DOI: 10.26693/jmbs04.05.149
UDC 616-089.5-083.94

Lyzohub M. V.

HEMODYNAMICS IN DIFFERENT TYPES OF ANESTHESIA DEPENDING ON THE INITIAL BLOOD CIRCULATION REGIME DURING SPINE SURGERY IN PRONE POSITION

Sytenko Institute of Spine and Joint Pathology, Kharkiv, Ukraine

nlizogub@gmail.com

During operations in prone position, the hemodynamics of the patient is influenced by two serious factors: anesthesia and the position during operation. Nonetheless, their influence prediction has not been thoroughly studied in modern literature.

The purpose of the study was to justify the choice of anesthesia method for operations on the lumbar spine in the prone position.

Material and methods. The study involved 254 patients who underwent planned surgery for degenerative diseases of the spine. The age of patients was between 16 and 77 years (45.8±11.7). There were 130 men (51.2%) and 124 women (48.8%). Before the operation, we examined hemodynamic changes when turning the patients to the prone position and chose the ones with labile reactions. Intraoperatively, hemodynamic reactions were compared when turning the patient to the prone position with spinal anesthesia (SA) with 0.5% hyperbaric solution of bupivacaine and total intravenous anesthesia (TIVA) based on propofol and fentanyl in standard doses.

Results and discussion. With the initially stable blood circulation regime, turning the patients to the prone position led to more significant hemodynamic changes in SA group than in TIVA group, but these changes did not require correction with sympathomimetics. We recorded a significant decrease in cardiac index and specific peripheral vascular resistance in SA group. With the initially labile blood circulation in SA group, a decrease in peripheral vascular resistance, cardiac index and stroke volume index in 16 % of patients led to a decrease in mean arterial pressure below 60 mm Hg. which required the correction of hemodynamics with phenylephrine, which was not observed in TIVA group.

Conclusions. Clinical assessment of hemodynamics with a change in body position in the preoperative period allowed identifying patients with labile reactions, who manifested a tendency to arterial hypertension and increase of peripheral vascular resistance. A greater risk of this condition occurred in younger individuals with an increased body mass index. SA inhibited the effects of the sympathoadrenal system more than propofol-based TIVA, which led to destabilization of hemodynamics in the labile circulation regime, and necessitated the introduction of α1-adrenomimetic phenylephrine. If a patient has initially labile hemodynamic response being turned to prone position, preference should be given to intravenous anesthesia based on propofol and fentanyl.

Keywords: hemodynamics, spine surgery, spinal anesthesia, intravenous anesthesia, prone position.

Interrelation of work with scientific programs, plans, themes. The study was performed in the frame of the research work “To study structural and functional changes in vertebral motor segments after their stabilization by dynamic and rigid implants in patients with lumbar osteochondrosis”, State Registration Number 01166 U001087.

Introduction. A significant part of spinal surgery takes place in the prone position. Hemodynamic changes in response to a patient's turning may have multidirectional character, which is noted in the works of different researchers. There are several works which proved a significant decrease in the cardiac output [5, 10], as well as those which did not detect hemodynamic changes [6]. Such ambivalent results can be explained by considerable heterogeneity of examined patients, comorbid pathology, different prone positions (more than ten positions are known today), etc. Another important factor affecting the circulatory system is the use of medications, because most of the research was carried out with different types of anesthesia.

A decrease in blood pressure after performing spinal anesthesia (SA) occurs in more than 50% of cases [3]. A significant decrease in blood pressure is extremely dangerous due to the hypoperfusion of organs and tissues. During spinal surgeries in prone position, the spinal cord and the optic nerve are considered to be the most vulnerable [2]. Therefore, it is

important to predict the possibility of adverse changes in SA [7, 8]. Negative effect of general anesthesia based on propofol on hemodynamics is explained by both a direct cardio depressive effect and a decrease in peripheral vascular resistance, which is associated with its mechanism of action called postcapillary venular vasodilation [9]. Thus, during operations in prone-position, the hemodynamics of the patient is influenced by two serious factors: anesthesia and the position during operation. Nonetheless, their influence prediction has not been thoroughly studied in modern literature.

