УДК 616.727.2-089.2:[612.13:[615.451.032:611.13/.14]](045)

DOI: http://dx.doi.org/10.15674/0030-59872025145-49

The impact of preoperative volume overload on hemodynamic parameters during shoulder arthroscopy

K. I. Lyzogub, M. V. Lyzogub

Sytenko Institute of Spine and Joint Pathology National Academy of Medical Sciences of Ukraine, Kharkiv

Objective. To investigate the influence of preoperative volemic loading on changes in hemodynamic parameters due to positioning of anesthetized patients in the beach chair position. Methods. A prospective randomized single-center study included 140 patients. Group I (n = 70) — patients who underwent preoperative loading in a volume of 12 ml/kg before changing the body position. Group II (n = 70) — patients who did not undergo preoperative loading. After induction with propofol/fentanyl in standard doses and orotracheal intubation, the patient was transferred from the supine position to the BCP. Non-invasive systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart rate were determined using a Mediana YM6000 monitor. The first measurement of SBP, DBP, and MAP was performed immediately after positioning the patient supine, the second after induction, the third 5 minutes after positioning in the NSP, and subsequently blood pressure measurements were performed every 5 minutes, heart rate, and SpO_2 continuously. In the postoperative period, the following criteria were evaluated: frequency of nausea/vomiting, frequency of orthostatic collapse within 48 hours, average heart rate within 6 hours. Results. Induction of general anesthesia caused comparable changes in hemodynamics in patients of the studied groups without significant differences between groups. When changing the body position in the BCP, hemodynamic changes had significant differences between groups. Only 7.1 % of the subjects in group I had nausea and vomiting in the early postoperative period, while in group II 21.4 % of patients had nausea and vomiting. The development of tachycardia was noted during the first 6 hours after surgery in patients in group II (95.0 ± 5.8), compared with group I (70.3 ± 6.5) ($p < 0.001$). The development of orthostatic collapse was observed more often in patients in group II and amounted to 14.3 % vs. 10.0 % of the subjects in group I. Conclusions. Preoperative infusion loading does not significantly affect hemodynamic reactions that occur during induction of general anesthesia in young patients ASA I-II. Preoperative infusion loading during operations in a BCP significantly reduces the number of early postoperative complications: postoperative nausea and vomiting, orthostatic collapse and the development of tachycardia.

Мета. Дослідити вплив передопераційного волемічного навантаження на зміни показників гемодинаміки внаслідок позиціювання анестезованих хворих у напівсидячому положенні (НСП). Методи. Проспективне рандомізоване одноцентрове дослідження включало 140 пацієнтів. Група I (n = 70) — хворі, яким проводилось передопераційне навантаження в обсязі 12 мл/кг перед зміненням положення тіла. Група II (n = 70) — особи, без передопераційного навантаження. Після проведення індукції пропофол/фентаніл у стандартних дозах та оротрахеальної інтубації пацієнт переводився з положення лежачи до НСП. Перше вимірювання систолічного артеріального тиску (СиАТ), діастолічного артеріального тиску (ДіАТ) та середнього артеріального тиску (САТ) виконувалось одразу після позиціювання хворого лежачи на спині, друге — після індукції, третє — через 5 хв після позиціювання в НСП та надалі вимірювання артеріального тиску здійснювали кожні 5 хв, частоту серцевих скорочень (ЧСС) та сатурацію периферичної крові (SpO_2) постійно. У післяопераційному періоді оцінювали: частоту нудоти/блювання та розвитку ортостатичного колапсу протягом 48 год, середню ЧСС протягом 6 год. Результати. Індукція загальної анестезії викликала співставні зміни гемодинаміки в пацієнтів досліджуваних груп без достовірної різниці між групами. Артеріальний тиск також достовірно відрізнявся в пацієнтів I та II груп. У 7,1 % досліджених у I групі спостерігалось нудота та блювання в ранньому післяопераційному періоді проти II групи 21,4 % хворих. Розвиток тахікардії протягом перших 6 год після операції в пацієнтів II групи склав (95,0 ± 5,8), проти (70,3 ± 6,5) ($p < 0,001$), а ортостатичний колапс у II групі був 14,3 проти 10,0 %. Висновки. Передопераційне інфузійне навантаження дозволяє мінімізувати постуральні зміни гемодинаміки під час операцій в напівсидячому положенні. Воно достовірно не впливає на реакції гемодинаміки, які виникають під час індукції загальної анестезії в молодих пацієнтів. За умов операції в напівсидячому положенні достовірно зменшуються кількість ранніх післяопераційних ускладнень: нудота та блювання, ортостатичний колапс, розвиток тахікардії. Ключові слова. Напівсидяче положення, загальна анестезія, інфузійна терапія, артроскопія

