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ORIGINAL ARTICLE

Are Postoperative Complications More Common with Single-Stage Bilateral (SBTKR) Than with Unilateral Knee Arthroplasty: Guidelines for Patients Scheduled for SBTKR

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Abstract A significant number of patients with degenerative arthritis of the knee require bilateral knee arthroplasty. Single-stage bilateral total knee arthroplasty (SBTKR) has been associated with increased patient morbidity and mortality. At our institution, the following steps have been taken to minimize the risks to patients undergoing this procedure: regional anesthesia and analgesia, invasive monitoring, postoperative observation in an intensive care unit setting, and aggressive management of hemodynamic aberrations. We reviewed the medical records of 462 sequential total knee arthroplasty patients, consisting of 169 SBTKR and 293 unilateral total knee arthroplasty (UTKR) cases. A total of 122 patients from each group were matched for age, weight, and a history of ischemic heart disease and hypertension. Patients for SBTKR exhibited a significantly higher incidence of fat embolism syndrome and cardiac arrhythmias than UTKR patients. There were no deaths in either group and the incidence of other serious postoperative complications was low and similar between the two groups. Elderly patients (~75 years old) had more postoperative complications. With aggressive clinical management SBTKR can be safely performed in selected patients. Guidelines for the selection of these patients are presented.

Introduction

A significant number of patients with degenerative arthritis of the knee require bilateral knee arthroplasty [1]. Arthroplasty can be performed sequentially as a single operation (SBTKR) or as a two-staged procedure, usually separated by several months. The advantages of SBTKR include (1) exposure to the risks of only one anesthetic, (2) one postoperative course of pain, (3) reduced rehabilitation and hospitalization, and (4) an earlier return to baseline function. Hence, if the risks of SBTKR were similar to staged (unilateral) procedures, then there would be a clear health care cost advantage to SBTKR. Critics of SBTKR have suggested that the risk of morbidity and mortality is higher in SBTKR compared to unilateral (UTKR) knee arthroplasty [2]. SBTKR has been reported to be associated with an increased risk of serious perioperative complications including myocardial infarction, fat embolization, and thromboembolic events [3, 4]. These more serious events have been reported to be more prevalent in elderly patients with cardiovascular comorbidities [5]. In addition, SBTKR patients often require increased numbers of blood transfusions, are more likely to be transferred to a rehabilitation center, and have a higher incidence of postoperative intensive care admissions—all of which increase health care costs [6].

If the serious perioperative complications associated with SBTKR were the result of increased fluid shifts, pain, hypoxemia, and tachycardia; then increased vigilance may result in a reduction in these complications. All of our SBTKR patients received a regional anesthetic and were invasively monitored with an arterial and a central venous or pulmonary artery catheter. All SBTKR patients spend the first 12–24 h after surgery in the Post Anesthesia Care Unit (PACU) and were not discharged from the unit until their pain, urine output, and hemodynamics are deemed acceptable by the covering physician. In this context, we assessed perioperative complications in SBTKR and UTKR patients, matched for demographics.

Methods

With IRB board approval the medical records of 462 sequential knee replacement patients at The Hospital for

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Table 1. Unmatched total knee arthroplasty patients

	SBTKR	UTKR	*p*
Patients (*n*)	169	293	
Age (years)	65 ± 11	68 ± 11	ns
Weight (kg)	83 ± 19	80 ± 17	ns
Age >80 years, *n* (%)	3 (1.8)	40 (13.6)	0.0001
Sex (male/female)	65/104	99/104	
CAD, *n* (%)	15 (9.0)	34 (11.6)	ns
MI, *n* (%)	2 (1.1)	19 (6.5)	0.02
COPD, *n* (%)	4 (2.4)	16 (5.5)	ns
DM, *n* (%)	11 (6.5)	34 (11.6)	ns
HTN, *n* (%)	76 (45.0)	143 (49.0)	ns
CVA, *n* (%)	1 (0.6)	3 (0.1)	ns
Current smoker, *n* (%)	10 (5.9)	32 (10.9)	ns
Postoperative events			
PACU (days)	1.3±0.7	0.4 ± 0.5	0.0001
PACU (days) >2, *n* (%)	12 (7.1)	11 (3.7)	ns
PMI, *n* (%)	2 (1.1)	2 (0.7)	ns
CHF, *n* (%)	1 (0.6)	1 (0.3)	ns
New onset Afib (*n*)	15 (8.9)	8 (2.7)	0.001
Renal failure, *n* (%)	1 (0.6)	1 (0.3)	ns
PE, *n* (%)	1 (0.6)	1 (0.3)	ns
Hypoxemia, *n* (%)	9 (5.3)	3 (1.0)	0.004
Confusion, *n* (%)	11 (6.5)	5 (1.7)	0.005
Transfer to ICU	2 (1.1)	3 (1.0)	ns
EBL (mL)	1,374 ± 411	786 ± 363	0.01

CAD: coronary artery disease, MI: myocardial infarction, COPD: chronic obstructive pulmonary disease, DM: diabetes mellitus, HTN: hypertension, CVA: cerebral vascular disease, CHF: congestive heart failure, Afib: atrial fibrillation, PE: pulmonary embolism.
Confusion, minimental status test. Hypoxemia, $pA(O_2)$ <60 on 3 L/min NC.

