



Original Research

Total Joint Arthroplasty in Patients With Atrial Septal Defects: What Are the 90-Day Complications?

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ABSTRACT

Background: Congenital heart defects, such as atrial septal defects (ASDs) and patent foramen ovale (PFO), may increase the risk of embolic events in total hip or knee arthroplasty (THA/TKA). The objective of this study was to determine the 90-day incidence of intraoperative and postoperative embolic events and all other complications in patients with a known ASD/PFO who underwent primary hip and knee arthroplasty.

Methods: This is a retrospective review of 160 patients with ASD/PFO undergoing 196 primary arthroplasties (94 THAs, 102 TKAs) at a single institution. The mean age was 64 years (standard deviation [SD] 11.1), 40.6% were male, and average body mass index was 31 kg/m² (SD 7.2). The mean follow-up period was 19 months (SD 16). Forty-three percent of patients were on anticoagulation preoperatively. All patients received postoperative thromboprophylaxis (48% aspirin, 31% direct oral anticoagulants, 18% warfarin, 3% enoxaparin).

Results: There were no embolic events identified. Fourteen patients (7%) developed complications within 90 days. Three had bleeding complications, and 8 had other nonoperative complications, which were all managed conservatively and had uneventful recoveries. Additionally, 3 patients had complications requiring reoperations: 2 for periprosthetic fractures (1 THA, 1 TKA) and 1 for a periprosthetic infection (TKA).

Conclusions: In this cohort of patients with a known ASD/PFO undergoing THAs and TKAs, there were no cases of embolic events. However, it would be advisable to have a thorough cardiology evaluation to assess potential risks and benefits of defect repair prior to total joint arthroplasty and to reduce the risk of paradoxical embolic events and the necessity of potent anticoagulation.

Level of evidence: Prognostic Level IV.

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Introduction

Atrial septal defects (ASDs) and patent foramen ovale (PFO) are congenital communications between the left and right atria that can allow for paradoxical emboli and increase the risk of perioperative stroke. ASDs occur in 1.6 per 1000 live births, and PFO is present in nearly 25% of adults [1]. The majority of patients with ASD or PFO are asymptomatic clinically, but the right-to-left shunting can cause shortness of breath and headaches, as well as

pulmonary embolism and paradoxical embolism, including fat embolism [2].

Perioperative stroke, which is defined as a new neurological deficit that occurs during or within 30 days of surgery, is a rare but devastating complication. It is estimated to occur in 0.1% to 1.9% of noncardiac surgeries, with 50% occurring within the first postoperative day [3]. ASD and PFO have been identified as risk factors for perioperative strokes, even when controlling for demographic and clinical covariates [1,2,4]. When looking at noncardiac surgeries, patients with ASD/PFO have a higher risk of postoperative ischemic strokes, in-hospital mortality, 30-day stroke, and 30-day readmission after surgery [4].

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) patients are at an increased risk of thromboembolic or fat embolic

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events, particularly those with hypercoagulable states and those with a prior history of venous thromboembolism (VTE). The increased risk of embolic events is due to the surgical trauma, increases in intramedullary pressure during stem insertion, and postoperative stasis [5,6]. The presence of an ASD or PFO may lead to paradoxical emboli and perioperative stroke [2,7].

The objective of this study was to determine the 90-day rate of postoperative embolic events in patients with a known ASD or PFO undergoing THA or TKA. The secondary aim was to determine the overall incidence of complications in this cohort. We hypothesize that given the use of potent anticoagulation in this population, there would be a low incidence of embolic events.

Material and methods

Study design and patient selection

Following approval from our institutional review board, we conducted a retrospective chart review of patients who underwent primary hip or knee arthroplasty at a single tertiary hospital from 2016 to 2020. Inclusion criteria included a documented ASD or PFO. Patients undergoing revision arthroplasty were excluded. A total of 160 patients with an ASD or PFO were identified. They underwent 196 total joint arthroplasties (TJAs; 94 primary THAs, 102 primary TKAs) during the study period. All bilateral procedures were staged (18 bilateral TKA and 10 bilateral THA), and 6 patients had both a THA and TKA. During the study period, there were 42,291 THAs and TKAs performed at the study location. Therefore, ASDs/PFOs were identified in 196 of 42,291 (0.5%) cases. All electronic patient charts were reviewed to identify patient demographics, past medical history, details of surgical procedure, and hospital stay, as well as postoperative complications occurring within 90 days.

