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Randomised controlled trial of analgesic effectiveness of three different techniques of single-shot interscalene brachial plexus block using 20 mL of 0.5% ropivacaine for shoulder arthroscopy

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Abstract

Background: Shoulder arthroscopic procedures impose a challenge to anaesthesiologists in terms of postoperative analgesia. Proper pain management after arthroscopic procedures improves patient satisfaction and facilitates early rehabilitation.

Methods: We performed a **r**andomized, prospective clinical study to assess the influence of anthropometric parameters and IBPB technique on the quality of postoperative analgesia. A total of 106 randomly selected patients of ASA I–III status scheduled for elective shoulder arthroscopy. Reasons for exclusion were neurological deficit in the upper arm, allergies to amide-type local anesthetics, coagulopathy, and pregnancy.The patients received 20 mL of 0.5% ropivacaine for an ultrasound-guided interscalene brachial plexus block (IBPB) (group U), peripheral nerve stimulation (PNS)-confirmed IBPB (group N), or ultrasound-guided, PNS-confirmed IBPB (dual guidance; group NU).

Results: We observed that the three groups did not differ in mean time of sensory and motor block terminations. In individual cases in each group, sensory block lasted up to 890–990 minutes, providing satisfactory long lasting postoperative analgesia in patients receiving IBPB. We observed a negative correlation between body mass index and termination of motor block ($P = 0.037$, Pearson's correlation coefficient) and a positive correlation between age and termination of sensory block ($P = 0.0314$, Pearson's correlation coefficient) in group U compared to the other two groups. We found a positive correlation between male gender and termination of motor block ($P = 0.0487$, Pearson's correlation coefficient) in group N compared to the other two groups.

Conclusion: In our study, patients received satisfactory analgesia in the postoperative period regardless of technique used, age, gender, or potentially uncommon anthropometry.

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Key words: interscalene brachial plexus block, interscalene brachial plexus, local anesthetic, Lovett's Rating Scale, ultrasound, peripheral nerve stimulator, body mass index, regional anesthesia, general anaesthesia

Arthroscopic procedures within the shoulder region impose a challenge to anaesthesiologists in terms of postoperative analgesia. Shoulder joint inflation enabling proper surgical field visualisation and repairs done intraoperatively by surgeons are usually associated with acute pain in the postoperative period [1]. Proper pain management after arthroscopic procedures improves patient satisfaction and facilitates early rehabilitation [2]. Currently, postoperative

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pain relief after shoulder arthroscopy can be achieved with preoperative interscalene brachial plexus block using local anaesthetics, usually followed by continuous infusion of local anaesthetics via a perineural catheter [3, 4], preoperative suprascapular nerve block [5, 6], a single interscalene block combined with a continuous intrabursal infusion [7], intraarticular [8, 9] or subacromial [10] injection of local anaesthetics, or postoperative intravenous opioid administration with patient-controlled intravenous analgesia [11]. There have been attempts to prolong the duration of sensory block by adding different adjuvants to local anaesthetics used in interscalene brachial plexus block (IBPB), such as dexamethasone [12, 13] or dexmedetomidine [14].

IBPB can be performed either with paraesthesia or with a peripheral nerve stimulator (PNS) [15] or ultrasound guidance. Ultrasound guidance for IBPB block has been gaining popularity because of the possibility of continuous observation of the end of the needle accompanied with visualisation of the spread of a local anaesthetic on a monitor. This is assumed to enhance both safety and efficacy of performed blocks with the possibility of reduction of local anaesthetic dose compared to the neurostimulation-guided technique [16]. Contrary to general anaesthesia, IBPB is assumed to produce relevant analgesia in the postoperative period [17]. However, only a few studies have compared the efficacy of PNS- vs. ultrasound-guided techniques in terms of needle placement precision [18, 19] resulting in potentially more relevant analgesia in the postoperative period. A dual-guidance method (ultrasound-guided and PNS-confirmed) is proven to gain superiority over the PNS technique in terms of lack of necessity of conversion to general anaesthetics. However, to our knowledge, there have been no studies on the quality of analgesia following IBPB performed with any of the three different techniques, or on the anthropometric parameters contributing to insufficient postoperative analgesia.

