journal homepage: <https://www.pjcm.net/>

Pakistan Journal of Chest Medicine

Official journal of Pakistan Chest Society



Examining the Impact of Pulmonary Embolism on Trauma and Orthopedic Patients: Incidence, Management, and Clinical Outcomes

Bahadar Ali Khan¹, Asghar Khan^{2✉}, Muhammad Saqib³, Khadija Rehman⁴, Nasir Azim⁵, Sohail Akhtar⁶

¹Department of Orthopedic and Trauma, Saidu Medical College, Swat - Pakistan

²Department of Orthopaedic, Saidu Teaching

Hospital, Swat - Pakistan

³Department of Orthopedic, Gaju Khan Medical College, Bacha Khan Medical Complex, Swabi -

Pakistan

⁴Department of Surgery, Jinnah Postgraduate Medical Center, Karachi - Pakistan

⁵Department of Pulmonology,

Fatima Jinnah Institutes of Chest Diseases, Quetta - Pakistan

⁶Bacha Khan Medical Complex, Swabi - Pakistan

Corresponding Author:

Asghar Khan

Department of Orthopaedic,
Saidu Teaching Hospital,
Swat - Pakistan
Email: drakyzai@yahoo.com

Article History:

Received: Feb 11, 2022

Revised: Jun 05, 2022

Accepted: Aug 19, 2022

Available Online: Sep 02, 2022

Author Contributions:

AK conceived idea, BAK MS drafted the study, KR NA collected data, AK SK did statistical analysis & interpretation of data, BAK KR did critical reviewed manuscript. All approved final version to be published.

Declaration of conflicting interests:

The authors declare that there is no conflict of interest.

How to cite this article:

Khan BA, Khan A, Saqib M, Rehman K, Azim N, Akhtar S. Examining the Impact of Pulmonary Embolism on Trauma and Orthopedic Patients: Incidence, Management, and Clinical Outcomes. Pak J Chest Med. 2022;28(03):331-338

A B S T R A C T

Background: A frequent reason of mortality and severe disability is pulmonary embolism (PE). High death rates continue to be a prevalent issue even with advancements in diagnosis and treatment.

Objective: The objective of the study was to explore the Incidence and outcome of pulmonary embolism in trauma and orthopedic patients.

Methodology: This retrospective study was conducted at the Department of Pulmonology and Orthopedic Saidu Teaching Hospital, Swat from January 2017 to December 2019 after obtaining approval from the ethical committee of the institute. All the participants admitted for acute trauma or elective orthopaedic procedures during the study period were included. All the individuals with suspected PE were examined through (CT-PA) to confirm PE, within 6 months following the operation or the injury. The study conducted a retrospective examination of case notes and computerized databases to determine the risk factors for venous thromboembolism (VTE), therapy type, thromboprophylaxis, and death of each patient.

Results: Only 88 (0.48%) of the 18,153 patients hospitalized over the research period reported PE (positive CT-PA). Of these, 62 received acute trauma and 26 received elective surgery. Out of these approximately 75% of these individuals were given thromboprophylaxis. The three most often identified risk factors were being overweight, cardiovascular illness, and high blood pressure. After PE, the mortality rate was 0.07%. The death rate in the trauma group was 0.15 percent, whereas it was 0.02 percent for elective orthopaedic surgical procedures. The frequency of death was substantially correlated with the presence of at least two co-morbidities (unadjusted OR = 3.52, 95% confidence interval (CI) (1.34, 18.99), P = 0.034).

Conclusion: The frequency of VTE was in parallel to previously reported results but there was a lower death rate. The treatment protocols were most effective performed in this study.

