The Journal of Arthroplasty Vol. 27 No. 5 2012

Predictors of Intensive Care Unit Admission After Total Joint Arthroplasty

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Abstract: Total joint arthroplasty (TJA) is a relatively safe orthopedic procedure. However, complications do occur, and some may necessitate admission to the intensive care unit (ICU). Our purpose was to determine risk factors associated with admittance to ICU after TJA. We evaluated 22 343 primary and revision total hip and knee arthroplasties from 1999 to 2008. One hundred thirty patients were admitted to the ICU. Cases were matched 1:2 for date of surgery, surgeon, and type of surgery. The causes for admission to ICU were recorded. Independent risk factors for ICU admission were smoking, cemented arthroplasty, general anesthesia, allogenic transfusion, higher C-reactive protein, lower hemoglobin level, higher body mass index, and older age. Proper identification and management of these “at-risk” patients may decrease the incidence of ICU admittance after TJA. **Keywords:** total joint arthroplasty, intensive care unit, smoking, cemented arthroplasty, general anesthesia.

Although total joint arthroplasty (TJA) is a very safe and well-tolerated surgery for most patients, it is not without minor and major complications [1-3]. The literature is replete with well-documented incidence reports of minor complications such as superficial wound infection, skin numbness, wound drainage, atelectasis, urinary tract infection, and anemia [2,4-8]. These complications, when present, are commonly managed by the treating orthopedic surgeon or comanaged with medical teams [9].

However, the more serious major surgical complications, reported by some to be as high as 6.3% [2], may depend on the operative site, primary or revision arthroplasty, and whether cement for prosthetic fixation is used [7,10,11]. These major surgical complications include cardiac arrest, tachyarrhythmia, myocardial infarction, congestive heart failure, hypotensive crisis, pulmonary embolism, pneumothorax, acute renal failure, cerebral vascular accidents and/or transient ischemic attack, and deep venous thrombosis [2,12,13].

The rates of both minor and major complications may not differ between academic and private practice services [14], but at least 1 study found that high-volume specialty orthopedic hospitals had less adverse outcomes such as sepsis, hemorrhage, pulmonary embolism, and deep venous thrombosis compared with general hospitals [15]. Furthermore, patient comorbidities such as hypertension, diabetes, obesity, and smoking typically reflected by a higher American Society of Anesthesiologists score [16] have been shown to increase complication rates after TJA [17-21]. Some of the patients with the aforementioned comorbidities and complications may require an unexpected admission to intensive care units (ICUs) after TJA for vigilant monitoring.

To our knowledge, there are few studies that describe the predisposing risk factors or predictors for ICU admission after TJA. Most of the literature focuses on 1 major complication after joint arthroplasty. Therefore, it may be worthwhile for the treating surgeon to highlight the major medical complications after joint arthroplasties, to know their incidences and try to reliably predict which patients have a greater likelihood of developing these complications, thus requiring ICU admission.

The objective of this study was to determine the incidence of and establish the risk factors for ICU admission after TJA. Our rationale for conduct of this study was that identification and reversal of predisposing factors for unexpected ICU admission, whenever possible, are likely to improve outcome after TJA. The study was conducted in a case-control fashion, with all patients evaluated from a single institution.

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Submitted December 20, 2010; accepted September 28, 2011.
The Conflict of Interest statement associated with this article can be found at doi:10.1016/j.arth.2011.09.027.
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0883-5403/2705-0010$36.00/0
doi:10.1016/j.arth.2011.09.027

Materials and Methods

With the use of our institutional electronic database and after institutional review board approval, a query from 22 343 TJA procedures performed from May 1999 to February 2008 was conducted. Of these, 130 patients (0.6%) developed a major complication and were subsequently admitted to the ICU during the same hospital stay. The records from our database in addition to the hard copy ICU charts of these patients were meticulously examined in a retrospective fashion. This cohort was matched according to date of surgery (±4 weeks); surgeon; and procedure type, in a 1:2 ratio against 260 patients who did not develop postoperative complications necessitating admission to the ICU.

Demographics

Demographic variables including age; sex; body mass index (BMI); Charlson index for comorbidities [22]; and social history significant for alcohol, tobacco, or illicit drug abuse were evaluated for both groups (Table 1).

