Drawing blood from a peripheral intravenous cannula and its effect on cannula dwell time, phlebitis, and bloodstream infection : A randomised controlled study

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Drawing blood from a peripheral intravenous cannula and its effect on cannula dwell time, phlebitis, and bloodstream infection: A randomised controlled study

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ABSTRACT

Background: Routine blood sampling can be conducted using venepuncture, inserting a new peripheral intravenous cannula (PIVC), or utilising an existing one. The practice of blood sampling from a cannula requires handling and movement of the cannula bung. It is discouraged due to safety concerns linked to increased risk of phlebitis, infection, or reduced dwell time.
Aim: To assess cannula dwell time, the prevalence of phlebitis, and bloodstream infection when using a PIVC compared with venepuncture for blood sampling.
Design: A randomised controlled study. Reporting followed CONSORT recommendations.
Methods: Adult patients admitted to the emergency department whose health condition required a blood sample to be drawn and insertion of a PIVC were screened for eligibility between May and July 2022. Participants were randomised to either have blood sampled by venepuncture as the control or drawn through the PIVC as the intervention. Follow-up occurred on day three post emergency department presentation.
Results: One hundred and five participants were randomised of whom 50 had blood sampled by venepuncture and 55 through the PIVC. No difference was observed in cannula dwell time, prevalence of phlebitis, or signs of bloodstream infection.
Conclusion: This study showed PIVC outcomes were no different when the PIVC was used to sample blood compared with participants whose blood was sampled by venepuncture.

Summary of relevance
Problem or Issue
The sampling of blood from a peripheral intravenous cannula carries safety concerns regarding excessive handling of the bung increasing the prevalence of cannula failure and the risk of infection.
What is already known
Evidence suggests sampling of blood from a newly inserted peripheral intravenous cannula can be performed without affecting the accuracy of blood test measurements.
What this paper adds
Findings from this study showed no differences in cannula dwell time or episodes of phlebitis when blood was sampled from a newly inserted peripheral intravenous cannula.

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1. Introduction

Peripheral intravenous cannulas (PIVCs) are the most common intravenous devices inserted for vascular access. It is estimated 37% of Australian hospital patients receive a PIVC and that worldwide more than 1 billion PIVCs are inserted annually (Alexandrou et al., 2015). The rationale for their use is predominantly for administration of fluids and delivery of medications. In some situations, PIVCs may be utilised to sample blood on insertion and provide existing access if venepuncture proves difficult or repeated blood sampling is required (Jacob, Jacob, Davies, Stoneman, & Coventry, 2021). State and Territory government health policy guidelines in Australia are either silent on the practice or provide evidence against the practice that is of poor quality (Jacob, Coventry, Davies, & Jacob, 2020). International standards recommend analysing risks versus benefit before obtaining blood samples, minimising the number of times a PIVC is accessed for convenience to decrease infection risks, and approves access when it adds value to the plan of care (Gorski et al., 2021; Meyer et al., 2020). It is unclear if patient comfort and faster access to blood results is considered to add to the plan of care.

In light of this debate, there is continued interest in whether it is safe to draw blood from a PIVC, not only when blood is sampled from a newly inserted cannula but used for blood sampling throughout hospital stay (Psaila, Parsons, Hahn, & Fichera, 2023; Shabat et al., 2022). Opponents of the practice express concern regarding the accuracy of values when blood is sampled through a PIVC and the risk of infection by repeated handling of the cannula bung leading to premature removal of the cannula (Jacob, Jacob, Davies, Stoneman, et al., 2021). To what extent this poses a threat to patient safety is unclear based on lack of evidence. This study conducted a randomised controlled study comparing cannula dwell time, phlebitis, and bloodstream infection in patients admitted to the emergency department when blood was drawn through a PIVC compared with venepuncture.

2. Background

Blood sampling is an invasive diagnostic procedure regularly undertaken by health professionals and is the most common patient procedure on admission to hospital (World Health Organisation, 2010). It involves inserting a needle into a vein and drawing blood through a syringe. The invasive procedure has disadvantages when access is difficult to obtain and painful, increasing patient anxiety if multiple stabs or serial blood sampling is required (Ulamis, Peker, Orbatu, Ozkalay, & Alaygut, 2020). It is also associated with a number of complications such as the formation of a haematoma at the insertion site caused when blood from the damaged blood vessel leaks in the surrounding tissue (Buowari, 2013).

