



Review article

Guidelines for the prevention of venous thromboembolism in hospitalized patients with pelvi-acetabular trauma



Sameer Aggarwal^a, Sandeep Patel^{a,*}, Saurabh Vashisht^a, Vishal Kumar^a,
Inderpaul Singh Sehgal^b, Rajeev Chauhan^c, Dr Sreedhara B. Chaluvashetty^d,
Dr K. Hemanth Kumar^e, Dr Karan Jindal^a

^a Department of Orthopaedics PGIMER, Chandigarh, India

^b Department of Pulmonary Medicine PGIMER, Chandigarh, India

^c Department of Anaesthesia and Intensive Care, PGIMER, Chandigarh, India

^d Department of Radiodiagnosis and Imaging, PGIMER, Chandigarh, India

^e Department of General Surgery PGIMER, Chandigarh, India

ARTICLE INFO

Article history:

Received 16 August 2020

Received in revised form

9 September 2020

Accepted 9 September 2020

Available online 16 September 2020

Keywords:

Venous thromboembolism

Pelvi-acetabular

Trauma

Thromboprophylaxis

Pulmonary embolism

Deep vein thrombosis

ABSTRACT

Background: Venous thromboembolism is a dreaded complication leading to increased morbidity and mortality in patients having pelvi-acetabular fractures.

Objectives: These evidence based guidelines aim to provide the decision making ability in the prevention of venous thromboembolism in patients with pelvi-acetabular trauma planned for operative or non operative treatment.

Methods: The patients were subclassified into 5 categories. The PICO framework was used to devise research questions in each category. The systematic reviews were performed for each research question. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to assess outcomes of critical interest. The guideline panel consisting of expert members of different subspecialties, analyzed the evidence and made recommendations.

Results: The guideline panel proposed 21 recommendations. There are five recommendations in category 1 to 3, two recommendations in category 4 and four recommendations in category 5.

Conclusion: In pelvi-acetabular fractures there is strong evidence to suggest that thromboprophylaxis should be given. It should be initiated as early as possible after control of hemorrhage. The chemical prophylaxis is the preferred mode and LMWH is the preferred agent of choice. The mechanical methods can be used as an adjunct. The routine prophylactic use of IVC filters is not recommended. However, the use of retrievable IVC filters in high risk patients with established VTE in preoperative period can be considered. The use of newer directly acting oral anticoagulants is gaining importance.

© 2020 Delhi Orthopedic Association. All rights reserved.

Introduction

Aims and objectives

The aim of these guidelines is to provide evidence based recommendations for the prevention of venous thromboembolism

(VTE) in patients sustaining pelvi-acetabular fractures. The target audience includes patients, Orthopaedic surgeons, general surgeons, anesthesiologists, pulmonologists, hematologists, pharmacists, nursing staff, and health policy makers (regional, national or international level).

Description of health problem

VTE is a dreaded complication that can lead to fatal outcome in trauma patients. It leads to high morbidity and mortality in patients with pelvi-acetabular trauma. The prevalence of deep vein thrombosis (DVT) varies and is estimated around 60% in patients without any prophylaxis.¹ The risk of pulmonary embolism ranges

* Corresponding author.

E-mail addresses: drsameer35@yahoo.co.in (S. Aggarwal), sandeepdrpatelortho@gmail.com (S. Patel), saurabh90019@yahoo.com (S. Vashisht), drkumarvishal@gmail.com (V. Kumar), inderpgi@outlook.com (I.S. Sehgal), rajeevchauhan@gmail.com (R. Chauhan), sridharbmc@gmail.com (D.S.B. Chaluvashetty), hemanthkr21@gmail.com (D.K. Hemanth Kumar).

between 2 and 10%.² The pulmonary embolism (PE) is third most common cause of death in trauma patients in postoperative period beyond 24 h of admission.³ The incidence of DVT in Indian population has been considered low previously based upon the studies conducted in arthroplasty patients.⁴ However, the studies conducted on the pelvi-acetabular or lower limb fractures were fewer in number but the incidence reported was significantly higher (up to 60%).^{5–8} The prevalence of VTE is more in pelvi-acetabular trauma in comparison to hip arthroplasty. This is attributed to multiple factors including high velocity injury, disruption of pelvic vessels, immobilization for long duration and manipulation during surgical procedure.⁵ All the three components of classical triad of Virchow namely circulatory stasis, endothelial damage and hypercoagulability are involved following pelvi-acetabular trauma.

Target population

These guidelines laid focus on adult patients having pelvi-acetabular trauma who are having potential risk for preoperative as well as postoperative VTE.

Risk assessment for VTE in Pelvic fractures

The Greenfield risk assessment profile (GRAP) is the most widely practiced validated scoring system used in trauma patients. Pelvic fracture is a major risk factor and given 4 points on the GRAP.⁹ The scores >10 on GRAP represent high risk of VTE. A recent study evaluated individual risk factors mentioned in GRAP scoring and proposed a modified score with predictive power similar to the original score.¹⁰ The five variables easily available at bedside (four or more transfusions in the first 24 h, operation >24 h, Glasgow coma scale, pelvic fracture, and age 40–59 years) can easily assess the risk for VTE in trauma patients. Other Scoring systems like Caprini risk assessment model (CRAM), the Trauma embolic scoring system (TESS) also place Pelvic fractures as a risk factor for VTE and hence it becomes necessary to provide thromboprophylaxis to this high risk group.^{11,12}

The guideline panel have devised a stepwise approach for decision making in assessment of VTE prophylaxis in Pelvi-acetabular fracture patients.

