Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

# Incidence and risk factors for deep vein thrombosis among pediatric burn patients

*Nouf Alturki* *, *Mohamed Alkahtani*, *Mamoon Daghistani*, *Tawfeik Alyafi*, *Salahaldin Khairy*, *Mohamed Ashi*, *Ahmed Aljuffri*

*Department of Plastic and Reconstructive Surgery, National Guard Hospital, Jeddah, Saudi Arabia*

ARTICLE INFO

*Article history:*
Accepted 28 September 2018

*Keywords:*
Deep vein thrombosis
Pediatric burns

ABSTRACT

*Background:* Patients with major burns covering a large total body surface area (%TBSA) fulfill all the criteria of Virchow's triad, as a sequela of their injury. This places these patients at increased risk for developing deep vein thrombosis (DVT). However, data regarding the incidence of DVT in burn patients are minimal, especially in the pediatric age group. Therefore, the aim of this study is to determine the incidence of DVT in pediatric burn patients, identify possible risk factors for developing DVT, and explore the need for prophylactic treatment.

*Methods:* A retrospective chart review of 95 patients admitted to our Burn Unit was conducted. We included all pediatric patients with second- and third-degree burns admitted to the unit. Exclusion criteria were adult patients, those with first-degree burns and admitted to the unit for <72 h, patients discharged against medical advice, those admitted for elective reconstructive surgery, secondary admissions for non-healing/infected burns, and patients with trauma-induced skin loss. A data collection sheet was utilized.

*Results:* The total incidence of thrombosis in our population was 4.2% (DVT, 3.1%; arterial thrombosis, 1.1%). Factors significantly associated with DVT included length of hospitalization ($p=0.012$), central venous catheter placement ($p=0.013$), and %TBSA ($p=0.004$). Unlike adult patients, weight for age (percentile) and body mass index were not significant risk factors for DVT in our patients.

*Conclusion:* Burns are a major risk factor for DVT, especially when covering large surface areas (≥40% TBSA) and combined with other factors (i.e., prolonged hospitalization and central lines). Thus, investigations for DVT and prophylactic anticoagulation should be considered for pediatric burn patients with these risk factors, even if they are asymptomatic.



## 1. Introduction

Deep vein thrombosis (DVT) is a major cause of morbidity and mortality among hospitalized patients. It is predominantly a disease of older populations, with an annual incidence of 1–2 per 1000 individuals in the United States. Males have a higher incidence than females in populations above the age of 45, but women have a slightly higher rate during the reproductive years [1]. However, the frequency among younger populations has been increasing and was found to be 5.3/10,000 hospital

* *Corresponding author at*: Department of Surgery– MC6477, National Guard Hospital, King Abdulaziz Medical City, P.O. Box 9515, Jeddah 21423, Saudi Arabia.
E-mail address: nouf.a.alturki@gmail.com (N. Alturki).

https://doi.org/10.1016/j.burns.2018.09.032
0305-4179/

admissions in children aged 1 month–18 years in 1990–1992 [2]. DVTs have been extensively studied and their mechanism and contributing risk factors are thus well known.

DVTs result from the dynamic interplay among factors of Virchow's triad: hemostasis, endothelial injury, and hypercoagulability. As understanding of this triad has increased, many risk factors have been identified, including both genetic and acquired factors [3]. Genetic factors include deficiencies in antithrombin and proteins C and S [4]. Other risk factors include increased age, obesity, surgery, prolonged immobility, trauma with multiple fractures, previous DVT, oral contraceptive use, and cancer [3]. In the pediatric age group, central venous catheters (CVCs), cancer and chemotherapy, severe infections, and sickle cell disease have been shown to increase the risk of developing DVT [5]. Burns are another risk factor for DVT.

