Vascular Access Support Team: A Multi-Disciplinary Response to Optimise Patients' Care during COVID-19 Pandemic

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Abstract

Objectives: To evaluate clinical outcomes of multidisciplinary vascular access support team (VAST) and the value of the service to critical care teams. Design: Prospectively collected data. Material and methods: All patients requiring vascular access at St Thomas' Hospital, London over a 5-week period during the first wave of the pandemic in the UK. At the end of study period, online anonymised questionnaire administered to critical care team members, including nursing and medical professionals, to evaluate their experience of the service. Results: 122 patients aged 52.1 ± 13 years with high rate of pre-existing co-morbidities, underwent line insertion including 190 catheters (central venous n=182, arterial n=8). Median (range) number of 5 (0-17) lines were placed per day in patients of whom 90% tested positive for Severe Acute Respiratory Syndrome Coronavirus-type 2 pathogen (SARS-CoV-2). A single line was inserted in 146 out of 172 patients (76.8%) and n=36 patients (18.9%) 'double puncture' technique used. 45 line insertions (24%) had complications with minor [bleeding (n=19), line infection (n=10)] and 2 lines (1%) with major complication. The survey respondents, n=54 professionals, highlighted ease of referral and timely access placement (>90% responses); with agreement that VAST service saved them precious time and allow them to focus on other jobs. Conclusions: We describe the successful deployment of a multidisciplinary vascular access team with low complication rates and high rates of satisfaction. We recommend similar models can be considered by health services to optimise patient care and ICU management.

What's known

1. The ongoing COVID-19 pandemic had created a huge workload of emergency care and required rapid expansion of critical care beds and staff.

2. Arterial and central venous access are often required for hemodynamic monitoring, administration of drugs and RRT of patients on ICU with demand beyond usual capacity.

3. Rapid development and innovation was needed to cope with this acute demand but limited data has been reported regarding short/medium term outcomes from the UK.

What does this article add?

1. Vascular Access Support Team (VAST) made of surgical and non-surgical staff was established rapidly and was able to successfully help with vascular access in complex patients being treated in a challenging environment with only minimal complications

2. Successful redeployment, structured training and governance can result in creation of a supportive team for ICU colleagues at the time of intense clinical pressure and demand.

Introduction

The coronavirus disease 2019 (COVID-19) global pandemic is projected to cause millions of deaths and continues to spread [1,2], with many of those who are symptomatic requiring hospitalisation [3-7]. In those requiring admission to an intensive care unit (ICU), acute hypoxemic respiratory failure from acute respiratory distress syndrome (ARDS) is commonly seen and is often associated with shock (30%), myocardial dysfunction (20–30%), acute kidney injury (10–30%) and the need for acute renal replacement therapy (RRT) (up to 30%) [3-8].

In the United Kingdom, our centre was one of the first to manage patients with COVID-19. In keeping with reports from similar centres, a high proportion of admitted patients required mechanical ventilation and ICU management and a rapid expansion of critical care beds and staff was required to manage these patients effectively. In these patients, arterial and central venous access was often required for hemodynamic and respiratory monitoring, administration of drugs and RRT [4,7,9,10].

To help offload procedural tasks from the critical care team and to enable them to focus on non-procedural care including supervision of non-critical care surge staff, a Vascular Access Support Team (VAST) made of surgical and non-surgical staff was established. This report evaluates the short-term clinical outcomes of this service and the impact that it made on the workload of ICU teams.

Method

A retrospective analysis of prospectively collected data on all patients requiring vascular access at St Thomas' Hospital during the first wave of the COVID-19 pandemic between 6th April to the 10th of May 2020 was carried out. St Thomas' Hospital is a regional high consequence infectious disease referral centre, with an academic intensive care unit (ICU). Before the COVID-19 pandemic, the hospital had 54 dedicated critical care beds, however during the pandemic, critical care bed capacity rapidly escalated and at the peak, the team cared for 147 critically ill patients across both established critical care areas and newer re-purposed units. These included postoperative recovery rooms, paediatric ICUs, and the respiratory failure unit. This project was registered as a service evaluation and was granted departmental and institutional approval in accordance with NHS best practice.

Study inclusion criteria

Any patient who underwent a bedside procedure on the ICU or the high dependency unit (HDU) units for placement of arterial or central venous access by the Vascular Access Support Team (VAST).