Therefore, we performed to compare the analgesic efficacy in the postoperative period with three different techniques of IBPB: (1) IBPB with PNS confirmation (group N); (2) IBPB with ultrasound guidance (group U); and (3) IBPB with ultrasound guidance and PNS confirmation (dual guidance; group NU). In all cases, 20 mL of 0.5% ropivacaine were used for IBPB.

METHODS

This prospective randomized clinical study was approved by the Bioethics Committee of Silesian University of Medicine in Katowice (no. KNW/0022/KB1/125/10). Data were obtained from 106 patients ASA I–III who underwent elective shoulder arthroscopy. Patients aged 18–60 years old, who gave a written consent, were randomly allocated to one of the three groups (N, U, or NU) using the sealed envelopes method. Exclusion criteria were: neurological deficit of upper arm, allergies to amide-type local anaesthetics, coagulopathy, pregnancy, and withdrawal of formerly given written consent. After blockade was performed, duration time, onset time, and block quality in the modified Lovett's rating scale were studied. In case of insufficient block, conversion to general anaesthesia was performed.

In the operation day, patients were premedicated with 7.5 mg of oral midazolam (Midanium, Polfa). In the operation room, venous access was placed and 500 mL of crystaloid were infused. All patients received 0.1 mg of fentanyl intravenously (Fentanyl, Polfa Warszawa) to improve comfort during regional anaesthesia. Heart rate, saturation of arterial blood (SaO2), noninvasive systolic (SAP), diastolic (DAP) and mean (MAP) blood pressure, and electrocardiographic data were continuously monitored on a multiparameter anaesthetic monitor (GE Datex-Ohmeda S/5, GE Healthcare). Data were recorded with a 5-minute sampling time and stored on the anaesthetic protocol.

In group N, all blocks were carried out according to Meier's modification (needle insertion placed at the level of the thyroid cartilage) and the needle was inserted at a 30-degree angle towards the middle of the clavicle, which is safer and more efficient than the traditional Winnie access. The procedure was started with palpable examination of the scalene muscle region in the medial neck triangle and the scalene grove lying between them. Palpation time was included in the regional block time. After sterilization, the skin was anaesthetized locally with 1 mL of lidocaine solution (Lignocainum Hydrochloricum 1%, Polfa Warszawa). IBPB was carried out with Contiplex set (Contiplex D, BBraun) connected to a nerve stimulator (Stimuplex HNS12, BBraun). Stimulator settings were 0.3 mA, impulse time duration of 0.1 ms, and impulse frequency of 2 Hz. Motor response of either pectoral muscles, triceps or biceps brachii was recognized as proper needle placement, and 20 mL of 0.5% ropivacaine (Ropimol, Molteni Farmaceutici) were administered. There was also a catheter placed in the region of anaesthetized brachial plexus for postoperative pain treatment with continuous 0.2% ropivacaine (Ropimol, Molteni Farmaceutici) infusion.

In group U, brachial plexus roots were visualized with an ultrasonograph (Sonosite M-Turbo Sonosite) equipped with a linear 13-MHz probe (MicroMaxx HFL38/13-6 MHz, Sonosite). The procedure was started with precise ultrasonographic lateral neck triangle examination with sterile hypoallergic transmission gel (Aquasonic 100, Parker). Examination time was calculated into IBPB time. After sterilization, the skin was anaesthetized locally with 1 mL lidocaine solution. A sterile cover (Safer Sonic Conti) was put on USG probe. IBPB was carried out with Contiplex set as in group N using the out-of-plane technique. Proper needle placement was confirmed with ultrasound visualization, and 20 mL of 0.5%

Table 1. Correlation between the three different techniques of performance of IBPB (group NU, U, and N) and time of sensory and motor blocks termination

	Group	n	Mean	Median	Min	Max	SD
Sensory	NU	33	559.09	555.00	255.00	890.00	149.75
	U	34	557.21	512.50	295.00	990.00	177.77
	N	39	608.45	650.00	150.00	945.00	194.94
Motor	NU	33	638.48	630.00	415.00	1020	149.26
	U	34	593.53	577.50	355.00	855.00	143.24
	N	39	648.62	645.00	270.00	975.00	181.61

SD — standard deviation

ropivacaine were administered. Additionally, spread of local anaesthetic around the nerve roots was observed on the ultrasonograph screen, and a catheter for continuous 0.2% ropivacaine infusion was placed.

In group NU, IBPB was carried out similarly to group U, but needle was attached to the PNS set as in group N. In this group, position of the needle end was confirmed in two ways (dual guidance).