Preoperative patient characteristics

The mean age at the time of arthroplasty was 64 years (standard deviation [SD] 11.1), 40.6% (65/160) were male, and the average body mass index (BMI) was 31 kg/m² (SD 7.2) (Table 1). One hundred thirty-three of 160 (83%) were White or Caucasian. A smoking history was reported in 62 of 160 (39%), and 6 of 160 (4%) were current smokers. The most common medical comorbidities included chronic pulmonary disease (16%), rheumatic disease (11%), and chronic kidney disease (8%). The Charlson Comorbidity Index (CCI) was 0 in 54%, 1 in 25%, 2 in 11%, and ≥ 3 in 10%. Fifty-seven of 160 patients (36%) had a previous history of stroke or transient ischemic attack (TIA). Twenty-nine of the 160 patients (18%) underwent ASD/PFO repair prior to arthroplasty. Of the patients with prior history of stroke or TIA, 15 of 57 (26%) underwent correction of their ASD/PFO. Sixty-nine of 160 (43%) patients were on preoperative anticoagulation, namely warfarin and direct oral anticoagulants (DOACs). Twenty-eight of 57 (49%) patients with a prior history of stroke or TIA were on anticoagulation therapy prior to the arthroplasty procedure.

Operative and in-hospital characteristics

Cementless fixation was used in 86 of 94 (91%) THA cases, and hybrid fixation with femoral cement fixation was used in 8 of 94 (9%) THA cases. Seventy-two of 94 (77%) THAs were done through a posterior approach, and 22 of 94 (23%) THAs utilized an anterior approach. Cement fixation was used in 99 of 102 (97%) TKA cases. A tourniquet was used in 97 of the 102 (95%) TKA cases. Multimodal thromboprophylaxis was used postoperatively including early mobilization, pneumatic compression devices, and chemoprophylaxis for 6 weeks tailored to the patient's risk [5,6]. Aspirin (ASA)

Table 1
Preoperative patient demographics.

n (Patients)	160
THA (%)	81 (50.6%)
TKA (%)	79 (49.4%)
Age, mean (SD)	64.27 (11.08%)
Male (%)	65 (40.6%)
Race (%)	
American Indian or Alaska Native	1 (0.6%)
Asian	3 (1.9%)
Black or African American	12 (7.5%)
Other	8 (5.0%)
Patient Declined	3 (1.9%)
White or Caucasian	133 (83.1%)
BMI, mean (SD)	30.76 (7.23)
Smoking status (%)	
Current every day smoker	6 (3.8%)
Current some day smoker	1 (0.6%)
Former smoker	53 (33.1%)
Light tobacco smoker	2 (1.2%)
Never smoker	98 (61.3%)
Prior stroke/TIA (%)	57 (35.6%)
Patients with repaired ASD/PFO	29 (18.1%)
Preop anticoagulant use (%)	69 (43.1%)
Charlson Comorbidity Index (%)	
0	87 (54.4%)
1	40 (25.0%)
2	17 (10.6%)
3	9 (5.6%)
4	3 (1.9%)
5	4 (2.5%)

was used as VTE prophylaxis in 94 patients (48%), DOACs in 62 patients (31%), warfarin in 35 patients (18%), and enoxaparin in 5 patients (3%). Eighteen of 29 (62%) patients with a repaired ASD/PFO received ASA, whereas 70 of 157 (45%) patients with unrepaired ASD/PFO received ASA ($P = .09$).

The mean length of hospital stay was 2.9 days (SD 1.3). The mean follow-up was 19 months (range: 1 to 60 months; SD 16). Three of 196 (2%) patients' last follow-up visit happened in less than 90 days, ranging from 31 to 61 days after surgery, with an average of 46 days (SD 15).

Statistical analysis

Descriptive statistics, such as means with ranges and frequency statistics, were used to report baseline characteristics. Differences in categorical variables were detected using chi-square or Fischer exact tests as indicated. Statistical significance was set at an $\alpha \leq 0.05$. All analyses were performed using SAS Software version 9.4 (SAS Institute, Cary, NC). Using the 7.14% perioperative stroke rate observed in the study of Perfetti et al. [7], only 52 patients were needed in the cohort to have 80% power to detect an event. With 196 patients, we were 100% powered to detect a perioperative stroke.

Results

Postoperative complications

There were no cases of stroke, transient ischemic attack, retinal artery thrombosis, or other embolic events. Fourteen patients (6 on ASA and 8 anticoagulated) had complications within the first 90 days after surgery.

Three patients (1.5%, 1 on ASA and 2 on potent anticoagulants) developed bleeding complications, including 1 upper gastrointestinal bleed, 1 recurrent TKA hemarthrosis, and 1 hematoma after TKA. The patient with an upper gastrointestinal bleed was

discharged on rivaroxaban, and the bleed occurred within 1 week of surgery. The rivaroxaban was not discontinued, and the bleed resolved without intervention. The recurrent hemarthrosis occurred in a patient who was on life-long warfarin due to prior TIAs. They underwent uneventful embolization [8]. The patient with a hematoma after TKA was discharged on ASA and was given antibiotics prophylactically to prevent infection. This resolved without further intervention. None of these patients required readmission.

