

CME Peripheral Intravenous Cannula Insertion and Use in the Emergency Department: An Intervention Study

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ABSTRACT

Objectives: The objective was to examine cannulation practice and effectiveness of a multimodal intervention to reduce peripheral intravenous cannula (PIVC) insertion in emergency department (ED) patients.

Methods: A prospective before and after study and cost analysis was conducted at a single tertiary ED in Australia. Data were collected 24 hours a day for 2 weeks pre- and post implementation of a multimodal intervention. PIVC placement and utilization within 24 hours were evaluated in all eligible patients.

Results: A total of 4,173 participants were included in the analysis. PIVCs were placed in 42.1% of patients' pre intervention and 32.4% post intervention, a reduction of 9.8% (95% confidence interval [CI] = 6.8 to -12.72%). PIVC usage within 24 hours of admission was 70.5% pre intervention and 83.4% post intervention, an increase of 12.9% (95% CI = 8.8% to 17.0%). Sixty-six patients were observed in the ED for cost analysis. The mean time per PIVC insertion was 15.3 (95% CI = 12.6 to 17.9) minutes. PIVC insertion cost, including staff time and consumables per participant, was A\$22.79 (95% CI = A\$19.35 to A\$26.23).

Conclusions: The intervention reduced PIVC placement in the ED and increased the percentage of PIVCs placed that were used. This program benefits patients and health services alike, with potential for large cost savings.

Peripheral intravenous cannulation is one of the most commonly performed invasive procedures in the emergency department (ED).¹ Peripheral intravenous cannulas (PIVCs) are intended for the delivery of fluid, medication, blood, or contrast during the patient's hospital stay. Previous studies report that

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while many patients presenting to ED receive a PIVC,² half the PIVCs inserted in the ED are not used^{3–7} or are used only for a secondary purpose such as for collection of pathology samples.⁸ Potential reasons for unused PIVCs include insertion being part of the “cultural” norm and PIVCs placed “just-in-case” rather than for a specific clinical indication.

Reducing the number of unnecessary PIVCs is important; insertion can be painful for patients, consumes staff time, costs money, and poses a risk of serious infection.^{9–12} The most serious complication of PIVC placement is infection with *Staphylococcus aureus* bacteremia (SAB). PIVC-related SAB represents as much as 25% of all health care–associated SAB episodes.^{11,13}

Quality improvement projects to reduce unnecessary placement of PIVCs in the wards have reduced insertions by 13% to 40%.^{14,15} In the prehospital setting, an education intervention also reported improvements.¹⁶ Promising results have been identified in a recent small study in the ED, which demonstrated the potential for a multimodal education program to improve appropriate PIVC insertion and utilization in this setting.²

No accepted guidelines currently exist that identify when PIVCs are required in an emergency setting.¹⁷ Researchers from Monash University suggest that the most practical guide for PIVC insertion should be when a clinician believes it is 80% likely to be used.¹⁷

The aim of our study was to compare PIVC placement and usage in an emergency setting before and after an educational intervention designed to improve appropriate use of PIVCs. Our hypothesis was that an education program designed to prompt clinical staff to be 80% sure PIVC will be used prior to insertion would decrease insertion and increase percentage of placed PIVC that are used.

METHODS

Study Design

This was a before-and-after study assessing PIVC insertion and usage before and after a multimodal intervention. Prior to study commencement ethical approval was granted by the local Hospital Human Research Ethics Committee.

Study Setting and Population

The study was conducted between February and June 2016 in a metropolitan tertiary ED in Australia, with

an annual presentation rate of 75,000 cases. Patients were eligible if they presented to the ED and were aged ≥ 18 years. Patients were excluded if they were triage category 1, had a PIVC inserted by ambulance services, or were transferred from another hospital.

Study Protocol

Data were collected over a 12-day period prior to the intervention and a 12.5-day period post intervention. Post intervention data were collected 1 month after the intervention concluded to allow for transition and implementation of the educational message. Research staff collected data prospectively 24 hours per day for both periods, with all eligible patients observed for 24 hours or until discharged. Standardized case report forms were used for data including demographics, cannula insertion and utilization, patient disposition, and diagnostic category. If cannula use was not evident during the ED phase of patient care, the electronic medical record was interrogated. A used PIVC was defined as one with evidence of intravenous drug, contrast, fluid, or blood product administration. An unused PIVC was defined as a cannula that was inserted and not used either prior to discharge or within 24 hours of presentation to the ED.

