Recommendations from the ICM-VTE: Sports

The ICM-VTE Sports Delegates*

1- Concerning VTE risk, which surgeries can be considered major, and which surgeries can be considered non-major in orthopaedic sports surgery?

Response/Recommendation: Overall, venous thromboembolism (VTE) incidence in sports surgery is low, and risk of VTE increases with immobilization and non-weight bearing. For this reason, upper extremity sports procedures are considered non-major concerning VTE risk due to the low impact on patient ambulation and post-operative mobility. Lower extremity procedures can be considered non-major if patients can weight bear and mobilize post-operatively. Patients undergoing lower extremity sports procedures that places weight bearing restriction and/or limits ambulation may be considered major.

Strength of recommendation: Consensus.

Delegates vote: Agree 96.15% Disagree 0.0% Abstain 3.85% (Strong Consensus).

Rationale: There have been several large cohort studies looking at overall risk of symptomatic VTE in common orthopaedic sports procedures[1-5] with overall a much lower incidence of VTE in this patient population than those undergoing trauma or arthroplasty procedures[6-9]. Despite this, VTE still remains an important, and potentially fatal, complication of orthopaedic surgery which warrants investigations. In 2012, the American College of Chest Physicians (ACCP) published guidelines on VTE prevention in patients undergoing knee arthroscopy, recommending that no thromboprophylaxis is needed in these patients[7]. There have not been significant revisions to these guidelines since their publication.

Risks for VTE after orthopaedic sports procedures have been described in various studies. While duration of surgery has been shown to be a risk factor in patients who develop VTE[10], this risk factors is not universally accepted as a reliable metric for determining the overall risk of a patient for VTE. Several studies have shown that orthopaedic procedures which require postoperative immobilization put patients at an increased risk of developing symptomatic VTE[11,12]. Additionally, patients who are required to be non-weightbearing on their operative extremity have been shown to have increased incidence of VTE postoperatively[13]. These factors were taken into account when formulating our recommendation above.

Upper extremity procedures in sports medicine primarily consist of open and arthroscopic shoulder and elbow procedures, of which VTE risk is reported to be a rare complication. Systematic reviews report the incidence of VTE to be 0.038% to 0.3% after shoulder arthroscopic procedures[4,14]. Weight-bearing restrictions are not as provocative for VTE formation in patients, as they typically do not significantly hinder ambulation, which has been shown to decrease VTE risk[15,16]. Upper limb immobilization was not found to increase VTE risk, with literature reporting only two cases of thrombosis of the arm after shoulder arthroscopy and immobilization on a total of 10,452 cases[17,18].

Lower extremity orthopaedic sports medicine procedures are very diverse in nature and severity. Arthroscopic and open procedures about the hip, including labral repair and reconstruction, osteochondroplasty procedures, and tendon repairs such as of the gluteus medius or proximal hamstring are more recently being treated with accelerated early weight-bearing and range of motion[19-21]. While there is a paucity of studies specifically evaluating the incidence of deep venous thrombosis (DVT) following these procedures, a recent systematic review estimated the risk in patients undergoing hip arthroscopy to be ~ 2%[5]. Similarly, for hamstring avulsion repair the estimated VTE incidence was found to be 0.5%[22].

Knee arthroscopy is one of the most common procedures in all of orthopaedics, and concomitant procedures can include anterior and/o posterior cruciate ligament repair/reconstruction, meniscus excision/repair/transplantation, osteochondral defect fixation/drilling/grafting, among others. The reported incidence of DVT without prophylaxis after knee arthroscopy varies from 0.2% to 18%, with higher rates detected when screening asymptomatic patients[23-25]. The higher-than-expected rate of DVT in knee arthroscopy without prophylaxis, has led some studies to recommend chemoprophylaxis after this procedure[26-29]. Nevertheless, consensus on VTE prophylaxis after knee arthroscopy has not been reached and varies by country. In the US, the ACCP guidelines suggest no VTE prophylaxis is necessary for

*A list of the ICM-VTE Sports Delegates is included in a note at the end of the article.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJS/G853).

arthroscopic knee procedures for patients without prior history of VTE[7]. For open procedures about the knee such as high tibial osteotomy (HTO), distal femoral osteotomy (DFO), and tibial tubercle osteotomy (TTO) the reported VTE risk varies over a wide range depending on inclusion of asymptomatic VTE. HTO has a reported VTE incidence that ranges from 2.4 - 41%[30,31] A recent study by Erickson et al., estimated symptomatic VTE rates after HTO, DFO or TTO to be less than 2%[32]. Currently, there is no consensus regarding thromboprophylaxis in HTO, DFO or TTO, however given the need for prolonged restricted weight-bearing, administration of VTE prophylaxis may need to be considered in this patient population.

In conclusion, the overall VTE risk is very low in patients undergoing orthopaedic sports surgery. Based on expert opinion and limited evidence, upper extremity sports medicine procedures should be considered non-major concerning VTE risk due to their low impact on ambulation and postoperative mobility. Similarly, lower extremity procedures for which patients are allowed to bear weight and mobilize postoperatively should be considered non-major. Lower extremity procedures for which patients have their weight-bearing restricted or their operative extremity immobilized in the postoperative period should be considered major as it pertains to VTE risk. Although rare, knee sports surgeries have a slightly higher VTE risk with VTE prophylaxis recommended based on risk stratification. For this reason, knee procedures in which patients are non-weight bearing and immobilized are considered major, while all other ones with no limitations on weight-bearing and range of motion are considered non-major.

Martina Rama, Bryson R. Kemler, Sommer Hammoud

References

1. Kanchanabat B, Stapanavatr W, Meknavin S, Soorapanth C, Sumanasrethakul C, Kanchanasuttirak P. Systematic review and meta-analysis on the rate of postoperative venous thromboembolism in orthopaedic surgery in Asian patients without thromboprophylaxis. Br J Surg. 2011 Oct;98(10):1356-64.

2. Sun Y, Chen D, Xu Z, Shi D, Dai J, Qin J, Qin J, Jiang Q. Deep venous thrombosis after knee arthroscopy: a systematic review and meta-analysis. Arthroscopy. 2014 Mar;30(3):406-12.

3. Maletis GB, Inacio MCS, Reynolds S, Funahashi TT. Incidence of symptomatic venous thromboembolism after elective knee arthroscopy. J Bone Joint Surg Am. 2012 Apr 18;94(8):714-20.

4. Dattani R, Smith CD, Patel VR. The venous thromboembolic complications of shoulder and elbow surgery: a systematic review. Bone Joint J. 2013 Jan;95-B(1):70-4.

5. Bolia IK, Fagotti L, McNamara S, Dornan G, Briggs KK, Philippon MJ. A systematic review-meta-analysis of venous thromboembolic events following primary hip arthroscopy for FAI: clinical and epidemiologic considerations. J Hip Preserv Surg. 2018 Aug 17;5(3):190-201.

6. Matharu GS, Kunutsor SK, Judge A, Blom AW, Whitehouse MR. Clinical Effectiveness and Safety of Aspirin for Venous Thromboembolism Prophylaxis After Total Hip and Knee Replacement: A Systematic Review and Meta-analysis of Randomized Clinical Trials. JAMA Intern Med. 2020 Mar 1;180(3):376-84.

7. Falck-Ytter Y, Francis CW, Johanson NA, Curley C, Dahl OE, Schulman S, Ortel TL, Pauker SG, Colwell CW Jr. 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 Feb; 141(2)(Suppl):e278S-325S.

8. Flevas DA, Megaloikonomos PD, Dimopoulos L, Mitsiokapa E, Koulouvaris P, Mavrogenis AF. Thromboembolism prophylaxis in orthopaedics: an update. EFORT Open Rev. 2018 Apr 27;3(4):136-48.

9. Patterson JT, Morshed S. Chemoprophylaxis for Venous Thromboembolism in Operative Treatment of Fractures of the Tibia and Distal Bones: A Systematic Review and Meta-analysis. J Orthop Trauma. 2017 Sep;31(9): 453-60.

10. Kim JYS, Khavanin N, Rambachan A, McCarthy RJ, Mlodinow AS, De Oliveria GS Jr, Stock MC, Gust MJ, Mahvi DM. Surgical duration and risk of venous thromboembolism. JAMA Surg. 2015 Feb;150(2):110-7.

11. Braithwaite I, Healy B, Cameron L, Weatherall M, Beasley R. Lower limb immobilisation and venous thromboembolism risk: combined case-control studies. Postgrad Med J. 2017 Jun;93(1100):354-9.

12. Bui MH, Hung DD, Vinh PQ, Hiep NH, Anh LL, Dinh TC. Frequency and Risk Factor of Lower-limb Deep Vein Thrombosis after Major Orthopedic Surgery in Vietnamese Patients. Open Access Maced J Med Sci. 2019 Dec 20;7(24): 4250-4.

13. Riou B, Rothmann C, Lecoules N, Bouvat E, Bosson JL, Ravaud P, Samama CM, Hamadouche M. Incidence and risk factors for venous thromboembolism in patients with nonsurgical isolated lower limb injuries. Am J Emerg Med. 2007 Jun;25(5): 502-8.

14. Sager B, Ahn J, Tran J, Khazzam M. Timing and Risk Factors for Venous Thromboembolism After Rotator Cuff Repair in the 30-Day Perioperative Period. Arthroscopy. 2019 Nov;35(11):3011-8.

15. Chindamo MC, Marques MA. Role of ambulation to prevent venous thromboembolism in medical patients: where do we stand? J Vasc Bras. 2019 Jun 25;18:e20180107.

16. Wilson K, Devito D, Zavotsky KE, Rusay M, Allen M, Huang S. Keep It Moving and Remember to P.A.C. (Pharmacology, Ambulation, and Compression) for Venous Thromboembolism Prevention. Orthop Nurs. 2018 Nov/Dec;37(6):339-45.

17. Garofalo R, Notarnicola A, Moretti L, Moretti B, Marini S, Castagna A. Deep vein thromboembolism after arthroscopy of the shoulder: two case reports and a review of the literature. BMC Musculoskelet Disord. 2010 Apr 8; 11:65.

18. Peivandi MT, Nazemian Z. Clavicular fracture and upper-extremity deep venous thrombosis. Orthopedics. 2011 Mar 11;34(3):227.

