PRACE ORYGINALNE I KLINICZNE

Risk factors for occurrence of failed interscalene brachial plexus blocks for shoulder arthroscopy using 20 mL 0.5% ropivacaine: a randomised trial

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Abstract

Background: Adequate pain management after arthroscopic procedures improves patients' satisfaction with the performed procedure, as well as facilitating early rehabilitation. The aim of the current randomised, prospective clinical study was to assess the influence of anthropometric parameters and the interscalene brachial plexus block (IBPB) technique on the quality of post-operational analgesia.

Methods: 109 randomly selected patients of ASA I–III status were scheduled for elective shoulder arthroscopy. Reasons for non-inclusion were as follows: neurological deficit in the upper arm; allergies to amide Las; coagulopathy; and pregnancy. The patients received 20 mL of 0.5% ropivacaine for an ultrasound (US)-guided IBPB (group U), peripheral nerve stimulation (PNS)-confirmation IBPB (group N), or US-guided, PNS-confirmed IBPB (*dual guidance*; group NU).

Results: We observed that the studied groups did not differ in mean time of sensory and motor block terminations and, surprisingly, in each group in individual cases the sensory block lasted up to 890-990 minutes providing satisfactory long-lasting post-operational analgesia in patients receiving IBPB. We observed a negative correlation between BMI and termination of the motor block and a positive correlation between age and termination of the sensory block in patients receiving US-guided IBPB (group U) in comparison with the two other groups. We found a positive correlation between the male gender and termination of the motor block in patients receiving PNS-guided IBPB (group N) in comparison with two other groups.

Conclusion: In our study, patients received satisfactory analgesia in the post-operational period no matter what technique was used regardless of their age, gender or potentially uncommon anthropometry.

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Unsuccessful regional block is a disappointing complication which makes an anaesthesiologist implement an alternative plan entailing the necessity of either performing additional distal nerves blocks, if possible, or converting to general anaesthesia (GA). Such a situation imposes unwelcomed extra costs, as well as the prolongation of the time needed to prepare the patient for surgical treatment — this is a matter of concern, especially in ambulatory anaesthesia. The introduction of ultrasound visualisation has revolutionised regional anaesthesia (RA) due to the possibility of observing the end of the needle and visualising the spread of local anaesthetic (LA) on the monitor. Moreover, it allows one to reduce the dose of LA [1], shortens the time of the onset of RA [2], minimises the rate of failed blocks [3]

and the occurrence of brachial plexopathy [4], as well as the frequency of other unwelcome adverse events, such as intravascular injections of cardio- or neurotoxic LA [5], and diaphragm paralysis [6, 7] with respiratory disorder [8]. In the end, IPBP produces appropriate analgesia for the postoperative period compared with general anaesthesia, which improves patients' satisfaction [9, 10].

Nevertheless, as incomplete blocks still happen, we assumed that incomplete or failed blocks are likely to occur in specific groups of patients undergoing IBPB. Therefore, the objective of the study is to assess the influence of anthropometric parameters and the technique of IBPB performance on the risk for interscalene brachial plexus block failure.

METHODS

The prospective, randomised, clinical study was approved by the Bioethics Committee of the Silesian University of Medicine in Katowice. The study was planned according to the statement on Human and Animal Rights. The study adhered to the tenets of the Declaration of Helsinki. Data were obtained from 109 patients with American Society of Anesthesiologists (ASA) grades I–III, who underwent elective shoulder arthroscopy. Using the sealed envelope method, patients aged 18–60 years, who had given written informed consent, were randomly allocated to one of three groups, namely: N — 34 patients, U — 37 patients, NU — 38 patients. Each group underwent IBPB with a different technique. All blocks were performed using 0.5% ropivacaine. Exclusion criteria were as follows: neurological deficit in the upper arm; allergies to amide Las; coagulopathy; pregnancy; and withdrawal of previously given written consent. After the block was performed, the duration, onset time, and block effectiveness according to the modified Lovett rating scale (LRS) were studied. When insufficient block occurred, conversion to general anaesthesia was performed.

