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PERIPHERALLY INSERTED CENTRAL VENOUS CATHETER SAFETY IN BURN CARE: A SINGLE CENTRE RETROSPECTIVE COHORT REVIEW

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Abstract

Objective—PICC line use for central venous access in thermally injured patients has increased in recent years despite a lack of evidence regarding safety in this patient population. A recent survey of invasive catheter practices among 44 burn centers in the United States found that 37% of burn units use PICC lines as part of their treatment protocol. The goal of this study was to compare PICC associated complication rates to existing literature in both the critical care and burn settings.

Methods—A single institution retrospective cohort review of patients who received a PICC line during admission to a regional burn unit between 2008–2013. Fifty-three patients were identified with a total of seventy-three PICC lines. The primary outcome measurement for this study was indication for PICC line discontinuation.

Results—The most common reason for PICC line discontinuation was that the line was no longer indicated (45.2%). Four cases of symptomatic upper extremity deep vein thrombosis (5.5%) and 3 cases of central line associated bloodstream infection (4.3%, 2.72 infections per 1000 line days) were identified. PICC lines were in situ an average of 15 days [range 1–49 days].

Conclusions—We suggest that PICC line associated complication rates are similar to those published in the critical care literature. Though these rates are higher than those published in the burn literature, they are similar to CVC associated complication rates. While PICC lines can be a useful resource in the treatment of the thermally injured patient, they are associated with significant, and potentially fatal risks.

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Conflicts of Interest: None

Keywords

Burns; Catheter-Related Infections; Central Venous Catheters; Safety; Upper Extremity Deep Vein Thrombosis

Introduction

Burn patients require central venous access not only during the acute burn resuscitation, but often also as part of their ongoing management. Traditionally, central venous catheters (CVCs) have been the primary method of central venous access in thermally injured patients, as they allow for rapid large volume fluid infusion, administration of vasoactive medications, and monitoring of hemodynamic status during acute burn resuscitation. In recent years, the use of peripherally inserted central catheters (PICCs) has increased as an alternative to CVCs, largely due to their comparative ease of insertion, perceived safety, and cost-effectiveness.[1–7]

Studies analyzing the safety of PICC lines have demonstrated inconsistent results.[8–11] In particular, concerns have been raised over the increased incidence of PICC associated upper extremity deep vein thrombosis (UEDVT), catheter malposition, PICC line failure, and catheter-related blood stream infection (CR-BSI).[12–18] A systematic review done by Pikwer et al. found that PICC lines are associated with higher rates of overall complications, with no difference in rates of catheter-related blood stream infection (CR-BSI).[19]

Unfortunately, evidence on the use of PICC lines in the burn population remains scarce. The majority of studies to date have focused on either critically ill patients in the intensive care unit setting or oncology patients. A search of the literature revealed very few studies on the use of PICC lines in burn units. In a retrospective study of twenty-nine burn patients (thirty-seven PICC lines), Fearonce et al. identified one case of PICC associated UEDVT (2.8%) with no cases of CR-BSI.[2] Compared to existing literature in the critical care setting, these PICC associated complication rates are seemingly quite low given that burn patients are typically high-risk patients for infectious and thrombosis complications.

In this study, we set out to review the use of PICC lines in patients admitted to the adult burn center at our institution. The goal of this study was to compare PICC associated complication rates to existing literature in both the critical care and burn settings. We believe that PICC associated complication rates in the burn unit are comparable to complication rates in the critical care setting, which is significantly higher than the rates previously published in the thermally injured patient population.

Methods

A retrospective review of the American Burn Association National TRACS® (NTRACS®) Burn Database was performed for all patients admitted to the regional burn center at a single tertiary trauma hospital between January 1, 2008 and June 30, 2013. Patients who received a PICC line during the course of their admission were identified. Patients admitted to the burn unit for complex or chronic wound issues (e.g. necrotizing fasciitis, necrotizing vasculitis,

toxic epidermal necrolysis) were included in the study. Patients admitted to the unit for reasons of bed-allocation from the critical care unit were identified and excluded.