Often at the same time blood sampling is required, the patient requires the insertion of a PIVC causing the patient to experience a second venepuncture as the cannula is placed into the vein (Davies, Coventry, Jacob, Stoneman, & Jacob, 2019). The device is generally intended to administer intravenous fluids and medications but may also provide an alternative pathway to access blood for sampling. Practice recommendations differ across Australian states and territories on if, when and how blood should be sampled from a PIVC , but most agree sampling of blood straight after insertion or in emergency situations when vascular access is difficult can be undertaken (Jacob et al., 2020). Recommendations by the Infusion Nurses Society suggest consideration should be given to the benefits of avoiding pain by the need for a second venepuncture against the potential risk of infection when handling the vascular access device (Gorski et al., 2021).

The practice of blood sampling from a PIVC is not uncommon in Australia (Davies et al., 2019) and is the subject of debate among nurses (Jacob, Jacob, Davies, Stoneman, et al., 2021). Awareness and practice of blood sampling from PIVCs continues to promote enquiry as an alternative to venepuncture (Alanaki, Alkhuder, Almurawhan, Alakash, & Almulhim, 2022). The debate has been based on evidence that is mixed in support of the practice for most routine laboratory tests (Jeong et al., 2019; Lesser, Lanham, & Davis, 2020) whilst recommendations have been suggested for more robust studies to be undertaken (Coventry et al., 2019). The practice of sampling blood from a PIVC is discouraged based on concern over the incidence of haemolysis corrupting biochemistry results that is less likely to occur when blood is drawn by venepuncture through a straight needle. It was observed in one study that other factors and not PIVC blood sampling alone can also influence the reported incidence of haemolysis (Jacob, Jacob, Davies, Jacob, et al., 2021).

The other area of concern is the possible risk of PIVC-related phlebitis and bloodstream infections caused when there is handling of the cannula for the purpose of sampling blood. The prevalence of PIVC-related complications leading to cannula failure continues to cause concern when it results in premature removal (Helm, Klausner, Klemperer, Flint, & Huang, 2015). It has been reported that up to 44% of PIVC-related complications leading to cannula failure have been the result of phlebitis (Simin, Milutinovic, Turkulov, & Brkic, 2019). A number of factors can influence the development of phlebitis, including when excessive movement of the cannula inside the vein causes friction and inflammation (Urbanetto, Peixoto, & May, 2016). If hygiene practices are not followed, the cannula hub attached to the PIVC can become a source of microbial migration. Unless measures are taken to reduce the risk of PIVC-associated infection, such as appropriate hand hygiene, skin preparation, dressings, insertion site selection, and cannula replacement strategies, the prospect of developing a serious bloodstream infection increases (Zhang et al., 2016). Practice recommendations advocate PIVC removal after 72 h or when clinically indicated (Australian Commission on Safety and Quality in Health Care, 2021). It has been reported practice standards in most Australian states and territories require removal of PIVCs after 72 h (Jacob et al., 2020).

3. Aim

The aim of this study was to assess cannula dwell time, the prevalence of phlebitis, and bloodstream infection when using a PIVC compared with venepuncture for blood sampling.

4. Methods

4.1. Design

The design was a randomised controlled study using a simple randomisation technique. The study was prospectively registered with the Australian New Zealand Clinical Trials Registry: https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?ACTRN=12622000626763. Reporting of the study followed CONSORT recommendations.

