

# Introducing an ultrasound-guided longer length peripheral IV catheter for patients with difficult venous access

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Approximately 90% of hospitalised patients require a peripheral catheter during their stay (Chen et al, 2021). Reports indicate that the majority (90%) fail before therapy completion, and that up to 50% can fail within the first 24 hours due to infiltration, dislodgement or extravasation (Helm et al, 2015; Steere et al, 2019). Failure may be more common in patients with difficult venous access (DVA), such as those with a high body mass index (BMI) leading to thicker subcutaneous adipose tissue to navigate, diabetic patients with difficult vasculature, and patients with repeated hospitalisations due to multiple comorbidities and consequentially repeated vascular access (van Loon et al, 2019; Rodríguez-Calero et al, 2020).

The effects of failed cannulation can be categorised as system impacts and patient experience impacts. For the healthcare system, repeated cannulation attempts lead to increased use of nursing time, as well as increased wastage of consumables such as the catheter itself, skin disinfectants and tourniquets. Moreover, local protocols may require that patients who have had multiple failed cannulation attempts are escalated to anaesthetists or vascular access specialist nursing teams, creating additional workload.

For patients, repeated cannulation attempts are not only painful and distressing (Schults et al, 2022), but may lead to delayed treatment. This can be extremely worrying for patients, as they know that their time to improvement may be protracted or hospital stay lengthened as a result (Shokoohi et al, 2020). The cannulation process itself may lead to increased feelings of anxiety and distress related to previous failed cannulation attempts, potentially increasing the risk of iatrogenic needle phobias and anticipatory procedural pain (McGowan, 2014). In addition, there may be increased risk of complications as a result of multiple puncture sites, such as infection, phlebitis or thrombosed veins (Steere et al, 2019).

Previously, in the authors' Trust, the standard practice for DVA patients was escalation to anaesthetists or the vascular access

## ABSTRACT

**Aim:** Insertion of a peripheral intravenous catheter (PIVC) is one of the most common procedures carried out in hospitals worldwide, but failure rates are unacceptably high. This local quality improvement project aimed to assess improvements in first-stick success rate, dwell time and overall catheter success rate when implementing a longer-length peripheral intravenous catheter (LPIVC) under ultrasound guidance for patients with difficult venous access (DVA). **Methods:** Data were collected from 386 DVA patients requiring a PIVC at one hospital. Number of catheter insertion attempts, catheter dwell time and reason for catheter removal were recorded for each patient. To implement the new DVA catheterisation pathway, registered nurses undertook a training programme comprising workshops and ultrasound-guided cannulation technique practice on phantoms. Costs and waste weights associated with LPIVC insertion, compared with midline insertion, were calculated. **Results:** First-stick success rate was 95.0% using the LPIVC under ultrasound guidance. Dwell time ranged from 1 to 80 days, with a large proportion of those dwelling <1 day being placed in day-case patients. Treatment success rate with the LPIVCs was 83.6%. Equipment costs for an LPIVC insertion were £89.22 lower than for a midline insertion, and the weight of waste generated per procedure was 1 kg lower for LPIVCs. **Conclusions:** First-stick success rate of LPIVCs, aided by improved purchase in the vein and visualisation with ultrasound guidance, was very high, superior to rates reported in other studies. The procedure provides a better patient experience as successful first attempts avoid unnecessary further insertion attempts. Other benefits are increased nursing time efficiency, a reduction in clinical waste and the lower cost of the equipment required.

**Key words:** Difficult venous access ■ Long intravenous peripheral catheter ■ Cannulation failure ■ Vascular access ■ Ultrasound guidance

team (for the placement of a midline or peripherally inserted central catheter (PICC) in accordance with the Vessel Health and Preservation Framework 2020 (Infection Prevention Society, 2020; Hallam et al, 2021). Midlines inserted by the vascular access team were found to be costly, time consuming to insert and required large amounts of consumables. To overcome the difficulties cannulating DVA patients and the costs associated with midlines, the vascular access team implemented a long peripheral intravenous catheter (LPIVC) (Introcan Safety® Deep Access (64 mm), B. Braun Medical, UK) 22G or 20G for all DVA patients and patients with complex coagulation issues which may make them susceptible to DVA (Figure 1), as per the evidence-driven definition of DVA proposed by Bahl et al (2021):

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**Figure 1.** A patient's hand showing phlebitis and haematoma after multiple failed attempts at short peripheral cannula insertion (a); insertion of an Introcan Safety® Deep Access under ultrasound guidance (b, c); an Introcan Safety® Deep Access in situ (d)

Table 1. Main content of the insertion record for ultrasound-guided peripheral intravenous cannulation	
Type: Introcan or standard cannula	
Site of insertion: Left/right	
Location: forearm/antecubital fossa	
Gauge and number of attempts	
Drug requiring insertion of device	
Sterile technique including sterile gel used	Yes/No
Disposable tourniquet used	Yes/No
Site decontaminated using 2% chlorhexidine gluconate in 70% isopropyl alcohol	Yes/No
Secured and sterile transparent semi-permeable dressing over site	Yes/No
Extension set with needle-free IV access device applied	Yes/No
Chlorhexidine-impregnated sponge applied	Yes/No
VIP score	
Do not remove line unless VIP score is >1 and contact vascular access team	
Insertion recorded	Yes/No
Referred for line care and maintenance	Yes/No

‘When a clinician has two or more failed attempts at peripheral intravenous access using traditional techniques, physical examination findings are suggestive of DVA (for example, no visible or palpable veins) or the patient has a stated or a documented history of DVA.’

