and body habitus can play a large role in the procedural difficulty of cannulation (21). We did not record body habitus or ethnicity of the patients in our study. Hopefully, the randomized study design helped to control for confounding factors between groups.

Limitations

This study was conducted at a single hospital ED and a single cannula brand was used.

The range of clinical seniority and procedural expertise in IV cannulation was typical of a tertiary center with a university affiliation. The procedural difficulties experienced might be different in a setting where IV cannulation is performed by experienced clinicians only. In addition, potential limits may arise when extrapolating these findings to different brands of cannula. We could not blind the clinicians to cannula size inserted, as needles are color-coded. Although patients were blinded, this was not audited. In addition, due to limited second and third attempts, the data analyzed were predominantly first attempts. Further research is needed to determine whether the outcomes correlate to number of cannulation attempts.

Site of insertion has an impact of procedural difficulties in IV cannulation. We made a pragmatic decision not to control the insertion site of the IV cannula because we did not want to apply too many constraints to the clinicians working in an already busy ED. We felt that limiting clinician to a specified site of insertion was likely to lead to noncompliance and nonparticipation. However, it would have been helpful if we had investigated the correlation between success rate and insertion site.

Rates of complication were only followed up during the patient's stay in the ED. This may be an important factor in deciding which cannulas should be inserted routinely, as past studies have found that the complication rate was affected by cannula size, insertion site, and clinician experience (21).

Conclusions

Our study found no difference in pain experienced by patients or procedural difficulty experienced by clinician when performing peripheral IV insertion between 18G and 20G cannulas in the ED setting. We suggest that, in the unpredictable setting of ED, insertion of an 18G cannula may be preferable to the smaller 20G cannula without

causing more pain to the patient or more procedural difficulty for the clinician.

Declaration of Competing Interest

None.

Acknowledgments

The authors acknowledge all the medical and nursing staff of Westmead Hospital's emergency department for participating in the study. Thank you to statistician Karen Blyth for her assistance.