The patients having Pelvi-acetabular fractures are subclassified into one of these 5 categories defined below.

Category1: Pelvis and acetabular fractures planned to be managed conservatively; Patient Haemodynamically stable, no contraindications to chemical prophylaxis and no medical co-morbidities.

Category2: Pelvis and acetabular fractures planned for operative management; Patient Haemodynamically stable, no contraindications to chemical prophylaxis and no medical co-morbidities.

Category3: Critically ill patient presenting to emergency department (Ongoing bleeding and high risk of Bleeding).

Category4: Patient with established DVT and planned for surgery (Pre-Operative developed DVT).

Category 5: Patient with medical co-morbidities.

The common modalities of VTE prophylaxis in pelvi-acetabular patients have been shown in [Table 1](#).

Methodology

Guidelines panel

The members of guidelines panel include Orthopaedic surgeons practicing pelvi-acetabular subspeciality, anaesthetists with major

trauma as subspeciality, general surgeons involved in trauma and critical care, pulmonologist and Interventional Radiologist.

Formulation of clinical questions and outcome of interest

The authors used PICO framework ([Table 2](#)) for the formulation of research questions in each category of patients with pelvi-acetabular trauma. The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach was used to select outcomes of interest.^{13,14} The outcomes were rated as critical or non critical. The outcome of interests include non fatal PE, DVT, mortality and major bleeding. Three databases of PubMed, EMBASE and SCOPUS were searched on July 21, 2020 using Medical subject headings (MeSH) terms. A systematic review was performed and all the studies addressing these important outcomes were included. The summary of finding tables were prepared and the quality of evidence for each outcome was calculated according to the factors outlined in GRADE approach (supplementary materials).

Details of search methodology

Three databases of PubMed, EMBASE and SCOPUS were searched on July 21, 2020 using MeSH terms ([Table 3](#)). A total number of 1164 hits were obtained. We also performed a secondary search from the references from all the articles selected as per the predefined criteria.

Studies assessing venous thromboembolism in patients with pelviacetabular trauma were included. Two reviewers (SP and SV), independently screened the studies. The titles and abstracts were screened for eligible studies, whose full texts were accessed and studied thoroughly. The articles that pertained to the study aim were identified and short listed for inclusion. Any selection conflicts between the two authors were resolved by discussion with the other co-authors for final consensus. The studies were analyzed and summary of evidence generated.

Evidence to decision

The guideline panel reviewed all the information generated from the systematic reviews. The members reassessed the information and after panel discussion, gave decision regarding critical outcomes. Finally, the panel formulated recommendations and revealed its direction (for or against) and graded its strength (strong or weak).

Interpretation of recommendation

Strong Recommendation: The guideline panel is confident that the desirable effects of intervention outweigh its undesirable effects (strong recommendation for an intervention) or that the undesirable effects of an intervention outweigh its desirable effects (strong recommendation against an intervention).

Weak Recommendation: According to the guideline panel, the desirable effects probably outweigh the undesirable effects (weak recommendation for an intervention) or undesirable effects probably outweigh the desirable effects (weak recommendation against an intervention) but appreciable uncertainty exists.

Summary of guidelines

Category1: Pelvis and acetabular fractures planned to be managed conservatively; Patient Haemodynamically stable, no contraindications to chemical prophylaxis and no medical co-morbidities

Table 1
Common modalities of VTE prophylaxis available for use.

Chemical (Pharmacological)
Low Molecular Weight Heparins (LMWHs)
Unfractionated Heparin
Oral Vitamin K Antagonist Anti-Coagulants
New Anticoagulant Therapies
Aspirin
Mechanical
Sequential compression devices (SCDs),
Graduated compression stockings (GCSs) or Venous foot pumps (VFPs)
IVC filters

Table 2
PICO Framework for defining research questions.

