Subacromial Bursitis and Shoulder Pain: Exploring the Predictors for a Negative Anaesthetic Response

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ABSTRACT

The aim of this retrospective cross-sectional study was to (1) investigate the association between the presence of subacromial bursal pathology and response to subacromial anaesthetic injection; (2) identify variables that are predictive of a negative anaesthetic response; and (3) calculate diagnostic accuracy of these predictors. A total of 208 people with shoulder pain referred from primary care received an ultrasound guided local anaesthetic injection into the subacromial bursa following standardised clinical examination. Pain was recorded on a visual analogue scale immediately prior to and within 15 min post-anaesthetic injection. No difference in pain reduction post injection was found between those with and without bursal pathology ($p < 0.05$). Five potential predictors of a negative anaesthetic response were identified, but did not reach statistical significance. Clusters of three of the five predictors (high occupational shoulder demands; high or low sport/recreational shoulder demands; no current history of night pain; loss of passive external rotation range of motion of more than 30° and shoulder pain reproduced on cervical spine testing) may have clinical relevance despite not reaching statistical significance. Use of a cluster of any three predictors results in post-test probability of 93% (pre-test probability 69%). The identified predictors may inform clinical decisions regarding the use of injection therapy in those with bursal pathology observed with ultrasound and therefore potentially reduce unnecessary and costly healthcare utilisation.

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INTRODUCTION

Shoulder pain is one of the most common musculoskeletal pain conditions for people seeking primary healthcare services (Urwin et al., 1998). The annual incidence has been reported as being between 0.9% and 2.5% in those aged 31–74 years, with a lifetime prevalence of up to 66.7% (Luime et al., 2004). Rotator cuff conditions account for up to 70% of reported shoulder conditions (Chard et al., 1991). *Rotator cuff related shoulder pain* is an over-arching term that includes common shoulder pathologies such as bursitis, rotator cuff tendinopathy and rotator cuff tears. This recent change in terminology is due to a greater understanding of aetiology in shoulder pain, pathological findings in asymptomatic individuals and the poor diagnostic accuracy of common shoulder special tests for identifying specific pathologies (Lewis, 2016).

Ultrasound imaging is an adjunct to the diagnostic process of rotator cuff-related shoulder pain. In the year 2018/19, the Accident Compensation Corporation (ACC) accepted 40,992 new claims for shoulder and rotator cuff sprains in New Zealand, of which approximately 37% received an ultrasound scan to aid diagnosis (Accident Compensation Corporation, 2019). Bursal pathology is common in both symptomatic and asymptomatic populations; however, its contribution to shoulder pain needs to be determined to avoid inappropriate treatment targeting the subacromial bursa (Cadogan et al., 2011). Girish et al. (2011) reported 78% (40/51) of healthy male asymptomatic volunteers were found to have subacromial bursal thickening. Furthermore, no significant differences in bursal thickness have been identified between people with shoulder pain and those without (Daghir et al., 2012).

Although it is known that pain is a multidimensional experience, the accepted reference standard test for identifying structures contributing to the experience of pain is a diagnostic injection of local anaesthetic (Bogduk, 2009; Cardone & Tallia, 2002). A cross-sectional study using intra-bursal anaesthetic injection in those with shoulder pain found radiological bursal features were similar in both responders and non-responders (Bouju et al., 2014). However, Lee et al. (2017) reported improved outcomes (i.e., self-reported pain intensity, active range of motion and ultrasound findings) following subacromial bursal corticosteroid injection in individuals with rotator cuff disease, and thickened or fluid-filled bursa when compared to those with normal bursal features.

Based on such conflicting evidence, it appears in some cases bursitis may be associated with shoulder pain (Lee et al., 2017); however, in others it may be an asymptomatic finding (Bouju et al., 2014). It is expected that if bursitis was the nociceptive source of shoulder pain, local anaesthetic injection into the

subacromial bursa would result in a significant reduction in pain. Further, a lack of anaesthetic response would indicate the bursa was not the predominant source of nociception and further targeted treatments may not confer any clinical benefit.

Several studies have investigated the radiological features, patient history and clinical examination findings associated with a positive anaesthetic response to local anaesthetic bursal injection (Bouju et al., 2014; Cadogan et al., 2012; Lee et al., 2017). There is however no previous research on characteristics of patients who do not respond to local anaesthetic subacromial bursa injection. Identification of negative predictors may inform the clinical reasoning process by indicating when bursitis may not be the source of nociception. This may aid clinical diagnosis and thereby assist in the development of appropriate treatment strategies. Further, the identified predictors may facilitate the selective use of invasive injection therapies in people with shoulder pain and avoid unnecessary use in those for whom it is unlikely to change symptoms.

The aims of this study were to (1) investigate the association between presence of subacromial bursal pathology and response to subacromial bursal anaesthetic injection; (2) identify variables that predict a negative anaesthetic response in those with shoulder pain and subacromial bursa pathology observed on ultrasound and (3) calculate the diagnostic accuracy of predictors of a negative anaesthetic response.

METHODS

The data analysed in this retrospective cross-sectional study were collected prospectively, as part of a wider diagnostic accuracy study of shoulder pain in primary care (Cadogan et al., 2011). The study procedures for the primary study have been described previously (Cadogan et al., 2011), and thus only key procedures are described below.

Participant population

A total of 373 consecutive participants with a new episode of shoulder pain attending their GP or a physiotherapist were referred into the study between July 2009 and June 2010. Participants included were over 18 years of age, able to read written instructions, presenting for the first time with a new episode of shoulder pain and without contraindications to injection procedures such as infection of overlying skin and allergy to local anaesthetic.

Those with pain of cervical origin, previous surgery to the shoulder or cervical region, sensorimotor deficits of the upper limb and history of fracture or dislocation of the shoulder were excluded. Ethical approval for the current study was granted by the University of Otago Human Ethics Committee (reference number HD19/041). Participants gave written consent for all examinations and procedures. A total of 208 participants were included and their data were used for analyses in the current study.

History and self-report questionnaires

Participants completed medical screening and history questionnaires, a symptom chart, the Short Form-8™ health survey (Ware et al., 2001), the Fear Avoidance Beliefs Questionnaire (FABQ) (Waddell et al., 1993) and the Shoulder Pain and Disability Index (SPADI) (Roach et al., 1991).

Physical examination

Participants underwent a standardised physical examination performed by an experienced physiotherapist (AC).

Imaging

Standard x-ray series and ultrasound evaluation of the shoulder were completed by radiographers and trained musculoskeletal sonographers. Findings were reported on a standardised form by fellowship trained radiologists.

