Early postoperative pain and opioid consumption after arthroscopic shoulder surgery with or without open subpectoral biceps tenodesis and interscalene block

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ABSTRACT

Objective: The addition of open subpectoral biceps tenodesis to arthroscopic shoulder surgery with interscalene block has been anecdotally observed to result in increased postoperative pain. This study aims to evaluate the impact of tenodesis on early postoperative pain and recovery.

Methods: A retrospective review of patients undergoing arthroscopic shoulder surgery with general anesthesia and interscalene block was conducted.

Results: Patients undergoing tenodesis experienced longer OR time, pain numeric rating scale (NRS), and consumed more morphine milligram equivalents (MME) in PACU. After controlling for confounding factors, tenodesis was significantly associated with increased opioid MME consumption in the PACU ($\beta = 1.045$, $p = .028$) and last PACU pain NRS ($\beta = 0.541$, $p = .009$).

Conclusion: Overall, pain scores and narcotic consumption were low after surgery, making these differences potentially clinically insignificant. Further study is required to evaluate whether these trends are consistent among this population.

1. Introduction

Shoulder arthroscopy is a commonly performed outpatient procedure that is growing in indication and complexity.¹ However, pain control in the early postoperative period remains a challenge,² especially in arthroscopic rotator cuff repair, which has been demonstrated to be more painful than other arthroscopic shoulder procedures.³ Biceps tenodesis is frequently performed at the time of arthroscopic shoulder surgery for treatment of anterior shoulder pain caused by inflammation, instability or trauma to the long head of the biceps tendon.⁴ The procedure involves removal of the long head of the biceps tendon from its attachment to the glenoid and reapproximation to the proximal humerus via a cortical button, anchors, or screws. A variety of arthroscopic and open techniques can be utilized, with both approaches providing satisfactory outcomes in most patients.^{5,6} Beyond the choice of an arthroscopic or open approach, technical considerations for the procedure include fixation method, position relative to the pectoralis major muscle tendon (supraperotral vs subpectoral), and intraosseous or extraosseous

fixation.⁴

Maintaining adequate pain control in the immediate postoperative period after arthroscopic shoulder surgery is essential to facilitate same-day discharge and avoid delays in mobilization. Unfortunately, up to 45% of patients undergoing arthroscopic shoulder surgery experience severe intra-operative or postoperative pain.⁷ Interscalene block (ISB) is considered the gold standard for shoulder anesthesia and is the most commonly used block for shoulder procedures.⁸ The technique, which traditionally involves injection of local anesthetic adjacent to the sheath of the C5–C6 nerve roots, or the superior or middle trunk, is most effective for procedures including the lateral two-thirds of the clavicle, proximal humerus, and shoulder joint by anesthetizing the nerves of the brachial plexus: the upper and lower subscapular, axillary, supra-scapular and lateral pectoral nerves.^{8,9} ISB has been demonstrated to be an effective anesthetic technique for both open and arthroscopic shoulder surgeries.¹ When combined with general anesthesia (GA), ISB has been shown to result in lower heart rate, lower pain scores on the day of surgery and one day after, lower intraoperative systolic blood

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pressure, a shorter extubation time, and lower incidence of adverse events compared with GA alone.¹⁰

A limitation of ISB is the potential for limited coverage in more distal surgical procedures in anatomic regions innervated by the lower trunk (C8-T1 roots) of the brachial plexus.⁸ Additionally, the technique does not anesthetize the axilla or medial proximal arm, which are innervated by the intercostal nerves.¹¹ This has led to reports⁹ that patients undergoing arthroscopic shoulder procedures with open subpectoral biceps tenodesis experience greater immediate postoperative pain than those undergoing arthroscopic shoulder surgery with ISB and no concurrent tenodesis. This study aims to quantify the impact of biceps tenodesis on immediate postoperative pain after arthroscopic shoulder surgery with interscalene block.

