Summary: As newer pharmacologic and procedural interventions, technology, and data on outcomes in pain management are becoming available, effective acute pain management will require a dedicated Acute Pain Service (APS) to help determine the most optimal pain management plan for the patients. Goals for pain management must take into consideration the side effect profile of drugs and potential complications of procedural interventions. Multiple objective optimization is the combination of multiple different objectives for acute pain management. Simple use of opioids, for example, can reduce all pain to minimal levels, but at what cost to the patient, the medical system, and to public health as a whole? Many models for APS exist based on personnel’s skills, knowledge, and experience, but effective use of an APS will also require allocation of time, space, financial, and personnel resources with clear objectives and a feedback mechanism to guide changes to acute pain medicine practices to meet the constantly evolving medical field. Physician-based practices have the advantage of developing protocols for the management of low-variability, high-occurrence scenarios in addition to tailoring care to individual patients with high-variability, low-occurrence scenarios. Frequent feedback and data collection/assessment on patient outcomes is essential in evaluating the efficacy of the APS’s intervention in improving patient outcomes in the acute and perioperative setting.

Key Words: Acute Pain Service—pain service—pain management—acute pain management.

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Our nation’s medical leaders recognized and mandated the reduction of pain scores toward the end of the last millennium. Unfortunately, while the goal was worthy, the pathway that pain management in the United States followed contributed to the tragic outcome that is the opioid epidemic.¹

Effective acute pain management with minimal morbidity and mortality and that allows our patients to become functional members of the community requires more than the prescription of opioids. Unfortunately, pain management is wide in scope of practice, but minimally taught in medical schools. Pain management designed to optimize functional outcomes after surgery requires an in-depth knowledge of the types of pain, pain trajectories, pharmacology of the different analgesic agents, and interventional pain management [regional anesthesia (RA)] and its role in multimodal analgesia. Acute pain should not be considered only as a symptom, but rather a pathophysiologic process.²

Acute pain management is a discipline. Its effective implementation requires a structured Acute Pain Service (APS) with meaningful goals and objectives and the allocation of the necessary resources to provide it with the flexibility to not only meet those goals on an individual level (customized patient care), but to also influence outcomes on a higher, more systems-based level. In addition, the APS is a product that must evolve to meet the constantly ever-changing medical environment.

This chapter will delineate the tactical and strategic objectives of a hospital-based APS as it pertains to perioperative pain management (for all surgical disciplines), explore the different goals when determining how to optimize pain management, describe the potential APS implementation models, and explain how a well-run APS cannot only tailor pain management regimens to individuals based on their specific needs but also influence the morbidity of poorly managed pain from a public health perspective.

TACTICAL AND STRATEGIC OBJECTIVES OF AN APS

The implicit goal of the APS is reduction in the intensity of acute pain. Theoretically, and from the perspective of a single-objective optimization problem, this is an incredibly simple task, as nearly all patients will cease complaints of pain given sufficient quantities of opioid. Yet clinical experience immediately demonstrates that the decisions guiding acute pain management are NOT simple problems of optimizing single objectives (eg, pain score), as respiratory arrest is not an acceptable side effect or risk, nor are the myriad other challenges inherent to any analgesic strategy commonly acceptable.³–⁵

Acute pain medicine is thus differentiated from simple symptom management by virtue of its goal of multiobjective optimization (MOO): decrease pain intensity while simultaneously improving functional capacity.⁶–⁸ In this rubric it is not sufficient to achieve a pain intensity rating of zero in a patient too somnolent to get out of bed; nor is a patient in moderate pain during engagement in aggressive physical therapy a failure of acute pain management. Yet between these 2 extremes exists a wide range of potential pain/function state combinations, the values of which often remain unclear.