Diagnosis of subacromial bursitis

For the purpose of this current study, criteria for diagnosis of subacromial bursitis (SAB) includes the following ultrasonographic features: hypoechoic fluid or effusion present and > 2 mm thick; or bursal thickening ≥ 2 mm, measured from the deep margin of deltoid to the superficial margin of supraspinatus. The diagnostic criteria were similar to previous studies (Cadogan et al., 2012; Chang et al., 2017; Girish et al., 2011; Wang et al., 2019).

Reference standard

An ultrasound-guided diagnostic injection of local anaesthetic into the subacromial bursa was completed by standardised aseptic technique. A 5ml solution of 1% lidocaine hydrochloride (Xylocaine™) was injected by the radiologist. Immediately prior to and 5–15 min post-injection, participants completed up to six of the most painful tests identified on clinical examination. Pain intensity for each test was documented on a 100mm visual analogue scale (VAS). A negative anaesthetic response (NAR) was recorded when a mean reduction in pain intensity of less than 80% over the six tests was reported, consistent with the definition of the primary study (Cadogan et al., 2011).

Blinding

To minimise the influence of bias and under- or over-reporting of symptoms, participants and radiologists were blinded to examination findings and the physiotherapist was blinded to all referring information.

Statistical analyses

Missing data were excluded pairwise. Only those with a pre-injection VAS ≥ 20mm were included in the analysis to allow for a detectable reduction in VAS post-injection (Bogduk, 2013). Analyses were performed using IBM SPSS Statistics (Version 25) predictive analytics software. Diagnostic accuracy was calculated using MedCalc Statistical Software (version 19.1).

Aim 1: Investigate the association between presence of subacromial bursal pathology and response to subacromial bursal anaesthetic injection.

Participants with sufficient data for aim 1 were placed into four groups: group 1, SAB including other ultrasound pathology, e.g., rotator cuff tear, calcific tendinopathy (SAB+); group 2, SAB alone (excluding other ultrasound pathology) (SAB-); group 3, other pathology not including SAB (other not SAB); and group 4, no pathology. Participant flow for aim 1 is shown in Figure 1. Group data were cross tabulated with anaesthetic response (Appendix A). Due to non-parametric distribution of the data, the Kruskal-Wallis test was used to calculate differences in anaesthetic response between groups.

Aim 2: Identify variables that predict a NAR in those with shoulder pain and subacromial bursa pathology observed on ultrasound.

Logistic regression analyses were conducted on variables, which were selected *a priori*, to identify potential predictors of a NAR (Appendix B). Only those with SAB (SAB+ and SAB-) reporting a NAR were included in the analysis (Figure 2). Following the recommendations of Peduzzi et al. (1996) a minimum of 10 events were required for each independent variable to be included in the univariate logistic regression. Variables were checked for collinearity with the dependant variable: NAR (yes or no). The remainder were included in univariate regression with a variable selection cut point of $p \leq 0.25$ (Hosmer et al., 2013). Variables meeting the *a priori* cut point were included in a multivariate regression ($p \leq 0.05$).

Aim 3: Calculate diagnostic accuracy of predictors of NAR

Diagnostic accuracy statistics were calculated including sensitivity, specificity, positive likelihood ratios (LR+), negative likelihood ratios (LR-), predictive values with 95% confidence intervals (CI) of each variable and clustered variables.

RESULTS

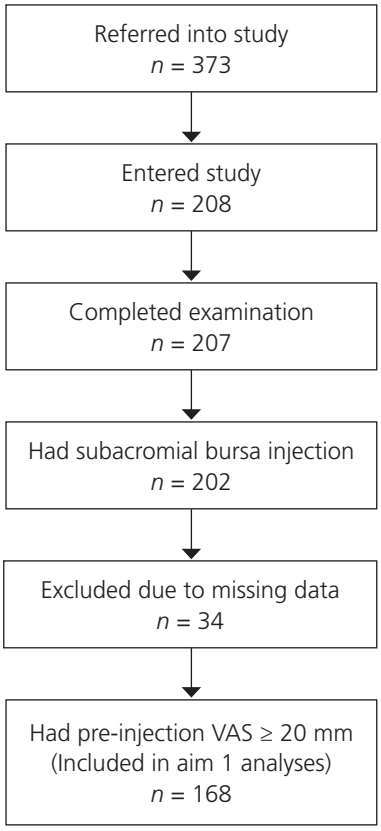
Participants

A total of 208 participants were enrolled in the primary study of whom 207 completed the clinical examination (Cadogan et al., 2011). Of the 202 participants who received a subacromial bursa local anaesthetic injection, 34 participants were excluded due to missing data (incomplete recording of ultrasound findings). A total of 168 participants had a pre-injection VAS ≥ 20mm and were included in the analysis linked to aim 1 (Figure 1). Of the 118 participants with SAB observed on ultrasound, three were excluded due to missing data. Seventy-nine of the remaining 115 had a NAR and were included in the analyses for aims 2 and 3 (Figure 2).

The mean age of participants was 43.4 (SD, 13.9) years, and median symptom duration was 7 weeks (Table 1). Overall prevalence of SAB observed with ultrasound was 57% (118/208) (Figure 2). As indicated in Table 1, there was no statistically significant difference between groups except for employment status.

Figure 1

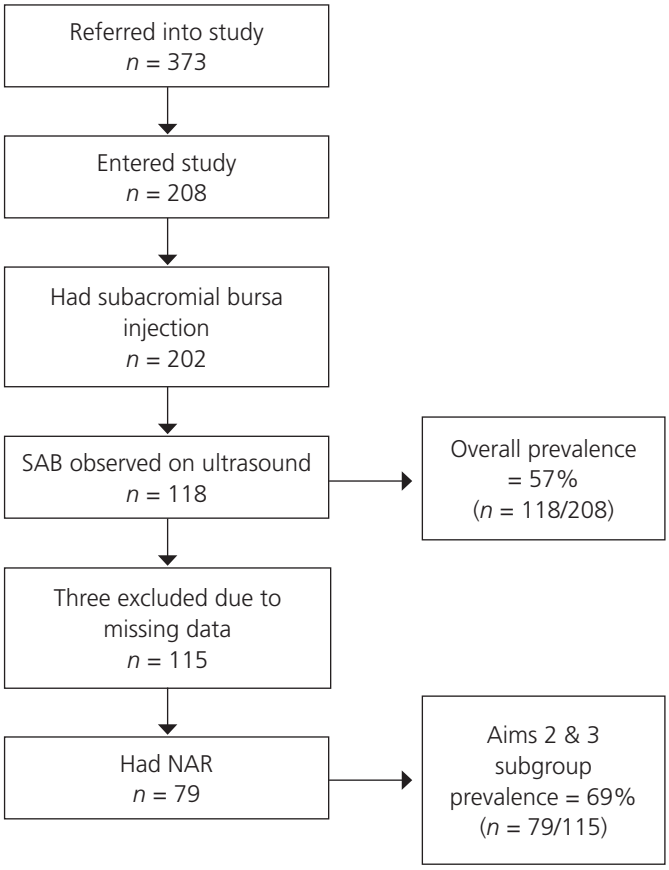
Participant Flow for Aim 1



Note. VAS = visual analogue scale.