2. Methods

This study is level three evidence using a retrospective cohort comparison design. After receiving exempt determination by the institutional clinical research committee, a retrospective review of all patients undergoing arthroscopic rotator cuff repair and/or arthroscopic acromioplasty with general anesthesia and interscalene block between July 2016 and June 2018 at a single regional medical center was conducted. Patients receiving general anesthesia only, patients undergoing arthroscopic tenodesis, and patients undergoing concurrent biceps tenotomy were excluded from this study. Patients were then grouped by whether they underwent open subpectoral biceps tenodesis at the time of arthroscopic shoulder surgery.

2.1. Variables

All variables were extracted from the electronic medical record (EMR). Preoperative demographics and surgical details included age, body mass index (BMI), gender, race, American Society of Anesthesiologists (ASA) rating, and the type of arthroscopic procedure performed. Procedures were grouped into rotator cuff repair, acromioplasty without rotator cuff repair, acromioplasty with rotator cuff repair, and concurrent distal claviclectomy. Endpoints assessed included operating room time, post anesthesia care unit (PACU) recovery time, the last pain numeric rating scale (NRS) on a scale of 1–10 recorded in PACU (10 represents the worst possible pain), narcotics received in PACU measured in morphine milligram equivalents (MME), and block failure—defined as a PACU pain NRS ≥ 7 or over 10 MME received for pain control.

2.2. Surgical approach and anesthesia details

After instituting appropriate monitoring and intravenous (IV) sedation, an interscalene nerve block was performed in the preoperative area or the operating room using continuous ultrasound guidance. A nerve stimulator may have also been utilized at the discretion of the anesthesiologist. Patients received 15–25 ml of local anesthetic ropivacaine 0.5% using single injection technique injected around the superior and middle trunks of the brachial plexus, between the anterior and middle scalene muscles. Injection accuracy was confirmed by ultrasound visualization of local anesthetic injection and stimulation of appropriate nerves.

In addition to the arthroscopic shoulder procedures (rotator cuff repair and/or acromioplasty with or without distal claviclectomy), an open subpectoral biceps tenodesis was performed via a 3 to a 4 cm incision in the anterior axillary skin crease. Blunt dissection under the pectoralis major tendon was then performed to expose the biceps and proximal humerus. Using a stitch at the musculotendinous junction, the long head of the biceps was attached to an anchor for unicortical fixation. Local anesthetic was injected into the axillary skin incision following the procedure at surgeon discretion.

2.3. Statistical analysis

Demographics, surgical details and postoperative outcomes were first compared using univariate analysis. Two samples independent t-tests were used to compare interval and ratio level measures between groups while the chi-square test was used to assess dichotomous variables. Multivariate linear and logistic regression models were then developed to assess the relationship between open subpectoral biceps tenodesis and postoperative outcomes. Significance was assessed using two-tailed p values with $\alpha \leq .05$ deemed significant. All statistical analysis was performed using SPSS version 26 (IBM, Armonk, NY).

3. Results

A total of 704 patients met inclusion criteria and were retrospectively reviewed. Their demographic and procedure details are presented in Table 1. 528 (75%) underwent arthroscopic shoulder surgery without biceps tenodesis while 176 (25%) had concurrent open subpectoral biceps tenodesis performed. Across the population, patients in the tenodesis group were younger (No tenodesis: 57.7 ± 10.2 yrs. vs. Tenodesis: 53.8 ± 9.4 yrs, $p < .001$), less likely to be female (No tenodesis: 43.8% female vs. Tenodesis: 21.6% female, $p < .001$), more likely to be white (No tenodesis: 77.1% white vs. Tenodesis: 86.9% white, $p = .005$), and had a lower proportion of patients with ASA ≥ 3 (No Tenodesis: 27.5% vs. Tenodesis: 16.5%, $p = .003$). Local anesthetic injection into the incision was more commonly given when biceps tenodesis was performed (No Tenodesis: 7.6% vs. Tenodesis: 58.5%, $p < .001$). Of the 143 patients who received local anesthetic the most common drugs used were 0.25% Marcaine (N = 73, 51%), 0.5% Marcaine (N = 36, 25%), 0.25% Marcaine-Epinephrine (N = 22, 15%), 0.5% Marcaine-Epinephrine (N = 5, 3%), Other (N = 7, 5%). No statistically significant differences in the types of arthroscopic procedures performed were observed between patients who underwent concurrent tenodesis and those who did not.