MOO is a common challenge throughout all of medicine. Recent therapeutic advances, and evidence in support thereof, have helped transition the APS from an “if this then that” single-objective approach to one that is much more multifaceted and focused on enhancing the overall trajectories of pain and function.⁹–¹¹ In many modern implementations this is covered as part of “enhanced recovery after surgery” pathways, which commonly maintain a core constituency in optimizing analgesia.¹²–¹⁵
Although recognition of the importance of MOO is increasingly common, data to support MOO decisions are not readily available. Evidence is generally constructed at a population level rather than personalized for the individual patient. Further, such evidence often considers either single interventions or general composite practices. Although both approaches to formulating evidence in support of treatment are helpful, neither are designed to directly inform personalized decision making for individual patients. Further, existing frameworks for studying such interventions often do not consider the role of sequential decision making even for single-objective optimization challenges, where prior experience with a given analgesic intervention may alter future analgesic decisions. For instance, when confronted with the patient suffering from refractory pain, how does the failure of a given intervention (eg, high-dose morphine patient-controlled analgesia) alter the next analgesic recommendation?

The lack of data on MOO places both surgical teams and APS between proverbial rocks and hard spots. An approach minimizing opioid analgesics may promote a potentially faster recovery, less opioid misuse, lower rates of nonunion…. but also a miserable, unsatisfied patient along with a perception of dispassionate care. Contrariwise, aggressive analgesic use may lead to perceptions of compassionate care, yet also lead to slower recovery, increased length of stay, and increased opioid exposure potentially leading to opioid dependence and/or use disorders. But which risks apply to which patients? Where lies the cut-offs in the utility of care offered by different analgesic strategies? For a given patient, what are the tangible, measurable rewards resulting from good analgesia?

One important advance in addressing such shortcomings is the evolving use of patient-reported outcomes (PROs). Although pain assessment has historically focused on pain intensity, PROs expand the assessment of pain into a multidimensional approach that considers the impact of pain on patient function. One of the more common implementations of PROs, the National Institutes of Health’s Patient-reported Outcome Measurement Information Systems, covers domains of physical health, mental health, and social health, thus permitting assessments of pain intensity and pain interference to be considered alongside other relevant domains such as cognitive function, psychosocial illness impact, self-efficacy, and ability to participate in social roles and activities. Given very rationale concerns over increasing survey burden, Patient-reported Outcome Measurement Information Systems’ development leveraging item response theory and its utilization of computer adaptive testing have made it possible to significantly advance the efficiency of data acquisition, permitting clinically useful tools that are also linked to more formal research instruments that can aid in translation of research findings.

Despite the considerable advantages of a multidimensional pain assessment, the additional dimensions present a conundrum: if we are unsure how best to optimize a single objective (eg, pain intensity), are we ready for optimization across multiple PROs? With the advent of electronic health records, analyses of large mixtures of PROs, and their associated perioperative decisions, should theoretically supply sufficient material for considering analytical optimizations. However, this approach will require movement beyond traditional statistical methods, instead considering mathematical approaches to decision optimization such as Markovian methods and Q-learning strategies. This may ultimately require a reconsideration of what it means to practice “evidence-based medicine” by virtue of the need to expand the traditional statistical toolbox of evidence-based medicine methods.

It is tempting to dismiss this conundrum as a “big data” problem best left to the data science community. However, as those best positioned to eventually use the potential decisions, physicians can begin laying the foundation on leveraging this framework today. For starters, querying patients on their recovery priorities may offer important insights into perceived barriers and opportunities in enhancing their recovery. This also affords opportunities to reinforce the realities and postoperative recovery, and offer context for realistic expectations following surgery. In making analgesic decisions, such discussions can revisit the agreed-upon priority schedule as evidence of patient-oriented performance.

CURRENT PATIENT-ORIENTED PERFORMANCE GOALS

Prioritization of acute pain management goals may vary by practice, but the most commonly used and quantifiable goals include reduction in pain scores balanced against improved physical rehabilitation metrics, reductions in iatrogenic complications, patient satisfaction, shorter length of stay, and optimized cost-effectiveness of treatment.

Compounding the issue of reduction in pain scores as a patient-oriented goal is the difficulty in pain assessment. Numeric and qualitative scales exist to quantify pain, but despite attempts to the contrary, these scales are subjected to various, inconsistent interpretations and personalized to the individual patient. A more balanced approach to the assessment of pain incorporates other aspects of function, such as with the Defense and Veterans Pain Rating Scale and the DoD/VA Pain supplemental questions (Fig. 1). This assessment tool focuses on the patient’s pain level within the context of other dimensions of well-being such as mood and sleep. The Defense and Veterans Pain Rating Scale has been preliminarily validated in the military population.

