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REPORTS OF ORIGINAL INVESTIGATIONS

Pre- or postoperative interscalene block and/or general anesthesia for arthroscopic shoulder surgery: a retrospective observational study

Bloc interscalénique pré- ou postopératoire et/ou anesthésie générale pour une chirurgie arthroscopique de l'épaule : une étude observationnelle rétrospective

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Abstract

Purpose *Arthroscopic shoulder surgery can be performed with an interscalene brachial plexus block (ISBPB) alone, ISBPB combined with general anesthesia (GA), or GA alone. Postoperative pain is typically managed with opioids; however, both GA and opioids have adverse effects which can delay discharge. This retrospective study compares the efficacy of four methods of anesthesia management for arthroscopic shoulder surgery.*

Methods *Charts of all patients who underwent shoulder surgery by a single surgeon from 2012-2015 were categorized by analgesic regimen: GA only ($n = 177$), single-shot ISBPB only ($n = 124$), or pre- vs postoperative ISBPB combined with GA (ISBPB + GA [$n = 72$] vs GA + ISBPB [$n = 52$], respectively). The primary outcome measure was the time to discharge from the postanesthesia care unit (PACU).*

Results *Mean (SD) time in the PACU ranged from 70.5 (39.9) min for ISBPB only to 111.2 (56.9) min for GA only. Use of ISBPB in any combination and regardless of timing resulted in significantly reduced PACU time, with a mean drop of 27.2 min (95% confidence interval [CI], 17.3 to 37.2; $P < 0.001$). The largest mean pairwise difference was between GA only and ISBPB only, with a mean difference of 40.7 min (95% CI, 25.5 to 55.8; $P < 0.001$). Use of ISBPB also reduced pain upon arrival at the PACU and, in some cases, upon discharge from the PACU (i.e., ISBPB only but not ISBPB + GA compared with GA). An ISBPB (alone or prior to GA) also reduced analgesic requirements.*

Conclusion *Previously reported benefits of an ISBPB for arthroscopic shoulder surgery are confirmed. Postoperative ISBPBs may also be beneficial for reducing pain and opioid requirements and could be targeted for patients in severe pain upon emergence. A sufficiently powered randomized-controlled trial could determine the relative efficacy, safety, and associated financial implications associated with each method.*

Résumé

Objectif *La chirurgie arthroscopique de l'épaule peut être réalisée avec un bloc interscalénique du plexus brachial seul, avec un tel bloc combiné à une anesthésie générale (AG), ou sous AG seulement. La douleur postopératoire est en général prise en charge à l'aide d'opioïdes; toutefois,*

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l'AG et les opioïdes ont tous deux des effets néfastes qui pourraient retarder le congé. Cette étude rétrospective porte sur l'efficacité de quatre méthodes de prise en charge anesthésique pour la chirurgie arthroscopique de l'épaule.

Méthode *Les dossiers de tous les patients ayant subi une chirurgie de l'épaule par un seul chirurgien entre 2012 et 2015 ont été catégorisés selon le régime analgésique utilisé : AG seule (n = 177), bloc interscalénique du plexus ('bloc') à injection unique seul (n = 124), ou bloc pré- ou postopératoire combiné à une AG (bloc + AG [n = 72] vs AG + bloc [n = 52], respectivement). Le critère d'évaluation principal était le temps jusqu'au congé de la salle de réveil.*

Résultats *Le temps moyen (ÉT) en salle de réveil allait de 70,5 (39,9) min pour le bloc seul à 111,2 (56,9) min pour l'AG seule. L'utilisation d'un bloc interscalénique, peu importe la combinaison ou le moment d'administration, a résulté en une durée de séjour significativement réduite en salle de réveil, avec une baisse moyenne de 27,2 min (intervalle de confiance [IC] 95 %, 17,3 à 37,2; P < 0,001). La différence moyenne la plus importante a été observée entre l'AG seule et le bloc seul, avec une différence moyenne de 40,7 min (IC 95 %, 25,5 à 55,8; P < 0,001). L'utilisation du bloc a également réduit la douleur à l'arrivée en salle de réveil et, dans certains cas, au congé de la salle de réveil – c.-à-d. bloc seul mais pas bloc + AG par rapport à AG. Un bloc interscalénique du plexus brachial (seul ou avant une AG) a également permis de réduire les besoins analgésiques.*