A univariate comparison of OR time, PACU recovery time, the last PACU pain NRS, PACU MME and block failure is presented in Table 2. Patients undergoing open subpectoral biceps tenodesis experienced longer OR time (No tenodesis: 108.9 ± 25.9 min. vs. 134.5 ± 29.7 min, $p < .001$), had higher last PACU pain NRS (No tenodesis: 0.84 ± 1.78 vs. Tenodesis: 1.50 ± 2.14 , $p < .001$), and consumed more opioid MME in PACU (No tenodesis: 1.55 ± 3.95 MME vs. Tenodesis: 2.89 ± 5.74 , $p = .004$). No significant differences in PACU recovery time or rates of block failure, which occurred in 53 (7.5%) of patients, were observed. Within the open subpectoral tenodesis cohort, no significant differences in

Table 1
Patient demographics and procedures performed.

	No Biceps Tenodesis N = 528	Open Subpectoral Biceps Tenodesis N = 176	P- Value
Age – avg. yrs.	57.7 $\pm$ 10.2	53.8 $\pm$ 9.4	<.001
BMI – avg. kg/m ²	30.7 $\pm$ 5.9	29.6 $\pm$ 4.7	.016
Female – N (%)	231 (43.8)	38 (21.6)	<.001
White Race – N (%)	407 (77.1)	153 (86.9)	.005
ASA Score ≥ 3	145 (27.5)	29 (16.5)	.003
Local Anesthetic Given	40 (7.6)	103 (58.5)	<.001
Procedures Performed			
Rotator Cuff Repair – N (%)	372 (70.5)	116 (65.9)	.257
Acromioplasty without RCR – N (%)	61 (11.6)	18 (10.2)	.629
Acromioplasty with RCR – N (%)	95 (18.0)	42 (23.9)	.088
Distal Claviclectomy	76 (14.4)	17 (9.7)	.123

BMI – Body mass index.

ASA – American Society of Anesthesiologists.

RCR– Rotator cuff repair.

Table 2
Univariate comparison of postoperative outcomes.

	No Biceps Tenodesis N = 528	Open Subpectoral Biceps Tenodesis N = 176	P- Value
OR Time – avg. minutes	108.9 ± 25.9	134.5 ± 29.7	<.001
PACU Recovery Time – avg. minutes	61.03 ± 30.5	61.2 ± 32.4	.966
Last PACU Pain NRS* - avg.	0.84 ± 1.78	1.50 ± 2.14	<.001
PACU MME – avg.	1.55 ± 3.95	2.89 ± 5.74	.004
Block Failure – N (%)	34 (6.4)	19 (10.8)	.058
Significant P-Values in bold			
Pain NRS reported for 487 no Tenodesis, and 168 tenodesis patients			
OR – operating room			
PACU – post anesthesia care unit			

MME – morphine milligram equivalents.

PACU recovery time, last PACU pain NRS, PACU MME or block failure rate were observed between patients who did (N = 103) and did not (N = 73) receive local anesthetic injection into the axillary incision at the conclusion of the procedure (Table 3).

To further evaluate the relationship between open subpectoral biceps tenodesis and perioperative outcomes, multivariate analysis was performed. After controlling for age, BMI, race, gender, ASA classification, procedure type, and use of local anesthetic, open subpectoral tenodesis was significantly associated with increased opioid MME consumption in the PACU ($\beta = 1.045$, SE = 0.476, $p = .028$) (Table 4) and last PACU pain NRS ($\beta = 0.541$, SE = 0.208, $p = .009$) (Table 5). After controlling for the same covariates using a logistic regression model, no significant relationship between open subpectoral tenodesis and block failure, defined as pain NRS ≥ 7 or ≥ 10 MME consumed in PACU, was observed (OR = 1.832, 95% CI: 0.849–3.954, $p = .123$) (Table 6).