19. Kaeding CC, Leger-St-Jean B, Gorica Z, Magnussen RA, Vasileff WK. Accelerated Rehabilitation Following Repair of Proximal Hamstring Avulsion: 4 Year Outcomes. Orthop J Sports Med. 2017 Jul;5(7_suppl6): 2325967117S0024.

20. Nho S, Rasio J. Editorial Commentary: Rehabilitation After Hip Arthroscopy-Bear in Mind the Bearing of Weight. Arthroscopy. 2020 Jan;36(1):165-6.

21. Grzybowski JS, Malloy P, Stegemann C, Bush-Joseph C, Harris JD, Nho SJ. Rehabilitation Following Hip Arthroscopy - A Systematic Review. Front Surg. 2015 May 26;2:21.

22. Asokan A, Plastow R, Chang JS, Kayani B, Moriarty P, Thompson JW, Haddad FS. Incidence of Symptomatic Venous Thromboembolism in Proximal Hamstring Repair: A Prospective Cohort Study. Orthop J Sports Med. 2021 Jul 19;9(7): 23259671211012420.

23. Reynolds AW, Garay M, Lynch S, Black KP, Gallo RA. Incidence of Venous Thromboembolism following Knee Arthroscopy: Effectiveness of a Risk-Based Stratified Chemoprophylaxis Protocol. J Knee Surg. 2020 Aug 31.

24. Ramos J, Perrotta C, Badariotti G, Berenstein G. Interventions for preventing venous thromboembolism in adults undergoing knee arthroscopy. Cochrane Database Syst Rev. 2008 Oct 8;(4):CD005259.

25. Mauck KF, Froehling DA, Daniels PR, Dahm DL, Ashrani AA, Crusan DJ, Petterson TM, Bailey KR, Heit JA. Incidence of venous thromboembolism after elective knee arthroscopic surgery: a historical cohort study. J Thromb Haemost. 2013 Jul;11(7):1279-86.

26. Wirth T, Schneider B, Misselwitz F, Lomb M, Tüylü H, Egbring R, Griss P. Prevention of venous thromboembolism after knee arthroscopy with low-molecular weight heparin (reviparin): Results of a randomized controlled trial. Arthroscopy. 2001 Apr;17(4):393-9.

27. Michot M, Conen D, Holtz D, Erni D, Zumstein MD, Ruflin GB, Renner N. Prevention of deep-vein thrombosis in ambulatory arthroscopic knee surgery: A randomized trial of prophylaxis with low—molecular weight heparin. Arthroscopy. 2002 Mar;18(3):257-63.

28. Marlovits S, Striessnig G, Schuster R, Stocker R, Luxl M, Trattnig S, Vécsei V. Extended-duration thromboprophylaxis with enoxaparin after arthroscopic surgery of the anterior cruciate ligament: a prospective, randomized, placebo-controlled study. Arthroscopy. 2007 Jul;23(7):696-702.

29. Camporese G, Bernardi E, Prandoni P, Noventa F, Verlato F, Simioni P, Ntita K, Salmistraro G, Frangos C, Rossi F, Cordova R, Franz F, Zucchetta P, Kontothanassis D, Andreozzi GM; KANT (Knee Arthroscopy Nadroparin Thromboprophylaxis) Study Group. Low-molecular-weight heparin versus compression stockings for thromboprophylaxis after knee arthroscopy: a randomized trial. Ann Intern Med. 2008 Jul 15;149(2):73-82.

30. Martin R, Birmingham TB, Willits K, Litchfield R, Lebel ME, Giffin JR. Adverse event rates and classifications in medial opening wedge high tibial osteotomy. Am J Sports Med. 2014 May;42(5):1118-26.

31. Miller BS, Downie B, McDonough EB, Wojtys EM. Complications after medial opening wedge high tibial osteotomy. Arthroscopy. 2009 Jun;25(6):639-46.

32. Erickson BJ, Tilton A, Frank RM, Park W, Cole BJ. Rates of Deep Vein Thrombosis Occurring After Osteotomy About the Knee. Am J Orthop (Belle Mead NJ). 2017 Jan/Feb;46(1):E23-7.

2- Is routine VTE prophylaxis required for patients undergoing knee arthroscopy who will be allowed to fully weight bear after surgery?

Response/Recommendation: There is insufficient evidence to recommend routine thromboprophylaxis to all otherwise healthy patients undergoing a knee arthroscopic procedure.

Strength of Recommendation: Moderate.

Delegates vote: Agree 96.15% Disagree 0.00% Abstain 3.85% (Strong Consensus).

Rationale: Knee arthroscopy (KA) is the most common outpatient orthopaedic procedure worldwide. Approximately 1 million knee arthroscopies are performed annually in the US, and 5 million worldwide[33,34]. Despite the high prevalence of this intervention, the risk of symptomatic venous thromboembolism (VTE), including deep venous thrombosis (DVT) or pulmonary embolus (PE), following the procedure is extremely low[1]. In addition, consideration must be given to the fact that thromboprophylaxis is not without its risks, with many reports of minor or major bleeding in the literature[35].

In a recent meta-analysis of seven randomized controlled trials (RCT), Huang et al.[36], found that the use of low-molecular-weight heparin (LMWH) after KA was not associated with reduced rates of symptomatic VTE. A subsequent systematic review and meta-analysis by the same authors included all RCT reporting the use of other types of anticoagulants (rivaroxaban and aspirin [ASA]) and found that these agents were also ineffective in the prevention of VTE as compared to no thromboprophylaxis[37].

In regards to patients undergoing KA ligament reconstruction, thromboprophylaxis should take into account the patient's risk factors[38-40]. Perrota et al., performed a meta-analysis of eight RCT and controlled clinical trials with 3,818 patients, comparing different thromboprophylactic methods in patients who had undergone KA procedures. While their results suggested that LMWH could reduce the incidence of asymptomatic DVT, there was no clear benefit of LMWH, ASA or rivaroxaban over placebo or no intervention in the prevention of PE or symptomatic DVT. They also found no difference in the rate of adverse events such as major or minor bleeding but acknowledged that the data for this endpoint was limited due to low number of events[40].

In evaluating the efficacy and safety of anticoagulants after KA, Yu et al.[41], performed another systematic review and meta-analysis, which included 4,097 patients. They concluded that anticoagulants could effectively reduce the overall risk of VTE after KA, although the increased risk of bleeding should be considered. They also found that the Number Needed to Harm (NNH) for any bleeding event was 20 and the NNH for a major bleeding or fatal event was 869.

In light of the evidence presented above, it is the recommendation of this workgroup that there is not sufficient data to recommend thromboprophylaxis to all otherwise healthy patients undergoing KA who will be weight-bearing postoperatively. This question still remains valid when encountering patients with procoagulant comorbidities, or those who are taking oral contraceptives (e.g., younger patients undergoing anterior cruciate ligament reconstruction). More research is needed to clarify if routine prophylaxis should be indicated in this group of individuals[38,41], and prophylactic measures should be individualized, taking into account all the risk factors present at the time of the surgical intervention.

Renny A. Cárdenas, Carlos G. Sánchez Valenciano

References

33. Mauck KF, Froehling DA, Daniels PR, Dahm DL, Ashrani AA, Crusan DJ, Petterson TM, Bailey KR, Heit JA. Incidence of venous thromboembolism after elective knee arthroscopic surgery: a historical cohort study. J Thromb Haemost. 2013 Jul;11(7):1279-86.

34. Camporese G, Bernardi E, Noventa F, Bosco M, Monteleone G, Santoro L, Bortoluzzi C, Freguja S, Nardin M, Marullo M, Zanon G, Mazzola C, Damiani G, Maniscalco P, Imberti D, Lodigiani C, Becattini C, Tonello C, Agnelli G; ERIKA Study Group. Efficacy of Rivaroxaban for thromboprophylaxis after Knee Arthroscopy (ERIKA). A phase II, multicentre, double-blind, placebo-controlled randomised study. Thromb Haemost. 2016 Aug 1;116(2):349-55.

35. Greene JW, Deshmukh AJ, Cushner FD. Thromboembolic complications in arthroscopic surgery. Sports Med Arthrosc Rev. 2013 Jun;21(2):69-74.

36. Huang HF, Tian JL, Yang XT, Sun L, Hu RY, Yan ZH, Li SS, Xie Q, Tian XB. Efficacy and safety of low-molecular-weight heparin after knee arthroscopy: A meta-analysis. PLoS One. 2018 Jun 21;13(6):e0197868.

37. Huang HF, Tian JL, Sun L, Yang XT, Shen YK, Li SS, Xie Q, Tian XB. The effect of anticoagulants on venous thrombosis prevention after knee arthroscopy: a systematic review. Int Orthop. 2019 Oct;43(10):2303-8.

38. Zhu J, Jiang H, Marshall B, Li J, Tang X. Low-Molecular-Weight Heparin for the Prevention of Venous Thromboembolism in Patients Undergoing Knee Arthroscopic Surgery and Anterior Cruciate Ligament Reconstruction: A Meta-analysis of Randomized Controlled Trials. Am J Sports Med. 2019 Jul;47(8):1994-2002.

39. Zheng G, Tang Q, Shang P, Pan XY, Liu HX. No effectiveness of anticoagulants for thromboprophylaxis after non-major knee arthroscopy: a systemic review and meta-analysis of randomized controlled trials. J Thromb Thrombolysis. 2018 May;45(4):562-70.

40. Perrotta C, Chahla J, Badariotti G, Ramos J. Interventions for preventing venous thromboembolism in adults undergoing knee arthroscopy. Cochrane Database Syst Rev. 2020 May 6;5:CD005259.

41. Yu Y, Lu S, Sun J, Zhou W, Liu H. Thromboprophylactic Efficacy and Safety of Anticoagulants After Arthroscopic Knee Surgery: A Systematic Review and Meta-Analysis. Clin Appl Thromb Hemost. 2019 Jan-Dec;25:1076029619881409.

3- What is the most optimal VTE prophylaxis for patients undergoing arthroscopic knee surgery who are instructed to remain non-weight bearing for a prolonged period of time?