The Vascular Access Support Team (VAST)

Through expressions of interest and central recruitment, the team members were selected from specialities including vascular surgery, transplant surgery, cardiology, and paediatric nephrology. There was an emphasis on recruiting attending grade team members working in pairs to tackle the environmental and situational challenges that were anticipated. Senior hospital teams supported the redeployment of selected members from different specialities, which was followed by a multi-stage induction with refresher training. Specialties were identified based on their routine clinical practice and familiarity with ultrasound-guided procedures. All team members additionally completed training for safe donning and doffing and use of personal protective equipment. Training included use of 'CareVue EHR' (Medsphere, CA, USA), the electronic health recording system on ICU/HDU, to standardise recording of performed access procedures.

Referral pathway and line placement

The VAST service was set up to provide cover 24-hours a day, 7 days a week. Each team was made up of two consultants covering 12 hour shifts. Initially there was one daytime team but with increasing demand, two teams were deployed during peak hours. There were 6 different critical care areas supported by VAST. ICU

teams called a centralised phone number to request help from the VAST service with clinical details and the type of vascular access needed. A vascular surgical trainee received referrals recording clinical urgency [urgent <2 hours; non-urgent 2-24 hours] before informing the on-call VAST team. Standard kits were prepared for the type of access required and stored in a centralised pick-up point.

The following guidelines were developed prior to initiating the VAST service to minimise the risk of bleeding complications: (i) If platelet count <20x103 per μL, or INR and/or APTTR > 3, do not insert line and discuss with ICU specialist; (ii) Platelet count 20-50 x103 per μL or INR/APTTR >1.5 and <3 (not bleeding): If urgent – most expert VAST member sites line in the femoral vein. For non-urgent line – site line under platelet cover; (iii) Platelet count >50 x103 per μL or INR/APTTR<1.5: to proceed as per pre-agreed standardised approach for line site selection; and (iv) Patient with clinical bleeding: site line in femoral vein. Arterial lines were placed only as directed by ICU specialists.

All lines were placed under ultrasound guidance. Central lines were preferably inserted into the right internal jugular vein, followed by the left internal jugular vein and then the femoral veins, depending on platelet and clotting screens as above. Temporary renal replacement lines were inserted into the right internal jugular vein preferably, followed by the femoral veins then the left internal jugular vein. The choice of site was modified if there were lines in-situ or if there was thrombus detected on ultrasound. Satisfactory line placement was confirmed with ultrasound and a blood gas sample taken from the distal lumen in all patients. Selected patients also had their lines transduced before use, and a chest radiograph arranged particularly in patients receiving ECMO therapy or in those who had a 'double-puncture' procedure for placement of multiple catheters within the same target vessel.

Case identification and data variables

Relevant patient details were maintained prospectively using an electronic database with manual searching of electronic health records for patient demographics, co-morbidities, and relevant clinical characteristics. In addition to line type and site, we recorded if a single catheter was placed at the time of insertion or a 'double-puncture' technique had been performed. Any complications (immediate and early) were recorded until discharge from our centre by searching the CareVue database. Vascular access-related complications included episode of catheter related bacteraemia, minor bleeding (not requiring invasive intervention), major bleeding (needing invasive intervention including surgery or external drain), line thrombosis, malposition confirmed following radiological confirmation and accidental arterial puncture. Any episodes of pneumothorax or haemothorax were additionally recorded.

Critical care experience of VAST

At the end of the study report period, members of the ICU staff including nursing and medical professionals were invited to respond to a structured anonymised questionnaire evaluating their experience of the VAST service using weblink to an online survey specifically developed by VAST [**supplementary appendix**].

Governance

The VAST lead maintained daily communication (huddle) with the ICU lead for feedback including review of activity and any complications. A weekly team meeting including senior ICU and Trust redeployment team members allowed any day-to-day adjustments and adaptations to the clinical service in a timely manner. All outcome data and complications over the previous week were presented and discussed in a virtual forum with recommendations and process adjustments agreed accordingly.

Statistical analyses

Subject characteristics are summarized as means ± standard deviation (SD) or median and interquartile range (IQR) if not normally distributed. Analysis was performed using SPSS version 25 (SPSS Inc., Chicago, Illinois) and $P < 0.05$ was taken as significant.

Results

During the 5-week period, 122 patients aged 52.1 ± 13 years underwent line insertion by VAST resulting in a total of 190 catheters (central venous lines n=182, arterial lines n=8). A median number of 5 lines were placed per day by VAST (range 0-17). Forty-one additional referrals for vascular access were received but lines were not placed because: (i) clinical decision changed (n=2); (ii) access was placed by ICU teams instead (n=14); and (iii) patient thought to be too unstable to tolerate a bedside vascular access procedure (n=2). In 23 cases, the exact reasons were not recorded but those lines that were not placed by VAST have been excluded.

