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ORIGINAL ARTICLE

Perioperative air travel increases the risk of venous thromboembolism following lower limb arthroplasty

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Abstract

Purpose Venous thromboembolism (VTE) is a significant complication following lower limb arthroplasty (LLA). There is a paucity of evidence with regard to air travel following LLA. Orthopaedic surgeons are often asked by patients regarding air travel following LLA, and there is a need for evidence to guide these patients.

Methods This was a retrospective cohort study. We identified two cohorts, one travelling to and from the hospital by air and another, by land. All patients received routine preoperative and post-operative care, and thromboprophylaxis, as per our hospital guidelines. We collected baseline demographics, ASA score and incidence of VTE at 90 days using local patient records and a national joint registry. We also recorded data on flight time and overland distance of travel.

Results Two hundred and forty-three patients travelled by air; mean flight time was 74 min. In total, 5498 patients travelled a mean 25.3 miles over land to the hospital. No differences in baseline demographics or ASA score were observed. Four patients developed a VTE in the flight group, with 32 patients suffering a VTE in the control group. There was a significant difference in the VTE rate between the flight and control groups ($p < 0.05$); the relative risk of developing a VTE in the flight group was 2.85.

Conclusions In our cohort, perioperative short haul air travel is associated with an increased risk of VTE at 90 days following LLA. Orthopaedic surgeons must ensure that their patients are cognizant of the risks associated with perioperative air travel and take measures to minimise these risks.

Keywords Venous thromboembolism · Lower limb arthroplasty · Air travel · Thromboprophylaxis · Flight

Introduction

Venous thromboembolism (VTE) is a serious complication following lower limb arthroplasty (LLA) that can lead to significant morbidity and potential mortality. The reported rate of VTE following LLA is around 1% [1, 2]; rates reported in the literature vary between 0.77 and 6.6% [3, 4]. It is well understood that the three factors noted in Virchow's triad (impaired blood flow, hypercoagulability and endothelial damage) are affected by orthopaedic surgery through factors such as the use of a tourniquet and immobilisation causing venous stasis, endothelial damage secondary to surgery and hypercoagulability secondary to inflammation [5]. In particular, the 'cytokine storm' caused by surgery results in a prothrombotic environment secondary to platelet activation and generation of tissue factor bearing microparticles which can trigger the coagulation cascade [6]. A variety of measures are routinely undertaken to minimise the risk of VTE, such as the use of pharmacological and mechanical thromboprophylaxis, coupled with early mobilisation of patients and adequate rehydration. Guidelines from the UK National Institute for Health and Care Excellence (NICE), updated in 2018 [7], suggest the use of pharmacological thromboprophylaxis for 4–6 weeks following total hip arthroplasty (THA) and 2 weeks following total knee arthroplasty (TKA). Similar recommendations are made by the American Academy of Orthopaedic Surgeons (AAOS) guidelines on VTE prevention [8]; however, these make no recommendation regarding flying following LLA. The UK NICE has produced a Clinical Knowledge Summary suggesting that patients avoid short and long haul travel for 6 and 12 weeks, respectively, acknowledging that there is a lack of evidence to support these recommendations [9].

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Air travel is understood to be a risk factor for VTE. VTE in air travellers was first recognised by Symington and Stack [10] and termed 'economy class syndrome'. VTE has subsequently been demonstrated in air travellers regardless of their position within the aircraft, suggesting that this phenomenon is related to risks generalisable to air travel itself. The absolute risk of VTE in air travellers from the general population has been estimated at 0.15% in a study of 2007 individuals travelling by air [11]. A larger study of 8755 employees of international organisations [12] suggested a threefold increase in the relative risk of VTE following air travel, with rates higher in travellers less than 30 years of age, women using the oral contraceptive pill or travellers who were particularly tall, short or overweight. Notably, undertaking multiple flights within a short period also led to an increased risk of VTE. In an editorial, Clark et al. [13] suggest that the symptomatic rate of VTE following long haul flights lies between 0 and 2% and can increase to 5% with risk factors such as obesity.

