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RESEARCH ARTICLE

Multimodal Pain Management Protocol Versus Patient Controlled Narcotic Analgesia for Postoperative Pain Control after Shoulder Arthroplasty

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Abstract

Background: Our institution's traditional pain management strategy after shoulder arthroplasty has involved the utilization of postoperative patient-controlled narcotic analgesia. More recently, we have implemented a protocol (TLC) that utilizes a multimodal approach. The purpose of this study was to determine whether this change has improved pain control and decreased narcotic utilization.

Methods: Patients undergoing primary total shoulder or reverse arthroplasty were retrospectively studied. All patients underwent interscalene brachial plexus blockade. "Traditional" patients were provided a patient-controlled analgesic pump postoperatively. TLC patients were given preoperative and postoperative multimodal, non-narcotic analgesic medications and breakthrough narcotics. Morphine equivalent units (MEU) consumed and Visual Analog Scale (VAS) scores for pain (0, 8, 16, and 24 hours) were considered.

Results: There were 108 patients in each group. Total postoperative narcotic consumption in the first 24 postoperative hours was 38.5 +/- 81.1 MEU in the "Traditional group" compared to 59.3 +/- 59.1 MEU in the TLC group ($P < 0.001$). Of patients in the TLC group, 88% utilized breakthrough narcotics. VAS pain was significantly higher in the "Traditional group" at 16 hours (4.1 +/- 2.9 vs 3.2 +/- 2.7, $P = 0.020$) and 24 hours (4.8 +/- 2.7 vs 3.7 +/- 2.6, $P = 0.004$).

Conclusion: Those treated with the TLC protocol had greater narcotic utilization but better VAS pain scores at 24 hours after surgery. Both groups experienced rebound pain. While the TLC protocol led to an improved pain experience, further modification of the currently protocol may be necessary to reduce overall narcotic utilization.

Level of evidence: III

Keywords: Arthroplasties, Multimodal pain management, Pain management, Pain-postoperative, Shoulder arthroplasty

Introduction

Studies suggest that a multimodal approach to pain management can lead to decreased pain and narcotic consumption after total joint arthroplasty and lumbar spinal procedures (1-4). In theory, multimodal-based approaches to pain management have the potential to minimize postoperative pain while, at the same time,

reducing the total opioid consumption and subsequent associated deleterious adverse effects. With concern regarding a pervading opioid epidemic in the United States, reduction in narcotic utilization after surgery is of paramount concern (5).

The optimal post-operative pain control regimen after

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total shoulder arthroplasty has not been well studied. The introduction of interscalene brachial plexus blockade has resulted in shorter hospital stays, reduced need for postoperative analgesics, less time in the postanesthesia care unit and high levels of satisfaction with their anesthesia (6-11). Despite this, postoperative pain management remains a concern as patients undergoing interscalene brachial plexus blockade can experience failure in up to 20% of cases and many patients experience "rebound pain", or a quantifiable increase in acute pain during the first few hours after the effects of nerve block resolves (12, 13). Because of this, patients often require substantial doses of intravenous and oral narcotics after shoulder arthroplasty.

Our institution's traditional pain management strategy after shoulder arthroplasty has involved the utilization of preoperative interscalene brachial plexus blockade and postoperative patient-controlled narcotic analgesia. More recently, we have implemented a protocol (TLC) that utilizes a preoperative and postoperative multimodal approach to pain control. The purpose of this study was to determine whether this change in protocol has improved pain control and decreased narcotic utilization after shoulder arthroplasty.

Materials and Methods

This retrospective comparative study was approved by the Institutional Review Board of Thomas Jefferson University. The last 108 patients who underwent primary total shoulder or reverse arthroplasty for the diagnoses of osteoarthritis or cuff tear arthropathy under the "Traditional protocol" and the first 108 patients who underwent primary total shoulder or reverse arthroplasty for the diagnoses of osteoarthritis or cuff tear arthropathy under the "TLC protocol" were compared (1/14/2015 to 6/22/2016). Based on a two-tailed t-test with 80% power, assuming an effect size (net difference normalized by within-group standard deviation) of 0.5 and a *P-value* for significance of 0.025, 78 patients were required in each group. All surgeries were performed at a single institution by one of four fellowship-trained shoulder surgeons. Patients with psychiatric illness as defined by comorbid diagnosis of bipolar disorder or schizophrenia, revision arthroplasty surgery, surgery for a diagnosis of fracture, workman's compensation/disability/litigation claim, known adverse drug reaction or allergy to the medications used, chronic pain syndromes (including reflex sympathetic dystrophy, fibromyalgia, chronic diffuse musculoskeletal pain), patients taking long acting narcotic pain medications (including extended release narcotic pain medications and methadone), and patients with hepatic and renal disease were excluded. Data regarding demographics, American Society of Anesthesiologists Score (0 - 6), short-acting narcotic usage, and non-narcotic analgesic usage were collected prospectively.