4.2. Sample and setting

Study participants were adult patients (> 18 years) admitted to the emergency department with a non-urgent health complaint triaged as either a category-3 or category-4 patient between May and July 2022 using the Australian Triage Scale (Ebrahimi, Heydari, Mazlom, & Mirhaghi, 2015). Power calculations were performed using G*Power software, The G*Power Team, Heinrich-Heine-Universitat, Dusseldorf, Germany (Faul, Erdfelder, Lang, & Buchner, 2007). Assuming a power of 80% and a risk of 0.05, a sample size of 64 for each group (N = 128) was required to detect a difference between two independent means. Patients were eligible if their

medical management included a blood sample to be drawn and the insertion of a PIVC with the likelihood of the patient being admitted. Only patients who were conscious, able to give informed consent in writing, and whose medical management would not be affected were recruited. Patients with a presenting mental health condition were excluded from the study. A large metropolitan hospital was selected for the investigation with approximately 300 emergency presentations per day associated with roughly 100,000 patients seen annually. Blood sampling at the study site was routinely performed by medical doctors, phlebotomists, and nursing staff.

4.3. Protocol

A member of the research team attended the emergency department every Monday and Tuesday from 10 am to 6 pm for 10 weeks. Eligible patients were approached and on gaining consent were randomised to have blood sampled either by venepuncture or from a newly inserted PIVC. Randomisation was achieved using software (https://www.graphpad.com/quickcalcs/randomize1/) to produce a computer-generated sequence of random numbers from 1 to 2. The sequence was repeated with each number indicating the method of blood sampling for the control group and intervention group (1 = venepuncture, 2 = PIVC) written on a slip of paper and placed in opaque sealed envelopes numbered consecutively. Access to the envelopes was restricted to the research nurse who was blinded to the blood sampling method allocated for each participant.

Following randomisation, the researcher informed staff collecting blood of the randomised selection, collected participant information, and recorded the method of blood sampling and details about the PIVC. A check was made on the original PIVC inserted in the emergency department or if participants were subsequently admitted into the hospital by reviewing nursing and medical notes. On occasions when the research nurse was unavailable, this information was documented by nursing staff involved in direct patient care at the end of each shift, who as part of standard practice, had received training on the management of PIVCs including indications for removal. Information on dwell time and reason for cannula removal was recorded using a paper-based data collection tool and then an entry made on an electronic database. The occurrence of cannula complications, including phlebitis and signs of infection, was obtained from daily assessments documented by a peripheral intravenous assessment score (PIVAS) (Government of Western Australia Department of Health, 2017). The assessment tool was originally developed by Jackson (1998) and uses a scale of 0–5 to describe a series of observations. It allows an objective assessment to be made on the health of tissues surrounding the cannula insertion site. A score of 1–3 suggests early-to-medium stages of phlebitis. Scores of 4–5 suggest the beginning of advanced stages of phlebitis and the start of thrombophlebitis (see Supplementary File 1).

4.4. Data analysis

Data were entered into SPSS version 28, IBM, Sydney, Australia (IBM SPSS Statistics). Continuous variables were summarised using means and standard deviations, and medians and interquartile ranges expressed as the 25th and 75th percentile. Frequencies and percentages summarised categorial variables. The Chi-square test and Fisher's exact test was used to examine differences between categorical variables. Comparisons of continuous variables between the control group and experimental group used the Mann–Whitney U test for data not normally distributed. A Kaplan–Meier log-rank test was used to estimate survival curves. A p-value < 0.05 was considered significant.

4.5. Ethical considerations

Ethical approval was received from both the participating healthcare facility (RHC WA/SA HREC2144W) and the contributing university (REMS no. 2021-03077-DAVIES). Patients were given an information sheet about the study and what it would involve with a written consent obtained from study participants.

5. Results

Of 174 patients screened, 120 agreed to participate in the study and were randomised into the control or interventional group. This number was reduced to 105 due to study protocol violations as shown in Fig. 1 . A breakdown of the 105 participants who were reviewed on day three following emergency department presentation showed 52.4% (n = 55) were female and 47.6% (n = 50) male with a median age of 48 years (IQR: 34.5–61.5). Most participants had an abdominal complaint (n = 27, 25.7%) as the reason for presentation and assessed as requiring the insertion of a PIVC for ongoing medical management. Participant demographics are detailed in Table 1 .