Response/Recommendation: There are no studies in the literature that have specifically investigated the correlation between non-weightbearing after knee arthroscopy and the incidence of venous thromboembolism (VTE). Consequently, no specific prophylactic measures have been recommended for this patient population. Considering that non-weight bearing is a known risk factor for VTE, we support the routine use of

VTE prophylaxis in these patients unless a high risk of bleeding is present or postoperative bleeding occurs.

Strength of Recommendation: Consensus.

Delegates vote: Agree 92.00% Disagree 4.00% Abstain 4.00% (Strong Consensus).

Rationale: Knee arthroscopy (KA) is one of the most common orthopaedic procedures performed worldwide, with an estimated 4 million surgeries performed each year[42]. One of the most frequent complication, and the most common cause of perioperative mortality after KA is VTE[43,44]. The incidence of VTE after KA has been reported to be 0.4% when clinically diagnosed and up to 17.9% when screening asymptomatic patients[45-48]. The largest retrospective cohort study in the literature (n = 20,770) showed a ninety-day incidence of 0.02% for pulmonary embolism (PE) and 0.25% for deep venous thrombosis (DVT) in patients undergoing KA without thromboembolic prophylaxis[49]. When diagnosed with ultrasound or venography, a previous meta-analysis found an overall DVT rate of 9.9% and a proximal DVT rate of 2.1% in KA patients who did not receive prophylaxis[50].

Although the main purpose of VTE prophylaxis is to avoid fatal PE, DVT alone can lead to substantial pain and swelling, as well as the development of post-thrombotic syndrome. This complication occurs in the lower extremities in approximately 30% of symptomatic DVT patients within 5 years of surgery[51]. Despite this, the use of VTE prophylaxis following KA procedures is controversial, and current recommendations vary across different countries[52-59]. A recent Cochrane Systematic Review and four separate meta-analyses concluded that the incidence of PE and symptomatic DVT following KA was not reduced with the use of low-molecular-weight heparin (LMWH), aspirin (ASA) or rivaroxaban (moderate- to low-evidence)[43,60-63]. On the other hand, LMWH use may reduce the risk of asymptomatic DVT when compared to no treatment, and a meta-analysis of randomized controlled trials (RCT) concluded that anticoagulants could reduce the overall incidence of VTE in patients undergoing KA[42,43,47,64-68]. The authors estimated that, in order to prevent one symptomatic or asymptomatic VTE, the Number Needed to Treat (NNT) was 26, and one major or fatal bleeding event could occur with every 869 patients treated with VTE prophylaxis (Number Needed to Harm [NNH] = 869)[64]. The conflicting conclusions regarding VTE prophylaxis underscores the need to consider the specific KA procedure performed and the postoperative protocol implemented[62,69].

There is a lack of studies investigating the risk of VTE in patients undergoing KA procedures that require a period of non-weight-bearing after surgery. Consequently, there may be a risk of underestimating the efficacy of DVT and VTE prophylaxis according to different KA procedures[70]. For example, Kosiur et al.[71], studied 567 osteochondral autograft transfer surgery (OATS) patients who were provided different instructions for non-weight-bearing after surgery. Overall, 68 patients were instructed not to bear weight for 4 weeks postoperatively (29 of which had a concomitant anterior cruciate ligament reconstruction), while 437 were allowed to bear weight as tolerated immediately after surgery. Thromboembolic prophylaxis was not provided to any patient. The authors found a significant difference between the incidence of DVT in patients who were non-weight-bearing (3.0%) and in those who were allowed to bear weight as tolerated (0.69%). Only one patient developed a PE in the non-weight-bearing group (1.5%), whereas no patients developed a PE in the weight-bearing as tolerated group.

Although current literature does not focus on non-weight-bearing KA procedures in particular, the use of LMWH, rivaroxaban and ASA as thromboembolic prophylaxis appears to be safe (moderate-certainty evidence) and logical in high-risk patients[43]. It has been shown that a higher incidence of VTE after KA is associated with patient-specific risk factors, such as classic VTE risk factors, be it genetic or acquired[58,70,72]. Age is considered a significant risk factor, with patients 50 years of age or older having a 1.54 times greater risk of VTE (LoE II)[49]. Also, ligament reconstruction, more complex procedures (cartilage or meniscal repair), and prolonged surgical and tourniquet time have been identified as possible VTE risk factors[46,49,58,73,74].

Overall, there is a paucity of research on the optimal VTE prophylaxis regime for patients undergoing non-weight-bearing KA procedures, and thus the current recommendations are based on expert consensus on general KA literature. Due to the significantly increased incidence of DVT in non-weight-bearing patients (3.0% vs. 0.7%), the NNT and NNH can be assumed to be much smaller for non-weight-bearing patients relative to data on overall KA (NNT = 26, NNH = 869)[64]. Until further evidence is available, clinicians should consider utilizing LMWH, rivaroxaban or ASA after non-weight-bearing KA procedures such as autologous chondrocyte implantation (ACI), OATS, microfracture, or meniscal repair in order to limit the thrombotic risk associated with prolonged non-weight-bearing. Future research should focus on preventing VTE specifically after non-weight-bearing KA procedures, rather than pooling all KA procedures together regardless of weight-bearing status. Clinical trials comparing different VTE prophylactic agents should be performed to determine the optimal drug and dosage to be administered.

Manuel G. Mazzoleni, Maxime Fabre-Aubrespy, Ryan W. Paul, Fotios P. Tjoumakaris, Filippo Randelli

References

42. Camporese G, Bernardi E, Noventa F, Bosco M, Monteleone G, Santoro L, Bortoluzzi C, Freguja S, Nardin M, Marullo M, Zanon G, Mazzola C, Damiani G, Maniscalco P, Imberti D, Lodigiani C, Becattini C, Tonello C, Agnelli G; ERIKA Study Group. Efficacy of Rivaroxaban for thromboprophylaxis after Knee Arthroscopy (ERIKA). A phase II, multicentre, double-blind, placebo-controlled randomised study. Thromb Haemost. 2016 Aug 1;116(2):349-55.

43. Perrotta C, Chahla J, Badariotti G, Ramos J. Interventions for preventing venous thromboembolism in adults undergoing knee arthroscopy. Cochrane Database Syst Rev. 2020 May 6;5:CD005259.

