Protocol-Based Arthroplasty: Less Is More

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ABSTRACT

Total joint arthroplasty is a successful orthopedic procedure that is performed in high volume in the United States and internationally. As economic pressures continue to mount in the US health care system, it will become increasingly important to minimize cost and improve quality and value. At the authors’ institution, a protocol-based arthroplasty model is used, in many ways based on simplification of the patient care pathway. The largely evidence-based protocol has its foundation in eliminating unnecessary dogmatic practices, enhancing the patient experience, and achieving cost-
effectiveness. The authors believe that a model like this can be applied to joint arthroplasty practices across the country in the future to maximize the value delivered to patients. [Orthopedics. 2015; 38(10):631-638.]

Over the past decade, dramatic innovations in total hip arthroplasty (THA) and total knee arthroplasty (TKA) have allowed these procedures to become among the most successful and value-delivering interventions in modern medicine. Demand for total joint arthroplasty (TJA) is increasing at an impressive rate, with annual rates of THA expected to reach 572,000 and TKA expected to reach 3.48 million by 2030. In consideration of the current economic climate, the projected increases in demand and restricted budgets, brief hospitalizations with minimized costs are increasingly favored. Pressure exists among providers to continually develop more efficient and effective practice habits to deliver value to patients and payers. In addition, mounting scrutiny from regulatory bodies or other reporting agencies tracking quality of care provided compels us to seek novel avenues to deliver better care under the current circumstances.

Despite the success of TJA, differences still exist regarding various perioperative practices. Over the past decade, extensive research has been conducted in the development of evidence-based protocols for perioperative care of patients undergoing TJA. Safety, improved clinical outcomes, and patient satisfaction are often best achieved through a focus on simplification. This article outlines the recent changes to TJA patient perioperative protocols that have been made at the authors’ institution as a result of emerging evidence. The implementation of these evidence-based care pathways has resulted in improved clinical outcomes, enhanced safety metrics, higher patient satisfaction, and increased cost-effectiveness as measured both by national and institutional standards.

**PREOPERATIVE AND INTRAOPERATIVE PRACTICES**

**Antibiotic Prophylaxis**

Prophylactic antibiotic administration during the perioperative period is considered one of the most important practices for prevention of surgical site infection after TJA. The goal of perioperative antibiotic prophylaxis is to achieve drug levels within serum and tissue that exceed the minimal inhibitory concentration for organisms likely to be encountered intraoperatively, for the duration of the operation, while minimizing the disadvantages of excessive broad-spectrum antibiotic use: the development of resistant organisms, that, if involved in postoperative infection, lead to worse clinical outcomes.

Current recommendations for perioperative antibiotic prophylaxis in elective TJA include cessation of therapy after 24 hours. Depending on patient factors such as weight and allergy to antimicrobial agents, various broad-spectrum antibiotics can be used at appropriate dosages and frequencies.

At the authors’ institution, antibiotics are ordered to expire after 24 hours, even in situations when a surgical drain is placed at the time of wound closure. With the duration of perioperative antibiotics limited to 24 hours, an increase in deep or superficial infection has not been observed among the authors’ patients.

**Blood Management**

Blood transfusion is relatively common after TJA, and several strategies exist that attempt to minimize the need for transfusion, in consideration of its adverse effects on outcome, including an increase in the risk of surgical site and deep periprosthetic joint infections. Evidence presented in the general surgery literature also suggests that transfusion for slightly hypovolemic or anemic patients is associated with an elevated risk of surgical site infection and 30-day mortality postoperatively. It has also been shown that lower postoperative hemoglobin levels can increase the length of hospital stay after THA. A well-powered article published in 2014 by Klika et al reviewed the complications associated with allogeneic blood transfusion after TKA with logistical regression modeling, controlling for patient covariates. They found that patients who received postoperative allogeneic transfusion trended toward higher rates of inpatient mortality, although this finding did not reach statistical significance. They were able to show statistically significant increases in length of stay and hospital cost in the transfused group of patients as compared with patients who did not receive a transfusion, as well as an increased likelihood of requiring a stay in an inpatient rehabilitation facility prior to returning home.

Preoperative autologous blood donation has been introduced in an attempt to decrease allogeneic blood usage and the associated risks. However, the autologous blood donation process can be complex, expensive, and wasteful when unneeded units are discarded (up to 86.3% of autologous blood units, in one study), and can carry cardiovascular risk for elderly patients who have limited cardiorespiratory reserve. In addition, there is an increased risk of perioperative anemia secondary to lower preoperative hemoglobin in patients who donated autologous blood preoperatively, which may lead to a paradoxically higher rate of postoperative transfusion and longer hospital stay. In a cost-minimization analysis, Green et al. found that while autologous blood transfusion is associated with a lower cost per unit as compared with allogeneic blood transfusion ($300/unit vs $512/unit, respectively), only 49% of units donated were actually used among patients undergoing TKA (and 74.3% among patients undergoing THA).
This inefficiency caused the actual cost of an autologous unit transfused to be $587/unit among TKA patients and $489/unit among THA patients, when factoring in the cost associated with the wasted units.