Conclusion *Les bienfaits précédemment rapportés du bloc interscalénique du plexus brachial pour la chirurgie arthroscopique de l'épaule sont confirmés. Un bloc interscalénique du plexus brachial réalisé en postopératoire pourrait également être avantageux pour réduire la douleur et les besoins en opioïdes et pourrait être proposé aux patients ressentant des douleurs importantes au réveil. Une étude randomisée contrôlée de grande envergure pourrait déterminer l'efficacité relative, l'innocuité et les implications financières associées de chaque méthode.*

Interscalene brachial plexus blocks (ISBPBs) are often used to provide perioperative analgesia and anesthesia for shoulder surgery. They target nerve roots C4-C6 and thereby provide regional analgesia to the shoulder and upper arm.[1] Although ISBPBs are often performed in combination with general anesthesia (GA) to enhance postoperative analgesia,[2] they are also sometimes used as a sole means of anesthesia.[3–6] Given the side effects associated with GA (short-term cognitive impairment, somnolence, and postoperative nausea and vomiting [PONV]) that can increase patient morbidity and delay discharge, avoidance of GA has the potential to improve outpatient surgical care.[3] In addition, even though opioids are effective for managing postoperative pain following outpatient surgical procedures, they are also associated with adverse effects, including PONV, somnolence, and dizziness, all of which can also delay recovery.[7]

Because of such issues and the fact that inadequately treated postoperative pain can itself delay discharge[8] and result in hospital admissions,[9,10] provision of optimal anesthesia and analgesia for outpatient surgical procedures (e.g., arthroscopic shoulder surgery) remains challenging. The number of arthroscopic shoulder surgeries in the USA increased by 600% from 1996-2006, and this increase was accompanied by a shift from inpatient to outpatient surgical procedures.[11] As a result of this growing demand and increasing financial constraints, efficient and effective anesthesia management for outpatient surgical procedures is becoming increasingly important.

Numerous studies have reported benefits of an ISBPB for arthroscopic shoulder surgery, including quicker recovery and even bypassing the postanesthesia care unit (PACU),[3,12,13] decreased time to discharge,[12,13] decreased pain scores,[3,14] opioid sparing,[12,14] reduced costs,[5,15] less intraoperative hemodynamic variability,[16] improved patient satisfaction,[3,17] and, in some cases, reduced GA- and/or opioid-related side effects.[2,3,12,13] A recent systematic review examining all modes of postoperative pain management following shoulder arthroscopy concluded that ISBPBs are superior to all other forms of postoperative pain control.[18]

Existing studies examining ISBPBs are small and heterogeneous in terms of methodology, outcome measures, and therapeutic techniques/interventions, which creates difficulty in making comparisons.[2,9] Also, the majority of investigations have compared preoperative ISBPB with GA alone or with an ISBPB-GA combination. This retrospective review examined postoperative outcomes for arthroscopic shoulder surgery patients who underwent surgery with GA, single-shot ISBPB, or pre- *vs* postoperative ISBPB combined with GA. The primary outcome was time to discharge from the PACU. Secondary outcomes included postoperative pain upon arrival at and discharge from the PACU, analgesic consumption, as well as GA and opioid-related side effects and ISBPB-associated neurological complications. Our hypotheses were that patients who received an ISBPB (alone or before GA) were discharged faster, had less postoperative pain, and reduced analgesic requirements when compared with patients who received GA Only. We also hypothesized that an ISBPB, even when administered postoperatively upon emergence from GA, would impart some benefits compared with GA Only.

Methods

Study design

The Queen's University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board granted approval for preparation and publication of the current retrospective investigation (SMED-105-13, May 3, 2013).

Patient population

Patients were included if they underwent arthroscopic shoulder surgery between September 2, 2012 and October 2, 2015 by one orthopedic surgeon specializing in shoulder surgery (R.B.) at our primary and tertiary care teaching centres. Patients were excluded if they underwent open surgical procedures, other concurrent surgical procedures, or were under 18 yr of age. Patients were categorized based on the mode of anesthesia: GA Only, ISBPB Only, preoperative ISBPB followed by GA (ISBPB + GA), or GA followed by postoperative ISBPB (GA + ISBPB).

Data collection

Demographic information and surgical characteristics, including the type of shoulder surgery, were collected from the anesthetic record. Information regarding pain scores (numeric rating scores [NRS] upon arrival and discharge from the PACU), episodes of nausea and/or vomiting, opioid consumption, and length of stay in the PACU were gathered from the PACU flowsheet. For nineteen patients, pain was recorded as a verbal description of "tolerable, moderate, severe, and very severe". For these situations, numerical scores were assigned for each qualitative descriptor: tolerable = 3, moderate = 5, severe = 7, and very severe = 9.