A retrospective chart review was performed for all identified patients. Information obtained through chart review included age, gender, % TBSA, etiology of injury, length of stay (LOS), number of ventilator days, and inhalation injury (diagnosed by bronchoscopy). Chart review was used to determine length of PICC line placement and reason for discontinuation. Patients who were transferred to another institution prior to removal of the PICC line were excluded from the study.

The criteria for infection rates were guided by the Centre for Disease Control's (CDC) definition of central line associated blood stream infection (CLABSI), as neither quantitative nor semi-quantitative culture results were available.[20] All cases of suspected CLABSI were identified and cross-referenced with the provincial reporting service for patient safety indicators provided by the Department of Infection Prevention & Control. CLABSI rates were reported as events per 1000 line days. PICC line tips are not routinely cultured at our institution.

All charts were reviewed for evidence of symptomatic PICC associated UEDVT. Patients were identified who had undergone ultrasound of the ipsilateral upper extremity while the PICC line was in situ. UEDVT was defined as any clot located in the basilic, brachial, cephalic, axillary, subclavian, brachiocephalic, or superior caval veins. Rates were reported as the number of events as a proportion of all total lines included in the study. Of note, all patients at our institution receive chemical thrombo-prophylaxis in the form of weight-adjusted low molecular weight heparin, as per our institutions thromboembolism guidelines.

Indications for PICC line insertion at our institution include anticipated long-term intravenous antibiotic administration, ongoing requirements for vasoactive medications, and ongoing need for blood draws with difficult/limited intravenous access. However, the final decision for PICC line insertion is at the discretion of the attending physician. At our institution, all PICC lines are inserted under ultrasound guidance by an interventional radiologist in the Department of Diagnostic Imaging. PICC lines are sited such that they are remote from any open wounds or active infection at the time of insertion, and typically after all burns have been excised. Records on the PICC insertion (site, location, size of catheter used) were collected from the patient's electronic health records. The manufacturer of the PICC lines is based on consignment in the Department of Diagnostic Imaging; however, all PICC lines used at our institution are non-antibiotic coated. Routine PICC line care protocols at our institution have been created and approved by the Medical Advisory Committee. In the burn ICU, PICC lines are flushed with 10–20cc of sterile 0.9% normal saline (NS) and locked to prime the line. PICC lines are flushed with 10cc of sterile NS after each use. If the line is not being used for continuous infusion, the line is primed with 10cc of sterile NS before use and subsequently flushed with 10cc of sterile NS before being saline-locked. Dressings for PICC line sites are changed every 7 days, sooner if there is concern of the security of the dressing. Dressing care for PICC sites includes a “no touch” dressing technique, whereby no direct physical contact is made with the line or at the site of insertion.

PICC line insertion sites are monitored on a daily basis for signs of infection or catheter malposition.

Results

Retrospective chart review identified fifty-three patients who received a total of seventy-three PICC lines during their admission(s) to the burn unit. Demographic data for these patients is shown in Table 1.

The primary indication for PICC line insertion included: long-term IV antibiotics (27.4%), difficult IV access (20.5%), general IV access [e.g. medication, bloodwork] (19.2%), long-term IV access (16.4%), PICC line complication (9.6%), total parenteral nutrition (5.5%), no CVC access due to burn (1.4%). PICC lines remained in situ for an average of 15 days, and ranged from 1 to 49 days. The majority of PICC lines were two-lumen (78.1%) 5 French (74.0%) lines placed in the left (58.9%) basilic (75.3%) vein (Table 2). The reasons for discontinuation of the PICC line were: line no longer indicated (46.6%), suspected PICC line infection (19.2%), blocked PICC line (8.2%), UEDVT (5.5%), death (5.5%), PICC line malfunction (4.1%), PICC line rupture (1.4%), PICC placed in infected site (1.4%), PICC line pulled by patient (1.4%), PICC malposition (1.4%), sepsis (1.4%), exchanged for CVC (1.4%), unknown (1.4%).

