Original paper

The assessment of haemodynamic stability, gas exchange parameters, and the quality of postoperative analgesia in patients undergoing arthroscopic shoulder joint surgery in two different types of anaesthesia – preliminary research

Ocena stabilności hemodynamicznej, parametrów wymiany gazowej oraz jakości analgezji pooperacyjnej u chorych poddawanych artroskopii stawu barkowego w dwóch różnych typach znieczulenia – badanie wstępne

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Medical Studies/Studia Medyczne 2020; 36 (1): 18–25
DOI: https://doi.org/10.5114/ms.2020.94084

Key words: anaesthesia, controlled hypotension, arthroscopic shoulder joint surgery.

Słowa kluczowe: znieczulenie, hipotensja kontrolowana, artroskopia stawu barkowego.

Abstract

Introduction: There are several methods available to conduct anaesthesia in patients undergoing arthroscopic shoulder joint surgery. The main aim of anaesthesia is to reach controlled hypotension to reduce bleeding in the operating field.
Aim of the research: To assess haemodynamic stability in patients undergoing arthroscopic shoulder joint surgery in two different types of anaesthesia: complex general anaesthesia and complex general and regional anaesthesia.
Material and methods: The research included 20 patients who underwent arthroscopic shoulder joint surgery in St. Rafal's Provincial Specialist Hospital in Czerwona Gora. Patients were randomly assigned into two groups – A and B. Patients from group A were subjected to complex general anaesthesia by infusion of remifentanil. In group B patients, brachial plexus block was performed. During anaesthesia haemodynamic parameters were monitored, and gas exchange parameters, the level of lactates, and the effectiveness of post-operative analgesia were assessed.
Results: Heart rate (HR) parameters between the two groups differed substantially after 30 min. *U* Mann-Whitney Test indicated salience $p = 0.009$. In group A HR and mean arterial pressure parameters were similar, which proves better haemodynamic stability. In group A the arterial blood pH value showed similar values ($p = 0.001$), which indicates better stability of the acid-base balance. Post-operative pain in group A was more persistent than in group B and required a supply of morphine in a higher dose.
Conclusions: The application of remifentanil results in higher haemodynamic stability in comparison to anaesthesia with brachial plexus block; however, the usage of block results in better post-operative analgesia in comparison to the first method.

Streszczenie

Wprowadzenie: Istnieje kilka metod przeprowadzenia znieczulenia u pacjentów poddawanych zabiegowi artroskopii stawu barkowego. Istotą znieczulenia jest uzyskanie hipotensji kontrolowanej w celu zmniejszenia krwawienia w polu operacyjnym.
Cel pracy: Ocena stabilności hemodynamicznej u pacjentów poddawanych artroskopii stawu barkowego w dwóch różnych typach znieczulenia: ogólnym złożonym oraz ogólnym złożonym i regionalnym.
Materiał i metody: W badaniu wzięło udział 20 pacjentów poddanych artroskopii stawu barkowego w Wojewódzkim Szpitalu Specjalistycznym im. św. Rafała w Czerwonej Górze. Chorych losowo podzielono na dwie grupy – A i B. Pacjentów z grupy A poddawano znieczuleniu ogólnemu złożonemu z użyciem remifentanylu. U pacjentów z grupy B wykonywano dodatkowo blokadę splotu barkowego. W trakcie trwania znieczulenia rejestrowano parametry hemodynamiczne, oceniano parametry wymiany gazowej, stężenie mleczanów oraz skuteczność analgezji pooperacyjnej.

Wyniki: Parametry tętna (HR) pomiędzy grupą A i B różniły się znacznie po 30 minutach. W teście *U* Manna-Whitneya stwierdzono istotność $p = 0{,}009$. W grupie A wartości HR oraz średnie ciśnienie tętnicze (MAP) były zbliżone, co świadczy o lepszej stabilności hemodynamicznej. W grupie A wykazywano zbliżone wartości ($p = 0{,}001$) pH krwi tętniczej, co przemawia za lepszą stabilizacją równowagi kwasowo-zasadowej. Ból pooperacyjny w grupie A był bardziej nasilony niż w grupie B i wymagał podania większych dawek morfiny.
Wnioski: Zastosowanie remifentanylu skutkuje większą stabilnością hemodynamiczną pacjenta w porównaniu ze znieczuleniem z użyciem blokady splotu barkowego, natomiast użycie blokady wpływa na lepszą analgezję pooperacyjną w stosunku do pierwszej metody.

