Improving the central venous access devices maintenance process to reduce associated infections in paediatrics: evaluation of a practical, multi-faceted quality-improvement initiative

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Improving CVAD maintenance process to reduce associated infections in paediatrics: evaluation of a practical, multi-faceted quality improvement initiative

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Short Summary: Central venous access devices (CVADs) are a necessary part of many acute and chronically ill children's medical treatment, but they are frequently the source of life-threatening bloodstream infections. This quality improvement initiative implemented and evaluated innovative strategies aimed to improve the management of CVAD within a tertiary paediatric facility. Within the initiative, a CVAD maintenance bundle and a dedicated CVAD trolley successfully reduced the rate of CVAD-related bloodstream infections and improved clinician compliance to evidence-based strategies.

Abstract

Introduction

Central venous access devices (CVADs) provide essential and reliable vascular access, but infection is a common and serious complication within paediatric patients. CVAD bundles have been demonstrated to effectively reduce central-line associated bloodstream infections (CLABSI), but primarily during CVAD insertion. Another emerging strategy to encourage best practice is the use of a dedicated CVAD trolley for maintenance.

Methods

A quality improvement initiative was undertaken to improve CVAD maintenance and to evaluate the effectiveness of the chosen interventions at the Royal Children's Hospital, Brisbane. Nursing staff from four wards within the hospital elected to participate and the wards were allocated to receive either: Intervention A (CVAD maintenance bundle only); or Intervention B (CVAD maintenance bundle and dedicated CVAD trolley). Effectiveness of the interventions was evaluated by: (a) rate of CLABSI per 1,000 catheter days; and (b) audits of clinician compliance with evidence-based CVAD maintenance strategies.

Results:

During the initiative, the hospital wide CLABSI rate decreased from 9.07 to 1.05 episodes per 1,000 catheter days (P=0.01). The rate of CLABSI in Intervention A wards reduced from 7.6 to 2.2 episodes per 1,000 catheter days (P<0.001) and in Intervention B wards reduced from 8.0 to 0.5 episodes per 1,000 catheter days (P<0.001). Hospital wide audits of clinician compliance increased from 11.9% to 35% (P=0.001) in the Intervention A wards and to 83% (P<0.001) in the Intervention B wards.

Conclusion:

Implementation of CVAD maintenance bundles and a dedicated CVAD trolley successfully reduced CLABSI and improved audited compliance to evidence-based practices within our tertiary paediatric hospital.

Implications

- Between 20-50% of central venous access devices in paediatrics fail prior to completion of therapy, with infection remaining the most significant cause.
- The use of improved maintenance processes, including dedicated trolleys and maintenance bundles, have the potential to improve clinician compliance with evidence-based central venous access device practice and reduce the incidence of central venous access associated bloodstream infections within paediatric acute care.

Introduction

Central venous access devices (CVADs) are integral to the medical management of many paediatric conditions. Reliable central venous access is essential for the safe and efficient delivery of medications including chemotherapy, antibiotics, haemodialysis, parenteral nutrition and other lifesaving infusions into large calibre vessels to allow adequate dilution of the drug and avoid vessel irritation and reduce the risk of drug extravasation (1, 2). Despite their necessity, between 20-50% of CVADs in tertiary paediatrics fail prior to completion of treatment, resulting in interrupted treatment, new catheter insertion and risks associated with the complication sequelae (3-7).

Central-line associated bloodstream infection (CLABSI) remains the most significant cause of treatment-related morbidity and mortality in patients with CVADs and is associated with increased healthcare costs in hospitalized patients (8-10). Numerous international clinical practice guidelines have been developed and summarise the best practice for care and prevention of infection in CVADs (8, 9, 11-18). These guidelines are lengthy and clinicians frequently encounter difficulty ensuring their implementation in the clinical setting (19). In the previous decade many hospitals have demonstrated that implementing simple interventions, such as hand hygiene, use of full barrier precautions and adequate site cleaning, can significantly reduce CLABSI(20). Landmark work accomplished by Pronovost and colleagues(21) validated the process of 'bundling' evidence-based central venous access insertion practices, demonstrating a significant reduction in CLABSI from 7.7 to 1.4 infections per 1,000 catheter days within the adult Intensive Care Unit (ICU) setting (21, 22).

