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(REVIEW ARTICLE)

Thrombosis and air travel: Risks, prevention, and management

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Abstract

Air travel is an established risk factor for venous thromboembolism (VTE), including deep vein thrombosis (DVT) and pulmonary embolism (PE). Prolonged immobility, hypobaric hypoxia, dehydration, and individual risk factors interact to elevate thrombosis risk during long-haul flights. While the absolute incidence of clinically significant events is low, the global scale of air travel renders this a relevant public health concern. This narrative review summarizes the epidemiology, mechanisms, preventive strategies, and guideline recommendations for thrombosis during air travel, with emphasis on evidence-based prophylaxis and identification of high-risk groups.

Keywords: Air travel; Venous thromboembolism; Deep vein thrombosis; Pulmonary embolism; Prevention; Compression stockings; LMWH

1. Introduction

Venous thromboembolism (VTE) remains a significant global health problem, representing one of the most common causes of preventable morbidity and mortality. Long-haul air travel has been consistently associated with an elevated risk of VTE, particularly in flights lasting longer than four hours. The World Health Organization's WRIGHT project has confirmed a dose-response relationship between flight duration and thrombotic events, particularly in individuals with pre-existing comorbidities. This review aims to provide a comprehensive overview of thrombosis during air travel, including epidemiology, risk factors, pathophysiology, and prevention strategies, with reference to the latest evidence and international guidelines.

2. Epidemiology

The risk of travel-associated VTE is estimated at 1 in 4,600–6,000 long-haul flights. The incidence increases with flight duration and is highest in the first two weeks following travel, returning to baseline by around eight weeks. Several large cohort studies, including the WHO WRIGHT project, demonstrate a clear link between prolonged immobility during air travel and venous thrombosis. High-risk groups include individuals with previous VTE, cancer, recent surgery, obesity, pregnancy, use of oral contraceptives, and inherited thrombophilia.

Multiple studies across different populations confirm the association between air travel and VTE. The WHO WRIGHT project highlighted that long-haul travel (>4 hours) approximately doubles the risk of VTE. Meta-analyses demonstrate a dose-response effect: risk increases with flight duration, frequency of flights, and cumulative immobility. For example, flights exceeding 12 hours confer nearly a fourfold increased risk compared to shorter flights. Certain subgroups such as older passengers, those with BMI ≥30, and those with additional risk factors experience disproportionately higher risks. It is estimated that 3–5% of all VTE cases in the community may be travel-related.

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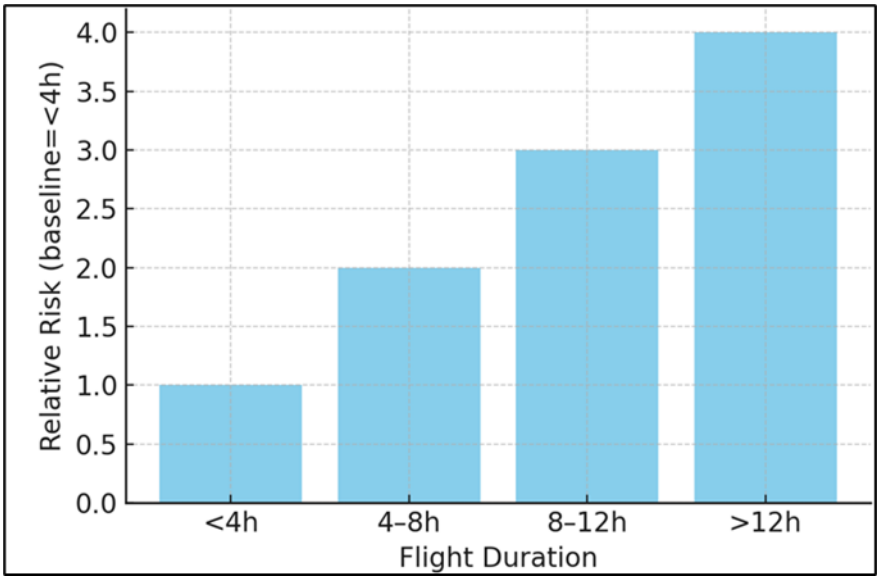

Figure 1 Relative risk of venous thromboembolism (VTE) by flight duration.

