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Complication rates and efficacy of single-injection vs. continuous interscalene nerve block: a prospective evaluation following arthroscopic primary rotator cuff repair without a concomitant open procedure

James Y.J. Lee, MD[a], John C. Wu, MD[a], Rishi Chatterji, MD[b], Denise Koueiter, MS[a], Tristan Maerz, PhD[a], Nicholas Dutcheshen, MD[a], Brett P. Wiater, MD[a], Kyle Anderson, MD[a], J. Michael Wiater, MD[a,*]

[a]*Department of Orthopaedic Surgery, Corewell Health William Beaumont University Hospital, Royal Oak, MI, USA*
[b]*Department of Orthopedic Surgery, Ascension Providence, Michigan State University, Southfield, MI, USA*

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Background: To compare the complications and efficacy of pain relief of the interscalene anesthetic block using either a single-injection (SI) vs. a continuous, indwelling catheter (CIC) for arthroscopic rotator cuff repair surgery.

Methods: Patients undergoing primary, arthroscopic rotator cuff repair without concomitant open procedure or biceps tenodesis were prospectively enrolled by 4 fellowship-trained sports medicine and shoulder surgeons. Patients received either a SI or CIC preoperatively based on surgeon preference. Patients were contacted by phone to complete a standard questionnaire on postoperative days (PODs) 1, 3, 7, 14, and 28. Patients were asked to rate the efficacy of their subjective pain relief (scale of 0-10), document issues with the catheter, describe analgesic usage, and report pharmacological and medical complications. The primary outcome was measured as complication rate. Postoperative narcotic use, patient satisfaction, and visual analog scale pain scores were measured as secondary outcomes.

Results: Seventy patients were enrolled, 33 CIC patients (13 male, 20 female, mean age 61 ± 8 years) and 37 SI patients (20 male, 17 female, mean age 59 ± 10 years). There were significantly more injection/insertion site complications in the CIC group (48%) vs. the SI group (11%, $P = .001$). The incidence of motor weakness was higher in the CIC group on POD 1 ($P = .034$), but not at any subsequent time points. On POD 1, CIC patients had a clinically significantly lower pain score compared to SI (3.2 vs. 5.4; $P = .020$). Similar scores were observed at subsequent time points until POD 28, when CIC again had a lower pain score (0.8 vs. 2.7; $P = .005$). However, this did not reach clinical significance. All patients in both groups rated a satisfaction of 9 or 10 (scale 0-10) with the anesthesia provided by their nerve block.

Conclusion: CIC interscalene nerve blocks had an increased risk for injection site complications and minor complications in the immediate postoperative period when using the CIC for arthroscopic rotator cuff repair without any concomitant open procedures. CIC blocks demonstrated clinically significant superior pain relief on POD 1 but were equal to SI blocks at every time point thereafter. Superior pain relief of CIC at POD 28 was not clinically significant. CIC catheters do not appear to markedly decrease the use of postoperative narcotics. Despite this trend in complication rates and pain scores, all patients in both groups were satisfied with their nerve block.

Adequate postoperative pain control after arthroscopic rotator cuff (RC) surgery is important for recovery, rehabilitation, and patient satisfaction.[17] Peripheral nerve blocks are often used to aid in analgesia and minimize narcotic use to avoid potential adverse effects such as nausea, vomiting, constipation, or ileus.[14,21,29] By decreasing narcotic use and the associated adverse effects,

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*Corresponding author: J. Michael Wiater, MD, Department of Orthopaedic Surgery, Corewell Health William Beaumont University Hospital, 3535 W 13. Mile Road, Suite 744, Royal Oak, MI 48073, USA.

E-mail address: J.Michael.Wiater@Corewellhealth.org (J.M. Wiater).

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peripheral nerve blocks have demonstrated decreased postoperative hospital admissions which can further reduce healthcare costs.[25,31] An interscalene block (ISB) is a peripheral nerve block that is commonly used in shoulder and upper extremity surgery as it provides anesthesia at the level of the upper roots (C5-C7) or superior and middle trunks. The C8 and T1 nerve roots are often spared.