In the morning before the surgery, all patients were premedicated with 7.5 mg of oral midazolam. In the operating theatre, venous access was placed, and 500 mL of crystalloid solution was infused. All patients received 0.1 mg of fentanyl intravenously to improve comfort during regional anaesthesia. Patients' heart rate, oxygen saturation of arterial blood, noninvasive systolic arterial pressure, diastolic arterial pressure, mean arterial pressure, and electrocardiogram were continuously monitored using a multiparameter anaesthetic monitor. Data were recorded with a 5-min sampling time in the anaesthetic protocol.

In the N group, all blocks were carried out using Meier's modification (the needle insertion point was at the level of the thyroid cartilage), and the needle was directed at a 30° angle towards the middle part of the clavicle; this modification is known to be as safe and more efficient than the traditional Winnie access site. The procedure was started with palpational examination of the scalene muscles in the medial neck triangle and the interscalene groove located between them. Palpation time was included in the regional block time. After skin sterilisation, local anaesthesia was performed using 1 mL of 1% lidocaine solution. IBPB was performed using a Contiplex D set (Contiplex D, B. Braun, Germany) connected to a nerve stimulator (Stimuplex HNS12, B. Braun, Germany). The stimulator settings were as follows: current, 0.3 mA; impulse time duration, 0.1 ms; and impulse frequency, 1 MHz. Motor response of either the pectoral muscles or the triceps or biceps brachii was considered to indicate proper needle placement. Subsequently, 20 mL of 0.5% ropivacaine was administered. A catheter was placed in the region of the anaesthetised BP (brachial plexus) for postoperative pain treatment with continuous infusion of 0.2% ropivacaine.

In the U group, BP roots/trunks were visualised using an ultrasound system (Sonosite M-Turbo, Sonosite) equipped with a 13-MHz linear probe (HFL38/13-6 MHz, Sonosite). The procedure was initiated with a precise ultrasonographic scan of the lateral neck triangle. The examination time was included in the IBPB time. After skin disinfection, local anaesthesia was performed using 1 mL of 1% lidocaine solution. The ultrasound transducer was covered using a sterile cover and was used together with a sterile hypoallergenic transmission gel. IBPB was performed using a Contiplex D set (Contiplex D, B. Braun, Germany) applying an out-of-plane technique similar to that used in group N. Ultrasound guidance was used to ensure proper needle placement, which was followed by the administration of 20 mL of 0.5% ropivacaine. The spread of the LA around the nerve roots was observed on the ultrasound monitor; subsequently, a catheter was placed for continuous infusion of 0.2 % ropivacaine.

In the NU group, although IBPB was performed in a manner similar to that in group U, the needle was attached to a PNS set as in group N. In this group, the placement of the needle was confirmed in two ways — visually, using an ultrasound system, and by electrostimulation (dual guidance). IBPB time was calculated until the end of the 0.5% ropivacaine injection. The time of catheter placement was calculated from the end of LA administration until the end of sterile catheter dressing placement.

All blocks were performed by experienced anaesthesiologists already skilled in both techniques. IBPB's effectiveness and onset times were assessed by anaesthesiologists who were unaware of the patients' group allocations and who did not perform the IBPBs in this study. Sensory block examinations were performed at 5-min intervals by using ethanol-sprayed woollen swabs and 22G needle pinpricks. Motor block examinations were performed according to the modified Lovett's Rating Scale (LRS), namely: 6 — normal muscular force; 5 — slightly reduced muscular force;

4 — pronounced reduction of muscular force; 3 — slightly impaired mobility; 2 — pronounced mobility impairment; 1 — almost complete paralysis; and 0 — complete paralysis. IBPB duration was calculated as the time interval from a satisfactory sensory block until the very first pain perception requiring infusion of LA via the catheter placed in the region of the BP roots/trunks.

In the operating room, patients were assisted by anaesthesiologists who were not involved in the study. Their role was to administer proper sedation by continuous intravenous infusion of propofol (Propofol 1% Fresenius, Fresenius Kabi) or single doses of intravenous midazolam (Sopodorm, ICN Polfa Rzeszów). In the case of pain perception during surgery, conversion to general anaesthesia was performed. Such cases were labelled as failed blocks.