Anesthetic plan

The anesthetic management plan for each patient was based on a combination of anesthesiologist preference and/or skill set, patient comorbidities, and patient preference, as per standard practice at our institution. Discharge from the PACU at our centres requires the patient to achieve an Aldrete score ≥ 9 and a Post Anesthetic Discharge Scoring System Score ≥ 9.

Single-shot interscalene brachial plexus block

For those patients who received a single-shot ISBPB, either with or without GA, a linear 10-13 MHz ultrasound probe was used to visualize the brachial plexus. A 5-cm 22G SonoPlex STIM (Pajunk GmbH, Geisingen, Germany) insulated needle was then placed through the middle scalene muscle in a lateral to medial approach, into the interscalene groove, and adjacent to the brachial plexus. In-plane ultrasound guidance was used to visualize the entire needle. After a 1-mL test dose to exclude obvious intraneural injection, 20-30 mL of 0.5% ropivacaine:2% lidocaine as a 1:1 mixture were injected in divided doses with frequent aspiration under ultrasound visualization. Preoperative ISBPBs were performed immediately prior to GA induction, which occurred following confirmation of successful sensory and motor block. Postoperative ISBPBs were performed as a rescue analgesia technique on a subset of patients who reported severe pain upon emergence from GA while in the PACU. Block success was confirmed as above. Patient consent was obtained and documented preoperatively for all blocks.

Statistics

Descriptive statistics of the demographic and surgical characteristics were calculated using Microsoft Excel 2010 (Microsoft Corporation, Seattle, WA, USA) and SPSS® (IBM Inc, Chicago, IL, USA), and the distributions were examined across the four anesthesia groups. Univariate statistics (independent samples Student's t tests or one-way analysis of variance [ANOVA] for categorical data and Pearson correlation for continuous data) were used to examine the association of demographic and surgical characteristics as well as type of anesthesia with the primary outcome measure (time in the PACU) and the secondary outcomes (pain upon arrival and discharge from the PACU and use of analgesia). Multivariable linear regression models (time to PACU discharge) and logistic regression models (i.e., pain upon arrival and discharge from the PACU and use of analgesia) were developed using type of anesthesia as the primary predictor of interest and adjusting for other covariates that were associated with the four outcomes on univariate testing ($P < 0.15$ as entry criteria). Pain scores upon arrival and discharge from the PACU, nausea and vomiting, and analgesic consumption were not included in the linear regression model for time in the PACU because they had been defined *a priori* as secondary outcomes. Significance was set at $P < 0.05$. No routine corrections were made for multiple comparisons, although comparisons utilizing one-way ANOVA did incorporate Tukey's *post hoc* testing.

Results

From September 2012 to October 2015, 499 charts were retrieved for all patients who underwent shoulder surgery by a single surgeon (R.B.) at two medical centres. The majority of the surgeries were performed at the ambulatory primary care outpatient centre, and only a small portion of the procedures were performed at the medium-sized tertiary care centre. Seventy-four of the 499 patient charts were excluded: 39 for patients undergoing open surgical procedures, 13 for concurrent surgical procedures, two were inaccessible, five for patients under the age of 18, 11 for missing data, and four were duplicates. Information for 425 patients is included in the current report (demographic information presented in Table 1).

Anesthetic management and time in the PACU

Analysis of variance revealed a significant overall effect of time in the PACU by the type of anesthetic ($P < 0.0001$). Patients receiving ISBPB Only spent the shortest amount of time in the PACU, and those receiving GA Only spent the longest amount of time (see Table 2 for group means and standard deviations, as well as the pairwise mean differences between groups with the associated 95% confidence intervals). Multiple comparisons revealed no significant difference between the GA Only *vs* the GA + ISBPB group ($P = 0.99$). The ISBPB + GA group had a reduced length of stay in the PACU compared with the GA Only group ($P = 0.01$), but they stayed in the PACU slightly (but not significantly) longer than the ISBPB Only group ($P = 0.054$). There was no significant difference between the ISBPB + GA and the GA + ISBPB group ($P = 0.16$).

Multivariable regression modelling revealed that sex and age, in addition to anesthetic, impacted time to discharge—with ISBPB Only discharged from the PACU almost 45 min quicker ($P < 0.001$) and ISBPB + GA released 23 min quicker ($P = 0.002$) *vs* GA Only. Females remained in the PACU an average of 15.8 min longer than males, and every ten years of age increased the PACU duration of stay by 3.9 min (Appendix - Table A).

