Clinical Pathways for Total Joint Arthroplasty: Essential Components for Success

James R. Hebl, M.D.
Professor of Anesthesiology
Mayo Clinic

Clinical Pathways: An Overview

The term *clinical pathway* refers to a multidisciplinary process of mutual decision-making that results in the organized care of a well-defined group of patients during a well-defined period of time.[1, 2] Clinical pathways were first introduced in the 1980’s when escalating medical costs pressured physicians to decrease resource utilization without jeopardizing patient safety or clinical outcomes. At that time, pathways were typically procedure-specific (e.g., coronary artery bypass grafting, total knee arthroplasty) and tailored to a specific institution.[3, 4] As a result, tremendous variability often existed from one institutional clinical pathway to another, making clinical comparisons between pathways and formal scientific study exceedingly difficult.

Despite this variability, it is generally agreed upon that clinical pathways provide several distinct advantages. These include the ability to (1) provide coordinated care between departments and across patient care units; (2) standardize patient care and reduce hospital length-of-stay; (3) convert typical inpatient (i.e., same-day admission) procedures to outpatient (i.e., same-day discharge) procedures; (4) prompt change in the care process to better emphasize patient outcomes and cost containment; (5) control hospital costs; and (6) serve as a marketing tool with the public or with third-party payers.[5]

Despite these challenges, this review will summarize the important components of a successful clinical pathway and attempt to evaluate the impact of differing clinical pathways on major perioperative outcomes after total joint arthroplasty. Perioperative outcomes that will be evaluated include postoperative complications, hospital length-of-stay, clinical outcomes, and medical costs.

Clinical Pathway Components

Effective clinical pathways for major orthopedic surgery include the coordination and standardization of several patient care activities during the pre-, intra-, and postoperative period. Essential components of some of the most effective orthopedic clinical pathways are listed in Table 1.

Preoperative Patient Education

Major orthopedic surgery can be a stressful and anxiety-provoking experience for most patients. Bondy and colleagues [6] examined the effect of anesthesia patient education on preoperative anxiety and found that a detailed patient education program may have several beneficial effects. Preoperative patient education may significantly relieve patient anxiety and emotional stress by providing a better understanding of the perioperative process (e.g., preoperative evaluation, hospital admission process, anesthetic options, expected clinical course) and establishing clear expectations with regard to hospital length-of-stay and the discharge process (e.g., dismissal to home vs. rehabilitation swing-bed vs. nursing home). Because patients have a better understanding of the perioperative process, they will often present for surgery with increased confidence in the therapeutic plan and a willingness to more actively participate in their care. Increased participation often results in greater patient satisfaction and potentially improved perioperative outcomes. However, the extent to which patient education influences postoperative outcomes is somewhat unclear.[7-9] McDonald and colleagues [8] demonstrated that preoperative patient education may result in a modest benefit in preoperative anxiety. However, this benefit failed to persist on Postoperative Day (POD) 2 or at the time of hospital discharge. A review of the Cochrane Database on this topic fails to demonstrate that preoperative patient education has a significant impact on postoperative clinical outcomes (e.g., postoperative pain, functional outcomes, hospital length-of-stay) in patients undergoing total hip or total knee arthroplasty.
Table 1. Essential Clinical Pathway Components

**Preoperative**
- Preoperative patient education program
- Appropriate management of preoperative pain and psychological symptoms (fear, anxiety, depression)

**Intraoperative**
- Development of a comprehensive multimodal analgesic regimen
- The use of peripheral nerve blockade and continuous perineural catheters
- Postanesthesia Care Unit (PACU) algorithms for the management of acute postoperative pain

**Postoperative**
- Standardized method of pain assessment on the nursing floors and pain score documentation within the medical record
- Early and accelerated rehabilitation regimen
- Development of an integrated and multidisciplinary Acute Pain Service
- Staff education regarding the importance of pain management
- Written protocols for acute postoperative pain management