Since the study by Pronovost and colleagues, many countries and centres have replicated the implementation of CVAD insertion bundles (23). Within Australia the insertion bundle was successfully implemented into 32 adult ICUs in New South Wales by Burrell and colleagues (24), reducing CLABSI from 3.0 to 1.2 per 1,000 catheter days; prompting a national roll-out into all ICUs. There is also some evidence that CVAD insertion bundles are effective in paediatrics, with a recent study describing a reduction in CLABSI in a paediatric ICU from 7.8 to 2.3 BSI per 1,000 catheter days (25). But the use of CVADs is not limited to the ICU, and paediatric patients in medical and surgical wards outside the ICU possess their own vulnerabilities and susceptibility to CLABSI (8, 26). Interventions for the reduction of CLABSI, such as CVAD maintenance bundles need to be evaluated for their effectiveness outside of the controlled ICU environment.

The majority of CLABSI occurs due to contamination of the catheter hub during daily manipulation, so a focussed strategy for the reduction of catheter hub contamination is necessary (27, 28). The Australian study by Burrell and colleagues (24) highlighted the gaps in current insertion-focussed bundles, describing an exponential increase in CLABSI nine days after CVAD insertion which is mostly because of CVAD maintenance processes. Melville and colleagues (29) from the United Kingdom demonstrated the effectiveness of CVAD maintenance bundles at reducing CLABSI in paediatrics, with a reduction in CLABSI from 220 to 108 per 100,000 patient days (51%; P=0.002). A recent strategy utilising a practical component to encourage implementation of best practice to prevent CLABSI in paediatrics was led by Miller-Hoover (30) from Cardon Children's Medical Center, Mesa, Arizona. In addition to implementing a CVAD maintenance bundle, Miller-Hoover added a dedicated CVAD maintenance trolley within the clinical area. Like the insertion trolleys used during Burrell and colleagues study in ICUs (24), the maintenance trolley provided an additional forcing function to empower other nurses to stop a procedure if any of the components of evidence-based CVAD maintenance were not being applied. The CVAD trolley also appealed to nursing staff as it increased efficiency by decreasing the amount of time to complete procedures, improving healthcare resource utilisation (30).

The implementation of CVAD maintenance bundles and dedicated CVAD trolleys has the potential to significantly improve practice in paediatrics, thereby reducing preventable CLABSI in this vulnerable population. Further evidence is required to evaluate their effectiveness in order to inform clinicians of their potential application internationally.

The overall aim of the quality improvement initiative was to improve the management of CVADs at the Royal Children's Hospital (RCH) Brisbane, Australia. As part of the projects evaluation it aimed to:

1. Assess and compare the effectiveness of CVAD maintenance bundles and CVAD trolleys on clinician compliance with evidenced based CVAD maintenance strategies as evidenced through audit results; and
2. Assess and compare the effectiveness of CVAD maintenance bundles and CVAD trolleys to decrease the rate of CLABSI in paediatrics.

Methods:

Design

A quality improvement initiative evaluated using a quasi-experimental pre-test, post-test design was undertaken between July 2011 and June 2012, at the RCH.

- Phase one (pre-implementation) (January – August 2011): Baseline data on audited compliance of clinicians with evidence-based CVAD maintenance strategies and CLABSI;
- Phase two (implementation) (September-October 2011):
  - Identification of knowledge deficits and education of nurses from participating wards regarding CVAD maintenance strategies;
  - Ward allocation to: Intervention A (CVAD maintenance bundles only) or Intervention B (CVAD maintenance bundles and dedicated CVAD trolley);
  - Implementation of CVAD maintenance bundles via education sessions and staff engagement strategies
  - Implementation of the dedicated CVAD trolleys into the wards; and
- Phase three (post-implementation) (November 2011 to June 2012): data collection on audited compliance of clinicians with evidence-based CVAD maintenance strategies and CLABSI. Continuation of staff engagement strategies.

Participants

The RCH is a tertiary hospital caring for high acuity patients from birth to 15 years admitting approximately 21,500 patients per year. Senior nursing management and general nursing staff from four wards within the RCH elected to participate in the hospital initiative. Each participating clinical area was motivated by a desire to reduce the number of infections related to CVADs in their clinical areas. The four participating wards included two oncology wards, one surgical ward and one infectious diseases ward which cared for a mixed cohort of patients including general medical, respiratory, haematology and oncology, surgical and gastroenterology.