Keywords. Semi-sitting position, general anesthesia, infusion therapy, arthroscopy

Introduction

The change in the patient's body position from the supine to the semi-sitting position (SSP) initiates physiological changes to adapt the cardiovascular system. In particular, this adaptation is impaired during general anesthesia due to the effects of anesthetics on sympathetic activity and dysregulation of the baroreceptor system. However, this is associated with significant hemodynamic instability, which leads to an increased risk of cerebral hypoperfusion [1]. Cerebral perfusion pressure decreases by approximately 15 % in the sitting position in non-anesthetized patients and drops significantly under anesthesia due to vasodilation and impaired venous return, resulting in hemodynamic instability, impaired oxygen delivery with possible subsequent organ dysfunction. Conversely, fluid overload leads to multisystem effects, including interstitial edema with effects on gas exchange, renal function, and the gastrointestinal system [2]. Perioperative hypotension is not necessarily indicative of an intravascular fluid deficit, but rather a result of general anesthesia causing a weakening of vascular tone [3]. A decrease in cardiac index by 24 % during the transfer of patients to the SSP occurs due to the transfer of 14 % of blood volume from the intra- to the extrathoracic space [4]. At the time of changing the body position, the hemodynamic problem becomes greater due to caudal accumulation of blood, and, in turn, a decrease in preload [5]. The effect of infusion loading before transferring an anesthetized patient to the SSP remains uncertain. Traditionally, infusion preload has been used to prevent intraoperative hypotension caused by spinal anesthesia, but this issue still remains controversial [6]. New data are emerging on the positive effect of infusion preload on hemodynamic stability in patients with SSP [7], so this issue requires further investigation.

Purpose: to investigate the influence of preoperative volemic load on changes in hemodynamic parameters due to positioning of anesthetized patients in a semi-sitting position.

Material and methods

The study was performed at the State Establishment "Professor M. I. Sytenko Institute of Spine and Joint Pathology of the NAMS of Ukraine". It was approved by the local Bioethics Committee (protocol No. 231 dated 20.05.2023) of the relevant institution in accordance with the rules of ICH GCP, the Helsinki Declaration of Human Rights of 2002, the Council of Europe Convention on Human Rights and Biomedicine approved in 1977, as well as the current legislation of Ukraine. Informed consent was obtained from all patients included in the study. The prospective randomized study included 140 patients, divided into 2 groups: I (n = 70) individuals who underwent preoperative loading in the amount of 12 ml/kg before changing the body position; II (n = 70) without preoperative loading. The average age of patients in group I was (42.4 ± 10.7), in group II (41.1 ± 13.3) years. Patients with cardiac arrhythmia, angina pectoris, respiratory, renal or hepatic failure were excluded from the study.

According to the American Society of Anesthesiologists (ASA) scale, all subjects were classified as Class I and II. Patients in Group I received a volume load of 12 ml/kg 30 min before surgery. The qualitative composition of the infusion therapy consisted of balanced crystalloid solutions. Patients in Group II did not receive a preliminary volume load before the intervention. Before induction, patients were administered pantoprazole 40 mg, diazepam 10 mg. Induction was provided with propofol 1 % 2 mg/kg, fentanyl solution 0.2 mg, muscle relaxation was provided with suxamethonium solution 1 mg/kg, and subsequently atracurium besylate 0.3 mg/kg. General anesthesia was maintained with propofol 1 % 5–7 mg/kg/h, and fentanyl solution was used for anesthesia. After orotracheal intubation and transfer of the patients to mechanical ventilation, their position was changed to the SSP.

Peripheral blood saturation (SpO_2), non-invasive systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP), heart rate (HR) were determined with a Mediana YM6000 monitor. The first measurement of SpO_2, SBP, DBP was performed immediately after positioning the patients lying on their back, the second one after induction, the third one 5 min after positioning in the SSP, subsequently blood pressure control was performed every 5 min, heart rate and SpO_2 constantly.

In the postoperative period, the following criteria were studied: the frequency of nausea/vomiting and the development of orthostatic collapse within 48 h, average heart rate within 6 h.

The groups were comparable in age and duration of surgery (Table 1).

Statistical analysis. The obtained data were analyzed using the IBM SPSS 9.0 software. The normal distribution of the samples was checked using the Kolmogorov-Smirnov test. The mean and standard deviation were determined. Differences between groups of indicators were assessed using the Student's t-test.