**Multimodal Analgesia**
Patients undergoing total knee and total hip arthroplasty experience significant postoperative pain.[10] Severe pain occurs in 60% of patients and moderate pain in up to 30% of patients undergoing total knee arthroplasty. Failure to provide adequate analgesia may impede early physical therapy and rapid rehabilitation,[11] which are both important factors for maintaining joint range of motion and facilitating hospital discharge.[12] In an effort to avoid many of the side effects commonly associated with opioid-induced analgesia, clinicians have begun adopting multimodal therapeutic regimens. Multimodal analgesia has become an important concept in the field of modern pain management.[12-17] The concept is designed to combat pain perception along several pathways of signal transmission, including the surgical site and surrounding tissues, local sensory nerves, and central nervous system. Advantages include superior analgesia secondary to the synergistic effects of multiple agents acting via different pathways, the ability to limit parenteral opioid administration, and minimizing opioid-related side effects. Several investigations have demonstrated the beneficial effects of multimodal analgesia,[14-16] including its value in patients undergoing major orthopedic joint replacement surgery.[17-24]

Several medications may be used as part of a multimodal analgesic pathway. Specifically, the use of acetaminophen,[25] non-steroidal anti-inflammatory agents,[26] selective cyclooxygenase-2 inhibitors,[18] pregabalin,[21] and ketamine,[22] have all been shown to have analgesic benefits in patients undergoing joint replacement surgery. Most experts recommend using multiple agents during the pre- and postoperative period in small quantitative doses to maximize the analgesic effect while minimizing associated side effects. Documented benefits include superior postoperative analgesia,[18, 22, 25, 26] reduced supplemental opioid requirements,[18, 21, 22, 25, 26] fewer opioid-related side effects,[13, 18] improved joint range-of-motion,[18, 21] fewer postoperative sleep disturbances,[18] shorter time to achieve hospital discharge criteria,[21] improved functional mobility,[22] and a lower incidence of chronic neuropathic pain.[21]

Finally, poorly controlled acute postoperative (i.e., nociceptive) pain may contribute to the development of chronic neuropathic pain or complex regional pain syndrome after total joint arthroplasty.[27] Nikolajsen and colleagues examined the Danish Hip Arthroplasty Registry and found that 12% of patients continue to experience moderate-to-severe pain 12-18 months after surgery.[28] Similarly, up to 13% of total knee arthroplasty patients may experience moderate-to-severe pain 12-months after surgery.[29] Additional risk factors for the development of chronic postoperative pain include preoperative pain for greater than 1-month, an increased intensity of preoperative pain, and a patient history of preoperative
fear, anxiety or depression.[29, 30] Poorly controlled postoperative pain has also been shown to impede global recovery and lower the reported quality of life 6-months after surgery.[31] Therefore, clinical pathways that integrate (1) a comprehensive multimodal analgesic regimen to adequately manage pre- and postoperative pain; and (2) a comprehensive psychiatric program to manage preoperative psychological symptoms may have a significant benefit in improving long-term clinical and psychiatric outcomes.

**Peripheral Nerve Blockade and Continuous Perineural Catheters**

Many treatment regimens for managing severe postoperative orthopedic pain include significant doses of parenteral opioids. These treatment regimens are commonly associated with significant opioid-related side effects such as sedation, nausea, vomiting, ileus, and urinary retention that can adversely affect patient outcomes and prolong hospital length-of-stay.[19] Therefore, clinical pathways that minimize (or eliminate) opioid administration may significantly reduce opioid-related side effects and improve postoperative patient outcomes.