Interventions

CVAD Maintenance Bundle

The CVAD maintenance bundle was developed in accordance with evidenced based clinical practice guidelines (11, 12) and followed a structure similar to Pronovost (21), Melville (29) and Miller-Hoover (30). As seen in Figure 1, it was comprised of:

1. Hand hygiene: Appropriate choice of hand hygiene prior to performing a variety of tasks including procedural preparation and CVAD access.
2. Aseptic non-touch technique (ANTT): Appropriate use of standard ANTT when risk of contaminating key parts is minimal (e.g. simple CVAD dressing change or accessing needless access device), or use of surgical ANTT when the procedure is more complex and key parts may be touched with non key parts (e.g. needling a totally implanted venous port device).
3. Scrub the Hub: Utilise 2% chlorhexidine & 70% alcohol unless contraindicated and apply with a vigorous scrubbing motion for 20 – 30 seconds, allowing a dry time of $\geq$ 20 – 30 seconds.
4. Dressing: Use of a semi-permeable dressing. Assess dressing daily to ensure it is clean, dry and intact. Change dressing weekly or when indicated. Document dressing assessment daily on CVAD nursing activity report.
5. Needleless access device (NAD): NAD will remain clear and free of bloody residue. Weekly NAD change is incorporated with weekly dressing change or as clinically

indicated. CVAD is assessed daily for patency (ability to aspirate and flush) and documented daily on CVAD nursing activity report.

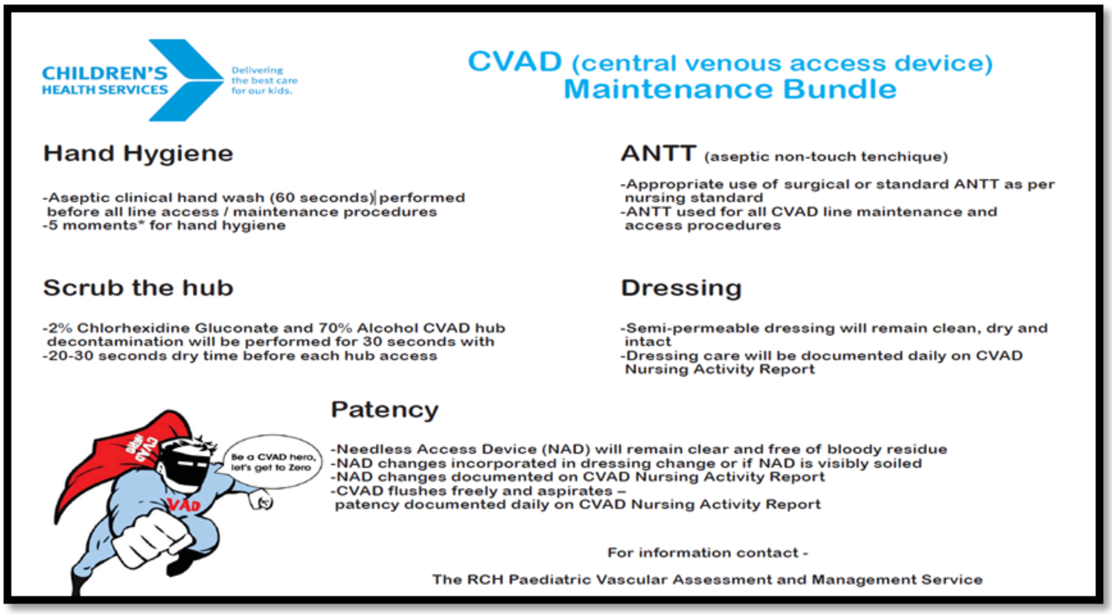

Figure 1: CVAD Maintenance Bundles education poster

Dedicated CVAD maintenance trolley

The dedicated CVAD maintenance trolley was developed using the strategies suggested by Miller-Hoover (30) and Burrell and colleagues (24). It was locally standardised and systematically developed in accordance with CVAD maintenance procedures (figure 2):

- Drawer 1 Elements required for antisepsis and NAD change
- Drawer 2 Elements required for blood sampling
- Drawer 3 Elements required for CVAD dressing change
- Drawer 4 Elements required for standard ANTT (31, 32)
- Flip Drawers on Cart Side Elements required for surgical ANTT (31, 32)

The dedicated CVAD trolley provided a forcing function to ensure compliance with components of the maintenance bundle, i.e. everything on the trolley should be used and items not found on the trolley are not appropriate for CVAD cares. The exception was children with sensitivity or allergy to antiseptic or dressing products.