Baseline preoperative Visual Analog Pain scores were obtained on the day of surgery prior to patient evaluation by the anesthesiologist. Preoperatively, all patients underwent interscalene brachial plexus blockade performed by one of 6 anesthesiologists, experienced

in ultrasound-guided regional anesthesia, using 30ml of 0.5% Ropivacaine.

The Traditional group was given no preoperative medication and was provided a patient-controlled analgesic pump in the post-operative ambulatory care unit (PACU). The pump dispensed hydromorphone with the dosage and frequency titrated based on the patient's pain. No additional oral narcotics were routinely ordered over the first 24 hours after surgery. In cases of ineffectiveness or reactions to hydromorphone, patient-controlled analgesic pumps were altered to dispense either morphine or fentanyl. Acetaminophen was utilized to treat fever in the perioperative setting on an "as needed" basis. No other analgesic or non-steroidal anti-inflammatory medications were given during the first 24 hours.

Patients in the TLC group were given acetaminophen 975 mg, celecoxib 400 mg, and pregabalin 75 mg orally 2 hours before incision. Postoperatively TLC patients were given acetaminophen 650 mg by mouth every 6 hours, pregabalin 150 mg by mouth every 12 hours, and ketorolac 30mg IV q6h. In addition to the TLC medications, patients in this group were offered one of the following for breakthrough pain: oxycodone IR 10 mg by mouth every 4 hours as needed, hydromorphone 2 mg by mouth every 4 to 6 hours as needed, tramadol 50mg by mouth every 4 to 6 hours as needed, and valium 2 by mouth every 12 hours as needed. If none of the oral medications were successful at relieving pain, an intravenous fentanyl or hydromorphone PCA was started at the discretion of the treating physician.

The primary outcome variable was morphine equivalent units (MEU) consumed over the first 24 hours after surgery. Secondary outcomes included intraoperative MEU consumed, Visual Analog Scale (VAS) for pain (0, 8, 16, and 24 hours), and length of hospital stay. Intraoperative narcotic administration was at the discretion of the anesthesiologist. The need for narcotic was generally determined based on physiologic indicators for pain, which includes hypertension and tachycardia.

Comparative statistics between groups were performed using Mann-Whitney tests for continuous variables and Fisher's exact test for non-continuous variables. A linear regression model was utilized to determine associations between demographic variables and MEU utilized in the first 24 hours after surgery and VAS pain score at 24 hours after surgery. All analyses were performed using R 3.2.3 (R Foundation for Statistical Computing, Vienna, Austria). The primary outcome variable was morphine equivalent units (MEU) consumed over the first 24 hours after surgery and the secondary outcome was intraoperative MEU consumed.