The integration of regional anesthesia and peripheral nerve blockade into clinical pathways for orthopedic surgery is an essential step to minimize opioid use and improve perioperative outcomes. Both single-injection[32-35] and continuous[36-40] peripheral nerve block techniques have been shown to provide superior analgesia, reduce supplemental opioid requirements, decrease opioid-related side effects, and improve functional outcomes after total joint arthroplasty. In a recent meta-analysis of 19 articles and 603 patients, Richman and colleagues[41] also demonstrated that patients receiving continuous peripheral nerve blockade have superior analgesia, fewer opioid-related side effects (nausea, vomiting, pruritus, sedation), and improved patient satisfaction when compared to traditional intravenous opioids alone. Although single-injection techniques have been shown to be superior to placebo or systemic analgesia[32-35], comparison studies have shown that single-injection blocks fail to provide the extended benefits of continuous perineural catheters.[37, 42, 43] Continuous peripheral nerve block techniques have also been shown to have similar analgesia — but a more desirable side effect profile — when compared to epidural analgesia.[44] A recent review by Fowler and colleagues[44] demonstrated that patients receiving peripheral nerve blocks had less urinary retention and fewer episodes of postoperative hypotension when compared to patients receiving neuraxial techniques.

A primary concern regarding the use of peripheral nerve blockade is the risk of neurologic complications. Barrington and colleagues[45] recently performed a prospective audit of more than 7,000 peripheral nerve blocks performed at 9 Australian hospitals. Overall, they identified a neurologic injury rate of 0.5%. However, only 10% of these injuries were attributed to peripheral nerve blockade suggesting that the vast majority of perioperative nerve injuries have a non-anesthesia related etiology. The nerve injury rate attributed to peripheral nerve blockade was found to be 0.04% — a rate similar to other large-scale investigations.[46, 47] Jacob and colleagues[48] have also demonstrated that neither the type of intraoperative anesthesia (general versus neuraxial) nor the use of peripheral nerve blockade was associated with an increased risk of perioperative nerve injury in 12,329 patients undergoing total knee arthroplasty. Rather, bilateral surgical procedures and total tourniquet time were found to be associated with an increased risk of nerve injury.[48]

**Standardized Pain Assessment and Documentation, Pain Management Protocols and Staff Education**
In 2001, the Joint Commission declared pain as the “Fifth Vital Sign” and instituted *Pain Management Standards* for accredited ambulatory care facilities, behavioral health care organizations, critical access hospitals, home care providers, hospitals, office-based surgery practices, and long-term care providers.[49] The standard requires health care providers to (1) Appropriately assess and manage pain; (2) Document pain management interventions and subsequent reassessments; (3) Perform pain screenings during initial patient assessments; and (4) Educate patients and their families about pain management. Benhamou[50] and Fletcher[51] report that similar guidelines and recommendations have been put forward by the Royal College of Surgeons, the French Ministry of Health, the French Society of Anesthesia and Intensive Care, the European Task Force on Pain Management, and the International
Association for the Study of Pain. The overwhelming consensus is that each of these interventions should be considered essential components to any clinical pathway designed to optimize pain management and patient care. Despite these recommendations, the literature suggests that pain remains under-treated in both U.S. [52] and European [53] health care facilities – in part, because of a lack of adherence to previously published standards and guidelines.

**Early and Accelerated Rehabilitation**

An early and accelerated rehabilitation program should also be integrated into clinical pathways designed for total hip and total knee arthroplasty patients. A review of the literature suggests that early and accelerated rehabilitation may have a major impact on improved perioperative outcomes in orthopedic patients.[9, 55] Munin and colleagues [55] demonstrated that early inpatient rehabilitation resulted in a shorter hospital length-of-stay and a more rapid attainment of short-term functional outcomes after joint replacement surgery when compared to a delayed rehabilitation program. Pour and colleagues [9] also examined the impact of an accelerated pre- and postoperative rehabilitation program versus a standard regimen on functional outcomes after total hip arthroplasty. Patients randomized to the accelerated pathway were seen earlier on the day of surgery and more frequently on subsequent postoperative days (twice daily versus once daily). There was also a greater emphasis on oral analgesics (versus intravenous patient-controlled analgesia) in patients receiving accelerated rehabilitation. In addition to a shorter hospital length-of-stay, accelerated pathway patients were able to walk for longer distances, had improved pain control, and reported higher patient satisfaction at the time of hospital discharge.[9]