An ISB can be administered as a single-injection (SI) bolus or with a continuous, indwelling catheter (CIC) to allow administration of anesthetic in the immediate postoperative period. Continuous infusion theoretically can provide anesthesia for a longer duration and is controlled by an electronic pump connected to an indwelling catheter, which can be removed by the patient when the medication is completed or when a predetermined period of time has elapsed. Previous studies have demonstrated that CIC provides superior postoperative analgesia after major shoulder surgery including RC surgery compared to a SI, especially in the first 1-2 days after surgery.[11,17,18,22] However, SI is still commonly used in the ambulatory setting by physicians as many surgeons feel that higher complication rates relating to the injection site outweigh the benefits of longer duration of pain relief provided by the CIC.[2] Also, in cases where immediate active and passive range of motion is desired postoperatively, an indwelling catheter may act as a barrier. In a survey of members of the American Shoulder and Elbow Surgeons, 58.7% would elect for a single-shot ISB for themselves, 15.0% would elect for a CIC, and 26.3% would not elect for the use of an ISB if undergoing shoulder surgery.[19] Previous investigations have demonstrated that preoperative and intraoperative interventions, such as anti-inflammatory medications and regional anesthesia including interscalene or suprascapular nerve blocks, can significantly improve postoperative pain.[24] However, there is currently no consensus regarding superiority of SI vs. CIC anesthesia for arthroscopic RC surgery.

Complications related to an ISB delivered by both SI and CIC can range from injection site irritation, injection site infection (from local cellulitis to abscess), pneumothorax, hematoma, temporary paralysis of the phrenic or recurrent laryngeal nerve, hoarseness, Horner's syndrome, and injection into the vertebral artery.[3,27] ISB of the brachial plexus has been shown to diminish phrenic nerve conduction more than 90% of the time, and this can lead to significant respiratory side effects such as shortness of breath (SOB) and hypoxia.[26] Complications specific to CIC include catheter irritation and infection, retained catheter fragment, unintentional removal, catheter migration resulting in unintended areas of paresthesia and/or paralysis, and prolonged paresthesia and/or paralysis.[8] Theoretically, SI patients will experience fewer complications by avoiding catheter-related events; however, this may not be the case.[1] There is limited literature profiling the differences of complications between SI and CIC anesthesia for arthroscopic RC surgery.

The objective of this study was to prospectively compare the efficacy and complication rates of acute and sub-acute postoperative pain relief of SI vs. CIC interscalene anesthetic blocks following all-arthroscopic RC repair surgery.

Materials and methods

After obtaining institutional review board approval for a prospective cohort study, 70 patients undergoing primary, arthroscopic RC repair were enrolled between July 2016 and August 2018. Prior to enrolling patients into the study, a thorough discussion of risks and benefits of the procedure and of the regional anesthesia were discussed with each patient. Informed consent was obtained via a written information sheet consent approved by the institutional review board. Exclusion criteria included patients aged less than 18 years, history of chronic pain or cervical radiculopathy, spine injury or surgery, preoperative neuropathy, and concomitant open procedures including biceps tenodesis. Four fellowship-trained sports and/or shoulder and elbow orthopedic surgeons participated at a single tertiary academic institution.

Table I
Average subjective pain scores between CIC and SI up to POD 28, mean ± st. dev.

	POD 1	POD 3	POD 7	POD 14	POD 28
CIC	3.2 ± 2.6	3.4 ± 2.2	2.4 ± 2.4	1.7 ± 2.3	0.8 ± 1.1
SI	5.4 ± 3.1	4.2 ± 3.0	3.4 ± 2.6	2.8 ± 2.7	2.7 ± 2.1
P value	.020	1.0	.635	.335	.005

CIC, continuous indwelling catheter; *POD*, postoperative day; *st. dev*., standard deviation; *SI*, single injection.