Results

Analysis of changes in hemodynamics depending on preoperative volume load

The primary hemodynamic indicators did not differ statistically between the groups (Table 2). Similarly, induction of general anesthesia caused comparable changes in hemodynamics in patients of the studied groups without a significant difference between them. In the case of a change in body position before SSP, hemodynamics had significant differences between the groups. The most significant were recorded in terms of heart rate (beats/min): (95.0 ± 5.8) in patients of group II compared to (70.34 ± 6.52) in group I ($p < 0.001$). Blood pressure also significantly differed in patients of groups I and II (mm Hg): Systolic blood pressure (103.9 ± 7.8) vs. (95.9 ± 5.9), respectively ($p < 0.001$); Diastolic blood pressure (63.3 ± 7.2) vs. (57.5 ± 5.0) ($p < 0.001$) and MBP (76.8 ± 7.2) vs. (69.6 ± 5.4) ($p < 0.001$). Considering that SSP support provides autoregulation of cerebral circulation, the study did not allow even a short-term decrease to 65 mm Hg.

Analysis of postoperative complications

The criteria for the adequacy of intraoperative volemic status and hemodynamic stability can be considered the frequency of postoperative complications: tachycardia in the postoperative period, vomiting and orthostatic collapse in the first 48 hours after the intervention. Our observation data showed that patients of the studied groups had a significant difference in these indicators. Thus, only in 7.1 % of cases in group I nausea and vomiting were recorded in the early postoperative period, while in group II in 21.4 %. The development of tachycardia was noted during the first 6 hours after surgery in patients of group II (95.0 ± 5.8), in group I (70.3 ± 6.5) beats/min ($p < 0.001$), and orthostatic collapse was observed more often in patients of group II and amounted to 14.3 versus 10.0 % of the studied in group I (Table 3).

Table 1

General characteristics of the examined patients

Patient group	Age of patients, years	Duration of surgical intervention, min
I (n = 70)	42.4 ± 10.7	126.0 ± 25.4
II (n = 70)	41.1 ± 13.3	129.1 ± 25.2

Discussion

Significant cardiovascular changes can occur when patients are placed in the upright position. Mean blood pressure, central venous pressure, and arterial partial pressure of oxygen (PaO_2) decrease, while the alveolar-arterial oxygen gradient (PAO_2–PaO_2), pulmonary vascular resistance, and total peripheral resistance increase. Under nonanesthetic conditions, these effects are compensated for by an increase in systemic vascular resistance of 50–80 %. However, this autonomic response is blocked by the vasodilatory effects of anesthetics, which further increase and impair cardiac output. Blood pressure remains unchanged or increases in nonanesthetic patients in the sitting position but decreases under anesthesia.

In the supine position, the blood pressure measured in the arm and that providing brain perfusion are essentially the same, but if the patient is in an upright position in a chair, it is lower in the brain than in the heart or arm. The difference in blood pressure will be equal to the hydrostatic pressure gradient between the heart/arm and the brain.

A study of 23,073 patients found that if the arm systolic blood pressure is 65 mm Hg and the distance to the external auditory canal (which is the base of the brain) is 30 cm above the heart, the pressure at the level of the cerebral cortex is 42 mm Hg (Figure). That is, when changing the body position in anesthetized persons in the SSP, each centimeter of verticalization leads to a decrease in blood pressure by 0.77 mm Hg [8].

Table 2

Hemodynamic variations observed in patients of the study groups

Patient group	Hemodynamics indicators											
	primary				after induction				after positioning			
	SBP (mm Hg)	DBP (mm Hg)	MBP (mm Hg)	HR (b/min)	SBP (mm Hg)	DBP (mm Hg)	MBP (mm Hg)	HR (b/min)	SBP (mm Hg)	DBP (mm Hg)	MBP (mm Hg)	HR (b/min)
I (n = 70)	141.5 ± 20.6	86.2 ± 12.6	104.7 ± 14.1	80.8 ± 11.5	104.6 ± 14.9	67.4 ± 7.9	79.8 ± 9.0	72.5 ± 10.5	103.9 ± 7.8	63.3 ± 7.2	76.8 ± 7.2	70.3 ± 6.5
II (n = 70)	145.5 ± 17.8	88.8 ± 14.8	104.0 ± 12.7	83.5 ± 9.4	104.0 ± 12.7	65.6 ± 9.2	78.4 ± 9.9	77.8 ± 10.4	95.9 ± 5.9 *	57.5 ± 5.0 *	69.6 ± 5.4 *	95.0 ± 5.8 *

Note. * — $p < 0.001$, comparing groups I and II.