Many other outcomes are easily quantifiable. For example, the range of motion during physical therapy sessions and the achievement of certain milestones, especially after orthopedic surgery is an easily measured data point. Improved mobilization can influence the incidence of complications such as deep vein thrombosis/pulmonary embolism, prolonged ileus (mostly after bowel surgery) or arthrofibrosis.

The growing popularity of patient satisfaction surveys has contributed to the perception that satisfaction is an acceptable global measure of health care quality. This is despite very poor correlation between outcomes and patient satisfaction scores. Because Medicare reimbursement currently is based on patient satisfaction, it needs to be addressed. Patient satisfaction is strongly influenced by physician-patient communication, continuity of care, and staff responsiveness. Interestingly, the development of a hospital-acquired condition was not associated with decreased satisfaction scores, and but rather to the response to such a condition. Although patient satisfaction should not be the primary goal, its measurement may be used as a crude gauge of medical provider responsiveness to the patient’s pain and effective communication between the patient and the medical providers.

IMPLEMENTATION MODELS FOR THE APS

APS usually start out as a rudimentary group of individuals with technical prowess in RA (stochastic model), but can evolve to a well-planned and interdisciplinary organization of individuals who operate with defined objectives, resources, and team members (deterministic model). In the stochastic...
model, acute pain management is usually offered in the setting of perioperative pain management, and interventions, such as nerve blocks, are performed out of necessity or enthusiasm by a few medical providers.

Once the benefits of acute pain management is recognized by the institution, resources are then allocated to the further development of an APS with a deterministic model, which incorporates protocols and systems-based practice to allow for more efficient and consistent care of the patient. An APS with a deterministic model has the capability to stratify patients into low-variability, high-occurrence, protocol-based management (less labor-intensive resource allocation) and high-variability, low-occurrence, individualized care (more intensive resource allocation) to better allocate resources.2

Although APS is variable in its structure across institutions, it is mainly either physician led or nurse led. A nurse-led APS tends to focus on standardization of pain assessment/management, patient education, research and auditing and occurs when a physician is not available to lead the APS. In this model, a physician pain specialist can assist with education of medical providers and practice-based recommendations for protocol implementation.38

However, an APS benefits from physician leadership, especially one in which the physician owns a skill set that includes, but is not restricted to, RA. A physician-led APS tends to focus on standardization of pain assessment/management, patient education, research and auditing and occurs when a physician is not available to lead the APS. In this model, a physician pain specialist can assist with education of medical providers and practice-based recommendations for protocol implementation.38

(1) Availability of pain management specialists to provide consultation and intervention for severe acute pain around the clock.

(2) Regular assessments of pain severity at rest and with movement. In an APS that provides RA, this includes rounding (more than once a day) to assess efficacy of interventional modalities and reduction of side effects of analgesic modalities.

(3) Pathway development with surgical teams, ward nurses and consultant services (Physical Therapy/Occupational Therapy), pharmacy to assist patients with goals for functional recovery and pain management.

(4) Continued education of all medical providers on safety, efficacy, and fiscally sound analgesia.

(5) Patient education of pain assessment, available treatment options and their potential adverse effects, and appropriate expectations for analgesia.

(6) Quality control through auditing on APS performance to determine effectiveness and adverse events from analgesic intervention to make decisions and affect any changes to pain management protocols and plans.

Which specialty should lead the APS? With training in multimodal analgesia, opioid pharmacology, and RA, anesthesiologists (specifically individuals who are fellowship trained in Acute Pain Medicine and Regional Anesthesiology) would be most suitably prepared for the safe and effective implementation of an APS.