All 105 participants received a newly inserted PIVC. Most blood samples were collected by a medical doctor (n = 64, 61.0%). Across the two groups, the cannula gauge size most frequently used was 20 mm (n = 85, 81.0%) and the antecubital fossa the most favoured insertion site (n = 93, 88.6%). A comparison of dwell times when all reasons for cannula removal between the two groups were included, showed no statistically significant difference if blood was sampled by venepuncture or through the cannula (median 7.39, IQR 38 versus 7.25, IQR 21, p = 0.41). Graphical representation of dwell time following insertion of cannula until the endpoint of 72 h is shown in Fig. 2 . The Kaplan–Meier survival probability estimates at 72 h were 0.1% for the interventional group and 0.5% for the control group.

In 93.3% (n = 98) of cases, cannulas were removed when no longer required. Observations documented at the end of each shift indicated no evidence of phlebitis with a PIVAS score above 0 not recorded for either group. A review of nursing and medical notes found no evidence to suggest participants had been exposed to a bloodstream infection. Blood sampling procedures and the follow-up of PIVCs are summarised in Table 2 .

6. Discussion

The randomised controlled design of the study allowed the effects of sampling blood through a PIVC to be compared with participants whose newly inserted cannula was not exposed to blood sampling. Outcomes in the dwell times of PIVCs and the prevalence of phlebitis were similar across the two groups. The findings from this study on the safety of blood draws from a PIVC add to existing evidence on its safety in terms of equivalence in accuracy and not causing excessive haemolysis when compared with blood sampled by venepuncture (Jacob, Jacob, Davies, Jacob, et al., 2021; Ortells-Abuye, Busquets-Puigdevall, Diaz-Bergara, Paguina-Marcos, & Sanchez-Perez, 2014). Despite not achieving the required powered sample size to determine equivalence, we observed no clinically significant difference in dwell times or episodes of phlebitis or bloodstream infection when blood was drawn from a newly inserted cannula.

The practice of selecting a 20-gauge cannula and antecubital fossa insertion site observed in this study has been reported by others investigating intravenous cannulation practices (Evison et al., 2021; Yalcinli, Akarca, Can, Sener, & Akbinar, 2019). A median dwell time of 7.33 h for all PIVCs suggests policies and procedures were followed during the study when vascular access was no longer required. Early removal of PIVCs that are no longer required has been reported to not always occur with one study reporting 33.3% of PIVCs