Figure 2

Participant Flow for Aims 2 and 3



Note. SAB = subacromial bursitis; NAR = negative anaesthetic response.

Table 1

Participant Characteristics

Characteristic	All				SAB+			SAB-			Other not SAB			No pathology			*p*
	n = 168				*n* = 91			*n* = 24			*n* = 30			*n* = 23			
	M	*SD*	Range	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*	%	
Age (years)	43.4	13.9	18–81		47.4	13.3		37.0	11.9		45.4	12.3		32.1	9.5		0.16
Body mass index	27.4	5.7	19–69		27.6	5.0		25.8	3.6		28.2	5.7		27.7	9.3		0.97
FABQ total %	26.6	16.7	0–79		28.5	17.8		22.7	14.2		26.0	18.0		23.7	11.9		0.28
Pre-injection VAS	68.8	20.1	20–100		71.0	19.8		71.4	18.5		68.4	18.7		57.6	22.1		0.31
Symptom duration (weeks)*	7.0	14.0	0–175		8.0	14.0		7.5	20.0		4.5	14.0		7.0	12.0		0.69
Gender (male)				54.8			56.0			41.7			56.7			60.9	0.57
Right hand dominant				88.1			90.1			87.5			86.7			82.6	0.95
Dominant arm affected				53.6			50.5			62.5			46.7			65.2	0.44
Receiving ACC				92.3			93.4			95.8			83.3			95.7	0.10
Physiotherapist referred				97.0			95.6			100			96.7			100	0.93
Employed				81.5			82.4			79.2			93.3			65.2	0.03**
Smoker				19.8			22.2			16.7			23.3			8.7	0.41

Note. ACC = Accident Compensation Corporation; FABQ = Fear Avoidance and Beliefs Questionnaire; SAB = subacromial bursitis; SAB- = subacromial bursitis excluding other pathology; SAB+ = subacromial bursitis including other pathology; VAS = visual analogue scale.

*Variable non-parametrically distributed, median (interquartile range) presented. **$p < 0.05$.

Aim 1: Investigate the association between presence of subacromial bursal pathology and response to subacromial bursal anaesthetic injection

A Kruskal-Wallis test revealed no statistically significant difference in percentage change of VAS scores across the four groups χ^2 (3, n = 168) = 3.25, p = 0.35 (Table 2).

Table 2

Change in Visual Analogue Scale Scores Following Subacromial Bursa Local Anaesthetic Injection

Group	Total	Median % change	Range
SAB+	91	–68	112
SAB-	24	–54	136
Other not SAB	30	–58	99
No pathology	23	–63	130
Total	168	–63	136

Note. SAB = subacromial bursitis; SAB- = subacromial bursitis excluding other pathology; SAB+ = subacromial bursitis including other pathology. Negative value indicates reduction in post-injection pain score.

Aim 2: Identify variables that predict a NAR in those with shoulder pain and subacromial bursa pathology observed on ultrasound

Of the 29 *a priori* selected independent variables included in the univariate logistic regression, none demonstrated a statistically significant association with a NAR (Appendix C). Five variables met the *a priori* cut point ($p \leq 0.25$) for inclusion in the multivariate analysis: high occupational shoulder demands (p = 0.20); high or low sport/recreational shoulder demands (i.e., not moderate) (p = 0.17); no current history of night pain (p = 0.10); loss of passive external rotation range of motion of more than 30° in neutral (p = 0.25); and shoulder pain reproduced on any cervical test (p = 0.11). Although our data suggested that participants with a loss of passive external rotation range of motion of more than 30° in neutral and those with reproduction of shoulder pain on any cervical test were both 3.6 times more likely to have a NAR (*OR* = 3.6, 95% CI [0.4, 30], p = 0.25; *OR* = 3.6, 95% CI [0.8, 16.7], p = 0.11), this finding should be considered carefully in light of the lack of statistical association. Those with high occupational shoulder demands, high or low sport/recreational demands and those with no current history of night pain were nearly two times more likely to have a NAR (*OR* = 1.9, 95% CI [0.7, 5.0], p = 0.20; *OR* = 1.8. 95% CI [0.8, 4.3], p = 0.17; *OR*, 2.1, 95% CI [0.9, 4.9], p = 0.10). Again, this finding should be considered carefully in light of the lack of statistical association.

No variables demonstrated collinearity with the dependent variable NAR (yes or no). Findings from the multivariate logistic regression analysis performed to explore how well individual variables included in the model predicted a NAR are provided in Table 3. Despite our Hosmer-Lemeshow test indicating good model fit (p = 4.6), none of the predictors were statistically significant in our multivariate analyses.

Table 3

Multivariate Analysis of Predictors of Negative Anaesthetic Response Following Subacromial Bursa Local Anaesthetic Injection

Predictor	*OR*	95% CI		*p*
		LL	*UL*	
High occupational shoulder demands [a]	2.3	0.8	7.1	0.14
High or low sport/recreation shoulder demands [b]	2.2	0.8	5.9	0.13
No current history of night pain	2.0	0.7	5.5	0.17
PROM ER loss > 30°	3.6	0.4	36.3	0.27
Shoulder pain on any cervical spine test [c]	7.8	0.9	67.9	0.06

Note. CI = confidence interval; *LL* = lower limit; *OR* = adjusted odds ratio; PROM ER, passive range of motion external rotation; *UL* = upper limit.

[a] Shoulder occupational demands: low e.g., clerical worker; moderate e.g., tradesperson; high e.g., heavy lifting or frequent overhead work. [b] Sport/recreation demands: low e.g., walking, running, hiking, lawn bowls, easy gardening, handcrafts; moderate e.g., golf, fishing, moderate gardening, soccer, mountain biking; high e.g., swimming, racquet sports, overhead sports, contact sports, throwing sports, weight-lifting, heavy landscaping. [c] Cervical tests: active range of motion, overpressure if pain free and Spurling's test.

Aim 3: Calculate diagnostic accuracy of predictors of NAR

The diagnostic accuracy of the five predictors included in the multivariate analyses are reported in Table 4. Most predictors had high specificity but low sensitivity values. Loss of passive external rotation of more than 30° in neutral and reproduction of shoulder pain on cervical testing both demonstrated the highest specificity of 97%, (95% CI [86, 100]) and 95%, (95% CI [82, 99]), respectively. The predictor with the highest sensitivity was sport/recreational shoulder demands rated as low or high (72%, 95% CI [60, 82]).

