Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are generally regarded as safe and well-tolerated procedures. Known complications following these procedures, not related to the implants used, include thromboembolism, postoperative anemia, infection, fractures, and death. However, despite the small incidence of mortality following total joint arthroplasty, a real number of deaths exists given the extensive number of procedures being performed.

Until recently, this topic has been relatively scarce in the literature. Most notably, investigation is lacking in elective total joint arthroplasty in patients who have benefited from newer cementation techniques. It is important that surgeons and facilities performing total joint arthroplasty examine their individual cases of sudden death in an attempt to identify common features and thus a consensus on prevention.

This article reviews our institution’s rate of postoperative, in-house mortality following elective THA or TKA over the past 5 years. Features common to the demise of our patients are discussed, in particular, the preoperative American Society of Anesthesiologists (ASA) score and the likelihood of postoperative death. Additionally, mortality rate information is provided for use in advising patients of overall risk.

MATERIALS AND METHODS

Our institution’s computer database was queried from January 1, 1995 to March 22, 2001, to identify all patients with a diagnosis-related group of 209, which included major joint and limb reattachment procedures of the lower extremity (including THA, TKA, and foot, leg, and thigh reattachment). Individuals with International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes reflecting various hip fractures or bony malignancy were excluded. The remaining patients had ICD-9-CM codes of 81.51 through 81.55, which represented patients who had undergone total, partial, primary, or revision THA or TKA. From this original list, patients who had died during their respective admission dates were identified.

Additionally, a second control group of patients was identified. These patients underwent elective THA or TKA at our institution during the same time period, and were matched according to age within 5 years, sex, and type of operation. Using a random numbers table, a randomized group of nine control patients was identified.

An extensive chart review was performed, focusing on preoperative patient information, preoperative anesthesia scoring based on the ASA rating scale, intraoperative surgical detail, postoperative hospital course, and details of the patient’s eventual death (Table 1). Autopsy information was obtained when performed.
Continuous variables were compared using the Students’ t test whereas comparison of categories was performed using the Wilcoxon signed ranks test. P values <.05 were considered statistically significant.

RESULTS

Preoperative Patient Information

A total of 3438 patients underwent elective THA or TKA. All patients and control patients examined in this study were derived from this original population. No intraoperative deaths occurred, and 9 (0.26%) patients died prior to discharge from our facility.

Control patients were matched preoperatively according to age at preadmission testing. Patients who died had a mean age of 75 years, whereas the average age of the control group was 75.5 ($P=.99$). Body mass index, calculated as weight in kilograms divided by height in meters-squared, was not statistically significant between the patients or controls. The mean values were 32.22 and 33.40, respectively ($P=5.52$).

Other variables compared and found to be statistically insignificant were basal heart rate, systolic blood pressure, history of substance abuse, complete blood count, blood urea nitrogen, or creatinine values determined at preadmission testing. Additionally, no statistically significant differences were noted in the preoperative cardiac work-up. Seven of nine deceased patients and six controls had only an electrocardiogram (ECG) preoperatively.

A statistically significant difference was noted in the preoperative anesthesia class between patients and controls. All patients and controls were either ASA class II or III. Seven of nine patients were ASA class III, whereas the remaining two were ASA class II. Conversely, seven of nine controls were ASA class II, whereas the remaining two were ASA class III. Table 2 presents details of the deceased patients as well as the controls included in the study. Anesthesia class of the patients was thus significantly higher than that of the controls ($P<.05$).

Intraoperative Surgical Details

No statistically significant difference was noted between patients and controls in type of anesthesia administered. Seven patients and six controls were exposed to general anesthetics. Mean operative time was 2 hours 39 minutes for patients, and 2 hours 23 minutes for controls. No statistically significant difference was noted between these times given the number of procedures ($P<.05$). Additionally, no difference was noted in bony preparation techniques or use of polymethylmethacrylate cement. In patients and controls, three procedures were cementless and six involved methylmethacrylate use for component stabilization.

