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# Long peripheral catheters for deep arm vein venous access: A systematic review of complications

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ABSTRACT

*Purpose:* Long peripheral catheters (LPCs) offer a quick, simple and cost-effective alternative for venous access in intensive care patients with difficult venous access, but the decision to use them must be balanced against an assessment of harm. The aim of this systematic review was to synthesise reports of complications associated with LPCs.

*Methods:* The electronic databases MEDLINE, EMBASE and CINAHL were searched systematically for randomised controlled trials, cohort studies and case control studies published in the period 1966 to 24th July 2018 reporting LPC associated occlusion, catheter related blood stream infections, phlebitis and infiltration. Study quality was assessed using the Methodological Index for Non-Randomised Studies. The studies were described and participant characteristics; type of catheter; setting; average dwell time; and rates of occlusion, catheter related blood stream infection, phlebitis and infiltration were extracted as summary measures.

*Results:* Five cohort studies and one randomised controlled study, comprising a total of 350 participants, fulfilled the inclusion criteria. Dwell time ranged from 1 to 15 days and the reported complication rate was 3–14%. The most common complication was catheter occlusion (4%), followed by phlebitis (1%), infiltration (0.9%), and catheter related blood stream infection (0.3%). Significant heterogeneity, particularly in identification and reporting of complications, means results should be interpreted with caution.

*Conclusion:* There is a lack of intervention specific and adequately powered randomised controlled trials investigating LPCs in an intensive care setting. Until the results of such studies are available, LPCs should be used as an alternative to ultrasound-guided PVCs in well monitored acute care environments.



## Introduction

Critically ill patients in the intensive care unit (ICU) almost always require venous access. This is often achieved acutely using a central venous catheter (CVC), but these are generally unsuitable for intermediate to long term use because they risk thrombosis, catheter related blood stream infections and central vein stenosis.[1–5] Peripheral venous cannulas (PVCs) are used once the CVC is no longer necessary. Many PVCs are placed in deep arm veins (cephalic, basilic and brachial) using ultrasound because superficial veins are often inaccessible, usually due to oedema in the critically ill population.[6] This technique is generally successful, especially when combined with a direct catheter over wire Seldinger approach, and may reduce CVC usage.[6–10] However, several studies have shown that the risk of infiltration and extravasation is as high as 50% within 24 h of placement of the PVC.[11–14] This is probably due to insufficient PVC length (<5.2 cm).[13] Some clinicians use midline catheters (15–30 cm), but these are significantly more expensive, invasive and time-consuming to insert than PVCs.

Recently, long peripheral catheters (LPC) have been introduced into clinical practice. They are 6–15 cm long, which is longer than PVCs but shorter than midline catheters. LPCs are inserted using ultrasound and a direct catheter over wire with a Seldinger approach, rather than the more complicated and invasive modified Seldinger approach that is used for midline catheters. They are also less expensive than midline catheters (typically less than one fifth of the price) but are made of the same biocompatible materials. The shorter, smaller diameter, and less invasive LPCs could offer low complication rates when used for ongoing intravenous access.

There are potential benefits of LPCs over both PVCs and midline catheters for accessing deep veins in the ICU but the potential complications are not well described. A detailed evaluation of the determinants and likelihood of complications is required in order to help clinicians decide the most appropriate vascular access device for patients requiring deep vein catheterisation. The purpose of this systematic review was to synthesise reports of adverse events associated

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with LPCs in hospitalised patients with difficult venous access. The focus is on occlusion, catheter related blood stream infection, phlebitis and infiltration.