The baseline demographics and clinical characteristics of all patients are shown in **Table 1** . Ninety percent of patients tested positive for Severe Acute Respiratory Syndrome Coronavirus-type 2 pathogen (SARS-CoV-2). Hypertension was the most common pre-existing co-morbidity and nearly a $1/3^{rd}$ of lines were placed in patients with [?]2 pre-existing co-morbidities. No pre-existing co-morbidity was recorded in 56 patients.

Eighty-nine (46.8%) lines were placed following an urgent referral.**Table 2** outlines the types of access and site of line placement. A single line was inserted in 146 out of 172 patients (76.8%). In 36 patients (18.9%) a 'double puncture' technique was required. Arterial lines were inserted in 8 patients (4.3%) by VAST.

Complications

Complications associated with catheters placed by VAST are shown in**Table 3** . In total there were 10. Bleeding complications included minor bleeding due to ooze around the catheter requiring compression (n=14, 7%) or local tranexamic acid (n=4, 2%). In one patient this also resulted in a neck haematoma that was managed conservatively. One further patient had a major bleed 24-hours following line insertion that required a blood transfusion and insertion of a chest drain for a hemopneumothorax. In two patients (1%) an arterial puncture was recognised prior to the dilatation of the vessel for insertion of the line. These were both managed with manual compression and there were no further complications noted. Line malposition was found in six patients on X-ray (3%). These were central venous catheters inserted successfully into the vein but the tip of the line was not in an ideal position and all were subsequently removed and re-sited. In one patient a symptomatic episode of venous thromboembolism (VTE) was recorded. We did not evaluate for line-related thrombosis unless the patient became symptomatic and avoided vessels that had partial thrombosis from previous line placement. Line occlusions that required replacement were noted in six patients (3%). A positive line culture treated by antibiotics was identified in 10 patients (5%). It is unclear whether this was due to seeding and only one patient had an established line infection as a cause for their sepsis.

Results of survey

We invited comments from ICU nursing, junior and senior medical colleagues to evaluate the VAST service at the end of the study period. Fifty-four colleagues responded and highlighted the ease of referral process [n=51/54, 95%]. They agreed that the presence of VAST service had met their access requirements during a period of clinical urgency [n=53/54, 98%]. Most confirmed that the VAST service was timely in their response following referral [n=50/54, 93%] and only occasionally did the ICU team have to place additional lines [n=49/54, 91%]. When asked to comment on estimate of time saved per shift in each critical care area, most estimated between 2-3 hours were saved per shift on each of the 6 different ITU units. Overall, at least 12 hours was saved across the different critical care areas per day when COVID-19 related challenges including donning, doffing and challenging environment were considered. Working with VAST appeared to result in ICU teams being able to focus on other important aspects of patient management. Following direct questions evaluating the added value of the VAST service, of n=51 respondents, agreed with one or more of the following including i) lines were placed by team of experienced consultant colleagues [n=24/51, 47%]; ii) saved precious time and allowed their teams to focus on other important jobs knowing that access would be sorted in adequate time [n=47/51, 92%]; iii) the VAST service supported complex cases and difficult access as well as standard access [n=30/51, 59%]; and iv) the service additionally supported junior medical and nursing colleague morale during a challenging environment [n=32/51, 63%].

Discussion

Herein we evaluate the outcomes of a multidisciplinary vascular access team created in response to the COVID-19 pandemic in the UK. We highlight the successful redeployment, structured training and governance that resulted in achieving the main objectives of the service - supporting ICU colleagues at the time of intense clinical pressure and demand. Overall, the VAST team were able to successfully help with vascular access in complex patients being treated in a challenging environment with only minimal complications.

The COVID-19 pandemic and the severity of infection [10,11] with the SARS-CoV-2 has resulted in extreme pressures on health services across the world with reports describing war-like circumstances necessitating rapid innovation to provide emergency care [12]. The urgency for these developments were most evident in ICU settings with several reports highlighting the need for a rapid increase in ICU capacity including beds, vital equipment and personnel [13-18]. It is, however, well recognised that a rapid increase in ICU workload may result in adverse patient outcomes [12,19] and that specific COVID-19 protocols and interventions are needed to reduce strains on available ICU resources [13,15,16,18].