Four of seventy-three PICC lines were complicated by symptomatic UEDVT, for an overall incidence rate of 5.5% (Table 3 and 4). Three of these four patients (5.1%) had large %TBSA burns with a prolonged hospital course and multiple operating room visits. The remaining patient had toxic shock syndrome with purpura fulminans. However, one of the thermally injured patients was treated at an outside institution for over a year prior to transfer to our institution, and was thus excluded from our acute burn injury group. When corrected to include only acute burn injuries, the incidence of UEDVT was 3.4% (2/59) (Table 3).

Three of seventy-three PICC lines in two patients (4.3%) developed CLABSI as defined by the CDC, for a total of 2.72 infections per 1000 line days (Table 3). All patients with CLABSI were thermally injured, and these infections were documented on post-burn day numbers 165, 166, 192 respectively.

It should be noted that in all patients in which there was a documented complication, either UEDVT or CLABSI, that 100% of their wounds had been excised and autografted at the time of the complication.

Discussion

A recent survey of invasive catheter practices among 44 burn centers in the United States found that 37% use PICC lines as part of their treatment protocol for burn patients.[21] Despite the lack of evidence in this unique and complex patient population, PICC lines are frequently used in burn units across North America.

PICC Line Associated Upper Extremity DVT

Upper extremity DVT remains a controversial topic, as there is no clear definition as to what constitutes an UEDVT.[7, 22] What is agreed upon, however, is that UEDVT can lead to significant and potentially fatal outcomes, ranging from post-thrombotic syndrome to pulmonary embolism.[12, 23, 24] Reported incidence rates of UEDVT range from 2% to 11% for symptomatic events[3, 5, 7, 13, 16, 22, 25, 26], and upwards of 38.5% in studies investigating both symptomatic and asymptomatic events.[9, 15, 27] Unfortunately, study conditions in these reports are highly heterogeneous, making it difficult to directly compare patient populations. The 5.1% incidence of symptomatic PICC associated UEDVT in this study falls within established ranges for symptomatic events in other patient populations (Table 3). Furthermore, the 3.4% incidence in acute thermal injury is higher than the 2.8% incidence previously described in the burn population, which suggests that PICC associated UEDVT may be more common in burn patients than previously reported.[2]

Thermally injured patients are a unique population, with physiologic derangements and a severe systemic inflammatory response that arise post-burn and persist up to 3 years.[28] In particular, thermally injured patients are at elevated risk for thromboembolic events.[23, 29, 30] It has been previously shown that thermally injured patients become hyper-coagulable within one week of burn injury, despite a normal coagulation profile on admission.[31] In regards to the PICC line itself, PICC associated UEDVT typically occurs day 7–14 after line insertion.[7, 9] This was in fact observed in our patient population, where UEDVT occurred on post-insertion day 7, 9, and 9 respectively, despite all receiving chemical thromboprophylaxis (Table 4). Given their physiologic derangements, thermally injured patients would appear to be high risk for PICC associated UEDVT for a prolonged period following the actual burn injury.

Commonly referred to as Virchow's Triad, thrombosis arises from a combination of hypercoagulability, stasis of blood flow, and endothelial damage. Burn patients are at high risk of venous stasis for multiple reasons, including prolonged mechanical ventilation, sedation, pain, multiple operations, post-operative immobilization, and the burn itself.[29, 30] Pannucci et al. reported that TBSA>10%, length of ICU stay, and number of operations were all independently associated with increased risk of VTE in thermally injured patients.[32] All PICC associated UEDVT patients with thermal injury in this study met the aforementioned criteria (Table 4).