## Methods

The electronic databases MEDLINE, EMBASE and CINAHL (time period between 1966 and 24th July 2018) were searched in order to identify reports of LPCs being used for deep arm vein cannulation. The free-text terms 'Seldinger', 'guidewire catheter', 'difficult venous access', 'difficult intravenous access', 'long peripheral', 'extended peripheral', 'short midline catheter' and 'ultrasound-guided' were used. Please see Appendix A for the full search strategy. The references cited in identified papers were also considered for inclusion. Studies were eligible for inclusion if they were published randomised controlled trials, cohort or case control studies available in English on the topic of using a >6 cm long catheter inserted using a direct Seldinger approach (without a dilating device) to access the deep arm veins (cephalic, basilic or brachial) of acute inpatients with difficult intravenous access. Initially, our focus was the adult ICU, but this was broadened to include all acute inpatients after preliminary searches revealed a dearth of evidence specific to intensive care. Studies were then eligible for inclusion if they reported complication rates (including occlusion, catheter related blood stream infection, phlebitis and infiltration) as an outcome. Studies were screened by title and abstract, and papers potentially meeting the inclusion criteria were read in full. We described the studies and extracted the following data: participant characteristics; type of catheter; setting; average dwell time; and rates of occlusion, catheter related blood stream infection, phlebitis and infiltration.

We assessed the quality of included studies using the Methodological Index for Non-Randomised Studies which has been validated for comparative and non-comparative studies.[15] 12 pre-defined quality criteria were available as a checklist and scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate). The best possible total score was 16 for non-comparative studies and 24 for comparative studies. The results were normalised by dividing the total score by the maximum score for the study type, which was then expressed as a percentage.

## Results

We identified a total of 665 publications, of which 656 were rejected based on their title and abstract. Of these, 636 were unrelated, 15 were duplicates, two were conference abstracts, two were letters and one was a case report. Nine full text publications were read in full, three of which were rejected because they did not report the considered complications.[16–18] Six full text publications were considered to be eligible (Fig. 1).

The included studies consisted of one randomised controlled trial and five cohort studies. One cohort study included a control group whereas the others were non-comparative. The median quality score was 85 and the interquartile range was 80–93 (Table 1).

### Summary of included studies

#### *Participants*

Six studies, comprising a total of 350 participants, were included in this review. The number of trial participants ranged from 20 to 157. All of the studies were conducted in a single-centre and included convenience samples of acute inpatients with difficult intravenous access. Adult participants were included in five studies[19–22,24] and paediatric participants (> 10 years old) in one study.[23] Participants were recruited from the ICU ($n = 29$),[19,20] Emergency Department ($n = 73$)[19,23,24] and other acute inpatient settings ($n = 248$) .[19–22] All but one of the studies were published within the last 6 years. Two studies were sponsored by the industry.[20,22]

#### *Interventions*

There were nine different LPCs used across the six studies. Catheter length and diameter ranged from 8 to 18 cm and 16G-22G respectively. The catheter material was polyurethane in four studies ($n = 259$),[19,20,22,24] polyethylene in one study ($n = 71$),[21] and unclear in one study ($n = 20$).[23] Different catheters were used depending on the calibre and anatomical course of the vein in two studies.[20,21] The remaining four studies used a single catheter. The LPCs were not always commercialised for the purpose; two studies used catheters commercialised for arterial access[20,21] and one study used a catheter commercialised for central venous access.[24] Average dwell time ranged between 1 and 15 days. The maximum reported dwell time was 55 days.[21] The majority of protocols required the removal of catheters when peripheral venous access was no longer required but one paper limited dwell time to a maximum of seven days.[20] Catheters were prematurely removed if a complication was identified.

#### *Outcomes*

All of the studies reported rates of occlusion, infiltration, catheter related blood stream infection and phlebitis as a primary or secondary outcome. Ultrasound was used to identify catheter tip thrombus in three studies.[19–21] Only one study provided diagnostic criteria for phlebitis and catheter related blood stream infection.[21]