The diagnostic accuracy of various numbers of clustered predictors was calculated and data are presented in Table 5. A cluster of three predictors generated the highest specificity of 97.3%, 95% CI [86.0, 100], with a LR+ of 6.1 (95% CI [0.8, 44.8]) and positive predictive value (PPV) of 92.9% (95% CI [63.9, 99.0]). Such a cluster resulted in an increase in post-test probability of a NAR to 93% from the pre-test probability of 69% (Figure 3). The presence of two predictors produced the highest sensitivity of 39.2% (95% CI [28.4, 50.9]) and lowest LR- of 0.9 (95% CI [0.7, 1.1]).

DISCUSSION

Our retrospective cross-sectional study found a lack of association between the presence of bursal pathology observed with ultrasound and anaesthetic response to subacromial anaesthetic injection. Five variables predicted a NAR to subacromial injection in univariate analyses: high occupational shoulder demands; high or low sport/recreational shoulder

Table 4

Diagnostic Accuracy of Individual Predictors in Model

Predictor	TP	FN	FP	TN	Sensitivity			Specificity			Likelihood ratios						PPV			NPV			Post-test probability [a]
	n				%	95% CI		%	95% CI		LR+	95% CI		LR-	95% CI		%	95% CI		%	95% CI		%
						LL	*UL*		*LL*	*UL*		*LL*	*UL*		*LL*	*UL*		*LL*	*UL*		*LL*	*UL*	
High occupational shoulder demands	25	45	7	26	33.8	22.8	46.3	78.8	61.1	91.0	1.6	0.8	3.3	0.8	0.7	1.1	76.7	61.1	87.3	36.6	31.1	42.5	78
High or low sport/ recreation shoulder demands	52	20	20	14	72.2	60.4	82.1	41.2	24.7	59.3	1.2	0.9	1.7	0.7	0.4	1.2	72.2	65.5	78.1	41.2	28.8	54.8	73
No current history of night pain	35	44	10	26	44.3	33.1	55.9	72.2	54.8	85.8	1.6	0.9	2.9	0.8	0.6	1.0	77.8	66.2	86.2	37.1	43.5	62.4	78
PROM ER loss > 30°	7	71	1	36	9.0	3.7	17.6	97.3	85.8	99.9	3.3	0.4	26.0	0.9	0.9	1.0	86.7	60.7	96.5	33.6	31.7	35.6	88
Shoulder pain on any cervical spine test	13	64	2	35	16.9	9.3	27.1	94.6	81.8	99.3	3.1	0.7	13.1	0.9	0.8	1.0	80.0	53.0	94.0	35.4	32.5	38.3	87

Note. CI = confidence interval; FN = false negative; FP = false positive; *LL* = lower limit; LR- = negative likelihood ratio; LR+ = positive likelihood ratio; PPV = positive predictive value; NPV = negative predictive value; PROM ER = passive range of motion external rotation; TN = true negative; TP = true positive; *UL* = upper limit.

[a] Pre-test probability = 69%.

Table 5

Diagnostic Accuracy of Clustered Predictors

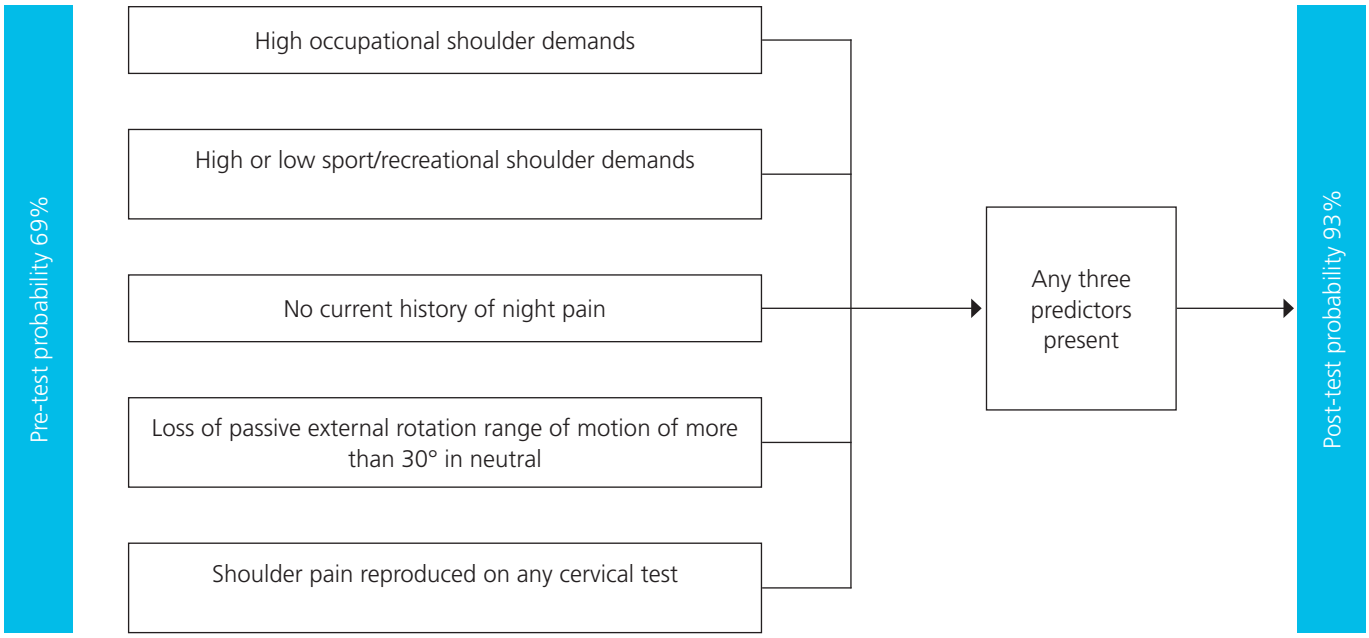
Predictors present	*n*				Sensitivity			Specificity			Likelihood ratios						PPV			NPV			Post-test probability [a]
	TP	FN	FP	TN	%	95% CI		%	95% CI		LR+	95% CI		LR-	95% CI		%	95% CI		%	95% CI		%
						LL	UL		*LL*	*UL*		*LL*	*UL*		*LL*	*UL*		*LL*	*UL*		*LL*	*UL*	
1/5	29	50	14	23	36.7	26.1	48.3	62.2	44.8	77.5	1.0	0.6	1.6	1.0	0.8	1.4	67.4	55.6	77.4	31.5	25.4	38.4	69
2/5	31	48	11	26	39.2	28.4	50.9	70.3	53.0	84.1	1.3	0.8	2.3	0.9	0.7	1.1	73.8	61.5	76.5	35.1	29.2	41.6	74
3/5	13	66	1	36	16.5	9.1	26.5	97.3	85.8	99.9	6.1	0.8	44.8	0.9	0.7	1.0	92.9	63.9	99.0	35.3	32.8	37.9	93
4/5	1	78	0	37	1.3	0.0	6.9	100	90.5	100	— [b]			1.0	1.0	1.0	100			32.2	31.6	32.7	— [b]
5/5	0	79	0	37	— [b]			— [b]			— [b]			1.0	1.0	1.0	— [b]			31.9	31.9	31.9	— [b]

Note. CI = confidence interval; FN = false negative; FP = false positive; *LL* = lower limit; LR- = negative likelihood ratio; LR+ = positive likelihood ratio; PPV = positive predictive value; NPV = negative predictive value; TN = true negative; TP = true positive; *UL* = upper limit.