Anesthetic management and postoperative pain upon PACU arrival

The reported mean (standard deviation [SD]) NRS scores upon arrival at the PACU were as follows: GA Only 4.82 (3.39), ISBPB Only 1.84 (2.90), ISBPB + GA 2.49 (3.30), and GA + ISBPB 3.60 (3.87). Nevertheless, given that pain scores were not normally distributed, they are more appropriately presented as dichotomous variables, where scores of 0-3 = no pain to mild pain, and scores $\geq$ 4 indicate moderate to severe pain. A Chi square analysis revealed an overall significant difference in the pain levels upon arrival at the PACU depending on the anesthesia ($P < 0.001$). Compared with the other groups, patients in the ISBPB Only group were more likely to report no pain to mild pain (93/123 = 76%), whereas those in the GA

Table 1 Patient demographic characteristics

		Total	GA Only	ISBPB Only	ISBPB + GA	GA + ISBPB	P Value[1]
Sex *n* (%)	*Male*	315 (74.1)	137 (77.4)	82 (66.1)	58 (80.6)	38 (73.1)	*0.08*
	Female	110 (25.9)	40 (22.6)	42 (33.9)	14 (19.4)	14 (26.9)	
Age mean (SD) yr		48.8 (13.8)	46.1 (14.1)	52.5 (12.2)	50.6 (14.8)	46.5 (13.2)	*<0.001*
BMI *n* (%)	*<30*	253 (60.4)	110 (63.2)	73 (59.3)	38 (54.3)	32 (61.5)	*0.26*
	30-35	91(21.7)	35 (20.1)	22 (17.7)	21 (30.0)	13 (25.0)	
	36-40	44 (10.5)	17 (9.8)	13 (10.5)	8 (11.4)	6 (11.5)	
	>40	31 (7.4)	12 (6.9)	15 (12.1)	3 (4.3)	1 (1.9)	
	Missing	6	4	1	2	1	
ASA *n* (%)	*I*	69 (16.4)	30 (17.5)	19 (15.3)	10 (13.7)	10 (13.7)	*0.64*
	II	224 (53.1)	96 (56.1)	60 (48.4)	41 (18.0)	27 (11.7)	
	III	125 (29.6)	47 (27.5)	42 (33.6)	21 (33.9)	15 (11.2)	
	IV	4 (0.9)	1	3	0	0	
	Missing	3	3	-	-	-	
Surgical year *n* (%)	*2012*	53 (12.5)	27 (15.2)	19 (15.3)	7 (9.7)	0	*<0.001*
	2013	125 (29.4)	65 (36.7)	38 (30.6)	12 (16.7)	10 (19.2)	
	2014	151 (35.5)	60 (33.9)	38 (30.6)	13 (18.1)	40 (76.9)	
	2015	96 (22.6)	25 (14.1)	29 (23.4)	40 (55.5)	2 (3.8)	

ASA = American Society of Anesthesiologists physical status; BMI = body mass index; GA = general anesthesia; ISBPB = interscalene brachial plexus block

[1] Tests of significance are based on the Pearson Chi square test or the one-way analysis of variance as appropriate

Table 2 Association between the type of anesthesia and time to discharge from the PACU

	GA Only	ISBPB Only	ISBPB + GA	GA + ISBPB	
Minutes in PACU, mean (SD)	111.2(56.9)	70.5 (39.9)	89.4 (48.6)	108.4 (48.4)	Omnibus $P < 0.0001$
Pairwise Comparisons, difference in minutes (95% CI of difference), P value	GA Only	ISBPB Only	ISBPB + GA	GA + ISBPB	Any ISBPB
GA Only	-	40.7 (25.5 to 55.8) $P < 0.001$	21.8 (3.7 to 39.8) $P = 0.011$	2.8 (−17.6 to 23.2) $P = 0.985$	27.2 (17.3 to 37.2) $P < 0.001$
ISBPB Only	-	-	18.9 (0.2 to 38.0) $P = 0.054$	37.9 (16.5 to 59.2) $P < 0.001$	-
ISBPB + GA	-	-	-	19.0 (−4.5 to 42.5) $P = 0.16$	-
GA + ISBPB	-	-	-	-	-

The first row of the Table summarizes the primary outcome (PACU length of stay) by group, with the P value from the analysis of variance omnibus hypothesis test

The bottom of the Table presents all pairwise comparisons possible for the primary outcome in our study. Shown are the differences (in minutes) between groups along with the 95% CIs of the differences between groups. P values are based on Tukey's *post hoc* testing, with the exception of the GA Only and Any ISBPB, which is based on the independent samples Student's t test

CI = confidence interval; GA = general anesthesia; ISBPB = interscalene brachial plexus block; PACU = postanesthesia care unit

Only group were more likely to report moderate to severe pain (117/176 = 67%) (Table 3).

