



Presented at the Academic Surgical Congress 2019

Symptomatic catheter-associated thrombosis in pediatric trauma patients: Choose your access wisely



Cory M. McLaughlin, MD^a, Erica N. Barin, BS^a, Michael Fenlon, MD^{a,b}, Colleen Azen, MS^{c,d}, Timothy W. Deakers, MD, PhD^e, James E. Stein, MD, MSc^{a,b}, David W. Bliss, MD^{a,b}, Jeffrey S. Upperman, MD^{a,b}, Aaron R. Jensen, MD, MEd^{a,b,*}

^a Division of Pediatric Surgery, Children's Hospital Los Angeles, Los Angeles, CA

^b Department of Surgery, Keck School of Medicine of the University of Southern California, Los Angeles, CA

^c Southern California Clinical and Translational Science Institute (SC-CTSI), Los Angeles, CA

^d Biostatistics Core, Children's Hospital Los Angeles, Los Angeles, CA

^e Department of Anesthesia and Critical Care Medicine, Children's Hospital Los Angeles, Los Angeles, CA

ARTICLE INFO

Article history:

Accepted 9 May 2019

Available online 13 September 2019

ABSTRACT

Background: Traumatic injury and the presence of a central venous catheter are 2 of the strongest risk factors for venous thromboembolism in children. The purpose of this study was to determine the incidence of symptomatic, catheter-associated thrombosis in critically injured children. We hypothesized that femoral venous catheters are associated with a greater rate of thrombotic complications when compared with all other central venous access points.

Methods: We reviewed a retrospective cohort (2006–2016) of injured children (≤ 18 years) admitted to a pediatric intensive care unit with central access placed ≤ 7 days from admission. Symptomatic, catheter-associated thrombosis was determined by radiographic evidence. Poisson regression was used to compare the incidence of catheter-associated thrombosis per 1,000 catheter days between femoral and nonfemoral catheters. All comparisons were 2-tailed with $\alpha = 0.05$.

Results: We examined 209 pediatric trauma patients with central access (65% femoral, 19% subclavian, 11% arm vein, and 5% internal jugular). Femoral catheters were removed earlier (median [interquartile range] 4 [2–7] vs 8 [3–12] days, $P < .001$) and were larger in diameter (5 Fr [4–7] vs 4 Fr [4–4], $P < .001$) when compared with all other catheters. Catheter-associated thrombosis was more frequent in femoral versus nonfemoral catheters (18.4 vs 3.5 per 1,000 catheter days, $P = .01$).

Conclusion: Femoral venous catheters are associated with a greater incidence of symptomatic, catheter-associated thrombosis in pediatric trauma patients. When central venous access is indicated for injured children, the femoral site should be avoided. If a femoral venous catheter is necessary, use of a smaller catheter should be considered.

© 2019 Published by Elsevier Inc.

Introduction

Venous thromboembolism (VTE) has been recognized increasingly as a major public health problem and source of morbidity and mortality in hospitalized adults, especially in trauma patients.^{1–4}

Supported by grants KL2TR001854, UL1TR001855, and UL1TR000130 from the National Center for Advancing Translational Science of the US National Institutes of Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Presented at the 2019 Academic Surgical Congress on February 7, 2019, Houston, TX.
* Reprint requests: Aaron R. Jensen, MD, MEd, UCSF Benioff Children's Hospital Oakland, Division of Pediatric General Surgery, 744 52nd Street, OPC 4th Floor, Oakland, CA 94609.

E-mail address: aaron.jensen@ucsf.edu (A.R. Jensen).

Although the incidence of VTE is less in children, their risk also increases after traumatic injury.⁵ Greater injury severity, immobility, major surgery, older age, and a low Glasgow Coma Score (GCS) are known risk factors for VTE in pediatric trauma patients, but the majority of clots in children occur in those with an existing or previous central venous catheter (CVC).^{6–12}

Avoiding use of CVCs unless absolutely indicated is considered standard of care to minimize the risk of catheter-associated complications, such as infection and thrombosis.¹³ When a CVC is needed, however, the location of the catheter may affect the risk profile of children. Femoral and subclavian CVCs have been reported to have a greater incidence of catheter-associated thrombosis in a mixed-population of pediatric and leukemia patients,^{14,15} but the incidence of catheter-associated thrombosis has not been

reported in pediatric trauma patients. The purpose of this study was to determine the association between CVC location and incidence of catheter-associated thrombosis in pediatric trauma patients.