[a] Pre-test probability - 69%. — [b] Missing information due to only one or no participants scoring positively for 4 or 5 out of 5 variables.

Figure 3

Post-test Probability of Predictors and Clustered Predictors



demands; no current history of night pain; loss of passive external rotation range of motion of more than 30° in neutral; and reproduction of shoulder pain on cervical testing. None of these variables predicted a NAR in multivariate analyses. However, clusters of three of the five predictors demonstrated clinically useful diagnostic accuracy to help identify those who are unlikely to respond to subacromial bursal anaesthetic injection. These results should be interpreted with caution due to wide confidence intervals and lack of statistical significance of identified predictors from our univariate analyses.

The overall prevalence of SAB in this symptomatic primary care population was 57% (118/208) (Figure 2); however, it is necessary to establish the clinical relevance of bursitis observed with ultrasound to the patients' symptoms, particularly if targeted interventions such as corticosteroid injections are being considered. Our findings suggest that subacromial bursa local anaesthetic injection reduces shoulder pain regardless of the presence, or lack, of pathology observed with ultrasound. These findings are comparable to Bouju et al. (2014) who found bursal abnormalities observed with ultrasound did not predict efficacy of subacromial injection of local anaesthetic only. However, this contrasts with the findings of Lee et al. (2017) who reported significantly greater pain reduction following corticosteroid injection in those with bursitis. Methodological differences may explain the contrasting results. In our study, pain reduction was measured within 15 min post-injection (anaesthetic only), whereas in the study by Lee et al. (2017) pain reduction was measured eight weeks post-injection, at which point, response to the injected corticosteroid may have been systemic. The subacromial bursa is well vascularised and in anatomical proximity to the rotator cuff tendons, and the coracohumeral and superior glenohumeral ligaments (Põldoja et al., 2017). It is likely that over the eight weeks, the corticosteroid may have infiltrated surrounding anatomical structures (e.g., the rotator cuff tendons). The immune response and anti-inflammatory effects of the steroid may have decreased nociception related to these structures, therefore reducing confidence in the assumption that the subacromial bursa was the nociceptive generator. Participant symptoms during this time course may also have improved due to natural history.

We also identified significant pain reduction in people without any shoulder pathology detected with ultrasound. Although we have not attempted to investigate the reported pain reduction in this group, it is possible that there was pathology present but that this was undetected by ultrasound (Levine et al., 2012; Pavic et al., 2013). An alternative explanation could be a placebo effect in response to the subacromial bursal injection (Simmonds, 2000) or that low pre-injection pain levels may have led to inaccurate post-injection pain reduction due to diurnal variation (Bogduk, 2013).

Despite our multivariate regression analyses not meeting statistical significance, the variables identified in our univariate regression analyses may be associated with alternative pathologies or normal adaptive variation, which support findings from previous studies. Loss of passive external rotation is a finding frequently associated with glenohumeral joint pathology such as osteoarthritis or frozen shoulder (Cadogan & Mohammed, 2016), which are typically responsive to injection of the glenohumeral joint (Burbank et al., 2008; Cadogan & Mohammed, 2016; Le et al., 2017). Reproduction of shoulder pain on cervical testing (active range of motion, overpressure if pain free and Spurling's test) indicates somatic referred pain of cervical spine origin or radicular pain, which can refer into the regions commonly described by those with shoulder pain such

as the lateral arm (Bokshan et al., 2016; Walker et al., 2018). Pain of cervical origin is unlikely to respond to subacromial bursal anaesthetic injection. Our findings suggest that, if a patient's shoulder pain is reproduced with cervical spine examination or if they have a significant (> 30°) loss of passive shoulder external rotation in neutral, they may not to respond to targeted bursal injections regardless of the appearance of bursal pathology observed with ultrasound.

Bursal thickening can be an adaptive response to occupational or recreational load or a normal anatomical variation. Connor et al. (2003) found bursal fluid in 47.5% of asymptomatic overhead athletes on magnetic resonance imaging. As such, a NAR could be anticipated in those with bursal thickening who report high occupational or sport/recreational demands. Low sport/recreation demands was an unexpected predictor of NAR; however, Girish et al. (2011) report bursal thickening can be a normal anatomical variation. Alternatively, pain may be related to pathology undetected by ultrasound such as intra-articular pathology, which would not be expected to respond to subacromial bursa injection.

Night pain is frequently described by those with shoulder pathology including rotator cuff tears and other subacromial pathologies (Gumina et al., 2016; Mulligan et al., 2015). Further, pro-inflammatory cells and pain mediators have been identified in the subacromial bursa of patients with shoulder pain and rotator cuff disease (Feng et al., 2019). Local anaesthetics act by blocking sodium channels and preventing nerve conduction (Catterall & Mackie, 2011). Injection of local anaesthetic into the subacromial bursa prevents nociception in those with symptomatic subacromial pathology. Therefore, it could be expected that those with night pain would be more likely to experience a positive anaesthetic response and those without night pain may be more likely to experience a NAR. In our study, absence of night pain was detected in univariate analysis as a possible predictor of a NAR. This may suggest that patients without night pain derive less benefits from anti-inflammatory therapies such as corticosteroid injections targeting the subacromial bursa, despite bursal pathology observed with ultrasound. However, it should be reiterated that the variables discussed above did not reach statistical significance in regression analysis. It is advised that these variables are not utilised in isolation for decision making regarding the use of subacromial injection.

In our study, we found four of the five identified predictors had specificity and positive predictive values that suggest they have some clinical utility for identifying patients who are unlikely to respond to a bursal injection. Predictors that resulted in the greatest change from pre- to post-test probability were loss of passive external rotation more than 30° (LR+ = 3.3) and shoulder pain reproduced on cervical spine testing (LR+ = 3.1) (Table 4). When a cluster of any three predictors was present, post-test probability increased from 69% to 93% (Table 5). These results should, however, be interpreted with caution due to wide confidence intervals and predictors not reaching significance levels in our multivariate regression analyses. The poor sensitivity, negative predictive value and negative likelihood ratios suggest that the absence of the predictors may not assist in ruling out a NAR.

Our study adds support to the evidence that the subacromial bursa may not be a nociceptive generator in patients despite structural changes of the bursa being observed with ultrasound. Reduction of reported pain levels following subacromial bursal injection was not statistically different between those with or without bursal pathology observed with ultrasound. These findings may assist clinicians in correlating ultrasound reports with clinical findings and patient education.