STATISTICAL ANALYSIS

All analysed groups were assessed using the Shapiro-Wilk test for estimating normal distributions. Because most of the distributions were normal, parametric tests were used for statistical analysis. Homogeneity of variances was assessed by the Levene test. Quantitative variables were compared using Student's t-test and one-way ANOVA. Statistical significance was set at $P < 0.05$.

RESULTS

Patients included in the study did not differ regarding age, height, body mass, or duration time of the surgical procedure. These parameters were comparable in all groups. A total of 44 out of 109 patients receiving IBPB required conversion to GA due to incomplete block which made surgery impossible under regional anaesthesia (Table 1, Fig. 1).

Our observations showed that patients requiring conversion to GA following IBPB were a statistically significant 3 centimetres taller compared with patients with complete IBPB (GA: 176 ± 7.7 cm vs. non-GA: 173.8 ± 8.41; $P = 0.04975$), were a statistically significant 7 kg heavier compared with

Table 1. Rate of failed IBPB

| Group	Conversion to GA	Gender	*P*-value
NU	9 (19%)	M-89%	0.3658
U	11 (22%)	M-80%	0.3596
N	24 (57%)	M-80%	0.5337
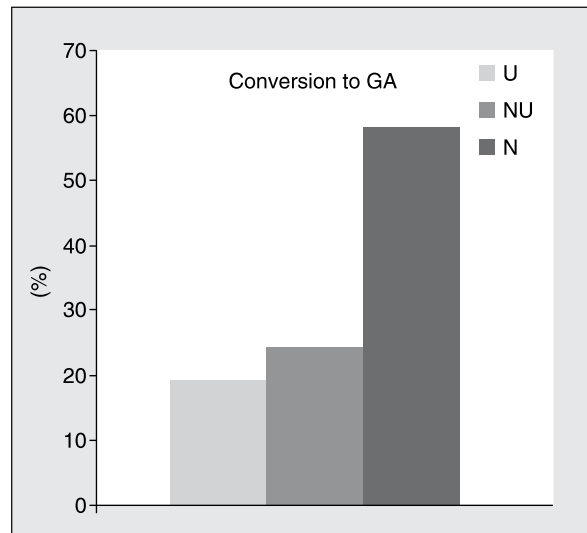
Figure 1. Rate of failed IBPB

patients with complete IBPB U (GA; 84.3 ± 14.51 cm vs. non-GA 77.6 ± 12.29; $P = 0.0078$) and had a statistically significant 1.3 points higher BMI score compared with patients with complete IBPB U (GA: 26.84 ± 3.7 cm vs. non-GA 25.54 ± 3.43; $P = 0.0483$). In terms of patients' age, although we observed a strong tendency towards a negative correlation of the necessity of converting to GA with seniority, this was not statistically significant ($P = 0.07$) (Table 2, Fig. 2).

We compared the global effectiveness of IBPB according to patients' gender and we found out that despite the technique used, only in 20% of female patients receiving