44. Kieser C. A review of the complications of arthroscopic knee surgery. Arthroscopy. 1992;8(1):79-83.
45. Dahl OE, Gudmundsen TE, Haukeland L. Late occurring clinical deep vein thrombosis in joint-operated patients. Acta Orthop Scand. 2000 Feb;71(1):47-50.
46. Demers C, Marcoux S, Ginsberg JS, Laroche F, Cloutier R, Poulin J. Incidence of venographically proved deep vein thrombosis after knee arthroscopy. Arch Intern Med. 1998 Jan 12;158(1):47-50.
47. Michot M, Conen D, Holtz D, Erni D, Zumstein MD, Ruflin GB, Renner N. Prevention of deep-vein thrombosis in ambulatory arthroscopic knee surgery: A randomized trial of prophylaxis with low—molecular weight heparin. Arthroscopy. 2002 Mar;18(3):257-63.
48. Ramos J, Perrotta C, Badariotti G, Berenstein G. Interventions for preventing venous thromboembolism in adults undergoing knee arthroscopy. Cochrane Database Syst Rev. 2008 Oct 8;(4):CD005259.
49. Maletis GB, Inacio MCS, Reynolds S, Funahashi TT. Incidence of symptomatic venous thromboembolism after elective knee arthroscopy. J Bone Joint Surg Am. 2012 Apr 18;94(8):714-20.
50. Ilahi OA, Reddy J, Ahmad I. Deep venous thrombosis after knee arthroscopy: a meta-analysis. Arthroscopy. 2005 Jun;21(6):727-30.
51. Prandoni P, Lensing AW, Cogo A, Cuppini S, Villalta S, Carta M, Cattelan AM, Polistena P, Bernardi E, Prins MH. The long-term clinical course of acute deep venous thrombosis. Ann Intern Med. 1996 Jul 1;125(1):1-7.
52. Abouali J, Farrokhyar F, Peterson D, Ogilvie R, Ayeni O. Thromboprophylaxis in routine arthroscopy of knee. Indian J Orthop. 2013 Mar;47(2):168-73.
53. Ettema HB, Mulder MC, Nurmohamed MT, Büller HR, Verheyen CCPM. Dutch orthopedic thromboprophylaxis: a 5-year follow-up survey. Acta Orthop. 2009 Feb;80(1):109-12.
54. Kalka C, Spirk D, Siebenrock KA, Metzger U, Tuor P, Sterzing D, Oehy K, Wondberg D, Mouhsine Y, Gautier E, Kucher N. Lack of extended venous thromboembolism prophylaxis in high-risk patients undergoing major orthopaedic or major cancer surgery. Electronic Assessment of VTE Prophylaxis in High-Risk Surgical Patients at Discharge from Swiss Hospitals (ESSENTIAL). Thromb Haemost. 2009 Jul;102(1):56-61.
55. Kessler P. [Venous thromboembolism prophylaxis in orthopaedics and traumatology]. Vnitr Lek. 2009 Mar;55(3):204-10. Czech.
56. Müller-Rath R, Ingenhoven E, Mumme T, Schumacher M, Miltner O. [Perioperative management in outpatient arthroscopy of the knee joint]. Z Orthop Unfall. 2010 May;148(3):282-7. German.
57. Redfern J, Burks R. 2009 survey results: surgeon practice patterns regarding arthroscopic surgery. Arthroscopy. 2009 Dec;25(12):1447-52.
58. van Adrichem RA, van Oosten JP, Cannegieter SC, Schipper IB, Nelissen RGHH. Thromboprophylaxis for lower leg cast immobilisation and knee arthroscopy: a survey study. Neth J Med. 2015 Jan;73(1):23-9.
59. Falck-Ytter Y, Francis CW, Johanson NA, Curley C, Dahl OE, Schulman S, Ortel TL, Pauker SG, Colwell CW Jr. 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 Feb;141(2)(Suppl):e278S-325S.
60. Huang HF, Tian JL, Sun L, Yang XT, Shen YK, Li SS, Xie Q, Tian XB. The effect of anticoagulants on venous thrombosis prevention after knee arthroscopy: a systematic review. Int Orthop. 2019 Oct;43(10):2303-8.
61. Huang HF, Tian JL, Yang XT, Sun L, Hu RY, Yan ZH, Li SS, Xie Q, Tian XB. Efficacy and safety of low-molecular-weight heparin after knee arthroscopy: A meta-analysis. PLoS One. 2018 Jun 21;13(6):e0197868.
62. Zheng G, Tang Q, Shang P, Pan XY, Liu HX. No effectiveness of anticoagulants for thromboprophylaxis after non-major knee arthroscopy: a systemic review and meta-analysis of randomized controlled trials. J Thromb Thrombolysis. 2018 May;45(4):562-70.
63. Zhu J, Jiang H, Marshall B, Li J, Tang X. Low-Molecular-Weight Heparin for the Prevention of Venous Thromboembolism in Patients Undergoing Knee Arthroscopic Surgery and Anterior Cruciate Ligament Reconstruction: A Meta-analysis of Randomized Controlled Trials. Am J Sports Med. 2019 Jul;47(8):1994-2002.
64. Yu Y, Lu S, Sun J, Zhou W, Liu H. Thromboprophylactic Efficacy and Safety of Anticoagulants After Arthroscopic Knee Surgery: A Systematic Review and Meta-Analysis. Clin Appl Thromb Hemost. 2019 Jan-Dec;25:1076029619881409.
65. Camporese G, Bernardi E, Prandoni P, Noventa F, Verlato F, Simioni P, Ntita K, Salmistraro G, Frangos C, Rossi F, Cordova R, Franz F, Zucchetta P, Kontothanassis D, Andreozzi GM; KANT (Knee Arthroscopy Nadroparin Thromboprophylaxis) Study Group. Low-molecular-weight heparin versus compression stockings for thromboprophylaxis after knee arthroscopy: a randomized trial. Ann Intern Med. 2008 Jul 15;149(2):73-82.
66. Kaye ID, Patel DN, Strauss EJ, Alaia MJ, Garofolo G, Martinez A, Jazrawi LM. Prevention of Venous Thromboembolism after Arthroscopic Knee Surgery in a Low-Risk Population with the Use of Aspirin. A Randomized Trial. Bull Hosp Jt Dis (2013). 2015 Dec;73(4):243-8.
67. van Adrichem RA, Nemeth B, Algra A, le Cessie S, Rosendaal FR, Schipper IB, Nelissen RGHH, Cannegieter SC; POT-KAST and POT-CAST Group. Thromboprophylaxis after Knee Arthroscopy and Lower-Leg Casting. N Engl J Med. 2017 Feb 9;376(6):515-25.
68. Wirth T, Schneider B, Misselwitz F, Lomb M, Tüylü H, Egbring R, Griss P. Prevention of venous thromboembolism after knee arthroscopy with low-molecular weight heparin (reviparin): Results of a randomized controlled trial. Arthroscopy. 2001 Apr;17(4):393-9.
69. Zhu J, Jiang H, Marshall B, Li J, Tang X. Low-Molecular-Weight Heparin for the Prevention of Venous Thromboembolism in Patients Undergoing Knee Arthroscopic Surgery and Anterior Cruciate Ligament Reconstruction: A Meta-analysis of Randomized Controlled Trials. Am J Sports Med. 2019 Jul;47(8):1994-2002.
70. Graham WC, Flanigan DC. Venous thromboembolism following arthroscopic knee surgery: a current concepts review of incidence, prophylaxis, and preoperative risk assessment. Sports Med. 2014 Mar;44(3):331-43.
71. Kosiur JR, Collins RA. Weight-bearing compared with non-weight-bearing following osteochondral autograft transfer for small defects in weight-bearing areas in the femoral articular cartilage of the knee. J Bone Joint Surg Am. 2014 Aug 20;96(16):e136.
72. Delis KT, Hunt N, Strachan RK, Nicolaides AN. Incidence, natural history and risk factors of deep vein thrombosis in elective knee arthroscopy. Thromb Haemost. 2001 Sep;86(3):817-21.
73. Mauck KF, Froehling DA, Daniels PR, Dahm DL, Ashrani AA, Crusan DJ, Petterson TM, Bailey KR, Heit JA. Incidence of venous thromboembolism after elective knee arthroscopic surgery: a historical cohort study. J Thromb Haemost. 2013 Jul;11(7):1279-86.
74. Sun Y, Chen D, Xu Z, Shi D, Dai J, Qin J, Jiang Q. Incidence of symptomatic and asymptomatic venous thromboembolism after elective knee arthroscopic surgery: a retrospective study with routinely applied venography. Arthroscopy. 2014 Jul;30(7):818-22.

4- What is the most optimal VTE prophylaxis for patients undergoing ACL reconstruction?

Response/Recommendation: There is a small risk of venous thromboembolism (VTE) following anterior cruciate ligament (ACL) reconstruction in healthy adult patients. There is moderate- to low-evidence supporting the use of low-molecular-weight heparin (LMWH), aspirin (ASA) or rivaroxaban in the prevention of pulmonary embolism (PE) and symptomatic deep venous thrombosis (DVT). Similarly, there is a very low level of evidence supporting the use of LMWH in preventing asymptomatic DVT when compared to no treatment. No difference in the rate of adverse events (including major and minor bleeding) between LMWH, ASA and rivaroxaban has been shown, although data on this safety endpoint is limited due to low numbers of events in existing studies. To this end, appropriate risk stratification, considering factors such as medical comorbidities, weight-bearing status, and the use of immobilization, is therefore necessary.

Strength of Recommendation: Moderate.

Delegates vote: Agree 100.00% Disagree 0.0% Abstain 0.00% (Unanimous Strong Consensus).

Rationale: There is lack of high-quality studies on the optimal VTE prophylaxis for ACL reconstruction patients postoperatively. In general, the incidence of VTE after ACL reconstruction is low, although complications can be devastating. Gaskill et al.[75], analyzed the United States Military Healthcare System (MHS) database across a seven-year period, which included 16,558 patients with a mean age of 29 years. The authors found that the risk of VTE was 0.53% (0.33% DVT and

0.21% PE). Jameson et al.[76], used the English National Health Service (NHS) database and found an incidence of VTE of 0.4% in 13,941 patients, with a mean age of 29 years in patients who underwent ACL reconstruction. Maletis et al.[77], analyzed the Kaiser Permanente ACL reconstruction registry and reported an incidence of VTE of 0.3% in 16,192 patients with a mean age of 30 years. An increased odds of VTE was identified in patients aged ≥ 35 years with a history of nicotine use, anticoagulant use, concomitant high tibial osteotomy, concomitant posterior cruciate ligament reconstruction, tourniquet time of more than 120 minutes and an operating time of more than 90 minutes[75,78].

Thromboprophylaxis recommendations after knee arthroscopic surgery vary from one country to another. According to the guidelines of the American College of Chest Physicians (ACCP)[79], the risk associated with arthroscopic surgery has been considered to be low, and while some societies have advocated for routine thromboprophylaxis after ACL reconstruction, the ACCP guidelines recommend against its routine use after arthroscopic procedures except in patients with previous VTE[76,78,80]. Although the ACCP guidelines do recommend routine thromboprophylaxis for "major" orthopaedic procedures[79], as arthroscopic procedures become more common and complex, the line between basic arthroscopic and "major" orthopaedic procedures is becoming more ambiguous. The National Institute for Clinical Health and Excellence (NICE) guidelines do not recommend the thromboprophylaxis after knee arthroscopy if the surgery is below 90 minutes and the patients is at low risk[81]. In contrast, pharmacological prophylaxis after knee arthroscopic surgery is recommended by the French Society of Anaesthesia and Intensive Care[82]. Also, according to a recent survey in Germany, most surgeons use anticoagulants as routine thromboprophylaxis after outpatient arthroscopic procedures of the knee[83].

LMWH is a very common anticoagulant used after knee arthroscopy. In a meta-analysis of 8 randomized clinical trials (RCT) including 4,113 patients performed by Zhu et al.[84], the authors found that LMWH had efficacy in preventing VTE (relative risk [RR], 0.22 95% confidence interval [CI], 0.06 - 0.73]; p = .01) for patients mainly undergoing ACL reconstruction and did not increase the risk of bleeding (RR, 1.12 95% CI, 0.72 - 1.74). Interestingly, they found that LMWH was conversely not effective in preventing VTE in patients undergoing simple knee arthroscopy and increased the risk of bleeding (RR, 1.64 95% CI, 1.18 - 2.28). In an RCT study by Marlovits et al.[85], on 175 ACL reconstruction patients receiving enoxaparin 40 mg once daily 12 to 18 hours pre-surgery and 3 to 8 days post-surgery, patients were randomized to 40 mg enoxaparin (n = 87) or placebo (n = 88) once daily for 20 days. DVT was confirmed by magnetic resonance venography (MRV) at the end of the study period (23 to 28 days after surgery). Two DVT (2.8%) were detected in the enoxaparin group vs. 28 (41.2%) in placebo group, including 1 (1.4%) proximal DVT in the enoxaparin group vs. 6 (8.8%) in the placebo group. None of the patients developed PE postoperatively. No major bleeding occurred, and minor bleeding rate was similar in both groups.

As an alternative antithrombotic agent, ASA has been widely used in orthopaedic surgery. Kaye et al.[86], conducted an RCT on a series of 170 arthroscopy patients (23 ACL reconstruction) and compared a group of 63 patients who were given ASA 325 mg for 14 days with 104 patients who were given no medical prophylaxis. No VTE event was detected based on bilateral, whole leg, compression venous duplex ultrasonography 10 to 14 days postoperatively. Similarly, Muñoa et al.[87], compared medical prophylaxis (rivaroxaban or Bemiparin) vs. mechanical prophylaxis (compression stocking) and did not find any VTE events in their small series of 60 ACL reconstruction patients.