Table 3

Presence of complications in early post-operative period

Patient group	Average heart rate in the first 6 hours after surgery, beats/min	Nausea and vomiting within 48 hours, patients	Orthostatic collapse within 48 hours, patients
I (n = 70)	70.3 ± 6.5	5	7
II (n = 70)	95.0 ± 5.8 *	15	10

Note. * — $p < 0.001$, comparing groups I and II.

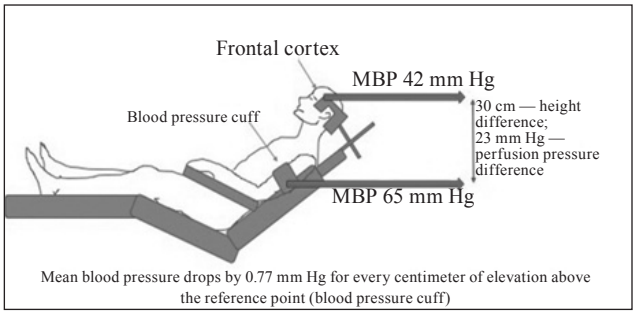

Figure. Comparison of MBP at shoulder and head level when changing body position in SSP (according to Rodney A. Gabriel)

A. Jesudoss et al. compared SSP and middle cerebral artery blood flow velocity and found that the semi-sitting position under general anesthesia resulted in an average decrease in SSP of 24.8 % and in middle cerebral artery blood flow velocity of 28.0 % [9]. Lee et al. noted that postural hemodynamic responses during transfer to the SSP were observed in patients with elevated baseline blood pressure [10].

Current guidelines recommend maintaining systolic blood pressure at a level of at least 70 mm Hg [11]. The issue of hemodynamic correction in the SSP remains controversial. In their studies, Soo Y Cho et al. found that the use of vasopressin solution before transferring the patient to the SSP helps reduce episodes of hypotension associated with verticalization [12], but correction of low intraoperative values of systolic blood pressure with vasoconstrictors alone does not guarantee good organ perfusion. Gokduman et al. performed fluid loading (crystalloid and colloidal solutions) in a volume of 10 ml/kg of ideal body weight 30 min before surgery before positioning, which contributed to a decrease in the frequency of episodes of postoperative nausea and vomiting [7]. The results obtained by the authors are comparable with our data. Other methods of preventing cerebral hypoperfusion in SSP include preventing hyperventilation and using high compression stockings [11]. Maintaining normovolemia may be more beneficial than using vasoconstriction to increase SSP to preserve cerebral perfusion; therefore, increasing intravascular volume may be more effective in protecting patients from possible hypoperfusion [13].

Conclusions

A preoperative infusion load of 12 ml/kg minimizes postural changes in hemodynamics during operations in the semi-sitting position.

Therefore, it does not significantly affect the hemodynamic responses that occur during induction of general anesthesia in young ASA I–II patients.

Preoperative infusion load during interventions in the semi-sitting position significantly reduces the number of early postoperative complications: nausea and vomiting, orthostatic collapse, and tachycardia.

Conflict of interest. The authors declare no conflict of interest.

Prospects for further research. Research on changes in hemodynamics and cerebral perfusion in the perioperative period during body position changes in anesthetized patients is relevant.

Information on funding. No benefit in any form has been and will not be received from a commercial party directly or indirectly related to the subject of this article.

Authors' contribution. Lyzogub K. I. — concept and design, analysis of the obtained data; Lyzogub M. V. — analysis of the obtained data, text editing, processing of materials.