Figure 2: Dedicated CVAD trolley

Outcome measures:

Audited compliance of clinicians with evidence-based CVAD-maintenance strategies

During the pre-intervention period, a group of expert nursing education, paediatric vascular access, and infection control clinicians developed an audit tool to assess the application of evidence-based CVAD-maintenance strategies. The audit tool was developed using the principles contained within the CVAD maintenance bundle: appropriate hand hygiene; use of ANTT; "scrub the hub" before accessing; assessment of CVAD dressing integrity, and assessment of CVAD patency.

During phase one and phase three of the quality improvement initiative, the project coordinator (AI) visually observed the clinicians providing CVAD maintenance in the clinical setting. Prior to the audit, the nurses were notified they were being assessed, as per standard quality-improvement practice within the hospital (33). Using an audit tool the project coordinator assessed whether the clinicians adequately implemented the CVAD maintenance bundle principles within their practice. Results of clinical audit were fed back to individuals and clinical leaders within each individual unit level.

Central-line associated bloodstream infection (CLABSI)

CLABSI was determined using National Healthcare Safety Network (NHSN) criteria for a laboratory-confirmed BSI in a patient with a CVAD and had been in use during the 48 hours preceding the development of the BSI (34). A laboratory-confirmed BSI was identified if one of two criteria was met as set out below:

a. Patient has a recognized pathogen cultured from $\geq$ 1 blood culture and the pathogen cultured from the blood and is not related to an infection at another site or.

b. Patient has a recognized pathogen cultured from ≥ 1 blood culture and the cultured pathogen is not related to an organ.

These definitions have already been used successfully in previous Australian studies (24) and are in accordance with Australian state reporting authorities (35). Prospective CLABSI surveillance was enabled through the Queensland Health pathology reporting system, confirmed through chart review, and verified with infection control clinical nurse consultant at weekly intervals (JT). Discrepancies between expert clinicians were resolved through discussion until consensus was reached; where consensus was not achieved the discrepancy was referred to the infectious diseases consultant for independent advice.

Allocation to intervention arms

Allocation to the intervention groups was based on ward preference. Two clinical areas caring for patients with general surgical, infectious diseases, medical, oncology and burns were eager to trial the trolleys on the basis that they are frequently rushing between areas to obtain necessary supplies to complete a CVAD procedure. Lack of preparation and inability to obtain all necessary equipment in a timely manner significantly increased the procedure time. This was particularly apparent in the infectious diseases ward as staff were required to attire additional personal protective equipment as required by their patient cohort prior to performing any CVAD maintenance cares. Conversely the two remaining areas caring for patients with oncological and haematological conditions were sceptical that the trolley would be beneficial to their practice and considered the additional trolley to impose on space and to be a potential threat to normal work flow. Collection of consumables for CVAD maintenance procedures in the two wards allocated to intervention A continued as per standard care; consumables were collected and prepared in the treatment room or at the patient bedside.

Staff education and engagement strategies:

During Phase two, mandatory detailed educational sessions regarding correct CVAD care and maintenance were conducted for all nurses working in the four clinical areas. At the commencement of the education session, nurses were invited to participate in an on-line questionnaire to identify knowledge deficits regarding correct care and management of CVADs. The questionnaire included questions surrounding hand hygiene, components of ANTT, daily assessment for patency and the correct technique for the 'scrub the hub' technique. Education sessions were facilitated through power-point presentations, real-time feedback, question and answer periods as well as audio-visual instruction outlining correct application of ANTT.

Additional engagement strategies involved the identification of "change champions" (36) and quarterly feedback of CR-BSI rates to nursing management representatives for each of the participating wards. Participating wards were furnished with posters highlighting the five components of the CVAD maintenance bundle as well as a poster demonstrating the correct sequence of ANTT procedures.

Data analysis

Data were entered and analysed using PASW Statistics Version 22.0 (SPSS Inc., Chicago, IL, USA); Microsoft Excel® and MedCalc Statistical Software Version 14.10.2 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2014). Basic frequencies were calculated for all variables and any extreme or obviously incorrect data were re-checked for accuracy. The results have been primarily summarised using descriptive statistics. The audited compliance of nurses in using the CVAD bundle maintenance practice is described using frequency, percentage and 95% CI. The effectiveness of the interventions in improving audited compliance was assessed using chi square. Statistical significance was set at $P < 0.05$. CLABSI rate was standardised and described using frequency of CLABSI per 1,000 catheter days and 95% confidence intervals (CI). The effectiveness of the interventions in reducing the rate of CLABSI was assessed using percentage reductions, incidence rate ratios (IRR) and 95% CI. There were no missing data.