3. Pathophysiology

Air travel predisposes to VTE through Virchow's triad: venous stasis, endothelial injury, and hypercoagulability. Prolonged immobility in cramped seating reduces venous return from the legs. Hypobaric hypoxia and dehydration may promote endothelial dysfunction and hemoconcentration. Hypercoagulability may be triggered by underlying genetic or acquired risk factors such as factor V Leiden, obesity, or hormone therapy.

Venous stasis is induced by immobility and cramped leg positioning, particularly in economy class seating. Studies using venous Doppler have shown reductions in popliteal venous flow velocity during prolonged sitting. Hypobaric hypoxia, typical of cabin pressures equivalent to 1,800–2,400 meters altitude, has been associated with mild hemoconcentration, platelet activation, and alterations in coagulation cascade. Endothelial dysfunction may result from dehydration and oxidative stress. These physiological changes become clinically significant in individuals with underlying prothrombotic predispositions, creating a 'second hit' effect.

4. Risk Factors

Risk factors can be grouped into passenger-related, flight-related, and situational categories. Passenger-related include prior VTE, active malignancy, thrombophilia (e.g., factor V Leiden, prothrombin mutation), pregnancy, hormone therapy, obesity, and increasing age. Flight-related risks include duration, restricted legroom, and seating position (window seat vs aisle). Situational risks include recent surgery, hospitalization, trauma, and dehydration. Importantly, synergistic risks exist—for instance, the combination of oral contraceptives and long-haul travel increases VTE risk by more than 10-fold compared to baseline.

Table 1 Risk factor**s**

Category	Examples
Patient-related	Previous VTE, active malignancy, pregnancy, obesity, thrombophilia, hormone therapy
Flight-related	Flight duration >4 hours, window seat, immobility, dehydration, alcohol use
Combined risks	Oral contraceptive use + long-haul travel, obesity + immobility

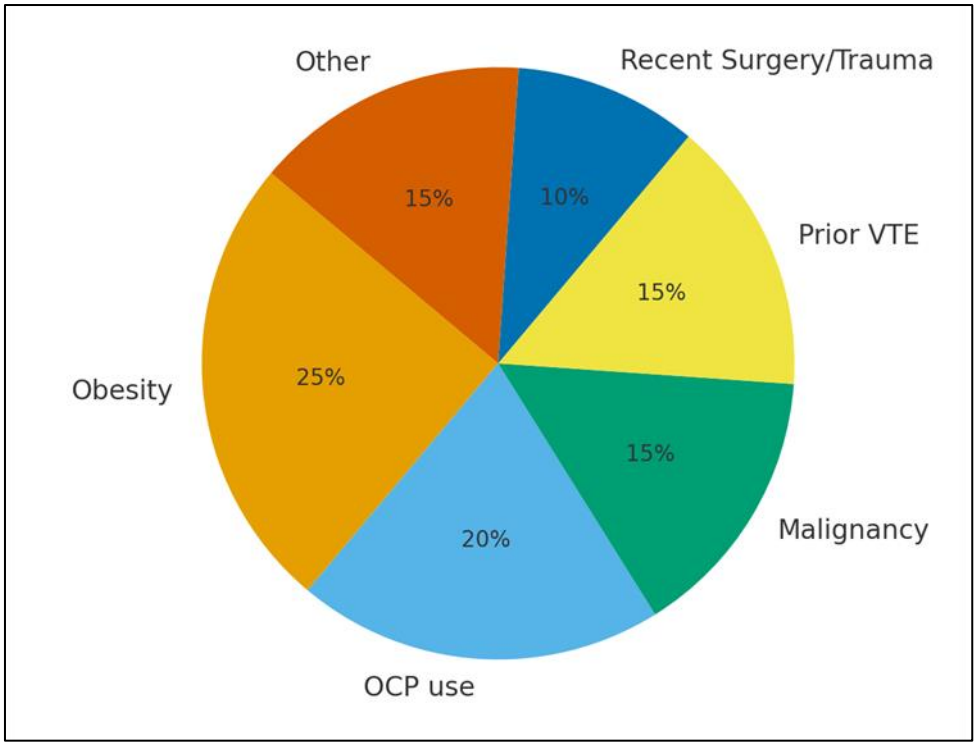

Figure 2 Distribution of risk factors contributing to travel-associated VTE cases.