The same group of physicians that performs the intervention must be the individuals that follow-up on the patients during rounds to avoid issues with (dis)continuity of care and lack of ownership. For instance, some models of APS have the nonpain specialist anesthesiologist in the operating room perform an epidural while the APS or chronic pain team follows up on the patient. These models may result in less optimal management of the patient’s pain due to lack of uniformity in practice. Patient follow-up also allows the APS to help the primary surgical team to determine optimal pharmacologic intervention, such as recommendations for nonopioid pain medications (acetaminophen, nonsteroidal anti-inflammatory agents, N-methyl D-aspartate antagonists, neuropathic agents, muscle relaxants, and α-2 agonists) as well as more effective choice and dosing of opioid medications. Whether the APS is responsible for pain medication prescription or the surgical team is the primary prescriber of pain medications...
(with recommendations provided by APS) should be an agreement between APS and the primary service since preferences, and coordination, vary widely among different surgical teams. In general, having the APS manage all pain prescriptions allows for more seamless transitions from RA to systemic pain medications but may lead to significant safety issues if the care is not coordinated appropriately. In addition, APS can assist the primary service in safer opioid prescription practices. Regardless, it is incumbent upon the APS to follow patients beyond the recovery room and monitor progress even in the case of arrangements whereby the APS does not order follow-up analgesics; otherwise, the APS has no mechanism to both understand the longer-range impact of their interventions, nor obtain the patient-specific feedback that is critical to improving global performance.

The development and sustainability of a well-organized APS does require appropriate resource allocation. Allocation of time, space, personnel, equipment, and money should be based on efficiency, safety, and cost-effectiveness in improving patient outcomes.

Dedicated time not only involves the extra time that regional anesthetics are performed outside of the operating room setting, but also dedicated time to the APS members to round and consult on patients. Time includes the earlier arrival time of patients before surgery if a regional anesthetic is part of the multimodal pain management plan to avoid intraoperative time delays. Procedures should be placed preoperatively before surgery for 2 reasons. First, intraoperative anesthetic doses for general anesthesia and even neuraxial anesthesia may be reduced with well-placed preoperative nerve blocks, thereby reducing the side effects of these intraoperative anesthetic modalities. Second, placing these blocks in the postoperative period when the patient is in pain poses many difficulties. Postoperative sedation for a patient who is in pain to perform a procedure may result in apnea after the regional anesthetic removes the inciting pain; similar issues may emerge due to lagging effects of intraoperative or preblock analgesics already administered in the recovery room. Regardless, these problems will inevitably lead to longer recovery room stays that can readily lead to operating rooms unable to leave the room at the end of the case due to full recovery rooms. In addition, placement of postoperative blocks in the recovery area will result in less efficient use of the recovery area when timing of the postoperative block is not predictable. APS members need time for administrative duties (billing, protocol creation and modification, committee roles), educational activities (both continuing medical education for the APS member and education of nonpain specialist medical providers and patients), and research efforts (quality improvement projects).

Dedicated space is a location where procedures can be performed with all the necessary equipment (ultrasound, kits, local anesthetics, nerve stimulators, airway devices, etc.) and monitoring capability (eg, capnography, electrocardiography, blood pressure). Performing regional anesthetics in the operating room is an inefficient and costly practice. A dedicated procedural space adjacent to the preoperative holding area can also function as an expanded preoperative holding area if the rooms are not being utilized for procedures. In addition to clinical space, individual office space is needed for the performance of administrative duties and meeting space for interdisciplinary, educational, or research meetings.

Core personnel in an APS may vary by need and accessibility of different disciplines. However, the basic APS unit will require input from physicians and nurses specialized in acute pain management. Pain resource nurses can help educate and interface with patients and other medical providers, standardize protocols for pain assessment and documentation, and collect data, which includes the identification of adverse outcomes from pain management (or lack of). If interventional techniques are offered as part of multimodal analgesic regimens, then nurses familiar with procedures and sedation must be trained appropriately to perform time-outs, administer sedation, apply appropriate monitoring, and recognize procedure-related side effects.

A truly functional APS requires multidisciplinary input from many specialties, while not necessary to round on a daily basis with the APS team, can provide valuable input to systems-based practice. These other specialty members include surgeons, primary care physicians, pharmacologists, physical and occupational therapists, psychiatrists, addiction specialists, palliative care providers, and equipment technicians.