The decision for SI or CIC was determined primarily by surgeon preference and experience. A fellowship-trained anesthesiologist administered the block using ultrasound guidance. At our institution, 20 mL of 0.5% ropivacaine is injected as an initial bolus. For patients receiving a CIC, 500 mL of 0.2% ropivicaine is administered at 5-6 mL/hr in the postoperative period using a portable effusion pump (ambiT, Avanos Medical, Alpharetta, USA). Beach chair positioning was used by all participating surgeons.

Postoperatively, patients were prescribed oxycodone 5 mg or hydrocodone 5 mg with acetaminophen 325 mg q4h or q6h, aspirin for deep vein thrombosis prophylaxis and were instructed to take nonsteroidal anti-inflammatory drugs as needed. Formal physical therapy began after removal of the sling at 2-4 weeks. Patients were contacted by phone to complete a block-specific standard questionnaire on postoperative days (PODs) 1, 3, 7, 14, and 28 (Supplementary Appendix S1). Patients with unresolved complications at 28 days were continued to be followed. Patients were asked to rate the efficacy of their subjective pain relief using the numeric rating scale (NRS; scale of 0-10). NRS is a pain screening tool widely used to assess pain severity, with 0 meaning "no pain" and 10 meaning "the worst pain imaginable".[4] Minimally clinically important difference (MCID) in NRS was considered to be >2.[13] In addition, patients were asked to document issues with the catheter itself, describe analgesic usage, and report pharmacological and medical complications. Patients were asked to choose from a list of common complications and describe their frequency and duration.

All statistical analyses were performed in SPSS (Version 22; IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality and variance using a Shapiro-Wilks test and Levene's test, respectively. An independent *t*-test was used to compare normal data and a Mann-Whitney Rank Sum test for non-normal or ordinal data. Pain scores were compared separately at each time point, and the *P* value was adjusted using a Bonferroni correction for family-wise comparisons. Categorical variables were compared with a chi-squared test. Statistical significance was defined as $P < .05$.

Results

Patients

There were 37 patients (20 male, 17 female, mean age 59 ± 10 years) in the SI group and 33 patients in the CIC group (13 male, 20 female, mean age 61 ± 8 years). There were no differences between groups in sex distribution ($P = .220$) and age ($P = .337$). Three patients were lost to follow-up in SI group and 1 patient in the CIC group.

Postoperative pain

On POD 1, CIC patients had a significantly lower pain score of mean 3.2 ± 2.6 compared to SI patients with a mean score of 5.4 ± 3.1 ($P = .020$, Table I). The difference in pain scores of 2.2 was

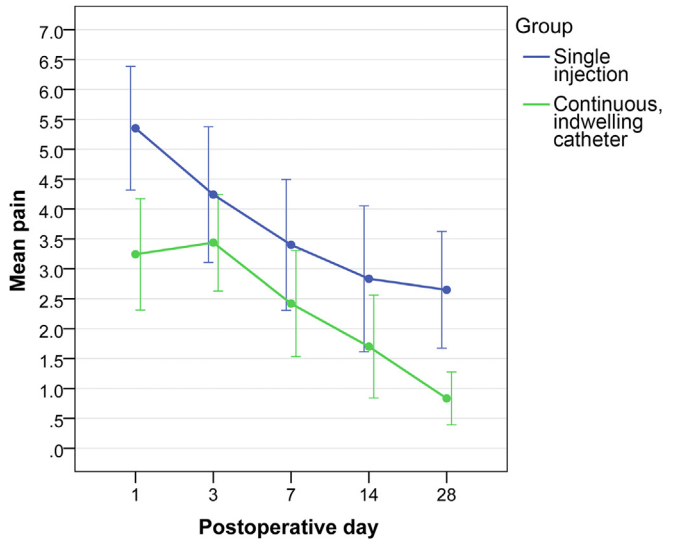

Figure 1 Mean pain scores at each postoperative day. Bars represent 95% confidence interval.

above the MCID of 2. Pain scores were not significantly different between CIC and SI patients on POD 3 through POD 14, and on POD 28, CIC patients again had lower pain scores ($P = .005$, Fig. 1). The difference in pain scores on POD 28 did not meet the MCID of 2.