Patients with Pelvi-acetabular trauma	Informal question	PICO Framework				
		Population	Intervention	Comparison	Outcome	Study design
Category-1	Is VTE prophylaxis Required?	Planned for conservative management	Any chemical agent/ Mechanical device	No chemical agent/ Mechanical device	Symptomatic/Asymptomatic DVT, Fatal/Non fatal PE, mortality	RCT/ Observational
	Preferred mode of prophylaxis	Same	Any chemical agent	Mechanical device	Same	Same
	Preferred chemical agent of prophylaxis	Same	Any chemical agent	Any chemical agent	Same	Same
	Timing of prophylaxis initiation	Same	Within 24 h of injury	More than 24 h post injury	Same	Same
	Duration of prophylaxis	Same	Less than 1 month	More than 1 month	Same	Same
Category-2	Is VTE prophylaxis Required?	Planned for operative management (hemodynamically stable)	Any chemical agent/ Mechanical device	No chemical agent/ Mechanical device	Symptomatic/Asymptomatic DVT, Fatal/Non fatal PE, mortality	RCT/ Observational
	Preferred mode of prophylaxis	Same	Any chemical agent	Mechanical device	Same	Same
	Preferred chemical agent of prophylaxis	Same	Any chemical agent	Any chemical agent	Same	Same
	Timing of prophylaxis initiation	Same	Within 24 h of injury	More than 24 h post injury	Same	Same
	Duration of prophylaxis	Same	Less than 1 month	More than 1 month	Same	Same
Category 3	Is VTE prophylaxis Required?	Critically ill patient presenting to emergency department (Ongoing bleeding and high risk of Bleeding)	Any chemical agent/ Mechanical device	No chemical agent/ Mechanical device	Symptomatic/Asymptomatic DVT, Fatal/Non fatal PE, mortality	RCT/ Observational
	Preferred mode of prophylaxis	Same	Any chemical agent	Mechanical device	Same	Same
	Preferred chemical agent of prophylaxis	Same	Any chemical agent	Any chemical agent	Same	Same
	Duration of prophylaxis	Same	Less than 1 month	More than 1 month	Same	Same
	Do IVC filters required?	Same	Retrieveable IVC filters	No filters	Same	Same
Category 4	Is VTE treatment Required?	Patient with established DVT and planned for surgery	Any chemical agent	No chemical agent	Symptomatic/Asymptomatic DVT, Fatal/Non fatal PE, mortality	RCT/ Observational
	IVC filters required in Pre Operative period?	Same	Retrieveable IVC filters	No filters	Same	Same
Category 5	Is VTE prophylaxis Required?	Patient with medical co-morbidities	Any chemical agent/ Mechanical device	No chemical agent/ Mechanical device	Symptomatic/Asymptomatic DVT, Fatal/Non fatal PE, mortality	RCT/ Observational
	Preferred mode of prophylaxis	Same	Any chemical agent	Any chemical agent	Same	Same
Hepatic dysfunction	Preferred chemical agent of prophylaxis	Same	Any chemical agent	Any chemical agent	Same	Same
Renal dysfunction (Cr Cl < 30)	Preferred chemical agent of prophylaxis	Same	Any chemical agent	Any chemical agent	Same	Same
Renal dysfunction (Cr Cl < 30)	Preferred chemical agent of prophylaxis	Same	Any chemical agent	Any chemical agent	Same	Same

Table 3
Search strategy.

Database	Period: Inception to July 21, 2020	Results
PubMed	((((("venous thrombosis" [MeSH Terms] OR ("venous" [All Fields] AND "thrombosis" [All Fields])) OR "venous thrombosis" [All Fields]) OR (("deep" [All Fields] AND "vein" [All Fields]) AND "thrombosis" [All Fields])) OR "deep vein thrombosis" [All Fields]) OR (("pulmonary embolism" [MeSH Terms] OR ("pulmonary" [All Fields] AND "embolism" [All Fields])) OR "pulmonary embolism" [All Fields])) OR (("venous thromboembolism" [MeSH Terms] OR ("venous" [All Fields] AND "thromboembolism" [All Fields])) OR "venous thromboembolism" [All Fields]) AND (((("pelvi-acetabular" [All Fields] AND (((("injuries" [MeSH Subheading] OR "injuries" [All Fields]) OR "trauma" [All Fields]) OR "wounds and injuries" [MeSH Terms]) OR ("wounds" [All Fields] AND "injuries" [All Fields])) OR "wounds and injuries" [All Fields]) OR "trauma s" [All Fields]) OR "traumas" [All Fields])) OR (((("pelvics" [All Fields] OR "pelvis" [MeSH Terms]) OR "pelvis" [All Fields]) OR "pelvic" [All Fields]) AND (((((((("injury" [All Fields] OR "injured" [All Fields]) OR "injuries" [MeSH Subheading]) OR "injuries" [All Fields]) OR "wounds and injuries" [MeSH Terms]) OR ("wounds" [All Fields] AND "injuries" [All Fields])) OR "wounds and injuries" [All Fields]) OR "injury s" [All Fields]) OR "injured" [All Fields]) OR "injurs" [All Fields]) OR "injury" [All Fields])))) OR (((("pelvics" [All Fields] OR "pelvis" [MeSH Terms]) OR "pelvis" [All Fields]) OR "pelvic" [All Fields]) AND (((((((("fractur" [All Fields] OR "fractural" [All Fields]) OR "fracture s" [All Fields]) OR "fractures, bone" [MeSH Terms]) OR ("fractures" [All Fields] AND "bone" [All Fields])) OR "bone fractures" [All Fields]) OR "fracture" [All Fields]) OR "fractured" [All Fields]) OR "fractures" [All Fields]) OR "fracturing" [All Fields]))))	534
Embase	venous AND ('thromboembolism'/exp OR thromboembolism) AND in AND ('pelvic'/exp OR pelvic) AND ('fractures'/exp OR fractures)	221
Scopus	TITLE-ABS-KEY (venous AND thromboembolism) (pelvic AND fractures)	409

- Recommendation 1.1 For patients undergoing non operative treatment for Pelvis and acetabular fractures, the guideline panel recommends using pharmacological prophylaxis ± mechanical.
- Prophylaxis (Grade 1D) (strong recommendation, very low evidence).
- Recommendation 1.2 For patients undergoing non operative treatment for Pelvis and acetabular fractures, the guideline panel recommends using pharmacological prophylaxis as a preferred mode of prophylaxis (Grade 1D) (strong recommendation, very low evidence).
- Recommendation 1.3 For patients undergoing non operative treatment for Pelvis and acetabular fractures, the guideline panel recommends using pharmacological prophylaxis with LMWH as a preferred agent for prophylaxis (Grade 1D) (strong recommendation, very low evidence).
- Recommendation 1.4 For patients undergoing non operative treatment for Pelvis and acetabular fractures, the guideline panel recommends use of early prophylaxis with LMWH (within 24 h after injury). (Grade 1D) (strong recommendation, very low evidence).
- Recommendation 1.5 For patients undergoing non operative treatment for Pelvis and acetabular fractures, guideline panel recommends using extended antithrombotic prophylaxis (>1

month) over short-term antithrombotic prophylaxis (Grade 1D) (strong recommendation, very low evidence).