Special Surgery (HSS) were reviewed; 169 SBTKR and 293 UTKR were reviewed. This period was unusual for a higher percentage of SBTKR, which at this institution is usually less than 20% of all knee arthroplasty. All patients received an epidural or combined spinal/epidural anesthetic, and the epidural catheter was infused with local anesthetic/narcotic for postoperative analgesia. All patients were monitored with an arterial catheter, and SBTKR patients were also monitored with a central venous (CV) or pulmonary artery (PA) catheter. All SBTKR patients were monitored for ~24 h in the PACU, whereas 34% of the UTKR group (101/293) were monitored overnight in the PACU for medical observation. An arterial blood gas was drawn upon entrance to the PACU and a decrease in oxygenation over the next 24 h was treated with i.v. Lasix if the CV or PA pressures were elevated. Heart rates greater than 100 bpm were treated with i.v. metoprolol. Blood was transfused to maintain a hematocrit greater than 28 mg%. Patients were transferred out of the PACU when their pain was controlled (VAS < 5) and they had a stable hemodynamic profile.

Both components of the knee prosthesis were inserted with acrylic cement. Constavac drains were inserted in each knee for ~12 h after surgery. Coumadin and a calf mechanical compression device were used for thromboembolic prophylaxis.

We were able to match 122 patients from each group (SBTKR and UTKR) from the 462 patients for age ±5 years, sex, weight ±5 kg, and a history of ischemic heart disease (previous MI, positive stress test, anginal symptoms) and hypertension. Also included in the analysis were 23 patients in the UTKR group, who returned within 1 year for replacement of the other knee.

The postoperative outcomes that were followed included death, myocardial infarction (MI), congestive heart failure (CHF), acute renal failure, pulmonary embolization (PE), days in the PACU, transfer to an ICU, estimated blood loss (EBL; intraoperative blood loss and postoperative drainage), and transfusion requirements. While they were in the PACU, patients were assessed for confusion (minimental status test) and hypoxemia [$pA(O_2) < 60$ mm Hg on 3 L/min nasal cannula].

Continuous variables were analyzed using ANOVA. Dichotomous variables were assessed for correlation using chi-square with a continuity correction and the Fisher exact test; $p < 0.05$ was considered significant.

Results

In this series of 462 patients for total knee arthroplasty, the majority of patients had preoperative medical comordities (Table 1). However, 74 (25.2%) of the patients for UTKR and 52 (30.8%) of the patients for SBTKR, had no major medical comorbidities. Significantly more patients in the UTKR group were 80 years or older ($p = 0.0001$) and had a past history of a myocardial infarction ($p = 0.02$) compared to the SBTKR group. The mean tourniquet time for UTKR was 63 ± 20 min compared to 123 ± 33 combined tourniquet times for both knees in the SBTKR. Total blood loss (intraoperative and postoperative constavac drainage) was 787 ± 363 mL for UTKR and 1,374 ± 441 mL for SBTKR. The SBTKR patients were transfused 2.8 units compared to 1.6 units of blood for the UTKR patients. Most patients were able to predonate two units of autologous blood, hence only 10% of the UTKR required the transfusion of allogenic blood, compared to 43% (74/169) of the SBTKR patients.

Table 2. 122 matched total knee arthroplasty patients

	SBTKR	UTKR	*p*
Comorbidities			
CAD (*n*)	13	15	ns
MI (*n*)	2	9	0.03
COPD (*n*)	2	3	ns
DM (*n*)	8	10	ns
HTN (*n*)	57	55	ns
Postoperative events			
PMI (*n*)	2	2	ns
CHF (*n*)	1	0	ns
New onset Afib	12	3	0.001
PE (*n*)	1	0	ns
PACU days >2 (*n*)	6	4	ns
Transfer to ICU (*n*)	2	2	ns
Hypoxemia (*n*)	7	0	0.001
Confusion (*n*)	6	2	0.005