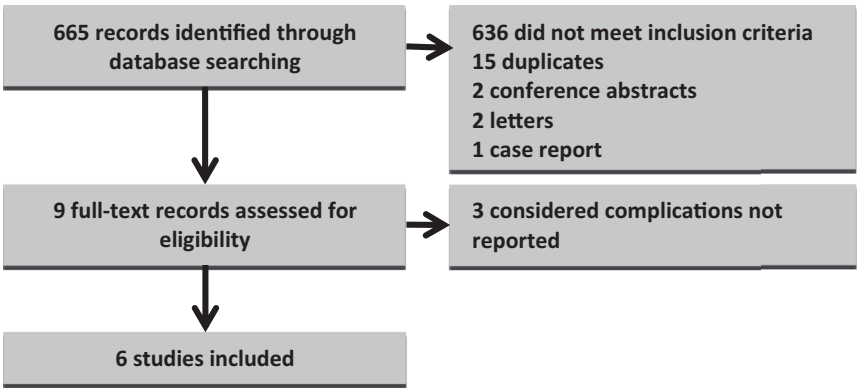


**Fig. 1.** Study flow diagram.

**Table 1**
Risk of bias summary

| Author | Design | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Quality score (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elia et al.[19] | RCT | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 23 (96) |
| Meyer et al.[20] | Cohort | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | NA | NA | NA | NA | 15 (94) |
| Fabiani et al.[21] | Cohort | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | NA | NA | NA | NA | 14 (88) |
| Warrington et al.[22] | Cohort | 2 | 0 | 2 | 1 | 2 | 2 | 2 | 2 | NA | NA | NA | NA | 13 (81) |
| Paladini et al.[23] | Cohort | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 0 | 2 | 2 | 1 | 1 | 19 (79) |
| Mills et al.[24] | Cohort | 1 | 0 | 2 | 1 | 2 | 2 | 1 | 0 | NA | NA | NA | NA | 9 (56) |

The author's risk of bias judgements. The scoring system used was the Methodological Index for Non-Randomised Studies which is based on 12 categories: 1. A clearly stated aim; 2. Inclusion of consecutive patients; 3. Prospective collection of data; 4. Endpoints appropriate to aim of study; 5. Unbiased assessment of the study endpoint; 6. Follow-up period appropriate to the aim of the study; 7. Loss to follow up less than 5%; 8. Prospective calculation of study size; 9. An adequate control group; 10. Contemporary groups; 11. Baseline equivalence of groups; 12. Adequate statistical analysis[15]. The items are scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate). The best possible score was 16 for non-comparative studies and 24 for comparative studies. *NA*, not applicable; *RCT*, randomised controlled trial.

The reported overall complication rate ranged from 3 to 14%. Occlusion was the most common complication (0–10%), followed by phlebitis (0–3%), then infiltration (0–4%) and catheter related blood stream infection (0–1%). The unweighted incidence of occlusion was 4% (12 of 300), phlebitis 1% (4 of 300), infiltration 0.9% (3 of 350) and catheter related blood stream infection 0.3% (1 of 350). All six studies concluded that LPCs are a safe alternative to ultrasound-guided PVCs in patients requiring short to medium term intravenous access. Please see Table 2 for a summary of study characteristics and outcomes.

## Discussion

To our knowledge, this is the first systematic review of LPC complications. The results suggest that LPCs are a safe alternative means of peripheral venous access in acute inpatients with difficult venous access. There were only three cases of infiltration overall, giving an unweighted incidence of 0.9% and the maximum reported incidence in a single study was 4%. This is considerably lower than the ultrasound-guided PVC infiltration rates published by Elia et al.,[19] Paladini et al.,[23] and elsewhere in the literature.[11–13] As such, LPCs may offer a better alternative to an ultrasound-guided PVCs.

Interestingly, only one case of catheter related blood stream infection was identified, giving an unweighted incidence was 0.3%. However, it is difficult to compare this finding with other venous access devices because the majority of cases of catheter related blood stream infections occur in the ICU,[25] a setting that was not well represented in this review. Moreover, only one study provided diagnostic criteria, which increases the risk of bias because the incidence of catheter related blood stream infection is known to be highly dependent on the diagnostic criteria used.[26] Further studies using clear diagnostic criteria in an ICU setting would be required to investigate this further.

The peripheral vascular access device with the lowest complication rate is yet to be established. Various catheters were used in the included studies but no consensus was reached regarding the optimal peripheral catheter choice. In particular, none of the studies identified compared midline and LPC complication rates. One possible benefit of LPCs over midlines is that the catheter tip is typically distal rather than proximal to the axilla. This enables the use of ultrasound to identify catheter tip thrombus and may also directly influence complication rates.[19–21] However, it is yet to be established whether catheter tip position and asymptomatic catheter tip thrombus are associated with complications. Future randomised controlled trials could investigate this. Further trials are also required to optimise catheter length, diameter, insertion technique and material.