4. Discussion

Our results suggest that in patients undergoing arthroscopic shoulder surgery with interscalene block, those who undergo concurrent open subpectoral biceps tenodesis experience statistically significantly higher levels of pain and consume more opioid MMEs in PACU than those who do not undergo tenodesis. However, the clinical relevance of this finding may be limited given the low overall pain scores and PACU opioid consumption after surgery. To our knowledge, this is the first study to quantify the potential for increased early postoperative pain after bicep tenodesis that is commonly observed anecdotally. Our results are in agreement with previous publications that interscalene blocks do not anesthetize the axilla or the medial proximal arm.¹¹

The efficacy of interscalene blocks in reducing early postoperative pain after shoulder arthroscopy is well described. In a meta-analysis of

Table 3
Univariate comparison of open subpectoral tenodesis outcomes with and without local anesthetic.

	No Local Anesthetic N = 73	Local Anesthetic N = 103	P- Value
PACU Recovery Time – avg. minutes	61.0 ± 28.54	61.3 ± 34.8	.938
Last PACU Pain NRS* - avg.	1.3 ± 2.1	1.7 ± 2.2	.298
PACU MME – avg.	2.2 ± 4.5	3.4 ± 6.4	.147
Block Failure – N (%)	7 (9.6)	12 (11.7)	.664
Significant P-Values in bold			
Pain NRS reported for 71 no local anesthetic, and 98 local anesthetic patients			
OR – operating room			
PACU – post anesthesia care unit			

MME – morphine milligram equivalents.

Table 4
Multivariate evaluation of PACU MME consumption.

	β	Std. Error	Standardized β	t	P- Value
(Constant)	–1.348	1.586		–.850	.396
Age	–.019	.018	–.044	–1.107	.269
BMI	.106	.033	.134	3.205	.001
White Race	.596	.422	.054	1.413	.158
Female	.719	.352	.078	2.045	.041
ASA ≥ 3	.373	.433	.036	.862	.389
Distal	.077	.514	.006	.149	.881
Claviclectomy					
Acromioplasty	–1.005	.567	–.071	–1.774	.076
Acromioplasty with RCR	–.484	.436	–.043	–1.112	.266
Local Anesthetic	.990	.495	.089	1.999	.046
Open Subpectoral Tenodesis	1.045	.476	.101	2.196	.028

Significant P-Values in Bold.

ASA – American Society of Anesthesiologists Rating Scale.

BMI – Body mass index in kg/m.².

RCR – Rotator cuff repair.

Table 5
Multivariate evaluation of PACU pain numeric rating scale.

	β	Std. Error	Standardized β	t	P- Value
(Constant)	.484	.693		.699	.485
Age	–.014	.008	–.075	–1.828	.068
BMI	.031	.014	.093	2.153	.032
White Race	.041	.184	.009	.222	.824
Female	.339	.154	.087	2.210	.027
ASA ≥ 3	.131	.189	.030	.694	.488
Distal Claviclectomy	.213	.225	.038	.950	.343
Acromioplasty	–.075	.247	–.012	–.302	.763
Acromioplasty with RCR	–.349	.190	–.073	–1.837	.067
Local Anesthetic	.460	.216	.098	2.128	.034
Open Subpectoral Tenodesis	.541	.208	.124	2.603	.009

Significant P-Values in Bold.

ASA – American Society of Anesthesiologists Rating Scale.

BMI – Body mass index in kg/m.².

RCR – Rotator cuff repair.