From a physiological perspective, numerous factors are thought to contribute to the increased incidence of VTE observed in air travellers. Schobersberger et al. [14] demonstrated activation of the coagulation cascade coupled with a reduction in fibrinolysis in 20 volunteers after a long haul flight and postulated a number of mechanisms for these findings. These include prolonged stasis in a seated position, resulting in reduced function of the calf muscle pump as well as dehydration with consumption of alcohol or caffeine [15]. At cruising altitude, cabin air pressure is below that routinely experienced at sea level resulting in hypobaric hypoxia, which in itself may lead to activation of the coagulation cascade [16], though these results have not been reproduced elsewhere[17]. Given the relatively low incidence of VTE in the general population, pharmacological thromboprophylactic measures are not recommended for healthy travellers, though measures such as avoiding immobility and remaining hydrated are routinely suggested [13]. However, the use of pharmacological measures may be appropriate in higher-risk patients [7, 8].

It is common for orthopaedic surgeons to be asked by patients when they can fly following LLA, yet there is a paucity of research data to guide them in their response. Given that both air travel and LLA increase the risk of VTE, it is pragmatic to counsel patients to avoid air travel for a period. Notably, the National Institute for Health and Care Excellence suggests avoiding air travel for 3 months following LLA, acknowledging that the guidelines on this topic are based on expert opinion (NICE [9]). Guidelines from the American Academy of Chest Physicians (ACCP) [18], the American Academy of Orthopaedic Surgeons (AAOS) [19] or the Scottish Intercollegiate Guidelines Network [20] do not provide guidance on the management of patients who wish to fly following LLA. However, advice from the Civil Aviation Authority in the UK [21] and the Centers for Disease Control and Prevention in the USA [22] suggests that patients contact their doctor or medical adviser for advice on when to travel following 'complex' or orthopaedic surgery. There is, therefore, a need for data to allow orthopaedic surgeons to advise patients who wish to fly in the short term surrounding LLA.

This study seeks to determine whether perioperative air travel was associated with a higher risk of VTE following LLA for patients attending a high-volume arthroplasty unit.

Methods

This was a retrospective cohort study performed in a high-volume, national arthroplasty unit over a 2-year period. Our hospital serves a geographic area that includes several remote islands, necessitating air transport of patients before and after surgery, as illustrated in Fig. 1. As we practice within a socialised health care system, the hospital is responsible for booking flights both for patient attendance for their procedure and for their subsequent return home following surgery. These circumstances allowed us to identify two cohorts of patients; those who travelled by air to and from our hospital and those who travelled by land. The flight group is comprised of patients from remote offshore islands who had undergone LLA at our hospital and were identified using our hospital booking records. An electronic patient records system was then used to identify all patients who had undergone LLA at our hospital during the same period. The aforementioned cohort was excluded to generate a second cohort—the control group—residing on the mainland. There are no commercial flights between cities on the mainland; hence, it was assumed that this latter cohort travelled to the hospital via road/rail. Our institution does not serve patients from the private sector or those residing outwith our geographic catchment area.

All patients received pharmacological and mechanical thromboprophylaxis in accordance with our hospital protocol, based on the UK National Institute for Health and Care Excellence guidelines [7]. All patients received 5000 i.u dalteparin whilst inpatients, commencing 6 h post-operatively. Those patients undergoing THA also received anti-embolism stockings; on discharge, they either continued dalteparin for 5 weeks post-operatively or were changed to Aspirin 150 mg. Patients undergoing TKA received similar measures, but were prescribed only 2 weeks of pharmacological thromboprophylaxis. Those patients who were willing to self-administer dalteparin were discharged on this medication, whilst those that were not were prescribed Aspirin instead. Furthermore, all patients were treated with a standardised package of care, including 'prehabilitation' and counselling preoperatively, through