Burn patients, especially those with burns covering a high percentage of the total body surface area (%TBSA), fulfill all three criteria of Virchow's triad, as sequelae of their injury. They usually undergo multiple procedures, receive many blood transfusions, and have indwelling CVCs during their extended hospital stays, placing them at high risk for DVT [6]. Among critically ill patients, CVCs have been shown to be the most significant factor for DVT [7]. However, data concerning the incidence of DVT in burn patients are minimal, and even more so among the pediatric age group, with only a few studies investigating burns in children [8,9].

DVTs associated with CVCs can be either symptomatic or asymptomatic in both adult and pediatric age groups. However, clinical distinction relative to the risk of developing PE does not alter the management for adults, whereas the impact of symptoms remains unclear in children [7]. Diagnosis of DVT depends mostly on clinical suspicion, and subsequent management is determined thereafter.

Suspicion of DVT is usually based on signs and symptoms and confirmed by duplex ultrasonography. It is essential to stratify patients according to their risk of developing venous thromboembolism (VTE; DVT or pulmonary embolism [PE]) to raise clinical suspicion, especially since findings are not always present. Stratification aids in deciding whether to implement prophylactic measures, such as compression devices, early mobilization, and low molecular weight heparin (LMWH) [8]. Current guidelines for DVT management focus on adults, whereas children are treated on a case-by-case basis [10]. Early intervention is vital because of the significant morbidity and mortality associated with VTE.

DVTs can either resolve with adequate treatment or lead to bleeding, extension, recurrence, PE, or mortality [11]. Death is associated with major bleeding (30% at 3 years) or development of a PE (13% at 30 days, 26% at 1 year, and 35.3% at 3 years) [11]. Overall, DVT represents a major risk to patients; therefore, all efforts should be focused on early detection and management. Studying populations at risk for DVT is one approach. Although extensively researched, data regarding burn patients remains incomplete, especially in pediatric populations. Therefore, this study aims to determine the incidence of DVT in pediatric burn patients and to identify possible risk factors for developing DVTs in this population. Based on our findings, we will explore the need for prophylaxis.

## 2. Materials and methods

### 2.1. Study design and ethics considerations

This study is a retrospective chart review of all pediatric burn patients admitted to the National Guard Hospital-Jeddah Burn Unit between January 2011 and December 2016. This research was reviewed and accepted by the King Abdullah International-Medical Research Center.

Ethics approval was obtained from our Institutional Review Board. No data corresponding to patient identity were collected, and only the investigators had access to the raw data. Patient confidentiality was thus protected.

### 2.2. Selection of participants

Patients were selected from all Burn Unit admissions based on the criteria, as shown in Fig. 1. The inclusion criteria were pediatric patients admitted with a second- or third-degree burn. The exclusion criteria were adult patients, those with first-

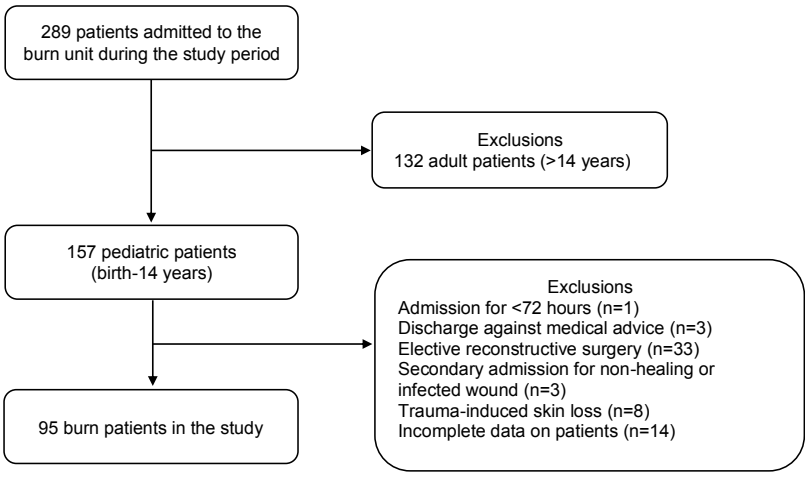


**Fig. 1 – Diagram of inclusion and exclusion of the study population.**

degree burns and admitted to the unit for <72h, patients discharged against medical advice, those admitted for elective reconstructive surgery, secondary admissions for non-healing/infected burns, and patients with trauma-induced skin loss.