Methods

Study design and cohort selection

Approval was obtained from the Institutional Review Board of the Children's Hospital of Los Angeles and University of Southern California. A retrospective cohort (2006–2016) was obtained from 2 American College of Surgeons (ACS) verified level-1 trauma centers that care for pediatric patients. We included all patients ≤ 18 years old in the trauma registry at each institution who were admitted to the pediatric intensive care unit and underwent CVC placement. Patients were excluded if the CVC was placed >7 days from injury or if they had a preexisting, indwelling CVC or a history of CVCs before admission.

Demographic and clinical data abstracted from chart review included patient age, weight, height, race, ethnicity, primary language, insurance status, comorbidities, mechanism of injury, GCS, and serum coagulation markers at admission, presence of traumatic brain injury, spine fracture, pelvic fracture, femur fracture, tibia fracture, venous injury, and blood stream infection. We followed the international standard¹⁶ to classify obesity by age and sex; calculating (with PediTools.org)¹⁷ weight-for-height percentile for infants 0 to 24 months using the growth standards of the World Health Organization, and body mass index (BMI) percentile for children >2 years old using the growth chart of the Centers for Disease Control and Prevention. Use of pharmacologic thromboprophylaxis and date of initiation was recorded.

The presence of a central venous catheter was determined via nursing or provider documentation or radiographic evidence. Specific CVC characteristics were recorded, including insertion site (femoral, subclavian, internal jugular, or arm vein), side of insertion, type of CVC (peripherally inserted central catheter, nontunneled, tunneled, or port), catheter size, date of placement, and date of removal. Catheter days were calculated by subtracting the date of placement from removal. If the date of removal could not be determined accurately from the chart review, catheter days were considered missing.

Definition of catheter-associated thrombosis

The primary outcome was the incidence of symptomatic, catheter-associated thrombosis. A thrombosis event was determined by radiographic evidence. We reviewed all diagnostic studies and recorded the type of diagnostic modality (ultrasonography, computed tomography, magnetic resonance imaging, or venography) and first date in which a VTE was present. The vein location and laterality of the VTE were also recorded. The incidence of catheter-associated thrombosis was calculated per 1,000 catheter days. Routine screening for asymptomatic DVT was not utilized at either of the participating centers. The decision to obtain an imaging study to diagnose a DVT was at the discretion of the treating physician and not determined by protocol.

Statistical analysis

The primary comparison groups in this study were patients with femoral versus upper extremity (subclavian, internal jugular, and arm vein) CVCs. Categorical data was compared using χ^2 or Fisher exact test (for cell counts <5). Continuous, nonparametric data were compared using Mann-Whitney U test. Poisson regression

was used to compare the incidence of catheter-associated thrombosis using catheter days as an offset. Statistical analyses were conducted with SAS software, version 9.4 (SAS Institute Inc, Cary, NC). All comparisons were 2-tailed with $\alpha = 0.05$.

Results

A total of 209 pediatric trauma patients met criteria to be included in the study. The distribution of CVC location in descending frequency was femoral (65%), subclavian (19%), arm vein (11%), and internal jugular (5%). There was no difference between patients with femoral versus upper extremity catheters with respect to age, sex, race, ethnicity, primary language, insurance, weight-for-length or BMI, comorbidities, mechanism of injury, admission coagulation profile, admission GCS, fractures of the spine, pelvis or tibia, venous injury, or acquired blood stream infection per bivariate comparison (Table 1). More frequent use of upper extremity versus femoral CVCs was seen in patients with non-accidental trauma (35% vs 18%, $P = .01$) and femur fractures (21% vs 5%, $P < .01$). Femoral CVCs were used more frequently in patients with traumatic brain injury (85% vs 64%, $P < .01$), more commonly placed on the right side (70% vs 53%, $P = .03$), more likely to be larger in diameter (median, interquartile range [IQR] 5 Fr [4–7] vs 4 Fr [4–4], $P < .001$), and were removed earlier (4 [2–7] vs 8 [3–12] days, $P < .001$) than upper extremity CVCs. Thromboprophylaxis was rarely used (5%) and not associated with CVC location.