There were 3 cases of superficial wound necrosis: 2 after an anterior approach THA and 1 after TKA (1 on warfarin, 1 on rivaroxaban, and 1 on ASA). They were treated with in-office debridement, antibiotics, and daily dressing changes, and all resolved within the first postoperative month. Additionally, 1 THA patient, discharged on ASA, sustained a greater trochanteric fracture after a fall 1 month after the index procedure and was managed non-operatively. Finally, 1 patient developed new-onset atrial fibrillation on postoperative day 5 after THA. Originally discharged on ASA, the patient was switched to rivaroxaban given the new atrial fibrillation. Three months after their THA, the patient underwent a percutaneous occlusion of the left atrial appendage to decrease the risk of future strokes.

There were 3 reoperations, including 2 revisions for periprosthetic fracture and 1 revision for a periprosthetic joint infection. One of the patients who sustained a periprosthetic fracture was discharged on ASA and fell 2 weeks after a TKA. The fracture was revised without complication. The other patient, also discharged on ASA, sustained a periprosthetic fracture after a fall 1 month after THA and was promptly revised. This patient with a BMI of 51 and a CCI of 2 developed a periprosthetic joint infection (>90 days after index procedure). Finally, 1 patient discharged on apixaban required a revision for a periprosthetic infection 6 weeks after a TKA. They were treated with irrigation and debridement and polyethylene liner exchange and had an uneventful recovery.

Within 90 days of the index procedure, none of the 29 patients with a repaired defect had a complication, and 14 of 157 (9%) patients with an unrepaired defect had a complication ($P = .08$). The 90-day cumulative probability of reoperation was 1.5%, and the 90-day cumulative incidence of any complication was 7%.

Discussion

This study was inspired by 4 early postoperative strokes after THA performed by 2 of the senior authors during the past 4 decades in patients with an *unknown PFO*. The most serious was a fat embolic event during the cementation of the femoral component, resulting in a large stroke, minimal motor function, and inability to speak and swallow. After 6 weeks of intensive care and several months of intensive physical therapy, the patient eventually recovered. Given the potential catastrophic consequences of intraoperative and postoperative embolic events in patients with ASD/PFO undergoing THA or TKA, this study sought to evaluate complications in a large cohort of patients with these cardiac defects.

In a normal physiologic state, the left atrial pressure exceeds that of the right by approximately 2–4 mmHg [9]. In the presence of ASD, with a reversal of the pressure gradient, paradoxical embolism can occur. In THA and TKA, acute perioperative events like intramedullary fat and thrombotic embolism can increase pulmonary artery pressure favoring reversal of the pressure gradient and right-to-left shunt through the ASD [7]. Chronic conditions such as tricuspid regurgitation and pulmonary hypertension also favor paradoxical embolism. In addition, positive pressure ventilation and positive end-expiratory pressure during anesthesia can

also cause a reversal of the pressure gradient and paradoxical embolism [10].

In this retrospective review of 160 patients with a documented ASD/PFO undergoing 196 primary THAs and TKAs, there were no embolic events during the 90-day study period. However, there were 14 complications, including bleeding complications as well as periprosthetic fractures and infection requiring revisions.

Perioperative strokes in the arthroplasty population are rare events. Prior studies have used various databases to report cerebrovascular accident incidences ranging from 0.2% to 0.3% in primary THA [11], while others have reported the 90-day cerebrovascular accident incidence in THA and TKA at 1.3% and 0.5%, respectively, [12]. Other studies focused on the subsection of arthroplasty patients with ASD/PFO. Hong et al. used the Humana national database to report a perioperative stroke rate of 0.015% in the TKA population [2]. In their multivariate analysis, the presence of a PFO was the largest predictor of a perioperative stroke [2]. Hong et al. also stated that due to their small sample size, they were unable to detect an association between anticoagulation use and the risk of stroke after TKA in patients with PFO [2]. Using the Nationwide Inpatient Sample database, Perfetti et al. reported a perioperative stroke rate of 99 per 100,000 THA, as well as a prevalence of 7.14% for patients with ASD/PFO compared with 0.26% in matched controls [7]. Notably, they did not report on anticoagulation use. Based on the 7.14% perioperative stroke rate observed in the study of Perfetti et al. [7], we should have expected approximately 14 embolic events in our cohort of 196 THA/TKA surgeries. All our patients received a multimodal thromboembolic prophylaxis and a judicious use of postoperative anticoagulation, which is most likely the reason we observed no embolic events.