Table 3. Staged bilateral total knee arthroplasty

	SBTKR	Staged BTKR	*p*
Patients (*n*)	169	23	
Age (years)	65±11	73±8	0.002
Weight (kg)	83±19	83±16	ns
Postoperative events			
Transfer to ICU	2	0	ns
Allogenic transfusions (*n*)	74	2	0.001
Hypoxemia (*n*)	9	0	ns
Confusion (*n*)	11	2	ns
PMI (*n*)	2	0	ns

The incidence of major acute postoperative complications (PMI, ARF, CHF, requirement for ICU care) were low and similar between both groups. Patients undergoing SBTKR, however, had a higher incidence of fat-embolism-like symptoms (FES; hypoxemia and confusion) and the development of atrial fibrillation than UTKR patients (Table 2). When patients from both groups were subsequently matched for age, weight, ischemic heart disease, and hypertension the results were similar. There were significantly more patients with hypoxemia, confusion, and new onset atrial fibrillation in the SBTKR group than in the UTKR group. Six of the seven patients with hypoxemia in the SBTKR group also exhibited signs of confusion and bilateral diffuse infiltrates on chest x-ray (FES syndrome). We were unable to demonstrate a positive correlation between any of the preoperative comorbidities and the development of the FES, except for age. Patients with both postoperative confusion and hypoxemia were 74±6 years old compared to 67±11 years old in those without these symptoms (p=0.008). The postoperative development of atrial fibrillation was significantly correlated (p=0.02) with the FES syndrome.

We were able to track 23 patients in the UTKR group who returned for a second knee arthroplasty within 1 year (Table 3). Compared to SBTKR patients, these patients were older but for both procedures combined had fewer postoperative complications including FES. In addition, only 9% (2/23) of these patients received allogenic blood transfusions.

Discussion

Patients who have symptomatic osteoarthritis of both knees require bilateral knee replacements before they can achieve a functional improvement in lifestyle. If the risks of serious complications are minimal, then SBTKR would be the best solution to this problem, because it would incur the cost of only one hospitalization [1]. Moreover, it would be beneficial to construct guidelines in which patients at the highest risk for perioperative complications from SBTKR would be eliminated from the procedure.

At most institutions as well as at HSS, SBTKRs are performed using sequential inflation of the tourniquets; the tourniquet on the first knee is deflated after the first implant is cemented and prior to inflation of the second tourniquet. In the report of Lynch et al [5] on 98 elderly patients undergoing SBTKR, the tourniquets were inflated concomitantly. They reported an overall complication rate significantly higher in the SBTKR group and, in particular, 10 of 98 patients in the SBTKR group compared to 2 of 98 patients in the UTKR group experienced CHF. Simultaneous inflation of both tourniquets can significantly increase the stress on the left ventricle through an increase in afterload. After both tourniquets are deflated, the circulation is exposed to acidosis, procoagulants, and cytokines from both limbs, which may be deleterious to an already compromised myocardium. In addition, with sequential inflation of tourniquets the anesthesiologist has time to observe the physiological response to the deflation of one tourniquet, which might result in a decision to defer the operation on the second knee [7]. Hence, for SBTKR procedures we advocate sequential inflation of knee tourniquets with a short pause (~5 min) between procedures.

Sequential inflation of tourniquets during SBTKR has also been associated with increased morbidity and mortality. Using the medicare provider files for knee arthroplasty from 1985 to 1990, Ritter et al [4] reported that SBTKR had the highest cumulative mortality rate at 30 days and 3 months compared to staged (6 weeks, 3, 6, and 12 months) bilateral knee replacements. However, by 2 years the cumulative mortality rates for all groups was similar. In a follow-up analysis of 4,100 SBTKR patients, Ritter and Harty [8] reported a mortality rate of 1.2% during the first year; older (>75 years old) men were at the highest risk for postoperative death. Parizi et al [9], in an analysis of 22,540 patients over 28 years, also found that mortality was statistically higher at 30 days postoperatively in SBTKR compared to UTKR. Males who are more than 70 years old had the highest mortality. Bullock et al [3], in their analysis of 514 UTKR and 255 SBTKR patients, showed that the incidence of myocardial infarction and 30-day mortality had a relative risk of 5.13 and 3.3 for SBTKR compared to UTKR. Again, patients who were 70 years or older at the time of the procedure had an increased risk of cardiac complications. In their review of the literature, Oakes and Hanssen [2] concluded that in the majority of the reports, SBTKR was associated with increased early postoperative death (3-fold) compared to UTKR.

In the current study of in-hospital postoperative complications after either SBTKR or UTKR, there were no deaths and the PMI incidence was low (~1%) and similar for both groups; slightly higher in the UTKR group. Patients were diagnosed as having a PMI by cardiac enzymes and they were older (75±5 years) than those who did not have a PMI (67±11). In another analysis of 501 SBTKR performed at the same institution, there were also no in hospital deaths and also no reported PMIs [10].