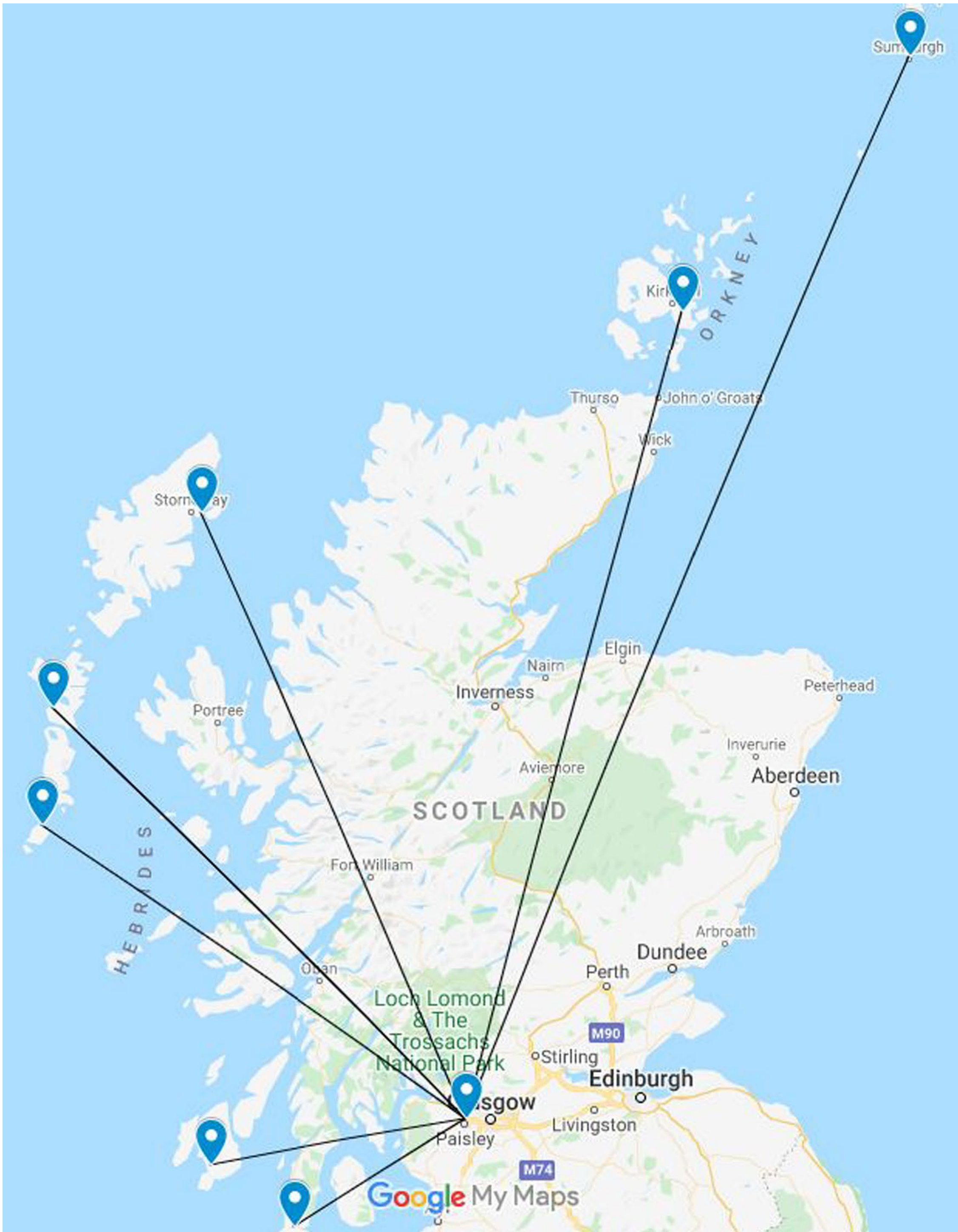

Fig. 1 Map illustrating location of remote island airports relative to our local airport (Image courtesy of Google Maps)

a 'joint school', intraoperative use of tranexamic acid, use of spinal anaesthesia combined with intra-articular and soft tissue local anaesthetic infiltration and physiotherapy post-operatively, commencing on the day of surgery.