In contrast, Perrotta et al.[88], updated their previous systematic review of pharmacological or non-pharmacological interventions to reduce thromboembolic risk after knee arthroscopy. They concluded that for the outcome of PE and symptomatic DVT in low-risk patients undergoing knee arthroscopic procedures, there was moderate to very low-certainty evidence of no clear benefit regarding the use of LMWH, ASA or rivaroxaban compared to placebo or no intervention for VTE prevention. Interestingly, the incidence of symptomatic DVT was higher in the compression stocking group compared to LMWH, ASA and rivaroxaban. Compression stocking had a 2% incidence of symptomatic DVT, while the literature reports an incidence below 0.5%[88]. Schmitz et al., used data from the Swedish Knee Ligament Register (SKLR) between 2006 and 2013, and analyzed 26,014 primary and revision ACL reconstruction. They found no difference in the incidence of VTE between those with and those without thromboprophylaxis[78], and recommended against the routine use of thromboprophylaxis, except older patients. Further, in an RCT involving 1,451 patients undergoing arthroscopy of the knee, thromboprophylaxis with LMWH for 8 days after knee arthroscopy conferred no benefit[89]. Interestingly, using the MHS data[75], 147 patients (0.89%) who received thromboprophylaxis were found to have an increased risk of VTE. This unanticipated finding suggests that the patients receiving thromboprophylaxis had probably been those deemed to have an increased risk of VTE. The authors nonetheless concluded that they could not recommend routine thromboprophylaxis for patients undergoing arthroscopic surgery of the knee.

The routine use of thromboprophylaxis is not without risks, which must be taken into account when deciding to prescribe anticoagulants to knee arthroscopy patients. Bleeding adverse events following below-knee surgery is significantly higher (odds ratio 2.79) in patients receiving thromboprophylaxis compared to those receiving no prophylaxis[90]. To this end, appropriate risk stratification, considering factors such as medical comorbidities, weight-bearing status, and the use of immobilization, is therefore necessary when deciding whether to prescribe VTE prophylaxis to knee arthroscopy patients after surgery.

Mohammad S Abdelaal, Usama H. Saleh, Hamed Vahedi

References

75. Gaskill T, Pullen M, Bryant B, Sicignano N, Evans AM, DeMaio M. The Prevalence of Symptomatic Deep Venous Thrombosis and Pulmonary Embolism After Anterior Cruciate Ligament Reconstruction. Am J Sports Med. 2015 Nov;43(11):2714-9.

76. Jameson SS, Dowen D, James P, Serrano-Pedraza I, Reed MR, Deehan D. Complications following anterior cruciate ligament reconstruction in the English NHS. Knee. 2012 Jan;19(1):14-9.

77. Maletis GB, Inacio MCS, Reynolds S, Funahashi TT. Incidence of symptomatic venous thromboembolism after elective knee arthroscopy. J Bone Joint Surg Am. 2012 Apr 18;94(8):714-20.

78. Kraus Schmitz J, Lindgren V, Janarv PM, Forssblad M, Stålman A. Deep venous thrombosis and pulmonary embolism after anterior cruciate ligament reconstruction: incidence, outcome, and risk factors. Bone Joint J. 2019 Jan;101-B(1):34-40.

79. Falck-Ytter Y, Francis CW, Johanson NA, Curley C, Dahl OE, Schulman S, Ortel TL, Pauker SG, Colwell CW Jr. 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 Feb; 141(2)(Suppl):e278S-325S.

80. Ye S, Dongyang C, Zhihong X, Dongquan S, Jin D, Jianghui Q, Jizhen Q, Pu Y, Huacheng H, Wei S, Qing J. The incidence of deep venous thrombosis after arthroscopically assisted anterior cruciate ligament reconstruction. Arthroscopy. 2013 Apr;29(4):742-7.

81. National Institute for Health and Care Excellence. Venous thromboembolism in over 16s: reducing the risk of hospital-acquired deep vein thrombosis or pulmonary embolism. Accessed June 23, 2021. https://www.nice.org.uk/guidance/ng89/chapter/recommendations#interventions-for-people-having-orthopaedic-surgery

82. Samama CM, Gafsou B, Jeandel T, Laporte S, Steib A, Marret E, Albaladejo P, Mismetti P, Rosencher N; French Society of Anaesthesia and Intensive Care. [French Society of Anaesthesia and Intensive Care. Guidelines on perioperative venous thromboembolism prophylaxis. Update 2011. Short text]. Ann Fr Anesth Reanim. 2011 Dec;30(12):947-51. French.

83. Müller-Rath R, Ingenhoven E, Mumme T, Schumacher M, Miltner O. [Perioperative management in outpatient arthroscopy of the knee joint]. Z Orthop Unfall. 2010 May;148(3):282-7. German.

84. Zhu J, Jiang H, Marshall B, Li J, Tang X. Low-Molecular-Weight Heparin for the Prevention of Venous Thromboembolism in Patients Undergoing Knee Arthroscopic Surgery and Anterior Cruciate Ligament Reconstruction: A Meta-analysis of Randomized Controlled Trials. Am J Sports Med. 2019 Jul;47(8):1994-2002.

85. Marlovits S, Striessnig G, Schuster R, Stocker R, Luxl M, Trattnig S, Vécsei V. Extended-duration thromboprophylaxis with enoxaparin after arthroscopic surgery of the anterior cruciate ligament: a prospective, randomized, placebo-controlled study. Arthroscopy. 2007 Jul;23(7):696-702.

86. Kaye ID, Patel DN, Strauss EJ, Alaia MJ, Garofolo G, Martinez A, Jazrawi LM. Prevention of Venous Thromboembolism after Arthroscopic Knee Surgery in a Low-Risk Population with the Use of Aspirin. A Randomized Trial. Bull Hosp Jt Dis(2013). 2015 Dec;73(4):243-8.

87. Muñoa L, González AB, Díaz de Rada P, Valentí A, Valentí JR. Rivaroxaban is as efficient and safe as bemiparin as thromboprophylaxis in knee arthroscopy. Musculoskelet Surg. 2014 Jun;98(1):21-5.

88. Perrotta C, Chahla J, Badariotti G, Ramos J. Interventions for preventing venous thromboembolism in adults undergoing knee arthroscopy. Cochrane Database Syst Rev. 2020 May 6;5:CD005259.

89. van Adrichem RA, Nemeth B, Algra A, le Cessie S, Rosendaal FR, Schipper IB, Nelissen RGHH, Cannegieter SC; POT-KAST and POT-CAST Group. Thromboprophylaxis after Knee Arthroscopy and Lower-Leg Casting. N Engl J Med. 2017 Feb 9;376(6):515-25.

90. Heijboer RRO, Lubberts B, Guss D, Johnson AH, Moon DK, DiGiovanni CW. Venous Thromboembolism and Bleeding Adverse Events in Lower Leg, Ankle, and Foot Orthopaedic Surgery with and without Anticoagulants. J Bone Joint Surg Am. 2019 Mar 20;101(6):539-46.

5- Do patients undergoing hip arthroscopy require routine VTE prophylaxis?

Response/Recommendation: The risk of venous thromboembolism (VTE) after hip arthroscopy (HA) is low and routine VTE prophylaxis is not required. In patients with particular risk factors, VTE prophylaxis might be considered.

Strength of Recommendation: Limited.

Delegates vote: Agree 92.31% Disagree 7.69% Abstain 0.00% (Strong Consensus)

Rationale: The use of arthroscopic techniques in and around the hip has rapidly increased in recent years[91,92]. For some conditions, such as femoroacetabular impingement (FAI) syndrome, there is randomized controlled trial evidence of the clinical effectiveness of HA[93]. The risk of complications, including VTE, following HA is low[94]. In order to answer the question whether patients undergoing HA require routine VTE prophylaxis, we conducted a comprehensive systematic review of the available literature (Table I). Most studies related to this subject matter are of low methodological quality[95]: retrospective case reports or series[96-105] or national guidelines[106,107]. There are three retrospective database studies that specifically evaluated the incidence of symptomatic VTE after HA[100,108,109]. Three prospective cohort studies used ultrasound screening to identify asymptomatic VTE[110-112]. Four previous systematic reviews found that their conclusions were limited by overall low-quality evidence, incomplete reporting, and poor definition of surgical and patient risk factors, and by heterogeneity of procedures performed, type and duration of prophylaxis, and method of detection of VTE events[113-116].

The overall risk of VTE, after HA, was reported to be between 0.2% to 9.5%[96,97,100,102,103,105,109,111,112,116,117]. Symptomatic deep venous thrombosis (DVT) rates were 0.4-3.5%[96,98,108,110,112,113,115,117], whilst the rate of asymptomatic DVT detected by ultrasound screening was 6.9%[21]. The risk of pulmonary embolism (PE) was 0.08-1.5%[96,97,108,113,115] with a mortality rate of 0.02%[108]. Some studies attempted to identify risk factors for VTE among patients undergoing HA that included smoking, diabetes, chronic obstructive pulmonary disease (COPD), age, obesity, oral contraceptive use, history of trauma, prolonged intraoperative traction or prolonged postoperative immobilization[117]. No prospective cohort studies had adequate sample size to explore these suggested risk factors. One retrospective database study of 9,477 patients[96], identified age ≥ 45, obesity, smoking, diabetes and COPD as independent risk factors, but neither gender nor oral contraceptive use were risk factors for VTE after HA.

Based on our review of the literature, no clinical trial to evaluate the effectiveness of thromboprophylaxis in patients undergoing HA was identified. One systematic review[116] explored the role of chemoprophylaxis in this patient population, that included aspirin (ASA), low-molecular-weight heparin (LMWH) or other unspecified drugs. The pooled VTE rate was 2.0% in patients with prophylaxis compared with 3.6% in those without, a difference which was not statistically significant. In a prospective study with 880 HA involved, high-risk VTE patients were treated with chemoprophylaxis and low-risk VTE patients with early mobilization and physiotherapy in first 24 hours. VTE rate in low-risk group was 0.16% and in high-risk group 1.2%[117].

In conclusion, although the evidence is sparse, the risk of VTE after HA is low. Thus, based on available data routine administration of VTE prophylaxis for patients undergoing HA is not justified. Patients at higher risk of VTE, may benefit from the use of mechanical and/or chemical prophylaxis, that includes ASA.