Finally, Mahomed and colleagues [56] have demonstrated that rehabilitation after total hip or total knee arthroplasty does not need to be restricted to the inpatient setting. Home-based rehabilitation programs may provide similar degrees of postoperative analgesia, functional outcomes, and patient satisfaction at a significantly lower cost when compared to hospital-based regimens.[56]

**Clinical Pathways and Perioperative Outcomes**

The goal of most clinical pathways is to provide standardized, evidence-based care to patients in such a way as to minimize the variability of care provided by individual providers. This process has the potential to significantly enhance the quality, improve the safety, and reduce the cost associated with surgical procedures. Several clinical pathways have been reported in the literature for patients undergoing total joint arthroplasty [1, 4, 19, 20, 57-59]; with no two pathways being identical. As a result, comparison of clinical pathways is exceedingly difficult – forcing systematic reviews or meta-analyses that examine the topic to comment on the “concept” of clinical pathways versus their individual component parts. Barbieri and colleagues [1] recently performed a systematic review of clinical pathways used for joint replacement surgery. The review examined 22 studies and included 6,316 patients. The aggregate results demonstrated a significant reduction in postoperative complications (deep venous thrombosis, pulmonary embolism, manipulation, superficial infection, deep infection, heel decubitus ulcers), a shorter hospital length-of-stay, and lower hospital costs in patients undergoing clinical pathways versus standard care.[1] Publications from the University of California – Irvine, the University of Utah, and the Mayo Clinic are described below; and represent typical examples of clinical pathways developed for orthopedic surgical patients.

**Clinical Pathways for Total Joint Arthroplasty**

Skinner and colleagues [57] performed a retrospective, case-controlled investigation of 102 patients undergoing total hip or total knee arthroplasty at the University of California – Irvine. They compared a multimodal clinical pathway that incorporated COX-II inhibitors, tramadol, dexamethasone, acetaminophen, and intra-articular bupivacaine to patients receiving “standard management” with patient-controlled analgesia and intravenous opioids. Importantly, the authors did not incorporate regional anesthesia or peripheral nerve blockade as a component of the clinical pathway. Clinical endpoints were evaluated during POD 1 through 4. For patients receiving the clinical pathway, opioid requirements were reduced 66% for total hip arthroplasty (POD 2 only) and 68% for total knee arthroplasty (POD 3 only). Although VAS pain scores were no different among total hip arthroplasty patients, patients undergoing
total knee arthroplasty reported lower VAS pain scores on POD 2 and at the time of hospital discharge. Implementation of the clinical pathway resulted in no differences in perioperative complications. Hospital length-of-stay was reduced in only total knee arthroplasty patients undergoing the clinical pathway (4.0 vs. 4.9 days; P<0.02). [57]

In contrast to clinical pathways not incorporating regional anesthesia [57] – multimodal regimens utilizing peripheral nerve blockade have been shown to consistently reduce hospital length-of-stay, improve perioperative analgesia with fewer opioid medications, facilitate postoperative rehabilitation, and reduce opioid-related side effects.[19, 20, 58] Peters and colleagues [58] performed a retrospective analysis of 100 patients undergoing total hip and total knee arthroplasty at the University of Utah.[58] The clinical pathway included a multimodal analgesic regimen (sustained-release oxycodone, COX-II inhibitors, and acetaminophen), intraoperative regional anesthesia with intrathecal opioids, and an ultrasound-guided femoral nerve catheter (total knee arthroplasty patients only) for extended postoperative analgesia. Prior to wound closure, patients undergoing both total hip and total knee arthroplasty received <1 mg/kg of 0.25% bupivacaine injected into the deep and subcutaneous tissues by the orthopedic surgeon. A multimodal oral analgesic regimen was then continued into the postoperative period. Control patients were managed with intraoperative general or spinal anesthesia (within intrathecal morphine), continuous femoral nerve blockade (total knee arthroplasty patients only), and postoperative patient-controlled analgesia with intravenous opioids. Patients receiving the clinical pathway had significantly lower pain scores at rest on POD 1 and 2, lower opioid requirements, improved ambulation during rehabilitation sessions, and reduced hospital length-of-stay. There were no differences in perioperative complications when comparing clinical pathway to control patients. Overall, the investigators concluded that the development and implementation of a comprehensive clinical pathway combined with early and aggressive physical therapy improves perioperative outcomes, shortens hospital length-of-stay, and allows patients to achieved physical therapy goals earlier when compared to non-clinical pathway patients.[58]