An electronic patient record system (EPR) was used to collect data on baseline characteristics, American Society of Anaesthesiologists (ASA) physical status score, date of procedure, date of discharge and incidence of VTE. All hospital episodes generated nationally are recorded by the Information Services Division of our National Health Service. Furthermore, all arthroplasties undertaken at our institution are recorded in a national arthroplasty register and any hospital episode generated within 90 days relating to a diagnosis of VTE is flagged up. We therefore used data from this national register which is routinely fed back to the hospital, to identify episodes of VTE, where it occurred within 90 days of LLA.

To determine the distance travelled by patients in each cohort, we recorded the airport of origin for patients travelling by air. All of the remote islands cover small geographic areas less than 2200 km^2 with a total population of < 20,000 per island. Our hospital is located < 10 miles (< 16.1 km) from the local airport; hence, road travel was considered negligible for the flight group. Using airline schedules, we determined the geographic distance and flight time for patients in the flight group.

For the control group, we retrieved postal code for patients using our EPR. An Excel spreadsheet which identified the latitude/longitude of the first part of each postcode was used to calculate the orthodromic distance between the local area of the patient's address and the hospital.

Statistical analysis was conducted using Student's t test for continuous variables and the chi-squared test for proportions. The study was conducted in accordance with our institutional guidelines and registered with our local Clinical Governance department. As all data presented, included VTE incidence was routinely collected as part of the patients' clinical care, and our Clinical Governance department deemed that formal ethical approval was not required.

Results

During the 2-year study period, a total of 243 patients travelled to and from the hospital by air, returning a mean of 6 days following arthroplasty (range 1–24 days). As per institutional policy, these patients travelled by plane at least one day prior to surgery. The mean flight time was 74 min (range 40–85 min). There were 5498 patients in the control group. The median orthodromic distance travelled to the hospital was 25.3 miles (interquartile range 27.06 miles). Baseline demographics and procedures for both groups are shown in Table 1. No significant differences were observed in the baseline demographics collected.

Four patients (1.64%) developed a VTE in the flight group (2 pulmonary emboli, 2 deep vein thromboses). Thirty-two patients (0.58%) sustained a VTE in the control group (25 pulmonary emboli, 7 deep vein thromboses). There was a significant difference in the VTE rate between flight and control groups ($p < 0.05$), with the relative risk of developing a VTE in the flight group 2.85 (95% confidence interval 1.01–7.98).

Discussion

Short haul air travel in the perioperative period appears to be associated with an increased risk of VTE at 90-day follow-up in our cohort. To our knowledge, this is the first study to identify such a risk in relation to perioperative air travel. Orthopaedic surgeons must ensure that their patients are cognizant of the risks associated with perioperative air travel and, where appropriate, take measures to minimise these risks.

Indeed, the issue of flying in the post-operative period is regularly raised by patients undergoing LLA. However, there is a paucity of strong evidence to guide physicians in advising their patients. A number of studies in the literature have examined this issue. Ball et al. [23] studied 608 patients, 462 of whom travelled more than 200 miles, a mean of 6.5 days following hip arthroplasty or hip resurfacing, finding no additional risk of VTE in those who had flown to their destination. A study of 1685 patients undertaking flights post-operatively following LLA reported similar findings [24]. The issue of preoperative air travel has also been examined in a series of 342 patients, with the authors again

Table 1 Baseline demographics and procedures

Baseline demographics				
	Flight		Control	
Number of patients	243		5498	
Age (years)	69.3 (range 47.1–91.6) (s.d. 8.8)		68.1 (range 24.9 – 94) (s.d. 9.3)	
BMI (kg/m2)	31.4 (range, 20– 52.5) (s.d. 5.6)		30.96 (range 15.5 – 68) (s.d. 6.6)	
Gender (%)	Female	58% (141)	Female	58% (3202)
	Male	42% (102)	Male	42% (2296)
ASA function score	2.05		2.07	
Hip replacement (%)	47.8% (119)		49.8% (2739)	
Knee replacement (%)	52.2% (130)		50.2% (2759)	

suggesting no increased risk [25]. The current study is the first in the literature which examines the issue of pre- and post-operative air travel and presents a significantly larger cohort than identified elsewhere.