Postoperative Hospital Course

Perioperative transfusions, operative time, post-anesthesia care unit scores, and time for orders to be executed by staff were not statistically significant between the patients who died and controls. The development of postoperative complications was different between the groups.

One of nine control patients had a urinary tract infection postoperatively, whereas seven of nine deceased patients had a documented postoperative complication—acute renal failure ($n=1$), congestive heart failure ($n=1$), acute delirium ($n=1$), ischemic bowel ($n=1$), postoperative myocardial infarction ($n=2$), and aspiration pneumonia ($n=1$), which led to a prolonged hospital stay prior to eventual death. This difference in complications was statistically significant ($P<.05$).

All patients were administered preoperative thromboembolism prophylaxis with either warfarin or low-molecular weight heparin. Generally accepted protocols were used to administer these drugs to the patients.

Details of Death

No intraoperative deaths occurred. Nine (0.26%) patients died prior to discharge from our facility. Seven of nine patients died within 5 days of their operation, whereas the remaining two patients died on postoperative days 8 and 40, respectively. Of the nine patients, 7 (78%) were ASA class III and 2 (22%) were ASA class II.

Causes of death as listed on the death certificate included acute myocardial infarction ($n=6$), respiratory failure ($n=1$), pulmonary embolism ($n=1$), and ischemic bowel ($n=1$) (Table 2).

Two of nine patients had “do not resuscitate” orders and did not have advanced cardiac life support protocols initiated at the time of code initiation. However, of the seven remaining patients, average initiation of advanced cardiac life support protocols initiated within 2 minutes. Seven of the nine deaths occurred between 3:00 PM and 7:00 AM, and most occurred between 3:00 PM and 11:00 PM ($n=4$). No relationship existed between ASA score and time to code.

Autopsy Information

An autopsy was performed on one patient who had a preoperative history of a six-graft coronary artery bypass fol-
lowed by later mechanical aortic valve replacement. Additionally, the patient had transient ischemic attacks with residual upper extremity weakness and bilateral carotid artery stenosis of 60%. A preoperative cardiac work-up consisting of ECG, negative treadmill stress test, and medical clearance from the patient’s personal physician was obtained.

The patient was admitted 2 days preoperatively for management of anticoagulation with intravenous heparinization, had an uneventful procedure, and was treated postoperatively with heparin. Due to accelerated wound drainage, the heparin was held for 1 day postoperatively and the patient was maintained on warfarin. By the second postoperative day, the patient developed periods of confusion followed by severe abdominal pain. During urgent general surgical consultation, the patient had hematemesis, which preceded hypotension and bradycardia refractory to medical management. Post-mortem examination revealed an ischemic bowel without perforation, and was listed as the most likely cause of death.

**DISCUSSION**

Mortality is a rare event during or following total joint arthroplasty. The specific risk for THA has been reported to be as low as 0.1%² and as high as 50%.³ This extensive variation in the literature is intimately related to the pre-existing comorbidities of the patients studied and to the time frame at which a death is considered significant. Death following THA for all diagnoses is a known complication and is highest in patients undergoing this procedure for a preoperative diagnosis of hip fracture or malignancy.⁴⁻¹¹ As the relationship between fractures, metastatic bony malignancy, and perioperative mortality have already been identified, the authors excluded all patients with these diagnoses to acquire a sample of patients who better represented those seen in elective arthroplasty.

An additional feature that is important to consider when comparing these types of death rates is the time frame in which a death would be considered significant. Parvizi⁶ noted in their study of 38,488 patients an overall 0.06% incidence of sudden intraoperative death in patients undergoing THA. Dearborn and Harris⁷ studied a similar but smaller group of patients but extended the time frame of interest to 90 days postoperatively. In their group of 2736 patients, no intraoperative deaths occurred; however, the overall death rate was 0.15%. Patients with