Keywords: Trauma; Orthopedic Surgery; Pulmonary Embolism; Deep Venous Thrombosis

Introduction

The spectrum of venous thromboembolic (VTE) disorder includes pulmonary embolism (PE) as well as deep vein thrombosis (DVT). Although there are no clear scientific information on the total frequency of VTE in the general population reported. A recent study estimated that the incidence varies somewhere in the range of 1 and 5/1,000. Without thromboprophylaxis, the prevalence in the postoperative patients might exceed 50%.¹

Over 50% of hospitalized patients worldwide have an increased risk for VTE, while surgically treated individuals are at greater risk than non-surgical people.² The most frequent possible cause of in-hospital death is pneumonia (PE), which accounts for five to ten percent of hospital-associated casualties.³⁻⁶ Furthermore, a significant portion of patient death and treatment expenses are attributed to VTE and its related consequences.^{7,8} The predicted incidence of PE and DVT in the fields of orthopedic and trauma is 0.93 percent and 1.16%, correspondingly.⁹ There have been reports of death rates ranging from 13.8 percent to 0.38%.^{10,11}

Although data on the general frequency of PE in the trauma & orthopedic population is available, there is still widespread perception that this complication may go undiagnosed since its clinical manifestations are non-specific and often silent. Trauma and orthopedic patients represent a unique cohort predisposed to the development of PE due to several contributing factors. Orthopedic surgeries, particularly those involving the lower extremities, increase the risk of DVT, which can subsequently lead to PE if left untreated. Similarly, traumatic injuries, especially those causing prolonged immobility or major fractures, elevate the likelihood of venous thromboembolism (VTE) and PE. Moreover, the perioperative period poses additional challenges, such as alterations in coagulation parameters and decreased mobility, further augmenting the susceptibility to thrombotic events. Several studies have documented varying incidences of PE among trauma and orthopedic patients, with reported rates influenced by factors such as the type of injury, surgical procedure, patient demographics, and prophylactic measures implemented. Understanding the epidemiology of PE in this population is crucial for implementing targeted interventions and optimizing patient outcomes.¹² The management of PE in trauma and orthopedic patients encompasses a multidisciplinary approach involving clinicians from various specialties, including orthopedic surgeons, trauma physicians, pulmonologists, and hematologists. Prompt diagnosis is paramount, as delayed recognition of PE can lead to devastating consequences. Diagnostic modalities such as computed tomography pulmonary angiography

(CTPA) and ventilation-perfusion (V/Q) scanning play crucial roles in confirming the diagnosis and guiding subsequent management decisions.

Once diagnosed, the management of PE revolves around the dual goals of preventing further embolic events and minimizing the risk of complications. Anticoagulation therapy with agents such as low molecular weight heparin (LMWH) or direct oral anticoagulants (DOACs) forms the cornerstone of treatment, aiming to prevent clot propagation and facilitate clot resolution. In select cases of massive or high-risk PE, thrombolytic therapy or surgical embolectomy may be warranted to rapidly restore pulmonary blood flow and alleviate hemodynamic compromise.

In this context, this study aims to research into the complicated background of VTE disorders, exploring their epidemiology, clinical implications, diagnostic challenges, and contemporary management strategies.

Objective

The purpose of this research is to find out the frequency of PE in orthopedic and trauma patients.

Methodology

This retrospective study was conducted at the department of pulmonology and orthopedic Saidu Teaching Hospital Swat from January 2017 to December 2019 after taking approval from the ethical committee of the institute. All the participants admitted for acute trauma or elective orthopedic procedures during the study period were included. Patients hospitalized for other surgical reasons unrelated to our area of research or for medical reasons were not included. The individuals in the study group were those who, within six months received orthopedic or acute trauma procedure, showed clinical features suggestive of PE and who received further radiological examination to either confirm or rule out the clinical doubt. Multi detector CT scanners were used. The ventilation/perfusion (V/Q) test was done to confirm the pulmonary embolism diagnosis. Other techniques include gadolinium enhanced MRI and pulmonary angiography, however they are not often employed or performed because of their logistical obstacles and uncomfortable nature. CT-PA scans were considered positive if met the criteria such as, Inability of the contrast material to completely occupy the lumen due to a central filling deficiency (the artery could be larger than other arteries of a comparable size) and contrast material across the central filling defect and the arterial wall on an in-plane, longitudinal picture; a peripheral intraluminal filling error that forms an acute angle with the artery wall; and a partial filling defect encircled by contrast material

