ORIGINAL ARTICLE

# A quality improvement project: Reducing bloodstream infection by improving adherence to the care bundle of peripheral vascular catheters at the COVID-19 treatment centre

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**ABSTRACT**

**Introduction: During the COVID-19 pandemic, bloodstream infection (BSI) rates were substantially rising in Sungai Buloh Hospital (HSB). It is believed that the COVID-19 pandemic has had an adverse impact on BSI incidence caused by contaminated periphery vascular catheters (PVCs). The study's objective is to reduce the BSI rates in HSB by improving adherence to the PVC care bundle via the Plan-Do-Study-Act (PDSA) approach.**

**Materials and Methods: A quality improvement (QI) project was employed over four months, from June to September 2021, during the COVID-19 pandemic in HSB. All adults hospitalised for COVID-19 with intravenous lines were subjected to data collection. A baseline audit was conducted to study BSI incidence from April to May 2021. Implementation was carried out by PDSA cycles and data on BSI rates per 100 admissions was described using a monthly run chart.**

**Results: At baseline, the BSI rate per 100 admissions was 5.44 before implementing our QI project. Initial changes via PDSA cycles did not bring significant improvements to BSI rates and a rising trend in BSI rates was observed after two PDSA cycles. Further audits identified the problem of non-compliance with the practice of aseptic non-touch technique (ANTT) and a lack of effective leadership in implementing the PVC care bundle. The third PDSA cycle focused on adopting practical leadership skills among senior clinicians to ensure compliance with the prevention bundle and to encourage the use of ultrasound guidance for difficult line insertion. After the third PDSA cycle, the BSI rate per 100 admissions was reduced from 6.41 to 4.34 ($p < 0.05$). The BSI rates continued to decline down the line for another five months.**

**Conclusion: Through QI initiatives, the risk of BSI can be significantly reduced.**

**KEYWORDS:**
*COVID-19, BSI, PDSA, QI*

## INTRODUCTION

With the global emergence of COVID-19, Sungai Buloh Hospital became the main COVID-19 treating centre in the Klang Valley from January 2020 onwards. Of note, all wards in HSB [including all general wards, intensive care unit (ICU), day care unit, day-care surgery unit, casualty ward, and the old hospital extension (also known as the *"Pusat Kawalan Kusta Negara"* (PKKN) (National Leprosy Centre)] were expanded to accommodate the sharp increase in the daily intake of patients with COVID-19. To meet the high demand for critically ill COVID-19 patients desperately requiring intensive care beds, critical care services in the ICU setting were augmented in the cardiac care unit, burn unit, and operation theatre. In general wards and ICU, the ratio of healthcare worker to patients was 1:6 and 1:1, respectively. The cohort of patients hospitalised to HSB were mainly the laboratory-confirmed COVID-19 cases with severe pneumonia and those with a high risk of potential deterioration.

In general, inpatient care often requires peripheral vascular catheters (PVCs) for intravenous (IV) administration of fluids, medications, blood products, or contrast media. However, PVCs may come with undesirable complications, such as phlebitis, catheter-related bloodstream infection (BSI), and extravasation leading to cellulitis or abscess formation. As COVID-19 cases surged daily in 2021 and with healthcare systems stretched by the COVID-19 pandemic, there was also a gradual surge of BSI. As experienced by other centres during this unprecedented period, BSI became a global issue due to the adverse impacts caused by the COVID-19 pandemic.[1-3] The severity of COVID-19 infection, prolonged hospital stays, use of steroids or immunomodulators, and a lack of adherence to infection control (IC) practices have contributed to a higher rate of nosocomial BSI and contaminated blood cultures.[4] Interestingly, BSI incidence was reported to be significantly higher in hospitalised individuals with COVID-19 compared with those without COVID-19.[4]

The BSI is suspected when one or more pathogens are obtained from cultured blood samples, possibly related to peripheral or central lines.[5] Having implemented a QI project using the Plan-Do-Study-Act (PDSA) approach, there was an improvement in adherence to care bundle targeted to reduce venous catheter-related BSI,[6] followed by improved BSI rates.[7] The main concepts in QI include: educating relevant staff on adherence to the PVC care bundle, developing measures to improve compliance with the bundle, plotting outcome data