A total of 289 burn patients were admitted during the study period. Among these, 157 were pediatric patients with second- or third-degree burns. We defined the pediatric age group as children from birth to 14 years of age, as per our hospital policy. Of these, 110 patients met the inclusion/exclusion criteria. We excluded another 15 patients with lost files, leaving 95 children in the final study population. Of note, the Burn Unit in our institution contains beds specifically designated for children with burns.

### 2.3. Data collection

A data collection sheet was used to gather information. Patient demographics, including age, sex, height, weight, body mass index (BMI), and prior medical history were collected. Data regarding the burn (type, site, %TBSA, and presence of inhalation injury) and type of interventions (DVT prophylaxis, blood transfusion, bed rest, and operations performed) were recorded. Patients received blood transfusions according to the permitted amount per kilogram. Regarding bed rest, all patients undergoing split-thickness skin grafting were immobilized at the graft site for a time period determined on an individual basis, with no standardized protocol. The number of operations was defined as the number of procedures requiring general anesthesia. Information regarding CVCs was collected, including the insertion site and duration of use. CVCs are not routinely inserted in burn patients at our institution; if deemed necessary based on the patient's clinical condition, a CVC is inserted by a pediatric intensivist or an anesthesiologist. Complications, including DVT, infection, and graft loss, were also documented. Patients were not routinely screened for DVT.

### 2.4. Data analysis

Data were analyzed using IBM-SPSS version 24. Qualitative data are expressed as frequency and percentage, whereas quantitative data are presented as median and interquartile range (IQR). *P*-values <0.05 were considered statistically significant. Chi-square and Fisher's exact tests were used to compare qualitative data. Quantitative data were compared using Mann-Whitney test for non-parametric data.

## 3. Results

### 3.1. Deep venous thrombosis incidence and characteristics

Study population characteristics, including demographics, burn description, and interventions, are summarized in Tables 1 and 2. Three patients were diagnosed with DVT, all of whom were female, with an overall incidence of 3.1%. Moreover, 1 patient was diagnosed with arterial thrombosis, with an incidence of 1.1%. Details regarding these 4 patients are shown in Table 3. The total thrombosis incidence was thus

**Table 1 – The frequency of qualitative variables in the study population.**

| Variable | Frequency (%) |
|---|---|
| Age category | |
| Infancy | 16 (17.6) |
| Toddler | 44 (48.4) |
| Pre-school | 6 (6.6) |
| School-age | 25 (27.5) |
| Sex | |
| Male | 54 (56.8) |
| Female | 41 (43.2) |
| Weight for age (percentile) | |
| <5 | 10 (10.8) |
| 5–10 | 2 (2.2) |
| 10–25 | 11 (11.8) |
| 25–50 | 16 (17.2) |
| 50–75 | 19 (20.4) |
| 75–90 | 14 (15.1) |
| 90–95 | 12 (12.9) |
| >95 | 9 (9.7) |
| Prior medical history | |
| None | 79 (84.9) |
| Asthma | 6 (6.5) |
| G6PD deficiency | 1 (1.1) |
| Hyperactive airway disease | 2 (2.2) |
| Cerebral palsy | 1 (1.1) |
| Febrile convulsion | 1 (1.1) |
| Neonatal seizure | 1 (1.1) |
| Osteomalacia | 1 (1.1) |
| Kawasaki disease | 1 (1.1) |
| DVT prophylaxis | |
| No | 91 (95.8) |
| Yes | 4 (4.2) |
| Type of burn | |
| Scald | 64 (68.8) |
| Flame | 20 (21.5) |
| Chemical | 3 (3.2) |
| Electrical | 3 (3.2) |
| Contact | 3 (3.2) |
| Site of burn | |
| Extremity | |
| No | 25 (26.3) |
| Yes | 70 (73.7) |
| Upper extremity | |
| No | 45 (47.4) |
| Bilateral | 23 (24.2) |
| Left | 14 (14.7) |
| Right | 13 (13.7) |
| Lower extremity | |
| No | 31 (33.3) |
| Bilateral | 35 (37.6) |
| Left | 13 (14) |
| Right | 14 (15.1) |
| Hand | |
| No | 55 (57.9) |
| Bilateral | 23 (24.2) |
| Left | 10 (10.5) |
| Right | 7 (7.4) |
| Inhalation injury | |
| No | 91 (95.8) |
| Yes | 4 (4.2) |
| CVC line[a] | |
| No | 72 (75.8) |
| Yes | 23 (24.2) |