An additional random sample of patients was observed during PIVC insertion for cost analysis between the pre- and post intervention periods. For each PIVC insertion, the time taken, number of attempts, equipment used, and the staff classification were recorded. Staff time was calculated at 1-minute intervals. Staff time was valued at the fixed industrial award wages in Queensland, Australia, at the time of the study (June 2016), using the middle pay grade for the staff involved. The equipment used was valued using negotiated hospital supply contract rates (2016) from the perspective of Queensland Health, Australia. The average cost per PIVC insertion comprised the average cost of equipment and staff time.

Intervention

The 10-week intervention, termed CREDIT (Cannulation Rates in Emergency Department Intervention Trial) commenced in March 2016. The post intervention data collection phase occurred 4 weeks after the intervention. The multimodal intervention included: 1) education and training, 2) change champions and advertising, and 3) surveillance and feedback. The intervention targeted all medical and nursing staff within the ED.

The education component comprised clinical nurse and ED consultant physician–led training to educate staff on PIVC risks, placement, and care. The key message prompted clinicians to think critically and empowered them to place a PIVC only if they believed it was 80% likely the hemodynamically stable patient would require a PIVC within the next 24 hours for medications, fluids, contrast, or blood product administration. The “80% sure” criteria was adopted from research conducted at Monash University Hospital, described as a simple and effective trigger to prompt clinical decision making regarding the need for PIVC placement in the ED.^{17,18} Clinicians were asked to consider the risk of PIVC and whether risk of PIVC placement outweighed the benefit. The use of venepuncture for phlebotomy as a procedure separate to cannula insertion was encouraged as this is policy within the institution. During the intervention minimal emphasis was placed on taking a moment to consider if the patient would benefit from oral analgesia/fluids or antiemetics. No suggested alternatives were given. The intervention did not attempt to change the therapies applied currently in the ED. The focus was on the idle cannula or the cannula only used for pathology collection.

Posters with the 80% logo and “PIVC are you sure?” were displayed in all clinical areas in the ED. Champions were recruited to disseminate the message over all shifts and disciplines. They were identified from a group of existing medical and nursing staff of varying seniority that assisted with the delivery of education in scheduled training time. While working clinical shifts the champions wore shirts bearing the CREDIT insignia and the question “are you 80% sure?” (Figure 1). The shirt enabled staff to promote the 80% message in the clinical area and aided in maintaining the momentum of the intervention.

Data Analysis

This study aimed to estimate PIVC insertion and use with high precision and detect a reduction in rates of placed and unused cannulas. Based on local audit findings we estimated that 65% of our ED patients have a cannula placed. Prior research has shown that 50% of PIVC are unused.³ To obtain precision of 3% and confidence level of 95%, we required 972 patients in each of the pre- and post intervention periods to estimate the proportion inserted and 1,068 patients in each of the pre- and post intervention periods with cannula placed to estimate the proportion unused



Figure 1. Credit shirt.

(1,644 patients overall in each time period if 65% have a PIVC placed). To detect a reduction in rates of placed PIVC by 15%, a sample size of 480 cannulated patients (240 patients pre- and 240 patients post intervention) would achieve power of 90% at a significance level of 0.05. We sought to obtain a sample size of 3,288 (1,644 in each period) to achieve adequate power for all aims of this study.

Data were analyzed using Stata version 14 (Stata-Corp). Baseline characteristics of the cohort were reported by participant group (pre- or post intervention). The proportion of patients with PIVC inserted and the proportion of patients with unused PIVC were calculated for each participant group. In both instances, the difference between the group proportions and the 95% confidence interval (CI) of the difference was reported. As patients could have multiple admissions during the study period, the 95% CI of the difference was adjusted for nonindependence using clustered robust standard errors. PIVC insertion status was unknown for five patients, with an additional two patients having unknown usage. Such patients were removed from the analyses examining insertion rates and usage, respectively.