Ethical considerations

Full ethical approval was not required as the initiative met the criteria for a quality improvement / audit review of practice, but ethical support was gained from the Children's Health Services Human Research Ethics Committee (HREC), Queensland, Australia (37).

Results

Audited compliance of clinicians with evidence-based CVAD-maintenance strategies

A total of 93 nurses were audited during the quality improvement initiative. Forty-two (46.2%) nurses were audited in phase one, as were 26 nurses (28%) from Intervention A in phase three and 24 (25.8%) from the Intervention B in phase three.

There was a significant improvement in total audited compliance of clinicians with CVAD-maintenance strategies between phase 1 (n=5; 11.9%) and phase 3 (n=29; 58%; $P<0.001$). Within phase 3, the wards using the combined CVAD bundle and trolley demonstrated a significantly higher audited compliance (n=20; 83%), in comparison to the CVAD bundle only group (n=9; 35%, P=0.001). This is depicted graphically in Figure 3.

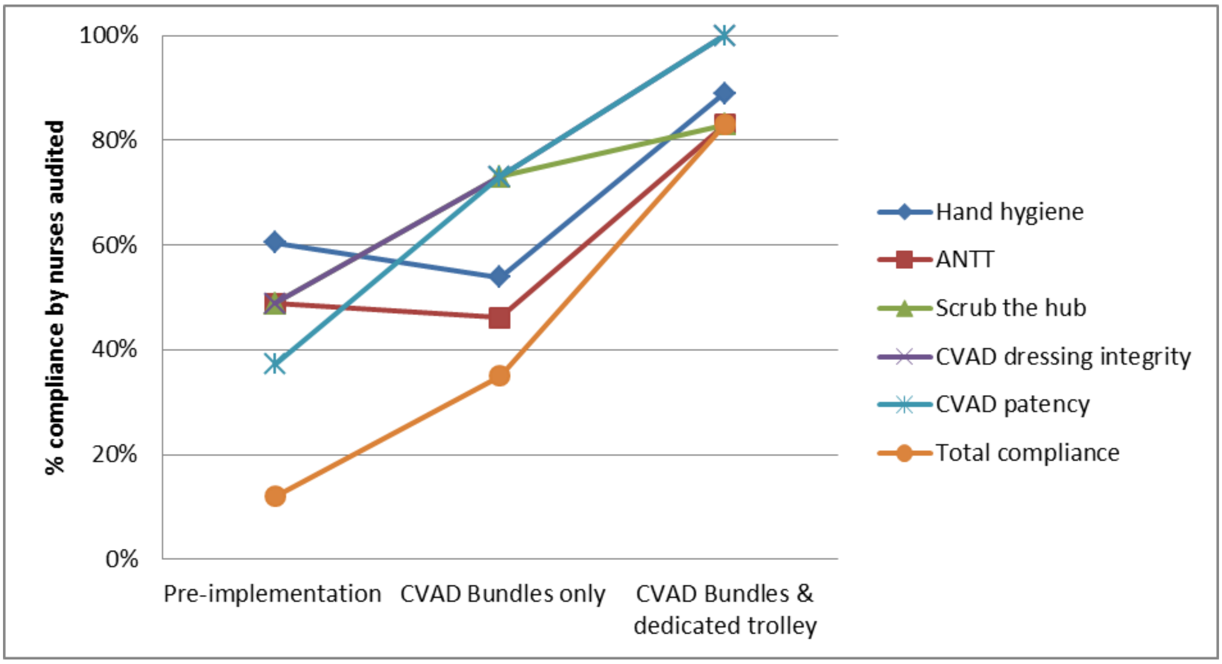

Figure 3: Audited compliance of nurses demonstrating evidence-based CVAD-maintenance strategies

Central-line associated bloodstream infection (CLABSI)

Table 1 describes the rates of CLABSI per 1,000 catheter days throughout the quality initiative phases, across the intervention groups. As described by the incident rate ratio (IRR) there was a significant reduction of CLABSI per 1,000 catheter days hospital wide and within the two intervention arms during the intervention periods. For the group receiving CVAD maintenance care using a bundle and a dedicated CVAD maintenance trolley, the incidence rate (IR) of CLABSI per 1,000 catheter days was over 16 times lower in the post-implementation period, than the pre-implementation period.