This LPIVC has shown clinical and economic benefits in other NHS trusts, as well as positive patient feedback (Smith and Irimia, 2023; Moreta, 2023).

### Methods

Staff at the Trust’s research and development department were approached for ethical review of the research, and approved the quality improvement project.

A standard operating procedure was designed by the lead vascular access advanced nurse practitioner to support the vascular access team in use of the LPIVC under ultrasound guidance. The standard operating procedure described:

- Skin preparation using 2% chlorhexidine in 70% isopropyl alcohol, with at least 30 seconds of contact time and 30 seconds of drying time
- A sterile ultrasound technique with sterile ultrasound gel, the ultrasound machine covered in a sterile drape, and the use of sterile gloves for insertion in view of longer cannula dwell time
- Sterile technique employed for the insertion of the LPIVC
- Post-insertion, securing of the LPIVC with an adhesive sutureless device, to be changed weekly
- Post-insertion, covering the insertion site with a chlorhexidine-impregnated patch, to be changed weekly
- Post-insertion, covering the LPIVC with a semipermeable transparent dressing, to be changed weekly.

The standard operating procedure was supported with a training programme designed by the vascular access team, to foster mastery of the ultrasound technique. Training consisted of a 4-hour workshop with phantom ultrasound guidance practice to train ultrasound novices, followed by 1:1 training with patients requiring cannulation. Nurses underwent ongoing assessment of their ultrasound technique and were required to complete 15 successful ultrasound-guided cannulations to achieve an adequate level of knowledge, along with workshops related to anatomy, physiology and vessel health preservation. An insertion record was also introduced (Table 1) and a database was maintained to document complications, dwell time and first-stick success rate. Additionally, the total cost for a midline insertion and LPIVC insertion were calculated with information provided by the Trust’s procurement department. The waste produced by each technique was also calculated by weighing the consumables used in each procedure.

All patients with a documented history of DVA, patients who are likely to have DVA (that is those with a high BMI, with diabetes, or with a history of multiple hospitalisations), and patients who are susceptible to DVA due to complex coagulation issues, were cannulated with the LPIVC. Data on patients receiving the device were retrospectively taken from March 2021 to March 2023 from the database maintained by the vascular access team.

## Results

Overall, 386 patients were cannulated with the LPIVC during the study period. Baseline characteristics of the patients receiving LPIVCs during the study period are detailed in *Table 2*.

In total, 367 (95.1%) cannulations were successful on the first attempt; 16 (4.1%) required two attempts and 3 (0.8%) required three attempts. There were no failed insertions observed.

Some 110 (28.5%) cannulations were carried out by nurses who were still undergoing the ultrasound training programme at the time of insertion; 276 (71.5%) were carried out by nurses who had already completed the programme.

Total dwell time ranged from 0 to 80 days (*Table 3*). Most patients with dwell times of more than 4 days required vascular access for the administration of IV antibiotics and fluids. Of the 245 LPIVCs with a 0–4 day dwell time, 96 (39.2%) were placed in day-case patients. The majority of day cases were haematology patients requiring vascular access for their treatment, such as iron infusions and blood products.

Treatment success rate was 83.5% (*Table 4*); this was defined as the LPIVC being removed due to treatment completion, or the patient dying for reasons unrelated to the cannulation with the LPIVC still in situ at the time of death. Data on removal reason was missing from 45 (11.7%) patients.

The equipment costs for midlines totalled £107.66 per attempt, compared with £18.44 per attempt with an LPIVC, resulting in a total saving of £89.22 per insertion attempt. When weighing the equipment (including packaging) needed for both procedures, the total weight of equipment for a midline insertion was 1105 g, compared with 91 g for a LPIVC, resulting in a 1014 g reduction in waste per procedure.

## Discussion

The first-stick success rate was considerably higher than the 66.0% reported when using a vein palpation technique to insert a non-ported intravenous catheter (González López et al, 2014) and the 73% reported in other studies using ultrasound guidance (Carr et al, 2019). Moreover, both of these studies included patients who were not DVA, making our findings more notable.

The treatment success rate achieved was also superior to other studies in DVA patients, which range from 27.0% for short peripheral intravenous catheters (SPIVCs) (48 mm) (Bahl et al, 2019) to 68.7% for LPIVCs (Bahl et al, 2020).