Time of IBPB was counted up to the end of the 0.5% ropivacaine injection. Time of catheter placement was counted from the moment of the end of 0.5% ropivacaine administration till the end of sterile catheter plaster attachment.

All blocks were performed by experienced anaesthesiologists already skilled in both techniques (> 5 years of experience in both techniques).

IBPB effectiveness and onset times were assessed by anaesthesiologists unaware of patient group allocations and not performing IBPB procedures in the study. Sensory block examinations were performed at 5-minute intervals with ethanol-sprayed woollen swab and 22-G needle pinpricks. Motor blocks examinations were performed according to modified Lovett's Rating Scale (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, 0 — complete paralysis) as an indicator for "readiness to surgery." IPBP duration was calculated as the time interval from satisfactory sensory block till the very first pain perception requiring infusion of local anaesthetic via the catheter placed in the region of the brachial plexus roots.

In the operation room, patients were assisted by anaesthesiologists who were not involved in the course of the study. Their role was to administer proper sedation of 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 reactions during surgery, conversion to general anaesthesia was performed. Those cases were labelled as incomplete blocks. After surgery patients were discharged to the postoperative unit where they were assisted by anaesthesiologists who were not involved in the course of the study. Their role was to monitor basic life parameters and provide analgesia using continuous infusion of 0.2% ropivacaine via a perineural catheter from the very first analgesic requirement. In the case of insufficient analgesia, patients received intravenous oxycodone (OxyNorm) according to the Polish Society of Anesthesiology and Intensive Care Recommendations of Acute and Postoperative Pain Treatment, 2011 [19].

RESULTS

In group NU, 80.43% patients received efficient IBPB for elective shoulder surgery under interscalene brachial plexus regional anaesthesia. Similarly, in group U, in 75.56% of cases conversion to general anaesthesia for elective surgery in the brachial region was not required. In group N, only 41.46% of patients were operated after they received brachial plexus block without the necessity of conversion to general anaesthesia. Chi^2 analysis (chi^2 = 12.24343, P = 0.00018) showed a statistically significant correlation between technique of brachial plexus block and necessity of conversion to general anaesthesia as a result of inefficient plexus block (C = 0.3399 and V = 0.3614).

We analysed the correlations between IBPB technique and onset of sensory and motor blocks as well as termination of sensory and motor blocks. We observed that studied groups did not differ in mean time of sensory block termination. In individual cases in each group, sensory block lasted up to 890–990 minutes, thus providing satisfactory long-lasting postoperative analgesia in patients receiving IBPB (H = 21.47, P = 0.62, Kruskal-Wallis test; Table 1 and Fig. 1).

We observed no differences in mean time of motor block termination between the three groups (H = 1.48, P < 0.47, Kruskal-Wallis test; Table 1 and Fig. 2).

After patients received IBPB, regardless of technique used, perineural catheter was placed using the same technique as performed for IBPB. We analysed time of perineural catheter placement according to allocation to studied groups. Time of catheter placement was significantly shorter in group N than in groups NU and U (H = 38.54, P < 0.001, Kruskal-Wallis test; Table 2). We also analysed times of sensory and motor block in all groups according to anthropometric parameters. We observed a negative correlation

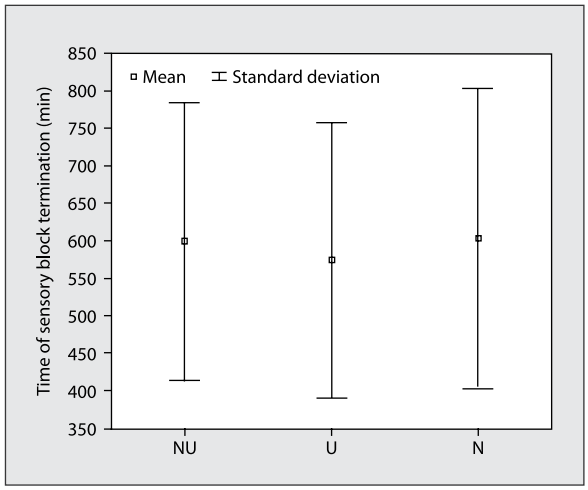

Figure 1. Correlation between the three different techniques of IBPB (group NU, U, and N) and mean time of sensory block termination