Damian R. Griffin, Óliver Marín-Peña, Marc W. Nijhof

TABLE I Overview of the results of selected studies

Authors	Year	Number of patients	Description of patients	Comment	Procedures	Incidence VTE	Risk factors	Effect of prophylaxis
Khazi et al.[96]	2019	9,477	Age > 20 (77.5% age ≥ 45)	Retrospective study.	HA	Overall VTE: 0.77% at 1-month and 1.14% at 3-months. DVT: 0.57% at 1-month and 0,82% at 3-months. PE: 0,3% at 1-month and 0,43% at 3-months.	Risk factor: obesity, smoking, diabetes. No risk factor: age, gender in comparison VTE vs. No-VTE cohort at 90-days.	No info.
Malviya et al.[108]	2015	6,395	Age 38 (11-38)	Retrospective NHS database.	HA 2005-2013	0.08% (5/6,395) for both 90-day DVT and PE rate 0.08%)	No info.	No info.
Bushnell et al.[114]	2008	5,554	No info.	Review 27 papers 1797-2007	HA	0%	No info.	No info.
Bolia et al.[115]	2018	4,577	Age 36 ± 1.8	Systematic review 2000-2017, 28 studies. Remark on publication bias.	HA for FAI	1.18%; 95% CI [0.8-1.74%] for DVT, 0.59%; 95% CI [0.38-0.92%] for PE. When corrected for publication bias: 2.02% for DVT (Small studies with low DVT rates were more likely to be published than larger studies with low DVT rates).	No info.	No info.
Haldane et al.[116]	2018	2,850	Age 40.7	Systematic review 14 papers (not included papers from 2016 to 2021) Only 2 studies level III/IV.	HA	2.0% (n 6/25 asymptomatic). To 3,6% (excluded 1 study 0% without treatment).	No clear statement about this topic	2.0% with prophylaxis vs. 4.2% without prophylaxis.
Truntzer et al.[100]	2017	2,581	Age not specified.	Retrospective	HA 2007-2014	0.79% (16)/2,581)	No info.	No info.
Nicolay et al.[99]	2019	2,023	Age of all pts 50.86 ± 14.6, 46.7% obese (27,8% of HA obese).	Retrospective. Not specified for HA	HA 2006-2016	Overall, 0,27% (382/all 141,335 scopes), not specified for HA.	All scopes (not specified for HA: overweight, BMI (OR 1.474) and class I obesity with DM (OR 1.469).	No info.
Larson et al.[109]	2016	1,615	Age 30.5 (12-76)	Retrospective.	HA	0.2% (3/1615)	DVT cases: clotting cascade disorder (n = 2) or arteriovenous anomaly (n = 1)	No pharmacological prophylaxis, except ASA (650 mg daily) for patients with a known thromboembolic history or clotting cascade disorder or those flying soon (within 3 weeks) after surgery.

continued

TABLE I (*continued*)

Authors	Year	Number of patients	Description of patients	Comment	Procedures	Incidence VTE	Risk factors	Effect of prophylaxis
Schüttler et al.[98]	2018	485	Age 43.9 (w/o range).	Retrospective, low quality.	HA 2006-2014	0,4% (2/484)	No info.	No info.
Seijas et al.[104]	2017	258	Age 36.6 ± 17.5 (18–61)	Retrospective (review of literature).	HA 2011-2014	0% (0/258)	Not studied.	Not studied (enoxaparin 10 days all patients).
Dutton et al.[101]	2016	159	Military, age 30.9 ± 8.3 years (range, 18-52 years).	Retrospective.	HA 2000-2014	0% (0	No info.	No info.
Niroopan et al.[113]	2016	144	Trauma patients, age range, 10 to 53 years.	Systematic review 2015. 32 studies (25 case reports -7 case series).	HA after trauma	0,7% (1 PE/144 0,7%)	No info.	Not studied (PE case on LMWH)
Alaia et al.[110]	2014	139	Age 37.7, all low risk VTE.	Case series. Use US only 58,3% cases. Only low VTE risk patients (exclude 5 high-risk). No VTE prophylaxis.	HA	1,4% symptomatic.	No clear statement about this topic.	No prophylaxis.
Mohtadi et al.[112]	2016	115	Age 35.4 ± 10.3 (> 18).	Prospective, US.	HA	4.4% (5/115, 4/5 symptomatic.3,5%).	No statistically significant patient or surgical factors (not powered for).	Not studied (all without prophylaxis)
Chaharbakhshi et al.[105]	2019	107	Age 41.6 ± 9.8 (21-61) 42.7 ± 9.9 (20 – 58).	Retrospective.	HA + microfracture (2008-2014); (57 large 50 small defect).	2,8% (3/107).	Not studied (DVT only in large defect, but similar traction times).	No info (not routinely administered).
Bayley et al.[102]	2017	82	Age 20.4 ± 2.5 (16-25).	Retrospective.	HA 2005-2013	1,2% (1/82)	No info.	No info.
Fukushima et al.[111]	2016	72	Age 46,3 mean.	Not included in systematic review by Brown et al.[118]. Asymptomatic DVT. Recommended prophylaxis in "old " patients.	HA	6.94% ultrasound distal DVT (up to 7 days after surgery).	DVT mean age 62. No traction time or surgical time.	No prophylaxis.
Perets et al.[97]	2018	66	Athletes, age 21.4 ± 8.1.	Prospective case series. No info on prophylaxis.	HA 2009-2011	1,5% (1 PE /66)	No info.	No info.

continued

TABLE I (*continued*)

Authors	Year	Number of patients	Description of patients	Comment	Procedures	Incidence VTE	Risk factors	Effect of prophylaxis
Collins et al.[103]	2015	39	21 obese/ 18 non-obese patients; Age 38 ± 11.7 (21-64).	Retrospective	HA 2009-2012	5% (2/39) (9,5% 2/ 21 in obese, 0% 0/ 18 in non-obese)	Obesity? (Both DVT in obese).	Not studied: all on ASA 325 mg daily for 2 weeks.
Randelli et al.[107]	2013	0		Expert consensus of every orthopaedic procedure. No VTE Prophylaxis low risk patients. LMWH 7 days in high risk.	HA & others.	Up to 3.7% no prophylaxis (literature review).	No info.	No info.
Jenny et al.[106]	2020	0		Survey French surgeons: 69.3% (131/ 189) of surgeons: prophylaxis in >90% of cases.	HA		No info.	Not mentioned/ advised in SFAR guideline 2011.
Verhoogt et al.[117]	2020	880		Two groups compared: High VTE risk vs. low VTE risk	HA		Oral contraceptives; BMI > 30kg/m^2; Previous VTE; Family Story; Hormone replacement Therapy; DM; Cardiac Pathology; Steroids; Malignancy.	High-risk with pharmacological prophylaxis: 1.2%. Low-risk with early ambulation: 0.16%.

VTE=Venous thromboembolism; HA=Hip arthroplasty; DVT=Deep venous thrombosis; PE=Pulmonary embolism; NHS=National health service; FAI=Femoroacetabular impingement; CI=Confidence interval; BMI=Body mass index; OR=Odds ratio; DM=Diabetes mellitus; ASA=Aspirin; LMWH=Low-molecular-weight heparin; US=United States; SFAR= Société Française d'Anesthésie et de Réanimation.

References

91. Marin-Peña O, Tey-Pons M, Perez-Carro L, Said HG, Sierra P, Dantas P, Villar RN. The current situation in hip arthroscopy. EFORT Open Rev. 2017 Apr 27;2(3):58-65.

92. von Glinski A, Yilmaz E, Goodmanson R, Pierre C, Frieler S, Shaffer A, Ishak B, Lee CB, Mayo K. The impact of the 30 most cited articles on hip arthroscopy: what is the subject matter? J Hip Preserv Surg. 2020 Feb 24;7(1):14-21.

93. Griffin DR, Dickenson EJ, Wall PDH, Achana F, Donovan JL, Griffin J, Hobson R, Hutchinson CE, Jepson M, Parsons NR, Petrou S, Realpe A, Smith J, Foster NE; FASHIoN Study Group. Hip arthroscopy versus best conservative care for the treatment of femoroacetabular impingement syndrome (UK FASHIoN): a multicentre randomised controlled trial. Lancet. 2018 Jun 2;391(10136):2225-35.

94. Hanke MS, Lerch TD, Schmaranzer F, Meier MK, Steppacher SD, Siebenrock KA. Complications of hip preserving surgery. EFORT Open Rev. 2021 Jun 28;6(6): 472-86.

95. Duong A, Kay J, Khan M, Simunovic N, Ayeni OR. Authorship in the field of femoroacetabular impingement: an analysis of journal publications. Knee Surg Sports Traumatol Arthrosc. 2017 Jan;25(1):94-100.

96. Khazi ZM, An Q, Duchman KR, Westermann RW. Incidence and Risk Factors for Venous Thromboembolism Following Hip Arthroscopy: A Population-Based Study. Arthroscopy. 2019 Aug;35(8):2380-2384.e1.

97. Perets I, Craig MJ, Mu BH, Maldonado DR, Litrenta JM, Domb BG. Midterm Outcomes and Return to Sports Among Athletes Undergoing Hip Arthroscopy. Am J Sports Med. 2018 Jun;46(7):1661-7.

98. Schüttler KF, Schramm R, El-Zayat BF, Schofer MD, Efe T, Heyse TJ. The effect of surgeon's learning curve: complications and outcome after hip arthroscopy. Arch Orthop Trauma Surg. 2018 Oct;138(10):1415-21.

99. Nicolay RW, Selley RS, Terry MA, Tjong VK. Body Mass Index as a Risk Factor for 30-Day Postoperative Complications in Knee, Hip, and Shoulder Arthroscopy. Arthroscopy. 2019 Mar;35(3):874-882.e3.

100. Truntzer JN, Hoppe DJ, Shapiro LM, Abrams GD, Safran M. Complication Rates for Hip Arthroscopy Are Underestimated: A Population-Based Study. Arthroscopy. 2017 Jun;33(6):1194-201.

101. Dutton JR, Kusnezov NA, Lanzi JT, Garcia EJ, Pallis MP. The Success of Hip Arthroscopy in an Active Duty Population. Arthroscopy. 2016 Nov;32(11):2251-8.

102. Bayley G, Poitras S, Parker G, Beaulé PE. Hip arthroscopy in patients less than 25 years of age in the treatment of labral tears: aetiology and clinical outcomes. Hip Int. 2017 Sep 19;27(5):436-42.