The overall incidence of symptomatic thrombosis was 6% in this cohort (Table 2). Patients developing DVT were younger, less often of Hispanic ethnicity, and more frequently thrombocytopenic on admission when compared with patients not developing DVT (Supplemental Table 1). Nearly all (92%) VTE events were diagnosed via ultrasonography, and only one via computed tomography (Table 3). All imaging studies potentially diagnostic of VTE were reviewed regardless of the indication for the study (eg, computed tomography or duplex ultrasonography for fever of unknown cause), and no asymptomatic thrombosis events were seen. The median time to diagnosis was 9 days (IQR 4–13 days) overall, and there was no difference between the 2 groups. The total number of catheter days was 598 and 580 days for femoral and upper extremity CVCs, respectively. The incidence of VTE when normalized for catheter days was greater in children with femoral catheters (18.4 vs 3.5 VTE per 1,000 catheter days, $P = .01$). There was no difference in hospital stay, intensive care unit duration of stay, or mortality among children with femoral or upper extremity catheters.

Discussion

This retrospective study found that femoral catheters were associated with a greater incidence of catheter-associated VTE in pediatric trauma patients. Femoral CVCs were placed more frequently in patients with traumatic brain injury and tended to be larger in diameter. Despite being removed earlier, femoral CVCs still had a greater rate of VTE. There was no difference in hospital or pediatric intensive care unit durations of stay. These findings suggest that when a CVC is absolutely indicated, an upper extremity catheter may be the best choice. If a lower extremity catheter is necessary, the use of the smallest functional catheter to meet resuscitation needs should be considered.

There are number of factors which have been associated with VTE in pediatric trauma patients, including critical illness, increased Injury Severity Score, lower GCS, operative intervention, and immobility.^{6,9,11,12} Older children have been associated with a greater risk for VTE,^{7,9,11} but our data suggest that younger children

Table I
Baseline characteristics of pediatric trauma patients with central venous catheters, comparing femoral to upper extremity catheter location

Category	Upper N = 72	Femoral N = 136	P value*
Age, y	7.6 (1.4–12.9)	5.6 (1.8–11.4)	.58
Male sex	82 (60%)	47 (65%)	.55
Weight-for-length/BMI percentile	69 (37–93)	63 (33–92)	.50
Race			.20
White	15 (21%)	26 (19%)	
Black	5 (7%)	13 (10%)	
Asian	2 (3%)	14 (10%)	
Other/unknown	50 (69%)	83 (61%)	
Hispanic/Latino ethnicity	51 (73%)	77 (60%)	.17
Admission GCS	7 (3–9)	6 (3–9)	.39
Mechanism of injury			.84
Blunt	67 (93%)	129 (95%)	
Penetrating	4 (5.6%)	6 (4.4%)	
Combined	1 (1.4%)	1 (0.7%)	
Nonaccidental trauma	25 (35%)	25 (18%)	.01
Type of injury			
TBI	46 (64%)	116 (85%)	<.001
Spine fracture	7 (10%)	25 (18%)	.11
Pelvic fracture	8 (11%)	17 (13%)	.83
Femur fracture	15 (21%)	7 (5%)	<.001
Tibia fracture	11 (15%)	11 (8.1%)	.15
Venous injury	1 (1.4%)	3 (2.2%)	1.0
Blood stream infection	5 (7.3%)	9 (7.0%)	1.0
Platelets			.17
Normal	50 (70%)	103 (76%)	
Low	20 (28%)	26 (19%)	
High	1 (1.4%)	7 (5.2%)	
INR			.77
Normal	28 (44%)	58 (45%)	
Low	—	1 (0.8%)	
High	36 (56%)	71 (55%)	
PTT			.46
Normal	40 (63%)	67 (53%)	
Low	7 (11%)	19 (15%)	
High	17 (27%)	40 (32%)	
CVC location			—
Femoral	—	136 (100%)	
Subclavian	39 (54%)	—	
Internal jugular	10 (14%)	—	
Arm vein	23 (32%)	—	
CVC on right side	38 (53%)	90 (70%)	.03
CVC size, Fr	4 (4–4)	5 (4–7)	<.001
DVT prophylaxis	5 (6.9%)	5 (3.7%)	.32

Continuous data presented as median (IQR), categorical data as N (%).

INR, international normalized ratio; PTT, partial thromboplastin time; TBI, traumatic brain injury.