In this report, atrial fibrillation was three times more common in patients after SBTKR than UTKR. The pathogenesis of atrial fibrillation is multifactorial, but postoperatively it is often the result of myocardial ischemia, pulmonary embolism, fluid shifts, and a hyperadrenergic state. Although usually self-limited, it can be problematic in patients with preexisting cardiac disease. Patients with FES were more likely to also have atrial fibrillation.

Blood loss and the requirement for homologous blood transfusions is a concern for surgical patients. Patients undergoing SBTKR lose more blood than UTKR and often require homologous transfusions. Despite autologous transfusions and the use of a cell saver system, Lane et al [11] reported a 17 times greater need for homologous blood in SBTKR vs UTKR. In this report, 43% of SBTKR patients required homologous blood. Hence, in patients who are candidates for SBTKR and who do not wish to receive homologous blood the following should be kept in mind: reinfusion of washed constavac drained blood should be instituted; predonation of three units of autologous blood; preoperative administration of erythropoietin to increase the hematocrit at the time of surgery; and in healthy patients tolerance for lower hemoglobin levels [12].

Echogenic emboli can be visualized in the hearts of patients upon tourniquet deflation during total knee arthroplasty [13]. The composition of this material may include fat particles, bone marrow debris, and fresh thrombus from the femoral vein. Migration of this material to the lung may trigger an FES response that includes diffuse alveolar infiltrates, hypoxemia, confusion, fever, tachycardia, tachypnia, petechial skin rashes, elevated pulmonary vascular resistance, and ultimately, in its extreme presentation, adult respiratory distress syndrome (ARDS) [14]. Several reports have demonstrated an increased prevalence of FES in SBTKR with concomitant pulmonary and neurological complications [3, 15, 16]. For this report, we characterized patients as demonstrating evidence of FES if they exhibited hypoxemia, confusion, and diffuse alveolar infiltrates on chest x-ray. Other indicators of FES, including tachycardia and fever, would have been masked by the administration of β-blockers and acetaminophen. In our matched group of patients, the incidence of FES was 5% in the SBTKR and nonexistent in the UTKR group. Again, as with other postoperative complications, FES was significantly more prevalent in our elderly patients. None of our patients progressed to ARDS.

This report shows that when indicated SBTKR can be performed without the consequences of serious postoperative consequences. In this analysis, we tried to minimize the selection bias for patients with fewer comorbid conditions undergoing staged UTKR, by matching both groups for age and cardiac disease. The overall postoperative complication rate for these patients and the patients presented in another publication from this institution may be low, however, due to their perioperative care [10]. All of the patients in these two reports received regional anesthesia and regional postoperative analgesia. Although still controversial, there are well-controlled studies suggesting that in orthopedic surgery regional anesthesia reduces the incidence of perioperative complications [17]. In fact, the two matched groups were not managed similarly, because all of the SBTKR patients spent the night of surgery in a intensive care setting and were discharged only when they exhibited stable cardiopulmonary parameters. This may explain the low incidence of serious (MI, CHF, death) perioperative complications in the SBTKR group. Evidence of diminished oxygenation and increased lung water was treated promptly with diuretics. Tachycardia and arrhythmias were treated immediately with appropriately medications, which may have avoided more extensive cardiac complications (e.g., CHF). Nevertheless, there were still significantly more episodes of FES and cardiac arrhythmias in SBTKR compared to UTKR patients. Furthermore, this study and the majority of previously published reports indicate that the elderly patient is more likely to have perioperative complications after SBTKR.

There is no study that can define an absolute age or set of medical comorbidities that places a patient at increased risk for morbidity or mortality after SBTKR. However, as elderly patients (~75 years old) have more complications after SBTKR and when patients with significant medical comordities have postoperative complications they may experience more dire consequences, at HSS we have developed guidelines for patients scheduled for elective SBTKR. Patients ≥75 years old or who are categorized as American Society of Anesthesiology Class III are excluded from SBTKR. In addition, patients with active ischemic heart disease (positive stress test), poor ventricular function (LVEF<40%), and/or have oxygen-dependent pulmonary disease are also excluded from SBTKR. Patients with other significant medical comorbidities—insulin-dependent diabetes, renal insufficiency, pulmonary hypertension, steroid-dependent asthma, morbid obesity (BMI>40), chronic liver disease, and cerebral vascular disease—should be considered at increased risk for perioperative complications and counseled to have staged UTKRs. In the future, we plan to review these guidelines with regard to changes in practice and perioperative complications.

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