Table 2. Anthropometric parameters of patients with failed IBPB

| Anthro-pometric parameter	Necessity of conversion to GA	N	mean	Standard deviation (SD)	Min	Max	*P*-value
Height (cm)	Yes	42	176.88	7.70	150	197	0.0497
	No	82	173.8	8.41	160	190	
Body mass (kg)	Yes	42	84.3	14.51	50	122	0.0078
	No	82	77.6	12.29	50	103	
BMI (kg m⁻²)	Yes	42	26.84	3.70	18.36	39.39	0.0483
	No	82	23.54	3.43	18.11	33.65	
Age (years)	Yes	42	38.38	14.89	18	64	0.0733
	No	82	43.40	15.17	18	74	
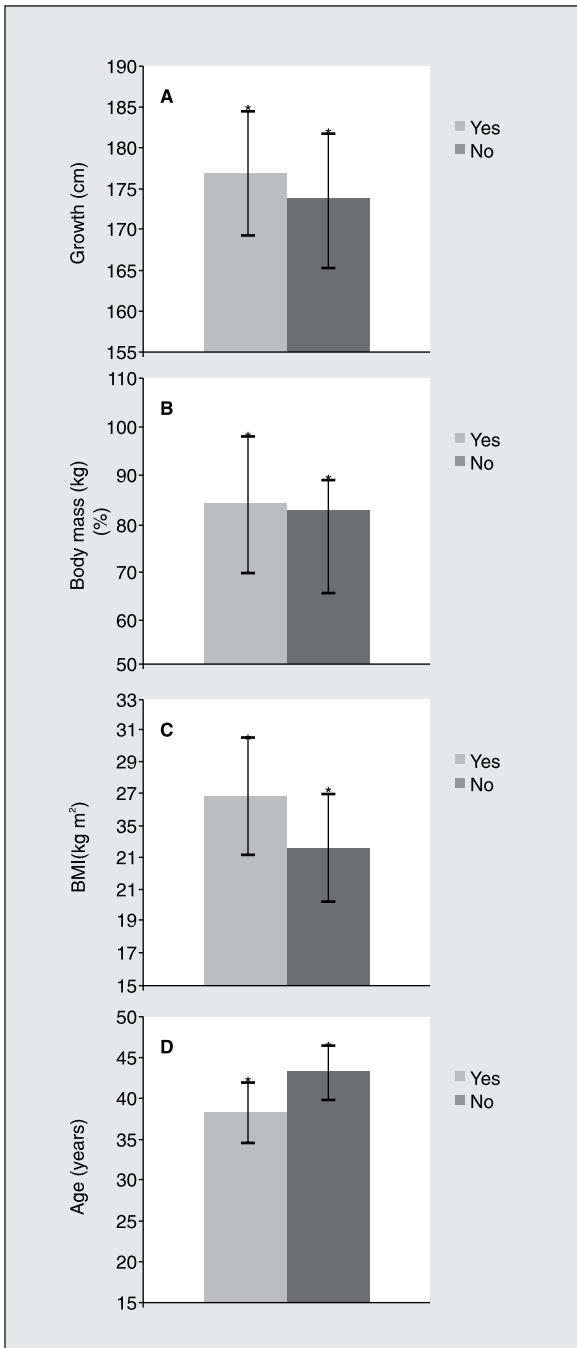
Figure 2. Anthropometric parameters of patients with failed IBPB.
A — growth; B — body mass; C — BMI; D — age

IBPB was there a necessity of converting to GA, whereas the regional block failed in 37% of male patients (F: 20% vs. 80%; M: 37.76% vs. 62.24%, $P = 0.0463$). This was deemed statistically significant (Table 3, Fig. 3).

In order to understand the correlation between failed block risk and patients' gender, we also carried out a comparative analysis of Lovett's Rating Scale scores and patients' gender despite their group allocation. We encountered an unexpected result showing that in female patients there

Table 3. Lovett's Rating Scale scores of female and male patients

LRS	Gender	
	F	M
	%	%
0	64.29	17.86
1	7.14	35.71
2	17.86	14.29
3	7.14	14.29
4	3.57	17.86
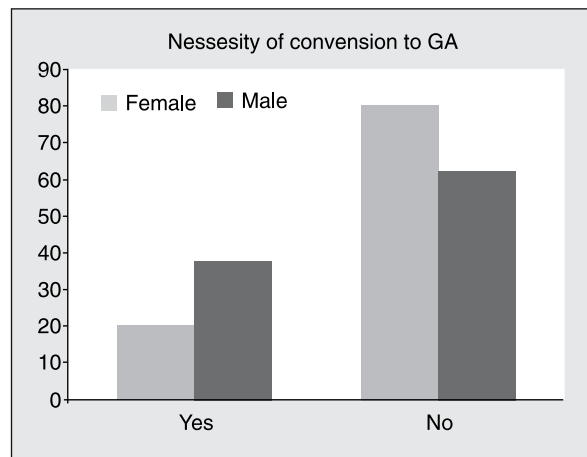
Figure 3. Necessity of conversion to GA according to patients' gender

was a strong tendency in the direction towards lower LRS in comparison with male patients (Table 4). We carried out an analysis of a potential correlation between patients' anthropometric parameters and failed block according one's allocation to a group differing with the technique of IBPB performance. We did not encounter any statistically significant difference between patients in terms of their height and age, whereas excessive body mass (see Fig. 4), as well as excessive BMI (Fig. 5) appeared to be independent risk factors for the occurrence of failed IBPB in group N (Table 5).