Table 1. Incidence, time of death and mortality among study cases

Procedure performed	N	Percentage	Death n (%)	Time to death after PE
Orthopedic Surgeries				
Total hip arthroplasty	7	7.9	0 (0)	
Total knee arthroplasty	11	12.5	0	
Spine	3	3.4	2 (2.2)	112 days
Knee arthroscopy	3	3.4	00	
Femoral osteotomy	1	1.1	00	
Metalwork removal	1	1.1	2 (2.2)	
Total	26	29.4		112
Trauma				
Femoral neck fixation	9	10.2	5	37 (60%) 22 days
Hemiarthroplasty	5	5.6	1	7
Other lower limb injury	36	40.9	4	21
Upper limb injury	9	10.2	2	135.5
Pelvis and acetabulum	2	2.27	0	
Vertebral fracture	1	1.1	0	
Total	62	70.2	12	Median 36
Entire study	88			Median 36

on a cross-sectional image.^{13,14} Patients who had a positive CT-PA were consistently performed a CT Venogram (CTV). PE is often categorized as either proximal or distal relying on the CT scan location of the emboli. Generally, any segmental or sub-segmental is referred to as distal PE, whereas emboli found within the main or lobar arteries are reported as proximal PE.¹⁵ Further scrutiny of digital databases and medical records was performed to find out a patient's risk factors for acquiring VTE illness. Co-morbidities of a patient, the duration of hospitalization, the kind of orthopedic techniques used, the use of thromboprophylaxis (TP), the day of PE identification from the time of admission, and death were all noted. With the use of the integrated Pulmonary Embolism Severity Index, the intensity of the PE incident

was determined.¹⁷

As per the Trust's current standard operating procedure, every individual who got admitted to our facility are supposed to undergo a preliminary risk assessment for VTE and fill out a particular form that identifies risk factors. This evaluation tool was designed in accordance with NICE guidance.¹⁶ Patients received elective complete knee or hip arthroplasty (THA, TKA) were managed with alternate pneumatic devices or anti-embolism stockings from the time of admission as well as mechanical VTE prevention (mechanical TP therapy). Low-molecular range heparin (LMWH) and chemical-based thromboprophylaxis (chemical TP) were administered post-operatively when the danger of bleeding is minimized. Patients getting THA undergo chemical TP therapy for 35

Table 2. Features of thromboprophylaxis among study cases

Treatment protocol	Frequency	Percentage (%)
Number of individuals	66	75
Type of TP treatment		
Low molecular weight heparin	60	68.1
Thromboprophylaxis	4	4.5
Inferior vena cava filter	2	2.2
Treatment protocol None		
Number of participants	22	
Reasons		
Surgery minor	8	9.0
Incomplete risk evaluation	12	13.6
Treatment refused	2	2.2

days, whereas those receiving TKA receive it for 14 days.¹⁸⁻²⁰ A vena cava filter was implanted when the risk of bleeding and VTE was significant and there was a history of positive PE.^{21,22}

Data was analyzed through Version 12.2.1 of MedCalc (software manufactured by MedCalc bvda, Mariakerke, Belgium) and presented in the form of frequency and percentage. After PE, mortality was modelled using a multivariate logistic regression to identify possible risk variables. A Wald test was used to evaluate them, and a P-value of 0.05 or less was regarded as statistically significant. The software development framework R version 3.0.0 was used for the modelling process.

Results

A total of 18153 participants (10,649 for elective surgical procedures and 7504 for trauma) were admitted. All medical specialties requested 5,658 CT-PA examinations in our research. Among them, 152 (2.68%) were from the orthopedics and trauma department. 652 individuals (11.5%) had PE tests that were positive 90 subjects (13.8%) from our field of expertise (trauma and orthopedics) constituted the study group out of the 652 positive cases. It was determined that 58% of the individuals presenting with clinical characteristics suitable with PE had positive radiographic CT-PA results,

taking into account the overall number of clinically diagnosed PE cases (153) and the number of patients with positive outcomes on the CT-PA (90). The research population included 88 participants, because two individuals were excluded from the research group as a result of a PE incident that occurred shortly before their hospital admission for TKA. Participants ranged in age from 19 to 99 years old, with a mean age of 66.4 years and an almost equal distribution of sexes (Figure 1). 26 (29.5%) of the 88 individuals studied had elective orthopedic surgeries performed on them. THA and TKA were the most frequent therapies. 62(70.4) patients were admitted following trauma as described in table 1.