An interrupted time-series analysis (or segmented regression analyses) was employed to identify whether there was a quantitative change in PIVC insertion after the implementation of the intervention, or whether there was a gradual change in rates across the data collection period, potentially due to a Hawthorne

effect. There was no change indicative of the Hawthorne effect; the analysis revealed that there was a decrease in PIVC insertion seen only in post intervention data. The results of this analysis are not presented in this paper; however, they are available upon request.

Cost Analysis

The economic evaluation was a within-trial cost analysis using Queensland Health costs. The number of ED presentations in the post intervention period was multiplied by the difference in PIVC insertion rates pre- and post intervention. This provided an estimate of the number of PIVCs avoided. This was multiplied by the average cost per PIVC. In estimating the 95% CIs, the number of avoided PIVCs and the cost per PIVC were assumed to be independent.

Missing data were assumed to be missing at random and excluded from the cost analysis. One thousand bootstrapped samples were used to estimate uncertainty in the cost and staff time estimates. All costs are presented in Australian dollars.

RESULTS

There were 5,347 presentations to the ED during the data collection period. A total of 1,174 were excluded (Figure 2) leaving data for 4,173 presentations. There were 746 patients who had multiple presentations during the study period. Baseline characteristics of the pre- and post intervention samples were similar (Table 1).

Peripheral intravenous cannulas were inserted in 869 (42.1%) of the pre intervention cohort and 682 (32.4%) of the post intervention cohort, a difference of -9.8% (95% CI = -12.7 to -6.8%). A total of 585/868 (67.4%) of pre intervention and 541/681 (79.4%) of post intervention PIVCs were used within the ED, equating to a difference of 12.0% (95% CI = 8.7% to 17.0%). PIVCs were used within 24 hours of admission (either ED or inpatient ward) for 612 (70.4%) and 568 (83.4%) of patients in the pre- and postintervention groups respectively (Table 2), a difference of 12.86% (95% CI = 8.7% to 17.0%).

We recorded health care resource utilization data for 66 patients. Overall, 58 patients had a PIVC inserted successfully. Eight patients were excluded, one refused after four attempts, two were deemed not to require a PIVC (after one and three attempts, respectively), and five patients had missing time data. Thirty-

one percent of patients needed more than one attempt to be successful. The average time per PIVC insertion was 15.3 minutes (95% CI = 12.6 to 17.9 minutes). In the 69% of patients with a successful first attempt, the average time was 10.9 minutes (95% CI = 9.8 to 12.0 minutes). The average equipment cost was A\$6.53 (95% CI = \$5.98 to \$7.07) per patient. The average cost of staff time was A\$16.26 (95% CI = \$13.10 to \$19.42) per patient. Total average cost was A\$22.79 (95% CI = \$19.35 to \$26.23) per patient (Data Supplement S1, available as supporting information in the online version of this paper, which is available at <http://onlinelibrary.wiley.com/doi/10.1111/ace.m.13335/full>). The costs associated with the education program were minimal as it was delivered in regular training time and reinforced in the clinical area with opportunistic short sessions. Shirt and poster printing and supply costs were A\$527.

Based on the observed reduction in PIVC insertion rates of 9.8% (95% CI = 6.8% to 12.7%), this would equate to 207 (95% CI = 143 to 268) PIVC insertions avoided in the post intervention period. At the average cost of A\$22.79 (95% CI = \$19.35 to \$26.23) this would result in a saving of A\$4,718 (95% CI = \$3,126 to \$6,309) over the 2-week post intervention trial period (Table 3).

DISCUSSION

The multimodal intervention empowered staff to appraise critically the requirement for PIVC placement and resulted in significant reduction in PIVC insertion, with a corresponding increase in PIVC usage. The campaign is a simple cost-saving intervention that can be conducted using minimal additional resources outside of existing department education.