CVC, central venous catheter; DVT, deep vein thrombosis; G6PD, glucose-6-phosphate dehydrogenase.
[a] Peripherally-inserted central catheters.

**Table 2 – Quantitative variables in the study population.**

| Variable | Median | Interquartile range |
|---|---|---|
| Age, months | 24 | 60 |
| Weight, kg | 13.95 | 10 |
| Height, cm | 90 | 41 |
| BMI | 16.43 | 4.26 |
| %TBSA | 10 | 14 |
| Hospitalization, days | 16.5 | 23 |
| Duration of mechanical ventilation, days | 0.5 | 9 |
| PICU, days | 9.5 | 27 |
| Operations | 0 | 1 |
| Blood transfusions | 0 | 1.5 |

BMI, body mass index; PICU, pediatric intensive care unit; TBSA, total body surface area.

4.2%. Mean time to DVT diagnosis was 37.3days from admission (range, 27–52 days).

### 3.2. *Deep vein thrombosis risk factors*

Age, weight, weight for age (percentile), and BMI were not statistically significant factors for developing DVT (Table 4). % TBSA was significantly associated with the development of DVT ($p=0.004$). Prior medical history was not related to the development of DVT. All patients with DVT underwent multiple surgical procedures, and the number of operations was significantly associated with the presence of a DVT ($p=0.001$). Presence of a CVC was also a significant risk factor for DVT ($p=0.013$). All patients with a DVT required blood transfusion; approximately half of the transfusions occurred before diagnosis of the first DVT. The number of blood transfusions was significantly associated with the development of DVT ($p=0.003$).

All three patients diagnosed with DVT were intubated and transferred to the pediatric intensive care unit (PICU) for variable periods during their hospitalizations (Table 5). Within the study population, the number of PICU admission days was significantly associated with the development of DVT ($p<0.001$). Hospital length of stay was significantly longer in patients with DVT than in those without DVT ($p=0.012$; Table 4).

No patient had a previous history of extremity DVT. None of the 3 patients who developed DVT received any form of DVT prophylaxis. Among the patients without DVT, only 4 received prophylactic LMWH, including 1 patient with a 32% electrical burn and unilateral femur fracture.

Several complications occurred in our patients (Table 6). Burn wound infection was not a significant risk factor for the development of DVT, in contrast to prior studies conducted in adult populations [12].