Multivariable logistic regression analyses, adjusting for covariates, revealed that patients in the ISBPB Only and ISBPB + GA groups experienced significantly less pain than those in the GA Only group upon arrival at the PACU (Appendix - Table B). Patients in the GA + ISBPB group were also in less pain upon arrival at the PACU than those in the GA Only group.

Anesthetic management and pain upon PACU discharge

The average reported mean (SD) NRS pain scores upon discharge from the PACU were as follows: GA Only 2.70 (1.68), ISBPB Only 0.93 (1.56), ISBPB + GA 1.60 (1.82), and GA + ISBPB 1.35 (1.80). Again, pain scores were lowest in the ISBPB Only group and highest in the GA Only group.

With pain scores classified as dichotomous variables as above, a Chi square test revealed overall significant differences between anesthesia groups in the proportion of patients experiencing moderate to severe pain upon discharge from the PACU ($P < 0.001$). Similar to pain scores reported upon PACU arrival, patients in the GA Only group were more likely to report moderate to severe pain upon discharge, whereas those in the ISBPB Only group were more likely to report no pain to mild pain upon discharge when compared with the other groups (Table 3).

Multivariable logistic regression analyses revealed that patients in the ISBPB Only and GA + ISBPB groups were less likely to experience moderate to severe pain upon discharge from PACU when compared with the GA Only group (Appendix - Table B). In the ISBPB + GA group, the pain upon discharge from the PACU was not significantly different from that in the GA Only group.

Postoperative analgesic consumption

The amount of analgesic consumed postoperatively was significantly lower in the ISBPB Only group than in the GA Only group; however, "missing data" resulted because so many individuals in all groups did not require analgesics. For this reason, analgesic requirement is presented as the proportion of patients requiring postoperative analgesics rather than the amount consumed. The proportion of patients requiring postoperative analgesics differed depending on the mode of anesthesia. The same trend is apparent whether we consider morphine/hydromorphone, fentanyl in the PACU, or all analgesics combined (Table 3). The proportion of patients in the ISBPB Only group requiring postoperative analgesics was smaller than that in the GA Only group, and

Table 3 Associations between type of anesthesia and secondary outcomes

	Total n (%) unless stated otherwise	GA Only	ISBPB Only	ISBPB + GA	GA + ISBPB
Pain upon arrival at the PACU					
None-mild	224 (53.0)	59 (33.5)	93 (53.0)	46 (63.9)	26 (50.0)
Moderate-severe	199 (47.0)	117 (66.5)	30 (47.0)	26 (36.1)	26 (50.0)
Missing	2	1	1	-	-
Pain upon discharge from PACU					
None-mild	308 (72.8)	108 (61.4)	107 (87.0)	51 (70.8)	42 (80.8)
Moderate-severe	115 (27.2)	68 (38.6)	16 (13.0)	21 (29.2)	10 (19.2)
Missing	2	1	1	-	-
Morphine/ Hydromorphone					
Yes	246 (53.0)	144 (73.5)	39 (29.1)	35 (44.3)	28 (50.9)
No	218 (47.0)	52 (26.5)	95 (70.9)	44 (55.7)	27 (49.1)
Fentanyl in PACU					
Yes	252(54.3)	154 (79.0)	36 (26.9)	31 (39.2)	31 (56.4)
No	211 (45.6)	41 (21.0)	98 (73.1)	48 (60.8)	24 (43.6)
Missing	1	1	-	-	-
Any analgesia					
Yes	285 (67.1)	157 (88.7)	50 (38.1)	44 (61.1)	34 (65.5)
No	140 (32.9)	20 (11.3)	74 (59.7)	28 (38.9)	18 (34.6)
Nausea and/or vomiting					
Yes	92 (21.7)	50 (28.2)	19 (15.4)	9 (12.5)	14 (26.9)
No	332 (78.3)	127 (71.8)	104 (84.6)	63(87.5)	38 (73.1)
Missing	1	-	1	-	-

GA = general anesthesia; ISBPB = interscalene brachial plexus block; PACU = postanesthesia care unit

the proportions in the two ISBPB combination groups were between those of the ISBPB Only and GA Only groups (Table 3).

Multivariable logistic regression controlling for covariates also confirmed that an ISBPB was associated with fewer patients requiring any postoperative analgesia whether administered alone, prior to GA, or upon emergence from GA (Appendix - Table B).