Over a 2-month period of this study, our centre saw more than 1500 positive cases of COVID-19 during the first wave of the pandemic. In order to cope, outpatient and elective activity was reduced significantly, which facilitated the redeployment of personnel where they were needed most. Within days of the pandemic our Trust sent questionnaires to all healthcare professionals asking about previous experience including central line insertion. These data were used to develop VAST. As opposed to other similar teams [20], we did not restrict ourselves to surgical specialities but chose members with complementary clinical skill-sets to minimise pressures on any specific speciality that were required to maintain emergency services across the hospital. We believe that the diversity of the team resulted in improved process review, a wider discussion and better sharing of ideas that was needed to rapidly adapt to the challenging environment and the distinct patient cohort that was being treated. The team was made of attendings with previous relevant experience. This was vital as only minimal targeted, or refresher training and simulation was needed and the team was ready to be deployed rapidly. The team design including two clinicians with a central collection point for kit allowed full outsourcing of the service across the multiple critical care areas in the hospital, allowing the team to safely deliver the service with minimal support from stretched ICU teams.

Such approach can be used in the future in response to COVID-19 or other emergent scenarios. Although VAST commenced with only a few team members at the start, from the outset, the team design and structure allowed for the continuation of recruitment and training of additional members if needed. If cases of COVID-19 had continued to increase, we had planned to add an extra four members to the team. Ultimately, this was not required but we remain prepared in case there is a second peak in the future.

With respect to outcomes, the team was able to perform 190 line insertions during the 5-week study peak period. This freed ICU teams to perform other essential tasks like reviewing and managing complex patients or talking to family members. In addition to our team, a separate team was developed to insert tracheostomies, a proning team to and a chest drain insertion team.

Recognised complications from central venous line insertion include infection; line related thrombosis; bleeding; pneumothorax; haemothorax; retained guidewires, and; iatrogenic arterial injury [21-23]. Complication rates seems to be significantly higher in the ICU environment. The ADVANCED study (prospective, single centre, randomised study) analysed 628 patients admitted to the ICU for an expected stay of at least 48 h requiring a catheter insertion as part of their clinical care (2214 catheters: 873 PVCs, 630 CVCs, 512 ACs and 199 HDCs and PACs). The overall complication rate was nearly 30%. In the complications related to central venous access, 7% were classified as severe and 3% as life threatening. In the complications associated with temporary dialysis catheter access, 17% were considered severe and 2% considered very severe. The most frequent CVC and temporary dialysis catheter complications leading to early catheter removal was infection [24]. Complication rates by our VAST service were, in comparison, low despite challenges with PPE and working within a busy critical care environment. Technical challenges faced by the team included a high proportion of patients requiring ECMO, and many patients had pre-existing line related thrombi that needed to be considered. In addition, there was a general trend to increase anticoagulation in order to manage a COVID-19 associated prothrombotic state. Our low complication rates underscore the effectiveness of the

VAST service. Our findings are similar to the recent multi-centre report by Chun et al [18], highlighting the important contribution of a similar service in centres outside of the UK and adds weight to their findings.

There have been several publications on central and peripheral access training as well as on volume, technical errors and decision making in this area. In times of crisis, concentrating tasks, such as line insertion, allows people to focus on one duty with improved outcomes [25-27]. Nearly 30% of our patients in this report were receiving ECMO and patients were often managed in units that were converted to critical care to manage the unprecedented demand. In established ICU areas, more patients per unit of ICU surface area led to a limited space around the patient to navigate equipment. Additional limitations included the need to wear full PPE. Despite these significant challenges we believe that the use of attendings to staff VAST allowed for non-technical skills, including situation awareness, decision making and communication, to be utilised effectively [28]. We have summarised our thoughts relating to the opportunities and challenges when considering a vascular access support team during a healthcare crisis in**Table 4** .

Limitations to this study include its retrospective nature with complications limited to those documented in the health records. We additionally did not actively look for thrombosis or complications outside of our centre and may have missed complications occurring in the following days or weeks after discharge. Further, changes in ITU management were made during the study period as our 'learning' regarding COVID-19 evolved including guidance regarding thromboprophylaxis, types of sheaths that were optimal and intravascular fluid status of patients on ITU. These are additionally likely to influence complication rates and resulted in a more heterogenous group.