**PERSONALIZED CARE**

Although evidence-based protocols can be created to provide a framework for acute pain management specific to certain surgeries or conditions, they do not factor in the different comorbid conditions of each patient. Just as no one-size fits all, acute pain management must be tailored to the individual patient to optimize the risk:benefit ratio of specific pain management modalities. Conditions such as opioid use disorder, central sensitization, opioid tolerance, obstructive sleep apnea, infection, organ system dysfunction (cardiovascular/pulmonary/hepatic/renal/gastrointestinal/neurological/hematologic/musculoskeletal/psychiatric), and cancer will each pose different challenges toward effective pain management that may minimize pharmacologic and procedure-related complications. For example, should a patient with previous history of opioid abuse currently being managed for addiction on buprenorphine be admitted for elective joint arthroplasty, the APS can coordinate buprenorphine dosing with the addiction specialist, recommend either buprenorphine continuation or discontinuation before surgery (and offer guidance on perioperative opioid management in either case), and help the primary team implement the most effective multimodal analgesic techniques to avoid the potential for readdiction (RA with use of nonseeding analgesics, avoidance of opioids on an as-needed basis).

Recently, the use of the pain trajectory, which characterizes the course of the patient’s pain over time, has led to increased insight into the course of postoperative pain.\(^{40,41}\) Anticipating the pain trajectory for individual surgical procedures, physicians may then tailor the duration of analgesic techniques (eg, catheter as opposed to single injection regional anesthetic). Not all patients have declining pain scores with time after undergoing an operation. In fact, a large proportion of patients have pain scores that remain the same or even increase with time.\(^{42}\) Recent studies have demonstrated that age, sex, type of surgery, and preoperative chronic opioid use influences the postoperative pain course.\(^{40,41}\)

The personalized care of the patient benefits from a physician-based APS team with the clinical knowledge and experience to adapt pain management techniques to the individual patient’s medical profile, to constantly elicit feedback about the efficacy of analgesic techniques (to provide a differential diagnosis and respond appropriately to undertreated pain), to recognize patient risk factors for persistent pain after surgery/trauma, to anticipate potential shortcomings of analgesic techniques based on patient comorbidities, and to enable a smooth transition from the inpatient to outpatient setting with

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an elevated risk of chronic pain development,47 sleep impair-
relation exists between inadequate treatment of acute pain and 
and social concerns involving the limitation of complex 
anesthetic care. In this study, the presence of obstructive sleep 
1000 with 58% occurring within 12 hours of release from 
postoperative, opioid-induced respiratory depression as 1.6 per 
the United States with a per capita increase in prescriptions of 
such as posttraumatic stress disorder and depression.49,50 
monetary cost increased, but real danger exists to the patients, 
treated for acute pain, and 16% reduced the dosage.48 A cor-
contributing to treatment cessation.47 To decrease unfavor-
ance supported by randomized clinical trials5,55 short-term effec-
table 1 for a sample 
first and duration of regional anesthetic, intraoperative optimization 
can create specific protocols and frameworks to promote effi-
cient patient care. These frameworks would include the type 
the consistent perioperative course of these patients, the APS 
7.3% from 2007 to 2012.56 With the escalation in the number of 
the undesirable sequela of opioid use skyrocketed as well. Serious adverse effects included opioid use 
and overdose (hypoxic brain injury, death). More than 165,000 individuals died from opioid-related 
overdose in the United States between the years of 1999 and 
As perspective, although the incidence of cancer and heart disease 
leaving deaths tied to opioid 
pain medication has substantially increased.65 In the attempt 
to better provide analgesia and reduce the acute to chronic pain transition, opioids must be prescribed judiciously and responsi-

PUBLIC HEALTH CONSIDERATIONS

Opioids

In the treatment of acute postsurgical pain, opioids are a 
mainstay in treatment. Although effective in pain control, they 
tinted with numerous and undesirable side effects. These 
side effects not only increase the morbidity and mortality of 
the patient, but also the overall cost of health care. The APS 
can help to limit these negative outcomes with balanced 
multimodal drug and interventional regimens.