**Table 3 – Characteristics of pediatric burn patients with confirmed thrombotic events.**

| | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| Age, years | 6 | 4 | 2 | 7 |
| Sex | Female | Female | Female | Female |
| Type of burn | Flame | Flame | Flame | Chemical |
| %TBSA | 80 | 60 | 40 | 50 |
| Operations, n | 19 | 15 | 4 | 5 |
| Blood transfusions, n | 23 | 21 | 6 | 18 |
| Hospitalization, days | 318 | 160 | 36 | 96 |
| Number/type of thromboses | 3 DVTs | 2 DVTs | 1 DVT | 1 arterial thrombosis |
| Timing of DVT diagnosis (after burn injury), days | 1st: 33<br>2nd: 84<br>3rd: 90 | 1st: 52<br>2nd: 55 | 27 | 105 |
| Thrombotic site | 1st: right common iliac vein<br>2nd: left internal jugular vein<br>3rd: right internal jugular vein | 1st: right internal jugular vein<br>2nd: left internal jugular vein | Right internal jugular vein | Aortic arch |
| CVC at site of thrombosis | Yes | Yes | Yes | No |
| Presenting symptom | 1st: fever<br>2nd: blocked line<br>3rd: incidental finding on follow-up US | 1st: fever<br>2nd: incidental finding on follow-up US | Blocked CVC | Incidental finding on US investigating a blocked CVC (Port-A-Cath) |
| Diagnostic test | 1st: CT<br>2nd and 3rd: US | US for both | US | US |
| Management | 1st and 2nd: conservative<br>3rd: LMWH | 1st: conservative<br>2nd: LMWH | LMWH | LMWH |
| Adverse effects of anticoagulation | None | None | None | None |

CT, computed tomography; DVT, deep vein thrombosis; CVC, central venous catheter; LMWH, low-molecular-weight heparin; TBSA, total body surface area; US, ultrasonography.

**Table 4 – Risk factors for deep vein thrombosis (DVT) in pediatric burn patients.[a]**

| Variable | DVT (n=3) | No DVT (n=92) | P-value |
|---|---|---|---|
| %TBSA | 60 (N/A) | 9.75 (11) | 0.004 |
| Hospitalization, days | 160 (N/A) | 16 (17) | 0.012 |
| PICU admission, days | 9 (N/A) | 0 (0) | <0.001 |
| Blood transfusions | 11 (N/A) | 0 (1) | 0.003 |
| Operations | 15 (N/A) | 0 (1) | 0.001 |
| CVC placement | 3 (100) | 20 (21.7) | 0.013 |

CVC, central venous catheter; N/A, not applicable (too few); PICU, pediatric intensive care unit; TBSA, total body surface area.
[a] Data expressed as median (interquartile range) or frequency (%).

**Table 6 – Burn complications in the presence or absence of deep vein thrombosis (DVT).**

| Complication | DVT (n=3) | No DVT (n=92) | P-value |
|---|---|---|---|
| UTI | 2 | 11 | 0.048 |
| Wound infection | 2 | 16 | 0.091 |
| Pneumonia | 1 | 3 | 0.122 |
| Sepsis | 1 | 5 | 0.180 |
| Graft loss | 0 | 2 | 0.938 |
| Miscellaneous | 2 | 22 | 0.156 |

UTI, urinary tract infection.

## 4. Discussion

In burn patients, especially those with major burns (i.e., high % TBSA), all criteria of Virchow's triad are fulfilled. Such patients typically receive numerous blood transfusions, undergo many procedures, and have indwelling CVCs during their prolonged hospitalizations, factors that increase their risk of DVT [6]. Nevertheless, data on incidence and risk factors of DVT in pediatric burn patients are very limited [8,9].

Considering the potential threat to life, extensive efforts should be directed towards early detection and management of DVT. Although none of our pediatric burn patients was routinely screened for asymptomatic thrombi, we initiated testing for DVT under two clinical circumstances: (1) if clinical suspicion of extremity DVT was raised; and (2) to rule out suppurative thrombophlebitis during bacteremia, as stipulated by the Infectious Disease Society of America (IDSA) guidelines for management of intravascular catheter-related infection [13].

### 4.1. *Incidence of DVT*

In the population of children admitted to our Burn Unit, the incidence of DVT was 3.1% (3/98). By comparison, a past study from Canada reported an incidence of VTE as 5.3/10,000 pediatric hospital admissions and 0.07/10,000 children nationwide [14].

