ISSN 2220-3141 (online)

World Journal of

Critical Care Medicine

World J Crit Care Med 2023 June 9; 12(3): 92-187

Published by Baishideng Publishing Group Inc

WJCCM World Journal of Critical Care Medicine

Contents

Quarterly Volume 12 Number 3 June 9, 2023

REVIEW

MINIREVIEWS

ORIGINAL ARTICLE

Case Control Study

Observational Study

World Journal of Critical Care Medicine

Quarterly Volume 12 Number 3 June 9, 2023

Contents

ABOUT COVER

AIMS AND SCOPE

The primary aim of the *World Journal of Critical Care Medicine* (*WJCCM*, *World J Crit Care Med*) is to provide scholars and readers from various fields of critical care medicine with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJCCM mainly publishes articles reporting research results and findings obtained in the field of critical care medicine and covering a wide range of topics including acute kidney failure, acute respiratory distress syndrome and mechanical ventilation, application of bronchofiberscopy in critically ill patients, cardiopulmonary cerebral resuscitation, coagulant dysfunction, continuous renal replacement therapy, fluid resuscitation and tissue perfusion, hemodynamic monitoring and circulatory support, ICU management and treatment control, sedation and analgesia, severe infection, *etc*.

INDEXING/ABSTRACTING

The *WJCCM* is now abstracted and indexed in PubMed, PubMed Central, Reference Citation Analysis, China National Knowledge Infrastructure, China Science and Technology Journal Database, and Superstar Journals Database.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: *Yi-Xuan Cai*; **Production Department Director:** *Xu Guo*; **Editorial Office Director:** *Li-Li Wang*.

NAME OF JOURNAL
World Journal of Critical Care Medicine

ISSN
ISSN 2220-3141 (online)

LAUNCH DATE
February 4, 2012

FREQUENCY
Quarterly

EDITORS-IN-CHIEF
Hua-Dong Wang

EDITORIAL BOARD MEMBERS
https://www.wjgnet.com/2220-3141/editorialboard.htm

PUBLICATION DATE
June 9, 2023

INSTRUCTIONS TO AUTHORS
https://www.wjgnet.com/bpg/gerinfo/204

GUIDELINES FOR ETHICS DOCUMENTS
https://www.wjgnet.com/bpg/GerInfo/287

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH
https://www.wjgnet.com/bpg/gerinfo/240

PUBLICATION ETHICS
https://www.wjgnet.com/bpg/GerInfo/288

PUBLICATION MISCONDUCT
https://www.wjgnet.com/bpg/gerinfo/208

ARTICLE PROCESSING CHARGE
https://www.wjgnet.com/bpg/gerinfo/242

STEPS FOR SUBMITTING MANUSCRIPTS
https://www.wjgnet.com/bpg/GerInfo/239

ONLINE SUBMISSION
https://www.f6publishing.com

E-mail: bpgoffice@wjgnet.com https://www.wjgnet.com

World Journal of Critical Care Medicine

Submit a Manuscript: https://www.f6publishing.com

World J Crit Care Med 2023 June 9; 12(3): 130-138

DOI: 10.5492/wjccm.v12.i3.130

ISSN 2220-3141 (online)

MINIREVIEWS

Upper extremity deep vein thrombosis: An intensivist's perspective

Omender Singh, Deven Juneja

Specialty type: Critical care medicine

Provenance and peer review: Invited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): 0
Grade C (Good): C, C
Grade D (Fair): 0
Grade E (Poor): 0

P-Reviewer: Bloomfield DA, United States; Navarrete Arellano M, Mexico

Received: December 29, 2022
Peer-review started: December 29, 2022
First decision: March 15, 2023
Revised: March 16, 2023
Accepted: April 20, 2023
Article in press: April 20, 2023
Published online: June 9, 2023

Omender Singh, Deven Juneja, Institute of Critical Care Medicine, Max Super Speciality Hospital, Saket, New Delhi 110017, India

Corresponding author: Deven Juneja, DNB, Director, Institute of Critical Care Medicine, Max Super Speciality Hospital, Saket, 1, Press Enclave Road, New Delhi 110017, India. devenjuneja@gmail.com

Abstract

Upper extremity deep vein thrombosis (UEDVT) is less common than lower extremity DVT but is a cause of significant morbidity and mortality in intensive care unit patients. Increasing cancer incidence, prolonged life expectancy and increasing use of intravascular catheters and devices has led to an increased incidence of UEDVT. It is also associated with high rates of complications like pulmonary embolism, post-thrombotic syndrome and recurrent thrombosis. Clinical prediction scores and D-dimer may not be as useful in identifying UEDVT; hence, a high suspicion index is required for diagnosis. Doppler ultrasound is commonly employed for diagnosis, but other tests like computed tomography and magnetic resonance imaging venography may also be required in some patients. Contrast venography is rarely used in patients with clinical and ultrasound findings discrepancies. Anticoagulant therapy alone is sufficient in most patients, and thrombolysis and surgical decompression is seldom indicated. The outcome depends on the cause and underlying comorbidities.