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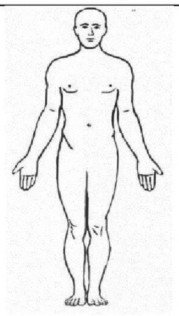
**Table I: The assessment form of PVC care bundle used in HSB**

| **Peripheral Vascular Catheter, PVC Daily Assessment** | Name: Age:<br>IC: MRN:<br>Diagnosis:<br>Comorbidity: ☐Stroke ☐CCF ☐ESRF ☐CA ☐RVD |
|---|---|
| Date of Admission: | Date of Insertion: |
| Size of PVC | ☐ Blue (22G) ☐ Pink (20G) ☐ Green (18G) ☐ Grey (16G) |
| Reason of Insertion<br>☐ Transfusion | ☐ Fluid<br>☐ TPN<br>☐ Intravenous medication(s)<br>☐ Others (SPECIFY) : |
| Site of Insertion (Circle "R", right or "L", left)<br>☐ Hand R / L ☐ Wrist R / L ☐ Forearm R / L<br>☐ Antecubital fossa R / L ☐ Others (SPECIFY) : |  <br>PLEASE MARK THE SITE OF INSERTION WITH CIRCLE(s) |
| Reason of removal<br>☐ No longer required<br>☐ Poorly complied with HII*<br>☐ VIP** ⩾ 2<br>☐ Others (SPECIFY) : | |

| INSERTION DATE | D1 (Date: ) | D2 (Date: ) | D3 (Date: ) | D4 (Date: ) |
|---|---|---|---|---|
| VIP score | | | | |
| REMOVED (Y/N) | | | | |

**HIGH-IMPACT INTERVENTION, HII of PVC***

1. Hand hygiene (hand washing before and after assessing PVC, with hand gloves).
2. Skin cleaning with 2% chlorhexidine or 70% alcohol.
3. Using sterile, transparent dressing. The dressing should be immediately changed if it is soiled or loose.
4. Recording PVC on the assessment form and medical record.
5. Scrub the hub with a 70% alcohol swab while using PVC.
6. Daily assessment of PVC (aseptic non-touch technique) with the visual infusion phlebitis (VIP) tool. Remove the PVC if one of the indications as stated above is fulfilled.

**Visual infusion phlebitis score, VIP****

| **Score** | **0**<br>Absent | **1**<br>1 of following | **2**<br>2 of following | **3**<br>> 2 of following |
|---|---|---|---|---|
| **Pain** | No | slight near IV site | pain near IV site | pain along cannula path |
| **IV site** | Healthy | Slight redness near intravenous site | Erythema swelling | Erythema induration |
| **Venous cord** | Not palpable | Not palpable | Not palpable | Palpable |
| **Result** | No phlebitis | Possible phlebitis | Early phlebitis | Medium stage of phlebitis |
| **Action** | Observe PVC | Observe PVC | Re-site PVC | Re-site PVC<br>Consider antibiotics |

CA, cancer; CCF, congestive cardiac failure; D, day; ESRF, end stage renal failure; G, gauge; HII, high-impact intervention; IC, identification card; IV, intravenous; PVC, peripheral vascular catheter; RVD, retroviral disease; TPN, total parenteral nutrition; VIP, visual infusion phlebitis; Y/N, yes/no

**Table II: The PDSA cycles executed from June to September 2021 in HSB**

| | First PDSA cycle (June–July 2021) | Second PDSA cycle (July–August 2021) | Third PDSA cycle (August–September 2021) |
|---|---|---|---|
| PLAN | To promote hand hygiene and create a safe work environment in the setting of isolation wards, in line with the guidelines established by the Ministry of Health | To reintroduce the concept of PVC care bundle to healthcare workers | To promote the adoption of a good leadership style among senior healthcare providers in executing the PVC care bundle |
| DO | 1. To emphasise the importance of adherence to the PVC care bundle by routinely using the PVC care checklist (Table I) for every individual on PVC.<br>2. To promote hand hygiene and avoid reusing, decontaminating, or utilising single-use medical gloves for an extended period<br>3. To prepare each cubicle of isolation wards with hand hygiene devices and instrument trolleys equipped with a complete set of tools essential for effective cannulation under the ANTT technique. | 1. To educate care providers on the PVC care bundle via video presentations, pictorial guidelines, and posters.<br>2. To promote compliance with the checklist of PVC care bundle through the teaching materials | 1. To encourage senior clinicians to act as role models in implementing strict PVC care bundle.<br>2. A set of standard questions was developed to help senior clinicians supervise the junior doctors and nurses during the ward round (Table III).<br>3. To encourage senior clinicians to assist junior doctors with difficult line placement using ultrasound guidance |
| STUDY | All wards, including ETD and ICU, were supplied with instrument trolleys. However, the qualitative experience revealed that most healthcare providers, especially junior doctors and nurses, were unsure how to execute an effective ANTT. | The BSI rates remained unsuppressed. In addition, qualitative experience revealed that full compliance with the PVC care bundle was still not achieved due to the new staff entry and a lack of supervision. | A reduction in the BSI rates was achieved. Adherence to PVC care bundle was sustained. |
| ACT | We proceeded with the implementation of the next PDSA. | The next PDSA cycle was discussed and executed. | Regular audits were continued. |