Conclusion

“We recommend chemical prophylaxis should be given. LMWH is the preferred choice in the patients planned for non operative management. The prophylaxis should be started within first 24 h. The duration of prophylaxis should be more 4 weeks”.

Details of Summary of evidence, summary of findings, study details, certainty of evidence, evidence to decision making criteria and conclusions for Category 1 are provided in supplementary materials.

Category 2: Pelvis and acetabular fractures planned for operative management; Patient Haemodynamically stable, no contraindications to chemical prophylaxis and no medical comorbidities

- Recommendation 2.1 For patients undergoing surgery for Pelvis and acetabular fractures, the guideline panel recommends using pharmacological prophylaxis or mechanical prophylaxis (Grade 1C) (strong recommendation, low evidence).
- Recommendation 2.2 For patients undergoing surgery for Pelvis and acetabular fractures, the guideline panel recommends using pharmacological prophylaxis as a preferred mode of prophylaxis (Grade 1C) (strong recommendation, low evidence)
- Recommendation 2.3 For patients undergoing surgery for Pelvis and acetabular fractures, the guideline panel recommends using LMWH as a preferred agent for prophylaxis (Grade 1C) (strong recommendation, low evidence)
- Recommendation 2.4 For patients undergoing surgical treatment for Pelvis and acetabular fractures, the guideline panel recommends use of early prophylaxis with LMWH (within 24 h after injury) (Grade 1B) (strong recommendation, moderate evidence)
- Recommendation 2.5 For patients undergoing operative treatment for Pelvis and acetabular fractures, guideline panel recommends using extended antithrombotic prophylaxis (>1 month) over short-term antithrombotic prophylaxis (Grade 1D) (strong recommendation, very low evidence)

Conclusion-

“We recommend early administration of prophylaxis with LMWH as soon as patient is hemodynamically stable and there is negligible risk of bleeding. The operative intervention should not be delayed beyond 2 weeks.^{15–18} The duration of prophylaxis should be more than 4 weeks postoperatively and can be extended further if period of immobilization increases further”.

Details of Summary of evidence, summary of findings, study details, certainty of evidence, evidence to decision making criteria and conclusions for Category 2 are provided in supplementary materials.

Special scenario: Delayed presentation of patients (category 1 and 2) to Hospital (more than 24 h) –

Usual practice Point-“Early initiation of prophylaxis is preferred over delayed prophylaxis; however when patients present late, it is still recommended to start prophylaxis as it is superior over not administering prophylaxis”

Category 3: Critically ill patient presenting to emergency department (Ongoing bleeding and high risk of Bleeding)

- Recommendation 3.1 For Critically ill patient patients having Pelvis and acetabular fractures, the guideline panel recommends using Immediate Mechanical prophylaxis (As patient's bleeding risk is high for initiation of pharmacological prophylaxis) (Grade 1C) (strong recommendation, low evidence)
- Recommendation 3.2 For Critically ill patient patients having Pelvis and acetabular fractures, the guideline panel recommends using pharmacological prophylaxis once the bleeding risk subsides (The risk assessment of bleeding should be done on daily basis) (Grade 1C) (strong recommendation, low evidence)
- Recommendation 3.3 For Critically ill patients having Pelvis and acetabular fractures, the guideline panel recommends using Unfractionated Heparin (UFH) as a preferred agent for prophylaxis (Grade 1D) (strong recommendation, very low evidence)
Usual practice Point- "Evidence for the chemical agent of choice is lacking in this scenario, however as a usual practice point the panel prefers UFH as an agent as it can be monitored; and if bleeding occurs, Protamine Sulfate is an available antidote."
- Recommendation 3.4 For Critically ill patients having Pelvis and acetabular fractures, at discharge (stable patient), the guideline panel recommends using extended antithrombotic prophylaxis (>1 month) over short-term antithrombotic prophylaxis (Grade 1D) (strong recommendation, very low evidence)
- Recommendation 3.5 For Critically ill patients having Pelvis and acetabular fractures, the guideline panel recommends against the use of Prophylactic IVC filters (Grade 1B) (strong recommendation, moderate evidence)

Conclusion-

"We recommend immediate mechanical prophylaxis and daily assessment of risk of bleeding; and to start chemical prophylaxis with Unfractionated heparin (UFH) when there is minimal or no risk of bleeding. Recent evidence is against use of prophylactic IVC Filters for this patient group".

Details of Summary of evidence, summary of findings, study details, certainty of evidence, evidence to decision making criteria and conclusions for. Category 3 are provided in supplementary materials.