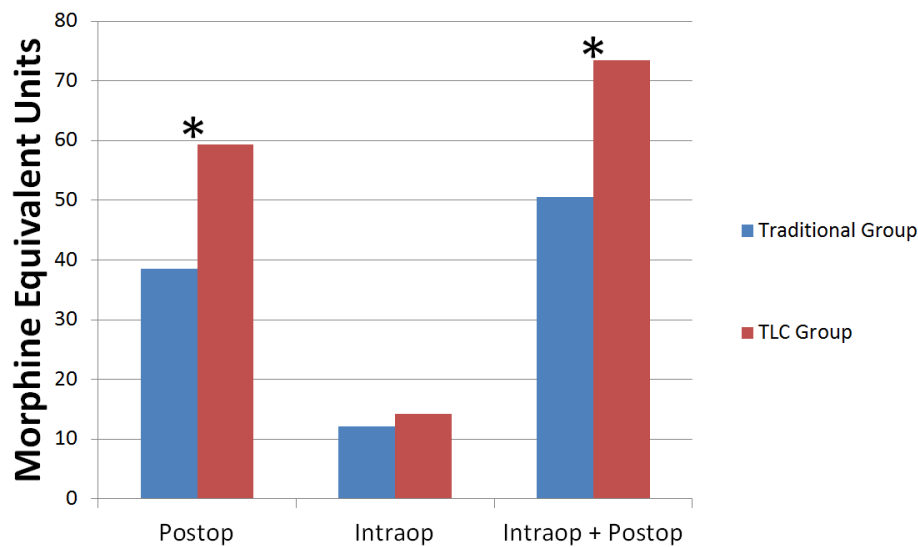
Results

There were 108 patients in the "Traditional group" and 108 patients in the TLC group. Mean age was 70.7 (+/- 9.5) years in the "Traditional group" and 70.0 (+/- 9.5) in the TLC group (*P=0.55*). There were no significant differences in gender, body mass index, arthroplasty type performed, or American Society of Anesthesiologists (ASA) Score [Table1]. Similarly, there were no significant differences in preoperative oral

Table 1. Preoperative Variables

Variable	Traditional Group	Range	TLC	Range	P-value
Age	70.7 (+/-9.5)	48.8-91.4	70.0 (+/-9.5)	39.5-87.0	0.55
Gender (male : female)	52 : 56		57 : 51		0.59
Mean ASA Score	2.5 (+/-0.5)	2-3	2.6 (+/-0.6)	1-4	0.08
Arthroplasty (aTSA:RTSA)	59 : 47		66 : 42		0.58
BMI	30.1 (+/-6.5)	20.3-53.7	30.0 (+/-6.6)	17.9-50.2	0.97
Preoperative Short-Acting Narcotics	16		22		0.37
Preoperative Non-Narcotics	32		25		0.35
Preoperative VAS Pain Score	3.3 (+/-3.3)	0-10	3.2 (+/-3.5)	0-10	0.89

aTSA = anatomic total shoulder arthroplasty, RTSA = reverse total shoulder arthroplasty, ISBPB = interscalene brachial plexus blockade, ASA = American Society of Anesthesiologists, VAS = Visual Analog Scale

**Figure 1. Intraoperative and Postoperative Narcotic Consumption.**

short-acting narcotic usage or non-narcotic analgesic usage [Table 1]. Preoperative VAS pain scores were similar between the "Traditional group" and the TLC group (3.3 +/- 3.3 vs 3.2 +/- 3.5, $P=0.89$).

Total postoperative narcotic consumption in the first 24 hours after surgery was 38.5 +/- 81.1 MEU in the "Traditional group" compared to 59.3 +/- 59.1 MEU in the TLC group ($P<0.001$) [Figure 1]. Of patients in the TLC group, 88% (95/108) utilized breakthrough narcotics in the postoperative setting. Intraoperative narcotics usage was similar in the "Traditional group" compared to the TLC group (12.1 +/- 5.8 vs 14.3 +/- 7.0, $P=0.030$) [Figure 1]. VAS pain score was similar between the "Traditional group" and the TLC group at zero (1.0 +/- 2.0 vs 1.3 +/- 2.2, $P=0.26$) and 8 hours (1.7 +/- 2.5 vs 1.6 +/- 2.2, $P=0.96$) after surgery [Figure 2]. VAS pain scores were significantly higher in the "Traditional

group" compared to the TLC group at 16 hours (4.1 +/- 2.9 vs 3.2 +/- 2.7, $P=0.020$) and 24 hours (4.8 +/- 2.7 vs 3.7 +/- 2.6, $P=0.004$) [Figure 2]. Patients in the "Traditional group" had a statistically significantly longer length of stay than patients in the TLC group (1.7 +/- 0.8 vs 1.5 +/- 0.9 days, $P=0.002$). In the Traditional group, 43 (39.8%) patients had 1 day length of stay and 57 patients had a two-day length of stay (52.8%) (Range 1 to 6 days). In the TLC group, 71 (65.7%) patients had 1 day length of stay and 25 patients had a two-day length of stay (23.1%) (Range 1 to 6 days).