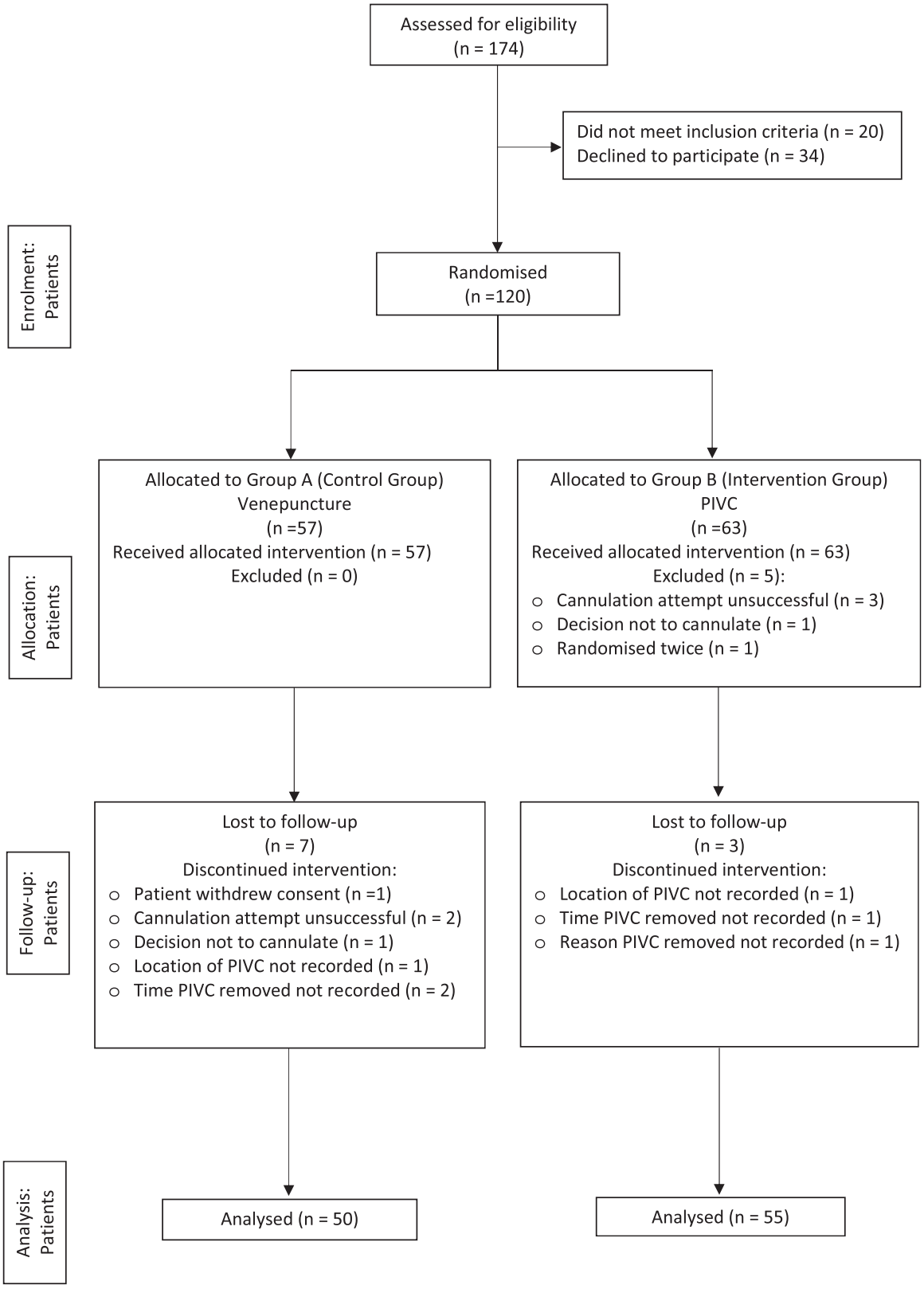

Fig. 1. Modified CONSORT flow diagram.

Table 1
Demographic characteristics of participants.

	All participants (N = 105)		Venepuncture (n = 50)		PIVC (n = 55)	
Variable	n (%)	Median (IQR)	n (%)	Median (IQR)	n (%)	Median (IQR)
Age (years)	105 (100)	48 (34.5–61.5)	50 (100)	51.5 (33.0–63.3)	55 (100)	45 (35.0–61.0)
Gender						
Female	55 (52.4)		25 (50)		30 (54.5)	
Male	50 (47.6)		25 (50)		25 (45.5)	
Admission diagnosis						
Abdominal	27 (25.7)		10 (20.0)		17 (31.0)	
Pain	19 (18.1)		11 (22.0)		8 (14.5)	
Infection	15 (14.3)		10 (20.0)		5 (9.1)	
Cardiac	12 (11.4)		4 (8.0)		8 (14.5)	
Endocrine	12 (11.4)		6 (6.0)		6 (10.9)	
Neurological	6 (5.7)		3 (6.0)		3 (5.5)	
Genitourinary	5 (4.8)		2 (4.0)		3 (5.5)	
Respiratory	2 (1.9)		1 (2.0)		1 (1.8)	
Reproductive	2 (1.9)		1 (2.0)		1 (1.8)	
Fall	2 (1.9)		1 (2.0)		1 (1.8)	
Fracture	1 (1.0)		0 (0.0)		1 (1.8)	
Other	2 (1.9)		1 (2.0)		1 (1.8)	

PIVC: peripheral intravenous cannula.