Opioid-related adverse drug events (ORADEs) can cost a 
great deal to treat and consequently result in an extended 
hospital stay; promoting increased depletion of health care 
resources.42 The incidence of ORADEs ranges from 1.8% to 
13.6% with an increased cost of 7.4% to 47% when comparing 
patients with ORADEs to those without.43,44 Not only is 
monetary cost increased, but real danger exists to the patients, 
with patients who have ORADEs experiencing a 1.9 to 3.4 
times greater risk of mortality.43,45

The occurrence of opioid-associated nausea and/or vom-
ting can range from 1.8% to 16%, and the resultant cost 
increase for a patient with nausea/vomiting ranges from 10.1% to 
215%.42 Regarding constipation, there is 30% to 70% 
reported incidence.46 These unfavorable gastrointestinal events 
can contribute to treatment cessation.37 To decrease unfavor-
able gastrointestinal-related events, data have shown that 13% 
of those surveyed stopped their opioid therapy while being 
treated for acute pain, and 16% reduced the dosage.48 A 
correlation exists between inadequate treatment of acute pain 
and an elevated risk of chronic pain development,47 sleep impair-
ment, and even the development of psychological sequelae 
such as posttraumatic stress disorder and depression.49,50

Unmitigated postoperative pain can decrease mobility of the 
patient, increasing complication risks such as deep venous 
thrombosis, pulmonary embolism, or pneumonia, all of which 
can contribute to the overall increase in cost of patient care.51

Most importantly, we must account for opioid’s effect on 
respiratory drive. A review of the anesthesia closed claims 
analysis revealed respiratory depression was implicated on 
some level in 92 claims from 1990 to 2009, of these 77% 
resulted in extensive cerebral injury or even death. Of the 
respiratory depression events that occurred, 88% were within 
24 hours of surgery, and 34% involved concurrent nonopioid 
medications with sedating effects such as gabapentinoids.52 In 
another study, Weingarten et al53 reported the incidence of postoperative, opioid-induced respiratory depression as 1.6 per 
1000 with 58% occurring within 12 hours of release from 
anesthetic care. In this study, the presence of obstructive sleep 
apnea was found to increase this risk.

Uncontrolled and persistent acute pain has been linked to 
chronic pain; associated with this are clinical, psychological, 
and social concerns involving the limitation of complex 
activities, decreased work performance, decline in quality of 
life, and stigma.54 In the 1990s, leading pain medicine 
specialists pushed for improved management of pain, which 
was supported by randomized clinical trials55 short-term effec-
tiveness of pain reduction and improved function in noncancer 
ociceptive and neuropathic pain with short duration (< 12 wk) 
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Chronic Postsurgical Pain (CPSP)

CPSP is a serious health concern, due to the extended 
usage of postoperative opioids along with analgesic adjuvants 
(i.e., gabapentinoids) possibly resulting in dependence and 
addiction.67,68 Moderate to severe pain continuing for a mini-
num of 3 months following all surgeries occurs in 6% to 10% 
of patients69 and approximately 20% of patients following total 
joint arthroplasty.70 CPSP can have a noteworthy effect on 
quality of life. Measurements taken using the Short Form 
Health Survey (SF36) has shown those with CPSP after 
arthroplasty of a total joint have a notably decreased quality of 
life.71 Central sensitization can also play a part in the level of 
pain both preoperatively and postoperatively.72,73

Allthaus et al74 developed an index highlighting 5 pre-
dictors contributing to CPSP: pain at the operative site before 
surgery, any preexisting chronic pain in the body, uncontrolled 
postoperative pain, capacity overload, and coexisting symp-
toms of stress. High-dose opioids taken preoperatively makes 
the risk of increased pain and protracted recovery more likely.75 The use of low-dose and/or weak opioids (tramadol) 
may induce hyperalgesia before surgery and serve to intensify 
postoperative pain.76

Evidence suggests that pain predicts pain,77 whether that 
relationship is preoperative pain to postoperative pain, post-
operative pain to CPSP, or most importantly, making the 
progression from preoperative pain and traversing all the way 
to CPSP. Effective acute pain management with the use of bal-
anced analgesia can be performed with the leadership of an 
APS to not only tailor the correct analgesic regimen to indi-
vidual patients, but also to influence outcomes on more global 
issues such as the ORADEs, the opioid epidemic, and CPSP.