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**TABLE 2**

American Society of Anesthesiologists Preoperative Rating Scale

<table>
<thead>
<tr>
<th>Patient No./ Sex/Age (y)</th>
<th>ASA Class</th>
<th>Operation</th>
<th>Anesthesia/ Time (hr:min)</th>
<th>Cement Used</th>
<th>Crystalloid (cc)</th>
<th>EBL (cc)</th>
<th>Diagnosis</th>
<th>Cause of Death</th>
</tr>
</thead>
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<td>Deaths</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>1/M/76</td>
<td>3</td>
<td>TKA</td>
<td>General/2:34</td>
<td>Yes</td>
<td>1200</td>
<td>250</td>
<td>Acute myocardial infarction</td>
<td>Pulmonary embolism</td>
</tr>
<tr>
<td>2/M/62</td>
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<td>THA</td>
<td>General/2:45</td>
<td>No</td>
<td>3700</td>
<td>300</td>
<td>Acute myocardial infarction</td>
<td>Ventricular arrhythmia</td>
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<tr>
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<td>THA</td>
<td>General/2:55</td>
<td>Yes</td>
<td>1750</td>
<td>300</td>
<td>Acute renal failure</td>
<td>Cardiopulmonary arrest</td>
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<tr>
<td>4/M/76</td>
<td>3</td>
<td>TKA</td>
<td>Spinal/1:35</td>
<td>Yes</td>
<td>1500</td>
<td>150</td>
<td>Acute myocardial infarction</td>
<td>Cardiopulmonary arrest</td>
</tr>
<tr>
<td>5/M/87</td>
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<td>TKA</td>
<td>Spinal/1:30</td>
<td>No</td>
<td>1100</td>
<td>10</td>
<td>Acute respiratory distress syndrome</td>
<td>Respiratory failure</td>
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<td>TKA</td>
<td>General/1:50</td>
<td>Yes</td>
<td>1600</td>
<td>200</td>
<td>Acute myocardial infarction</td>
<td>Cardiopulmonary arrest</td>
</tr>
<tr>
<td>7/M/73*</td>
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<td>TKA</td>
<td>General/2:10</td>
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<td>1400</td>
<td>100</td>
<td>Coronary artery disease, peripheral vascular disease, thrombus</td>
<td>Ischemic bowel</td>
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<td>General/6:34</td>
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<td>1200</td>
<td>Coronary artery disease, acute myocardial infarction</td>
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<tr>
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<td>General/2:05</td>
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<td>Controls</td>
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<td>General/2:50</td>
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<tr>
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<td>General/2:20</td>
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</tr>
<tr>
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<td>TKA</td>
<td>General/1:45</td>
<td>No</td>
<td>2300</td>
<td>300</td>
<td>Acute myocardial infarction</td>
<td>Cardiopulmonary arrest</td>
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<tr>
<td>13/M/73</td>
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<td>Epidural/5:25</td>
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<td>6100</td>
<td>1300</td>
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<td>Cardiopulmonary arrest</td>
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<tr>
<td>14/M/76</td>
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<td>TKA</td>
<td>General/1:45</td>
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<td>1300</td>
<td>100</td>
<td>Acute myocardial infarction</td>
<td>Cardiopulmonary arrest</td>
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<tr>
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<td>2</td>
<td>TKA</td>
<td>General/1:45</td>
<td>Yes</td>
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<td>10</td>
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<td>Cardiopulmonary arrest</td>
</tr>
<tr>
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<td>Epidural/1:50</td>
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<td>1900</td>
<td>10</td>
<td>Acute myocardial infarction</td>
<td>Cardiopulmonary arrest</td>
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<tr>
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<td>General/1:30</td>
<td>Yes</td>
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<td>1200</td>
<td>10</td>
<td>Acute myocardial infarction</td>
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</tbody>
</table>

Abbreviations: ASA=American Society of Anesthesiologists, EBL=estimated blood loss, RTHA=revised total hip arthroplasty, THA=total hip arthroplasty, and TKA=total knee arthroplasty. *Only patient to have an autopsy; ischemic bowel as a result of a thrombotic or embolic event was the cause of death.
parvizi et al 8,13 have explored 30-day post-of retrospective follow-up.
higher than the control population. This had undergone THA was significantly to cardiovascular events in patients who any particular surgery. The mortality due to cardiovascular events expected following therefore this study approximated the nat-
duction some confounding factors. Most notably, canal preparation techniques such as pulsatile lavage and low-pressure cementation were not used as often as they are today. Thus, their population of patients had inherent differences in operative technique. Interestingly, Parvizi et al13 made an association between a higher average anesthesia class and likelihood of death. However, this formed, the details of demise must be viewed with caution.