Category 4: Patient with established DVT and planned for surgery (Pre-Operative developed DVT)

- Recommendation 4.1 For pelvi-acetabular trauma patients with established DVT and planned for surgery, the guideline panel recommends using pharmacological treatment for DVT (Grade 1C) (strong recommendation, low evidence)
- Recommendation 4.2 For patients with established DVT and planned for surgery, the guideline panel suggests retrievable IVC filters as prophylaxis to prevent PE risk during surgery (as manipulation is a risk factor) (Grade 3D) (weak recommendation, very low evidence)
- Usual Practice point- "The VTE treatment has to be stopped 12 h before surgery and to be restarted after surgery"

Conclusion-we recommend standard pharmacological treatment of DVT and in addition use of the retrievable IVC filters for category 4 patients

Details of Summary of evidence, summary of findings, study details, certainty of evidence, evidence to decision making criteria and conclusions for Category 4 are provided in supplementary materials.

Category 5: Patient with medical co-morbidities

- Recommendation 5.1 For patients with medical co-morbidities having pelvi-acetabular fractures, the guideline panel recommends using Immediate mechanical prophylaxis (Grade 1D) (strong recommendation, very low evidence)
- Recommendation 5.2 For patients with medical co-morbidities (Hepatic Dysfunction) having pelvi-acetabular fractures, the guideline panel recommends using UFH as a preferred pharmacological prophylaxis agent (Grade 1D) (strong recommendation, very low evidence)
- Usual practice Point- "Evidence for the chemical agent of choice is lacking in this scenario, however as a usual practice point the panel prefers UFH as an agent as it can be monitored; and if bleeding occurs, Protamine Sulfate is an available antidote."
- Recommendation 5.3 For patients with medical co-morbidities (Renal dysfunction with Cr Clearance <30) having pelvi-acetabular fractures the guideline panel recommends using UFH as a preferred pharmacological prophylaxis agent (Grade 1D) (strong recommendation, very low evidence)
- Recommendation 5.4 For patients with medical co-morbidities (Renal dysfunction with Cr Clearance >30) having pelvi-acetabular fractures the guideline panel recommends using Fondaparinux as a preferred pharmacological prophylaxis agent (Grade 1C) (strong recommendation, low evidence)

Details of Summary of evidence, summary of findings, study details, certainty of evidence, evidence to decision making criteria and conclusions for Category 5 are provided in supplementary materials.

Role of newer anticoagulants

Dabigatran, rivaroxaban and apixaban are oral, reversible and directly acting anticoagulants. This new class of anticoagulants is quite convenient to the patients as there is no need of monitoring as pharmacodynamics of this class is quite predictable and there is no need of frequent dosing. The baseline renal function should be assessed.¹⁹ The majority of the studies demonstrating the role of newer anticoagulants have been performed in hip and knee arthroplasty,^{20–23} and few in hip fractures.^{24,25} Patients with polytrauma or pelvic-acetabular fractures are a totally different group and very few studies have mentioned their use.^{26,27} Positive results from arthroplasty cannot be extrapolated and there is need for good studies to evaluate their role. There is lack of evidence demonstrating superiority of these newer agents in pelvi-acetabular trauma and hence there is no strong evidence to support the use of these newer agents in pelvic trauma.

Conclusion

In pelvi-acetabular fractures there is strong evidence to suggest that thromboprophylaxis should be given. It should be initiated as early as possible after control of hemorrhage. The chemical prophylaxis is the preferred mode and LMWH is the preferred agent of choice. The mechanical methods can be used as an adjunct. The routine prophylactic use of IVC filters is not recommended. However, the use of retrievable IVC filters in high risk patients with established VTE in preoperative period can be considered. The use of newer directly acting oral anticoagulants is gaining importance.

Acknowledgements-

Part of the Recommendation panel.- all 9 authors part of recommendation panel.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jcot.2020.09.011>.

Financial disclosures

None.

Conflicts of interest

None.