PUTTING IT ALL TOGETHER: APS IN 
ORTHOPEDIC SURGERY

Elective Joint Surgery

For low-variance, high-volume elective surgeries, due to 
the consistent perioperative course of these patients, the APS 
can create specific protocols and frameworks to promote effi-
cient patient care. These frameworks would include the type 
and duration of regional anesthetic, intraoperative optimization 
of pain and minimization of anesthetic side effects, and 
postoperative multimodal analgesics (Table 1 for a sample 
guideline).

Protocols allow medical staff to know what to expect and 
allow for a routine. They allow for better preparedness so that 
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TABLE 1. Frameworks for Total Joint Arthroplasty

Preoperative
1. Continuous cervical paravertebral catheter (C5-C6) for shoulder arthroplasty, continuous femoral catheter and single injection sciatic nerve block for knee arthroplasty, continuous lumbar (L1-L2) epidural or lumbar paravertebral for hip arthroplasty.
2. All continuous peripheral nerve catheters will be loaded with 20 mL of ropivacaine 0.5% in divided doses, all epidurals will be loaded with 10 mL of ropivacaine 0.5% in divided doses.
3. All continuous catheters will be attached to infusion pumps with ropivacaine 0.2% to be set at a basal infusion of 5 mL/h with a patient-controlled bolus of 5 mL every 60 min as needed for pain.

Intraoperative
1. General anesthesia for total shoulder arthroplasty, spinal anesthesia with sedation for knee arthroplasty (lower spinal dose if patient to be discharged on the day of surgery), epidural anesthesia with sedation for nonrevision hip arthroplasty (general anesthesia for revision hip arthroplasty).
2. Bladder catheterization should only be reserved for revision surgery or for patients with a need for intraoperative urine volume monitoring.
3. Intravenous acetaminophen 1 g 1 dose.
4. Intravenous ketorolac 30 mg.
5. Intravenous dexamethasone 0.1 mg/kg.
6. Antimetic prophylaxis with intravenous ondansetron.
7. If possible, limit intravenous fluids to <1 L.
8. If patient with chronic use of opioids, consider 0.1-0.3 mg/kg ketamine.

Postoperative
1. APS checks on patient in the recovery area, confirm that the patient has satisfactory pain control, confirm knee immobilizer if patient had femoral block.
2. Patient education on the bolus option for nerve catheter.
3. Celebrex 100-200 mg orally bid scheduled for pain.
4. Acetaminophen 1 g orally 4 times a day (2 to 3 times of day if patient is above 75 y old) scheduled for pain.
5. Tramadol 50 mg every 8 h as needed for pain.
6. If pain is not adequately managed with tramadol, acetaminophen and celecoxib, then oxycodone 5-10 mg as needed every 4 h may be given for pain.
7. If the patient’s pain is not adequately controlled despite these modalities, contact the APS.
8. Anticipated discharge date of shoulder arthroplasty—the day after surgery unless otherwise specified. Patients are discharged home with ambulatory pump for their cervical paravertebral catheter.
9. Anticipated discharge date for knee and hip arthroplasty is 2 days after surgery. Regional anesthetic infusion to be removed on the second day after surgery to allow for titration of opioid analgesics.
10. Upon discharge, patients will be given scripts for a 3 wk supply of either tramadol or oxycodone.

APS indicates Acute Pain Service.

Trauma Surgery

In cases of orthopedic trauma, pain management must be individualized to the patient, their comorbidities, and their anticipated perioperative course. An APS can contact the trauma surgeons to discuss patients that may benefit from regional anesthetic techniques to minimize pain, even well before the patients are scheduled for the operating room. Patients with traumas of limbs in which frequent visits to the operating room are anticipated can be managed comfortably with continuous nerve catheters if the injuries are isolated to the limbs (see Table 2 for regional anesthetic techniques for limb trauma). Thoracic epidural or paravertebral blockade for patients with rib fractures or exploratory laparotomies, whose pain prevents them from optimizing their oxygenation and ventilation, can simultaneously improve comfort while potentially minimizing posttrauma complications.