* χ^2 or Fisher exact test (for counts <5) for categorical data; Mann-Whitney *U* test for continuous data. Missing data: CVC location (*n* = 1), ethnicity (*n* = 9), platelets (*n* = 1), INR (*n* = 14), PTT (*n* = 18), bacteremia (*n* = 10), CVC side (*n* = 7).

Table II
Incidence of catheter-associated thrombosis and outcomes by CVC location

Outcome	Upper N = 72	Femoral N = 136	P value*
Thrombosis, total	2 (2.8%)	11 (8.2%)	.23
Days to diagnosis	8 (6–9)	11 (3–13)	.85
CVC days	8 (3–12)	4 (2–7)	<.001
Thrombosis per 1,000 catheter days	3.5	18.4	.01
Hospital duration of stay, d	16 (7–28)	13 (6–25)	.26
ICU duration of stay, d	5 (3–10)	7 (3–13)	.22
Mortality	13 (18%)	24 (18%)	1.0

Continuous data presented as median (IQR), categorical data as N (%).

ICU, intensive care unit.

* χ^2 or Fisher exact test (for counts <5) for categorical data; Mann-Whitney *U* test for continuous data. Poisson regression for events per 1,000 catheter days. Missing data: CVC days (*n* = 35).

are still quite susceptible—potentially related to the injury burden from nonaccidental injury or related to small vessel size. For example, the group with the greatest frequency of VTE events was children <1 year of age (10%). The risk for thrombosis may be so disproportionately increased by the presence of a CVC^{6,9,12}; however, that the effect of age on thrombosis is marginalized. The decision to place a CVC in children requires careful consideration. The population of children in which a CVC is typically needed are patients who already have an increased risk for VTE based on their clinical state. This would include hemodynamically unstable, polytrauma patients with poor vascular access and those who need parenteral nutrition.

The main finding of this study that femoral CVCs are associated with a greater rate of thrombosis is consistent with two previous studies from general pediatric populations. Shah et al examined

Table III
Characteristics of children with catheter-associated thrombosis

No.	Age	Sex	BMI*	Associated injuries	Non-accidental trauma	CVC location	CVC size (F)	PICC	CVC days	Days to diagnosis	DVT prophylaxis	Diagnostic study	Hospital duration of stay	ICU duration of stay	Mortality
1	17 y	F	2	TBI	No	Femoral	7	No	5	13	No	CT	18	8	No
2	10 y	F	<1	Spine injury Tibula/fibula fracture	No	Femoral	—	No	3	13	No	US	31	3	No
3	14 y	F	64	TBI Tibula/fibula fracture Femur fracture	No	Subclavian	—	No	2	6	Yes	US	60	5	No
4	9 y	F	99	TBI	No	Femoral	4	No	6	18	No	US	24	13	No
5	22 mo	M	48	TBI	No	Femoral	4	No	8	6	No	US	27	14	No
6	15 mo	F	95	TBI	No	Femoral	4	No	8	13	No	US	30	16	No
7	5 mo	M	100	TBI	Yes	Arm	4	Yes	6	9	No	US	34	4	No
8	23 mo	M	1	TBI Tibula/fibula fracture	Yes	Femoral	4	No	3	3	No	US	44	14	Yes
9	3 mo	F	17	TBI	No	Femoral	4	No	4	4	No	US	45	16	No
10	1 mo	F	72	TBI	Yes	Femoral	—	No	2	3	No	US	8	8	No
11	3 y	M	6	TBI	Yes	Femoral	—	No	15	11	No	US	25	15	No
12	5 mo	M	1	TBI	No	Femoral	—	No	10	2	No	US	26	13	No
13	13 mo	M	87	TBI spine injury	No	Femoral	—	No	5	110	No	US	160	62	No

CT, computed tomography; PICC, peripherally inserted central catheter; TBI, traumatic brain injury; US, ultrasonography.
* Weight-for-length percentile for infants <2 years, BMI percentile for children ≥2 years. Missing data: CVC size (n = 6).

3,733 CVCs over 3 years and found that femoral CVCs had an odds ratio of 11.1 for thrombosis.¹⁴ Male et al used a multicenter cohort of 158 children with CVCs and found that 32% of VTE events occurred in children with femoral catheters.¹⁸ In contrast, other studies have reported that internal jugular¹⁹ and subclavian¹⁵ lines confer a greater risk for thrombosis. Our hypothesis was based on the reports that the incidence of thrombosis is greater in the lower extremity in adult patients²⁰ and that younger and smaller children have proportionally smaller femoral veins in comparison to their internal jugular veins.²¹ In our cohort, 8 of 11 children (73%) with femoral-associated thrombosis were <3 years old. Ultrasonographic data suggest that the femoral vein does not double in diameter until 5 to 7 years old,²² suggesting that younger age and size may have played in role in the increased incidence of femoral thrombosis in our cohort.