Table 1. Demographic Distribution, Preoperative Vital Signs and Laboratory Values, and Surgical Data

	Cases (n = 130)	Controls (n = 260)
Demographic distribution		
Age, (y) mean (SD)	72.8 (12.3)	66.1 (13.0)
Female	67 (51.5%)	173 (66.5%)
Male	63 (48.5%)	87 (33.5%)
BMI, mean (SD)	30.6 (8.8)	20.8 (6.8)
Charlson index, mean (SD)	3.9 (2.1)	2.7 (1.6)
Ever smoked	49 (37.7%)	14 (5.3%)
Preoperative vital signs and laboratory values		
Heart rate, mean (SD)	82.98 (15.81)	74.48 (10.72)
Systolic BP, mean (SD)	131.07 (24.37)	133.63 (18.39)
Diastolic BP, mean (SD)	70.16 (16.26)	75.90 (10.87)
Hemoglobin level, mean (SD)	11.64 (1.63)	13.11 (1.51)
Glucose, mean (SD)	120.56 (47.49)	107.54 (32.69)
ESR, mean (SD)	43.42 (30.36)	26.92 (12.45)
CRP, mean (SD)	4.24 (5.71)	1.98 (1.37)
Surgical data		
Hip vs knee	60 (46.2%)	120 (46.2%)
Revision	48 (36.9%)	46 (17.4%)
Bilateral	26 (20%)	38 (14.4%)
Cement	95 (73.1%)	189 (72.7%)
Primary knee	70 (73.7%)	140 (74.1%)
Revision knee	21 (22.1%)	40 (21.2%)
Revision hips	4 (4.2%)	9 (4.8%)
General anesthesia	34 (26.2%)	19 (7.2%)
Surgery duration, mean (SD)	109.20 (52.31)	68.74 (30.29)
EBL, (mL), mean (SD)	545.0 (926.2)	230.8 (292.1)
Total PAD units		
0	84 (64.6%)	114 (43.2%)
1	26 (20%)	103 (39%)
2	20 (15.4%)	45 (17.1%)
3	0	1 (0.4%)
4	0	1 (0.4%)
Total allogenic units, mean (SD)	4.92 (6.40)	0.78 (1.55)
Cell saver, mean (SD)	77.76 (167.49)	46.95 (135.05)

BP indicates blood pressure; ESR, erythrocyte sedimentation rate.

Preoperative Vital Signs and Laboratory Values

The preoperative vital signs, mean heart rate, mean systolic blood pressure, and mean diastolic pressure as well as hemoglobin level, glucose, erythrocyte sedimentation rate, and C-reactive protein (CRP) levels were reviewed for both groups, (Table 1).

Surgical Data

Surgical variables analyzed included location (hip or knee), primary or revision procedure, unilateral or bilateral procedures, the type of fixation (cemented vs cementless), the type of anesthesia, the duration of surgical procedure, estimated blood loss (EBL), preautologous donation (PAD) of blood, the number of autologous or allogenic blood transfused, and the use or not of cell saver (Table 1). All surgeries were performed using the same approach, direct lateral (Hardinge) approach for total hip arthroplasty (THA) and a midline incision and medial parapatellar arthrotomy approach for total knee arthroplasty (TKA). The average length of operation and estimated blood loss during the index surgery were 109 minutes and 545 mL, respectively, for the cases admitted to the ICU. Conversely, the length of operation and EBL for the control series were 69 minutes and 230 mL, respectively.

Statistical Analysis

All statistical analyses were performed using STATA 10.0 (College Station, TX). The variables from the 130 cases and 260 controls were intercorrelated with each other; therefore, study of each single parameter individually was not sufficient because of the paired nature of the data. Baseline and operative characteristics were compared between cases and controls using the *t* test for continuous variables and the Fisher exact test for categorical variables. The odds ratio with 95% confidence intervals and the associated *P* value were determined for each variable using a multivariable logistic regression analysis preformed, which included variables found to be significant ($P < .05$) and not close to 1.00 in the preceding univariate analysis. Multivariate analyses can statistically accommodate imbalances between study groups in nonrandomized studies. All *P* values reported are 2 sided.

Results

Descriptive analysis for the variables mentioned in the "Materials and Methods" section demonstrated no statistically significant differences in the following: BMI, systolic blood pressure, arthroplasty location, unilateral vs bilateral procedures, and the use of cell saver. All other variables analyzed yielded statistically significant differences.

A multivariate analysis controlling for potential confounders was then performed. Variables included are depicted (Table 2). Body mass index was included in this analysis, as it had some statistical significance over

Table 2. Multivariate Controlling for Potential Confounders

	Odds Ratio	SE	z	P >|z|	(95% CI)	
Age *	1.085811	0.0522473	2.18	.029	1.010653	1.215732
Male	3.623346	3.093399	1.51	.132	.6798357	19.31148
Charlson index	0.7938284	0.2441919	−0.75	.453	0.4343961	1.450665
Ever smoked *	65.13127	77.56051	3.51	.000	6.311755	672.0924
Preoperative hemoglobin level *	0.6033949	0.1355704	−2.25	.025	0.3884671	0.9372362
Preoperative CRP *	1.767725	0.3350285	3.01	.003	1.219244	2.562943
Revision	0.7826181	0.9998799	−0.19	.848	0.0639804	9.573101
Cement *	55.74804	100.2756	2.24	.025	1.641152	1893.696
BMI *	1.100199	0.431867	2.43	.015	1.018729	1.188185
General anesthesia *	45.21955	85.6508	2.01	.044	1.104223	1851.807
Total PAD	0.5064138	0.235599	−1.46	.144	0.2034702	1.260405
Total allogenic units *	3.485317	1.318627	3.30	.001	1.660353	7.316173