DISCUSSION

To our knowledge, there are few studies aiming to evaluate the risk factors for the occurrence of unsuccessful regional anaesthesia of the brachial plexus performed from different approaches.

Nielsen et al. [11] evaluated 9,038 different regional blocks performed on 6,920 patients and analysed them according to their BMI (< 25 kg m^{-2}, 25–29 kg m^{-2}, ≥ 30 kg m^{-2}). In their study, although the rate of acute complications appeared to be higher in obese patients ($P = 0.001$), when they compared patients with a normal BMI, postoperative pain at rest and overall satisfaction from regional anaesthesia were similar in overweight and obese patients. Their conclu-

Table 4. Anthropometric parameters of patients with failed IBPB according group allocation

Conversion to GA		Yes		No		
		Mean	SD	Mean	SD	P-value
Height (cm)	N	177.27	8.98	172.69	8.57	0.143332
	U	176	6.72	174.47	8.03	0.560074
	NU	177	5.83	173.76	10	0.200472
Body mass (kg)	N	85.77	14.66	74.63	12.96	0.029776
	U	80.55	14.56	79.41	18.6	0.452323
	NU	85.33	14.97	77.85	14	0.2329
BMI (kg m^{-2})	N	27.21	3.64	24.87	2.96	0.044383
	U	25.86	3.77	26.18	7.03	0.395898
	NU	27.15	3.98	25.92	4.63	0.446491
Age (years)	N	39.14	14.03	43	11.14	0.238959
	U	40.73	17.42	41.88	15.64	0.877206
	NU	37.33	14.72	45.38	15.86	0.173196
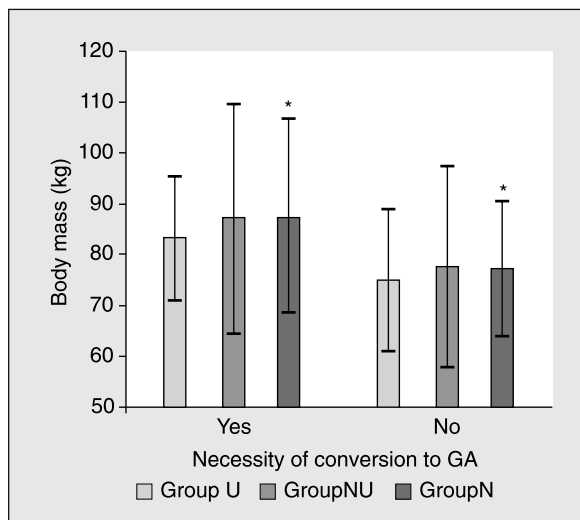
Figure 4. Body mass of patients with failed IBPB according to group allocation
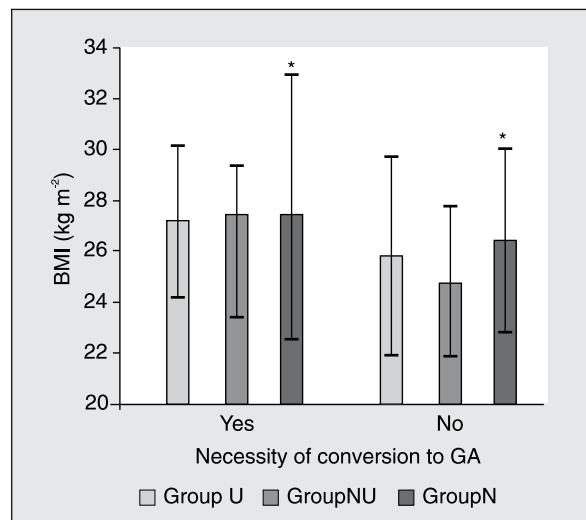
Figure 5. Body mass index (BMI) of patients with failed IBPB according to group allocation