Key Words: Catheter associated deep vein thrombosis; Pacemaker associated deep vein thrombosis; Paget-von Schröetter syndrome; Thoracic outlet syndrome; Upper extremity deep vein thrombosis

Core Tip: Upper extremity deep vein thrombosis (UEDVT), is largely under-recognised and an often missed diagnosis. Even though it is less common than the lower extremity DVT, it is increasingly being diagnosed, especially in intensive care unit patients because of presence of venous catheters and devices in these patients. Traditionally used clinical probability scores and tests like D-dimer may not be as effective in diagnosing UEDVT. Bedside Doppler ultrasound is the most commonly employed diagnostic tool which may aid in clinching the diagnosis. Contrast venography remains the gold standard, but is rarely required. Pulmonary embolism is the most dreaded complication but the rates of other complications including post thrombotic syndrome and recurrent DVT also remain significant. Anticoagulant therapy alone is sufficient in most patients. However, UEDVT may be associated with high mortality rates unless early diagnostic and therapeutic measures are initiated.

Citation: Singh O, Juneja D. Upper extremity deep vein thrombosis: An intensivist's perspective. *World J Crit Care Med* 2023; 12(3): 130-138
URL: https://www.wjgnet.com/2220-3141/full/v12/i3/130.htm
DOI: https://dx.doi.org/10.5492/wjccm.v12.i3.130

INTRODUCTION

Lower extremity deep vein thrombosis (LEDVT) is a well-recognized and dreaded complication among critically ill patients. All efforts regarding its early recognition and prompt treatment are incorporated into the teachings of critical care physicians and nurses. However, upper extremity DVT (UEDVT) is largely under-recognized and an often missed diagnosis. Even though it is less common than the LEDVT, it is increasingly being diagnosed, especially in intensive care unit (ICU) patients, because of certain inherent risk factors present in these patients. It may lead to several complications causing significant morbidity and mortality. Simple tests like bedside doppler ultrasound may enable us to make an early diagnosis and initiate prompt therapeutic measures with anticoagulants to improve clinical outcomes. Hence, critical care physicians must be aware of this dreadful condition and keep a high index of suspicion to diagnose it.

EPIDEMIOLOGY

UEDVT refers to the formation of fibrin clots within the deep veins of the upper extremities. Superficial veins, like the basilic and cephalic, which have anastomoses with the deep veins, can also be affected with superficial thrombophlebitis, which may progress to cause DVT. As the UEDVT involving the distal veins (radial, ulna and interosseous veins) is generally asymptomatic and does not require any clinical intervention, clinically relevant UEDVT generally denotes thrombosis of subclavian, axillary, and brachial veins. Subclavian veins (SCVs) are most commonly implicated in 76% of cases, followed by axillary (47%) and brachial veins (36%). Multiple veins are usually involved; a single vein is involved in only 38% of cases. Other deep veins, like the internal jugular and brachiocephalic, may also be involved in up to 50% of cases[1,2].

LEDVT is a much more commonly recognized and reported complication, with UEDVT constituting only 10% of all cases of DVT[3,4]. However, the risk and incidence of UEDVT would depend on the population studied, with certain patient populations having a much higher incidence. Nonetheless, the incidence of UEDVT is increasing, especially in ICU patients with several risk factors for developing UEDVT[5,6]. In an observational study conducted in a surgical ICU, out of 862 patients, 15% developed UEDVT despite standardized heparin thromboprophylaxis[7]. Some reports even suggest that the UEDVT may be as common in hospitalized medical patients as the LEDVT[8].

RISK FACTORS

UEDVT may be classified as primary or spontaneous, without any apparent risk factors and secondary, due to identifiable risk factors.

Primary UEDVT

Primary UEDVT may be further categorized due to "effort thrombosis", Paget-Schroetter syndrome (PSS), and idiopathic thrombosis. Primary causes account for up to 33% of cases of UEDVT, among which PSS is reported to be more common[9-11]. PSS generally affects young, otherwise healthy, adult males. The underlying anatomical abnormalities at the thoracic outlet, like the cervical rib, congenital

bands, scalenus tendons hypertrophy, and abnormal insertion of the costoclavicular ligament, cause compression of the SCV and stasis to the flow of blood. The repetitive movements of the dominant arm, as in athletes, cause repetitive trauma to the endothelium of the SCV, leading to intimal hyperplasia, inflammation, and fibrosis, which may worsen venous stasis and lead to the formation and progression of thrombus. People involved in occupations requiring excessive upper extremity motion, such as painting, hairdressing or sports like golf, tennis, weightlifting, baseball or gymnastics, are more commonly affected. The onset of symptoms is generally acute or subacute, precipitated by repeated arm movement, but rarely patients may present with chronic symptoms[12,13]. A subset of patients in whom no cause can be identified are labelled as having idiopathic thrombosis. Underlying occult malignancies have been reported in up to 25% of such patients[14]. These patients are older and have a higher prevalence of underlying coagulation abnormalities[10,15]. Their prognosis is also worse than those with PSS[5].