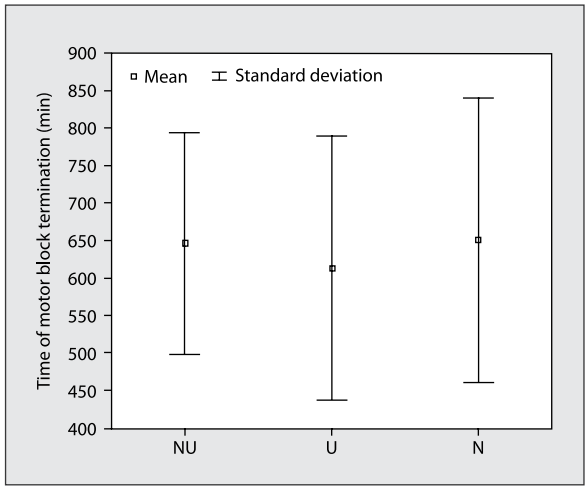

Figure 2. Correlation between the three different techniques of IBPB (group NU, U, and N) and mean time of motor block termination

Table 2. Correlation between the three different techniques of performance of IBPB (group NU, U, and N) and time of perineural catheter placement

Group	n	Mean (sec)	Median (sec)	Min (sec)	Max (sec)	SD
NU	33	70.30	70.00	45.00	160.00	24.62
U	34	72.53	70.50	30.00	130.00	21.29
N	29	47.28	45.00	20.00	130.00	22.92

SD — standard deviation

between body mass index and termination of motor block ($P = 0.037$, Pearson's correlation coefficient) and a positive correlation between age and termination of sensory block ($P = 0.0314$, Pearson's correlation coefficient) in patients receiving ultrasound-guided IBPB (group U) in comparison to the other two groups (Table 3).

We observed a positive correlation between male gender and termination of motor block ($P = 0.0487$, Pearson's correlation coefficient) in patients receiving PNS-guided IBPB (group N) in comparison to the other two groups (see Table 4).

DISCUSSION

IBPB is widely performed for arthroscopic shoulder surgeries in adults [20] and in children [21] because it provides sufficient conditions for operation and relevant postoperative analgesia. When postoperative analgesia is prolonged by continuous infusion of a local anaesthetic via a perineural catheter [22], it provides better condition for rehabilitation and improved patient satisfaction. In our study, a perineural catheter was placed using three different techniques. We observed statistically significant shorter time of perineural catheter placement in patients allocated to group N in comparison to both group NU and U, what is similar to findings of Fredrickson *et al.* [23].

Eroglu *et al.* [24] showed that 30 mL of 0.5% bupivacaine and ropivacaine for IBPB anaesthesia produced similar surgical block. They prolonged the block with a patient-controlled interscalene analgesia infusion, and 0.15% bupivacaine or ropivacaine provided adequate pain relief, similar side effects, and high patient satisfaction after shoulder surgery.

Similar findings were obtained by Ciccone *et al.* [25], who evaluated the efficacy of IBPB and infusion pumps for postoperative pain control after arthroscopic subacromial decompression with or without arthroscopic rotator cuff repair. They concluded that IBPB provided more pain relief than infusion pumps immediately after arthroscopic shoulder surgery.

In our study, we obtained different success rates of IBPB defined as "readiness for operation," from 41.46% in group N, to 75.56% in group U and 80.43% in group NU.

Despite the possibility of failed IBPB defined as necessity of conversion to general anaesthesia, both successful and failed IBPBs provided patients with sufficient analgesia regardless of IBPB technique. We observed satisfactory analgesic effect in the postoperative period defined as time to the first request for oral analgesic lasting on average 555 minutes in group NU, 650 minutes in group N, and 512 minutes in group U. These differences were not statistically significant.

Even in the case of failed IBPB, despite technique used, IBPB for shoulder arthroscopic surgeries produced satisfactory analgesic effect despite the lack of "readiness for operation" under regional anaesthesia only in some patients at different rates according to group allocation. We sup-

Table 3. Correlation coefficients between terminations of motor and sensory blocks, and anthropometric parameters of patients receiving IBPB in group N, NU and U