References

- Cohen-Levy WB, Liu J, Sen M, Teperman SH, Stone ME. Prophylactic inferior vena cava filters for operative pelvic fractures: a twelve year experience. *Int Orthop*. 2019;43(12):2831–2838. <https://doi.org/10.1007/s00264-019-04384-0>.
- Montgomery KD, Geerts WH, Potter HG, Helfet DL. Thromboembolic complications in patients with pelvic trauma. *Clin Orthop Relat Res*. 1996;329:68–87. <https://doi.org/10.1097/00003086-199608000-00010>.
- Pan Y, Zhao J, Mei J, Shao M, Zhang J, Wu H. Evaluation of nonpermanent inferior vena cava filter placement in patients with deep venous thrombosis after lower extremity fracture: a single-center retrospective study. *Phlebology*. 2016;31(8):564–572. <https://doi.org/10.1177/0268355515597632>.
- Mavalankar AP, Majmundar D, Rani S. Routine chemoprophylaxis for deep venous thrombosis in Indian patients: is it really justified? *Indian J Orthop*. 2007;41(3):188–193. <https://doi.org/10.4103/0019-5413.33680>.
- Sen RK, Kumar A, Tripathy SK, Aggarwal S, Khandelwal N, Manoharan SRR. Risk of postoperative venous thromboembolism in Indian patients sustaining pelvis-acetabular injury. *Int Orthop*. 2011;35(7):1057–1063. <https://doi.org/10.1007/s00264-010-1093-6>.
- Agarwala S, Bhagwat AS, Modhe J. Deep vein thrombosis in Indian patients undergoing major lower limb surgery. Published online December 31 Accessed September 8, 2020 <https://tspace.library.utoronto.ca/handle/1807/22439>; 2003.
- Bhan S, Dhaon BK, Gulati Y, Aggarwal S. Deep venous thrombosis prophylaxis: a multicentric study. ResearchGate. Accessed September 8 https://www.researchgate.net/publication/293144293_Deep_venous_thrombosis_prophylaxis_A_multicentric_study; 2020.
- Maini L, Sharma H. Routine chemoprophylaxis for deep vein thrombosis in Indian patients: is it really justified? *Indian J Orthop*. 2008;42(2):231–232. <https://doi.org/10.4103/0019-5413.40265>. author reply 232–233.
- Greenfield LJ, Proctor MC, Rodriguez JL, Luchette FA, Cipolle MD, Cho J. Post-trauma thromboembolism prophylaxis. *J Trauma*. 1997;42(1):100–103. <https://doi.org/10.1097/00005373-199701000-00017>.
- Meizoso JP, Karcutskie CA, Ray JJ, et al. A simplified stratification system for venous thromboembolism risk in severely injured trauma patients. *J Surg Res*. 2017;207:138–144. <https://doi.org/10.1016/j.jss.2016.08.072>.
- Caprini JA. Thrombosis risk assessment as a guide to quality patient care. *Dis Mon*. 2005;51(2-3):70–78. <https://doi.org/10.1016/j.disamonth.2005.02.003>.
- Rogers FB, Shackford SR, Horst MA, et al. Determining venous thromboembolic risk assessment for patients with trauma: the Trauma Embolic Scoring System. *J Trauma Acute Care Surg*. 2012;73(2):511–515. <https://doi.org/10.1097/ta.0b013e3182588b54>.
- Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ*. 2008;336(7650):924–926. <https://doi.org/10.1136/bmj.39489.470347.AD>.
- Guyatt G, Oxman AD, Akl EA, et al. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol*. 2011;64(4):383–394. <https://doi.org/10.1016/j.jclinepi.2010.04.026>.
- Wang P, Kandemir U, Zhang B, et al. Incidence and risk factors of deep vein thrombosis in patients with pelvic and acetabular fractures. *Clin Appl Thromb Hemost*. 2019;25, 1076029619845066. <https://doi.org/10.1177/1076029619845066>.
- Arroyo W, Nelson KJ, Belmont PJ, Bader JO, Schoenfeld AJ. Pelvic trauma: what are the predictors of mortality and cardiac, venous thrombo-embolic and infectious complications following injury? *Injury*. 2013;44(12):1745–1749. <https://doi.org/10.1016/j.injury.2013.08.007>.
- Stannard JP, Lopez-Ben RR, Volgas DA, et al. Prophylaxis against deep-vein thrombosis following trauma: a prospective, randomized comparison of mechanical and pharmacologic prophylaxis. *J Bone Joint Surg Am*. 2006;88(2):261–266. <https://doi.org/10.2106/JBJS.D.02932>.
- Dennis M, Mordi N, Graham C, Sandercock P. CLOTS trials collaboration. The timing, extent, progression and regression of deep vein thrombosis in immobile stroke patients: observational data from the CLOTS multicenter randomized trials. *J Thromb Haemostas*. 2011;9(11):2193–2200. <https://doi.org/10.1111/j.1538-7836.2011.04486.x>.
- Quinlan DJ, Eriksson BI. Novel oral anticoagulants for thromboprophylaxis after orthopaedic surgery. *Best Pract Res Clin Haematol*. 2013;26(2):171–182. <https://doi.org/10.1016/j.beha.2013.07.003>.
- Blin P, Samama C-M, Sautet A, et al. Comparative effectiveness of direct oral anticoagulants versus low-molecular weight heparins for the prevention of venous thromboembolism after total hip or knee replacement: a nationwide database cohort study. *Pharmacol Res*. 2019;141:201–207. <https://doi.org/10.1016/j.phrs.2018.12.018>.