CI indicates confidence interval.
* Independent predictors of increased risk to requiring ICU admission.

dichotomous versions of the variable such as BMI more than 25 kg/m^2 and BMI more than 30 kg/m^2.

The results of this analysis indicate that smoking history, cemented arthroplasty, general anesthesia, greater allogenic blood units transfused, higher preoperative CRP levels, lower preoperative hemoglobin levels, increased BMI, and older age are independent predictors of an increased risk for ICU admission after TJA (Table 2).

Discussion

It is estimated that the number of TJA procedures per year is well over half a million in the United States and will continue to rise given the aging population [23]. Therefore, it follows that given the prevalence of comorbidities in these patients, admission rates to the ICU are also on the rise [24]. In a study by Mantilla et al [12], increased age was found to be the strongest predictor of major complications after TJA. Our study found that older age (>65 years) was a weak (1.1× greater risk) but an independent risk factor for ICU admission. Other authors have concluded that male sex, a positive smoking history, and ethnicity (blacks at higher risk than whites) may predict who will need ICU monitoring after TJA [12,13,19,25]. Interestingly, although some demographic features reported by others were not significant in our study, obesity did result in an independent risk factor after multivariate analysis, albeit very weakly significant. The patient population had a mean BMI of 30.6 kg/m^2 for the study cohort and a BMI of 20.8 kg/m^2 for the control cohort. We recommend evaluation of a patient's BMI as a general consideration, part of the overall evaluation of a surgical candidate but would generally refrain from advocating all obese patients strongly be considered for ICU admission after TJA.

Smoking has a deleterious effect on TJA outcomes. Forty-nine patients (37.7%) in the study cohort compared with only 14 control patients (5.4%) had a positive smoking history. Smokers were 65 times more likely than nonsmokers to be admitted to the ICU. Our results were consistent with another report in the literature by Sadr et al [21] who found that heavy tobacco use was associated with an increased risk of systemic postoperative complications (P = .004). In their study, previous and current smokers had a 43% and 56% increased risk of systemic complications, respectively, when compared with nonsmokers. In heavy smokers, the risk increased by 121% [21]. Similarly, Moller et al [19], in their investigation of 811 patients who had elective orthopedic surgery, found that smoking affected the rate of wound healing and cardiopulmonary complications and had an 8-fold increase in the need for admission to the ICU. We recommend preoperative counseling with patients who smoke and encourage the implementation of recent advances in cessation strategy to decrease the likelihood of admittance to ICU after TJA.

The second greatest risk factor for ICU admission after TJA from our analysis was cemented joint replacement. Although all TKAs were cemented procedures, only 70 TKA patients in the study cohort were admitted to the ICU. Sixty THA patients developed complications and were sent to the ICU. Of these, 35 were press fit cementless implants, whereas 25 cases were cemented (42%). This is in contrast to 114 (95%) of 120 THA patients in the control group who underwent cementless implantation. The adverse reactions associated with acrylic bone cement (polymethylmethacrylate) are well known and have been documented for nearly 40 years [26]. This reaction, the so-called cement implantation syndrome, may include systemic hypotension, anaphylactoid reaction, pulmonary hypertension, hypoxemia, and cardiovascular collapse [13,27-29]. In a study by Sanborn et al, 5% of all cemented arthroplasty procedures were associated with hypotension after femoral stem prosthesis placement; however; this high figure has been reduced by adequate medullary lavage, intraoperative canal suctioning, the use low-viscosity polymethylmethacrylate, and other efforts to decrease intramedullary pressure that may lead to fat microemboli [13,30-32]. Furthermore, uncemented arthroplasty has been associated with less hemodynamic changes when compared with cemented procedures [7]. The true incidence of adverse events after cement implantation syndrome is difficult to know based on a variety of patient populations and the defined complications in the literature [33]. The surgeons at this institution routinely perform uncemented THA on all primary hips. A decision to use cement to achieve proper fixation of the femoral or acetabular components may occur depending on conditions such as preoperative analysis, poor intraoperative bone stock encountered, or inadequate fixation of a traditional press fit prosthesis during a primary or revision THA. Some caution must be taken when interpreting these results of potentially higher risk of ICU admission with cemented prostheses. Although we did elect to use the Charlson index for comorbidities, this method has limitations and may not adequately capture all potential confounding variables. Specifically, long-term steroid exposure, inflammatory arthropathies, and metabolic bone disease all affect bone stock and can influence the decision to perform cemented THA. All patients in our investigation had a diagnosis of osteoarthritis for primary TJA in both the study cohort and control group. Diagnoses among the revision TJA were as follows: aseptic loosening in 29 patients (14.6%) in the study cohort and 39 patients (15%) in the control group, periprosthetic joint infection (including irrigation and debridement, resection arthroplasty, and reimplantation) in 20 patients (15.4%) in the cohort study and 2 (0.8%) in the control group, and conversion from previous hip fracture or from hemiarthroplasty in 4 patients (3.1%) in the study cohort and 5 patients (1.9%) in the control group. Furthermore, cement fixation may be the only option for the treating surgeon to achieve stability and a predictable long-term result in the setting of pathologic bone.