Finally, Hebl and colleagues have described the development and implementation of the Mayo Clinic Total Joint Regional Anesthesia (TJRA) Clinical Pathway in patients undergoing both minimally-invasive [19] and traditional [20] total hip and total knee arthroplasty. The TJRA Clinical Pathway incorporates preoperative patient education, a multimodal analgesic regimen emphasizing peripheral nerve blockade, standardized PACU algorithms, pain assessments, and medical record documentation, pain management protocols, and a standardized postoperative physical therapy regimen for patients undergoing total joint arthroplasty. Similar to most clinical pathways, the TJRA Clinical Pathway was developed by a multidisciplinary group of Mayo Clinic surgeons, anesthesiologists, pharmacists, nurses, and physical therapy staff based upon their collective experience and exposure to physicians and practice models outside the institution. Although the basic principles of the pathway have remained unchanged (e.g., preoperative patient education, multimodal analgesia, peripheral nerve blockade, pain management protocols), its individual components are continually being evaluated and modified as necessary based upon changes in clinical practice. The current multimodal analgesic and regional anesthesia components of the TJRA Clinical Pathway are listed in Appendix 1.

The Mayo Clinic TJRA Clinical Pathway was first used in patients undergoing minimally-invasive total hip (n=20) and total knee (n=20) arthroplasty.[19] Study patients were prospectively enrolled and compared to matched historical controls undergoing traditional surgical and anesthetic techniques. Matching criteria included the type of surgical procedure, age, gender, and American Society of Anesthesiologists physical status (ASA PS) classification. Patients undergoing minimally-invasive surgery in combination with the TJRA Clinical Pathway had significantly lower pain scores both at rest and with physical therapy, required fewer opioid medications, were able to ambulate significantly sooner, and experienced less urinary retention and postoperative cognitive dysfunction when compared to matched controls. Cognitive dysfunction was defined as disorientation to person, place, or time, hallucinations, or any other cognitive condition requiring further assessment by a physician. Based upon these criteria, approximately 15% of control patients and 1% of TJRA patients experience postoperative
cognitive dysfunction during their hospitalization. Hospital length-of-stay was also significantly shorter among TJRA patients (2.8 days vs. 5.0 days; P<0.01).[19]

The Mayo Clinic TJRA Clinical Pathways has also been utilized in patients undergoing traditional (i.e., non-minimally invasive) total hip and total knee arthroplasty.[20] Patients undergoing joint replacement surgery with the TJRA Clinical Pathway experience superior analgesia with fewer opioid-related side-effects when compared to control patients. Verbal analog pain scores (VAS) were significantly lower among TJRA patients both at rest (P<0.001) and with activity (P<0.001) during their entire hospital stay. Opioid requirements were significantly less among TJRA patients from the pre-/intra-operative period until the beginning of Postoperative Day 2 (P=0.04). Opioid related side-effects such as nausea (P<0.001), vomiting (P=0.01), and urinary retention (P<0.001) were also significantly reduced for TJRA patients throughout most of the perioperative period. There was no significant difference in the frequency of pruritus between groups.[20]

Postoperative milestones (bed-to-chair transfer, discharge eligibility, and hospital dismissal) were achieved significantly sooner in patients receiving the multimodal TJRA protocol. The ability to transfer from bed to chair occurs a mean of 0.2 ± 0.6 days sooner among TJRA patients when compared to matched controls (P=0.001). However, nearly all patients were able to accomplish this milestone by the end of POD 1. Discharge eligibility was also achieved a mean of 1.7 ± 1.9 days sooner among TJRA patients when compared to matched controls (P<0.0001). Hospital length-of-stay was 3.8 days for TJRA patients and 5.0 days for controls (P<0.001). At the time of hospital dismissal, joint range-of-motion was significantly better among TJRA patients (90° vs. 85°; P=0.008). Importantly, the small gains in range-of-motion observed at hospital dismissal persisted at 6-8 weeks postoperatively (106° vs. 99°; P=0.03).[20]