Introduction

Orthopaedic surgeries concerning upper limbs are nowadays very commonly performed medical procedures. However, being considerably invasive procedures, they require the presence of an anaesthetist. The modern era of shoulder affliction treatment was commenced by Codman in the 1930s. Shoulder joint arthroscopy was a rarely performed procedure until the 1980s. Today more than 1.4 million shoulder joint arthroscopies are performed annually [1]. This minimally invasive surgery is used to perform surgical procedures such as reconstruction of the rotator cuff, superior labrum anterior-posterior (SLAP) damages, long head of biceps tendinitis, glenoid labrum treatment, frozen shoulder (adhesive capsulitis) surgeries, or suprascapular nerve block [2]. There are several available methods of performing anaesthesia in patients undergoing shoulder joint arthroscopy. Each of them has to take into account, as well as the comfort of the patient, the reduction of bleeding in the operating field. Intraoperative hypotension can be obtained via two approaches: intravenous medications and peripheral nerve block. Attenuating pain during and after the procedure is a significant issue, which requires the application of an appropriate method of treatment [3–8]. Performing an interscalene muscle block of the brachial plexus is a method of regional anaesthesia applied by choice for procedures of the shoulder joint [9, 10]. A relevant advantage of this method, other than hypotension, is prolonged analgesia – up to 18 h [8, 11–14]. Unfortunately, even with properly blocked nerves, the necessity to change to general anaesthesia reaches 8.7–13% [3], or even 20% [15], which in the case of positioning a patient on his/her side or in a beach chair position is critically constricted. Therefore, as a rule, taking patients' comfort and safety into consideration, after peripheral nerve block, general anaesthesia is conducted. The method of choice, which is peripheral nerve block, has its limitations. Among them the most common are: primary damage of brachial plexus – a risk of deterioration of the condition and chronic obstructive pulmonary disease (COPD), a risk of phrenic nerve palsy, and lack of consent to perform the block [11, 12, 16].

In the instance, when only general anaesthesia is performed, medications usually applied to obtain controlled hypotension are sodium nitroferricyanide, nitroglycerin, urapidil, labetalol, esmolol, and adenosine [11]. Another alternative is remifentanil, which, due to its pharmacokinetic properties, such as quick start and short duration of action, is especially advisable for patients with chronic respiratory distress [17, 18]. Post-operative pain treatment, in this case, must be executed by the use of intravenous analgesic. Obtaining controlled hypotension, inevitable to perform shoulder arthroscopy procedure is related to a number of risks. Currently, there is no agreement regarding the definition of the marginal level to which systemic blood pressure can be lowered safely without the risk of tissue ischaemia. Eckenhoff defined controlled under-pressure as pharmacologically lowering mean arterial pressure (MAP) to 50–60 mm Hg. The pharmacological effect is often amplified by positioning a patient (beach chair position) and lifting the operated body part above the level of the heart [11, 16, 18, 19].

Aim of the research

The main objective of the thesis is to assess haemodynamic stability in patients undergoing arthroscopic shoulder joint surgery in two different types of anaesthesia: complex general anaesthesia and complex general and regional anaesthesia. The additional objective was the assessment of postoperative analgesia on the post-operative day (day 0) after surgery.

Material and methods

The research included 20 patients of both sexes, aged 18 to 69 years, classified pre-operatively as category I and II of physical status classification according to American Society of Anaesthesiologists (ASA), qualified to planned shoulder joint surgery performed with arthroscopy method. Exclusion criteria comprised: lack of consent to anaesthesia, neurological disorders, psychological disorders, addiction to alcohol or abusive substances, obesity (body mass index – BMI > 30.0 kg/m^2), haemorrhagic shock during the procedure, and allergic reaction to medicine administered during the anaesthesia. Pilot research was conducted in 2018–2019 in St. Rafal's Provincial Specialist Hospital in Czerwona Gora. Thirty minutes before the planned procedure every patient was given oral premedication consisting of 1 g paracetamol (Paracetamol 500 mg Laboratoria Polfa, Lodz, Poland) and 75 mg pregabalin (Linefor 75 mg Polpharma, Poland). After the arrival at the operating theatre, standard monitoring of vital signs was implemented: EKG, pulse oximetry, and noninvasive arterial pressure measurement. Distal vein cannulation and radial artery cannulation were performed under the control of ultrasound. Prior to the procedure patients were randomly divided into two groups: A and B.