136 patients from 5 studies, Yan et al. compared patient reported pain scores on the day of surgery between patients receiving GA and ISB with GA. Mean pain NRS in the GA group ranged from 3.2 to 7.3 while patients who received ISB with GA reported pain NRS ranging from 1.8 to 3.9 (overall effect $Z = 2.34$, $p = .02$) yielding the conclusion that the addition of ISB to GA results in significant improvement in day of surgery pain management for patients undergoing arthroscopic shoulder surgery.¹⁰ Similarly, Bosco et al. performed a retrospective cohort study of 425 patients comparing GA, ISB only, ISB with GA, and GA with postoperative ISB, and concluded that patients receiving ISB alone or preoperatively with GA experienced shorter PACU times, less pain and less narcotics compared to GA alone.¹² While the conclusion that ISB at the time of shoulder arthroscopy provides sufficient pain control in the PACU and early postoperative period is echoed in multiple other studies,^{13–15} descriptions of the procedures performed are limited, and none specifically evaluate the impact of concurrent open subpectoral biceps tenodesis on postoperative pain.

Early motion after joint surgery has been demonstrated to enhance outcomes, with pain being a primary roadblock to early mobilization.^{16,17} A potential opportunity to enhance early postoperative pain control after arthroscopic shoulder surgery with open subpectoral biceps tenodesis under ISB exists via the addition of concomitant intercosto-brachial block to anesthetize the medial upper arm and axilla, which are innervated by a branch of the T2 intercostal nerve.¹¹ This technique,

Table 6

Multivariate evaluation of block failure.

	β	S.E.	Wald	Odds Ratio	95% C.I. for Odds Ratio		Sig.
					Lower	Upper	
Age	-.016	.016	1.103	.984	.954	1.014	.294
BMI	.046	.027	2.943	1.047	.993	1.103	.086
White Race	.638	.419	2.323	1.893	.833	4.303	.127
Female	.657	.308	4.547	1.928	1.055	3.526	.033
ASA ≥ 3	.539	.355	2.306	1.714	.855	3.434	.129
Distal Claviclectomy	.099	.477	.043	1.104	.433	2.815	.835
Acromioplasty	-1.452	.768	3.577	.234	.052	1.054	.059
Acromioplasty with RCR	-.437	.400	1.192	.646	.295	1.415	.275
Local Anesthetic	.345	.390	.785	1.413	.658	3.033	.376
Open Subpectoral Tenodesis	.605	.392	2.380	1.832	.849	3.954	.123

Significant P-Values in Bold.

ASA – American Society of Anesthesiologists Rating Scale.

BMI – Body mass index in kg/m.².

RCR – Rotator cuff repair.

which can be performed simply by injecting local anesthetic subcutaneously superiorly and inferiorly along the axillary crease carries a low risk for complication,¹⁸ but its efficacy in enhancing pain control following subpectoral biceps tenodesis has not been established.

A future direction in anesthetic management of patients undergoing open subpectoral biceps tenodesis is the addition of a Pectoral Nerve II block (Pecs II) to ISB. This technique, described by Reynolds in 2019,⁹ was traditionally used in breast surgery, and involves utilizing local anesthetic between the pectoralis major and minor muscles to anesthetize the medial and lateral pectoral nerves,¹⁹ and a second injection between the pectoralis minor and serratus anterior muscles to anesthetize the intercostal nerves.⁹ In a double-blind, randomized controlled trial of 40 patients undergoing arthroscopic shoulder surgery with open subpectoral biceps tenodesis, Reynolds compared Pecs II + ISB to ISB alone and found that patients receiving the combination block had lower pain NRS at 6 h postoperatively (ISB mean NRS: 3.0 vs. ISB + Pecs II 0.0, $p = .026$), fewer reports of axillary pain, and fewer requirement for opioids in PACU.⁹ Despite these promising early findings, further investigation of the risks and benefits of this technique in a larger population are required before it may be considered for widespread adoption.