- Adam SS, McDuffie JR, Lachiewicz PF, Ortel TL, Williams JW. Comparative effectiveness of new oral anticoagulants and standard thromboprophylaxis in patients having total hip or knee replacement: a systematic review. *Ann Intern Med*. 2013;159(4):275–284. <https://doi.org/10.7326/0003-4819-159-4-201308200-00008>.
- Yu Z, Shan P, Yang X, Lou X-J. Comparison of efficiency and safety of rivaroxaban, apixaban and enoxaparin for thromboprophylaxis after arthroplastic surgery: a meta-analysis. *Biosci Rep*. 2018;38(6). <https://doi.org/10.1042/BSR20180423>.
- As-Sultany M, Pagkalos J, Yeganeh S, et al. Use of oral direct factor Xa inhibiting anticoagulants in elective hip and knee arthroplasty: a meta-analysis of efficacy and safety profiles compared with those of low-molecular-weight heparins. *Curr Vasc Pharmacol*. 2013;11(3):366–375. <https://doi.org/10.2174/157016111311030011>.
- Goh EL, Gurung PK, Ma S, et al. Direct oral anticoagulants in the prevention of venous thromboembolism following surgery for hip fracture in older adults: a population-based cohort study. *Geriatr Orthop Surg Rehabil*. 2020;11, 2151459319897520. <https://doi.org/10.1177/2151459319897520>.
- Bruckbauer M, Prexl O, Voelckel W, et al. Impact of direct oral anticoagulants in patients with hip fractures. *J Orthop Trauma*. 2019;33(1):e8–e13. <https://doi.org/10.1097/BOT.0000000000001329>.
- Tsiridis E, Gamie Z, George MJ, Hamilton-Baille D, West RM, Giannoudis PV. Early postoperative bleeding in polytrauma patients treated with fondaparinux: literature review and institutional experience. *Curr Vasc Pharmacol*. 2011;9(1):42–47. <https://doi.org/10.2174/157016111793744670>.
- Godoy Monzon D, Iserson KV, Cid A, Vazquez JA. Oral thromboprophylaxis in pelvic trauma: a standardized protocol. *J Emerg Med*. 2012;43(4):612–617. <https://doi.org/10.1016/j.jemermed.2011.09.006>.
- Hamidi M, Zeeshan M, Sakran JV, et al. Direct oral anticoagulants vs low-molecular-weight heparin for thromboprophylaxis in nonoperative pelvic fractures. *J Am Coll Surg*. 2019;228(1):89–97. <https://doi.org/10.1016/j.jamcollsurg.2018.09.023>.
- Jehan F, O'Keefe T, Khan M, et al. Early thromboprophylaxis with low-molecular-weight heparin is safe in patients with pelvic fracture managed nonoperatively. *J Surg Res*. 2017;219:360–365. <https://doi.org/10.1016/j.jss.2017.06.049>.
- Falk-Ytter Y, Francis CW, Johanson NA, 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–e325S. <https://doi.org/10.1378/chest.11-2404>.
- Ricci WM, Broekhuysen H, Keating JF, Teague DC, White TO. Thromboprophylaxis an update of current practice: can we reach a consensus? *OTA International*. 2019;2(4):e027. <https://doi.org/10.1097/O19.0000000000000027>.
- Fishmann AJ, Greeno RA, Brooks LR, Matta JM. Prevention of deep vein thrombosis and pulmonary embolism in acetabular and pelvic fracture surgery. *Clin Orthop Relat Res*. 1994;305:133–137.
- Steele N, Dodenhoff RM, Ward AJ, Morse MH. Thromboprophylaxis in pelvic and acetabular trauma surgery. The role of early treatment with low-molecular-weight heparin. *J Bone Joint Surg Br*. 2005;87(2):209–212. <https://doi.org/10.1302/0301-620x.87b2.14447>.
- Moed BR, Miller JR, Tabaie SA. Sequential duplex ultrasound screening for proximal deep venous thrombosis in asymptomatic patients with acetabular and pelvic fractures treated operatively. *J Trauma Acute Care Surg*. 2012;72(2):443–447. <https://doi.org/10.1097/TA.0b013e318241090d>.
- Kim J-W, Oh C-W, Oh J-K, et al. The incidence and the risk factors of venous thromboembolism in Korean patients with pelvic or acetabular fractures. *J Orthop Sci*. 2014;19(3):471–477. <https://doi.org/10.1007/s00776-014-0553-z>.
- Niikura T, Lee SY, Oe K, et al. Incidence of venous thromboembolism in pelvic and acetabular fractures in the Japanese population. *J Orthop Sci*. 2012;17(3):233–238. <https://doi.org/10.1007/s00776-012-0203-2>.
- Benjamin E, Aiolfi A, Recinos G, Inaba K, Demetriades D. Timing of venous thromboprophylaxis in isolated severe pelvic fracture: effect on mortality and outcomes. *Injury*. 2019;50(3):697–702. <https://doi.org/10.1016/j.injury.2019.02.009>.
- Ostrowka C, Bonhomme S, Jouffroy P, Riouallon G. Evaluation of venous thromboembolic complications in patients operated on for pelvic fracture. *Orthop Traumatol Surg Res*. 2018;104(6):917–921. <https://doi.org/10.1016/j.otsr.2018.04.017>.
- Geerts WH, Code KI, Jay RM, Chen E, Szalai JP. A prospective study of venous thromboembolism after major trauma. *N Engl J Med*. 1994;331(24):1601–1606. <https://doi.org/10.1056/NEJM199412153312401>.
- Dwyer EP, Moed BR. Venous thromboembolism after hospital discharge in pelvic and acetabular fracture patients treated operatively. *J Orthop Surg*.