The majority of those receiving treatment had multiple risk factors or comorbidities. Each patient has a multiple risk element, thus the total combination is greater than 100%. In our study the common risk elements and comorbidities were hypertension, vascular disease, heart disease, and obesity (Figure 1). The Co-morbidity Index significantly 1.7, which is (range: 0 to 10) and in twenty-three patients (30.26% of the overall), it was above or equal to three.

Among study cases, a total of 66 individuals (75%) had thromboprophylaxis prescribed and given; these cases comprise the "prescribed TP" category and 22 individuals had not received treatment as shown in table 1.

Table 3. Thromboembolic events description among study cases

PE location	Patients	Percentage (%)
Right lung	32	36.3
Left lung	8	9
Bilateral	48	54.5
Total	85	
Concomitant deep venous thrombosis extension		
Proximal to the knee	12	13.6
Distal to the knee	7	7.9
Above and below the knee	12	13.6
Total	31	35.2

With 0.8% in the trauma group and 0.18 percent in elective orthopedic operations, the total rate of PE was 0.46%. Acute tachycardia, dyspnea, hypoxia, and pleuritic chest discomfort were the most often reported signs and symptoms. It was also frequently noted that the D-dimer level was elevated. Simplified Pulmonary Embolism Severity Index was the median value 2.27 (SD = 1.14) as displayed in table 2. Concomitant DVT was found in 31 (35.2%) PE patients. 12 individuals had proximal

DVT, while 7 of them had distal DVT. 12 participants had DVT both proximal and distal to the knee joint as described (Table 3). In our study the percentage of mortality was 2.31%. After PE, the mortality rate were 0.07% (fourteen out of 18,153 cases), with an abnormal CT-PA representing 15.9 percent (14 total of 88) of all participants. The death rate in the trauma group was 0.15 percent, whereas it was 0.02 percent for elective orthopedic surgical procedures (Table 1). The frequency

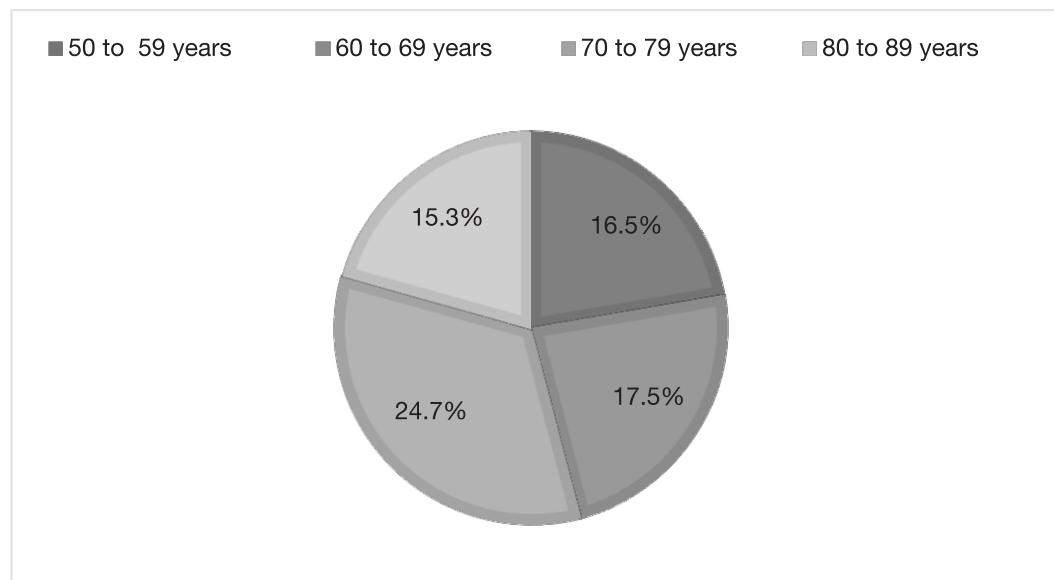


Figure 1. Age distribution of the study cases

of death was substantially correlated with the presence of at least two co-morbidities (unadjusted OR = 3.52, 95% confidence interval (CI 1.34 - 18.99; P = 0.034).