In light of the available evidence, a less aggressive transfusion strategy has been developed, and preoperative autologous blood donation has been eliminated at the authors’ institution. Several intraoperative measures to reduce blood loss are used, including hypotensive spinal anesthesia, intravenous administration of tranexamic acid, and an emphasis on expeditious surgery.\(^{19,21}\) In addition, administration of intravenous crystalloid fluid is minimized perioperatively and discontinued on the day after surgery, thereby minimizing the dilutional effects on hemoglobin and reducing unnecessary transfusion. These strategies have resulted in a marked reduction in the rate of blood transfusion and the length of hospital stay after TJA at the authors’ institution.

**Computer Navigation**

It is known that implant malalignment and malpositioning are associated with decreased function and higher revision rates after TKA.\(^{22}\) Motivated by this understanding, computer-assisted TKA was developed and was initially recognized as being beneficial in patients with extraarticular deformity.\(^{23}\) Although it has been shown that navigation can reduce the number of outliers in the coronal mechanical axis of patients undergoing navigated TKA as compared with conventionally performed TKA,\(^{24-26}\) studies have not demonstrated improvement in clinical or functional outcome, quality of life, or patient satisfaction at 5-year follow-up.\(^{27}\)

Fractures have been reported at or around the pin sites used by the navigation system, occurring in up to 1% of patients\(^{28}\) and requiring costly surgical treatment. It was thought that avoidance of intramedullary canal instrumentation would be protective against fat and marrow embolization and would also limit blood loss. However, a comparison study failed to show a decrease in postoperative confusion or respiratory thromboembolic events in patients undergoing navigated TKA vs conventional TKA.\(^{29,30}\) Similarly, many studies reveal no difference in hemoglobin drop, blood loss, or transfusion requirements.\(^{30}\) Although a reduction in outliers of mechanical axis may be achieved with the technique, other proposed outcomes have not been borne out in the research to date.\(^{27}\)

With added expense (eg, start-up costs, training, software, maintenance, preoperative imaging) and increased operative time associated with computer-assisted TKA, in conjunction with the lack of convincing literature to support its adoption, there is insufficient evidence to support the routine use of navigation in TKA.\(^{27,31}\) Thus, the use of navigation for performing TKA has been largely abandoned at the authors’ institution.

**Surgical Drains**

Postoperative surgical drains may complicate nursing care and interfere with postoperative rehabilitation. Drains require dressing maintenance, emptying, and volume documentation, and they are uncomfortable with removal and may get sewn in or caught, requiring a return to the operating room for surgical removal. Similarly, drains may complicate early mobilization, getting caught or snagged on objects and getting trapped under patients. Esler et al\(^{32}\) were unable to provide evidence to support the use of a drain in their randomized, controlled study conducted in 2003: they found that total blood loss was significantly greater in those patients undergoing primary TKA who received a drain as compared with those who did not receive a drain. They showed no difference in postoperative swelling or pain, incidence of pyrexia, ecchymosis, time at which flexion was gained, need for manipulation under anesthesia, or infection rate at 5 years. Two similar studies revealed significantly less blood loss and lower transfusion rates among patients randomized to the group without a drain as compared with those receiving a drain.\(^{33,34}\) A recent Cochrane database review deemed surgical drains in THA and TKA “of doubtful benefit.”\(^{35}\) In the absence of a clear advantage to endorse drain use after primary TJA, the use of drains was eliminated at the authors’ institution, resulting in simplification of nursing and postoperative care, early mobilization of patients, and cost savings.

**Anesthesia and Pain Management**

Pain control after TJA has been shown to be the most important component of patient satisfaction.\(^{36}\) Adequate pain control after TJA facilitates faster rehabilitation and is associated with shorter hospital stays, reduced rates of unanticipated readmissions secondary to pain, and an overall reduced cost of care.\(^{37}\) A coordinated and multi-disciplinary approach to anesthesia, with preference to the use of regional anesthesia in all TJA cases, and multimodal pain management has resulted in an improvement in patient satisfaction while reducing opiate consumption and length of hospital stay.