Secondary UEDVT

Secondary UEDVT is much more common and is responsible for up to 80% of cases[10]. The risk factors for UEDVT differ from the traditionally recognised factors for LEDVT (Table 1). These risk factors are particularly important in critically ill patients admitted to ICUs. Central venous catheters (CVCs) have been recognized as the single most important factor associated with the development of UEDVT and are responsible for up to 50% of cases[5,6]. The use of CVC has been shown to increase the risk of developing UEDVT by up to 14 times[16]. The use of peripherally inserted central catheters is associated with an even higher risk of developing UEDVT[8]. Even among those with CVCs, patients with technically difficult insertions, those with left-sided catheters, misplaced catheter tips, previous catheter placements, and large or multiple lumen catheters have a higher risk of developing UEDVT[17]. Underlying malignancies, especially ovarian cancers and lung adenocarcinomas, have been associated with a higher risk of UEDVT[3]. The risk of developing UEDVT may be compounded if multiple risk factors exist. The reported risk as high as 66%, has been reported in cancer patients having CVCs[18]. Patients who develop non-CVC-associated UEDVT are more likely to be younger, thinner (body mass index of < 25 kg/m^2) and smokers[16].

PATHOPHYSIOLOGY

The presence of the contributing factors from Virchow's Triad (venous stasis, vascular injury, and hypercoagulability) is implicated in thrombus formation in patients with UEDVT. In patients with PSS, thoracic outlet obstruction leads to venous stasis, and repeated movement of the arm causes trauma and endothelium injury leading to thrombosis. CVC or venous devices also cause venous stasis, platelet adherence, and endothelial trauma, increasing the risk of thrombus formation. Patients with malignancies have underlying hypercoagulable states, and excessive cancer cells may lead to vascular damage and venous stasis, making these patients prone to develop thrombosis.

CLINICAL FEATURES

Patients with UEDVT generally present with unilateral upper limb erythema, oedema, reduced mobility, pain, discomfort and low-grade fever. Urschel's sign, dilated and visible veins over the affected shoulders and upper arms, may be seen, especially in patients with long-standing thrombosis [13]. If CVC is present, it may be blocked. Cyanosis and pain while movement or exercise may be reported by patients with PSS. Clinical features related to complications may also be present. Patients with pulmonary embolism (PE) may develop breathlessness, chest pain and haemoptysis. In patients with central vein obstruction or occlusion, superior vena cava (SVC) syndrome features may be present. Brachial plexus compression may present with paraesthesia and arm pain, worsening with hyperabduction of the shoulder. However, in up to 19% of patients, UEDVT may be asymptomatic[5].

DIAGNOSIS

The clinical prediction scores used for LEDVT have been shown to have poor sensitivity and specificity, 78% and 64%, respectively, for diagnosing UEDVT. Hence, specific scores like the Constans clinical decision score have been developed for predicting UEDVT. It uses four variables to risk stratify patients with suspected UEDVT (Table 2)[19]. Only a few studies have evaluated its efficacy in diagnosing UEDVT and have reported sensitivity and specificity of up to 86% and 93%, with an area under the curve ranging from 0.70-0.81[20]. Hence, because of its comparatively low diagnostic accuracy and lack of clinical evidence, it is not recommended to use this clinical probability score as a standalone tool to diagnose UEDVT. However, it may aid physicians in recognizing high-risk patients and undertaking

Table 1 Risk factors for developing upper extremity deep vein thrombosis

Risk factors
Central venous catheters/dialysis catheters
Implantable cardiac rhythm devices
Personal or family history of thrombosis and thrombophilia
Surgery or trauma of the arm
Immobilization of the arm
Pregnancy
Use of oral contraceptive
Malignancy
Post-operative *e.g.*, esophagectomy, retrosternal reconstruction

Table 2 Constans clinical decision score

Patient characteristic	Score	
Venous material present (CVC/pacemaker)	Yes	1 point
	No	0 point
Localised pain	Yes	1 point
	No	0 point
Unilateral oedema	Yes	1 point
	No	0 point
Other diagnosis at least as plausible	Yes	-1 point
	No	0 point
Risk for UEDVT		
Low: 12% probability of UEDVT	-1 to 0 points[1]	
Intermediate: 20% probability of UEDVT	1 point[1]	
High: 70% probability of UEDVT	2-3 points[1]	

[1]Total score.
CVC: Central venous catheter; UEDVT: Upper extremity deep vein thrombosis.

further diagnostic testing. Variations of this score, like the extended Constans score, have also been tried, but they require further testing and validation[20].