Discussion

Over the past three decades, the frequency of VTE and its associated consequences has been largely constant despite ongoing advances in medical knowledge and methods of therapy.^{24,25} In this study we determined the incidence and outcome of pulmonary embolism in trauma and orthopedic patients. In our study it was evaluated that the incidence of pulmonary embolism in trauma and orthopedic individuals was 0.46 percent. The findings of our research are similar to the previous studies published.²⁶⁻²⁸ The frequency of PE in the current study was lower for elective surgery (0.1%) this was with contrast to the newly published research²⁶ but was similar to the findings of study conducted by Jean-Marie Janue.¹² The frequency noted among trauma participants were consistent with the findings of Maneker et al.²⁹ Who, in his research population, revealed a rate of 0.27%, which is smaller than the rates other studies have demonstrated.^{9,30} However, these variations are challenging to explain in retrospective investigations conducted in various geographic regions using various prophylactic and therapeutic protocols. Based on available data, CT-PA is regarded as the standard of excellence for PE diagnosis.³¹ The indicated sensitivity of CTPA in the detection of PE differs from forty five to 100 percent and the specificity from seventy eight to 100 percent. Consequently considerably raising the rate of PE detection (sensitivity: 83%, the degree of specificity 96 %).³² Many researchers have made an effort to correlate specific risks to the onset of PE. A significant correspond has been observed among the period of hospital stay, prior history of VTE, and the quantity and number of surgeries performed.³³ The 2nd most risk factor of PE was cardiovascular disease.³⁴ TP therapy was given to 75% of the participants in the study group, although PE still affected some of those participating. Although we were unable to find any other specific associated variables to the development of VTE, we did note that 62.4% of patients in our cohort were over 60 years old, and 22.4 percent were more than eighty years old. Age has been identified in many studies as a separate risk factor for VTE.³⁵ Among the research participants, one-third had concurrent DVT was reported in this study .which was similar to the findings of study carried out by Knudsonet.³⁶ The rate of mortality explored in the current study 0.07% which was associated with at least two co-morbidities. This decreased number of deaths was in accordance with previous data published by Januel JMet al.¹² This low death rate could be due to not severe traumatic injuries and prescription of TP treatment protocol. There were

many limitation of the current study. The nature of data collecting is retrospective, small size and there was no control group.

Conclusion

In conclusion, this study reaffirms the established frequency of venous thromboembolic (VTE) disorders, aligning with previously reported epidemiological data. However, the noteworthy finding of a lower death rate suggests a potentially positive trend in patient outcomes, indicative of advancements in treatment protocols and interventions. The efficacy of treatment regimens employed in this study underscores the critical importance of implementing evidence-based management strategies to mitigate the morbidity and mortality associated with VTE complications. Moving forward, continued efforts to refine treatment protocols, enhance risk stratification, and optimize patient care are essential for further improving outcomes in individuals at risk of or afflicted by VTE. Findings of the present study may be helpful in clinical practice and healthcare providers can strive to achieve better patient outcomes and reduce the burden of VTE-related morbidity and mortality on a global scale.