sion was that although obesity was correlated with higher block failure and complication rates in regional anaesthesia performed in the ambulatory setting, the rate of successful blocks and overall satisfaction also remained high in patients with increased BMI. Therefore, the authors underlined that overweight and obese patients should not be excluded from regional anaesthesia procedures in the ambulatory setting. From our point of view, while the results of above analysis revealed only a tendency of a deteriorating feasibility of RA techniques with increasing body weight, the difficulty and specificity of particular regional blocks must be considered separately for each individual procedure. Similarly, Carles *et al.* [12] prospectively studied 1,417 patients undergoing upper limb surgery with a brachial plexus block at the humeral

canal (1,468 blocks) in order to evaluate for the first time the efficacy and safety of the multiple peripheral nerve block technique at the humeral canal (humeral block) with the use of a neurostimulator. They established that the risk of failure increased for any equal or higher stimulation level threshold for the median, ulnar and radial nerves of 0.8 mA, 0.7 mA, 0.6 mA, respectively.

Hanouz *et al.* [13] prospectively studied axillary brachial plexus blocks with a triple-injection technique using 42 mL of ropivacaine 0.5% performed in patients scheduled for upper limb surgery. In their study, they observed that additional nerve blocks at the elbow were performed more frequently in obese than in non-obese patients. They concluded that obesity that obesity (BMI ≥ 30 kg m^{-2}) or = 30 kg m^{-2}

increased the failure rate and immediate complications of axillary brachial plexus block. Furthermore, they encountered an interesting correlation that more obese patients were dissatisfied with received regional anaesthesia. From our experience, the performance of regional block is more challenging with the use of PNS as a method of detection of body landmarks in obese patients due to repeated needle punctures and the more frequent necessity of needle redirections. Koscielniak-Nielsen *et al.* [14] had similar observation. They performed axilliary blocks without sedation and this factor reduced satisfaction with the regional block. A similar interesting conclusion was drawn by Fuzier *et al.* [15], who tried to assess anxiety and pain scores using a numeric scale at different times during the procedure of performing an axilliary block. They concluded that the patient's anxiety level before an axillary brachial plexus block was a risk factor for failure, especially in emergency conditions and suggested evaluating patient anxiety prior to the block and recommended specific anxiolytic treatment prior to a regional anaesthesia procedure.

Schwemmer *et al.* [16] analysed the success rate of 70 consecutive IBPBs performed with US visualisation for total shoulder arthroscopy. In their study, patients were analysed according to their BMI score: overweight patients with a BMI > 25 kg m^{-2} were compared with normal weight patients with a BMI < 25 kg m^{-2}. Autgors achieved complete plexus blockade in 33 patients (94%) of normal weight and in 27 patients (77%) with excessive weight. The difference in the success rates of IBPB was not significant ($P = 0.08$) and they concluded that US used for the guidance of a regional blockade renders similar results despite patients' weight.

In this study, we observed a tendency towards the deteriorating quality of IBPB with an increase in BMI. In our study, patients requiring conversion to GA due to incomplete IBPB had a BMI 1.3 points higher compared with patients in a state of "readiness for operation" following IBPB. The above tendency is especially visible in group N patients, whereas in the case of the addition of US visualisation to neurostimulation for IBPB, the observed tendency disappears. Moreover, withdrawal from PNS-confirmation of needle placement in patients in the U group did not deteriorate the success rate of IBPB, while a tendency towards an incomplete IBPB with an increasing BMI did not occur. In terms of patients' gender, we discovered that, globally, the male gender was an independent risk factor for failed IBPB. As a result, we hypothesise that such a finding may be a result of the hydrophilic potential of ropivacaine [17] rather than the IBPB technique. Assuming that water concentration in female patients' tissues is higher in comparison with male patients and that ropivacaine is characterised as an LA with hydrophilic potency, we may draw the conclusion that in female patients who have been administered ropivacaine, the drug diffuses more easily via the tissues of female patients and in the end produces a successful block, despite the technique used. In contrast, a lower water concentration in the tissues of male patients hinders easy diffusion in the case of imprecise LA administration.

In conclusion, we report that in our study a high BMI, excessive body weight, male gender and tall height were independent global risk factors for incomplete brachial plexus block, despite the technique of IBPB performance. We also observed a negative correlation of seniority with an increasing necessity of conversion to GA due to block failure. In addition, US visualisation during IBPB performance leads to the disappearance of the above correlations, which makes US visualisation especially useful in patients with uncommon anthropometry.

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