While insertion of PICC lines has become less traumatic with the aid of ultrasound guidance, movement of the catheter within the vessel can directly damage the endothelium.[13–16, 22] Larger diameter PICC lines have been associated with increased risk of UEDVT, likely secondary to the greater amount of time in contact with the endothelial lining of the vessel.[14, 16] This too was reflected in our results, as all four cases of UEDVT had double-lumen 5 French PICC lines or triple-lumen 6 French PICC lines.

PICC Line Associated Blood Stream Infection

As invasive central venous catheters, PICC lines are at risk of introducing pathogens directly into the bloodstream. Though early studies showed that CR-BSI rates in PICC lines were

significantly lower than in CVCs (0.4–0.8 vs. 2.0–5.0 per 1000 line days), recent evidence suggests little difference between the two.[3, 5, 7, 25, 26]

In fact, data suggests that PICC lines are the most common central access device associated with CR-BSI in critically ill patients.[1–7, 33] Studies have shown that PICC line CR-BSI rates are significantly higher in the ICU setting, and that hospitalized patients with PICC lines have higher rates of CR-BSI compared to outpatients.[8–11, 26, 34] It seems that critically ill patients with PICC lines are at an increased risk of CR-BSI compared to other patient populations, though the reasons behind this phenomenon are not yet clear.

Thermally injured patients are prone to the development of infections. Rates of CR-BSI in thermally injured patients with CVCs have been reported as high as 20 per 1000 line days. [12–18, 35] In 2007, the American Burn Association developed a definition for CR-BSI in burn patients, though this definition is less stringent than that developed by the CDC for research purposes.[19, 20, 35] For this reason one must be careful when interpreting the literature.

This study reports an overall PICC line CLABSI rate of 2.72 infections per 1000 line days in thermally injured patients (Table 3). Though similar to published rates amongst critically ill and hospitalized patients, this is slightly higher than the seven-year average CLABSI rate (1.86 per 1000 line days) on our burn unit for all central lines (CVC and PICC).

Nevertheless, we believe these rates are more accurate than those previously reported in the burn literature. To date, only one study has commented specifically on PICC associated CR-BSI in thermally injured patients, reporting a rate of 0 infections per 1000 line days in a population of patients with 37 PICC lines.[2, 21] It should be noted that we are comparing CLABSI rates to CR-BSI rates, which are defined very differently, and it is possible that the CR-BSI rate in thermally injured patients is actually lower than the CLABSI rate we report. [2, 36] Armstrong et al. found a significant decrease in PICC associated bacteremia with the institution of antibiotic impregnated PICC lines (50% vs. 0% of all PICC lines), however, this study makes no comment on CR-BSI or the clinical significance of this bacteremia.[1, 7, 22] It is particularly difficult to determine the source of bacteremia in burn patients, given the nature of their injury and resuscitation.

In the end, CVCs remain the gold standard for vascular access in the thermally injured patient, though they do not exist without their own inherent risks. Studies have found that 93% of burn patients with a documented DVT had a local CVC in place prior to clot development.[12, 23, 24, 30] Furthermore, studies have shown a symptomatic CVC associated DVT incidence of 7%, with asymptomatic rates as high as 12.6%.[5, 7, 13, 16, 22, 37] Similarly, CVC associated CR-BSI rates have been shown to vary from 4% to 12% depending on the timing of catheter exchange, which correlates with an overall CVC associated sepsis rate of 5.8%.[9, 15, 27, 38, 39] A study by O'Mara et al. reported a CVC associated CR-BSI rate in adults of 9.8 per 1000 line days, though rates as high as 20 per 1000 line days have been previously published.[2, 35, 40]

Overall, like the evidence behind PICC lines, the evidence examining risks associated with CVC use in burn patients is relatively limited with a lack of unanimity. CVCs appear to have

become the gold standard in thermally injured patients as a result of limited alternative options, though this may change now that more reliable options are readily available.