In the CIC group, 1-2 days of pain relief was reported in 13 patients (39%) and 2-5 days of pain relief was reported in 20 patients (61%). All patients had removed their pump by day 5, with the highest percentage of patients (40%) removing it on POD 2. At time of catheter removal, 12 patients had run out of medications, 4 patients accidentally had tubing come out, and 4 patients had pump malfunction and were advised to remove the catheter. Patients with a SI reported an average duration of pain relief of 19 hours ± 6 (range 8-30 hours).

Narcotic usage

All patients were prescribed either oxycodone 5 mg or hydrocodone 5 mg depending on surgeon postoperative pain regimen. Regular acetaminophen 325 mg was combined with each dose of the narcotic. Patients were also instructed to use over the counter nonsteroidal anti-inflammatory drugs as needed. Narcotic use was reported as (1) none, (2) regular q4h (30 MME) or q6h (20 MME), or (3) as needed (Table II). There was no significant difference in the proportion of patients regularly taking narcotics across all time points between the two groups. There was a significantly higher proportion of patients in the SI group who had stopped taking narcotics by POD 14 (81% vs. 43%) and POD 28 (95% vs. 68%) compared to CIC group ($P < .05$). A greater proportion of patients in the CIC group were taking narcotics on an as needed basis at POD 7 and POD 14 ($P < .05$). In both cohorts, all patients taking narcotics on an as needed basis past POD 14 reported taking 5 MME or less per day.

Complications

Injection/insertion site

There were significantly more injection/insertion site complications in the CIC group vs. the SI group (Table III; $P = .001$). A total of 16 patients in the CIC group (48%) vs. 4 in SI group (11%) reported minor complications at the catheter site. No antibiotic treatment was needed in any patients. There were 7 patients in the SI group who reported SOB, and 7 patients in the CIC group that reported SOB, one of which directly associated SOB with use of the pump. No patients in our study suffered a major complication. However, 3 patients presented to the emergency room (ER) postoperatively. Two patients in CIC presented to the ER, one for SOB and one for bilateral leg swelling. One patient in the SI group presented to ER for uncontrolled pain.

Table II
Narcotic use, broken down by percentage using none, using regularly, and using as needed at each postoperative time point.

	POD 1	POD 3	POD 7	POD 14	POD 28
None					
CIC	15%	12%	39%	43%	68%
SI	5.5%	24%	56%	81%	95%
P value	.247	.323	.282	.010	.031
Regular use*					
CIC	67%	53%	19%	10%	3%
SI	89%	66%	28%	5%	0
P value	.359	.435	.532	.634	1.00
As needed					
CIC	18%	34%	42%	47%	29%
SI	5.5%	10%	16%	14%	5%
P value	.140	.034	.045	.019	.061

CIC, continuous indwelling catheter; *POD*, postoperative day; *SI*, single injection.
*q4h or q6h.

Mechanical problems

Eight patients in the CIC group had mechanical problems with their pump. Four patients had the catheter come out, 2 of which had leakage. Four patients had a malfunctioning pump. Of these, 2 had kinked catheters, 1 had an alert beeping, and 1 had an inoperable pump with no anesthetic infused.

Pharmacologic

There was a significantly greater incidence of paresthesia and motor weakness in the CIC group than in the SI group on POD 1 (Table IV). There were no differences in pharmacological complications after POD 1.

Satisfaction

All patients in both groups rated a satisfaction of 9 or 10 (scale 0-10) with the anesthesia provided by their nerve block.