References

1. Meta, F., Ulrich, M. N., Simon, K. N., Tagliero, A. J., & Camp, C. L. (2024). Basics of Shoulder Arthroscopy Part I: Beach-Chair Patient Positioning and Operating Room Setup. *Arthroscopy techniques, 13*(10), 103082. https://doi.org/10.1016/j.eats.2024.103082.
2. Hansen B. (2021). Fluid Overload. *Frontiers in veterinary science, 8*, 668688. https://doi.org/10.3389/fvets.2021.668688
3. Kappen, T., & Beattie, W. S. (2021). Perioperative hypotension 2021: a contrarian view. *British journal of anaesthesia, 127*(2), 167–170. https://doi.org/10.1016/j.bja.2021.03.015
4. Buhre, W., Weyland, A., Buhre, K., Kazmaier, S., Mursch, K., Schmidt, M., Sydow, M., & Sonntag, H. (2000). Effects of the sitting position on the distribution of blood volume in patients undergoing neurosurgical procedures. *British journal of anaesthesia, 84*(3), 354–357. https://doi.org/10.1093/oxfordjournals.bja.a013439
5. Larsen, S. L., Lyngeraa, T. S., Maschmann, C. P., Van Lieshout, J. J., & Pott, F. C. (2014). Cardiovascular consequence of reclining vs. sitting beach-chair body position for induction of anesthesia. *Frontiers in physiology, 5*, 187. https://doi.org/10.3389/fphys.2014.00187
6. Decuyper, N., & Van De Velde, M. (2023) Fluid co-loading or preloading for the prevention of hypotension during spinal anesthesia for C-section: a narrative review. *Acta anaesthesiologica Belgica, 74*(2),113–121. https://doi.org/10.56126/74.1.09
7. Gokduman, H. C., Aygun, E., Canbolat, N., Canbaz, M., Abdullah, T., Ersen, A., & Buget, M. I. (2022). Fluid preloading before beach chair positioning for arthroscopic shoulder procedures: a randomized controlled trial. *Brazilian journal of anesthesiology (Elsevier), 72*(6), 702–710. https://doi.org/10.1016/j.bjane.2021.08.007
8. Gabriel, R. A., Beverly, A., Dutton, R. P., & Urman, R. D. (2017). Patterns of intra-arterial blood pressure monitoring for

patients undergoing total shoulder arthroplasty under general anesthesia: a retrospective analysis of 23,073 patients. *Journal of clinical monitoring and computing, 31*(5), 877–884. https://doi.org/10.1007/s10877-016-9939-0
9. Jesudoss, A., Georgene, S., Bijesh, Ya., Melvin, A. A., & Sajan, P. G. (2021). Effect of Beach-Chair Position on Cerebral Blood Flow in Patients Undergoing Shoulder Surgery — A Preliminary Observational Study. *Journal of neuroanaesthesiology and critical care, 1,* 016–020. https://doi.org/10.1055/s-0041-1732830
10. Lee, S., Seo, J., Kim, D. Y., Lee, Y., Kang, H. Y., Choi, J. H., Kim, Y., Kim, M. K., & You, A. H. (2024). Comparison of Hemodynamic Parameters Based on the Administration of Remimazolam or Sevoflurane in Patients under General Anesthesia in the Beach Chair Position: A Single-Blinded Randomized Controlled Trial. *Journal of clinical medicine, 13*(8), 2364. https://doi.org/10.3390/jcm13082364
11. Ensor, D., Gwilym, S. E., Imam, M., West, S., Elgebaly, A., & Baring, T. (2024). Should the beach chair position have national guidelines to reduce the risk of cerebrovascular complications? Results from a National Survey of Surgeons and Anaesthetists. Shoulder & elbow, 17585732241269147. Advance online publication. https://doi.org/10.1177/17585732241269147.
12. Cho, S. Y., Kim, S. J., Jeong, C. W., Jeong, C. Y., Chung, S. S., Lee, J., & Yoo, K. Y. (2013). Under general anesthesia arginine vasopressin prevents hypotension but impairs cerebral oxygenation during arthroscopic shoulder surgery in the beach chair position. *Anesthesia and analgesia, 117*(6), 1436–1443. https://doi.org/10.1213/ANE.0b013e3182a8fa97
13. Frey, K., Rehm, M., Chappell, D., Eisenlohr, J., Crispin, A., Saller, T., Groene, P., Ockert, B., & Hofmann-Kiefer, K. F. (2018). Preemptive volume therapy to prevent hemodynamic changes caused by the beach chair position: hydroxyethyl starch 130/0.4 versus Ringer's acetate-a controlled randomized trial. *Journal of shoulder and elbow surgery, 27*(12), 2129–2138. https://doi.org/10.1016/j.jse.2018.08.003

The article has been sent to the editors	Received after review	Accepted for printing
26.01.2025	26.02.2025	28.02.2025

THE IMPACT OF PREOPERATIVE VOLUME OVERLOAD ON HEMODYNAMIC PARAMETERS DURING SHOULDER ARTHROSCOPY

K. I. Lyzogub, M. V. Lyzogub

Sytenko Institute of Spine and Joint Pathology National Academy of Medical Sciences of Ukraine, Kharkiv

✉ Kseniia Lyzogub, MD, PhD: kslizogub@gmail.com; https://orcid.org/0000-0001-9149-7208

✉ Mykola Lyzogub, MD, DMSci: nlizogub@gmail.com; https://orcid.org/0000-0003-4776-1635