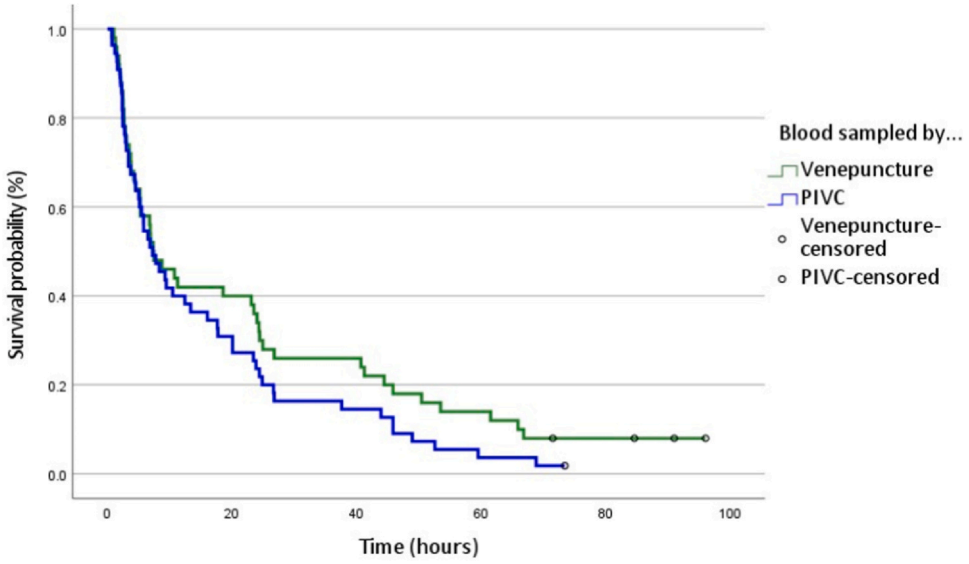

Fig. 2. Dwell time comparisons between venepuncture and PIVC presented as time to failure in a Kaplan–Meier survival curve.

inserted in the emergency department remained idle for over 24 h (Evison et al., 2021). In over 90% of PIVCs, the reason for removal was the cannula was no longer required. This was reflected in a short median dwell time suggesting cannulas did not remain idle when not used.

Two healthy PIVCs were removed after a dwell time of 72 h had elapsed in accordance with policies and procedures at the study site (Government of Western Australia Department of Health, 2017). The debate on whether to remove PIVCs electively after 72 h or only when clinically indicated continues to cause controversy. The practice of routinely replacing PIVCs is based on studies that reported a decrease in phlebitis when canulae were removed 72 h beforehand (Barker, Anderson, & MacFie, 2004; Nishanth, Sivaram, Kalayarasan, Kate, & Ananthakrishnan, 2009), but a more recent study has cast doubt on such findings. Rickard et al. (2012) found no evidence to show that removal of PIVCs was associated with increased reporting of phlebitis when cannulas remained in place after 72 h. A Cochrane review of studies has confirmed no difference in the reporting of phlebitis when cannula removal is indicated rather than following a policy of routine placement (Webster, Osborne, Rickard, & Marsh, 2019).

A core component in the delivery of quality care is patient safety. The introduction of checklists like the PIVAS assessment tool is widely used for monitoring cannula health. Checklists are commonly used by nurses that provide a simple way to minimise omissions in nursing care (Sharp, Dahlen, & Bergenmar, 2019). Despite our study showing missing daily scores on cannula health, it is unlikely that a PIVAS of five (showing phlebitis and possible infection) would have not been identified during shift changeovers and recorded the next day in the patient's medical records.

It is not uncommon for patients to require intravenous access, and at the same time, venepuncture is required for the sampling of blood, make the proposition of only requiring one stab instead of two appealing. It has been reported that placing a PIVC brings pain and anxiety for patients (Cooke et al., 2018; Tee, Low, & Matizha, 2015). Efforts to demonstrate that drawing blood from a freshly inserted PIVC does not affect cannula dwell time nor increase the prevalence of phlebitis and infection offers the opportunity to limit discomfort by patients only experiencing pain and anxiety once instead of twice when blood is sampled at the same time of cannula insertion.

Table 2
Blood sampling procedures and follow-up of PIVCs.