This study has several limitations. Given its retrospective single-institution cohort design, our patient population may not be representative of the broader population of patients undergoing arthroscopic shoulder surgery with concurrent biceps tenodesis and is subject to selection bias. In addition, our use of the pain numeric rating scale as an endpoint is inherently subjective based on patients' individualized perception of pain. Similarly, our definition of block failure based on postoperative pain and narcotic usage sets a lower threshold for 'failure' than the more stringent definition of failure to produce a satisfactory condition to proceed with surgery,²⁰ potentially limiting comparison of this endpoint with other studies. Finally, while our findings yielded statistically significant results, the relatively low differences in pain scores and opioid MME consumption may not be clinically significant. The endpoints evaluated by this study are commonly captured as standard of care. We therefore suggest that others replicate our design to determine if the magnitude and difference in pain scores and narcotic consumption are similar across a broader population of patients undergoing open subpectoral tenodesis.

5. Conclusions

After controlling for patient demographics, comorbidities, procedure type, and the use of local anesthetic, patients undergoing arthroscopic shoulder surgery with open subpectoral biceps tenodesis using interscalene blocks experienced statistically significantly higher levels of early postoperative pain and consumed higher opioid MME in the PACU

than those who did not have a concurrent biceps tenodesis performed. Overall, pain scores and narcotic consumption were low after surgery, making these differences potentially clinically insignificant. Further study is required to evaluate whether these trends are consistent among patients undergoing open subpectoral biceps tenodesis.

Level of evidence

Level III retrospective comparative study IRB exempt determination provided by the Anne Arundel Medical Center Clinical Research Committee. Study #1497235.

CRedit authorship contribution statement

Justin J. Turcotte: Funding acquisition, Formal analysis, Data curation, Writing - original draft, substantial contributions to research design, or the acquisition, analysis or interpretation of data, drafting the paper or revising it critically, All authors have read and approved of the final submitted manuscript. **Dimitri M. Thomas:** Funding acquisition, Formal analysis, Data curation, Writing - original draft, substantial contributions to research design, or the acquisition, analysis or interpretation of data, drafting the paper or revising it critically, approval of the submitted and final versions, All authors have read and approved of the final submitted manuscript. **Cyrus J. Lashgari:** Funding acquisition, Formal analysis, Data curation, Writing - original draft, substantial contributions to research design, or the acquisition, analysis or interpretation of data, drafting the paper or revising it critically, approval of the submitted and final versions, All authors have read and approved of the final submitted manuscript. **Sohail Zaidi:** Funding acquisition, Formal analysis, Data curation, Writing - original draft, substantial contributions to research design, or the acquisition, analysis or interpretation of data, drafting the paper or revising it critically, approval of the submitted and final versions, All authors have read and approved of the final submitted manuscript. **James J. York:** Funding acquisition, Formal analysis, Data curation, Writing - original draft, substantial contributions to research design, or the acquisition, analysis or interpretation of data, drafting the paper or revising it critically, approval of the submitted and final versions, All authors have read and approved of the final submitted manuscript. **Jeffrey M. Gelfand:** Funding acquisition, Formal analysis, Data curation, Writing - original draft, substantial contributions to research design, or the acquisition, analysis or interpretation of data, drafting the paper or revising it critically, approval of the submitted and final versions, All authors have read and approved of the final submitted manuscript. **Benjamin M. Petre:** Funding acquisition, Formal analysis, Data curation, Writing - original draft, substantial contributions to research design, or the acquisition, analysis or interpretation of data, drafting the paper or revising it critically, approval of the submitted and final versions, All authors have read and approved of the final submitted manuscript.

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Declaration of competing interest

All authors declare that they have no conflicts of interest to disclose.