Recent comprehensive studies by Parvizi et al.13 have explored 30-day postoperative mortality in patients following THA and TKA. Both studies included patients who had undergone total joint arthroplasty as early as 1969, which introduced some confounding factors. Most notably, canal preparation techniques such as pulsatile lavage and low-pressure cementation were not used as often as they are today. Thus, their population of patients had inherent differences in operative technique.

What is already known on this topic
- Total joint arthroplasty performed for fracture or malignancy has a higher risk of mortality than elective total joint arthroplasty.
- Anesthesia class is a useful indicator of perioperative patient health status.

What this article adds
- Anesthesia class provides risk stratification for perioperative mortality in patients undergoing total joint arthroplasty. The rates are approximately 0.07% and 0.92% in American Society of Anesthesiologists classes II and III, respectively. These values provide for a more accurate preoperative risk assessment.
- Importance of autopsy information for drawing meaningful conclusions regarding patient mortalities.
- Variation of mortality rates in the literature depends on the pre-existing medical condition of patients being treated and the time at which investigators consider death to be significant.

femoral neck fractures and metastatic malignant tumors were included in this group.
Visuri et al12 studied the causes of death in 1018 patients following cemented THA. No time limit was set at which a patient was excluded from the study, therefore this study approximated the natural course of events expected following any particular surgery. The mortality due to cardiovascular events in patients who had undergone THA was significantly higher than the control population. This was especially true during the first 4 years of retrospective follow-up.

Recent comprehensive studies by Parvizi et al.13 have explored 30-day postoperative mortality in patients following THA and TKA. Both studies included patients who had undergone total joint arthroplasty as early as 1969, which introduced some confounding factors. Most notably, canal preparation techniques such as pulsatile lavage and low-pressure cementation were not used as often as they are today. Thus, their population of patients had inherent differences in operative technique. Interestingly, Parvizi et al13 made an association between a higher average anesthesia class and likelihood of death. However, this formed, the details of demise must be viewed with caution.

Details available prior to the actual time of death are much more reliable. In particular, preoperative anesthesia class is one piece of information that was available in all patients and is considered a reliable indicator of health status. Patients with an ASA classification of IV are not permitted to undergo elective surgical procedures by the anesthesiologists at our institution. Allowing for only elective cases of THA or TKA provides a better population in which to draw inferences. Preoperative ASA scores of II or III appear to be the standard findings in the population of patients undergoing elective total joint arthroplasty. This scoring system also allows for a better stratification for risk of postoperative death. In the group studied, ASA class III patients had the highest risk of death (0.92%), whereas ASA class II patients had a much lower risk (0.07%).

It is a valid argument that a better comparison group for ASA score would have been the entire population of patients undergoing elective arthroplasties who did not encounter mortality. However, obtaining this information at our institution would have necessitated a chart review for each patient. Although this information would have been academically beneficial, the amount of time required to perform such a review prevents its completion. Instead, it was decided to obtain an age-, sex-, and procedure-matched group to make this comparison. Despite our limited number of patients for comparison, it is interesting to note that a general trend exists regarding lower ASA scores in the control group and higher ASA scores in the deceased population.

Death following THA for all diagnoses is a known complication and is highest in patients undergoing this procedure for a preoperative diagnosis of hip fracture or malignancy. The risk of perioperative death following TKA is considerably lower. However, preoperative knowledge of patient features, such as anesthesia class, allows the operating surgeon to better prepare for postoperative complications.

REFERENCES