References

1. Markovic-Denic L, Zivkovic K, Lesic A, Bumbasirevic V, Dubljanin-Raspopovic ER, Bumbasirevic M. Risk factors and distribution of symptomatic venous thromboembolism in total hip and knee replacements: prospective study. *Int Orthop*. 2012;36:1299–1305.
2. Cohen AT, Tapson VF, Bergmann JF, Goldhaber SZ, Kakkar AK, Deslandes B, et al. Venous thromboembolism risk and prophylaxis in the acute hospital care setting (ENDORSE study): a multinational cross-sectional study. *Lancet*. 2008;371:387-94.
3. Geerts WH, Pineo GF, Heit JA, Bergqvist D, Lassen MR, Colwell CW, et al. Prevention of venous thromboembolism:the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy.*Chest*. 2004;126:338S-400.
4. Linblad B, Sternby NH, Bergqvist D. Incidence of venous thromboembolism verified by necropsy over 30 years. *BMJ*. 1991;302:709-11.
5. Sandler DA, Martin JF:Autopsy proven pulmonary embolism in hospital patients: are we detecting enough deep vein thrombosis? *J R Soc Med*. 1989; 82:203-5.
6. Alikhan R, Peters F, Wilmott R, and Cohen AT. Fatal pulmonary embolism in hospitalized patients: a necropsy review. *J Clin Pathol*. 2004, 57:1254-7.

7. Prandoni P, Villalta S, Bagatella P, Rossi L, Marchiori A, Piccioli A, et al. The clinical course of deep-vein thrombosis. Prospective long-term follow-up of 528 symptomatic patients. *Haematologica*. 1997; 82:423-8.
8. Pengo V, Lensing AW, Prins MH, Marchiori A, Davidson BL, Tiozzo F, et al. Thromboembolic Pulmonary Hypertension Study Group: Incidence of chronic thromboembolic pulmonary hypertension after pulmonary embolism. *N Engl J Med*. 2004;350: 2257-64.
9. Paffrath T, Wafaisade A, Lefering R, Simanski C, Bouillon B, Spanholtz T, et al. Trauma Registry of DGU: Venous thromboembolism after severe trauma: incidence, risk factors and outcome. *Injury*. 2010; 41:97-101.
10. Ho KM, Burrell M, Rao S, and Baker R. Incidence and risk factors for fatal pulmonary embolism after major trauma: a nested cohort study. *Br J Anaesth*. 2010; 105:596-602.
11. Poultsides LA, Gonzalez Della Valle A, Memtsoudis SG, Ma Y, Roberts T, Sharrock N, et al. Meta-analysis of cause of death following total joint replacement using different thrombo-prophylaxis regimens' *Bone Joint Surg Br*. 2012;94:113-121.
12. Januel JM, Chen G, Ruffieux C, Quan H, Douketis JD, Crowther MA, et al. Symptomatic in-hospital deep vein thrombosis and pulmonary embolism following hip and knee arthroplasty among patients receiving recommended prophylaxis: a systematic review. *JAMA*. 2012;307:294-303.
13. Subramaniam RM, Blair D, Gilbert K, Sleigh J, Karalus N. Computed tomography pulmonary angiogram diagnosis of pulmonary embolism. *Australas Radiol*. 2006;50:193-200.
14. Stein PD, Fowler SE, Goodman LR, Gottschalk A, Hales CA, Hull RD, et al. Multidetector computed tomography for acute pulmonary embolism. *N Engl J Med*. 2006, 354:2317-27.
15. Pruszczyk P, Torbicki A, Pacho R, Chlebus M, Kuch-Wocial A, Pruszynski B, et al. Noninvasive diagnosis of suspected severe pulmonary embolism: transesophageal echocardiography vs. spiral CT. *Chest*. 1997;112:722-8
16. NICE guidelines. Venous thromboembolism - reducing the risk (CG92). Available from URL: <http://guidance.nice.org.uk/CG92>.
17. Jiménez D, Aujesky D, Moores L, Gómez V, Lobo JL, Uresandi F, et al. Simplification of the pulmonary embolism severity index for prognostication in patients with acute symptomatic pulmonary embolism. *Arch Intern Med*. 2010;170:1383-9.
18. Cohen AT, Edmondson RA, Phillips MJ, Ward VP, Kakkar VV. The changing pattern of venous thromboembolic disease. *Haemostasis*. 1996;26:65-71.
19. MacDonald D, Hobson S. VTE Prophylaxis for Elective Knee Replacement, e-Clinical VTE Guidelines Template. Leeds Teaching Hospitals Trust. Publication date: 1 July 2010.
20. MacDonald D, Hobson S: VTE Prophylaxis for Elective Hip Replacement, e-Clinical VTE Guidelines Template. Leeds Teaching Hospitals Trust. 2010.
21. Rao A, Monkhouse R, Gummerson N, Hobson S. VTE Prophylaxis for Hip Fracture, e Clinical VTE Guidelines Template. Leeds Teaching Hospitals Trust. 2010.
22. Rao A, Monkhouse R, Gummerson N, Hobson S. VTE Prophylaxis for Other Orthopedic Surgery, e-Clinical VTE Guidelines Template. Leeds Teaching Hospitals Trust. 2010.
23. Rao A, Monkhouse R, Gummerson N, Hobson S. VTE Prophylaxis for Lower Limb Plaster Casts, e-Clinical VTE Guidelines Template. Leeds Teaching Hospitals Trust. 2010.
24. Core Team R. A language and environment for statistical computing. Vienna, Austria: Foundation for Statistical Computing; 2013. Available from URL: <http://www.R-project.org/>.
25. Heit JA. The epidemiology of venous thromboembolism in the community. *Arterioscler Thromb Vasc Biol*. 2008;28:370-2.
26. Falck-Ytter Y, Francis CW, Johanson NA, Curley C, Dahl OE, Schulman S, et al. Prevention of VTE in orthopedic surgery patients: Antithrombotic Therapy and Prevention of Thrombosis, 9th Ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*. 2012;141(2 suppl): e278S-325.
27. Jawa RS, Warren K, Young D, Wagner M, Nelson L, Yetter D, et al. Venous thromboembolic disease in trauma and surveillance ultrasonography *Surg Res*. 2011;167:24-31.
28. Huseynova K, Xiong W, Ray JG, Ahmed N, Nathens AB. Venous thromboembolism as a marker of quality of care in trauma. *J Am Coll Surg*. 2009;208:547-552.
29. Menaker J, Stein DM, Scalea TM. Incidence of early pulmonary embolism after injury. *J Trauma*. 2007; 63:620-4.
30. McNamara I, Sharma A, Prevost T, Parker M.