	All participants (N = 105)		Venepuncture (n = 50)		PIVC (n = 55)		p-value
Variable	n (%)	Median (IQR)	n (%)	Median (IQR)	n (%)	Median (IQR)	
Sample collected by							
Doctor	64 (61.0)		30 (60.0)		34 (61.8)		0.92[a]
Nurse	40 (38.1)		20 (40.0)		20 (36.4)		
Other	1 (1.0)		0		1 (1.8)		
Cannula gauge size (mm)							
24	2 (1.9)		0		2 (3.6)		0.40[a]
22	15 (14.3)		8 (16.0)		7 (12.7)		
20	85 (81.0)		41 (82.0)		44 (80.0)		
18	2 (1.9)		0		2 (3.6)		
16	0		0		0		
14	1 (1.0)		1 (2.0)		0		
Insertion site							
Hand	17 (16.2)		10 (20.0)		7 (12.7)		0.70[a]
Antecubital fossa	93 (88.6)		38 (76.0)		45 (81.8)		
Wrist	4 (3.8)		2 (4.0)		2 (3.6)		
Forearm	1 (1.0)		0		1 (1.8)		
Number of PIVAS observations							
1st day	91 (86.7)		44 (88.0)		47 (85.5)		
2nd day	28 (26.7)		16 (32.0)		12 (21.8)		
3rd day	13 (12.4)		8 (16.0)		5 (9.1)		
Cannula dwell time (hours)							
All		7.33 (22)		7.39 (38)		7.25 (21)	0.41[b]
No longer required		6.85 (21)		6.87 (22)		6.83 (21)	
After 72 h		93.5 (-)		93.5 (-)		-	
Dislodgement		48.5 (-)		85		12	
Reason unknown		50.42 (-)		36.96 (-)		69	
Treatments received							
0.9% normal saline	4 (3.8)		2 (4.0)		2 (3.6)		0.84[a]
Medications	18 (17.1)		9 (18.0)		9 (16.4)		
Infusion	10 (9.5)		6 (12.0)		4 (7.3)		
Medications and infusion	19 (18.1)		10 (20.0)		9 (16.4)		
Not recorded	54 (51.4)		23 (46.0)		31 (56.4)		
Reason for removal							
No longer required	98 (93.3)		45 (90.0)		53 (96.4)		0.51[a]
After 72 h	2 (1.9)		2 (4.0)		0		
Dislodgement	2 (1.9)		1 (2.0)		1 (1.8)		
Not specified	3 (2.9)		2 (4.0)		1 (1.8)		

PIVC: peripheral intravenous cannula; PIVAS: peripheral intravenous assessment score.
[a] Fisher's exact test.
[b] Mann–Whitney U test.

7. Strengths and weaknesses

A strength of this study is in the research design that ensured participants were randomly selected when comparisons were made between the control group and intervention group. Despite the lack of daily score checking, it was clear that none of the cannulas in the study sample experienced phlebitis or indicated the possibility of bloodstream infection. Several weaknesses are associated with the study. Concern over reliability and validity of scales such as the PIVAS to measure the episode of phlebitis has been reported (Ray-Barruel, Polit, Murfield, & Rickard, 2014). The study did not achieve the intended powered sample size to demonstrate equivalence between the two groups. Phlebitis can occur post cannula removal (Webster et al., 2015). Once the patient was discharged from hospital, monitoring of insertion site was not possible.

8. Conclusions

This study observed no differences in cannula dwell times across the two groups when blood sampling methods were compared. Adult patients who had blood sampled from a PIVC did not experience additional complications in episodes of phlebitis or bloodstream infections. Drawing blood from a PIVC may be a safe alternative to a traditional venepuncture blood draw, particularly when patients require both the insertion of intravenous access device and blood sampling to occur. This study contributes to existing knowledge surrounding the safety of blood sampling from PIVCs, but further research with larger sample sizes to meet power calculations in different clinical settings is required.

Authorship contribution statement

AJ, EJ, HD, and LC conceived the study. LA and HD were responsible for collecting data. Data analysis was performed by HD and LA with interpretation of findings reviewed by AJ, EJ, and LC. HD drafted the paper. AJ, EJ, LA, and LC made revisions before the final version was submitted for publication.

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Ethical statement

The ECU Human Research Ethics Committee (HREC) has reviewed your application and has granted ethics approval for your research project. The Committee noted that the project has previously been approved by Ramsay Health Care WA/SA HREC. In granting approval, the HREC has determined that the research project meets the

requirements of the National Statement on Ethical Conduct in Human Research.

Clinical trial registration

The study was prospectively registered with the Australian New Zealand Clinical Trials Registry (ANZCTR). https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?ACTRN=12622000626763

Conflict of interest

The authors declare no conflict of interest.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.colegn.2024.04.001.

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