References

- Bishop JY, Sprague M, Gelber J, et al. Interscalene regional anesthesia for arthroscopic shoulder surgery: a safe and effective technique. *J Shoulder Elbow Surg.* 2006;15(5):567–570.
- Fontana C, Di Donato A, Di Giacomo G, et al. Postoperative analgesia for arthroscopic shoulder surgery: a prospective randomized controlled study of intraarticular, subacromial injection, interscalenic brachial plexus block and intraarticular plus subacromial injection efficacy. *Eur J Anaesthesiol.* 2009;26(8):689–693.
- Calvo E, Torres MD, Morcillo D, Leal V. Rotator cuff repair is more painful than other arthroscopic shoulder procedures. *Arch Orthop Trauma Surg.* 2019;139(5):669–674.
- Patel KV, Bravman J, Vidal A, Chrisman A, McCarty E. Biceps tenotomy versus tenodesis. *Clin Sports Med.* 2016;35(1):93–111.
- Abraham VT, Tan BH, Kumar VP. Systematic review of biceps tenodesis: arthroscopic versus open. *Arthroscopy.* 2016;32(2):365–371.
- Duchman KR, DeMik DE, Uribe B, Wolf BR, Bollier M. Open versus arthroscopic biceps tenodesis: a comparison of functional outcomes. *Iowa Orthop J.* 2016;36:79–87.
- Kumara AB, Gogia AR, Bajaj JK, Agarwal N. Clinical evaluation of post-operative analgesia comparing suprascapular nerve block and interscalene brachial plexus block in patients undergoing shoulder arthroscopic surgery. *Journal of clinical orthopaedics and trauma.* 2016;7(1):34–39.
- Bowens Jr C, Sripada R. Regional blockade of the shoulder: approaches and outcomes. *Anesthesiol Res Pract.* 2012;2012:971963.
- Reynolds JW, Henshaw DS, Jaffe JD, et al. Analgesic benefit of pectoral nerve block II blockade for open subpectoral biceps tenodesis: a randomized, prospective, double-blinded, controlled trial. *Anesth Analg.* 2019;129(2):536–542.
- Yan S, Zhao Y, Zhang H. Efficacy and safety of interscalene block combined with general anesthesia for arthroscopic shoulder surgery: a meta-analysis. *J Clin Anesth.* 2018;47:74–79.
- Neal JM, Gerancher JC, Hebl JR, et al. Upper extremity regional anesthesia: essentials of our current understanding, 2008. *Reg Anesth Pain Med.* 2009;34(2):134–170.
- Bosco L, Zhou C, Murdoch JAC, et al. Pre- or postoperative interscalene block and/or general anesthesia for arthroscopic shoulder surgery: a retrospective observational study. *Can J Anaesth.* 2017;64(10):1048–1058.
- Kim Y-M, Park K-J, Kim D-S, et al. Efficacy of interscalene block Anesthesia on the early postoperative pain after arthroscopic shoulder surgery: comparison with general anesthesia. *J Korean Orthop Assoc.* 2011;46(4):288–293.
- Kim JY, Song KS, Kim WJ, et al. Analgesic efficacy of two interscalene blocks and one cervical epidural block in arthroscopic rotator cuff repair. *Knee Surg Sports Traumatol Arthrosc.* 2016;24(3):931–939.
- Hadzic A, Williams BA, Karaca PE, et al. For outpatient rotator cuff surgery, nerve block anesthesia provides superior same-day recovery over general anesthesia. *Anesthesiology.* 2005;102(5):1001–1007.
- Faryniarz D, Morelli C, Coleman S, et al. Interscalene block anesthesia at an ambulatory surgery center performing predominantly regional anesthesia: a prospective study of one hundred thirty-three patients undergoing shoulder surgery. *J Shoulder Elbow Surg.* 2006;15(6):686–690.
- Gurger M, Ozer AB. A comparison of continuous interscalene block versus general anesthesia alone on the functional outcomes of the patients undergoing arthroscopic rotator cuff repair. *Eur J Orthop Surg Traumatol.* 2019;29(8):1659–1666.
- Nysora. <https://www.nysora.com/techniques/upper-extremity/distal-nerves/cutaneous-blocks-upper-extremity/>.
- Blanco R. The 'pecs block': a novel technique for providing analgesia after breast surgery. *Anaesthesia.* 2011;66(9):847–848.
- Failed spinal anesthesia: mechanisms, management, and prevention. *Surv Anesthesiol.* 2009;53(6):280–281.