Severe postoperative complications (neurologic injury, myocardial infarction, renal dysfunction, localized bleeding, deep venous thrombosis/pulmonary embolism, joint dislocation, wound infection) are similar among TJRA patients and patients receiving patient-controlled analgesia (PCA). However, urinary retention (P<0.001) and postoperative ileus occurred significantly more often among control patients (7% vs. 1%; P=0.01) resulting in delayed postoperative feedings.[20]

Clinical Pathways and Economic Outcomes

Total hip and total knee arthroplasty are two of the most commonly performed surgical procedures in the United States and represent the single greatest Medicare procedural expenditure.[60, 61] Recent data from the United States Healthcare Cost and Utilization Project report that both the number and cost of total knee and total hip replacement surgeries have increased more than 300% during the past decade.[62, 63] Furthermore, the American Academy of Orthopaedic Surgeons and other independent population-based studies estimate that the number of total joint replacement surgeries will continue to grow.[64, 65] In fact, the number of total hip arthroplasties is expected to increase by as much as 50% per year; and the number of total knee arthroplasties by 300% per year through the year 2030.[64] Given this trend, and the fact that Medicare reimbursement continues to decline, orthopedic patients may have a major economic impact on hospitals and other health care facilities during the next 20 years.[66] Therefore, any changes in surgical or anesthetic practice that can reduce the cost associated with these procedures – while maintaining the same degree of high-quality and efficient patient care – may have a significant impact on overall United States health care expenditures.

Medical costs associated with an episode of care can be classified into three major categories (1) indirect costs; (2) intangible costs; and (3) direct costs.[67] Indirect costs include the cost of lost productivity related to the morbidity and mortality of the disease state. Intangible costs include the cost associated with pain and suffering from the disease state. Direct costs include medical supplies, labor, and time – and can be further divided into Medicare Part A costs and Medicare Part B costs (Figure 1). Several cohort studies have linked the use of clinical pathways with lower variable costs.[7, 68-74] Other studies have demonstrated that the development and implementation of a clinical pathway for patients
undergoing total hip or total knee arthroplasty may significantly reduce both total hospital [4] and direct medical costs [62] while maintaining or improving perioperative outcomes.

**Figure 1.** Classification of Episode of Care Costs.

A reduction in hospital length-of-stay is often considered a cost-saving benefit during the perioperative period. However, cost savings associated with reductions in hospital length-of-stay are directly related to the total duration of stay; and may not necessarily reflect a significant source of cost savings. For example, although hospital “room and board” costs remain constant throughout a hospitalization, treatment costs associated with a hospitalization are often greatest during the initial 48-72 hours of care (reflecting greater care demands during the patient’s initial illness); with a subsequent decline in daily direct medical (i.e., treatment) costs (Figure 2).[75] Therefore, a reduction in hospital length-of-stay from 72 hours to 48 hours will result in significantly greater cost savings than a length-of-stay reduction from 7 days to 6 days. As a result, hospital administrators must understand that an isolated reduction in length-of-stay may (or may not) result in a positive financial impact for the hospital or institution.