Even D-dimer has not been extensively evaluated in diagnosing UEDVT and has shown low specificity of only 14%[21]. Hence, it should be used cautiously to rule out UEDVT. Combination of D-dimer and Constans score has been shown to increase their accuracy in predicting UEDVT[20]. Duplex ultrasonography (US) is commonly employed as the initial diagnostic procedure. It has several advantages: Easy availability, non-invasive nature, easy portability, inexpensive and no radiation exposure (Table 3)[22]. It has high sensitivity and specificity of 97% and 96%, respectively[23]. The presence of echogenicity's in the vascular lumen can suggest a thrombus. Further, a normal vein easily compresses on pressure, but when a thrombus is present, the vein becomes incompressible. However, as the pressure cannot be applied to central veins like SVC, a compression test cannot be used for such veins. Blood flow dynamics can further be evaluated using pulsed wave and colour flow Doppler, which may show an absence of flow or change of normal biphasic flow into a non-pulsatile flow pattern suggestive of obstruction[10,24]. As per a systematic review by Di Nisio *et al*[23], compression US (97% and 96%), Doppler US (84% and 94%) and Doppler US with compression (91% and 93%) all showed high sensitivity and specificity.

Contrast venography is considered the gold standard for diagnosing UEDVT with good sensitivity and specificity and can even visualize areas not accessible to ultrasound. However, because of inherent disadvantages, it is not routinely performed but may be done when there are contradictory clinical and US findings[24]. Contrast venography may also be required before performing catheter-directed

Table 3 Advantages and disadvantages of various diagnostic tests for upper extremity deep vein thrombosis

Diagnostic tests	Advantages	Disadvantages
D-dimer	High sensitivity. Readily available	Poor specificity. Not extensively evaluated for UEDVT
Ultrasound	Non-invasive. Readily available. Bedside. Less expensive. Good sensitivity and specificity	Not appropriate for evaluating central veins. Operator dependant
Doppler ultrasound	Non-invasive. Readily available. Bedside. Less expensive. Good sensitivity and specificity	Operator dependant
Computed tomography venography	Can help in diagnosing other underlying pathologies or rule out other diagnosis	Radiation exposure. Logistical issues. Moderate sensitivity and specificity
Magnetic resonance venography	Can help in diagnosing other underlying pathologies or rule out other diagnosis	Not widely available. Expensive. Logistical issues. Not suitable for patients with surgical implants and pacemakers. Moderate sensitivity and specificity
Contrast venography	Gold standard. High sensitivity and specificity. Can visualize the entire deep venous system. Can define complex and difficult anatomy	Invasive. Radiation exposure. Allergic reactions

UEDVT: Upper extremity deep vein thrombosis.

thrombolysis or surgery for thoracic outlet decompression as a part of a comprehensive workup[13].

Computed tomography (CT) and magnetic resonance imaging (MRI) venography can also be performed for diagnosing UEDVT. However, they have not been extensively evaluated, have moderate sensitivity and specificity, and are less accurate than contrast venography[25,26]. Routine screening for the underlying hypercoagulable state should also be conducted. Homocysteinemia should also be ruled out in such patients. Patients with primary UEDVT have a higher incidence of antiphospholipid antibodies, factor V Leiden, and prothrombin gene mutations[27].

TREATMENT

The treatment of UEDVT is primarily based on the data extrapolated from the studies on LEDVT. Hence, the management principles remain the same. However, in contrast with LEDVT, there is a lack of evidence regarding the effectiveness of compression devices in patients with UEDVT; hence, they are not recommended[28]. In most patients, only anticoagulant therapy is required, along with supportive management[29]. Use of low molecular weight heparin (LMWH), unfractionated heparin, or fondaparinux is generally recommended in the acute phase, followed by vitamin K antagonists (VKA) for 3 mo in patients with idiopathic thrombosis. Prolonged VKA therapy beyond three months is generally not advocated after the first episode of idiopathic UEDVT[28]. However, in patients with underlying malignancy, prolonged LMWH monotherapy extended for up to 6 mo or till cancer remains active, is recommended in non-CVC associated UEDVT[28]. In CVC-associated UEDVT, anticoagulant therapy is recommended for 3 mo if the CVC has been removed. However, if the CVC remains in situ, anticoagulation should be continued until the CVC is present[28]. The routine removal of the catheter is not advocated, even in patients with CVC-associated UEDVT, as long as the catheter is required and is functional[28].

The role of direct oral anticoagulants has not been extensively evaluated in the management of UEDVT. Even though early data from small studies suggest that they may be effective in preventing complications and the need for catheter removal, larger studies are required before they are routinely prescribed for managing UEDVT[30]. However, they may provide an excellent therapeutic alternative to LMWHs in cancer patients in whom VKA may not be as effective[29,31]. Patients on anticoagulants for UEDVT have significant bleeding risks; up to 5% have been reported to develop major bleeding[32]. The risk of bleeding may be higher in patients with underlying malignancies; hence, they must be monitored accordingly[32].

Additional therapeutic measures are rarely required to manage UEDVT[29]. Evidence regarding the efficacy of thrombolysis in UEDVT is lacking. Even though it may improve the patency of the vein, it is associated with a high risk of bleeding[28]. Hence, the American College of Chest Physician guidelines suggests using anticoagulation alone over thrombolysis[28]. Thrombolysis should be considered only in patients with severe symptoms, in patients with extensive involvement of SCV or axillary vein, acute symptoms of less than 14 d duration, good functional status and low risk for bleeding complications [28]. Anticoagulation should be initiated after thrombolysis and continued for at least three months to prevent a recurrence. SVC filters may be considered in patients with PE, and in those with contraindications to anticoagulants[28].