Table 1: Rates of CLABSI per 1,000 catheter days across initiative phases between intervention arms

	Pre	Post	Reduction	IRR (95% CI)	P Value
Hospital-wide	9.0	1.1	88 %	8.8 (1.2-394.5)	0.01
Intervention A: CVAD maintenance bundle only	7.6	2.2	71%	3.7 (1.7-9.3)	<0.001
Intervention B: CVAD maintenance bundle and dedicated CVAD trolley	8.0	0.5	94%	16.6 (2.7-688.9)	<0.001

CVAD= Central venous access device; CI=Confidence Interval; Central line associated bloodstream infection (CLABSI); IRR= Incidence rate ratio

Discussion

To our knowledge this is the first study to introduce CVAD maintenance bundles outside the ICU into a mixture of general paediatric medical and surgical, and haematology/oncology wards to show a sustained reduction of CLABSI and an increase in compliance. Previous studies have been conducted in adult, paediatric and neonatal ICU's, as well as paediatric haematology and oncology units (20, 22, 24, 29, 30, 36, 38, 39). The uniqueness of this initiative is within the breadth of its clinical application. Such clinical diversity provided the rationale for the implementation strategy which encompassed a multifaceted program. Barriers and facilitators of implementing this new practice were considered when developing the project. We anticipated that by increasing clinicians knowledge base, best practice would be inferred which would assist in achieving an overall reduction in CLABSI. We also supposed that the addition of a CVAD trolley as an added forcing function would improve compliance with the components of the maintenance bundle and further reduce the rate of CLABSI.

Prospective surveillance of CLABSI allowed for the calculation and quarterly feedback of CLABSI rates, resulting in increased awareness of the CLABSI burden. This information was important for engaging both staff and leadership and encouraging a culture change within the participating clinical areas(38). As with other similar studies (38) we found feedback to be an essential key to compliance with CVAD best practice and ultimately CLABSI prevention as it increased staff cognisance of CLABSI rates in other wards. A culture of 'if they can do it, we can do it too' became apparent.

Throughout the period of implementation we discovered that implementation of a post-insertion CLABSI prevention programme requires not only education (40), but also engagement of staff to change and maintain staff behaviour(36, 41, 42). The ultimate goal of the quality improvement initiative was to integrate behavioural changes with a subsequent desire to adhere to components of CVAD maintenance bundles into everyday practice. The success of this intervention was noticeable at completion of phase 3, however ensuring continued adherence to components of the maintenance bundle will take time to be fully realised. Strategies to improve compliance for CVAD insertion and management best practices to further reduce the CLABSI rate at the RCH are ongoing. This includes the institution of a CVAD insertion bundle and trolley within the paediatric ICU, similar to Burrell and colleagues (24).

Limitations of this initiative include lack of randomisation, poor description of the patient clinical characteristics within the initiative phases, small sample size and the brevity of the evaluation period. This limits the generalisation of the research to other sites, as the real success of the intervention will not be realised until additional follow up has been evaluated to determine its sustained success and the participant population is controlled for potential confounders.

Conclusion

This quality improvement initiative has described the potential for improving compliance with best practice recommendations through the use of a CVAD maintenance bundle. The use of CVAD maintenance bundles has also been associated in a reduction in CLABSI in this study population. However, checklists such as maintenance and insertion bundles should not be considered the panacea in environments as complex as healthcare settings. Compliance to components of the CVAD maintenance bundle requires continued championing, education and practice audit. Compliance in this study was optimised through the introduction of a dedicated CVAD trolley. The trolley ultimately acted, as a forcing function for nursing staff – to use approved and recommended products and techniques; and as a clinical prompt – if it is not on the trolley it should not be used.

Further research to qualify the effectiveness of hospital wide CVAD maintenance bundles and the use of dedicated CVAD trolleys for the reduction of CLABSI is necessary. As the use of CVADs increase across hospital settings, so to should the introduction of interventions to control CLABSI. This intervention has demonstrated how a bundle of care, combined with education and prior success within the confines of ICUs can be successfully integrated into the wider hospital with encouraging results. It is imperative that these interventions are supported to maintain a reduction in catheter failure due to infection.

Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper. AU has received unrestricted research funding from CVAD product manufacturer, Centurion Medical Products, which is not relevant to this project.

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