### 4.2. *Presenting signs and symptoms*

DVT can involve either the central or peripheral deep venous system. Peripheral DVT can present as limb edema, pain, or erythema, which can be masked by the presence of a burn in the same extremity. Central CVC-related DVTs can present with signs of inflammation, venous obstruction, or CVC dysfunction, or they can be asymptomatic and detected only by radiologic imaging [7]. The acute implications of a DVT in the upper venous system include loss of venous access, superior vena cava syndrome, and PE, and may even result in death [13].

DVT presenting as blockage of a CVC can lead to many missed diagnoses. One study calculated the incidence of CVC-related DVT at 1.7/10,000 pediatric admissions, which is likely an underestimate, as children with blocked CVCs and no other clinical symptoms are rarely evaluated by venography [13]. In 1 of our cases, CVC blockage led to the diagnosis of central DVT.

Persistent fever or bacteremia with a history of previous CVC should raise suspicion of central DVT, according to IDSA guidelines. In the absence of another source of intravascular infection, suppurative thrombophlebitis should be considered. This infection may involve central or peripheral vessels and lead to high-grade fever, as well as persistent bacteremia or fungemia; it may continue even after initiating antimicrobial therapy. The infection may also persist after CVC removal, if the infected thrombus remains in place. Suppurative thrombophlebitis requires at least 3–4 weeks of antibiotics, along with removal of the catheter. Although no consensus has been reached, anticoagulation with heparin should be considered after the diagnosis [15].

In our small group of patients, 2 presented with persistent fever despite treatment with antibiotics, which led to the

**Table 5 – Intubation/mechanical ventilation profiles in pediatric burn patients with DVT.**

| Case | Duration of intubation | Reason for intubation | Timing of DVT |
|---|---|---|---|
| 1 | Days 3–7, Day 20 (6 days) | First intubation at another facility prior to transfer (unknown reasons)<br>Intubated upon transfer to PICU for postoperative care | 1st: Day 33<br>2nd: Day 84<br>3rd: Day 90 |
| 2 | Unknown | Unknown (transferred from another facility)[a] | 1st: Day 52<br>2nd: Day 55 |
| 3 | Day 19 (half day) | Patient transferred to PICU, intubated postoperatively | Day 27 |

[a] The patient was transferred to our facility from another hospital 36 days post-burn. The provided medical report stated that the patient required mechanical support. The patient was transferred in a stable condition without the need of any ventilatory support.

diagnosis of suppurative thrombophlebitis. The patients were started on antibiotic treatment, which was continued for an extended period. Anticoagulant therapy was considered for 1 patient immediately after the diagnosis of DVT, whereas in the other patient, it was started after the second recurrence.

One of our cases involved an arterial thrombosis diagnosed incidentally in a 7-year-old with a 50% TBSA chemical burn. This boy had a Port-A-Cath inserted as a long-term CVC. Ultrasonography was conducted to investigate blockage of the CVC, and anticoagulant treatment was initiated after identifying a clot involving the aortic arch.

### 4.3. *Location of thrombosis*

The most common thrombus location was at the site of a previous CVC. This included the internal jugular vein and common iliac vein. One patient developed a thrombus within the aortic arch.

### 4.4. *Risk factors*

CVC placement, cancer/chemotherapy, severe infection, and sickle cell disease have been previously implicated as risk factors for DVT in pediatric populations [5]. Analysis of the Canadian registry has indicated that CVCs are the single most important risk factor for DVT in children, contributing directly to one-third of all DVTs and to 78% of upper extremity DVTs [14].

CVCs are commonly required in major burn patients. Although burns are considered a risk factor for DVT, the role of CVCs in this patient population is not well established. In their study of 101 pediatric ICU patients, Braga and Young identified 6 patients with DVT; 2 of these had 70% and 65% scald burns [10]. Both burn patients developed DVT at CVC insertion sites. All 3 of our patients diagnosed with DVT developed thrombosis at CVC sites, but their presentations differed. Of the remaining 95 patients without a DVT, 20 underwent CVC insertion during their hospital stay. Presence of a CVC was significantly associated with the development of DVT, adding to the available evidence that CVCs increase the risk of DVT.