**Table III: Relevant questions for leaders to evaluate the PVC care during ward round during the third PDSA cycle**

1. How many intravenous cannulas are there at a given time?
2. Where is the intravenous cannula site?
3. Why is the intravenous cannula required?
4. Does the healthcare provider practise ANTT during the procedure?
5. Does the healthcare provider do daily inspection, cleaning/scrubbing hubs, and dressing on the patient's intravenous cannula?
6. Have any complications from intravenous cannula arisen?

over the study period, and studying the effectiveness of these interventions. We aimed to reduce the BSI rates over four months by addressing flawed IC practices and improving compliance with the ANTT in maintaining PVCs among patients admitted for COVID-19.

## MATERIALS AND METHODS

A multidisciplinary team was created, comprising of clinicians, ward nurses, the infection control unit, and microbiologists. The interventions were implemented from June to September 2021 at all wards, including the emergency and trauma department, general wards, ICU, and PKKN. From April to September 2021, all adult patients admitted to HSB who required IV cannulation were recruited. The PVC care bundle was based on local PVC guidelines for preventing PVC complications, and its implementation was ensured with the help of a PVC assessment form (Table I).[8-11] The outcome measure of this QI project was the BSI rates. An initial audit of 3-month BSI incidence was conducted to establish a baseline. Implementation of monthly PDSA cycle was described in Table II.

*Data Interpretation and statistical methods*

The incidence of BSI was described in numerical value. In contrast, the BSI rate was calculated in percentage with a formula of (total number of BSI per month/total number of admissions per month x 100 admissions). The data was analysed using SPSS version 26. The *p* value was measured using a paired student t-test, and its value of less than 0.05 was considered statistically significant.

## RESULTS

The PDSA cycles described in Table II were implemented over four months, from June to September 2021, to improve the BSI rates. All the healthcare workers were briefed about the guidelines in Tables I and III.