Postoperative nausea and/or vomiting

The incidence of nausea and/or vomiting differed depending on the mode of anesthesia ($P = 0.008$). A smaller proportion of patients in the ISBPB Only (15.4%) or ISBPB + GA (12.5%) group experienced nausea and/or vomiting. Likewise, patients in the GA + ISBPB (26.9%) group experienced more nausea than those in the ISBPB Only group, but the proportion was comparable with those in the GA Only (28.2%) group (Table 3).

Neurological complications or injury

No permanent cases of Horner's syndrome or phrenic nerve palsy were observed. One patient in the ISBPB Only group was referred to an ear, nose and throat specialist with vocal cord paralysis ipsilateral to the block. This resolved in three to six months postoperatively with voice therapy.

Discussion

We examined the efficacy of four anesthetic methods for arthroscopic shoulder surgery. Our results, largely congruent with previous research, suggest that an ISBPB (whether administered alone or prior to GA) reduces the time to discharge from PACU,[3,12,13] reduces pain,[3,14] and reduces analgesic requirements[6,12,20] (with associated adverse effects) [2,3,12,13] compared with GA. While anesthesia played a major role in time to discharge, multivariable analysis revealed that age and sex also had a significant impact. Additional multivariable logistic regression revealed that, compared with GA Only, the anesthesia method was the only variable that significantly impacted the proportion of patients requiring any postoperative analgesics and those experiencing moderate to severe pain upon arrival and discharge from the PACU.

When compared with GA alone, the beneficial effects of ISBPB + GA are not as pronounced as those of ISBPB alone. This is likely because of the adverse effects associated with GA. Less GA is required when an ISBPB is already active,[17,19] but there may still be some GA-associated adverse effects that can counteract the beneficial effects associated with ISBPB Only. This is supported by the fact that patients in the ISBPB Only group were discharged from the PACU almost 45 min earlier than those in the GA Only group. On the other hand, patients in the ISBPB + GA group were discharged only 23 min earlier than those in the GA Only group.

Conversely, patients who received postoperative ISBPB (GA + ISBPB) were most similar to the GA Only group in terms of time to discharge from the PACU because the amount of intraoperative GA and opioids would have been similar. It is interesting that, even with ISBPB upon emergence (GA + ISBPB), benefits were observed in pain upon discharge from the PACU and analgesic requirements. Because pain and opioid side effects can extend the stay in the PACU,[7,8,10] this finding may be clinically significant. Nevertheless, these data must be considered cautiously since this patient group also experienced significantly less pain upon arrival at the PACU (Appendix - Table B). This highlights the possibility that the results were due to an initial difference between groups rather than attributable to the ISBPB *per se*. In theory, this group should have been similar to the GA Only group at this time point, i.e., prior to ISBPB administration. Although our data indicate no improvements in PACU discharge time or PONV compared with GA Only, they do suggest the possibility that this mode of analgesia could be targeted to patients in severe pain upon emergence. An ISBPB at this point may serve to prevent further associated delays in discharge.

Although our findings are generally consistent with the literature,[18] there are several discrepancies. For example, Zoremba *et al.*[20] observed no difference in PACU discharge time with ISBPB + GA or GA Only. Nevertheless, their ISBPB was continuous rather than single-shot as used here, and their mean reported stay in the PACU was 22 min compared with our 93 min. This disparity suggests major differences in patient care and/or criteria to discharge. Similarly, Salviz *et al.*[13] reported that an ISBPB (continuous or single-shot) was associated with faster PACU discharge times than GA, but their average stay was 20 min for continuous, 30 min for single-shot, and 165 min for GA Only. Again, the PACU discharge times are in sharp contrast to ours.

Another discrepancy exists in reported neurological complications. Ryu *et al.*[21] reported that 59.6% of patients with an ISBPB exhibited Horner's syndrome, whereas none of the 248 patients in our ISBPB groups exhibited the syndrome. Nevertheless, Horner's syndrome is transient and typically resolves before the conclusion of surgery, in which case, it may not have been documented. Similarly, Zoremba *et al.* observed frequent impaired lung function due to phrenic nerve palsy.[20] The current study did not encounter phrenic nerve palsy. Nevertheless, due to the study design, it would not have been expected, and thus, we are unable to comment on whether this represents a discrepancy. Another potential explanation for the reported differences in complication rates may be the skill level and/or experience of the clinicians who performed the blocks at the different centres.