The effect of age on CVC-related DVTs is unclear. Some studies have noted an increased risk in younger children, especially those less than 1 year of age [12]. However, in a study of 101 pediatric ICU patients screened for asymptomatic DVT, Faustino et al. found that DVT was diagnosed in 15.8% of children (24.7 cases/1000 CVC days), and increased age was independently associated with DVT: compared with children aged <1 year, children aged >13 years had significantly higher odds of DVT [7]. In their study of pediatric trauma patients, Murphy et al. found that VTE occurred in 0.058% of patients with lower extremity trauma, and the incidence was higher in adolescents over 12 years of age [15]. In their study, VTE was most commonly associated with femur fractures. Our study failed to show a significant association between age and DVT in pediatric burn patients.

All patients who developed thromboses in our study were bedridden for more than 60% of their hospital stay. However, the exact number of days immobilized was not known because of inconsistent documentation. They all had a 40% or more TBSA burn, and their hospital stay was prolonged. All 3 patients with DVT had a flame burn. Because of the small population size, we could not determine whether this type of burn is a risk factor for DVT. Indeed, the majority of pediatric admissions for burns covering more than 40% TBSA were flame burns, suggesting that flame burns per se may not be an independent risk factor. Our study did not confirm the results of De Jonge et al., which showed that burn wound infections were a significant risk factor for DVT [12]. However, our study did show that the number of operations was a significant risk factor. Obesity and higher BMI are known risk factors for DVT in adults, but weight, weight for age (percentile), and BMI were not significant risk factors for developing DVT in our pediatric population.

### 4.5. *Treatment*

In our study, the first 2 patients diagnosed with DVT were treated conservatively without anticoagulation because of concerns of excessive bleeding from the large burn surface area. This decision was made by the plastic surgeon, pediatric hematologist, and pediatric intensivist. Unfortunately, both patients developed recurrent DVT: 1 had a single recurrence, and the other had 2 more DVTs. They were both eventually treated with LMWH, after which there were no further DVTs.

As no complications were observed from initiating anticoagulant treatment in our pediatric major burn patients, our multidisciplinary burn team began to advocate therapeutic anticoagulant once DVT was diagnosed. The next 2 patients (Cases 3 and 4) received LMWH immediately upon diagnosis of a DVT and aortic arch thrombosis, and neither developed a recurrence. None of the 4 patients had an underlying coagulopathy. No complications were observed with the anticoagulant treatment.

Previous studies have described treatment of children with DVT, although the clinical settings differed. Levy et al. conducted a study in which 14 pediatric neurosurgery patients were diagnosed with DVT during hospitalization [16]. They were given either warfarin or LMWH. One of their patients treated with LMWH also required a filter for DVT involving the inferior vena cava (IVC) and left iliac vein.

A pediatric hematologist supervised the anticoagulation management in our patients. LMWH was administered twice daily as a weight-based dosage and did not require frequent blood testing. It was held for 12 h pre- and post-operatively to reduce the risk of excessive intra-operative bleeding. Patients were followed with serial ultrasonography to monitor for proximal DVT extension. An IVC filter was not required for the patient with internal iliac vein thrombosis.

Prevention of DVT is a separate issue. Braga and Young surveyed 28 centers to inquire about methods of preventing VTE in children [10]. They found that 1 center developed their own strategy for prevention, whereas the majority had no specific guidelines for children and used adult guidelines (or a modified version) for prophylaxis.

In our burn unit, we have no general guidelines for preventing DVT, and prophylactic anticoagulants are not used routinely in our pediatric patients. Our study included 4 patients who received prophylactic anticoagulants. The first patient was an 11-year-old boy who sustained a 32% flame burn and left femur fracture. The second and third patients suffered 20% and 34% flame burns after a car explosion. They were aged 13 and 14 years and weighed 94 and 70 kg (with BMIs of 31 and 20),

respectively. The fourth patient was a 3-year-old boy with a 22% flame burn. None of these patients developed DVT.

