Joint Range of Motion After Total Shoulder Arthroplasty With and Without a Continuous Interscalene Nerve Block: A Retrospective, Case-Control Study

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Background and Objectives: Although a continuous interscalene nerve block (CISB) has been shown to provide potent analgesia after major shoulder surgery, its potential effects on postoperative rehabilitation remain uninvestigated. Therefore, this retrospective case-control study was undertaken to determine the association between CISB and joint range-of-motion after total shoulder arthroplasty (TSA).

Methods: The medical records for patients who underwent TSA at our institution in the previous 3 years were examined. Each patient with a CISB (cases) was matched with a patient without a CISB (controls) for the following variables: age, gender, and TSA type (primary *v* revision). Data collected included maximum shoulder elevation and external rotation (primary endpoints), along with pre- and postoperative pain scores.

Results: Of 134 charts reviewed, 25 cases were matched with an equal number of controls. On postoperative day 1, patients with or without a CISB achieved a median (5th-95th percentiles) of 85% (51-100) and 33% (11-56) of their surgeon-defined goal for elevation ($P = .048$), respectively, and attained 100% (33-100) and 17% (−81-68) for external rotation ($P < .001$), respectively. The median numeric rating pain score (NRS) during shoulder movement for patients with CISB was 2.0 (0.0-8.7) versus 8.5 (1.8-10.0) for patients without CISB ($P < .001$). Least, median, and highest resting NRS for the 24 hours after surgery were 0.0 (0.0-5.8), 1.0 (0.0-6.4), and 3.0 (0.0-9.0) for patients with CISB, respectively, versus 2.0 (0.0-7.7), 6.0 (0.3-9.6), and 8.0 (0.0-10.0) for patients without CISB ($P = .030$, $P < .001$, and $P < .001$ between groups, respectively).

Conclusions: The day after TSA, a CISB is associated with increased shoulder range of motion, most likely resulting from the potent analgesia these nerve blocks provide. *Reg Anesth Pain Med 2005;30:429-433.*

Key Words: Continuous peripheral nerve block, Continuous interscalene block, Postoperative analgesia, Postoperative physical therapy, Postoperative rehabilitation.

Over 80,000 shoulder arthroplasty procedures are performed annually in the United States alone.[1,2] The number of replacements has doubled for each of the past 2 decades and is expected to continue to increase as the population ages.[1] Yet, although these procedures improve patients' quality of life, the operation rarely returns patients to a normal level of functioning. A major determinant of the ultimate success of total shoulder arthroplasty (TSA) is the ability to move the shoulder joint during postoperative rehabilitation.[3,4] This importance stems from the effects of immobilization on muscles and synovial joints, including muscular atrophy, ligament weakening, and adhesion formation.[5] Because these damaging changes begin immediately after surgery,[5] frequent and intensive physical therapy is usually initiated the morning after surgery.[3,4] Unfortunately, TSA results in severe pain that is greatly exacerbated with joint motion, dramatically limiting patients' ability to tolerate this critical intervention. Consequently, many surgeons and physical therapists consider potent analgesia of paramount importance after TSA.

In the United States, the current analgesic standard of care includes a multimodal regimen of oral analgesics combined with intravenous (IV) opioids. However, perineural infusion, also called a continuous interscalene nerve block (CISB), offers an al-

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Accepted for publication June 10, 2005.

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1098-7339/05/3005-0001$30.00/0
doi:10.1016/j.rapm.2005.06.003

ternative analgesic option. This technique involves the percutaneous insertion of a catheter directly adjacent to the brachial plexus. Local anesthetic is then infused via the catheter providing potent, site-specific analgesia without significant side effects.[6,7] Previous studies have provided evidence that a CISB results in superior analgesia compared with IV opioids after major shoulder surgery.[8,9] Perineural infusion therefore offers the potential of fundamentally improving shoulder mobility and rehabilitation by providing potent analgesia in the immediate postoperative period.[7,10] However, data involving the effect, if any, of CISB on postoperative shoulder mobility are unavailable. Therefore, this retrospective case-control study was designed to examine the relationship between CISB and shoulder range of motion after TSA.

Methods

After institutional review board approval, the medical records for patients who underwent total shoulder arthroplasty at our institution (Shands Hospital at the University of Florida, Gainesville, FL) in the previous 3 years with a single orthopedic surgeon (T.W.W.) were examined. Extracted data included the procedure date; specific surgical procedure (e.g., primary *v* revision); and patient demographics at the time of the procedure including age, gender, height, weight, history of diabetes mellitus, and underlying shoulder pathology (e.g., osteoarthritis).