Group N	Sensory block termination	Motor block termination
Height	r = –0.0834	r = 0.3690
	P = 0.712	*P* = 0.091
Weight	r = 0.0571	r = 0.1873
	P = 0.801	*P* = 0.404
BMI	r = –0.0555	r = –0.1331
	P = 0.806	*P* = 0.555
Age	r = –0.2637	r = 0.0104
	P = 0.100	*P* = 0.949
Group NU	**Sensory block termination**	**Motor block termination**
Height	r = –0.0137	r = 0.0913
	P = 0.947	*P* = 0.657
Weight	r = –0.0304	r = 0.2388
	P = 0.883	*P* = 0.240
BMI	r = –0.0422	r = 0.1641
	P = 0.838	*P* = 0.423
Age	r = 0.2294	r = 0.1755
	P = 0.1444	*P* = 0.266
Group U	**Sensory block termination**	**Motor block termination**
Height	r = –0.0501	r = 0.0057
	P = 0.808	*P* = 0.978
Weight	r = –0.2936	r = –0.3382
	P = 0.145	*P* = 0.091
BMI	r = –0.3377	r = –0.4110
	P = 0.092	*P* = 0.037
Age	r = 0.3303	r = 0.1211
	P = 0.0314	*P* = 0.439

BMI — body mass index

Table 4. Correlations between terminations of motor, sensory blocks and gender of patients receiving IBPB in group N, NU and U

	Sensory block termination	Motor block termination
Group NU		
Female	574.54 ± 204.60	614.19 ± 148.48
Male	662.72 ± 184.87	644.51 ± 149.96
t-Test	*P* = 0.556	*P* = 0.731
Group N		
Female	557.77 ± 231.08	548.33 ± 190.15
Male	625.48 ± 213.16	679.67 ± 174.84
t-Test	*P* = 0.376	*P* = 0.049
Group U		
Female	533.18 ± 173.61	615.90 ± 264.92
Male	586.71 ± 189.32	612.18 ± 139.63
t-Test	*P* = 0.414	*P* = 0.953

pose that above phenomenon could be explained based on the work of Gautier *et al.* [26] who measured the spread of radiocontrast in the interscalene space after injection under different pressures in nine healthy volunteers receiving ultrasound-guided injections of 10 mL of radio-opaque NaCl 0.9% in both interscalene spaces. They found that regardless of injection pressure, the interscalene space was filled with 10 mL of radiocontrast injectate spilling over the surface of the anterior and/or middle scalene muscles underneath the cervical fascia. Supposedly, in the N group, ropivacaine was partly injected over the cervical fascia but due to its more hydrophilic than lipophilic potential in comparison to bupivacaine it partly diffused via cervical fascia producing relevant postoperative analgesia comparable to U and NU group [27].

In our experience, routine performance of IBPB is a technique of choice for regional anaesthesia. Conversion to general anaesthesia should be perceived as an alternative in case of failed block rather than an unwelcome complication, and should be explained to the patient beforehand.

Some anaesthesiologists prefer general anaesthesia in combination with IBPB for arthroscopic shoulder surgeries over IBPB alone because of a high degree of patient acceptance in comparison to general anaesthesia or IBPB alone. The above conclusion was drawn by Ozturk *et al.* [28], who compared general anaesthesia with desflurane alone or in combination with a preoperative IBPB by either 40 mL of 0.25% bupivacaine or 40 mL of 0.25% levobupivacaine for shoulder arthroscopy. They reported lower desflurane consumption and a superior recovery profile in patients from the general anaesthesia/IBPB group. Similar observation was made by Lee *et al.* [29], who performed ultrasound-guided IBPB using either 5 mL or 10 mL of 0.75% ropivacaine in the in-plane technique, and then general anaesthesia was administered. They found that general anaesthesia with ultrasound-guided IBPB with 5 mL of 0.75% ropivacaine showed no significant difference in terms of analgesic efficacy (mean time to first analgesic requirement and the postoperative pain visual analogue scale score were comparable), rate of postoperative nausea and vomiting, and patient satisfaction compared to 10 mL of 0.75% ropivacaine, but had a lower incidence of hemidiaphragmatic paralysis.

Conversion to general anaesthesia after failed IBPB may supposedly impose a concern over hemodynamic stability as beach-chair position is thought to be associated with arterial hypotension and subsequent risk of cerebral ischaemia. Janssen *et al.* [30] compared general anaesthesia alone with general anaesthesia plus IBPB using 40 mL of 1% mepivacaine for outpatient shoulder arthroscopy. They analysed the incidence of mean arterial pressure under 60

mm Hg or a decrease in systolic pressure of more than 20% from baseline, a heart rate lower than 50, and a concomitant blood pressure decrease. They concluded that IBPB with general anaesthesia for surgeries in the beach-chair position in ASA I and II patients can be safely combined.