Physical therapy and lifestyle modification may be helpful in patients with UEDVT secondary to PSS. However, if symptoms persist and there is persistent SCV stenosis, as evidenced by positional venography, surgical decompression may be indicated to open the thoracic outlet[13]. Some authors have reported better symptom relief with thrombolysis followed by early surgical decompression by removing the first rib and the costoclavicular ligament, restoring normal blood flow in the SCV[33].

COMPLICATIONS

Common complications associated with UEDVT include recurrent DVT, post-thrombotic syndrome (PTS), PE, SVC syndrome and compression of the brachial plexus[13]. Even though the incidence of PE is lesser than that in LEDVT, it is the most dreaded complication associated with UEDVT[34]. The reported incidence ranges from 2.6% to 17%, with higher incidence reported in secondary UEDVT, especially in CVC-associated cases[7,35]. PE following non-CVC-associated UEDVT is rare, with a reported incidence of less than 1%[36]. Studies evaluating long-term outcomes of patients with UEDVT have reported an incidence of PE of up to 36% over a 2 years follow-up[37]. A review of data from the RIETE registry reported that the incidence of recurrent PE was similar in patients with UEDVT and LEDVT[38].

Recurrent DVT is another significant complication after UEDVT, with some data suggesting that incidence is even higher than that after LEDVT[38]. The data from a recent systematic review suggests that the rate of recurrent UEDVT in patients with idiopathic thrombosis ranges from 0%-23%[39]. Another meta-analysis has reported a pooled incidence of 7.5% for the development of recurrent thrombosis after UEDVT[40]. The reported rate of recurrent UEDVT is significantly higher in secondary DVT, more so in patients with CVC-related UEDVT[40]. Cancer patients have also been reported to have a 2-3 times higher risk of recurrent thrombosis[41].

Persistent obstruction and valvular insufficiency in patients with UEDVT may lead to PTS in around 4% to 32% of cases[28,29]. The incidence of PTS is significantly lower than that in patients with LEDVT, in whom it may develop in up to 50% of cases[34]. PTS has been reported to be more common in primary UEDVT than secondary[40]. It is characterized by persistent pain, oedema, and functional limitation of the affected arm. However, compression therapy, as used in managing LEDVT, is not recommended for PTS of the arm because of lack of evidence of efficacy given the different underlying pathophysiology. Hence, management is mainly supportive[28].

PROGNOSIS

The reported long-term mortality, two and 12 mo, after diagnosis of UEDVT is 30 and 40%, respectively [42,43]. However, these studies included patients with significant comorbidities, and mortality attributable to UEDVT could not be determined. The prognosis depends on the cause of UEDVT and underlying comorbidities. A systematic review of 45 studies with 4580 patients compared clinical courses and outcomes of UEDVT in patients with and without cancer. Overall, the one-year mortality rate in prospective trials was 24%, whereas, in retrospective studies, it was 35%. However, patients with cancer had an 8-fold higher risk of death than non-cancer patients. Patients with PSS are generally younger and have good functional status without many comorbidities. Hence, they have good overall outcomes and longer life expectancies.

CONCLUSION

UEDVT is an under-recognized and under-diagnosed complication in critically ill patients. Its incidence may be attributable to the increasing incidence of cancer, improving life expectancy, and increasing use of intravenous devices and catheters in hospitalized patients. Any unilateral oedema or erythema in an ICU patient with underlying risk factors should raise a concern, and further workup should be initiated. Bedside ultrasound with Doppler may help make a rapid diagnosis and contrast venography or CT/MRI venography is rarely indicated. Most patients can be managed with anticoagulant therapy, which is safe and effective. However, many patients may develop complications like bleeding, PTS and PE, so they should be monitored closely. The long-term outcome of these patients may depend on the cause of UEDVT and the underlying comorbidities. Early recognition and prompt therapy may help achieve favorable outcomes and prevent complications.

FOOTNOTES

Author contributions: Singh O and Juneja D performed all the writing, researched the project, prepared the tables, performed data accusation, and reviewed the manuscript.

Conflict-of-interest statement: All the authors report no relevant conflicts of interest for this article.

Country/Territory of origin: India

ORCID number: Omender Singh 0000-0002-3847-4645; Deven Juneja 0000-0002-8841-5678.