Despite the increased incidence of femoral catheter-associated VTE, there was no difference in hospital days, intensive care unit days, or mortality between upper extremity and femoral CVC groups. These outcomes, however, may not be an appropriate measure of the clinical importance of VTE in pediatric trauma. The benefit of preventing VTE may reside in decreasing the need for therapeutic anticoagulation. Many children who develop thrombosis will be placed on therapeutic anticoagulation, but patients with traumatic brain injury (traumatic brain injury, 78% of our cohort) or gastrointestinal bleeding pose a substantial risk of bleeding. Prophylactic anticoagulation may be considered for VTE prevention, but current guidelines of the Eastern Association for the Surgery of Trauma (EAST) only recommend pharmacologic prophylaxis for postpubertal patients,²³ which represented a minority of patients with VTE in our cohort. Perhaps there may be a role for prophylaxis in younger pediatric trauma patients with CVCs, but future study will be needed to support this measure, because there has been no benefit of chemoprophylaxis demonstrated for young children. Decreasing the use of femoral CVCs, and thereby decreasing the risk for VTE may obviate the need to make this challenging decision.

Studying an outcome as infrequent as VTE in children presents several challenges from the standpoint of research design. The main limitation is often sample size because a large study cohort is needed to detect a difference in VTE incidence. Although we did find a statistically significant association between femoral CVCs and thrombosis, the low number of VTE events excluded the possibility of performing a robust multivariate analysis. Another notable limitation is that this study aimed to detect clinically evident events of VTE that were diagnosed because clinical suspicion warranted further investigation. We did not intend to capture asymptomatic VTEs which are relatively common,¹⁹ and therefore, the effect of catheter location on overall thrombosis events (symptomatic and asymptomatic) is not known. It is possible that asymptomatic VTE may have a different relationship with catheter location particularly in the upper extremity location,^{19,24} which could have led to a type 1 error. This study was also limited by its retrospective design, which resulted in missing data owing to inadequate documentation and our inability to randomize groups to control for confounding. Provider-level factors at the time of CVC placement (such as trainee versus attending, use of ultrasonographic guidance, reason for site selection, and number of attempts) are a potential source of unmeasured confounding that may affect the incidence of VTE. Despite these limitations, this study was the first to our knowledge to report an association between femoral CVCs and catheter-associated thrombosis in critically injured, pediatric trauma patients.

In summary, femoral venous catheters are associated with greater rate of catheter-associated thrombosis in pediatric trauma patients. Although CVCs are commonly needed in injured children

for resuscitation, inotropic support, and delivery of parenteral nutrition, a CVC should be inserted only when indicated, and femoral catheters should be avoided if at all possible. If a lower extremity line is necessary, perhaps the use of a smaller diameter catheter should be considered.

Funding/Support

This work was supported by grants KL2TR001854, UL1TR001855, and UL1TR000130 from the National Center for Advancing Translational Science (NCATS) of the U.S. National Institutes of Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Conflict of interest/Disclosure

None of the authors have any conflicts of interest to disclose.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.surg.2019.05.018>.