To our knowledge, predictors of a negative response following an anaesthetic injection into the subacromial bursa have not been investigated previously. With emerging research, physiotherapists are gaining a greater understanding of the prevalence of imaged pathology and its relevance to symptoms. Using evidence-based practice to identify those unlikely to respond to a local anaesthetic bursal injection may facilitate improved treatment planning and patient education in line with best-practice guidelines (Lin et al., 2019). Often patients' understanding of persistent pain is tissue-based. The use of education and treatments that reduce anxiety and fear and minimise unnecessary investigations and treatments could improve patients' pain experience and outcome (Caneiro et al., 2019; Lin et al., 2019).

The strengths of this cross-sectional study include evaluating a large primary care population with shoulder pain in New Zealand. This allows the study findings to be translated into day-to-day practice. However, the following limitations need to be acknowledged. First, it is unknown how long the local anaesthetic was contained within the subacromial bursa. As it was not possible to track the injectate with ultrasound we were unable to be certain the subacromial bursa was the only structure targeted by the Xylocaine™, which may confound results. To mitigate this, the index tests were repeated within 15 min of injection administration, thus limiting the effects of ongoing infiltration of the local anaesthetic. Second, the numbers of patients in whom predictors were present were low for some variables. It is possible that other variables may have reached our cut point ($p \leq 0.25$) had there been greater numbers. The wide confidence intervals of adjusted *OR*s and diagnostic accuracy calculations also suggest a larger sample size was needed. Third, the cut point used for NAR (< 80% reduction in VAS scores) was based on accepted anaesthetic response criteria to anaesthetic blocks (Bogduk, 2013) and sample size. However, 80% could be considered a high cut point for a NAR, and a reduction of less than 50% may be considered both appropriate and clinically relevant, although this is likely to have resulted in a smaller sample size with analytical implications.

CONCLUSION

Our study findings suggest that not all bursal pathology identified by ultrasound is symptomatic and that the administration of injection therapy based upon ultrasound findings may not be beneficial for some people with such findings. The high specificity and moderate LR+ associated with the presence of any three of the five predictors (high occupational shoulder demands; low or high sport/recreational shoulder demands; no current history of night pain; loss of passive external rotation more than 30°; and shoulder pain

reproduced on cervical spine testing) provides support for an assumption that a patient with such a finding would be more likely not to respond to targeted injection therapies. Ultrasound results should be considered alongside clinical findings to better inform decisions regarding most appropriate treatment. This may lead to a reduction in the use of unnecessary injections in patients with shoulder pain.

KEY POINTS

1. Subacromial bursitis on ultrasound is not always symptomatic.
2. Of the five identified predictors, loss of passive external rotation range of motion of more than 30° in neutral, reproduction of shoulder pain on cervical testing; or a cluster of any three predictors resulted in the greatest post-test probability values. The presence of these predictors may help identify patients less likely to respond to injection therapies targeting the subacromial bursa. Although these did not reach statistical significance level they are of clinical relevance.
3. The absence of predictors does not imply symptomatic subacromial bursitis as indicated by the poor sensitivity and negative likelihood ratios of the identified predictors.
4. Findings should be interpreted with caution due to methodological limitations, e.g., lack of prospective validation in an independent sample, relatively broad criteria for negative anaesthetic response and low numbers of participants in later analyses.

DISCLOSURES

No funding was obtained for the completion of this retrospective cross-sectional study. There are no conflicts of interest that may be perceived to interfere with or bias this study.

PERMISSIONS

Permission was granted to complete this retrospective cross-sectional study by the University of Otago Human Ethics Committee (reference number HD19/041). All patients involved in the study provided written informed consent for participation.

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REFERENCES

Accident Compensation Corporation. (2019, August 27). *Official Information Act (OIA) response 50623: Shoulder injuries and imaging claims, x-rays and scans, 2017/18 and 2018/19* [Data set].

Bogduk, N. (2009). On the rational use of diagnostic blocks for spinal pain. *Neurosurgery Quarterly, 19*(2), 88–100. https://doi.org/10.1097/WNQ.0b013e3181a32e8b

Bogduk, N. (2013). *Practice guidelines for spinal diagnostic and treatment procedures*. International Spine Intervention Society.

Bokshan, S. L., DePasse, J. M., Eltorai, A. E. M., Paxton, E. S., Green, A., & Daniels, A. H. (2016). An evidence-based approach to differentiating the cause of shoulder and cervical spine pain. *American Journal of Medicine, 129*(9), 913–918. https://doi.org/10.1016/j.amjmed.2016.04.023

Bouju, Y., Bouilleau, L., Dubois de Montmarin, G., Bacle, G., & Favard, L. (2014). Do subacromial ultrasonography findings predict efficacy of intra-bursal injection? Prospective study in 39 patients. *Orthopaedics & Traumatology: Surgery & Research, 100*(8, Supplement), S361–S364. https://doi.org/10.1016/j.otsr.2014.09.003

Burbank, K. M., Stevenson, J. H., Czarnecki, G. R., & Dorfman, J. (2008). Chronic shoulder pain: Part I. Evaluation and diagnosis. *American Family Physician, 77*(4), 453–460.

Cadogan, A., Laslett, M., Hing, W. A., McNair, P. J., & Coates, M. H. (2011). A prospective study of shoulder pain in primary care: Prevalence of imaged pathology and response to guided diagnostic blocks. *BMC Musculoskeletal Disorders, 12*, Article 119. https://doi.org/10.1186/1471-2474-12-119

Cadogan, A., Laslett, M., Hing, W., McNair, P., & Taylor, S. (2012). Clinical predictors of a positive response to guided diagnostic block into the subacromial bursa. *Journal of Rehabilitation Medicine, 44*(10), 877–884. https://doi.org/10.2340/16501977-1049

Cadogan, A., & Mohammed, K. D. (2016). Shoulder pain in primary care: Frozen shoulder. *Journal of Primary Health Care, 8*(1), 44–51. https://www.readcube.com/articles/10.1071%2Fhc15018

Caneiro, J. P., Roos, E. M., Barton, C. J., Sullivan, K., Kent, P., Lin, I., Choong, P., Crossley, K. M., Hartvigsen, J., Smith, A. J., & Sullivan, P. (2019). It is time to move beyond 'body region silos' to manage musculoskeletal pain: Five actions to change clinical practice. *British Journal of Sports Medicine, 54*(8), 438–439. https://doi.org/10.1136/bjsports-2018-100488

Cardone, D. A., & Tallia, A. F. (2002). Joint and soft tissue injection. *American Family Physician, 66*(2), 283–288.