5. Prevention Strategies

Prevention must balance efficacy, safety, feasibility, and cost. Non-pharmacological measures are universally safe and should be encouraged for all passengers: frequent ambulation, calf exercises every 1–2 hours, hydration, and avoiding excessive alcohol or sedatives. Compression stockings have high-level evidence from randomized trials; Cochrane analyses confirm their ability to significantly reduce asymptomatic DVT, though their effect on clinically overt PE remains unproven. Pharmacological prophylaxis with LMWH is reserved for very high-risk individuals, as trials such as LONFLIT3 demonstrated marked reductions in travel-associated DVT. Aspirin has not demonstrated benefit and carries bleeding risks; guidelines consistently recommend against its use. DOACs, while theoretically attractive, lack trial evidence and are not guideline-endorsed.

Prevention can be divided into non-pharmacological, mechanical, and pharmacological approaches:

5.1. Non-Pharmacological

Ambulation during flights, calf exercises, and selecting an aisle seat are simple and effective strategies. Hydration is widely encouraged, though direct evidence for its protective role is lacking.

5.2. Mechanical

Graduated compression stockings (15–30 mmHg) significantly reduce the incidence of asymptomatic DVT on flights longer than four hours, as demonstrated in Cochrane reviews. Their use is recommended for passengers at elevated risk of VTE.

5.3. Pharmacological

Low-molecular-weight heparin (LMWH), given as a single prophylactic dose prior to travel, has shown benefit in high-risk passengers. Aspirin is not effective and is not recommended. Direct oral anticoagulants (DOACs) are not yet validated for this indication.

6. Guideline Recommendations

International guidelines provide a risk-stratified approach. The American College of Chest Physicians (ACCP) advises against routine prophylaxis in average-risk travelers, recommending mechanical methods for high-risk groups. The American Society of Hematology (ASH) suggests LMWH or compression stockings in substantially increased risk individuals, with aspirin considered only if other measures are not feasible. The CDC Yellow Book emphasizes mobility, hydration, and mechanical measures.

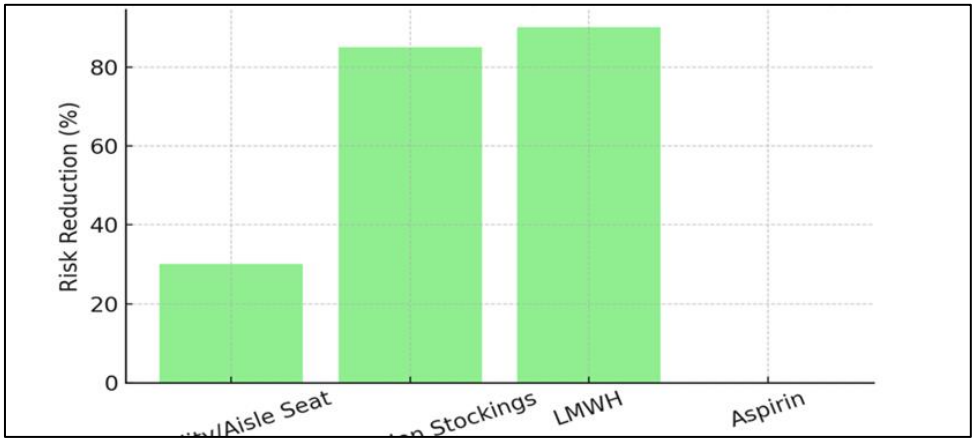

Figure 3 Relative Risk reduction by preventive strategy

7. Discussion

Air travel-related thrombosis is a multifactorial problem requiring a balanced approach. For most healthy individuals, the absolute risk remains low, and general measures such as ambulation are sufficient. For high-risk individuals, evidence supports mechanical prophylaxis and, in select cases, LMWH. The role of DOACs remains to be investigated. Policy changes by airlines, including educational materials and promoting in-flight movement, could further reduce risk. Future research should focus on large-scale trials of DOACs and innovative preventive measures.