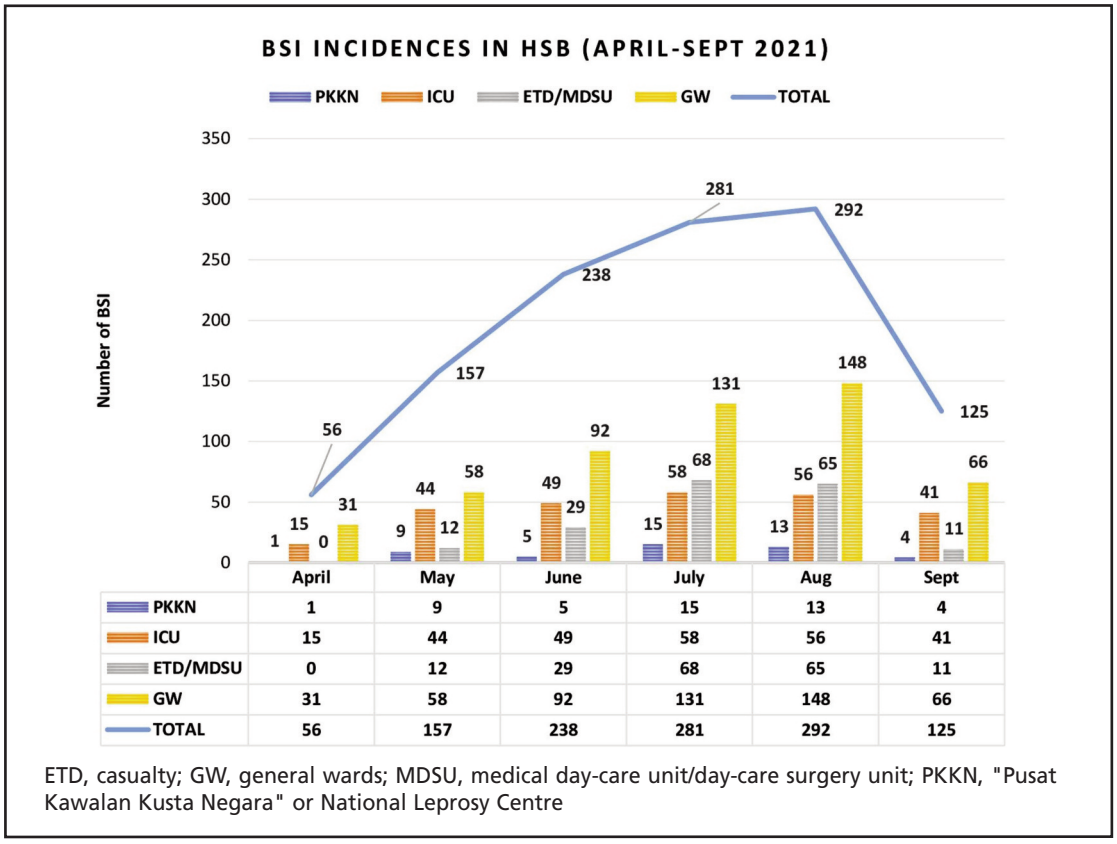



**Fig. 1:** The number of BSI incidence in HSB from April to September 2021

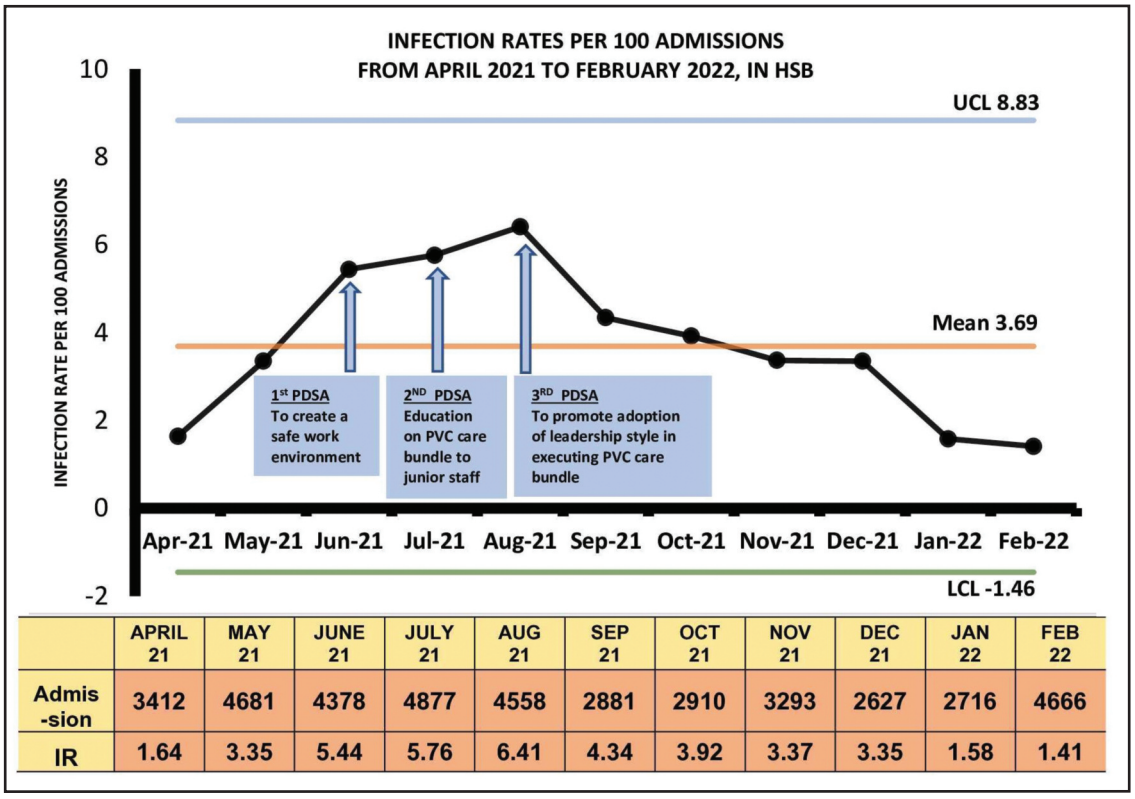



**Fig. 2:** The trend of the BSI infection rates per 100 admissions in HSB from April 2021 to February 2022

From April to September 2021, 24,787 patients required hospitalisation at HSB (Figure 2). A baseline of BSI incidence and rate from April to May 2021 was studied (Figure 1 and 2). All plot points (Figure 2) were within the control limit range [mean 3.69, upper control limit of 8.83, lower control limit of –1.46]. Before the intervention, the BSI rates were on the rise, with a monthly increment of 40–50%. During the four months of intervention, challenges were encountered during the initial implementation of interventions and new PDSA approaches were applied to reduce the BSI rates. As shown in Figure 2, the infection rates per 100 admissions declined after the third PDSA cycle, from 6.41% to 4.34% ($p < 0.05$). At the end of interventions by September 2021, the total number of BSI cases at HSB significantly dropped off 57.2% from the peak of 292 in August 2021 ($p < 0.05$). This reduction was sustained for half a year following the completion of the QI project through the continuous effort and coordination between treating clinicians, ward nurses, and the infection control unit.

## DISCUSSION

In conjunction with the local guidelines on managing the COVID-19 pandemic, infection prevention and control standards were adapted to prevent the transmission of nosocomial COVID-19 infections and maintain the integrity of environmental hygiene.[12] However, one of the challenges in sustaining existing infection control practices posed by the COVD-19 pandemic was the massive increase in demand for healthcare systems, which was characterised by the shortage of workforce and personal protective equipment (PPE) caused by the staggering numbers of COVID-19 cases.[13] As a result, compliance with infection control practices had decreased.

Our first PDSA cycle aimed to improve the quality of PVC care in understaffed and overcrowded wards and to promote environmental infection prevention and control in the healthcare setting. The PPE and instruments for PVC maintenance were stockpiled consistently to address shortages. Procedure trolleys with a complete set of instruments necessary for intravenous line insertion and maintenance were prepared and made readily available in each isolation room to promote easy access and compliance.[14] In addition to decontamination prior to use, the trolleys were cleaned every week, after each use, or when soiled. Next, increasing hand hygiene devices at the isolation facilities promoted compliance with hand hygiene practice. Rykkje et al. reported that increased hand rub availability improved hand hygiene compliance.