Discussion

There is no consensus among orthopedic surgeons whether an ISB with an indwelling catheter is more efficacious in the setting of arthroscopic RC repair or whether a single injection is sufficient. In this study, we prospectively compared pain scores, narcotic usage, and complications associated with a CIC vs. a SI ISB. Our results demonstrate that CIC and SI resulted in largely similar patient-reported pain profiles following surgery, with only small differences at POD 1 and POD 28. The difference in pain scores was above the MCID threshold on POD 1 but not at POD 28. There were no differences in the rate of major complications between the 2 groups, but we observed significantly higher incidences of minor injection site complications in the CIC group. Both nerve blocks resulted in excellent patient satisfaction.

Previous studies have reported that SI administration has a shorter duration of anesthesia compared to CIC. It has been reported that SI has up to 8-12 hours of effective pain control, with up to 14 hours of opioid sparing effect compared to CICs which can have effects lasting even up to 7 days.[22] Not surprisingly, our study found significantly higher pain scores for the SI group on POD 1 compared to CIC, with a difference in NRS of 2.2. This is thought to

Table III
Minor complications at injection site reported by patients, broken down by type of complication.

Injection site complication	Group	# Reported
Itching	CIC	5
	SI	0
Swelling	CIC	2
	SI	0
Skin hardening	CIC	1
	SI	0
Drainage	CIC	2
	SI	0
Redness or bruising	CIC	6
	SI	4
Total	CIC	16 (48%)
	SI	4 (11%)
P value		.001

CIC, continuous indwelling catheter; *SI*, single injection.

Table IV
Incidence of pharmacological complications.

	POD 1	POD 3	POD 7	POD 14	POD 28
Paresthesia					
CIC	76%	28%	7%	3%	0%
SI	46%	21%	8%	10%	0%
P value	.011	.501	.823	.355	-
Dysesthesia					
CIC	15%	6%	0%	0%	0%
SI	11%	0%	0%	0%	0%
P value	.588	.171	-	-	-
Motor Weakness					
CIC	27%	6%	7%	3%	7%
SI	8%	0%	4%	5%	0%
P value	.034	.171	.685	.796	.214

CIC, continuous indwelling catheter; *POD*, postoperative day; *SI*, single injection.

be clinically significant (NRS > 2).[13] We did not detect any significant difference in the later time points until POD 28, where statistically but not clinically significantly lower pain scores were found in the CIC group. In addition to the shorter duration of action of SI administration, rebound pain phenomenon likely contributed to higher pain scores in SI group at POD 1.[20,22,32] Rebound pain often occurs at 16-24 hours after administration of single-shot anesthesia.[1,8,20,30]

Although SI and CIC come with their own advantages and disadvantages, both advocates of SI and advocates of CIC acknowledge that effective oral analgesia can significantly help in managing pain in the early postoperative period.[20,22,32] In our study cohort, we did not find a significant difference in regular narcotic usage at all times points from POD 1 to POD 28. However, there were a significantly higher proportion of patients in the SI group that were completely opioid-free by POD 14 and POD 28. A higher proportion of patients in the CIC group were using narcotics as needed. However, all patients using narcotics on an as needed basis, in either group, were using a minimal total daily dose of narcotics (equal to or less than 5 MME/ day). It is unclear whether this is truly related to the type of regional anesthesia or other patient characteristic/factors. Our findings were contradictory to the current literature which suggests that narcotic consumption decreases with a CIC. Malik et al[18] has previously demonstrated less narcotic use in CIC group undergoing arthroscopic RC repair at POD 1-3. Study by Salviz et al[22] also demonstrated decreased narcotic use in the CIC group, at POD 1 and 2. Similar results were seen in study by Vorobeichik.[28]

Paresthesia and motor weakness was present in significantly higher percentage of CIC patients at POD 1 but we were not able to detect any significant differences past POD 1. Current literature is consistent with our findings that temporary neurologic deficits improve in 4 weeks, on average, without long-term disability.[5] In addition to neuropraxia and associated symptoms, complications from both CIC and SI ISBs may include diaphragmatic paresis, infection, myotoxicity, inadvertent spinal anesthesia, vertebral artery injection, and cardiotoxicity.[7,15,28] While no patients in our cohort suffered a major complication related to the interscalene nerve block, 3 patients had unanticipated visits to the ER postoperatively. One patient in the SI group presented to ER for uncontrolled pain. Two patients in CIC presented to the ER, 1 for bilateral leg swelling and 1 for SOB. While unanticipated emergency department visits and readmissions related to pulmonary complications are thought to occur at a low rate (0.5%), it has been associated with use of CIC, especially in patients with pre-existing pulmonary disease such as obstructive sleep apnea and chronic obstructive pulmonary disease.[13]