S-Editor: Wang JJ
L-Editor: A
P-Editor: Xu ZH

REFERENCES

1 **Lee JA**, Zierler BK, Zierler RE. The risk factors and clinical outcomes of upper extremity deep vein thrombosis. *Vasc Endovascular Surg* 2012; **46**: 139-144 [PMID: 22328450 DOI: 10.1177/1538574411432145]
2 **Khan O**, Marmaro A, Cohen DA. A review of upper extremity deep vein thrombosis. *Postgrad Med* 2021; **133**: 3-10 [PMID: 33618595 DOI: 10.1080/00325481.2021.1892390]
3 **Engelberger RP**, Kucher N. Management of deep vein thrombosis of the upper extremity. *Circulation* 2012; **126**: 768-773 [PMID: 22869858 DOI: 10.1161/CIRCULATIONAHA.111.051276]
4 **Isma N**, Svensson PJ, Gottsäter A, Lindblad B. Upper extremity deep venous thrombosis in the population-based Malmö thrombophilia study (MATS). Epidemiology, risk factors, recurrence risk, and mortality. *Thromb Res* 2010; **125**: e335-e338 [PMID: 20406709 DOI: 10.1016/j.thromres.2010.03.005]
5 **Grant JD**, Stevens SM, Woller SC, Lee EW, Kee ST, Liu DM, Lohan DG, Elliott CG. Diagnosis and management of upper extremity deep-vein thrombosis in adults. *Thromb Haemost* 2012; **108**: 1097-1108 [PMID: 23093319 DOI: 10.1160/TH12-05-0352]
6 **Blom JW**, Doggen CJ, Osanto S, Rosendaal FR. Old and new risk factors for upper extremity deep venous thrombosis. *J Thromb Haemost* 2005; **3**: 2471-2478 [PMID: 16241945 DOI: 10.1111/j.1538-7836.2005.01625.x]
7 **Malinoski DJ**, Ewing T, Patel MS, Nguyen D, Le T, Cui E, Kong A, Dolich M, Barrios C, Cinat M, Lekawa M, Salim A. The natural history of upper extremity deep venous thromboses in critically ill surgical and trauma patients: what is the role of anticoagulation? *J Trauma* 2011; **71**: 316-21; discussion 321 [PMID: 21825933 DOI: 10.1097/TA.0b013e318222f3f4]
8 **Winters JP**, Callas PW, Cushman M, Repp AB, Zakai NA. Central venous catheters and upper extremity deep vein thrombosis in medical inpatients: the Medical Inpatients and Thrombosis (MITH) Study. *J Thromb Haemost* 2015; **13**: 2155-2160 [PMID: 26340226 DOI: 10.1111/jth.13131]
9 **Bernardi E**, Pesavento R, Prandoni P. Upper extremity deep venous thrombosis. *Semin Thromb Hemost* 2006; **32**: 729-736 [PMID: 17024601 DOI: 10.1055/s-2006-951458]
10 **Czihal M**, Hoffmann U. Upper extremity deep venous thrombosis. *Vasc Med* 2011; **16**: 191-202 [PMID: 21343260 DOI: 10.1177/1358863X10395657]
11 **Joffe HV**, Goldhaber SZ. Upper-extremity deep vein thrombosis. *Circulation* 2002; **106**: 1874-1880 [PMID: 12356644 DOI: 10.1161/01.cir.0000031705.57473.1c]
12 **Zell L**, Kindermann W, Marschall F, Scheffler P, Gross J, Buchter A. Paget-Schroetter syndrome in sports activities--case study and literature review. *Angiology* 2001; **52**: 337-342 [PMID: 11386385 DOI: 10.1177/000331970105200507]
13 **Urschel HC Jr**, Patel AN. Surgery remains the most effective treatment for Paget-Schroetter syndrome: 50 years' experience. *Ann Thorac Surg* 2008; **86**: 254-60; discussion 260 [PMID: 18573433 DOI: 10.1016/j.athoracsur.2008.03.021]
14 **Girolami A**, Prandoni P, Zanon E, Bagatella P, Girolami B. Venous thromboses of upper limbs are more frequently associated with occult cancer as compared with those of lower limbs. *Blood Coagul Fibrinolysis* 1999; **10**: 455-457 [PMID: 10636455 DOI: 10.1097/00001721-199912000-00001]
15 **Héron E**, Lozinguez O, Alhenc-Gelas M, Emmerich J, Fiessinger JN. Hypercoagulable states in primary upper-extremity deep vein thrombosis. *Arch Intern Med* 2000; **160**: 382-386 [PMID: 10668841 DOI: 10.1001/archinte.160.3.382]
16 **Joffe HV**, Kucher N, Tapson VF, Goldhaber SZ; Deep Vein Thrombosis (DVT) FREE Steering Committee. Upper-extremity deep vein thrombosis: a prospective registry of 592 patients. *Circulation* 2004; **110**: 1605-1611 [PMID: 15353493 DOI: 10.1161/01.CIR.0000142289.94369.D7]
17 **Saber W**, Moua T, Williams EC, Verso M, Agnelli G, Couban S, Young A, De Cicco M, Biffi R, van Rooden CJ, Huisman MV, Fagnani D, Cimminiello C, Moia M, Magagnoli M, Povoski SP, Malak SF, Lee AY. Risk factors for catheter-related thrombosis (CRT) in cancer patients: a patient-level data (IPD) meta-analysis of clinical trials and prospective studies. *J Thromb Haemost* 2011; **9**: 312-319 [PMID: 21040443 DOI: 10.1111/j.1538-7836.2010.04126.x]