Conclusions

In summary, we describe the successful deployment of a multidisciplinary vascular access support team (VAST) created during the COVID-19 pandemic. Evaluation of the outcomes showed a low complication rate in a challenging group of patients during unprecedented demands for ICU services. ICU teams believed VAST helped free their precious time and allowed them to perform other important clinical tasks. Finally, in the unfortunate scenario of a second surge or any other similar emergency in the future, the same team can be redeployed again rapidly and recommend similar models be considered by health services to optimise patient care and ICU management.

Author contributions

Study design: MDS, PS, NM, NK, MO, MD and MS; VAST study team: MDS, PS, NM, NK, LB, CB, CC, TD, MO, SP, NW, HZ, MD and MS; Data collection and review: MDS, PS, NM, NK, MD and MS; Writing: MDS, PS, NM, NK, LB, CB, CC, TD, MO, SP, NW, HZ, MD and MS.

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Compliance with ethics standards

The authors confirm that this project has been registered as a service evaluation and has departmental and institutional approval. No consent from patients was indicated and ethical approval was not required

Conflicts of interest statement

None.

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Table legend

Table 1 : Demographics and clinical characteristics of patients who had lines placed by the Vascular Access Support Team over 5-week COVID-19 surge period.

Table 2 : Anatomical location and type of vascular access placed by the Vascular Access Support Team in 122 patients over 5-week COVID-19 surge period.

Table 3 : Iatrogenic complications following 190 vascular access placed in 122 patients by the Vascular Access Support Team over 5-week COVID-19 surge period.

Table 4: Opportunities and challenges of vascular access support teams during health care crises

Figure: Summary of key findings from online anonymised questionnaire to evaluate experience of the VAST service, including n=54 nursing and medical health professionals.

Table 1 : Demographics and clinical characteristics of patients who had lines placed by the Vascular Access Support Team over 5-week COVID-19 surge period.

Patient demographics	**n=122**
Age*	51.6 ± 13.1
Gender (M/F)$^{+}$	73/27
Weight (kg)*	89.7 ± 18.0
BMI*	30.2 ± 6.3
Primary Diagnosis T1RF – Covid19^{+}	92.6
ECMO^{+}	28.7
Mortality^{+}	13.1
Pre-existing comorbidities:	
Hypertension^{+}	37.7
Diabetes^{+}	31.1
Dyslipidaemia^{+}	16.4
IHD/CAD^{+}	0.8
COPD^{+}	0.8
CKD^{+}	3.31
Thrombophilia	1.6
Cancer	3.3
Mean ± SD; $^{+}$ Percentage	

BMI; Body mass index, ECMO; extra corporeal membrane oxygenation, IHD; ischaemic heart disease, CAD; coronary artery disease, COPD; chronic obstructive pulmonary disease, CKD; chronic kidney disease

Table 2 : Anatomical location and type of vascular access placed by the Vascular Access Support Team in 122 patients over 5-week COVID-19 surge period.

Type of line inserted	**Number of lines *n (%)***
CVC	104 (54.7)
Temporary dialysis catheter	78 (41)
Arterial	7 (3.7)
PiCCO line	1 (0.5)
Insertion site	**Number of lines *n (%)***
Right internal jugular vein	75 (39.5)
Left internal jugular vein	59 (31.1)
Right femoral vein	24 (12.6)
Left femoral vein	24 (12.6)
Left dorsalis pedis	3 (1.6)
Right Brachial Artery	2 (1.1)
Right radial artery	1 (0.5)
Left Subclavian Vein	1 (0.5)
Left femoral artery	1 (0.5)

CVC; central venous catheter, PiCCO; pulse-induced contour cardiac output

Table 3 : Iatrogenic complications following 190 vascular access placed in 122 patients by the Vascular Access Support Team over 5-week COVID-19 surge period.

Complication	**Incidence of complication, *n (%)***
Bleeding – minor	19 (10)
Infection	10 (5.3)

Complication	**Incidence of complication, *n (%)***
Malposition	6 (3.2)
Occluded line	6 (3.2)
Arterial puncture	2 (1.1)
Bleeding – major	1 (0.5)
Venous thromboembolism	1 (0.5)

Table 4: Opportunities and challenges of vascular access support teams during health care crises

Opportunities	**Challenges / risks**
Efficient use of staff	De-skilling of critical care staff
Procedures performed by team of experts	Potential need to make adjustments/changes rapidly in response to dynamic s
Reduction of workload of critical care team	Need for personal protective equipment
Application of standardised techniques	Unavailability of team for other clinical duties
Opportunities for training of junior staff	Need for close oversight and governance
Multi-disciplinary team working	
Cross-fertilisation	
Preparedness for future pandemics