Preemptive administration of analgesics, the use of spinal anesthesia, and a multimodal pain control strategy postoperatively combine to minimize opiate use during the perioperative period. Opiates may induce nausea, constipation, confusion, and lethargy in patients and adversely affect postoperative rehabilitation while leading to consumption of resources allocated to investigating these adverse events.\(^{37}\) With multimodal pain management, various agents are used to affect nociceptors in different regions of the pain pathway to reduce perceived pain. Multiple studies have demonstrated better visual analog scale (VAS) pain scores, fewer adverse effects, lower nar-
cotic usage, higher satisfaction rates, and earlier times to physical therapy milestones with multimodal analgesic strategies.38,39

Preemptive analgesia has become an increasingly common tactic for reducing pain in TJA. First described by Wall40 in 1988, preemptive analgesia involves the administration of analgesia prior to painful stimuli to prevent establishment of central sensitization and subsequent amplification of postoperative pain.41-43 Patients receive several classes of pain medication to target different steps in the pain pathway. Acetaminophen, which acts as a central analgesic agent, is available in oral form and has recently become available in intravenous form.44 The second component of multimodal pain management is the nonsteroidal anti-inflammatory drugs (NSAID) celecoxib,44,45 a selective COX-2 inhibitor. In addition to celecoxib, which is administered preoperatively, the NSAID ketorolac may be used for breakthrough pain postoperatively. The third component, pregabalin, may ease neuropathic pain by decreasing the excitatory signal release along the afferent pain pathway.46 This agent is used pre- and postoperatively along with acetaminophen and an NSAID.

Spinal anesthesia is usually administered for TJA and has been shown to decrease many of the adverse cardiopulmonary effects associated with general anesthesia in the patient population undergoing TJA.47,48 At the authors’ institution, administration of intrathecal opioids and use a local anesthetic agents were eliminated, the former after an internal study that detected no difference in pain relief with or without the use of intrathecal opioids. However, the elimination of intrathecal opioids eliminated the postoperative nausea and vomiting that had been seen frequently. Another change at the authors’ institution was the elimination of epidural catheters. The use of epidural anesthesia can be associated with technical failure, hypotension, ileus, urinary retention, and motor block that delays physical therapy. On catheter removal, the risk of rebound pain and spinal hematoma is present.49

Injection or continuous intra-articular administration of local anesthetic via catheter has also been shown to lead to better pain relief and a reduction in opioid consumption, better patient satisfaction, and a reduced length of hospital stay after TKA.50-53 Injection of a combination of medications, including bupivacaine, an opiate (morphine or fentanyl, most often), and corticosteroid administered via local injection, has also been shown to be beneficial.53,54 Recently, intra-articular and periarticular injection of liposomal bupivacaine during TJA has been explored. Small early studies exploring analgesic efficacy are encouraging, demonstrating lower reported pain scores, lower opioid use, and lower incidence of opioid-related adverse events in blinded patients receiving this injection perioperatively compared with those who received placebo.55 A recently published meta-analysis of data from 10 randomized, double-blinded studies has shown acceptable tolerability and safety in patients undergoing 5 different procedures: hemorrhoidectomy, breast augmentation, TKA, hernia repair, and bunioectomy.56 Studies are currently underway at the authors’ institution’s arthroplasty department comparing the clinical efficacy and adverse events related to this strategy with the current practice of intrathecal catheter–administered bupivacaine.

For breakthrough pain, oral opiates, tramadol, and one-time doses of intravenous morphine or hydromorphone are available, although these are not always necessary. Ice is provided as needed.57

**POSTOPERATIVE CARE**

**Rehabilitation and Physical Therapy**

Early mobilization is a priority for patients undergoing THA and TKA. Patients who begin rehabilitation within 24 hours of TKA spend fewer average days in the hospital and have better knee range of motion (ROM), muscle strength, and pain scores compared with matched patients who received therapy for the first time in 48 to 72 hours.58

In addition to mobilization, continuous passive motion (CPM) machines have been used in patients undergoing TKA to increase ROM. However, CPM offers only modest ROM improvement (average active knee flexion difference of 3°), which is clinically insignificant.59 Continuous passive motion does not improve length of stay and may distract patients from the importance of active physical therapy participation. In addition, CPM use has been associated with peroneal nerve palsy and pressure ulcers.60,61 Because of all these factors, the use of CPM after elective primary TKA at the authors’ institution has been eliminated without affecting the ROM of the operated knee.

Patient satisfaction after THA has also improved with the elimination of postoperative hip precautions. The latter practice change was as a result of a randomized, prospective study conducted at the authors’ institution.62 Patients undergoing THA either through a direct lateral or a direct anterior approach are not subjected to any hip precautions postoperatively. Hip ROM, including flexion and adduction, is no longer specifically limited. Patients are permitted to drive or ride in a car whenever they are comfortable doing so. Abduction pillows in bed and elevated toilet seats and chairs have also been eliminated. A follow-up study of the patients who were not subject to hip precautions detected no change in the rate of hip dislocation.63 Patients free of postoperative restrictions have been shown to progress to ambulation with a cane, without a cane, and without a limp faster than matched patients with restrictions. In addition, patients drove earlier, returned to side-sleeping sooner, returned to work sooner, and reported higher satisfaction with the pace of their recovery. Elimination of common postoperative precautions saves approximately $655 per patient, an important consideration in today’s cost-conscious medical environment.62
Nursing Care: Indwelling Urinary Catheters