Regression Analysis

Multivariate linear regression models were created to determine the association between preoperative variables (demographics, comorbidities, procedure type, surgeon performing the surgery, preoperative VAS

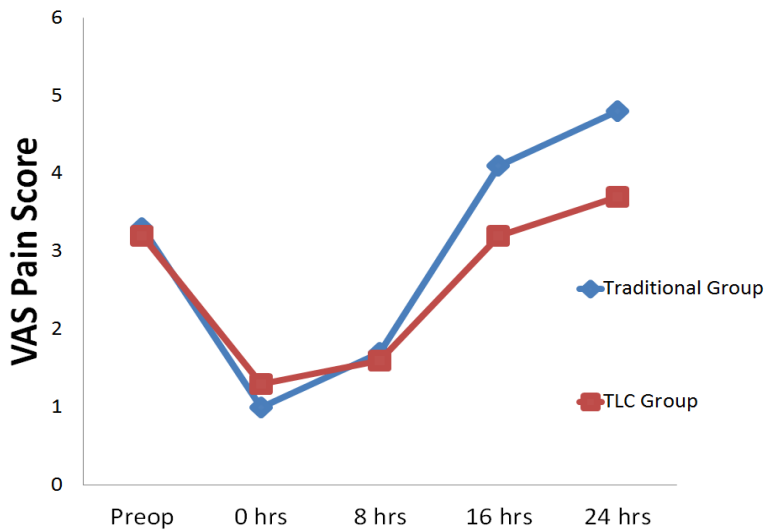


Figure 2. Preoperative and Postoperative VAS Pain Scores.

pain score) and the outcomes of 24 hour VAS pain score, postoperative narcotic consumption in the first 24 hours after surgery, or intraoperative narcotic consumption. VAS pain score at 24 hours was associated with higher preoperative VAS pain score (slope = 0.2114, SE = 0.057, $P=0.0026$) irrespective of the treatment group (net effect -0.548, SE .714, $P=0.444$). The TLC protocol was independently predictive of increased post-operative narcotic use (33.619 units, SE 16.0325, $P=0.037$) TLC was not a significant predictor of intra-operative MEU (1.249 units, SE 1.437, $P=0.386$). There were no significant interaction terms with TLC and other predictors, suggesting that age, gender, etc., acted the same in the TLC as in the Traditional group.

Discussion

Pain management after shoulder arthroplasty can be challenging and optimal pain management strategies have yet to be established. Traditionally, opioid medications have been at the forefront of postoperative pain management. Unfortunately, narcotic medications are linked with substantial economic burden of adverse events, including nausea, vomiting, and constipation, resulting in high hospital costs, prolonged hospital stays, and substantial health care resource usage in inpatients and outpatients (14). Additionally, narcotic addiction remains a prominent concern in health care (15). The purpose of this study was to determine whether the utilization of an oral, multimodal pain management protocol resulted in an improvement in the postoperative pain experience and reduction in the need for narcotics after shoulder arthroplasty. Though the specific TLC protocol utilized in this study led to improved pain experience at 24 hours, there was a greater overall utilization of narcotics.

In this study, a combination of 3 medications was

administered before surgery and a different combination of 3 medications was administered after surgery in the TLC group. Additionally, a large percentage of patients in the TLC group still required breakthrough narcotic medications postoperatively. Because of this, even though patients in the TLC group reported improved pain scores at 24 hours after surgery, it is impossible to determine whether this difference was a result of any specific medication in the “cocktail”, the multimodal pathway as a whole, or the greater consumption of postoperative narcotics. The multimodal pathway used in this study included the nonsteroidal anti-inflammatory drug (NSAID), ketorolac. No studies specifically evaluate the effect of NSAIDs after shoulder arthroplasty. Takada et al compared the analgesic effect of IV flurbiprofen with placebo after arthroscopic rotator cuff repair in a randomized, double-blinded clinical trial (16). Patients who received flurbiprofen (1mg/kg) five minutes before surgery reported improved pain scores for the first 6 hours after surgery and reduced narcotic consumption for the first 2 hours after surgery. There was no difference in narcotic consumption or pain scores beyond 6 hours after surgery. Given the potential side-effects of NSAIDs, including negative influence on tissue healing and bone metabolism, further study will be necessary to determine whether a true benefit exists acutely after shoulder arthroplasty (17, 18). Pregabalin was also included in the TLC group both preoperatively and postoperatively. Previous studies have not specifically evaluated the efficacy of pregabalin as an adjunct to pain management protocols after shoulder arthroplasty. In a randomized controlled trial of patients undergoing arthroscopic shoulder surgery, 60 patients were randomly assigned to receive either pregabalin (150 mg) or placebo one hour before anesthetic induction (19). Patients in the pregabalin group consumed less narcotic over the first

48 hour after surgery and reported significantly less pain at 6, 24, and 48 hours after surgery. The inclusion of pregabalin in our TLC protocol did not appear to decrease the need for narcotics in the postoperative setting.