### *Limitations*

The studies were mostly single group observational studies of heterogeneous methodology including: complication identification and diagnosis; catheter manufacturer, material, length and gauge; acute inpatient settings; catheter care protocols (often inadequately described); and dwell time. Context and device specific studies with robust and systematic methods for identifying and diagnosing complications are required. Reporting of both absolute and relative incidence of complications per 1000 catheter days would help correct for variation in dwell time.

There are also review level limitations. It could be argued that the number of published studies does not reflect the evolving range of LPCs available on the market. This may be due to publication bias, the lack of established terminology for LPCs resulting in the omission of relevant manuscripts, the lack of a search for unpublished studies, and language bias.

## Conclusion

The safety of using LPCs for accessing deep veins is supported by a small number of heterogeneous observational and preliminary controlled studies. LPCs are likely to have a lower infiltration rate than

**Table 2**
Characteristics of included studies

| Study | *n* | Catheter | Material | Length and gauge | Average dwell time, days | Occlusion, *n* (%) | CR-BSI, *n* (%) | Phlebitis, *n* (%) | Infiltration, *n* (%) | Complications, *n* (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Elia et al.[19] | 50 | Arrow | Polyurethane | 12 cm 20G | 6 | * | 0 | * | 1 (2) | 6 (12) |
| Meyer et al.[20] | 29 | Seldicath | Polyurethane | 8 cm 18–20G | 6 | 2 (7) | 0 | 0 | 0 | 2 (7) |
| Fabiani et al.[21] | 71 | Leader-Cath | Polyethylene | 8–18 cm 18–20G | 15 | 7 (10) | 1 (1) | 2 (3) | 0 | 10 (14) |
| Warrington et al.[22] | 157 | Power Wand | Polyurethane | 8 cm 16G | 7 | 1 (1) | 0 | 2 (1) | 1 (1) | 4 (3) |
| Paladini et al.[23] | 20 | Leader-Cath/ Leader-Flex | Polyethylene/ Polyurethane | 8 cm 20G | 9 | 2 (10) | 0 | 0 | 0 | 2 (10) |
| Mills et al.[24] | 23 | Cook | Polyurethane | 15 cm 16G | 1 | 0 | 0 | 0 | 1 (4) | 2 (4) |
| | | | | | Unweighted incidence, % | 4 | 0.3 | 1 | 0.9 | 7 |

CR-BSI: catheter related bloodstream infection; *: 5 occlusion/phlebitis cases.

ultrasound-guided PVCs, but there is a lack of large intervention and ICU specific controlled studies to accurately estimate the risk of complications. Until such studies are realised, it is suggested that LPCs should only be used as an alternative to ultrasound-guided PVCs in acute care environments where they are rigorously maintained, carefully observed and regularly audited.

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## Conflicts of interest

None.

## Appendix A. Search strategy

Searched 24th July 2018

Titles and abstracts from the databases MEDLINE (1946-present), EMBASE (1974-present) and CINAHL (1937-present) were searched using the following terms:

"("seldinger" AND "difficult venous").ti,ab OR ("guidewire" AND "difficult venous").ti,ab OR ("long peripheral" AND "difficult venous").ti,ab OR ("extended peripheral" AND "difficult venous").ti,ab OR ("extended peripheral" AND "difficult intravenous").ti,ab OR ("long peripheral cannula").ti,ab OR ("long peripheral catheter").ti,ab OR ("short midline catheter").ti,ab OR ("short midline").ti,ab OR ("difficult venous" AND "ultrasound guided").ti,ab OR ("seldinger" AND "peripheral").ti,ab OR ("catheter" AND "difficult intravenous access").ti,ab OR ("seldinger" AND "peripheral").ti,ab OR ("catheter" AND "difficult venous").ti,ab OR ("seldinger" AND "cannula").ti,ab OR ("long cannula").ti,ab OR ("difficult intravenous" AND "ultrasound guided").ti,ab"

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