Catterall, W. A., & Mackie, K. (2011). Local anesthetics. In L. Brunton, B. A. Chabner, & B. Knollman (Eds.), *Goodman & Gilman's: The pharmacological basis of therapeutics* (12th ed., pp. 565–582). McGraw-Hill.

Chang, K.-V., Wu, W.-T., Han, D.-S., & Özçakar, L. (2017). Static and dynamic shoulder imaging to predict initial effectiveness and recurrence after ultrasound-guided subacromial corticosteroid injections. *Archives of Physical Medicine and Rehabilitation, 98*(10), 1984–1994. https://doi.org/10.1016/j.apmr.2017.01.022

Chard, M. D., Hazleman, R., Hazleman, B. L., King, R. H., & Reiss, B. B. (1991). Shoulder disorders in the elderly: A community survey. *Arthritis & Rheumatology, 34*(6), 766–769. https://doi.org/10.1002/art.1780340619

Connor, P. M., Banks, D. M., Tyson, A. B., Coumas, J. S., & D'Alessandro, D. F. (2003). Magnetic resonance imaging of the asymptomatic shoulder of overhead athletes: A 5-year follow-up study. *American Journal of Sports Medicine, 31*(5), 724–727. https://doi.org/10.1177/03635465030310051501

Daghir, A. A, Sookur, P. A, Shah, S., & Watson, M. (2012). Dynamic ultrasound of the subacromial–subdeltoid bursa in patients with shoulder impingement: A comparison with normal volunteers. *Skeletal Radiology, 41*(9), 1047–1053. https://doi.org/10.1007/s00256-011-1295-z

Feng, H., He, Z., Twomey, K., Ilaltdinov, A. W., Leong, D., Wang, Y., Li, J., Gonzalez, D., & Sun, H. B. (2019). Epigallocatechin-3-gallate suppresses pain-related and proinflammatory mediators in the subacromial bursa in rotator cuff tendinopathy. *Discovery Medicine, 27*(147), 63–77.

Girish, G., Lobo, L. G., Jacobson, J. A., Morag, Y., Miller, B., & Jamadar, D. A. (2011). Ultrasound of the shoulder: Asymptomatic findings in men. *AJR. American Journal of Roentgenology, 197*(4), W713–W719. https://doi.org/10.2214/AJR.11.6971

Gumina, S., Candela, V., Passaretti, D., Venditto, T., Mariani, L., & Giannicola, G. (2016). Sleep quality and disturbances in patients with different-sized rotator cuff tear. *Musculoskeletal Surgery, 100*(Supplement 1), 33–38. https://doi.org/10.1007/s12306-016-0405-4

Hosmer, D. W., Jr., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied logistic regression* (Vol. 398). [ebook]. Wiley.

Le, H. V., Lee, S. J., Nazarian, A., & Rodriguez, E. K. (2017). Adhesive capsulitis of the shoulder: Review of pathophysiology and current clinical treatments. *Shoulder & Elbow, 9*(2), 75–84. https://doi.org/10.1177/1758573216676786

Lee, D.-H., Hong, J. Y., Lee, M. Y., Kwack, K.-S., & Yoon, S.-H. (2017). Relation between subacromial bursitis on ultrasonography and efficacy of subacromial corticosteroid injection in rotator cuff disease: A prospective comparison study. *Archives of Physical Medicine and Rehabilitation, 98*(5), 881–887. https://doi.org/10.1016/j.apmr.2016.11.025

Levine, B. D., Motamedi, K., & Seeger, L. L. (2012). Imaging of the shoulder: A comparison of MRI and ultrasound. *Current Sports Medicine Reports, 11*(5), 239–243. https://doi.org/10.1249/JSR.0b013e31826b6baa

Lewis, J. (2016). Rotator cuff related shoulder pain: Assessment, management and uncertainties. *Manual Therapy, 23*, 57–68. https://doi.org/10.1016/j.math.2016.03.009

Lin, I., Wiles, L., Waller, R., Goucke, R., Nagree, Y., Gibberd, M., Straker, L., Maher, C., & O'Sullivan, P. P. B. (2019). What does best practice care for musculoskeletal pain look like? Eleven consistent recommendations from high-quality clinical practice guidelines: Systematic review. *British Journal of Sports Medicine*, *54*, 79–86. https://doi.org/10.1136/bjsports-2018-099878

Luime, J. J., Koes, B. W., Hendriksen, I. J. M., Burdorf, A., Verhagen, A. P., Miedema, H. S., & Verhaar, J. A. N. (2004). Prevalence and incidence of shoulder pain in the general population; A systematic review. *Scandinavian Journal of Rheumatology, 33*(2), 73–81. https://doi.org/10.1080/03009740310004667

Mulligan, E. P., Brunette, M., Shirley, Z., & Khazzam, M. (2015). Sleep quality and nocturnal pain in patients with shoulder disorders. *Journal of Shoulder and Elbow Surgery, 24*(9), 1452–1457. https://doi.org/10.1016/j.jse.2015.02.013

Pavic, R., Margetic, P., Bensic, M., & Brnadic, R. L. (2013). Diagnostic value of US, MR and MR arthrography in shoulder instability. *Injury, 44*(Supplement 3), S26–S32. https://doi.org/10.1016/S0020-1383(13)70194-3

Peduzzi, P., Concato, J., Kemper, E., Holford, T. R., & Feinstein, A. R. (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal of Clinical Epidemiology, 49*(12), 1373–1379. https://doi.org/10.1016/s0895-4356(96)00236-3

Põldoja, E., Rahu, M., Kask, K., Weyers, I., & Kolts, I. (2017). Blood supply of the subacromial bursa and rotator cuff tendons on the bursal side. *Knee Surgery, Sports Traumatology, Arthroscopy, 25*(7), 2041–2046. https://doi.org/10.1007/s00167-016-4379-4

Roach, K. E., Budiman-Mak, E., Songsiridej, N., & Lertratanakul, Y. (1991). Development of a shoulder pain and disability index. *Arthritis Care & Research, 4*(4), 143–149. https://doi.org/10.1002/art.1790040403

Simmonds, M. J. (2000). Pain and the placebo in physiotherapy: A benevolent lie? *Physiotherapy, 86*(12), 631–637. https://doi.org/10.1016/S0031-9406(05)61299-0

Urwin, M., Symmons, D., Allison, T., Brammah, T., Busby, H., Roxby, M., Simmons, A., & Williams, G. (1998). Estimating the burden of musculoskeletal disorders in the community: The comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. *Annals of the Rheumatic Diseases, 57*(11), 649–655. https://doi.org/10.1136/ard.57.11.649

Waddell, G., Newton, M., Henderson, I., Somerville, D., & Main, C. J. (1993). A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. *Pain, 52*(2), 157–168. https://doi.org/10.1016/0304-3959(93)90127-B

Walker, T., Salt, E., Lynch, G., & Littlewood, C. (2018). Screening of the cervical spine in subacromial shoulder pain: A systematic review. *Shoulder & Elbow, 11*(4), 305–315. https://doi.org/10.1177/1758573218798023

Wang, J.-C., Chang, K.-V., Wu, W.-T., Han, D.-S., & Özçakar, L. (2019). Ultrasound-guided standard vs dual-target subacromial corticosteroid injections for shoulder impingement syndrome: A randomized controlled trial. *Archives of Physical Medicine and Rehabilitation, 100*(11), 2119–2128. https://doi.org/10.1016/j.apmr.2019.04.016

Ware, J. E. J., Kosinski, M., Dewey, J. E., & Gandek, B. (2001). *How to score and interpret single-item health status measures: A manual for users of the SF-8™ health survey* (3rd ed.). QualityMetric Incorporated.