[15] Additionally, the World Health Organisation (WHO) guidelines on hand hygiene in health care strongly recommend that hand hygiene devices must be readily available at the point of care.[16] However, this earlier initiative did not significantly impact BSI rates. We postulated that the primary contributory cause involved behavioural factors among healthcare providers. Thus, the next PDSA cycle was undertaken.

The following PDSA cycle in our study raised awareness among healthcare workers, especially untrained ones, about the importance of adherence to PVC care bundle and ANTT. As a general rule, the PVC care bundle is a collection of evidence-based interventions that, when grouped, are proven to reduce BSI rates and improve patient care outcomes significantly.[6] Agreed by experts in infection control,[8,10,17,18] there are several essential aspects to the PVC care bundle, which are to first consider the requirement of catheter insertion by referring to the PVC checklist, secondly assess the necessity of inserted lines daily, appropriately maintain PVC care by applying the concept of ANTT, and consider the prompt removal of unnecessary PVC. Recognised internationally as an essential clinical competency in healthcare, ANTT is a standardised framework of infection prevention measures to protect patients from nosocomial infections.[19-21] Of note, implementing ANTT during intravenous line insertion and maintenance is critical in avoiding infections.[22]

In our study, we speculated several factors contributing to non-compliance with the PVC care bundle and ANTT, notably lack of knowledge of their importance and inconsistent implementation, especially by new untrained staff. Hence, attention was focused on improving the education and training programmes to enhance compliance with infection prevention and control practices, including hand hygiene, donning and doffing of PPE, ANTT, and appropriate ways of venous cannulation in the setting of a quarantine facility. As suggested by other studies,[22,23] simulated teaching programmes involving posters and videos were proven effective. Continuous education helps healthcare providers, especially new staff, develop essential skills in intravenous line insertion and maintenance.[21,22,24] Additionally, onboarding education has been proven to effectively improve role clarity and equity of care.[22,25] Nevertheless, despite these emphases, our aim to reduce BSI rates was unmet even after the execution of the second PDSA cycle. Thus, we next focused on the component of leadership to facilitate behavioural change.