It is recognised that patient outcomes, including length of stay, dislocation and costs, following LLA are improved when undertaken by high-volume surgeons in high-volume centres [26, 27]. Somewhat paradoxically, the rate of VTE has been reported to increase in these patients, compared to lower volume facilities [28], with the authors suggesting that the increased rate of VTE may reflect increased travel time to particular institutions. Notably, this result has not been replicated in other studies [27]. The consolidation of hospitals into high-volume units due to economic factors [29] is leading to the creation of regional arthroplasty units [27]. This regionalised delivery of LLA services requires many patients to travel larger distances, potentially by air, both before and after their surgery. A further factor which may drive patients to seek treatment in regional units is the coronavirus pandemic, which has led to the suspension of elective activity across the globe. Establishment of elective-only arthroplasty centres, where all patients and staff are screened for coronavirus prior to surgery, is likely to occur on a regional basis, requiring patients to travel further for their treatment. This study suggests that the risk profile of such patients may be increased in relation to VTE. This is of particular relevance in both health care systems where centralisation of services requires travel both to and from the hospital. It is also pertinent in the case of medical tourism, an industry which is estimated to have treated 15 million patients in 2017 and which is expected to increase markedly in future [30]. A significant proportion of patients undertaking such tourism will be flying both pre- and post-operatively.

Our study has several strengths. As noted, we have a large cohort of patients. Our institution booked patient flights, ensuring our data were robust. Furthermore, clinical data were corroborated with local and national reporting databases, lending reliability to our results. In addition to this, the management of both arms of our cohort was standardised such that the package of treatment received by both groups was similar. However, VTE is, fortunately, an uncommon occurrence and even in a large cohort, in common with other studies in the literature, our event rate is small. We did not screen patients for VTE, in line with our normal clinical practice and national guidelines in both the UK and USA. Thromboprophylaxis for our patients was, in keeping with current national guidelines, undertaken with one of two agents for differing time periods. We did not collect data on how many patients were prescribed either dalteparin or aspirin on discharge, though notably, large-scale meta-analyses and randomised controlled trials have shown no difference in the clinical effectiveness of these agents following both lower limb arthroplasty and trauma [31–33]; hence, we would not expect any difference in effectiveness of these agents in our cohort. Equally, we did not extend the thromboprophylaxis regimen in the TKA group to 5 weeks, as this would expose this cohort to a risk of complications for no benefit in terms of reduced VTE risk. We also have limited data on patients' individual risk factors for VTE as well as their comorbidities, as these patients were treated at other hospitals. In ideal circumstances, a more complete data set in this regard would have allowed for multivariate analysis of the risk of VTE in both groups. The low event rate in the flight group precludes us from drawing conclusions regarding VTE risk following flights of particular duration or after specific procedures. In addition to this, we did not collect data on the length of journey from patients' destination airports to their homes, nor for time spent in transit at the airport. The journey time to the airport from our institution was less than 15 min by road. We combined data from elective knee and hip replacement, as our national registry data suggest that the incidence of VTE in our population is similar in both procedures [2]. Finally, as a study of a retrospective cohort, we demonstrate only association, not causation.

In conclusion, our work suggests that perioperative air travel is associated with an increased risk of VTE following LLA. Further investigation, in the form of prospective study of matched cohorts, is required to quantify this risk. An expanding evidence base will allow development of robust guidelines to direct the management of such patients, who form part of a population base which is likely to expand over the coming years due to a combination of centralisation of arthroplasty services and rising medical tourism. More evidence in relation to this issue will also provide surgeons with data to appropriately consent and guide patients undergoing LLA.

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Declarations

Conflict of interest F Picard discloses committee appointments for CAOS International and paid presentations for B Braun and Brain Lab. F Picard discloses royalties from Oxford University Press and financial support from Zimmer, Stryker and Mathys.

Data availability Data are available by contacting the corresponding author.

Ethical approval The study was conducted in accordance with our institutional guidelines and registered with our local Clinical Governance department. As we were using routinely collected patient data, ethical approval was not required.

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