Patients from group A were subjected to general complex anaesthesia with tracheal intubation with the use of atropine (Atropinom Sulfuricum WZF 0.5 mg/ml, Polfa Warsaw, Poland), remifentanil (Ultiva 2 mg Aspen, Ireland), propofol (Propofol 1% MCT/LCT Fresenius, Germany), rocuronium (Roqurum 10 mg/ml, Pharma Swiss, Czech Republic), oxygen, air, and sevoflurane (Sojourn 100% Primal Healthcare, United Kingdom).

Prior to the induction of anaesthesia, patients were preoxygenated with 100% oxygen through a face mask, and intravenous infusion of balanced multi-electrolyte fluid was implemented (Optilyte 500 ml Fresenius Kabi, Poland). The induction of anaesthesia was administered with a starting dose of 0.05 µg/kg/min of remifentanil infusion, additionally implementing a bolus of propofol 1.5–2.5 mg/kg total body weight (TBW). After obtaining unconsciousness, patients were ventilated with 100% oxygen.

Neuromuscular anaesthesia was provided by the administration of rocuronium 0.6 mg/kg TBW. Following tracheal intubation, the conduction anaesthesia was obtained by the supply of inhaled sevoflurane, in order for the minimum alveolar concentration (MAC) to amount to 1.0. In the event of a heart rate under 50 beats per minute, atropine was supplied in a dose of 500 µg. The infusion of remifentanil was performed with a syringe infusion pump (Perfusor Space B Braun, Germany). Remifentanil was titrated in doses from 0.05 µg/kg/min to 2.0 µg/kg/min. The aim was to maintain MAP at 55–65 mm Hg. If MAP decreased to 50 mm Hg, the implementation of 5 mg ephedrine (Ephedrinum hydrochloricum 25 mg/ml WZF Polfa Warszawa, Poland) was planned. Ten minutes before the end of the procedure every patient was supplied with 5 mg of morphine (Morphine 10 mg/ml, Kalceks, Latvia) prior to the termination of the infusion of remifentanil.

In group B patients interscalene muscle block of the brachial plexus using an out of plane technique was performed with the usage of 10 ml of 0.5% ropivacaine (Ropimol 5 mg/ml, Molteni, Italy) under the supervision of ultrasound and distal nerve stimulant with the following general complex anaesthesia with tracheal intubation with the use of: atropine, fentanyl (Fentanyl WZF 50 µg/ml, Polfa Warszawa, Poland) propofol, rocuronium, oxygen, air, and sevoflurane. Prior to the induction of anaesthesia, patients were preoxygenated with 100% oxygen through a face mask, and intravenous infusion of balanced multi-electrolyte fluid was implemented. The induction of anaesthesia was administered with a starting dose of 100 µg fentanyl, subsequently implementing a bolus of propofol (1.5–2.5 mg/kg TBW). After obtaining unconsciousness, patients were ventilated with 100% oxygen through a face mask. Neuromuscular anaesthesia was provided by the administration of rocuronium – 0.6 mg/kg TBW. Following tracheal intubation, the conduction anaesthesia was obtained by the supply of sevoflurane, in order for the MAC to amount to 1.0. In the event of a heart rate below 50 bpm, atropine was supplied in a dose of 500 µg. If the MAP decreased to 50 mm Hg, the implementation of 5 mg of ephedrine was planned.

During the procedure, in both groups, the parameters of haemodynamic condition were monitored every 10 min: heart rate (HR), mean arterial pressure (MAP), and oxygen saturation measured by pulse oximetry (SpO_2). Additionally, gas exchange parameters were assessed through arterial blood gas analysis. Oxygen saturation was assessed by defining the lactate level in the serum. The samples (blood) to both tests were drawn from the radial artery immediately before the input and after the termination of anaesthesia. Haemodynamic levels were registered with a vital signs monitor (BSM-3562, Nihon Khoden, Japan). General anaesthesia was performed with an anaesthetic device (Flow-i, Mauqet, Sweden). Brachial plexus block was conducted with an ultrasound device (Ezono 4000, Germany). Nerve stimulator (MultiStim, Pajunk, Germany), and regional anaesthesia needles (echplex+, Vaygon, France) were used to identify the plexus.