Advantages/disadvantages of ISBPB

Although the literature supports using an ISBPB for patients undergoing arthroscopic shoulder surgery,[18] there are some potential disadvantages, including 1) the requirement for highly trained anesthesiologists, 2) delays in workflow,[3] 3) increased costs, and 4) the potential for serious and long-lasting neurological complications.[22]

The main barrier to adopting ISBPBs may be the requirement for highly trained anesthesiologists. Nevertheless, this is a skill that one anesthesiologist can acquire, practice with skilled clinicians, and then subsequently teach to others at their centre. Another major concern may be the extra time required for block administration and its impact on workflow. Then again, the block can be performed while the operating room (OR) is being prepared, and some report even shorter times to OR departure with regional anesthesia compared with GA.[23] Others report reductions in time to surgical preparation, emergence, anesthesia control time, and PACU times with an ISBPB compared with GA.[5] Regional anesthesia may also be financially cost effective because of the improved pain control, fewer opioids, and faster discharge.[5,15] While such economic benefits have been shown for spinal anesthesia compared with GA,[24,25] there is a lack of direct economic comparisons between GA and ISBPB performed by attending anesthesiologists.

A large review estimated the risk of *any* neurological complication (including transient) following an ISBPB to be 2.84% (95% CI, 1.33 to 5.98).[26] Nevertheless, the magnitude of this risk varies widely across institutions, anesthesiologists, and patient groups.[27] Horner's syndrome and phrenic nerve palsy may be among the most widely reported of the neurological complications. Horner's syndrome is characterized by transient partial paralysis of the face. Phrenic nerve palsy can be far more serious because it involves partial paralysis of the diaphragm which can affect lung function and be long-lasting. As mentioned previously, we did observe one case in which a patient's voice was affected following the ISBPB, and this condition resolved in several months with voice therapy.

The fact that no other neurological complications were observed in the 248 ISBPBs suggests that ISBPBs can be performed with a low incidence of transient neurologic injury. Overall, the rate of permanent neurological injury after regional anesthesia is rare in contemporary anesthesia practice,[18,26] although the small size and retrospective nature of the current investigation does not allow us to comment on the incidence of such injuries.

This novel study examined specific postoperative outcome measures in patients who received an ISBPB following emergence from GA. Even so, there are limitations to this study. First, these data were retrospectively (rather than prospectively) gathered by research personnel not blinded to the purpose of the study. In addition, patients were not randomly assigned to their respective anesthesia management regimens but instead were assigned based on a combination of the anesthesiologist skill set and/or preference, the patient's health status, pain scores, and/or the patient's preference. This assignment method resulted in high variability in group size (52-177 patients), some of which are quite small. This may have resulted in basic differences between patient groups; for example, the GA + ISBPB group was in significantly less pain than the GA Only group on arrival at the PACU. In theory, the baseline characteristics of these groups should have been comparable since there was no difference in the intervention up until this point. In addition, since the ISBPBs were administered in the PACU for rescue analgesia, the pain scores (i.e., 3.6) upon PACU entry were not representative of the patients' pain status immediately prior to ISBPB administration. Unfortunately, the time of block administration and pain scores at that moment are not routinely collected at our centre. The problems of group assignment method and small sample size are also reflected in the fact that patients in the ISBPB + GA group did not differ significantly from the GA Only group in terms of pain at discharge from the PACU. The fact that the ISBPB + GA group was different from the ISBPB Only group suggests that the ISBPBs were not entirely effective in the ISBPB + GA group. The non-randomization and small group sizes may also be problematic since many other factors, such as anxiety, depression, and preexisting chronic pain, may play a role in the severity of postoperative pain.[28,29] Unfortunately, the retrospective nature of this investigation precludes any examination of such factors since this information is not routinely collected. All observational studies encounter residual confounding, and therefore, our results show associations rather than cause-effect relationships. Finally, it is questionable whether these results can be generalized to other centres, because this study included only those patients from two centres undergoing surgery by a single surgeon and under the care of a small group of anesthesiologists. Conversely, the fact that only a small group of clinicians cared for these patients may have served to strengthen the homogeneity and reduce the variability of the data.

Conclusion

Overall, our findings are consistent with the literature and confirm that regional anesthesia for arthroscopic shoulder surgery is associated with a faster PACU discharge time, less postoperative pain, and reduced analgesic requirements (and associated adverse effects) when compared with GA.[18] Our data also suggest that ISBPB may be beneficial even when administered postoperatively upon emergence from GA. Interscalene brachial plexus block is associated with reduced pain scores upon discharge from the PACU and reductions in analgesic consumption, factors that can potentially prolong patients' stay in the PACU. Nevertheless, a future prospective randomized-controlled trial will be necessary to confirm these findings and determine the absolute relative efficacy, safety profile, and associated financial implications associated with each method.