An industry-sponsored randomized controlled trial by Lassen et al. compared the use of apixaban vs enoxaparin as VTE prophylaxis for THA [13]. The rate of bleeding complications was approximately 5% in both groups [13], highlighting the increased risk of bleeding with potent anticoagulants. Anderson et al. compared ASA vs rivaroxaban as VTE prophylaxis for TKA in a randomized control trial [14]. The rate of bleeding complications was less than 1.5% and did not differ significantly between the 2 groups [14]. All the bleedings occurred at the surgical site. Our study, which had 48% of patients discharged on ASA, observed a 1.5% rate of bleeding complications, which is in accordance with the study by Anderson et al. [14].

Of the 3 reoperations in this cohort, 1 was a revision for periprosthetic infection in a patient who received apixaban for postoperative chemoprophylaxis. Parvizi et al. reported in a retrospective study that patients using stronger anticoagulation, such as intravenous heparin or high-dose DOACs, were more likely to develop wound complications and then periprosthetic infections [15]. In addition, patients on warfarin with a mean international normalized ratio greater than 1.5 were more likely to develop wound complications and subsequent infections.

There were also 2 revisions for periprosthetic fractures. To our knowledge, there is no literature establishing an association between ASD/PFO and anticoagulation with the risk of fracture. We hypothesize that these complications were likely due to the higher comorbidity level of these 2 patients. The periprosthetic fracture after THA occurred in a patient with a BMI of 51 and a CCI of 2, who had a history of pulmonary and cardiac disease. The periprosthetic fracture after TKA occurred in a frail 79-year-old patient with a history of uterine cancer.

None of the 29 patients who had the ASD repaired prior to surgery had a complication within 90 days of surgery, while 14 patients with unrepaired defects had complications. Despite our encouraging results, we suggest that patients with a known ASD/PFO contemplating TJA should be evaluated by the cardiology team

to determine the possible benefits and risks of defect closure, particularly in patients with predisposing factors for thromboembolism [6]. Four recent studies demonstrated significant reductions in rate of recurrent stroke after PFO closure in comparison to medical treatment, and the American Academy of Neurology redefined the guidelines accordingly [16–20]. Murphy et al. recognize that while a properly repaired defect should prevent right/left paradoxical emboli, these patients still have a higher risk of arrhythmia [21].

To reduce the risk of thromboembolism in hip and knee arthroplasties, we recommend a multimodal prophylaxis, which includes discontinuation of procoagulant medications prior to surgery, risk-stratification for the selection of VTE prophylaxis, and regional anesthesia. During the posterior approach THA, the duration of femoral preparation should be minimized, as the lower extremity is kept in an extreme position, kinking the femoral vein, and thus favoring local clot formation. Careful lavage and aspiration of intramedullary contents during reaming, cementation, and stem insertion reduces their extravasation to the venous circulation. Early mobilization, intermittent pneumatic compression, and frequent and vigorous dorsiflexion of ankles will also reduce postoperative venous stasis and the risk of VTE [5,6].

There are limitations to this study. It is a retrospective study of a very rare event at 1 institution; thus, our sample size is limited. Also, the number of patients with ASDs in this study is likely an underestimate since its prevalence in the adult population is roughly 25% and only 0.5% of patients undergoing TJA in this study period at our institution had ASDs. Furthermore, since 36% of our patients had a prior stroke history, our study group may be skewed toward larger PFOs or those with higher pressure gradients. However, we were able to review every patient chart and provide granular information on the patient's postoperative course.

Conclusions

In this cohort of patients with known ASD/PFO undergoing THAs and TKAs, there were no cases of intraoperative or postoperative embolic events, most likely due to the use of multimodal thromboembolic prophylaxis and judicious use of prophylactic anticoagulation. However, it would be advisable to have a thorough cardiology evaluation to assess potential risks and benefits of defect repair prior to TJA and to reduce the risk of paradoxical embolic events and the necessity of potent anticoagulation, with its inherent risk of bleeding.

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Conflict of interest

Dr. Michael Cross receives royalties from Exactech, Depuy, and PSI (Orthophor); is in the speakers' bureau or gave paid presentations to Flexion Therapeutics, Depuy, and 3M; is a paid consultant for 3M, DePuy, A Johnson & Johnson Company, Exactech Inc., and Flexion Therapeutics; has stock or stock options in BICMD, Imagen, Insight Medical, Intellijoint, and Parvizi Surgical Innovation; receives research support from 3M, Exactech Inc., and Intellijoint; and is a board member in *Bone & Joint*

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