Previous investigators have emphasized the importance of careful patient selection for interscalene nerve blocks. Patients with a prior pulmonary history, sleep apnea, or those who may have difficulty managing a catheter management independently may be at risk for complications with continuous interscalene infusion.[12,28] In regards to operative setting, Ambulatory Surgery Centers have traditionally been reluctant to perform continuous interscalene analgesia due to concerns for complications and inability to monitor patients after surgery.[10] However, a prospective study of 300 patients receiving continuous interscalene analgesia for ambulatory shoulder surgery demonstrated continuous interscalene infusion to be safe even in an Ambulatory Surgery Center setting, with minimal oral opioid intake and very few complications with only one infection.[9]

While no patients suffered any major complications, our study did find a high rate of minor complications with CIC, with 48% of patients reporting minor complications such as redness and bruising at the catheter site. Despite this, overall patient satisfaction was high for both groups. Every patient in both groups reported a satisfaction score of 9 or 10 of 10 despite higher incidence of minor complications (skin, injection site) and 4 equipment malfunctions in the CIC group.

When considering cost, single shot may be cost-effective for equivocal analgesia in RC surgery, while minimizing the potential for equipment maintenance and minor complications associated with a continuous pump. The material cost of CIC is approximately $450 more than SI according to a large cost analysis study by Jones et al.[13] There are also additive costs in personnel such as a nurse or clinical team to follow patients after the procedure, as well as unanticipated costs related to presentation to ER or readmissions due to pulmonary complications after a CIC. While this is rare, expense of a readmission for pulmonary complications costs an average $6849.[11,13] Furthermore, a recent study comparing SI to CIC for shoulder arthroplasty found that CIC was associated with potential barriers to discharge and increased length of stay after shoulder arthroplasty.[6,23] Time and resources spent on catheter pump education and pump mechanical issues must also be considered.

This study should be viewed in light of its limitations. While this is prospectively collected data, all data are patient-reported and therefore prone to biases such as response and recall bias. Furthermore, we do not have the exact, quantifiable data for narcotic usage for each patient limiting this study's ability to draw conclusions on this matter. Lack of randomization is a limitation of the study. Unaccounted bias due to differences in surgeon-specific techniques and protocols cannot be ruled out. Finally, a power analysis was not performed. However, a literature review of previously published studies using CIC and SI for major shoulder surgeries and RC repair was used as a reference to determine the appropriate sample size of this study.[11,16]

The main strength of this paper is the relatively long duration of follow-up (28 days) in evaluation of the effect of the block. To our knowledge, this is the longest follow-up investigating differences between CIC and SI ISBs in the current literature for RC repair and major shoulder surgery. In addition, our study included only patients undergoing arthroscopic RC repairs without any concomitant open procedures, limiting potential confounding variables that can occur with a more heterogenous study population.

Conclusion

When comparing CIC to SI, this study found no difference in rate of major complications in patients undergoing arthroscopic RC repair without any concomitant open procedures. However, CIC did result in a higher risk of minor complications compared with SI. Despite high rates of mechanical malfunction in the CIC group, it showed clinically significantly better pain relief at POD 1 compared with SI. Despite the above findings, all patients in both groups were highly satisfied with their nerve block. Evidence-based recommendations when choosing between a SI and CIC ISB remain inconclusive. Surgeon preference, patient's preoperative health, specific goals and expectations regarding postoperative pain management, and preoperative discussion regarding the risks and benefits of both methods should be factored into a final patient-shared decision.

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Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jseint.2023.10.008.

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