Appendix A

ANAESTHETIC RESPONSE

Group	Total	PAR	NAR
SAB+	91	34	57
SAB-	24	2	22
Other not SAB	30	10	20
No pathology	23	5	18
Total	168	51	117

Note. NAR = negative anaesthetic response; PAR = positive anaesthetic response; SAB = subacromial bursitis; SAB+ = subacromial bursitis including other pathology; SAB- = subacromial bursitis excluding other pathology.

Appendix B

A PRIORI VARIABLES INCLUDED IN LOGISTIC REGRESSION ANALYSES

Variable type	Variable
Demographic	Gender
	Age
	Co-existing health condition
	BMI
Outcome measure	SF-8 mental component
	SF-8 physical component
	SPADI
	FABQ
History	Description of current episode
	Mechanism of onset
	Shoulder 100% prior to onset
	Occupational shoulder demand
	Sport/recreation shoulder demand
	Main pain description
	Pain nature
	Pain medication taken within last 24 hr
	No current history of night pain
Physical examination	Positive Hawkins Kennedy
	Positive empty can
	Positive AROM abduction painful arc
	PROM ER loss of > 30°
	Shoulder pain reproduced on any cervical spine test
	Resisted abduction painful and weak
	Resisted abduction painful and strong
	Resisted ER painful and weak
	Resisted ER painful and strong
	Resisted IR painful and weak
	Resisted IR painful and strong
Radiographic	Pathology on x-ray

Note. AROM = active range of motion; BMI = body mass index; ER = external rotation; FABQ = Fear Avoidance and Beliefs Questionnaire; IR = internal rotation; PROM ER = passive range of motion external rotation; SF-8 = Short Form-8 health survey; SPADI = Shoulder Pain and Disability Index.

Appendix C

UNIVARIATE LOGISTIC REGRESSION OF *A PRIORI* VARIABLES: PREDICTORS OF A NEGATIVE ANAESTHETIC RESPONSE TO SUBACROMIAL BURSA LOCAL ANAESTHETIC INJECTION

Variable type	Variable name	*OR*	95% CI		*p*
			LL	*UL*	
Demographic	Gender (1= male, 0 = female)	1.0	0.5	2.4	0.86
	Age (continuous)	1.0	0.8	1.3	0.95
	Co-existing health factors (1 = yes, 0 = no)	0.8	0.3	2.0	0.64
	BMI high (1 = yes, 0 = no)	0.8	0.4	2.1	0.84
	SF-8 mental component (continuous)	0.1	1.0	1.0	0.89
	SF-8 physical component (continuous)	1.0	1.0	1.1	0.72
	SPADI total (continuous)	1.0	1.0	1.0	0.70
	FABQ total (continuous)	1.0	1.0	1.0	0.48
History	Description current episode (1 = new, 0 = recurrent)	1.2	0.4	3.3	0.74
	Mechanism of onset				
	1 = trauma	1.2	0.3	4. 8	0.84
	2 = strain	0.5	0.1	1.9	0.28
	3 = repetitive/overuse	0.5	0.1	2.3	0.36
	Shoulder previously 100% (1 = yes, 0 = no)	0. 9	0.3	2.5	0.83
	Occupational shoulder demands				
	1 = low	0. 9	0.4	2.1	0.79
	2 = moderate	0.6	0.3	1.5	0.31
	3 = high	1.9	0.7	5.0	0.20*
	Sport/recreational shoulder demands				
	1 = low	0.6	0.2	2.1	0.45
	2 = moderate**	-0.6	0.2	1.3	0.17*
	3 = high	1.3	0.6	2.9	0.59
	Sport/recreational shoulder demands NOT moderate (e.g., high or low) (1 = yes, 0 = no)	1.8	0.8	4.3	0.17*
	Main pain description				
	1 = sharp	1.4	0.7	3.2	0.37
	2 = aching	0.8	0.3	1.8	0.53
	3 = sharp and aching	0.9	0.3	2.2	0.75
	Pain nature (1 = constant, 0 = intermittent)	0.7	0.3	1.6	0.42
	Analgesics taken in last 24 hr (1 = yes, 0 = no)	1.9	0.6	5.5	0.26
	No current history of night pain (1 = yes, 0 = no)	2.1	0.9	4.9	0.10*
Clinical exam	Hawkins Kennedy (1 = yes, 0 = no)	1.4	0.6	3.3	0.39
	Empty can (1 = yes, 0 = no)	1.0	0.4	2.7	0.97
	AROM abduction painful arc (1 = yes, 0 = no)	1.2	0.5	2.9	0.62
	PROM external rotation loss > 30° (1 = yes, 0 = no)	3.6	0.4	30.0	0.25*
	Shoulder pain reproduced on any cervical spine test (1 = yes, 0 = no)	3.6	0.8	16.7	0.11*
	Resisted abduction, painful weak (1 = yes, 0 = no)	1.0	0.4	2.5	0.97
	Resisted abduction, painful strong (1 = yes, 0 = no)	1.4	0.1	3.1	0.44
	Resisted external rotation painful weak (1 = yes, 0 = no)	1.5	0.4	4.9	0.53
	Resisted external rotation painful strong (1 = yes, 0 = no)	1.4	0.7	2.6	0.39
	Resisted internal rotation painful weak (1 = yes, 0 = no)	0.8	0.3	2.1	0.61
	Resisted internal rotation painful strong (1 = yes, 0 = no)	0.9	0.4	2.0	0.74
Radiology	X-ray – any pathology (1 = yes, 0 = no)	0.7	0.3	1.5	0.35

Note. AROM = active range of motion; BMI = body mass index; FABQ = Fear Avoidance and Beliefs Questionnaire; *LL* = lower limit; PROM = passive range of motion; SF-8 = Short Form-8 health survey; SPADI = Shoulder Pain and Disability Index; *UL* = upper limit.

*$p \leq 0.25$. **Due to negative *OR*, NOT moderate sport/recreational shoulder demands was utilised and renamed high or low for clarity.