Study Group Assignment

For the purpose of study group assignment, "cases" were defined as patients who had an accurately-placed interscalene catheter demonstrated by appropriate sensory/motor deficits following local anesthetic introduced via the catheter itself (not via the introduction needle). The catheter had to be placed before surgical incision and removed after the initial physical therapy session the day after surgery (postoperative day [POD] 1). Patients who had participated in a randomized, double-masked, placebo-controlled investigation were excluded. The infusion of local anesthetic had to be a plain solution of ropivacaine 0.2%, with a basal rate of at least 7 mL/h.[11] Patients who had received a perineural catheter but did not meet these requirements (e.g., removal before POD 1 physical therapy) were excluded. In addition, patients who required complete shoulder immobilization the day after surgery were excluded. Patients who did not receive a perineural catheter were designated as "controls." If a patient had received a single-injection peripheral nerve block with mepivacaine or ropivacaine more than 24 hours before the first physical therapy session, he or she was assigned to the control group (IV opioids without a CISB).

Pain scores at our institution are recorded with a numeric rating score (NRS; 0-10, 0 = "no pain" and 10 = "worst imaginable pain").[12] Preoperative NRS was extracted from the anesthesia preoperative history, whereas the NRS for the first 24 hours after surgery was extracted from nursing and acute pain service records. From this latter group, the least, median, and highest NRS were determined for the purposes of analysis. Dynamic pain or the NRS reported during shoulder movement was extracted from the initial POD 1 physical therapy records.

Primary Endpoints

Primary endpoints included the maximum elevation and external rotation achieved during the physical therapy session in the morning of POD 1. These measurements were performed in the same manner by all physical therapists. For the first 2 to 6 weeks after surgery, patients undergo passive elevation and external rotation up to surgeon-defined maximums—or "goals"—to avoid damaging the subscapularis repair.[3,13] These goals are defined intraoperatively with the repaired subscapularis muscle under direct vision to determine the maximum motion possible without suture line damage and were extracted from the physical therapy records. For this reason, the defined goals for elevation or external rotation are individualized to each patient at the time of surgery.

To measure elevation, the patient's arm against the side of the body defines 0°, and elevation increases as the arm is raised (without elbow flexion) in the sagittal plane (Fig 1, panel A).[3,13] For external rotation, the measurement is performed with the elbow at the patient's side and the forearm at a 90° angle with the upper arm (Fig 1, panel B). The patient's hand directly in front of the elbow defines 0°, and external rotation increases with lateral hand motion.[3,13] During range-of-motion measurement, patients are instructed to tell the therapist "when to stop" as determined by comfort level and to always stop before an NRS above 8 is reached. For purposes of analysis, the percentage of the goal attained by each patient for both elevation and external rotation was calculated. For example, if the surgeon-defined elevation goal was 150° and the maximum elevation achieved was 75°, then the variable used for comparison would be 50%.

After data collection, the information was transferred by keypunch entry into a computerized database (Office Excel 2003; Microsoft Corporation, Bellevue, WA), and each of the cases was matched

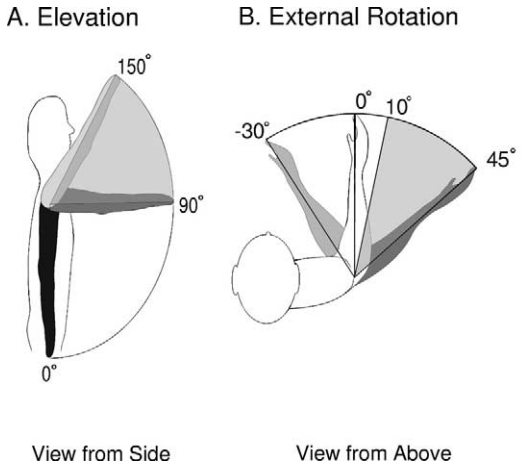

Fig 1. Method for measuring the degrees of passive shoulder elevation and external rotation. (A) For elevation, the patient's arm against the side of the body defines 0°, and elevation increases as the arm is raised in the sagittal plane (without elbow flexion). (B) For external rotation, the measurement is performed with the elbow at the patient's side and the forearm at a 90° angle with the upper arm. The patient's hand directly in front of the elbow defines 0°, and external rotation increases with lateral hand motion.

with a control for the following variables: age (±10 years), gender, and TSA type (primary *v* revision).