A transition from epidural to spinal anesthesia has facilitated the elimination of indwelling urinary catheters. In a study comparing patients with an indwelling Foley catheter placed at the time of TJA with a group who did not receive a catheter but had intermittent straight catheterization if needed, a urinary retention rate of 9.7% was noted in the non-catheter group vs 2.8% in patients who received a catheter and developed urinary retention after removal of catheter. The incidence of urinary infection was significantly higher in the group that received a urinary catheter. Based on the findings of this study, the authors have abandoned the use of urinary catheters in patients undergoing TJA under spinal anesthesia (without intrathecal opioids) at their institution. Without the use of indwelling urinary catheters, patients experience better ease of mobility, have better satisfaction, and recover faster because they are required to walk to the bathroom for urination. In addition, Hälleberg Nyman et al showed that normal bladder function was regained sooner in patients who received as-needed intermittent catheterization as compared with an indwelling urinary catheter. In the current authors’ study, no incidences of neurogenic bladders were detected in patients who did not receive an indwelling catheter. A follow-up study that is being completed at the authors’ institution has identified the group of patients who may be at higher risk of urinary retention and may benefit from an indwelling urinary catheter at the time of index surgery: preliminary data analysis suggests that 2 significant predictors (P<.05) of postoperative urinary retention are benign prostatic hypertrophy and history of perioperative urinary complication. There is also a trend toward significance for smoking as well as undergoing bilateral TJA as additional risk factors (internal data).

Venous Thromboembolism Prophylaxis

Postoperative venous thromboembolism (VTE) prophylaxis in TJA has been an area of debate and disagreement among orthopedic surgeons, cardiologists, and pulmonary physicians over the past decade. Over the past several years, increasing numbers of arthroplasty surgeons have transitioned from warfarin, low-molecular-weight heparin, and other chemoprophylactic strategies to the use of aspirin for VTE prophylaxis. This practice is based on the large body of evidence that exists supporting the use of aspirin as an effective VTE prophylaxis. In a recent evaluation of all available literature, the American College of Chest Physicians issued antithrombotic guidelines that give aspirin a 1B endorsement (the highest in their guidelines) for use as a VTE prophylaxis after TJA. Similarly, the American Academy of Orthopaedic Surgeons, in their newly issued guidelines for VTE prevention after TJA, could not find superiority for one agent over another.

The authors have been using aspirin as VTE prophylaxis at their institution for the past few years. A recent study from the authors’ institution detected that patients undergoing TJA who received 325 mg of aspirin twice per day for 4 weeks experienced significantly lower rates of symptomatic pulmonary embolism, deep venous thrombosis, and wound-related issues and shorter hospital stays compared with a matched cohort receiving warfarin. Another study from the authors’ institution used nomogram analyses to determine patients at high risk of VTE for whom a more aggressive VTE prophylactic agent may be used. A study is currently under way to measure the financial effect of using aspirin as the main modality for VTE prevention compared with warfarin, and early multivariate analysis suggests aspirin to be independently associated with a lower cost of index hospitalization and lower costs associated with postoperative complications and resulting readmissions (internal data) while lowering rates of VTE.

Hypoxia Evaluation

Given the concern about thromboembolic disease, blood oxygenation has been routinely monitored after THA and TKA with the use of pulse oximetry machines. Episodes of postoperative hypoxia are common, and further diagnostic workup, including computed tomography scans of the chest, is routinely performed. With the increased sensitivity of the imaging modalities, small, peripheral, clinically irrelevant pulmonary vascular filling defects have been discovered with increasing frequency. Aggressive treatment is initiated with significant expense and potential morbidity for the patient.

Eliminating the use of routine pulse oximetry monitoring except in symptomatic patients has reduced the need for diagnostic workup in patients exhibiting hypoxia. In addition, for patients with a hypoxic episode, pulmonary toilet and oxygen through nasal cannula followed by rechecking pulse oximetry has greatly reduced the need for further studies. These protocol changes have simplified postoperative hypoxia management without affecting patient morbidity and mortality. This serves as an example of efficiency and safety maximization with cost reduction, by implementing a protocol that eliminates unnecessary steps and tests (Figure).

Conclusion

With mounting pressure on the health care professionals to provide cost-effective care, more comparative effectiveness research is likely to be performed. The authors share their institutional experience of conducting such studies that have led to the implementation of changes with immense cost savings while improving care. The improvements in care have been made through the elimination of many facets of perioperative care in favor of a simplified strategy. These changes have facilitated improved patient satisfaction, safety, and efficiency (Table).
Recent Protocol Changes That Decrease Complications and Improve Care

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