**Figure 2.** Estimating the cost savings associated with reductions in hospital length-of-stay. Hospital stays include a daily fixed cost called the “hotel” cost. Additionally, a “treatment” cost is added to each hospital day. During hospitalization the treatment costs are often greatest during the initial portion of the hospital stay reflecting greater care demands during the patient’s initial illness (represented above). The result is that decreasing the length of stay from \(d_1\) to \(d_2\) at the end of hospitalization will likely not result in the same amount of savings as the daily average cost (line c) would estimate.
Limitations of Clinical Pathways

Effective perioperative pain management is not without potential consequences. In 2001, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) declared pain as the 5th vital sign and mandated that pain management become an integral component of all patient care activities as a condition of hospital accreditation. As a result, many institutions implemented aggressive pain management protocols that were guided by patient reports of pain intensity as quantified by a numeric pain scale. Although numeric pain scales may be useful to monitor pain trends within a given patient, these subjective methods of pain assessment are an extremely poor guide for directed analgesic management. In fact, because these subjective and often non-reproducible pain scales do not take into consideration patient comorbidities or associated medication risks, adverse outcomes such as oversedation and respiratory depression may lead to catastrophic outcomes – including death.[70, 76, 77]

Vila and colleagues [78] demonstrated the potential negative impact of implementing a hospital-wide pain management protocol that treats pain based upon patient self-reports. After implementation of a numeric pain treatment algorithm, the number of adverse drug reactions secondary to opioid oversedation more than doubled when compared to pre-implementation values (24.5 vs. 11 adverse events per 100,000 inpatient hospital days; P<0.001). A decreased level of consciousness preceded 94% of events, emphasizing the importance of careful clinical assessment and ongoing patient monitoring while managing pain.[78] Overmedication in preparation for an imaging study,[70] overmedication after discharge from the ICU,[70] and the first 24 hours after surgery [77] appear to be the clinical scenarios or time periods in which patients are at greatest risk for respiratory depression and oversedation.

Finally, clinical pathways that incorporate regional anesthesia and peripheral nerve blockade may increase the likelihood of residual motor blockade – which may impede early mobilization, increase the risk of patient falls, and prolong hospital length-of-stay.[43, 79-82] Kandasami and colleagues [80] recently reported a fall rate of 2% in patients undergoing total knee arthroplasty with the use of femoral nerve blockade. Fall-related injuries included wound dehiscence (n=4) and periprosthetic fracture (n=1). Hospital length-of-stays were extended 10 to 42 days secondary to complications from the fall. However, it has been argued that residual motor blockade is a multifactorial phenomenon – and cannot be entirely attributed to regional anesthesia. In addition to local anesthetic-induced quadriceps weakness, it is believed that motor block can occur secondary to surgical pain, muscle spasm, joint stiffness, swelling, dysesthesias, or other surgical factors.[83] Regardless of the cause, anesthesia providers need to play their role in minimizing the risk of residual motor blockade in patients undergoing total hip and total knee arthroplasty. Clinical pathways that incorporate peripheral nerve blockade need to do so in such a way that the benefits of regional anesthesia are achieved (i.e., identifying the optimal local anesthetic, dose, and concentration); while the contemporary concerns of delayed rehabilitation, prolonged hospital length-of-stay, and increased hospital costs are avoided.

Summary

Total hip and total knee arthroplasty are two of the most commonly performed surgical procedures in the United States with increased volumes expected over the next several decades. Clinical pathways represent a standardized, evidence-based approach to patient care designed to enhance the quality, improve the safety, and reduce the cost associated with surgical procedures. Clinical pathways for total joint arthroplasty have been shown to significantly improve the perioperative outcomes of patients undergoing joint replacement surgery. Effective clinical pathways include preoperative patient education, a multimodal analgesic regimen, peripheral nerve blockade, standardized pain assessment and medical record documentation, pain management protocols, staff education, and early and accelerated rehabilitation. Potential clinical benefits include superior postoperative analgesia, fewer opioid-related side effects, earlier ambulation, improved joint range-of-motion, fewer postoperative complications, and reduced hospital length-of-stays. The financial benefits of clinical pathways include a reduction in both total hospital and direct medical costs. However, further study is needed to determine precisely which component(s) of a comprehensive clinical pathway are most active in contributing to these clinical and financial benefits.
References