Statistical Analysis

Sample size calculations were centered around our primary hypothesis that a basal infusion of local anesthetic via an interscalene perineural catheter is associated with an increase in postoperative shoulder mobility compared with traditional analgesics alone. To this end, we used percentage of surgeon-defined goals achieved for both maximum elevation and external rotation in the morning of POD 1 to estimate a probable sample size. Based on a previously published pilot study, we anticipated patients with CISB (cases) to achieve a mean of 75% of the surgeon's goals for both elevation and external rotation.[14] We considered a 25 percentage-point difference in range of motion between groups to be clinically relevant. Assuming a standard deviation (SD) in both groups of 20 (on the 0%-100% scale) for both variables,[14] a 2-sided type I error protection of 0.05, and a power of 0.80, approximately 22 pairs of patients were required to show a clinically significant difference between study groups for both primary endpoints (SigmaStat 3.1; SPSS, Inc, Chicago, IL).

Normality of distribution was determined by using the Kolmogorov-Smirnov test with Lilliefors correction (Sigma Stat 3.1). Continuous, parametric data are reported as mean ± SD. Nonparametric data are graphically presented as median with 25th to 75th percentile bars and 5th to 95th percentile whiskers or textually noted using median (5th-95th percentiles). For continuous data, possible differences between groups were analyzed using a *t* test or Mann-Whitney rank sum test for parametric and nonparametric data, respectively. Categorical data were analyzed using the chi-square test with Yates continuity correction. If categorical data had any cell with less than 5 observations, the Fisher exact test was used in place of the chi-square test to account for the smaller number of observations. $P < .05$ was considered significant.

Results

Of 166 TSA procedures identified, 134 (81%) charts were reviewed. Of these, 69 (51%) met all criteria for inclusion, with 33 cases and 36 controls. Subsequently, 25 cases were successfully matched with an equal number of controls (Table 1).

On the day after surgery, cases with a CISB

Table 1. Demographic and Surgical Information

Parameter	Cases With a CISB (n = 25)	Controls Without a CISB (n = 25)	*P* Value
Age (y)	63 (33-83)	63 (33-80)	.59
Sex (F/M)	14/11	14/11	.78
Height (cm)	171 ± 10	169 ± 12	.61
Weight (kg)	80 (45-128)	82 (48-153)	.66
Body mass index (kg/m^2)	27 (17-38)	29 (18-60)	.60
Diabetes mellitus (no. of subjects)	4	5	1.0
Underlying shoulder pathology			
Osteoarthritis (no. of subjects)	18	16	.54
Avascular necrosis (no. of subjects)	1	3	.61
Failed prior TSA (no. of subjects)	6	6	1.00
Primary/revision	19/6	19/6	1.00
Surgeon-defined elevation goal (°)	150 (90-150)	150 (150-150)	.33
Surgeon-defined external rotation goal (°)	30 (10-30)	30 (13-39)	.07

NOTE. Values are reported as mean ± SD or median (5th-95th percentiles) for parametric and nonparametric data, respectively.
Abbreviations: CISB, continuous interscalene nerve block; F, female; M, male; TSA, total shoulder arthroplasty.

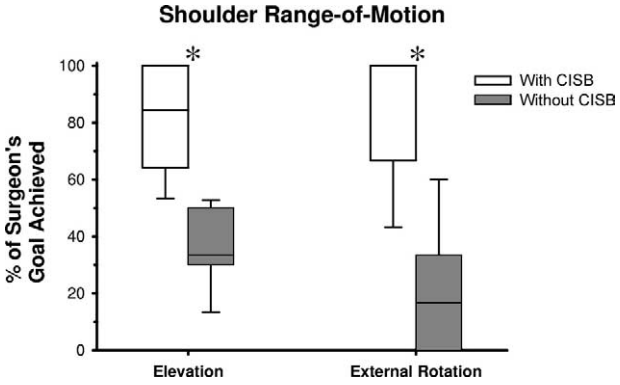

Fig 2. Maximum-tolerated passive shoulder elevation and external rotation for patients with and without a CISB the morning after total shoulder arthroplasty. Because patients' surgeon-defined maximums differed based on intraoperative observations and the specific surgical repair, shoulder range of motion is analyzed as the percentage of the surgeon-defined maximum the patient achieved. For example, if the set maximum was 150° and the patient achieved 75°, then the range of motion used for analysis would equal 50%. Data are expressed as median (horizontal bar) with 25th to 75th (box) and 5th to 95th (whiskers) percentiles. Regarding the results for external rotation in patients with a CISB, the median is 100 and only the 5th and 25th percentiles are clearly noted. $P < .05$: *, between-group comparisons.

achieved a median (5th-95th percentiles) of 85% (51-100) of their surgeon-defined elevation goal compared with 33% (11-56) for control patients without a CISB ($P = 048$, Fig 2). Similarly, patients with a CISB achieved 100% (33-100) of their surgeon-defined external rotation goal compared with 17% (−81-68) for control patients without a CISB ($P < .001$, Fig 2). Regarding secondary end points, dynamic and resting least, median, and highest NRS were lower in the cases with CISB compared with controls to a statistically significant degree for all comparisons (Table 2).