The assessment of post-surgical analgesia was held in the post-operative room of the operating theatre, and after sending patients to the Orthopaedic Unit of St. Rafal's Provincial Specialist Hospital in Czerwona Gora the following parameters were recorded: the intensity of the post-operative pain with VAS scale (visual analogue scale) immediately after sending them to the post-operative room and then every 4 h. In post-operative analgesia ketoprofen (Ketonal 50 mg/ml, Sandor, Austria) and metamizole (Metamizole 500 mg/ml, Kalceks, Latvia) were provided intravenously in doses enabling effective alleviation of post-operative pain, which was established at VAS 1-3. In the case of unsatisfactory pain management (VAS scale > 3) morphine intravenously was provided. Additionally, a total requirement of pain medication was assessed on the post-operative day (day 0). Consent to conduct the research was granted by the Bioethics Committee of Świętokrzyska Medical Chamber in Kielce (Komisja Bioetyki Świętokrzyskiej Izby Lekarskiej w Kielcach) (no. 63/2018).

Statistical analysis

The results elicited were stored in one database elaborated statistically. Several statistical techniques were used to evaluate the variables, e.g. arithmetic mean, standard deviation (SD), and median. The *U* Mann-Whitney test was used in two groups to compare haemodynamic parameters such as heart rate, mean arterial pressure, and oxygen saturation measured by pulse oximetry. In respective time criteria, Spearman rank correlation was applied to analyse haemodynamic parameters. *T*-test for dependable samples was used to determine the correlation between gas exchange parameters. The results were recorded in Statistica 13 software. The statistical salience was established at the level $p < 0.05$.

Results

Spearman rank correlation demonstrated a significant dependence between heart rate parameters (HR) after 30 min in regard to HR parameters in each time interval in group A. Additionally, a positive correlation was declared in the majority between, for example, HR after 20 min and HR after 10 min ($r = 0.6590$, $p = 0.038$), HR after 40 min ($r = 0.7759$, $p = 0.008$), and HR after 50 min ($r = 0.6623$, $p = 0.037$). Consecutively, HR after 40 min and HR after 50 min ($r = 0.9504$, $p < 0.001$), HR after 60 min ($r = 0.8580$, $p = 0.001$), and HR after 70 min ($r = 0.8289$, $p = 0.003$). Subsequently, the correlation was displayed between HR after 50 min and HR after 60 min ($r = 0.8802$, $p = 0.001$) as well as HR after 70 min ($r = 0.8562$, $p = 0.002$), and between HR after 60 min and HR after 70 min ($r = 0.7922$, $p = 0.006$).

In group B fewer dependencies were manifested between HR parameters in comparison to group A. The correlation was identified between HR after 30 min and HR after 10 min ($r = 0.6372$, $p = 0.048$), HR after 20 min ($r = 0.8832$, $p = 0.001$), and HR after 40 min ($r = 0.7205$, $p = 0.019$). Additionally, the dependence occurred between HR after 20 min and HR after 10 min ($r = 0.8159$, $p = 0.004$), HR after 40 min and HR after 50 min ($r = 0.9478$, $p < 0.001$), HR after 60 min ($r = 0.7869$, $p = 0.007$), as well as between HR after 50 min and HR after 60 min ($r = 0.8377$, $p = 0.002$). The *U* Mann-Whitney test demonstrated a statistically significant distinction between HR parameters after 30 min and the type of anaesthesia applied ($p = 0.009$) (Table 1).

After the analysis of the MAP in group A the Spearman rank correlation shown a relevant relationship between MAP parameters after 10 min and MAP after 30 min ($r = 0.7978$, $p = 0.006$), and MAP after 70 min ($r = 0.7193$, $p = 0.019$). Consecutively, between MAP after 50 min and MAP after 20 min ($r = –0.9652$, $p < 0.001$), MAP after 40 min ($r = 0.6412$, $p = 0.046$), as well as between MAP after 70 min and MAP after 30 min ($r = 0.6775$, $p = 0.031$), and MAP after 60 min ($r = 0.7204$, $p = 0.019$).

In group B fewer dependencies between MAP parameters were proven in comparison to group A. The correlation was displayed between MAP after 40 min and MAP after 50 min ($r = 0.7425$, $p = 0.014$). The *U* Mann-Whitney test showed a statistically relevant distinction between MAP parameters after 60 min and the type of anaesthesia applied ($p = 0.035$) (Table 2).