We found that PIVC placement was reduced by 9.8% after the intervention. This finding is consistent with prior research in a ward and prehospital setting.¹⁴⁻¹⁶ One previous ED study utilized data from 300 patients to examine the effect of system changes including stickers for documentation of PIVC insertion and removal stickers, new venepuncture devices, changing the intravenous trolley layout, and an educational campaign.² Similar to our research, this study found a reduction in PIVC placement following the intervention. However, these investigators did not find a corresponding increase in PIVC usage post intervention. Several potential explanations exist for the findings. A small sample size, unstable estimates, and low

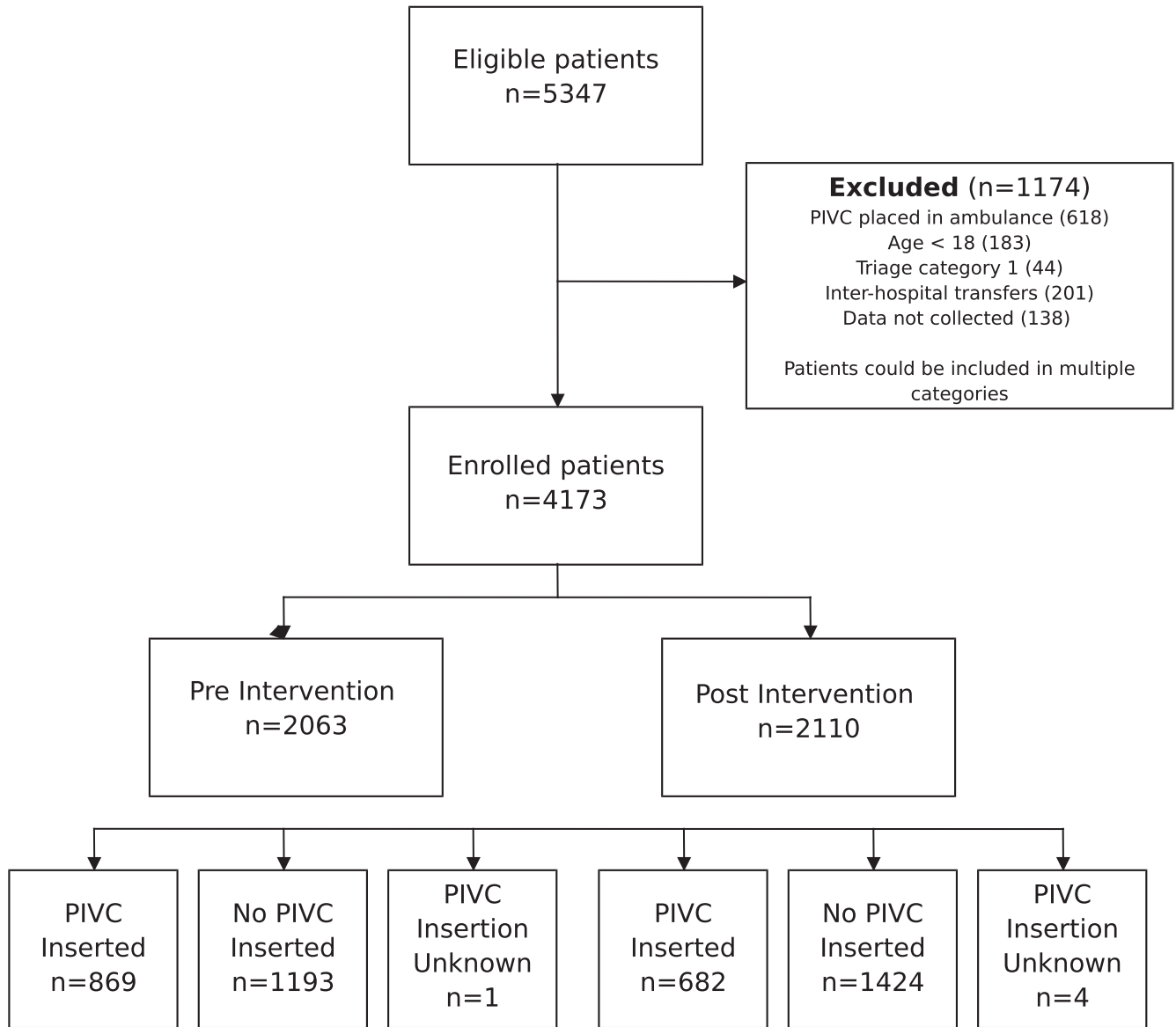


Figure 2. Flow diagram. PIVC = peripheral intravenous cannula.