The clinical dilemma lies in stratifying which passengers' merit active prophylaxis beyond general advice. While the absolute risk for the general travelling population is low, the consequences of missed prophylaxis in high-risk individuals can be severe, including life-threatening pulmonary embolism. Current practice emphasizes a risk-stratified approach: lifestyle and mechanical measures for most, pharmacological prophylaxis for the select few at highest risk. Airlines and regulatory bodies play an important role by providing pre-travel health information, encouraging in-flight exercises, and considering modifications to seating design. Future research priorities include randomized controlled trials of DOACs, evaluation of wearable devices that stimulate calf muscle activity, and cost-effectiveness analyses of universal vs targeted interventions. Additionally, longitudinal studies are needed to assess the real-world impact of travel-related thrombosis prevention campaigns.

Air travel-related thrombosis remains an important clinical and public health challenge, intersecting the domains of aviation medicine, hematology, cardiology, and primary care. Several points merit deeper discussion:

7.1. Risk Stratification Challenges

Although guidelines consistently emphasize a risk-based approach, accurately stratifying risk in routine practice remains difficult. Many individuals travel without prior medical consultation, leaving their risk factors unidentified. Additionally, subclinical or undiagnosed conditions, such as inherited thrombophilia or occult malignancy, can elevate risk unexpectedly. This complicates the decision-making process for clinicians tasked with advising travelers. Risk scores for travel-related VTE are not yet validated, creating a gap in clinical tools.

7.2. Evidence Gaps in Pharmacological Prophylaxis

LMWH has been studied in small trials such as LONFLIT3, which demonstrated reduced DVT incidence in high-risk travelers. However, large-scale randomized controlled trials are lacking, and questions remain regarding optimal dosing, timing, and cost-effectiveness. DOACs, with their oral administration and favorable safety profiles, are

theoretically attractive, yet remain untested in this context. The absence of RCT data limits their adoption, even though anecdotal off-label use is likely increasing. This represents a key research priority.

7.3. Role of Airlines and Public Health

Airlines could play a significant role in prevention through passenger education and cabin design. In-flight magazines, pre-boarding announcements, or seat-pocket cards could provide exercise instructions. Modifications in seating layout to allow increased legroom, particularly in economy class, may reduce venous stasis. However, commercial pressures and profit margins challenge implementation. Public health campaigns led by organizations such as WHO or CDC could standardize messaging worldwide, ensuring consistency in advice.

7.4. Cost-effectiveness Considerations

Universal prophylaxis with LMWH or DOACs would not be cost-effective given the very low absolute risk in the general population. Even compression stockings, though relatively inexpensive, may not be justified for low-risk travelers. Targeted prophylaxis for high-risk groups is more economical, balancing the costs of interventions against the potential cost of VTE treatment and complications. Economic models are needed to quantify these trade-offs more clearly.

7.5. Long-term Outcomes and Research Priorities

While acute travel-related VTE has been studied, the long-term outcomes of recurrent events or chronic post-thrombotic syndrome remain understudied. Prospective cohort studies are required to understand recurrence risk after a travel-associated event. Furthermore, ongoing surveillance is necessary to evaluate the real-world effectiveness of preventive measures. Future research should also explore novel strategies such as wearable compression devices, personalized risk prediction algorithms using genetic data, and the role of telemedicine in pre-travel counselling.

In summary, thrombosis during air travel is a multifactorial condition where individual susceptibility, environmental exposures, and behavior interact. Prevention strategies must remain dynamic, evolving with new evidence and balancing safety, efficacy, and feasibility. Clinicians, airlines, and policymakers share a responsibility to reduce risk while ensuring interventions are rational and evidence-based.

8. Conclusion

Thrombosis during air travel represents a preventable public health issue. A risk-stratified approach is essential: general preventive advice for most passengers, with compression stockings or LMWH for those at elevated risk. Ongoing research is needed to refine pharmacological strategies and improve implementation of preventive practices.

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