Table 1. Descriptive statistics of haemodynamic stability parameter HR in respective time intervals according to the anaesthesia used

Parameter		Descriptive statistics of analysed parameters							
		Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	*U* Mann-Whitney test
HR after 10 min	A	70.40	6.22	59	65	71	76	79	$p = 0.218$
	B	75.80	9.13	63	69	75.50	85	88	
HR after 20 min	A	68.80	6.58	59	61	70	72	80	$p = 0.165$
	B	74.90	10.98	54	70	74.50	83	91	
HR after 30 min	A	68.60	6.11	62	63	68	73	79	$p = 0.009$
	B	78.80	9.85	57	76	81.50	85	88	
HR after 40 min	A	73.00	9.14	62	65	73	77	90	$p = 0.217$
	B	79.20	11.84	59	69	81	87	100	
HR after 50 min	A	74.80	8.99	61	69	74	78	94	$p = 0.353$
	B	81.50	13.75	65	70	79.50	91	110	
HR after 60 min	A	74.90	10.68	62	65	76	77	97	$p = 0.123$
	B	80.70	10.48	66	72	80.50	87	99	
HR after 70 min	A	75.20	11.32	65	68	73.50	76	104	$p = 0.089$
	B	80.10	8.84	65	76	79	85	99	

A – anaesthesia with the use of remifentanil, B – general anaesthesia with brachial plexus block.

Table 2. Descriptive statistics of haemodynamic stability parameter MAP in respective time intervals according to the anaesthesia used

Parameter		Descriptive statistics of analysed parameters							
		Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	*U* Mann-Whitney test
MAP after 10 min	A	71.60	11.27	52	62	74	81	88	p = 0.912
	B	71.50	10.15	47	69	72.50	78	84	
MAP after 20 min	A	70.50	6.45	57	68	71	76	78	p = 0.063
	B	65.10	7.06	52	60	68.50	70	70	
MAP after 30 min	A	66.00	7.32	54	62	64	72	78	p = 0.247
	B	70.40	8.91	55	65	71	75	86	
MAP after 40 min	A	68.20	7.33	56	63	68.50	75	77	p = 0.393
	B	65.20	7.25	53	62	64.50	69	78	
MAP after 50 min	A	69.70	6.25	62	65	68	73	81	p = 0.165
	B	64.60	9.16	52	57	64	71	79	
MAP after 60 min	A	69.00	5.44	60	64	70	73	78	p = 0.035
	B	63.10	6.28	49	62	63.50	66	72	
MAP after 70 min	A	70.00	5.33	60	65	71	73	79	p = 0.684
	B	69.80	11.55	49	65	69	80	90	

A – anaesthesia with the use of remifentanil, B – general anaesthesia with brachial plexus block.

Analysing the parameter of saturation with general anaesthesia with remifentanil applied Spearman rank correlation demonstrated significant dependency between SpO_2 parameters after 60 min and SpO_2 after 10 min (r = 0.7294, p = 0.017), SpO_2 after 20 min (r = 0.6508, p = 0.042), SpO_2 after 30 min (r = 0.7043, p = 0.023), and SpO_2 after 50 min (r = 0.7454, p = 0.013). Consecutively, between SpO_2 parameters after 70 min and SpO_2 after 30 min (r = 0.7906, p = 0.006), SpO_2 after 40 min (r = 0.6642, p = 0.036), SpO_2 after 50 min (r = 0.7968, p = 0.006), and SpO_2 after 60 min (r = 0.8018, p = 0.005). Additionally, the relationship occurred between SpO_2 parameters after 30 min and SpO_2 after 40 min (r = 0.8402, p = 0.002) as well as between SpO_2 parameters after 40 min and SpO_2 after 50 min (r = 0.6880, p = 0.028). *U* Mann-Whitney test did not prove any relevant correlation between the two groups.

In the case of general anaesthesia with brachial plexus block, fewer dependencies were noted between SpO_2 parameters in reference to general anaesthesia with remifentanil. The relationship between SpO_2 parameters after 40 min and SpO_2 after 30 min (r = 0.7516, p = 0.012), SpO_2 after 50 min (r = 0.8810, p = 0.001), and SpO_2 after 70 min (r = 0.7327, p = 0.016). Additionally, the correlation occurred between SpO_2 after 50 min and SpO_2 after 70 min (r = 0.9031, p < 0.001) (Table 3).