18 **Verso M**, Agnelli G, Kamphuisen PW, Ageno W, Bazzan M, Lazzaro A, Paoletti F, Paciaroni M, Mosca S, Bertoglio S. Risk factors for upper limb deep vein thrombosis associated with the use of central vein catheter in cancer patients. *Intern Emerg Med* 2008; **3**: 117-122 [PMID: 18317868 DOI: 10.1007/s11739-008-0125-3]

19 **Constans J**, Salmi LR, Sevestre-Pietri MA, Perusat S, Nguon M, Degeilh M, Labarere J, Gattolliat O, Boulon C, Laroche JP, Le Roux P, Pichot O, Quéré I, Conri C, Bosson JL. A clinical prediction score for upper extremity deep venous thrombosis. *Thromb Haemost* 2008; **99**: 202-207 [PMID: 18217155 DOI: 10.1160/TH07-08-0485]

20 **van Es N**, Bleker SM, Di Nisio M, Kleinjan A, Beyer-Westendorf J, Camporese G, Aggarwal A, Verhamme P, Righini M, Büller HR, Bossuyt PM. Improving the diagnostic management of upper extremity deep vein thrombosis. *J Thromb Haemost* 2017; **15**: 66-73 [PMID: 27732764 DOI: 10.1111/jth.13536]

21 **Merminod T**, Pellicciotta S, Bounameaux H. Limited usefulness of D-dimer in suspected deep vein thrombosis of the upper extremities. *Blood Coagul Fibrinolysis* 2006; **17**: 225-226 [PMID: 16575263 DOI: 10.1097/01.mbc.0000220248.04789.79]

22 **Kucher N**. Clinical practice. Deep-vein thrombosis of the upper extremities. *N Engl J Med* 2011; **364**: 861-869 [PMID: 21366477 DOI: 10.1056/NEJMcp1008740]

23 **Di Nisio M**, Van Sluis GL, Bossuyt PM, Büller HR, Porreca E, Rutjes AW. Accuracy of diagnostic tests for clinically suspected upper extremity deep vein thrombosis: a systematic review. *J Thromb Haemost* 2010; **8**: 684-692 [PMID: 20141579 DOI: 10.1111/j.1538-7836.2010.03771.x]

24 **Noyes AM**, Dickey J. The Arm is Not the Leg: Pathophysiology, Diagnosis, and Management of Upper Extremity Deep Vein Thrombosis. *R I Med J (2013)* 2017; **100**: 33-36 [PMID: 28459919]

25 **Baarslag HJ**, Van Beek EJ, Reekers JA. Magnetic resonance venography in consecutive patients with suspected deep vein thrombosis of the upper extremity: initial experience. *Acta Radiol* 2004; **45**: 38-43 [PMID: 15164777 DOI: 10.1080/02841850410003428]

26 **Bosch FTM**, Nisio MD, Büller HR, van Es N. Diagnostic and Therapeutic Management of Upper Extremity Deep Vein Thrombosis. *J Clin Med* 2020; **9** [PMID: 32630244 DOI: 10.3390/jcm9072069]

27 **Hendler MF**, Meschengieser SS, Blanco AN, Alberto MF, Salviú MJ, Gennari L, Lazzari MA. Primary upper-extremity deep vein thrombosis: high prevalence of thrombophilic defects. *Am J Hematol* 2004; **76**: 330-337 [PMID: 15282664 DOI: 10.1002/ajh.20131]

28 **Kearon C**, Akl EA, Comerota AJ, Prandoni P, Bounameaux H, Goldhaber SZ, Nelson ME, Wells PS, Gould MK, Dentali F, Crowther M, Kahn SR. Antithrombotic therapy for VTE disease: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest* 2012; **141**: e419S-e496S [PMID: 22315268 DOI: 10.1378/chest.11-2301]

29 **Key NS**, Khorana AA, Kuderer NM, Bohlke K, Lee AYY, Arcelus JI, Wong SL, Balaban EP, Flowers CR, Francis CW, Gates LE, Kakkar AK, Levine MN, Liebman HA, Tempero MA, Lyman GH, Falanga A. Venous Thromboembolism Prophylaxis and Treatment in Patients With Cancer: ASCO Clinical Practice Guideline Update. *J Clin Oncol* 2020; **38**: 496-520 [PMID: 31381464 DOI: 10.1200/JCO.19.01461]

30 **Davies GA**, Lazo-Langner A, Gandara E, Rodger M, Tagalakis V, Louzada M, Corpuz R, Kovacs MJ. A prospective study of Rivaroxaban for central venous catheter associated upper extremity deep vein thrombosis in cancer patients (Catheter 2). *Thromb Res* 2018; **162**: 88-92 [PMID: 28416213 DOI: 10.1016/j.thromres.2017.04.003]

31 National Comprehensive Cancer Network (NCCN) Guidelines 2020. Cancer-Associated Venous Thromboembolic Disease. [cited 15 December 2022]. Available from: https://www.nccn.org/professionals/physician_gls/pdf/vte.pdf