Appendix 1. Mayo Clinic Total Joint Regional Anesthesia Clinical Pathway *

<table>
<thead>
<tr>
<th>Patient Waiting Area (Pre-op)</th>
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<tr>
<td>• Oxycodone controlled release (OxyContin®) 20 mg PO once on arrival to patient waiting area if patient 18-59 years old; or 10 mg PO if patient 60-74 years old.</td>
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<tr>
<td>• Acetaminophen (Tylenol®) 1000 mg PO once on arrival to patient waiting area.</td>
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<tr>
<td>• Celecoxib (Celebrex®) 400 mg PO once on arrival to patient waiting area.</td>
</tr>
<tr>
<td>• Gabapentin (Neurontin®) 600 mg PO once on arrival to patient waiting area if patient 18-59 years old; or 300 mg PO if patient 60-69 years old.</td>
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Peripheral Nerve Catheter Infusions
(1) Femoral Nerve or Adductor Canal Catheter (TKA): 20 mL (Adductor) or 30 mL (Femoral) bolus dose of Bupivacaine 0.5% + 1:200,000 epinephrine at time of placement
| • Bupivacaine 0.2% 10 mL bolus upon arrival in PACU; then initiate continuous infusion Bupivacaine 0.2% at 10 mL/hour. |
| • Continue Bupivacaine 0.2% continuous infusion at 10 mL/hour until 0600 the day after surgery. At 0600 the day after surgery, change to Bupivacaine 0.1% continuous infusion at 10 mL/hour. On the second day after surgery, stop infusion and discontinue femoral nerve catheter infusion before 0800. |
(2) Posterior Lumbar Plexus Catheter (THA): 30 mL bolus dose of Bupivacaine 0.5% + 1:200,000 epinephrine at time of placement
| • Bupivacaine 0.2% 10 mL bolus upon arrival in PACU; then initiate continuous infusion Bupivacaine 0.2% at 10 mL/hour |
| • Continue Bupivacaine 0.2% continuous infusion at 10 mL/hour until 0600 the day after surgery. At 0600 the day after surgery, change to Bupivacaine 0.1% continuous infusion at 10 mL/hour. On the second day after surgery, stop infusion and discontinue psoas nerve catheter infusion before 0800. |

Intraoperative
| • Spinal anesthesia preferred intraoperative primary anesthetic |
| • Fentanyl 50-150 mcg IV PRN |
| • Ketamine 10-20 mg IV (150-200 mcg/kg; Maximum 20 mg) |
| • Dexamethasone 4-8 mg IV |
| • Tranexamic acid 1 g I.V. prior to incision and 1 g I.V. during closure |

NOTE: Tranexamic acid is not administered to high-risk ASA III or IV patients (High risk = Prior history of DVT, PE, MI, CVA CABG, Stent placement, or other Pro-thrombotic conditions)

Post-Anesthesia Care Unit (PACU)
| • Oxycodone 5-10 mg PO PRN once for pain rated 4 or greater. Give 5 mg if patient 70 years old or older; give 10 mg if patient 18-69 years old. |
| • Fentanyl 25 mcg IV PRN for pain rated 7 or greater; may repeat every 5 minutes (maximum 100 mcg) |
| • K totorolac (Toradol®) 15 mg IV PRN once for pain rated 4 or greater |

Postoperative Nursing Floor †
| • Acetaminophen (Tylenol®) 1000 mg PO 3 times daily at 0800, 1200, and 1600 hours. |
| • Tramadol (Ultram®) 50–100 mg PO every 6 hours |
| • Celecoxib (Celebrex®) 200 mg PO BID x 10 days |
| • K totorolac (Toradol®) 15 mg IV every 6 hours PRN for pain rated more than 4 (maximum of 4 doses) |
| • Oxycodone 5–10 mg PO every 4 hours PRN. Give 5 mg if patient reports pain and rates pain score less than 4; give 10 mg if patient complains of pain rated 4 or greater. |

Monitoring
| • Continuous pulse oximetry telemetry monitoring for 48 hours postoperatively |

* Perioperative analgesic options are selected based upon each patient’s associated comorbidities.
† Selection of postoperative medications at surgeon’s discretion.