The average pH value before and after the implementation of general anaesthesia with remifentanil presented similar values, which is indicated by values of standard deviation (before ±0.01, after ±0.04). *T*-test for dependent samples displayed relevant correlation for the pH (p = 0.001) parameter in group A (Table 4). T-test for dependent samples did not present any relevant dependency for the lactate levels before and after applied anaesthesia in the group mentioned.

T-test for dependent samples presented relevant correlation for gas exchange parameters pH p = 0.005 in group B (Table 5). Greater discrepancies of the average value of standard deviation were noted in comparison to the same parameters of gas exchange in the group in which general anaesthesia with remifentanil was performed.

The *U* Mann-Whitney test did not prove any relevant correlation between the pain medications administered following the surgery and the type of anaesthesia. Patients after general anaesthesia with remifentanil required the provision of higher doses of morphine in pain treatment. In the case of the medication mentioned, the statistical salience amounted to p = 0.052 (Table 6). Analysing the VAS scale and the type of anaesthesia, pain scores in group A patients reached maximally 6.40 points. In group B the above value amounted to 3.75 points. The salience value totalled p = 0.052 (Table 7).

Discussion

The usage of controlled hypotension in conjunction with positioning a patient in a 'beach chair' posi-

Table 3. Descriptive statistics of haemodynamic stability parameter SpO_2 in respective time intervals according to the anaesthesia used

Parameter		Descriptive statistics of analysed parameters							
		Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	*U* Mann-Whitney test
SpO_2 after 10 min	A	97.80	1.14	96	97	98	99	99	*p* = 0.853
	B	97.80	1.62	95	96	98	99	100	
SpO_2 after 20 min	A	97.80	0.92	97	97	97.50	99	99	*p* = 0.631
	B	98	0.82	97	97	98	99	99	
SpO_2 after 30 min	A	98	0.82	97	97	98	99	99	*p* = 0.529
	B	97.70	0.95	96	97	98	98	99	
SpO_2 after 40 min	A	97.50	0.97	96	97	98	98	99	*p* = 0.684
	B	97.40	0.97	96	97	97	98	99	
SpO_2 after 50 min	A	97.50	1.08	96	96	98	98	99	*p* = 0.684
	B	97.40	0.97	96	97	97	98	99	
SpO_2 after 60 min	A	97.60	0.97	96	97	98	98	99	*p* = 0.267
	B	97.10	1.20	96	96	97	98	99	
SpO_2 after 70 min	A	97.80	1.03	96	97	98	99	99	*p* = 0.631
	B	97.60	1.35	96	97	97	99	100	

A – anaesthesia with the use of remifentanil, B – general anaesthesia with brachial plexus block.

Table 4. Descriptive statistics of gas exchange parameters before and after the application of general anaesthesia with the use of remifentanil – group A

Parameter		Descriptive statistics of analysed parameters							
		Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	*T*-test
Lactates	Before	10.52	3.89	5.70	7.00	10.35	16.80	16.80	*p* = 0.524
	After	11.50	5.28	5.30	9.50	10.50	24.00	24.00	
pH	Before	7.40	0.01	7.39	7.40	7.41	7.43	7.430	*p* = 0.001
	After	7.31	0.04	7.26	7.28	7.31	7.36	7.360	

Table 5. Descriptive statistics of gas exchange parameters before and after the application of general anaesthesia and brachial plexus block – group B

Parameter		Descriptive statistics of analysed parameters							
		Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	*T* test
Lactates	Before	9.84	3.23	5.80	7.30	9.10	12.50	16.00	*p* = 0.190
	After	19.33	22.26	6.30	7.70	13.70	17.40	81.30	
pH	Before	7.41	0.95	7.40	7.39	7.42	7.43	7.43	*p* = 0.005
	After	7.33	0.035	7.29	7.31	7.33	7.35	7.41	

tion is the most popular method to suppress inter-operative bleeding. Thereby this approach ensures better visualisation of the operating field, reduces blood loss, and shortens the length of the procedure [18, 20].

In the research haemodynamic parameters such as MAP, HR, and SpO_2 were subjected to analysis. The heart rate measured in every time interval in patients after general anaesthesia with brachial plexus block (group B) was higher in comparison to the heart rate in patients who were subjected to anaesthesia with remifentanil (group A). The HR parameter between the two groups differed substantially after 30 min

Table 6. Descriptive statistics of the pain medications applied, according to the anaesthesia used

Parameter		Descriptive statistics of analysed parameters							
		Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	*U* Mann-Whitney test
Metamizole [mg]	A	1650	1001.39	0	1000	1500	2500	3000	$p = 0.436$
	B	2000	1054.09	0	1000	2000	3000	3000	
Ketoprofen [mg]	A	130	67.50	0	100	100	200	200	$p = 0.739$
	B	120	63.25	0	100	100	200	200	
Morphine [mg]	A	12	7.53	0	5	15	20	20	$p = 0.052$
	B	5.50	5.50	0	0	5	10	15	

A – anaesthesia with the use of remifentanil, B – general anaesthesia with brachial plexus block.