General anesthesia was also found to be a predisposing factor for early postoperative complications requiring ICU admission after TJA. In our study, we found that 34 ICU patients (26.15%) had arthroplasty procedures under general anesthesia compared with only 19 control patients (7.2%). After multivariable analysis, we found that patients, for whom general anesthesia was used, were more than 45 times more likely to develop postoperative major complications and need ICU admission. This finding corroborates other studies, which suggest that regional anesthesia may be associated with less morbidity and mortality compared with general anesthesia [13]. A meta-analysis by Rodgers et al [34] found that neuraxial blockade significantly reduced the rates of deep vein thrombosis, pulmonary embolism, respiratory depression, myocardial infarction, and blood transfusion requirements. Furthermore, general anesthesia has been shown to be associated with a greater likelihood of oxygen desaturation compared with regional anesthesia [35]. The rate of unanticipated ICU admissions after TJA is decreased when neuraxial anesthesia is used both in average and in higher risk patients [36]. We advocate the use of regional anesthesia, when not contraindicated, for the TJA patient and routinely implement this strategy presently at our institution.

Another risk factor for ICU admission after TJA from our analysis was the need for blood transfusion. Patients who were transfused allogenic blood products intraoperatively were 3.5 times more likely to be admitted to the ICU. This seems somewhat intuitive given the spectrum of complications associated with blood transfusion ranging from febrile reaction to the more serious transfusion-related acute lung injury. The need for blood transfusion also portends a more complex or challenging reconstruction. Circumstances encountered intraoperatively such as multiple changes to acetabular version or inclination, component trialing to obtain proper soft tissue balance, stability, and limb length or iatrogenic fracture correction among others may increase the operative time and blood loss. The treating surgeon should be aware that patients who require blood transfusion are more likely to be admitted to the ICU; however, this finding may also reflect the surgeon's preference for close postoperative monitoring after extensive blood loss or difficulty of reconstruction. We also advocate correcting preoperative anemia (defined as <13.5 g/dL in males and <12.0 g/dL in females), which was found to be an independent risk factor in our study. Although this finding marginally reached statistical significance, normalizing preoperative hemoglobin level may serve to decrease the need for intraoperative blood transfusion and potentially the need for ICU admissions after TJA.

Patients who had preoperative elevated levels of the acute phase reactant CRP had a slight increased risk (1.8) to be admitted to the ICU. C-reactive protein is a nonspecific marker of inflammation and often used as a marker for periprosthetic infection. At our institution, the upper limit of normal CRP is 0.8 mg/dL. The individuals in the study cohort had a mean CRP level of 4.24 mg/dL compared with the control group mean of 1.98 mg/dL. The results of this study suggest that perhaps the inflammatory cascade may trigger systemic effects that required ICU monitoring after TJA. We recommend that patients who have an increased preoperative CRP be considered for more vigilant postoperative monitoring.

This study has some limitations in addition to those defined previously in the discussion. Perhaps the most important one is its retrospective design with the inherent deficiency of variability in data collection. The other shortcoming of this study is that all patients in this study received TJA procedures in a large-volume center by surgeons specializing in joint reconstruction that might limit the applicability of the findings to some extent. Despite the aforementioned limitations, we identified patients who are at greater risk for developing complications requiring ICU admission. The authors believe that the conclusions drawn from this investigation have relevant application to the treating adult reconstruction surgeon of varying practice volume. The overall incidence of ICU admission after TJA at this single institution, 0.6%, represents an acceptable number. This incidence is more favorable than the authors expected at the onset of this investigation. To our knowledge, the true incidence of complications or risk factors that necessitate ICU has not yet been firmly established. This study proceeds on a continuum of work that is uncovering those patients that are predisposed to complications after TJA.

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