Discussion

This retrospective case-control study provides evidence that CISB is associated with increased shoulder range of motion the day after TSA, most likely resulting from the potent analgesia these nerve blocks provide. Although this increased range of motion may have been predicted given the previously shown analgesic quality of CISB,[6,7] the degree of differences in mobility between patients with and without a CISB is compelling. Comparison to the published data after total knee arthroplasty may help to put these new data in perspective.

Three randomized, unmasked studies have investigated potential differences in knee flexion after total knee arthroplasty between analgesia provided primarily with IV opioids versus a continuous femoral—or "extended femoral"—nerve block (CFNB).[15-17] Although all 3 had similar results, the report by Singelyn and colleagues[15] provides the most data on postoperative knee flexion. In this study, CFNB was associated with an increase in flexion of 23° compared with IV opioids on POD 1 (mean 56° ± SD 22° *v* 33° ± 13°, $P = .009$). Converting these angles into percentages of a flexion "goal" of 135° (the maximum reported flexion by any patient at 3 months), patients with CFNB and IV opioids achieved 41% and 24% of their flexion goals on POD 1, respectively. This is a difference of 17 percentage points and was noted to be a significant achievement.[18] By comparison, the current investigation found that CISB, compared with IV opioids, was associated with an improvement of 52 percentage points for elevation and 83 percentage points for external rotation on POD 1 after TSA (Fig 2).

A significant limitation of the present study is its retrospective, nonrandomized design, which introduces inherent biases shared by all case-control studies. We attempted to control for several confounding variables but certainly do not imply definitive conclusions with these data. Further study with a randomized, double-masked, placebo-controlled design is required to confirm these findings.

Similarly, because the majority of patients included in this study were discharged home on POD 1, it remains unknown whether the benefits associated with CISB the day after surgery continued in the postoperative period. Future investigation designs

Table 2. Pain Intensity Scores

Parameter	Cases With a CISB (n = 25)	Controls Without a CISB (n = 25)	*P* Value
Preoperative NRS	5.0 (1.3-8.0)	5.8 (0.6-9.8)	.19
Postoperative NRS at rest			
Least	0.0 (0.0-5.8)	2.0 (0.0-7.7)	.03
Median	1.0 (0.0-6.4)	6.0 (0.3-9.6)	<.001
Highest	3.0 (0.0-9.0)	8.0 (0.0-10.0)	<.001
Postoperative dynamic NRS	2.0 (0.0-8.7)	8.5 (1.8-10.0)	<.001

NOTE. Values are reported as median (5th-95th percentiles).
Abbreviations: CISB, continuous interscalene nerve block; NRS, numeric rating score.

should include serial measurements to provide an answer to this important question. It is notable that, in the previously discussed total knee arthroplasty study, the difference in knee flexion between treatment groups persisted for 6 weeks following CFNB removal 48 hours postoperatively (mean 103° ± 12° *v* 116° ± 12°, $P = .03$), although the difference was no longer statistically significant at 3 months.[15] This persistent benefit after CFNB suggests, or at least raises the possibility, that the benefits in shoulder mobility associated with CISB in this study may outlast the perineural infusion itself. Furthermore, it should be noted that although many orthopedic surgeons and physical therapists believe that early joint mobilization is critical to maximizing TSA outcome,[3,4] others disagree with this assessment. Unfortunately, definitive prospectively collected data regarding the association of early postoperative and ultimate joint range of motion is unavailable. Lastly, because perineural local anesthetic infusion may be provided on an ambulatory basis with the use of a portable infusion pump,[19] many patients need not remain hospitalized to gain the benefits of CISB.[20]

In conclusion, this retrospective, case-control study found that the day after TSA, a CISB is associated with increased shoulder range of motion, most likely resulting from the potent analgesia these nerve blocks provide. These findings require confirmation with a prospective, controlled investigation.

Acknowledgments

The authors gratefully acknowledge the invaluable assistance of Kendra Kuck and Anita Yeager, both of the Department of Anesthesiology, University of Florida, for their assistance in preparing this manuscript.

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