### 4.6. *Study limitations*

Drawbacks to our study include the small sample size and lack of surveillance for asymptomatic DVT. Further research assessing a larger population and performing investigations to assess the presence of DVT will facilitate precise determination of which patients are at risk for developing this complication.

### 4.7. *Recommendations*

Although data on DVT incidence and risk factors are abundant in adult burn patients, this is not the case in children. There is a clear need for further studies to assess requisite screening and preventative measures in high risk groups.

## 5. Conclusions

Many epidemiological features of DVT in children differ substantially from those seen in adults, suggesting that optimal intervention strategies for children may also vary [6]. There are currently no defined guidelines for treating DVT in pediatric patients in general, let alone those with burns. There is a need for further studies to determine significant risk factors associated with the occurrence of DVT. This should allow the implementation of effective preventive measures and the development of appropriate treatment plans.

## Disclosure

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

REFERENCES

[1] Beckman MG, Hooper WC, Critchley SE, Ortel TL. Venous thromboembolism: a public health concern. Am J Prev Med 2010;38(4):S495–501.
[2] David M, Andrew M. Venous thromboembolic complications in children. J Pediatr 1993;123(3):337–46.
[3] Kesieme E, Kesieme C, Jebbin N, Irekpita E, Dongo A. Deep vein thrombosis: a clinical review. J Blood Med 2011;2:59.
[4] Rosendaal F, Reitsma P. Genetics of venous thrombosis. J Thromb Haemost 2009;7(Suppl. 1):301–4.
[5] Gerotziafas G. Risk factors for venous thromboembolism in children. Int Angiol 2004;23(3):195.
[6] Mullins F, Mian MAH, Jenkins D, Brandigi C, Shaver JR, Friedman B, et al. Thromboembolic complications in burn patients and associated risk factors. J Burn Care Res 2013;34 (3):355–60.
[7] Faustino EVS, Spinella PC, Li S, Pinto MG, Stoltz P, Tala J, et al. Incidence and acute complications of asymptomatic central venous catheter-related deep venous thrombosis in critically ill children. J Pediatr 2013;162(2):387–91.
[8] Faucher LD, Conlon KM. Practice guidelines for deep venous thrombosis prophylaxis in burns. J Burn Care Res 2007;28 (5):661–3.
[9] Wahl W, Brandt M, Ahrns K, Zajkowski P, Proctor M, Wakefield T, et al. Venous thrombosis incidence in burn patients: preliminary results of a prospective study. J Burn Care Rehabil 2002;23(2):97–102.
[10] Braga AJ, Young AE. Preventing venous thrombosis in critically ill children: what is the right approach? Pediatr Anesth 2011;21 (4):435–40.
[11] Spencer FA, Gore JM, Lessard D, Douketis JD, Emery C, Goldberg RJ. Patient outcomes after deep vein thrombosis and pulmonary embolism: the Worcester Venous Thromboembolism Study. Arch Intern Med 2008;168(4):425–30.
[12] de Jonge RC, Polderman KH, Gemke RJ. Central venous catheter use in the pediatric patient: mechanical and infectious complications. Pediatr Crit Care Med 2005;6(3):329–39.
[13] Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. Clin Infect Dis 2009;49(1):1–45.
[14] Andrew M, David M, Adams M, Ali K, Anderson R, Barnard D, et al. Venous thromboembolic complications (VTE) in children: first analyses of the Canadian Registry of VTE. Blood 1994;83(5):1251–7.
[15] Murphy RF, Naqvi M, Miller PE, Feldman L, Shore BJ. Pediatric orthopaedic lower extremity trauma and venous thromboembolism. J Child Orthop 2015;9(5):381–4.
[16] Levy ML, Granville RC, Hart D, Meltzer H. Deep venous thrombosis in children and adolescents. J Neurosurg 2004;101:32–7.