- Symptomatic venous thromboembolism following a hip fracture. *Acta Orthop.* 2009;80:687-92.
31. Estrada-Y-Martin RM, Oldham SA. CTPA as the gold standard for the diagnosis of pulmonary embolism. *Int J Comput Assist Radiol Surg.* 2011;6:557-63.
 32. Vedovati MC, Becattini C, Agnelli G, Kamphuisen PW, Masotti L, Pruszczyk P, et al. Multidetector CT for acute pulmonary embolism: embolic burden and clinical outcome. *Chest.* 2012;142(6):1417-24.
 33. Pedersen AB, Sorensen HT, Mehnert F, Overgaard S, Johnsen SP. Risk factors for venous thromboembolism in patients undergoing total hip replacement and receiving routine thrombo-prophylaxis. *J Bone Joint Surg Am.* 2010;92:2156-64.
 34. Pedersen AB, Mehnert F, Johnsen SP, Husted S, Sorensen HT. Venous thromboembolism in patients having knee replacement and receiving thrombo prophylaxis: a Danish population-based follow-up study. *J Bone Joint Surg Am.* 2011;93:1281-7.
 35. Haut ER, Chang DC, Pierce CA, Colantuoni E, Efron DT, Haider AH, et al. Predictors of posttraumatic deep vein thrombosis(DVT): hospital practice versus patient factors - an analysis of the National Trauma Data Bank (NTDB). *J Trauma.* 2009;66:994-1001.
 36. Knudson MM, Ikossi DG, Khaw L, Morabito D, Speetzen LS. Thromboembolism after trauma: an analysis of 1602 episodes from the American College of Surgeons National Trauma Data Bank. *Ann Surg.* 2004;240:490-8.