Patients in both the PCA group and the TLC group experienced "rebound pain". We demonstrated a change in pain score from 1.7 to 4.8 between 8 and 24 hours after surgery in the "Traditional group" and a change in pain score from 1.6 to 3.7 in the TLC group. We associate this increase in pain scores with the acute heightened pain experience that occurs after resolution of the effects of an interscalene brachial plexus blockade. Alternative strategies to reduce the rebound pain experience may include intraoperative infiltration of the soft-tissues with analgesic or anesthetic medications (20-22). In a meta-analysis that examined the effects of interscalene brachial plexus blockade on analgesic outcomes after shoulder surgery, Abdallah et al reviewed a total of 23 randomized controlled trials and demonstrated that ISBPB can provide effective analgesia up 8 hours after shoulder surgery, with no demonstrable benefits thereafter (23). While the TLC group experienced a less substantial spike in pain scores between 8 and 24 hours compared to the Traditional group, it is unclear whether this difference is a result of the multimodal analgesic medications administered or from the increased narcotic utilization in this group. We hypothesize that the less substantial spike in pain score in the TLC group may account for the significantly shorter hospital length of stay demonstrated in this study. It is important to note that, though statistically significant, it is unknown whether a 0.2 day mean difference in length of stay represents a clinically significant difference.

In both the Traditional and the TLC groups, patients with higher preoperative VAS pain scores were more likely to have high 24 hour VAS pain scores. This association has been previously demonstrated in studies of open and arthroscopic rotator cuff repair (13, 24). With use of either a Traditional or a TLC protocol, patients with high preoperative pain scores should be counseled regarding the challenges they may face in achieving pain relief in the first 24 hours after surgery. In this study, preoperative short-acting narcotic usage was not associated higher pain scores postoperatively. Other studies have associated preoperative narcotic utilization with postoperative pain experience after shoulder surgery. Cuff et al reviewed 181 cases of arthroscopic rotator cuff repair and noted that preoperative narcotic use was strongly predictive of higher pain scores on postoperative days 1 and 7 (25). We excluded patients taking long-acting narcotics preoperatively which may account for the lack of this association in our study.

This study has several limitations. The retrospective study design is a primary limitation that did not allow

for assessment of certain variables, such as pain scores beyond 24 hours after surgery and satisfaction that could be available in a prospective evaluation. Since this study investigates a change in protocol over a specified period of time and since we excluded patients with certain characteristics (long-term narcotic use, psychiatric comorbidities, etc) that could create outliers in each group, we attempted to minimize the impact of this limitation on the results. Additionally, this study evaluated a specific TLC protocol; and so, it is not possible to generalize the results to other multimodal pain management strategies. We utilized single-injection interscalene brachial plexus blockade in this study as it is the standard of care at our hospital. It is likely that interscalene brachial plexus blockade with placement of a catheter for continuous infusion of analgesic medication would have resulted in longer-lasting pain relief and perhaps a less substantial "rebound pain" experience. Finally, while reported narcotic usage in terms of MEUs is common in the literature, there is growing concern that a single, effective method does not exist that allows opioids to be accurately and consistently converted to another opioid (10, 26-29). Similarly, we compared patients who utilized intravenous narcotics via a patient controlled pain pump to patients who used oral narcotics. As intravenous medications are fast-acting and short lived; whereas oral opioids are slowly in onset but result in more sustained effect, the differences could be explained by the different method of narcotic administration.

When compared to patients in the "Traditional group", those treated with the TLC protocol had greater narcotic utilization postoperatively but better VAS pain scores at 24 hours after surgery. Both groups experienced a substantial increase in pain experience after the 8-hour time point, indicating the experience of rebound pain after interscalene brachial plexus blockade. This data indicates that the non-narcotic medications included in the TLC protocol were not sufficient to eliminate, or even reduce, narcotic utilization. While the TLC protocol led to an improved pain experience, further modification of the currently protocol may be necessary to reduce overall narcotic utilization.

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