103. Collins JA, Beutel BG, Garofolo G, Youm T. Correlation of obesity with patient-reported outcomes and complications after hip arthroscopy. Arthroscopy. 2015 Jan; 31(1):57-62.

104. Seijas R, Ares O, Sallent A, Cuscó X, Álvarez-Díaz P, Tejedor R, Cugat R. Hip arthroscopy complications regarding surgery and early postoperative care: retrospective study and review of literature. Musculoskelet Surg. 2017 Aug;101(2):119-31.

105. Chaharbakhshi EO, Hartigan DE, Spencer JD, Perets I, Lall AC, Domb BG. Do Larger Acetabular Chondral Defects Portend Inferior Outcomes in Patients Undergoing Arthroscopic Acetabular Microfracture? A Matched-Controlled Study. Arthroscopy. 2019 Jul;35(7):2037-47.

106. Jenny JY; Francophone Arthroscopy Society (SFA). Thromboprophylaxis in arthroscopy: Survey of current practices in France and comparison with recommendations. Orthop Traumatol Surg Res. 2020 Dec;106(8S):S183-7.

107. Randelli F, Romanini E, Biggi F, Danelli G, Della Rocca G, Laurora NR, Imberti D, Palareti G, Prisco D. II Italian intersociety consensus statement on antithrombotic prophylaxis in orthopaedics and traumatology: arthroscopy, traumatology, leg immobilization, minor orthopaedic procedures and spine surgery. J Orthop Traumatol. 2013 Mar;14(1):1-13.

108. Malviya A, Raza A, Jameson S, James P, Reed MR, Partington PF. Complications and survival analyses of hip arthroscopies performed in the national health service in England: a review of 6,395 cases. Arthroscopy. 2015 May;31(5): 836-42.

109. Larson CM, Clohisy JC, Beaulé PE, Kelly BT, Giveans MR, Stone RM, Samuelson KM; ANCHOR Study Group. Intraoperative and Early Postoperative Complications After Hip Arthroscopic Surgery: A Prospective Multicenter Trial Utilizing a Validated Grading Scheme. Am J Sports Med. 2016 Sep;44(9):2292-8.

110. Alaia MJ, Patel D, Levy A, Youm T, Bharam S, Meislin R, Bosco Iii J, Davidovitch RI. The incidence of venous thromboembolism (VTE)—after hip arthroscopy. Bull Hosp Jt Dis (2013). 2014;72(2):154-8.

111. Fukushima K, Takahira N, Uchiyama K, Moriya M, Minato T, Takaso M. The incidence of deep vein thrombosis (DVT) during hip arthroscopic surgery. Arch Orthop Trauma Surg. 2016 Oct;136(10):1431-5.

112. Mohtadi NG, Johnston K, Gaudelli C, Chan DS, Barber RS, Walker R, Patel C, Mackay E, Oddone Paolucci E. The incidence of proximal deep vein thrombosis after elective hip arthroscopy: a prospective cohort study in low risk patients. J Hip Preserv Surg. 2016 Aug 18;3(4):295-303.

113. Niroopan G, de Sa D, MacDonald A, Burrow S, Larson CM, Ayeni OR. Hip Arthroscopy in Trauma: A Systematic Review of Indications, Efficacy, and Complications. Arthroscopy. 2016 Apr;32(4):692-703.e1.

114. Bushnell BD, Anz AW, Bert JM. Venous thromboembolism in lower extremity arthroscopy. Arthroscopy. 2008 May;24(5):604-11.

115. Bolia IK, Fagotti L, McNamara S, Dornan G, Briggs KK, Philippon MJ. A systematic review-meta-analysis of venous thromboembolic events following primary hip arthroscopy for FAI: clinical and epidemiologic considerations. J Hip Preserv Surg. 2018 Aug 17;5(3):190-201.

116. Haldane CE, Ekhtiari S, de Sa D, Simunovic N, Safran M, Randelli F, Duong A, Farrokhyar F, Ayeni OR. Venous Thromboembolism Events After Hip Arthroscopy: A Systematic Review. Arthroscopy. 2018 Jan;34(1):321-330.e1.

117. Verhoogt WAM, Pietrzak JRT, Ayeni OR, Cakic JN. Post-operative oral chemoprophylaxis in patients undergoing hip arthroscopy mitigates VTE risk with a low side-effect profile. J Hip Preserv Surg. 2020 Dec 22;7(3):524-32.

118. Brown CA, McAdams TR, Harris AHS, Maffulli N, Safran MR. ACL reconstruction in patients aged 40 years and older: a systematic review and introduction of a new methodology score for ACL studies. Am J Sports Med. 2013 Sep;41(9):2181-90.

6- Should patients undergoing mini-open femoroacetabular osteoplasty receive routine VTE prophylaxis?

Response/Recommendation: There is dearth of data related to this question. Available evidence suggests that aspirin is an effective prophylactic agent against venous thromboembolism (VTE) in standard-risk patients undergoing mini-open femoroacetabular osteoplasty (FAO).

Strength of Recommendation: Low.

Delegates vote: Agree 88.46% Disagree 7.69% Abstain 3.85% (Strong Consensus)

Rationale: The majority of patients undergoing FAO are young, healthy, active, and may not be considered at high-risk for VTE[119]. The optimal VTE prophylaxis regimen after mini-open FAO remains unclear with little published on this subject matter[120,121]. VTE prophylaxis after hip preservation procedures is not addressed by the American College of Chest Physicians (ACCP)[122], the American Academy of Orthopaedic Surgeons (AAOS) or any other guidelines. Hence, specific VTE prevention protocols are required to implement an optimal prophylaxis method after FAO. Azboy et al.[120] compared different VTE pharmacological prophylaxis in patients undergoing hip preservation surgery between 2003 and 2016. Their cohort had 603 patients who underwent mini-open FAO and 80 patients who underwent periacetabular osteotomy (PAO)[120]. Their results demonstrated a symptomatic VTE rate of 0.16% and 1.1% after mini-open FAO and PAO surgery, respectively[120]. There were no significant differences in symptomatic VTE rates in patients receiving warfarin, aspirin (ASA) 325 mg or ASA 81 mg, with no events of bleeding or hematoma formation[120]. In a prospective case series of 407 consecutive patients who underwent mini-open FAO procedure, Tischler et al.[123], found that the rate of symptomatic VTE was 0.25% when ASA 325 mg daily dose was administered. The majority of the patients included in this cohort were young, healthy and active, and were ambulated within hours of their surgery[123]. Based on institutional experience, a review study from the Rothman Institute recommended that ASA 81 mg two times daily is a safe and effective modality in minimizing the risk of VTE in patients undergoing hip preservation surgery[119]. Regarding patient factors, increased age, obesity, oral contraceptive use, trauma, and prolonged traction were identified as factors in patients who had VTE events after arthroscopic FAO procedures[124]. However, it is unclear how these factors might contribute to the VTE events after mini-open FAO. Further research on potential risk factors for VTE and the optimal prophylaxis modality for FAO surgery via the mini-open approach is warranted.

Mohammad S. Abdelaal, Ryan M. Sutton, Óliver Marín-Peña, Javad Parvizi

References

119. Aali Rezaie A, Azboy I, Parvizi J. Venous thromboembolism prophylaxis after hip preservation surgery: a review and presentation of institutional experience. J Hip Preserv Surg. 2018 Oct 1;5(3):181-9.

120. Azboy I, M Kheir M, Huang R, Parvizi J. Aspirin provides adequate VTE prophylaxis for patients undergoing hip preservation surgery, including periacetabular osteotomy. J Hip Preserv Surg. 2018 Apr 5;5(2):125-30.

121. Cohen SB, Huang R, Ciccotti MG, Dodson CC, Parvizi J. Treatment of femoroacetabular impingement in athletes using a mini-direct anterior approach. Am J Sports Med. 2012 Jul;40(7):1620-7.

122. Falck-Ytter Y, Francis CW, Johanson NA, Curley C, Dahl OE, Schulman S, Ortel TL, Pauker SG, Colwell CW Jr. 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 Feb; 141(2)(Suppl):e278S-325S.

123. Tischler EH, Ponzio DY, Diaz-Ledezma C, Parvizi J. Prevention of venous thromboembolic events following femoroacetabular osteoplasty: aspirin is enough for most. Hip Int. 2014 Jan-Feb;24(1):77-80.

124. Haldane CE, Ekhtiari S, de Sa D, Simunovic N, Safran M, Randelli F, Duong A, Farrokhyar F, Ayeni OR. Venous Thromboembolism Events After Hip Arthroscopy: A Systematic Review. Arthroscopy. 2018 Jan;34(1):321-330.e1.

7- How should athletes receiving chemical anticoagulation for VTE prophylaxis or treatment of active VTE be managed?

Response/Recommendation: There is no consensus regarding the optimal management of venous thromboembolism (VTE) in athletes. Treatment of active VTE consists of early mobilization and uninterrupted anticoagulation for at least 3 months with abstinence from contact sports during the entire treatment duration. The choice of pharmacologic agent should be tailored according to patient-, physician-, and sport-related factors. However, some authors favor direct-acting oral anticoagulant agents (DOAC), which may allow earlier return to sport in athletes requiring prolonged anticoagulation. Athletes receiving treatment for active VTE may begin low-risk exercises (e.g., swimming) 3 weeks after initial diagnosis, progressing to full participation in non-contact sports at 6 weeks.

Strength of Recommendation: Consensus.

Delegates vote: Agree 100.00% Disagree 0.0% Abstain 0.00% (Unanimous Strong Consensus).

Rationale: While athletes are believed to have a low risk of VTE[125], this population is uniquely exposed to pro-thrombotic factors such as oral contraceptive use, prolonged travel, and immobilization after injury[126], often placing them at a higher risk than expected. One study by Erickson et al., demonstrated an 8% incidence of deep venous thrombosis (DVT) in athletes after arthroscopic anterior cruciate ligament (ACL) reconstruction[127], and another cited VTE as a major cause of death in adolescent athletes across the United States[128]. While there is no official recommendation for DVT prophylaxis in athletes with a lower extremity injury without prior history of VTE, some authors recommend anticoagulation with low-molecular-weight heparin (LMWH) along with physical antithrombotic measures such as sequential compression devices (SCD) for immobilized, recently injured athletes or high-risk athletes undergoing long-distance travel[129-131]. A Cochrane review recommended that all adults with injuries requiring low or above knee casts or braces should receive LMWH for the duration of immobilization[132].