32 **Bleker SM**, van Es N, Kleinjan A, Büller HR, Kamphuisen PW, Aggarwal A, Beyer-Westendorf J, Camporese G, Cosmi B, Gary T, Ghirarduzzi A, Kaasjager K, Lerede T, Marschang P, Meijer K, Otten HM, Porreca E, Righini M, Verhamme P, van Wissen S, Di Nisio M. Current management strategies and long-term clinical outcomes of upper extremity venous thrombosis. *J Thromb Haemost* 2016; **14**: 973-981 [PMID: 26866515 DOI: 10.1111/jth.13291]

33 **de Kleijn RJCMF**, Schropp L, Westerink J, de Borst GJ, Petri BJ. Timing of Thoracic Outlet Decompression after Thrombolysis for Primary Upper Extremity Deep Venous Thrombosis: A Systematic Review. *Ann Vasc Surg* 2020; **66**: 654-661 [PMID: 32035261 DOI: 10.1016/j.avsg.2020.01.083]

34 **Duijzer D**, de Winter MA, Nijkeuter M, Tuinenburg AE, Westerink J. Upper Extremity Deep Vein Thrombosis and Asymptomatic Vein Occlusion in Patients With Transvenous Leads: A Systematic Review and Meta-Analysis. *Front Cardiovasc Med* 2021; **8**: 698336 [PMID: 34490367 DOI: 10.3389/fcvm.2021.698336]

35 **Kooij JD**, van der Zant FM, van Beek EJ, Reekers JA. Pulmonary embolism in deep venous thrombosis of the upper extremity: more often in catheter-related thrombosis. *Neth J Med* 1997; **50**: 238-242 [PMID: 9232088 DOI: 10.1016/s0300-2977(97)00020-x]

36 **Newton DH**, Monreal Bosch M, Amendola M, Wolfe L, Perez Ductor C, Lecumberri R, Levy MM; RIETE Investigators. Analysis of noncatheter-associated upper extremity deep venous thrombosis from the RIETE registry. *J Vasc Surg Venous Lymphat Disord* 2017; **5**: 18-24.e1 [PMID: 27987605 DOI: 10.1016/j.jvsv.2016.08.002]

37 **Prandoni P**, Polistena P, Bernardi E, Cogo A, Casara D, Verlato F, Angelini F, Simioni P, Signorini GP, Benedetti L, Girolami A. Upper-extremity deep vein thrombosis. Risk factors, diagnosis, and complications. *Arch Intern Med* 1997; **157**: 57-62 [PMID: 8996041]

38 **Cote LP**, Greenberg S, Caprini JA, Tafur A, Choi C, Muñoz FJ, Skride A, Valero B, Porras JA, Ciammaichella M, Hernández-Blasco LM, Monreal M; RIETE Investigators. Comparisons Between Upper and Lower Extremity Deep Vein Thrombosis: A Review of the RIETE Registry. *Clin Appl Thromb Hemost* 2017; **23**: 748-754 [PMID: 27572888 DOI: 10.1177/1076029616663847]

39 **Yuen HLA**, Tan E, Tran H, Chunilal SD. Idiopathic upper extremity deep vein thrombosis: A systematic review. *Eur J Haematol* 2022; **109**: 542-558 [PMID: 36053912 DOI: 10.1111/ejh.13842]

40 **Thiyagarajah K**, Ellingwood L, Endres K, Hegazi A, Radford J, Iansavitchene A, Lazo-Langner A. Post-thrombotic syndrome and recurrent thromboembolism in patients with upper extremity deep vein thrombosis: A systematic review and meta-analysis. *Thromb Res* 2019; **174**: 34-39 [PMID: 30553163 DOI: 10.1016/j.thromres.2018.12.012]

41 **Bleker SM**, van Es N, van Gils L, Daams JG, Kleinjan A, Büller HR, Di Nisio M. Clinical course of upper extremity deep

vein thrombosis in patients with or without cancer: a systematic review. *Thromb Res* 2016; **140** Suppl 1: S81-S88 [PMID: 27067985 DOI: 10.1016/S0049-3848(16)30104-9]

42 **Martinelli I**, Battaglioli T, Bucciarelli P, Passamonti SM, Mannucci PM. Risk factors and recurrence rate of primary deep vein thrombosis of the upper extremities. *Circulation* 2004; **110**: 566-570 [PMID: 15262837 DOI: 10.1161/01.CIR.0000137123.55051.9B]

43 **Hingorani A**, Ascher E, Markevich N, Yorkovich W, Schutzer R, Mutyala M, Nahata S, Jacob T. Risk factors for mortality in patients with upper extremity and internal jugular deep venous thrombosis. *J Vasc Surg* 2005; **41**: 476-478 [PMID: 15838483 DOI: 10.1016/j.jvs.2004.12.038]

Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: bpgoffice@wjgnet.com
Help Desk: https://www.f6publishing.com/helpdesk
https://www.wjgnet.com