Notably, a lack of competency in leadership could contribute to BSI.[26,27] In other words, leadership is the key to eliminating BSI.[28] Involvement of leadership helps engage every healthcare provider in the same ward to handle PVC more effectively. When ward leadership is emphasised, every staff member in the ward plays a pivotal role in the PCV care bundle. In our third intervention, every ward specialist and consultant were empowered as leaders to educate their subordinates about the PCV care bundle and enforce the execution of PVC care in the ward. Successful leadership strengthens the IPC culture by providing tangible support to team members, listening meticulously to workforce concerns, and actively engaging staff in IPC.[27] With the participation of these leaders in the improvement plans, PVC preventive efforts materialise into organisational priorities and related processes, leading to good outcomes.[29]

Patients with difficult PVC access are often subjected to multiple attempts by cannulation and are more likely to experience treatment delays, high-risk vascular procedures, and infection.[30] To overcome this challenge, ultrasonography (USG)-guided venous cannulation was implemented, and it was shown to significantly reduce mechanical complications and infection rates.[17,31,32] Furthermore, timely utilisation of USG guidance for PVC helps clinicians obtain precise

vascular cannulation[33] in one go and avoid unnecessary central venous catheter placement,[34] which provides a safe outcome and reduces financial impact. In our study, the use of USG performed by senior clinicians for difficult placement of intravascular cannulation led to a good outcome. Besides, senior clinicians and experienced technicians were assigned to inculcate junior staff with the skill of obtaining vascular access via USG guidance. Development of didactic and hands-on training was found effective in achieving competency for frontliners in establishing USG-guided PVC insertion.[35]

Our findings demonstrated that the implementation of PDSA cycles was fundamental in identifying shortfalls and designing improvement initiatives to increase good adherence with PVC care bundle. After regular evaluation of each PDSA cycle, an eventual improvement in the adherence of the PVC care bundle reflects a successful QI project. In the PDSA initiative, in our case, the multidisciplinary approach helped explore various potential reasons for higher BSI rates and identify any deficiencies. This teamwork approach allowed us to brainstorm solutions from different angles, including nursing care and infection control practices. In addition to implementing the PVC care bundle, regular meetings and educational sessions proved effective and vital during the initiative. Furthermore, it was found effective in implementing and sustaining change by promoting teamwork, welcoming feedback from all staff, stimulating knowledge sharing in the workplace, and measuring the outcomes of interventions.

## LIMITATION

One major confounder to the findings of this project is that there was a significant reduction in the number of admissions by September 2021. As it is readily agreed, infection control practices tend to be compromised when admissions are numerous and healthcare systems are stretched; the reverse is true. Nevertheless, although the number of admissions had declined during this time, the number of healthcare workers had also decreased. Thus, the "healthcare worker-patients" ratio did not vary significantly during these months. Secondly, all studied cases were inclusive of blood culture contamination (BCC), primary and secondary BSI. Worthy of note, primary BSI is often related to central or peripheral venous lines in place at the time of or within two days prior to infection onset, whereas secondary BSI results from an infection derived from another body site.[5] Interestingly, BCC is reflective of poor compliance with ANTT[36], and this issue has been addressed in our study. Further study of these findings is warranted.

## CONCLUSION

This study demonstrates that all quality improvement (QI) initiatives require timely reviews via PDSA cycles, and not all changes will result in improvement. Teamwork and effective leadership are recognised as a substantial core of QI to deal with behavioural change among healthcare providers.

The development of leadership skills is essential to implement behavioural changes while facing challenges, especially during this unprecedented time. With leadership in place, it allows the healthcare organisation to build a strong IC team and develop a sustainable IC programme. Complications of intravenous lines can be caused by a lack of knowledge among junior staff. In certain circumstances of difficult line insertion, using ultrasound guidance can prove superior and strategic.

## ETHICS APPROVAL

Approval of this study was obtained from the National Medical Research Register, Ministry of Health, Malaysia.

## COMPETING INTERESTS

None to declare.

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