Table 1
Baseline Characteristics of the Pre- and Post intervention Groups

	Preintervention (n = 2,063)	Postintervention (n = 2,110)
Age (y), median (IQR)	37 (27–53)	37 (26–55)
Male sex, n (%)	1,036 (50.2)	1,024 (48.5)
Triage category*		
2	222 (10.8)	200 (9.5)
3	755 (36.6)	820 (38.9)
4	821 (39.8)	885 (41.9)
5	264 (12.8)	205 (9.7)
Arrival by ambulance	694 (33.6)	638 (30.2)

*One patient had missing data for triage category

Table 2
PIVC Use With the ED or Within 24 Hours of Admission

	Preintervention (n = 612)	Postintervention (n = 568)
Administration of fluid	434 (70.9)	392 (69.0)
Administration of drugs	446 (72.9)	428 (75.4)
Administration of blood	13 (2.1)	27 (4.8)
Administration of contrast	49 (8.0)	57 (10.0)

Data are reported as n (%).
PIVC could be used for more than one purpose so numbers do not add to total.
PIVC = peripheral intravenous cannula.

power may have precluded the detection of an effect. The intervention differed in its focus on environment change rather than an education and cultural change

promoting critical thinking to support behavioral change.

In our study we identified between 42% (pre) and 32% (post) of patients had a PIVC inserted and of

Table 3
Within-trial Cost Analysis, in Australian Dollars (2016 Terms)

Number of ED presentations post intervention	2,110
Difference in PIVC insertion rate, % (95% CI)	-9.8% (-12.7 to -6.8%)
Number of fewer PIVCs inserted, mean (95% CI)	207 (143 to 268)
Average cost per PIVC inserted, mean (bootstrap 95% CI)	\$22.79 (\$19.35 to \$26.23)
Saving over the post intervention trial period	\$4,718 (\$3,126 to \$6,309)

PIVC = peripheral intravenous cannula.

these 70% (pre) and 83% (post) were used. These figures differ from the only other ED study that reported PIVC insertion in 16% of the cohort and a usage rate of 50%.³ Given this study's retrospective chart review design with reliance on documentation of cannula insertion, these results must be interpreted with caution. Examination of a chart for evidence of insertion is likely to identify PIVC that have been accessed for therapy. Evidence of PIVC insertion may be difficult to identify as documentation is poor. Results identified in prospective studies outside the ED setting are more in keeping with our findings. A study of 1,000 general medical patients identified that 67% of PIVC were used.¹⁹ Another study in an acute medical admission unit found that 80% of patients received a PIVC and of these 66% were used.²⁰

LIMITATIONS

We acknowledge that our study has limitations. Influences such as rotations of new staff may have contributed to changes in PIVC use. We did not collect data on the number of patients who had a PIVC subsequently inserted as an inpatient, making it unclear whether PIVC insertion was avoided or merely delayed for some patients. Given that only 20% of patients without a PIVC were admitted, insertion in the ward is likely to be a rare event. Further, while there is a risk that patients without a PIVC may have a decline in their clinical status, emergency clinicians can identify this change and are trained to insert a PIVC in emergency circumstances. Evidence suggests that placing cannulas "just in case" potentially exposes patients to infection and this is more harmful than their risk of deterioration without a cannula.

The cost of separate venesection was not included in the analysis. We did not tailor our intervention to optimize use of oral therapies nor did we attempt to reduce avoidable intravenous therapies. While cost of venesection and use of alternative therapies are important to consider, they were outside the scope of this study. Future studies that examine 1) use of oral therapies and 2) reducing unnecessary intravenous tests and therapies are needed.

CONCLUSIONS

Peripheral intravenous cannula insertion can be reduced using a multimodal approach designed to support critical thinking and promote clinically appropriate peripheral intravenous cannula insertion and use.