Conflicts of interest None of the authors have any conflicts of interest associated with publication of the current manuscript.

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Author contributions *Vidur Shyam*, *Cheng Zhou*, *John A. C. Murdoch,* and *Ryan Bicknell* were involved in study conception. *Laura Bosco* and *Cheng Zhou* collected the data. *Laura Bosco* and *Rachel Phelan* drafted the manuscript. *Ryan Bicknell* performed all of the shoulder surgery. *Wilma Hopman* performed the data analysis. All authors were involved in the manuscript revision process and made significant intellectual contributions.

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Appendix

Table A Multivariable linear regression model for time in postanesthesia care unit (minutes)

Characteristics	Multivariable Model	
	Parameter Estimate (95% CI)	*P* value
Constant	88.3 (70.3 to 106.2)	<0.001
Age / 10 (Continuous)	3.9 (0.4 to 7.4)	0.031
Sex (Reference male)	15.8 (4.8 to 26.7)	0.005
Surgery (Reference Shoulder arthroscopy with Rotator Cuff)		-
Shoulder Arthroscopy	7.4 (−5.7 to 20.6)	0.268
Anesthesia Type (Reference GA Only)		
ISBPB Only	−44.8 (−56.1 to −32.9)	<0.001
ISBPB + GA	−22.5 (−36.2 to −8.8)	0.001
GA + ISBPB	−2.6 (−18.0 to 12.8)	0.740

Model F = 11.7; $P < 0.001$; Adjusted $r^2 = 0.132$

CI = confidence interval; GA = general anesthesia; ISBPB = interscalene brachial plexus block

Table B Multivariable logistic regression models for secondary outcomes of pain at admission, pain at discharge, and use of analgesia

	Multivariable Model	
	Odds Ratio (95% CI)	*P* value
Pain at Arrival		
(0 = None-Mild, 1 = Moderate-Severe)		
Age / 10 (Continuous)	1.02 (0.87 to 1.19)	0.842
BMI (Continuous)	0.89 (0.71 to 1.11)	0.308
Surgery (Reference Shoulder arthroscopy with Rotator Cuff)		
Shoulder Arthroscopy	1.06 (0.59 to 1.92)	0.839
Anesthesia Type (Reference GA Only)		
ISBPB Only	0.17 (0.10 to 0.29)	<0.001
ISBPB + GA	0.29 (0.16 to 0.52)	<0.001
GA + ISBPB	0.52 (0.27 to 0.97)	0.041
Pain at Discharge		
(0 = None/Mild, 1 = Moderate/Severe)		
Age / 10 (Continuous)	0.99 (0.84 to 1.17)	0.942
BMI (Continuous)	1.10 (0.84 to 1.37)	0.557
Surgery (Reference Shoulder arthroscopy with Rotator Cuff)		
Shoulder Arthroscopy	1.02 (0.55 to 1.89)	0.963
Anesthesia Type (Reference GA Only)		
ISBPB Only	0.23 (0.12 to 0.42)	<0.001
ISBPB + GA	0.69 (0.38 to 1.27)	0.236
GA + ISBPB	0.39 (0.18 to 0.83)	0.015
Any Analgesia (0 = No, 1 = Yes)		
Age / 10 (Continuous)	0.99 (0.83 to 1.18)	0.893
BMI (Continuous)	0.87 (0.68 to 1.11)	0.254
Surgery (Reference Shoulder arthroscopy with Rotator Cuff)		
Shoulder Arthroscopy	1.80 (0.89 to 3.65)	0.101

Table B continued

	Multivariable Model	
	Odds Ratio (95% CI)	*P* value
Anesthesia Type (Reference GA Only)		
ISBPB Only	0.09 (0.05 to 0.16)	<0.001
ISBPB + GA	0.20 (0.10 to 0.39)	<0.001
GA + ISBPB	0.26 (0.12 to 0.54)	<0.001

Pain at arrival: model Chi square = 55.9; $P < 0.001$; Cox & Snell $r^2 = .126$

Pain at discharge: model Chi square = 28.2; $P < 0.001$; Cox & Snell $r^2 = .065$

Analgesia = model Chi square = 87.05; $P < 0.001$; Cox & Snell $r^2 = .188$

BMI = body mass index; CI = confidence interval; GA = general anesthesia; ISBPB = interscalene brachial plexus block

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