Almost one-third of LPIVCs were inserted by nurses who were still undergoing the ultrasound-guided cannulation training at the time, and the first-stick success rate and treatment success rate were nevertheless very high. This suggests not only that the training programme was successful, but that the ultrasound guidance technique and the LPIVC itself are intuitive and easily mastered even by nurses without previous ultrasound skills.

Many patients cannulated with the LPIVC were haematology patients who, by the nature of their treatment, require frequent venous access and may have vessel damage, leading to DVA. The high cannulation success rate and first-stick success rate suggest that the LPIVC under ultrasound guidance is a highly effective device for use in these patient subgroups.

Additionally, the transition from midlines to LPIVCs results in a £89.22 saving per procedure as well as a 1 kg reduction in

**Table 2. Baseline characteristics of patients cannulated with the long peripheral intravenous catheter**

Patient characteristics	Number (percentage) n=386
<b>Sex</b>	
Male	135 (35.0%)
Female	251 (65.0%)
<b>Side of insertion</b>	
Right arm	184 (47.7%)
Left arm	188 (48.7%)
Data missing	14 (3.6%)
<b>Gauge of PIVC</b>	
20G	163 (42.2%)
22G	214 (55.4%)
Data missing	9 (2.3%)

**Table 3. Dwell time of the long peripheral intravenous catheters**

Dwell time (days)	Number (percentage) n=386
0–4	245 (63.5%)
of which day cases	96 (39.2%)
5–10	99 (25.6%)
11–15	24 (6.2%)
16–20	10 (2.6%)
21–25	2 (0.5%)
26–56	5 (1.3%)
57–70	0 (0.0%)
71–80	1 (0.3%)

**Table 4. Reasons for removal of the long peripheral intravenous catheter**

Reason for removal	Number (percentage) n=341
Visual infusion phlebitis score >1	26 (7.6%)
Dislodged or removed by patient	31 (9.1%)
Treatment success	284 (83.5%)
■ Treatment completed	263 (77.4%)
■ Patient death	21 (6.2%)

waste. Consequentially, the LPIVC and associated equipment are more cost-effective to procure, but also require fewer resources to produce and cost less to dispose of in both clinical and non-clinical waste streams. Considering the high first-stick success rate in the cohort, this saving becomes even more remarkable, as expenditure increases with the number of attempts (Bahl et al, 2019; van Loon et al, 2020). This finding is consistent with other cost-effectiveness studies comparing LPIVCs with SPIVCs (Smith and Irimia, 2023; Bahl et al, 2023; Moreta, 2023).

The benefits observed in the hospital setting in this quality improvement project have additionally been realised in the outpatient parenteral antibiotic therapy (OPAT) ‘Hospital at Home’ service in operation at the authors’ Trust. Prior to the roll-out of the LPIVC, patients who were discharged to virtual

**KEY POINTS**

- Ultrasound-guided long peripheral intravenous catheters for patients with difficult venous access resulted in high first-stick success and catheter success rates, avoiding repeated failed cannulations and treatment delays
- Use of the new catheters reduces nursing time input as well as the need for more invasive devices
- The new long peripheral intravenous catheters resulted in savings in both cost of equipment and volume of waste, when compared with the previous standard practice of using midlines in this patient cohort
- Efficiencies have been shown in the hospital and community settings

**CPD reflective questions**

- In your experience, what defines a difficult venous access patient?
- Do ultrasound-guided peripheral intravenous catheters have a simpler insertion process than a midline?
- Can you identify any patients in your hospital who would benefit from the use of ultrasound-guided long intravenous peripheral catheters?

wards would have to have their SPIVCs removed, and a midline or PICC placed instead, which were costly, invasive and time-consuming to insert. Now, if patients have a LPIVC in place already, this can remain in situ for OPAT delivery, thus easing their transition to virtual ward treatment.

The success of the new LPIVC pathway can be attributed to the device’s length within the vein, the accurate placement using ultrasound guidance, the implementation of a standard operating procedure and comprehensive training, and the follow-up care and maintenance carried out by the vascular access team. Following the success of the project, the roll-out of the pathway is being extended to other clinical areas in the Trust, in order to improve the patients’ experience when the placement of a PIVC is required for treatment.

**Conclusion**

The introduction of LPIVCs inserted under ultrasound guidance for patients with DVA led to a very high first-stick success and catheter success rates. Avoidance of repeated failed cannulations improves the experience for patients, while also avoiding escalation, which may lead to delays in treatment. This may improve patients’ satisfaction and confidence in healthcare staff to provide a high standard of care (Shaukat et al, 2019; Schults et al, 2022). Reduction in repeated cannulation attempts improves nursing time efficiency across multiple departments and reduces the need for more invasive devices. In addition, the new pathway represented savings in both cost of equipment and volume of waste, when compared with the previous standard practice of using midlines in this patient cohort. **BJN**

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