References

- Mahan CE, Borrego ME, Woerschling AL, et al. Venous thromboembolism: Annualised United States models for total, hospital-acquired and preventable costs utilising long-term attack rates. *Thromb Haemost.* 2012;108:291–302.
- Beckman MG, Hooper WC, Critchley SE, Ortel TL. Venous thromboembolism: A public health concern. *Am J Prev Med.* 2010;38(4 Suppl):S495–S501.
- Centers for Disease Control and Prevention (CDC). Venous thromboembolism in adult hospitalizations—United States, 2007–2009. *MMWR Morb Mortal Wkly Rep.* 2012;61:401–404.
- Geerts WH, Code KI, Jay RM, Chen E, Szalai JP. A prospective study of venous thromboembolism after major trauma. *N Engl J Med.* 1994;331:1601–1606.
- Jaffray J, Bauman M, Massicotte P. The impact of central venous catheters on pediatric venous thromboembolism. *Front Pediatr.* 2017;5:5.
- Hanson SJ, Punzalan RC, Greenup RA, Liu H, Sato TT, Havens PL. Incidence and risk factors for venous thromboembolism in critically ill children after trauma. *J Trauma.* 2010;68:52–56.
- Van Arendonk KJ, Schneider EB, Haider AH, Colombani PM, Stewart FD, Haut ER. Venous thromboembolism after trauma: When do children become adults? *JAMA Surg.* 2013;148:1123–1130.
- O'Brien SH, Candrilli SD. In the absence of a central venous catheter, risk of venous thromboembolism is low in critically injured children, adolescents, and young adults: Evidence from the National Trauma Data Bank. *Pediatr Crit Care Med.* 2011;12:251–256.
- Vavilala MS, Nathens AB, Jurkovich GJ, Mackenzie E, Rivara FP. Risk factors for venous thromboembolism in pediatric trauma. *J Trauma.* 2002;52:922–927.
- Azu MC, McCormack JE, Scriven RJ, Brebbia JS, Shapiro MJ, Lee TK. Venous thromboembolic events in pediatric trauma patients: Is prophylaxis necessary? *J Trauma.* 2005;59:1345–1349.
- Yen J, Van Arendonk KJ, Streiff MB, et al. Risk factors for venous thromboembolism in pediatric trauma patients and validation of a novel scoring system: The risk of clots in kids with trauma score. *Pediatr Crit Care Med.* 2016;17:391–399.
- Landisch RM, Hanson SJ, Cassidy LD, Braun K, Punzalan RC, Gourlay DM. Evaluation of guidelines for injured children at high risk for venous thromboembolism: A prospective observational study. *J Trauma Acute Care Surg.* 2017;82:836–844.
- O'Grady NP, Alexander M, Burns LA, et al, and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Guidelines for the Prevention of Intravascular Catheter-Related Infections, 2011. Centers for Disease Control and Prevention. Available at: <https://www.cdc.gov/hai/pdfs/bsi-guidelines-2011.pdf>. Accessed September 9, 2019.
- Shah SH, West AN, Sepanski RJ, Hannah D, May WN, Anand KJS. Clinical risk factors for central line-associated venous thrombosis in children. *Front Pediatr.* 2015;3:35.
- Male C, Chait P, Andrew M, et al. Central venous line-related thrombosis in children: Association with central venous line location and insertion technique. *Blood.* 2003;101:4273–4278.
- Styne DM, Arslanian SA, Connor EL, et al. Pediatric obesity—assessment, treatment, and prevention: An endocrine society clinical practice guideline. *J Clin Endocrinol Metab.* 2017;102:709–757.
- Chou J. PediTools. Available at: <https://peditools.org/>. Accessed May 24, 2018.
- Male C, Julian JA, Massicotte P, Gent M, Mitchell L, PROTEKT Study Group. Significant association with location of central venous line placement and risk of venous thrombosis in children. *Thromb Haemost.* 2005;94:516–521.
- Faustino EVS, Spinella PC, Li S, et al. Incidence and acute complications of asymptomatic central venous catheter-related deep venous thrombosis in critically ill children. *J Pediatr.* 2013;162:387–391.
- Joffe HV, Kucher N, Tapson VF, Goldhaber SZ. Upper-extremity deep vein thrombosis: A prospective registry of 592 patients. *Circulation.* 2004;110:1605–1611.
- López Álvarez JM, Pérez Quevedo O, et al. Vascular ultrasound in pediatrics: Estimation of depth and diameter of jugular and femoral vessels. *J Ultrasound.* 2017;20:285–292.
- Warkentine FH, Pierce MC, Lorenz D, Kim IK. The anatomic relationship of femoral vein to femoral artery in euvoletic pediatric patients by ultrasonography: Implications for pediatric femoral central venous access. *Acad Emerg Med.* 2008;15:426–430.
- Mahajerin A, Petty JK, Hanson SJ, et al. Prophylaxis against venous thromboembolism in pediatric trauma: A practice management guideline from the Eastern Association for the Surgery of Trauma and the Pediatric Trauma Society. *J Trauma Acute Care Surg.* 2017;82:627–636.
- Wall C, Moore J, Thachil J. Catheter-related thrombosis: A practical approach. *J Intensive Care Soc.* 2016;17:160–167.