In addition, patients at risk for compartment syndrome should have a steady and analgesic level (not too dense) of a local anesthetic infusion that does not mask the excessive pain or motor dysfunction that may be markers for the diagnosis of compartment syndrome. Performed well and with appropriate oversight, this approach may even allow for earlier detection of compartment syndrome pathophysiology by better defining pain due to somatic surgical pain (present in a poorly functioning block) versus ischemic pain occurring despite otherwise intact somatic sensory blockade. In the case of a patient complaining of pain in the absence of a block, baseline probabilities favor existence of anticipated somatic pain that is often treated with several rounds of escalating doses of opioids which may delay recognition of observed pain intensity out of proportion to the anticipated postoperative course. In addition, continuous nerve block catheters must be tunneled well away from the surgical site.

This patient population also may, in certain circumstances, have a higher incidence of substance abuse (opioid/cocaine/alcohol) which poses different challenges for pain management. Patients with current opioid abuse will have a high tolerance to opioids and rely on different analgesic modalities for effective pain management.

Orthopedic Oncology

In orthopedic oncology, the type and extent of surgery is often quite different for each patient, and APS communication with the surgical team before surgery is very crucial in offering the correct regional anesthetic and pain management plan. Excision of larger soft tissues may benefit from single injection or continuous regional anesthetic techniques. For excision of bony tumors, continuous techniques would allow for superior

on the day of the surgery, enough nursing and staff resources will be allocated to the procedural suite to minimize delays in the patient arriving in the operating room. The minimization of variance permits more reliable scheduling and resource allocation, together enhancing economic efficiency of the elective total joint service line. Protocols also allow for monitoring of process measures; tracking of iterative changes to protocols can further demonstrate which specific tasks yield significant improvements to patient care.

Should practice changes occur, such as the implementation of enhanced recovery after surgery, the APS can likewise adjust protocols that would support that mission, such as conversion of a sciatic nerve block for knee arthroplasty to an iPACK block.
analgesia. In patients whose anticipated surgery in large (hemipelvectomy, forequarter amputation, rotationplasty), multiple continuous catheters may be needed to provide complete coverage and neuropathic medications/mirror therapy/N-methyl D-aspartate antagonists may need to be initiated earlier in the course of pain management to reduce the potential for phantom limb pain. And in the case of inoperable orthopedic malignancy, the APS can still provide the patient with pain relief and organize with the patient and their family a discharge pain management plan for end-of-life care. Further work is necessary to highlight the potential role of regional anesthetics in minimizing tumor growth and metastatic progression by immunomodulation through μ-opioid and adrenergic receptor-mediated pathways.

FUTURE OF APS

In recent times, much of the focus of research in acute pain has focused on RA, where public and publishing incentives often favor development of “new” nerve block needle placements and trajectories. Although there has also been growing attention in recent times to interventions which modulate the kinetics of a nerve block, these areas of focus miss some very important points to address:

- Which patients are best served by which type of block (or which pharmacologic analgesic intervention)?
- How long should performed blocks (or any analgesic intervention) last?
- At what intensity should analgesia be to optimize both analgesic efficacy and safety?

No matter how novel or helpful the block, the block will fail to realize its full potential if the parameters for optimal use cases are not fully elucidated. Given this, the most striking advances yet to come are probably not very ... striking. Rather, the most impact will likely follow methodological incorporation of acute pain medicine principles into broader frameworks of perioperative care.

Ongoing refinement of block processes, along with education and technological advances surrounding block placement, will continue to make simple nerve blocks simpler. Variations of old interventions are nothing new ... but application and additional considerations, as well as new teams with different training backgrounds and practice cultures, nevertheless lead to increasing complexity necessitating further subspecialization in acute pain medicine.

REFERENCES