On the other hand, haemodynamic events, such as hypertension after IBPB in patients with history of hypertension, is a complication due to the irregular spread of local anaesthetic causing a blockade of carotid sinus baroreceptors leading to such adverse event. Gianesello *et al.* [31] compared ultrasound-guided IBPB with 20 mL or 40 mL of 0.5% with neurostimulation for rotator cuff repairs, and recorded the need for antihypertensive drug. They found that three patients of group NS required urapidil administration because of hypertension and concluded that ultrasound-guided IPBP permitted the use of a low volume of local anaesthetic and seemed to reduce the incidence of hypertension. As a result, even in the case of the necessity of conversion to general anaesthesia after failed IBPB it can be of benefit for the patient as general anaesthesia reduces the incidence of hypertension and IBPB provides sufficient analgesia in the postoperative period.

Yuan *et al.* [32] compared combined IBPB with general anaesthesia in elderly patients with general anaesthesia alone for upper extremity fractures surgeries. They found that combined IBPB with general anaesthesia in elderly patients hold a greater potential for upper extremity fractures surgery due to its improved clinical effectiveness and fewer side effects.

We also tried to investigate anthropometric parameters of patients supposedly constituting risk factors of occurrence of insufficient post-operational analgesia following single shot IBPB. To our surprise, no matter what technique of IBPB was performed, mean time of sensory block was comparable between groups providing satisfactory analgesia in the post-operational period lasting in individual cases up to 990 minutes. Height, weight, and body mass index did not affect sensory block termination. Only in group U in patients with higher body mass index motor block lasted shorter in comparison to group NU and N, what was statistically significant. Similarly in group N, motor block was terminated statistically significantly shorter in female patients. We hypothesized that as female tissues are characterized by higher water concentration, lesser precision of local anaesthetics deposition in techniques in both group N and U leads to reduction of number of local anaesthetic particles free to diffuse to the centre of nerve roots where motor neurons are situated. In the case of patients with abnormally high body mass index, precision of needle placement is more challenging in comparison to patients with normal body mass index, which was proven by Hanouz *et al.* [33], who compared axillary brachial plexus blocks with a triple-injection technique using 42 mL of 0.5% ropivacaine performed in patients in obese and non-obese patients scheduled for upper limb surgeries. When precision of needle placement is challenging less particles of LA diffuse to nerve roots what usually results in complete sensory block with deficit of motor block or shortened motor block in the post-operational period. In the end, likewise in our study, postoperative motor block in female patients and with higher body mass index lasted shorter. Above observations can be beneficial for anaesthesiologist providing regional anaesthesia for operations where short motor block is essential for early evaluation of surgical effect of tendons repair. Our finding is similar to Nielsen *et al.* [34], who attempted to assess the impact of body mass index on 6,920 patient outcomes (block efficacy, rate of acute complications, postoperative pain at rest and with movement, postoperative nausea and vomiting, rate of unscheduled hospital admissions, and overall patient satisfaction) after ambulatory regional anaesthesia. Their study revealed that obesity was not associated with higher rate of postoperative pain at rest when compared with patients with a normal body mass index receiving different regional blocks performed with different ultrasound-guided techniques. Similarly, Schwemmer *et al.* [35] performed under ultrasound-guided IBPB and allocated patients to groups according to their body mass (body mass index less than or greater than 25). They tested the quality of the ultrasound-guided IBPB postoperatively and concluded that IBPB in obese patients and, when used for guidance of regional anaesthesia, renders similar results as in patients of normal weight. Moreover, in group U in our study sensory block lasted statistically significantly longer with age. We suppose that with age concentration of water in tissues decreases so ropivacaine is injected not as precisely around the IBP as in the NU group so that ropivacaine diffused via tissues reaching its target more slowly and in the end produced longer lasting sensory block.

In conclusion, despite different success rates of different techniques of IBPB performed for shoulder surgeries, patients should be encouraged to give consent to receive IBPBs. They should be explained that conversion to general anaesthesia following failed block is rather an alternative plan rather than unwelcome complication. In the end patients will receive satisfactory analgesia in the post-operational period no matter what technique was used regardless of their potentially uncommon anthropometry, age or gender. Further studies are required to investigate above issues in details.

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