References

1. McPherson D, Adekanye O, Wilkes AR, Hall JE. Fluid flow through intravenous cannulae in a clinical model. Anesth Analg 2009;108:1198–202.
2. Cheung E, Baerlocher MO, Asch M, Myers A. Venous access: a practical review for 2009. Can Fam Physician 2009;55:494–6.
3. Kingston RJ, Young N, Sindhusake DP, Truong M. Study of patients with intravenous contrast extravasation on CT studies, with radiology staff and ward staff cannulations. J Med Imaging Radiat Oncol 2012;56:163–7.
4. Rüsch D, Koch T, Spies M. Hj Eberhart L. Pain during venous cannulation. Dtsch Arztebl Int 2017;114:605–11.
5. Patout M, Lamia B, Lhuillier E, et al. A randomized controlled trial on the effect of needle gauge on the pain and anxiety experienced during radial arterial puncture. PLoS One 2015;10(9). doi:10.1371/journal.pone.0139432.
6. Yee K, Shetty AL, Lai K. ABG needle study: a randomised control study comparing 23G versus 25G needle success and pain scores. Emerg Med J 2015;32:343–7.
7. Carr PJ, Rippey JCR, Budgeon CA, Cooke ML, Higgins N, Rickard CM. Insertion of peripheral intravenous cannulae in the emergency department: factors associated with first-time insertion success. J Vasc Access 2016;17:182–90.
8. Cooke M, Ullman AJ, Ray-Barruel G, Wallis M, Corley A, Rickard CM. Not "just" an intravenous line: consumer perspectives on peripheral intravenous cannulation (PIVC). An international cross-sectional survey of 25 countries. PLoS One 2018;13(2) e0193436-e0193436. doi:10.1371/journal.pone.0193436.
9. StataCorp LP. Stata data analysis and statistical software. Spec Ed Release 2007;10:733.
10. Kelly AM. The minimum clinically significant difference in visual analogue scale pain score does not differ with severity of pain. Emerg Med J 2001;18:205–7.
11. Yılmaz D, Güneş ÜY. The effect on pain of three different non-pharmacological methods in peripheral intravenous catheterisation in adults. J Clin Nurs 2018;27:1073–80.
12. Tee FY. Patient perceptions and experience of pain, anxiety and comfort during peripheral intravenous cannulation in medical wards: topical anaesthesia, effective communication, and empowerment. Int J Nurs Sci 2015;5(2):41–6.
13. van Loon FHJ, Puijn LAPM, van Aarle WH, Dierick-van Daele ATM, Bouwman ARA. Pain upon inserting a peripheral intravenous catheter: Size does not matter. J Vasc Access 2018;19:258–65.
14. Kimori K, Sugama J. Investigation of vasculature characteristics to improve venepuncture techniques in hospitalized elderly patients. Int J Nurs Pract 2016;22:300–6.
15. Panebianco NL, Fredette JM, Szyld D, Sagalyn EB, Pines JM, Dean AJ. What you see (sonographically) is what you get: vein and patient characteristics associated with successful ultrasound-guided peripheral intravenous placement in patients with difficult access. Acad Emerg Med 2009;16:1298–303.
16. Ford C. Cannulation in adults. Br J Nurs 2019;28:838–41.
17. Salameh MA, Shatarat AT, Badran DH, Abu-Abeeleh MA, Massad IM, Bani-Hani AM. The best vein to be accessed based on descriptive study of dorsal metacarpal vein. Anat Cell Biol 2019;52:390–6.
18. Prottengeier J, Albermann M, Heinrich S, Birkholz T, Gall C, Schmidt J. The prehospital intravenous access assessment: a prospective study on intravenous access failure and access delay in prehospital emergency medicine. Eur J Emerg Med 2016;23:442–7.
19. Goudra BG, Galvin E, Singh PM, Lions J. Effect of site selection on pain of intravenous cannula insertion: a prospective randomised study. Indian J Anaesth 2014;58:732–5.
20. Larsen E, Keogh S, Marsh N, Rickard C. Experiences of peripheral IV insertion in hospital: a qualitative study. Br J Nurs 2017;26(19):S18–25.
21. Wallis M, McGrail M, Webster J, et al. Risk factors for peripheral intravenous catheter failure: a multivariate analysis of data from a randomized controlled trial. Infect Control Hosp Epidemiol 2014;35:63–8.
22. Limm EI, Fang X, Dendle C, Stuart RL, Warburton DE. Half of all peripheral intravenous lines in an Australian tertiary emergency department are unused: pain with no gain? Ann Emerg Med 2013;62:521–5.
23. Wong K, Cooper A, Brown J, Boyd L, Levinson M. The prevalence of peripheral intravenous cannulae and pattern of use: a point prevalence in a private hospital setting. J Clin Nurs 2018;27:e363–7. doi:10.1111/jocn.13961.

Article Summary

1. Why is this topic important?

IV cannulation is an essential procedure in the emergency department that allows clinicians to provide fluids and medications and collect multiple sets of blood tests from unstable patients as needed. A larger-gauge cannula can allow a higher flow rate and delivery or acquisition of fluids, blood products, and medications; however, the perception is that larger-bore cannula placement will result in increased pain for the patient and increased difficulty for the clinician who inserts the cannula.

2. What does this study attempt to show?

This study attempts to investigate whether there are any differences in pain and procedural difficulty when inserting two of the most common types of cannulation gauges (18G and 20G).

3. What are the key findings?

The findings suggest there was no difference between pain reported by the patients or procedural difficulty for experienced clinicians when comparing an 18G and 20G cannula insertion.

4. How is patient care impacted?

By providing evidence that larger cannulas do not cause more pain for the patient and are not more difficult for experienced clinicians, we can provide assurance for patients, while ensuring that we have the optimal IV access to provide faster rates of fluid and medications if needed without causing additional pain to our patients.