- 2019;27(1), 2309499019832815. <https://doi.org/10.1177/2309499019832815>.
41. Stannard JP, Riley RS, McClenney MD, Lopez-Ben RR, Volgas DA, Alonso JE. Mechanical prophylaxis against deep-vein thrombosis after pelvic and acetabular fractures. *J Bone Joint Surg Am.* 2001;83(7):1047–1051. <https://doi.org/10.2106/00004623-200107000-00010>.
 42. Slobogean GP, Lefavre KA, Nicolaou S, O'Brien PJ. A systematic review of thromboprophylaxis for pelvic and acetabular fractures. *J Orthop Trauma.* 2009;23(5):379–384. <https://doi.org/10.1097/BOT.0b013e3181a5369c>.
 43. El-Daly I, Reidy J, Culpán P, Bates P. Thromboprophylaxis in patients with pelvic and acetabular fractures: a short review and recommendations. *Injury.* 2013;44(12):1710–1720. <https://doi.org/10.1016/j.injury.2013.04.030>.
 44. Anderson DR, Morgano GP, Bennett C, et al. American Society of Hematology 2019 guidelines for management of venous thromboembolism: prevention of venous thromboembolism in surgical hospitalized patients. *Blood Adv.* 2019;3(23):3898–3944. <https://doi.org/10.1182/bloodadvances.2019000975>.
 45. Hamada SR, Espina C, Guedj T, et al. High level of venous thromboembolism in critically ill trauma patients despite early and well-driven thromboprophylaxis protocol. *Ann Intensive Care.* 2017;7(1):97. <https://doi.org/10.1186/s13613-017-0315-0>.
 46. Malinoski D, Ewing T, Patel MS, et al. Risk factors for venous thromboembolism in critically ill trauma patients who cannot receive chemical prophylaxis. *Injury.* 2013;44(1):80–85. <https://doi.org/10.1016/j.injury.2011.10.006>.
 47. Arnold JD, Dart BW, Barker DE, et al. Gold Medal Forum Winner. Unfractionated heparin three times a day versus enoxaparin in the prevention of deep vein thrombosis in trauma patients. *Am Surg.* 2010;76(6):563–570.
 48. Hemmila MR, Osborne NH, Henke PK, et al. Prophylactic inferior vena cava filter placement does not result in a survival benefit for trauma patients. *Ann Surg.* 2015;262(4):577–585. <https://doi.org/10.1097/SLA.0000000000001434>.
 49. Sarosiek S, Rybin D, Weinberg J, Burke PA, Kasotakis G, Sloan JM. Association between inferior vena cava filter insertion in trauma patients and in-hospital and overall mortality. *JAMA Surg.* 2017;152(1):75–81. <https://doi.org/10.1001/jamasurg.2016.3091>.
 50. Ho KM, Rao S, Honeybul S, et al. A multicenter trial of vena cava filters in severely injured patients. *N Engl J Med.* 2019;381(4):328–337. <https://doi.org/10.1056/NEJMoa1806515>.
 51. Mismetti P, Laporte S, Pellerin O, et al. Effect of a retrievable inferior vena cava filter plus anticoagulation vs anticoagulation alone on risk of recurrent pulmonary embolism: a randomized clinical trial. *J Am Med Assoc.* 2015;313(16):1627–1635. <https://doi.org/10.1001/jama.2015.3780>.
 52. Rajasekhar A, Lottenberg L, Lottenberg R, et al. A pilot study on the randomization of inferior vena cava filter placement for venous thromboembolism prophylaxis in high-risk trauma patients. *J Trauma.* 2011;71(2):323–328. <https://doi.org/10.1097/TA.0b013e318226ece1>. discussion 328–329.
 53. Kidane B, Madani AM, Vogt K, Girotti M, Malthaner RA, Parry NG. The use of prophylactic inferior vena cava filters in trauma patients: a systematic review. *Injury.* 2012;43(5):542–547. <https://doi.org/10.1016/j.injury.2012.01.020>.
 54. Haut ER, Garcia LJ, Shihab HM, et al. The effectiveness of prophylactic inferior vena cava filters in trauma patients: a systematic review and meta-analysis. *JAMA Surg.* 2014;149(2):194–202. <https://doi.org/10.1001/jamasurg.2013.3970>.
 55. Pan Y, Mei J, Wang L, et al. Investigation of the incidence of perioperative pulmonary embolism in patients with below-knee deep vein thrombosis after lower extremity fracture and evaluation of retrievable inferior vena cava filter deployment in these patients. *Ann Vasc Surg.* 2019;60:45–51. <https://doi.org/10.1016/j.avsg.2019.02.027>.
 56. Webb LX, Rush PT, Fuller SB, Meredith JW. Greenfield filter prophylaxis of pulmonary embolism in patients undergoing surgery for acetabular fracture. *J Orthop Trauma.* 1992;6(2):139–145. <https://doi.org/10.1097/00005131-199206000-00002>.
 57. Giannoudis PV, Pountos I, Pape HC, Patel JV. Safety and efficacy of vena cava filters in trauma patients. *Injury.* 2007;38(1):7–18. <https://doi.org/10.1016/j.injury.2006.08.054>.
 58. Skeik N, Westergard E. Recommendations for VTE prophylaxis in medically ill patients. *Ann Vasc Dis.* 2020;13(1):38–44. <https://doi.org/10.3400/avd.ra.19-00115>.
 59. Mismetti P, Samama C-M, Rosencher N, et al. Venous thromboembolism prevention with fondaparinux 1.5 mg in renally impaired patients undergoing major orthopaedic surgery. A real-world, prospective, multicentre, cohort study. *Thromb Haemostasis.* 2012;107(6):1151–1160. <https://doi.org/10.1160/TH11-09-0640>.
 60. Hester W, Fry C, Gonzalez D, Cohen-Wolkowicz M, Inman BA, Ortel TL. Thromboprophylaxis with fondaparinux in high-risk postoperative patients with renal insufficiency. *Thromb Res.* 2014;133(4):629–633. <https://doi.org/10.1016/j.thromres.2013.11.019>.
 61. Zufferey PJ, Ollier E, Delavenne X, Laporte S, Mismetti P, Duffull SB. Incidence and risk factors of major bleeding following major orthopaedic surgery with fondaparinux thromboprophylaxis. A time-to-event analysis. *Br J Clin Pharmacol.* 2018;84(10):2242–2251. <https://doi.org/10.1111/bcp.13663>.