There are several limitations to this study. As a retrospective review, we only comment on symptomatic UEDVT rates. It is possible that asymptomatic UEDVT rates in the burn population are higher than reported in this study. Further, as our laboratory does not routinely provide quantitative or semi-quantitative culture results, we were only able to comment on CLABSI rates. A small number of patients were identified to have multiple lines in situ concurrently, which may have impacted CLABSI rates. Finally, at our institution PICC lines are not used in the acute resuscitation of burn patients.

Conclusion

This study raises the question of what method of central venous access is the safest and most reliable for burn patients. With more burn units using these vascular access devices in the treatment of thermally injured patients, particularly during the acute burn resuscitation phase, it will be important to closely monitor complication rates going forward.[21, 28]

Based on the results of this study, we suggest that PICC line associated complication rates are similar to those published in the critical care literature and higher than those previously published in the burn literature. However, these PICC associated complication rates are similar to those reported for CVCs. We believe that, overall, this study demonstrates non-inferiority of PICC lines. Though PICC lines can be a useful resource in the treatment of the thermally injured patient, they are associated with significant, and potentially fatal risks. Moving forward, we will be more judicious with the use of PICC lines in thermally injured patients at our institution, particularly in patients with large burns and long ICU stays.

This is the largest study to date to examine the rate of PICC line associated complications in the burn patient population. A large scale, prospective study is needed to more accurately determine the complication rates for PICC lines and CVCs in the burn population, in both the acute resuscitation and chronic settings.

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Table 1

Demographic and admission information for patients admitted to a regional burn center (n=53) treated with PICC line (n=73).

Age (years)	52.62 [17.14 – 91.67]
Gender	
Male	28 (52.8%)
Female	25 (47.2%)
%TBSA	29.72 [0.0–75.0]
2 nd Degree TBSA	7.1 [0.0–49.5]
3 rd Degree TBSA	21.2 [0.0–60.5]
Inhalation Injury	16 (30.2%)
Length of Stay	68 [4–263]
Ventilator Days	25.17 [0–110]
Etiology	
Flame	33 (62.3%)
Scald	5 (9.4%)
Necrotizing Fasciitis	3 (5.7%)
Contact	2 (3.8%)
Chemical	2 (3.8%)
Necrotizing Vasculitis	2 (3.8%)
Toxic Epidermal Necrolysis	2 (3.8%)
Chronic Wound	2 (3.8%)
Lymphedema	1 (1.9%)
Toxic Shock Syndrome	1 (1.9%)

Table 2

Characteristics of PICC lines inserted in the burn center (n=73).

Lumen	
1	1 (1.4%)
2	57 (78.1%)
3	15 (20.5%)
Size	
4Fr	2 (2.7%)
5Fr	54 (74.0%)
6Fr	11 (15.1%)
Unknown	6 (8.2%)
Site	
Basilic	55 (75.3%)
Brachial	11 (15.1%)
Cephalic	6 (8.2%)
Unknown	1 (1.4%)
Side	
Left	43 (58.9%)
Right	27 (37.0%)
Unknown	3 (4.1%)

Table 3

Complication rates associated with PICC lines placed in the burn unit.

	Upper Extremity Deep Vein Thrombosis Incidence	Central Line Associated Blood Stream Infection (PICC)
All Burn Unit Patients	5.5%	
Thermally Injured Patients	5.1% (all) 3.4% (acute)	2.72 per 1000 line days

Table 4
Characteristics of patients with PICC lines who developed symptomatic upper extremity deep vein thrombosis.

	Age	TBSA (%)	LOS (days)	OR Visits (#)	Etiology	PICC Length (days)	Post-Burn Day at Time of UEDVT	PICC Details	Clot Location
1	47	52.5	127	10	Flame	7	92	5Fr, 2 Lumen	Subclavian, Brachial, Basilic
2	24	75	159	6	Flame	9	526	6Fr, 3 Lumen	SVC
3	46	57	92	9	Flame	9	62	5Fr, 2 Lumen	Basilic
4	61	N/A	34	2	Necrotizing Vasculitis	13	N/A	5Fr, 2 Lumen	Cephalic