Therapeutic anticoagulation regimens for athletes after VTE diagnosis of VTE also lacks consensus, although the current recommendations follow the same guidelines for non-athletes as listed in the American College of Chest Physicians 10th Edition of the Antithrombotic Guidelines and comprises the use of established VTE risk prediction scores to determine the appropriate prophylactic agent, dosage, and duration[125,133,134]. Individualized anticoagulation regimens should consider type of anticoagulation, the athlete's sport and preference, and expert opinion[133]. The most common treatment described involves initiating LMWH or unfractionated heparin, followed by a vitamin K antagonist such as warfarin until a target International Normalized Ratio (INR) of 2.0 – 3.0 is reached[125]. DOAC such as rivaroxaban or apixaban may be preferred due to greater convenience and shorter half-lives that offer the possibility of intermittent dosing during sport participation[133]. Nahza et al., recommended an individualized approach to DOAC prescribing in high-risk patients after return to non-contact sport, which was analogous to the periprocedural management of DOAC use in the general population. This approach consists of limiting DOAC use in the days leading up to sporting events with the aim of ensuring low physiologic levels of anticoagulant use when an athlete is competing, and then returning to higher levels of DOAC use outside of competition[133,135,136]. Although there is no consensus recommending one DOAC over another, one study showed that apixaban had shorter thrombin inhibition compared to rivaroxaban. This may favor apixaban for intermittent anticoagulation due to its shorter half-life relative to rivaroxaban[137]. Treatment with uninterrupted anticoagulation and abstinence from contact sports for three months during active treatment is the standard management for athletes receiving chemical anticoagulation for VTE treatment[131,138]. Additionally, early mobilization (within 24 to 48 hours of starting anticoagulation) and compression stockings may be used for lower extremity DVT to reduce the rate of post-thrombotic syndrome[125,134,139].

There is currently no literature comparing the efficacy of various anticoagulants in the treatment or prevention of VTE in athletes. Despite a growing trend towards aspirin (ASA) use for VTE prophylaxis in total joint arthroplasty, recent studies in athletes have demonstrated no postoperative benefit with ASA use after arthroscopic surgeries[140,141]. Additionally, a meta-analysis of randomized controlled trials by Zhu et al., demonstrated nearly 5-fold decrease in VTE rate after ACL reconstruction with the use of prophylactic LMWH. Despite these findings, a recent survey highlighted that the majority of arthroscopy surgeons still prescribe ASA for postoperative DVT prophylaxis[142].

Return to sport following VTE should follow a gradual progression of increasing activity after the initiation of anticoagulation[143,144]. Several randomized trials and observational studies have recommended that patients may begin ambulation within 24 hours of anticoagulation initiation if they do not have any evidence of active pulmonary embolism (PE) or cardiopulmonary compromise[143]. During the first 3 weeks, athletes should be limited to walking and activities of daily living. After 3 weeks, athletes may begin low-risk activities such as swimming, and gradually intensifying activity participation to include low-impact exercises such as cycling, followed by running at 6 weeks[139,143,144]. Athletes in non-contact sports may return to full sports participation within 6 weeks, while contact athletes should wait till 3 months after anticoagulation treatment is complete and coagulation labs are within their reference ranges[125,139,144]. Return to contact sport can be permitted gradually while monitoring for VTE recurrence and treating post-thrombotic symptoms[138].

John P. Prodoehl, William L. Johns, Marcos Arêas Marques, Marcone L. Sobreira, Sommer Hammoud

References

125. Grabowski G, Whiteside WK, Kanwisher M. Venous thrombosis in athletes. J Am Acad Orthop Surg. 2013 Feb;21(2):108-17.
126. Elikowski W, Małek M, Montewska D, Kurosz J, Wróblewski D, Zawilska K. [Venous thromboembolism triggered by spinning in a young woman with thrombophilia]. Pol Merkur Lekarski. 2011 Jan;30(175):29-31. Polish.
127. Erickson BJ, Saltzman BM, Campbell KA, Fillingham YA, Harris JD, Gupta AK, Bach BR Jr. Rates of Deep Venous Thrombosis and Pulmonary Embolus After Anterior Cruciate Ligament Reconstruction: A Systematic Review. Sports Health. 2015 May;7(3):261-6.

128. Boden BP, Breit I, Beachler JA, Williams A, Mueller FO. Fatalities in high school and college football players. Am J Sports Med. 2013 May;41(5):1108-16.

129. Eichner ER. Clots and consequences in athletes. Curr Sports Med Rep. 2014 Sep-Oct;13(5):287-8.

130. Hilberg T, Jeschke D, Gabriel HHW. Hereditary thrombophilia in elite athletes. Med Sci Sports Exerc. 2002 Feb;34(2):218-21.

131. Mont MA, Jacobs JJ. AAOS clinical practice guideline: preventing venous thromboembolic disease in patients undergoing elective hip and knee arthroplasty. J Am Acad Orthop Surg. 2011 Dec;19(12):777-8.

132. Testroote M, Stigter WAH, Janssen L, Janzing HMJ. Low molecular weight heparin for prevention of venous thromboembolism in patients with lower-leg immobilization. Cochrane Database Syst Rev. 2014 Apr 25;(4):CD006681.

133. Nazha B, Pandya B, Spyropoulos AC, Kessler CM. Treatment of Venous Thromboembolism in Elite Athletes: A Suggested Approach to Individualized Anticoagulation. Semin Thromb Hemost. 2018 Nov;44(8):813-22.

134. Singh A, Foster M, Chapman P, Hattab Y, Alhassan S, Bajwa O. Special Circumstances and Populations. Crit Care Nurs Q. 2017 Jul/Sep;40(3):276-87.

135. Kichloo A, Amir R, Wani F, Randhawa S, Rudd B, Rechlin D. Anticoagulation and antiplatelet therapy in contact sports: is it career limiting? J Investig Med. 2021 Mar;69(3):781-4.

136. Moll S, Berkowitz JN, Miars CW. Elite athletes and anticoagulant therapy: an intermittent dosing strategy. Hematology Am Soc Hematol Educ Program. 2018 Nov 30;2018(1):412-7.

137. Kreutz R, Persson PB, Kubitza D, Thelen K, Heitmeier S, Schwers S, Becka M, Hemmrich M. Dissociation between the pharmacokinetics and pharmacodynamics of once-daily rivaroxaban and twice-daily apixaban: a randomized crossover study. J Thromb Haemost. 2017 Oct;15(10):2017-28.

138. Berkowitz JN, Moll S. Athletes and blood clots: individualized, intermittent anticoagulation management. J Thromb Haemost. 2017 Jun;15(6):1051-4.

139. Meyering C, Howard T. Hypercoagulability in athletes. Curr Sports Med Rep. 2004 Apr;3(2):77-83.

140. McIntire SC, Bernstein EM, Tompane TM, Briggs AM, Ferris WJ, Renninger CH, McDonald LS, Hurvitz AP. Aspirin for Deep-Venous Thrombosis Prophylaxis After Anterior Cruciate Ligament Reconstruction. Mil Med. 2021 Jul 1;186(7-8):656-60.

141. Kaye ID, Patel DN, Strauss EJ, Alaia MJ, Garofolo G, Martinez A, Jazrawi LM. Prevention of Venous Thromboembolism after Arthroscopic Knee Surgery in a Low-Risk Population with the Use of Aspirin. A Randomized Trial. Bull Hosp Jt Dis (2013). 2015 Dec;73(4):243-8.

142. Keller RA, Moutzouros V, Dines JS, Bush-Joseph CA, Limpisvasti O. Deep Venous Thrombosis Prophylaxis in Anterior Cruciate Ligament Reconstructive Surgery: What Is the Current State of Practice? Sports Health. 2018 Mar/Apr;10(2):156-9.

143. Depenbrock PJ. Thromboembolic disorders: guidance for return-to-play. Curr Sports Med Rep. 2011 Mar-Apr;10(2):78-83.

144. Roberts WO, Christie DM Jr. Return to training and competition after deep venous calf thrombosis. Med Sci Sports Exerc. 1992 Jan;24(1):2-5.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/G854).

NOTE: The ICM-VTE Sports Delegates includes Sommer Hammoud, MD, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Mohammad S. Abdelaal, MD, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Renny A. Cárdenas, MD, Universidad de los Andes Venezuela, Mérida, Venezuela; Emanuele Chisari, MD, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Maxime Fabre-Aubrespy, MD, Sainte Marguerite Hospital, Marseille, France; Graham S. Goh, MD, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Damian R. Griffin, MD, University of Warwick, Coventry, United Kingdom; William L. Johns, MD, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Bryson R. Kemler, MD, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Óliver Marín-Peña, MD, Hospital Universitario Infanta Leonor, Madrid, Spain; Marcos Arêas Marques, MD, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil; Manuel G. Mazzoleni, MD, Unit of Orthopedics and Traumatology, Department of Life Health & Environmental Sciences, University of L'Aquila, L'Aquila, Italy; Marc W. Nijhof, MD, Orthopedic Surgery, Sint Maartenskliniek, Nijmegen, The Netherlands; Javad Parvizi, MD, FRCS, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Ryan W. Paul, BS, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; John P. Prodoehl, BS, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Martina Rama, BS, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Filippo Randelli, MD, Gaetano Pini Orthopedic Institute - University of Milan, Milan, Italy; Camilo Restrepo, MD, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Usama H. Saleh, MD, Medcare Orthopaedic and Spine Hospital, Dubai, United Arab Emirates; Carlos G. Sánchez Valenciano, MD, Centro Médico de Caracas, Caracas, Venezuela; Marcone L. Sobreira, MD, Division of Vascular and Endovascular Surgery, Botucatu Medical School, UNESP, São Paulo, Brazil; Ryan M. Sutton, MD, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; Fotios P. Tjoumakaris, MD, Rothman Orthopaedic Institute, Philadelphia, Pennsylvania; and Hamed Vahedi, MD, West Virginia University Medicine, Morgantown, West Virginia.