Table 7. Descriptive statistics of the VAS scale of pain according to the anaesthesia used

Parameter		Descriptive statistics of analysed parameters							
		Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	*U* Mann-Whitney test
VAS scale	A	3.46	1.41	1.50	2.60	3.19	4.17	6.40	$p = 0.052$
	B	2.30	0.82	1.33	1.60	2.19	2.67	3.75	

A – anaesthesia with the use of remifentanil, B – general anaesthesia with brachial plexus block.

of the surgery. *U* Mann-Whitney test demonstrated salience $p = 0.009$. In every examined case the heart rate was lower in group A than in group B. During the procedure, patients from group A had lower heart rate levels, which remained in a similar range. In the available literature concerning controlled hypotension the authors emphasise the importance of not only the lowered arterial pressure but also prevention of reflexive tachycardia as being the element that may lead to the increase of inter-operative bleeding and the deterioration of visibility of the operating field [18, 21].

The analysed parameter of mean arterial pressure had more similar values to one another in A group, which indicates higher haemodynamic stability. Moreover, MAP values in the majority of patients in group A were higher in comparison to group B patients. In the 60^{th} min of the surgery, the widest discrepancy in MAP values was recorded between the analysed groups. The statistical salience for this parameter amounted to $p = 0.035$. In patients from group B, greater fluctuations of MAP values were noted, which suggests lower haemodynamic stability for this method of anaesthesia. Despite the popularity of controlled hypotension with the considerable lowering of MAP in procedures of shoulder arthroscopy, the risk of serious complications due to ischaemia of internal organs has to be taken into consideration. There are reports in the literature about neurological complications such as cerebral vascular accident, cerebral death, vision loss, internuclear paralysis (ophthalmoplegia), and other critical conditions regarding the central nervous system [18, 20–22]. Available literature does not point to unequivocally safe MAP values in controlled hypotension. The majority of authors advise maintaining MAP > 50 mm Hg or MAP reduction by no more than 20% of the output value for each patient. In the population partaking in the study, lowering of MAP, which required pharmacological intervention resulting in the necessity of providing ephedrine, occurred in 3 patients from group B.

Arterial blood saturation in both groups had similar values. *U* Mann-Whitney test did not present any relevant correlation between the examined groups.

The lactate level and the rate of acid-base balance were used as a standard of tissue perfusion (safe hypotension).

The analysis of the arterial blood pH values before and after applying general anaesthesia with remifentanil demonstrated similar values, which proves better stability of acid-base balance during anaesthesia. In the case of the mentioned parameter in group A a high statistical salience occurred: $p = 0.001$. Analysing the arterial blood pH values in group B patients the *T*-test also showed the statistical salience ($p = 0.005$). The analysis of the lactate levels did not present relevant statistical values in any study group.

Another aspect under observation was the analysis of total demand for pain medications on the post-operative day (day 0). Comparing the application of pain medications in the two groups, a greater demand for morphine was displayed in group A almost by half. Post-operative pain measured by VAS scale was analogically more persistent in the group anaesthetised with remifentanil. The above result confirms the effectiveness of brachial plexus block in treating postoperative pain after a shoulder arthroscopy procedure and thereby the reduction of the provision of narcotic pain medications in the post-operative period [3]. The analysis of the intake of ketoprofen and metamizole did not present statistical salience.

Conclusions

If the necessity of implementing controlled hypotension for the surgical procedure occurs, the use of remifentanil results in higher haemodynamic stability than in the case of anaesthesia with brachial plexus block. Using brachial plexus block for shoulder arthroscopy results in better post-operative analgesia in comparison to anaesthesia with remifentanil.

Acknowledgments

The research was conducted within project no. WND-RPSW.02.01.00-26-005/13 'The purchase of scientific and testing equipment for the needs of St. Rafal's Provincial Specialist Hospital in Czerwona Góra.'

Conflict of interest

The authors declare no conflict of interest.

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