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References

1. Carr PJ, Rippey JC, Cooke ML, et al. Development of a clinical prediction rule to improve peripheral intravenous cannulae first attempt success in the emergency department and reduce post insertion failure rates: the Vascular Access Decisions in the Emergency Room (VADER) study protocol. *BMJ Open* 2016;6:e009196.
2. Decker K, Ireland S, O'Sullivan L, et al. Peripheral intravenous catheter insertion in the emergency department. *Australas Emerg Nurs J* 2016;19:138-42.
3. Limm EI, Fang X, Dendle C, Stuart RL, Egerton Warburton D. 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.
4. Goransson KE, Johansson E. Indication and usage of peripheral venous catheters inserted in adult patients during emergency care. *J Vasc Access* 2011;12:193-9.
5. Abbas SZ, Klass de Vries TK, Shaw S, Abbas SQ. Use and complications of peripheral vascular catheters: a prospective study. *Br J Nurs* 2007;16:648.
6. Velasco Diaz L, Fernandez Gonzalez B, Garcia Rios S, Hernandez del Corro E. The evaluation of unnecessary venous access ports in an emergency service. *Med Clin (Barc)* 2000;114:89-90.

7. Henderson RA, Thomson DP, Bahrs BA, Norman MP. Unnecessary intravenous access in the emergency setting. *Prehosp Emerg Care* 1998;2:312–6.
8. Fry M, Romero B, Berry A. Utility of peripheral intravenous cannulae inserted in one tertiary referral emergency department: a medical record audit. *Australas Emerg Nurs J* 2016;19:20–5.
9. Rickard CM, Webster J, Wallis MC, et al. Routine versus clinically indicated replacement of peripheral intravenous catheters: a randomised controlled equivalence trial. *Lancet* 2012;380:1066–74.
10. Dychter SS, Gold DA, Carson D, Haller M. Intravenous therapy: a review of complications and economic considerations of peripheral access. *J Infus Nurs* 2012;35:84–91.
11. Stuart RL, Cameron DR, Scott C, et al. Peripheral intravenous catheter-associated *Staphylococcus aureus* bacteraemia: more than 5 years of prospective data from two tertiary health services. *Med J Aust* 2013;198:551–3.
12. Trinh TT, Chan PA, Edwards O, et al. Peripheral venous catheter-related *Staphylococcus aureus* bacteremia. *Infect Control Hosp Epidemiol* 2011;32:579–83.
13. Austin ED, Sullivan SB, Whittier S, Lowy FD, Uhlemann AC. Peripheral intravenous catheter placement is an underrecognized source of *Staphylococcus aureus* bloodstream infection. *Open Forum Infect Dis* 2016;3:ofw072.
14. Champion K, Mouly S, Lloret-Linares C, et al. Optimizing the use of intravenous therapy in internal medicine. *Am J Med* 2013;126(925):e1–9.
15. Parenti CM, Lederle FA, Impola CL, Peterson LR. Reduction of unnecessary intravenous catheter use. Internal medicine house staff participate in a successful quality improvement project. *Arch Intern Med* 1994;154:1829–32.
16. Siriwardena AN, Iqbal M, Banerjee S, Spaight A, Stephenson J. An evaluation of an educational intervention to reduce inappropriate cannulation and improve cannulation technique by paramedics. *Emerg Med J* 2009;26:831–6.
17. Kelly AM, Egerton-Warburton D. When is peripheral intravenous catheter insertion indicated in the emergency department? *Emerg Med Australas* 2014;26:515–6.
18. Egerton-Warburton D, Ieraci S. First do no harm: in fact, first do nothing, at least not a cannula. *Emerg Med Australas* 2013;25:289–90.
19. Lederle FA, Parenti CM, Berskow LC, Ellingson KJ. The idle intravenous catheter. *Ann Intern Med* 1992;116:737–8.
20. Barlow G, Palniappan S, Mukherjee R, Jones M, Nathwani D. Unnecessary peripheral intravenous catheterisation on an acute medical admissions unit: a preliminary study. *Eur J Intern Med* 2002;13:380.

Supporting Information

The following supporting information is available in the online version of this paper available at <http://onlinelibrary.wiley.com/doi/10.1111/acem.13335/full>
Data Supplement S1. Resource use per PIVC insertion, in Australian dollars (2016 terms).