The purpose of the study was to justify the choice of anesthesia method for operations on the lumbar spine in prone position.

Material and methods of research. The research was conducted at the State Institution "Sytenko Institute of Spine and Joint Pathology, NAMS of Ukraine". The study involved 254 patients who underwent planned surgery because of degenerative diseases of the spine. The age of patients was between 16 and 77 years (45.8 ± 11.7). There were 130 men (51.2%) and 124 women (48.8%).

Before the operation, we determined the circulatory regime of the patients by calculating the prognostic index of hemodynamic instability (PIHI). If PIHI value is more than 0.5 it indicates the lability of the circulatory regime and suggests a high probability of destabilization during anesthesia because of turning the patient into prone position, and the need to correct hemodynamics with α_1-adrenomimetics [1]. PIHI exceeded 0.5 in 25 of 144 (17.4%) patients who underwent SA, and in 22 of 110 (20.0%) patients who underwent TIVA. Thus, we formed the following study groups shown in **Table 1.**

Patients with PIHI> 0.5 were significantly younger and had a statistically significantly greater body mass index (BMI). Hemodynamic parameters were recorded at three stages: 1) supine position; 2) 5 minutes after turning to prone position; 3) 20 minutes after turning to the prone position. The dynamics of systolic (SAP), diastolic (DAP) and mean (MAP) arterial pressure, stroke volume index (SVI) and cardiac (CI) index, as well as systemic peripheral vascular resistance (SPVR) were studied. Arterial pressure was measured using a patient's monitor; MAP, SVI, CI and SPVR were measured by the rheographic complex of the KhAI-Medika. SA group patients were administered 3.5 ml of 0.5% hyperbaric solution of bupivacaine in a sitting position. After the local anesthetic was injected, the patient was lying on his back 5–10 minutes, and then turned to the prone position. In order to induce intravenous anesthesia followed by tracheal intubation, fentanyl 0.1 mg, propofol 2.5 mg / kg, rocuronium bromide 0.6 mg / kg were administered. Later, propofol maintenance infusion of 6–9 mg / kg was established. 5 minutes after tracheal intubation, patients turned to prone position. When MAP was reduced to 60 mm Hg. hemodynamic correction was carried out with phenylephrine (with prior administration of 0.5 mg of atropine sulfate). The distribution of patients into groups was performed using random number randomization.

The research was approved by the local bioethics committee (record No. 147 dated September 14, 2015). All patients signed a voluntary consent to conduct it. The obtained data were analyzed using the IBM SPSS 9.0 computer program. The normal distribution of the samples was checked using Kolmogorov-Smirnov test. We also calculated the mean ± standard deviation. The differences between the groups of indicators were calculated using Student's t-test.

Results and discussion. *The course of SA and TIVA with the initially stable circulation (PIHI < 0.5).* The initial hemodynamic parameters in the SA1 and TIVA 1 groups did not have significant differences (**Fig. 1**). 5 minutes after turning to prone position, the studied parameters changed as follows. MAP in both groups was significantly reduced. Moreover, in SA1 group it was significantly less than in TIVA 1 group, primarily due to SAP. The SPVR also significantly decreased in both groups, but there were no statistically significant differences between the groups. SVI in both groups decreased unreliably and equally, while CI in SA1 group decreased significantly, but still did not differ from CI in TIVA1 group. 20 minutes after turning to prone position, the difference between the groups in the level of MAP became more pronounced. While SAP continued to decline significantly in both groups, DAP continued to decrease only in SA1 group, in TIVA1 group it did not change. SPVR also continued to decline significantly in both groups, but in patients from SA1 group, this decrease was statistically more pronounced. SVI did not change significantly; CI increased insignificantly equally in both groups, but remained significantly lower the initial level.

Table 1 – Groups of patients under study

Group	Anesthesia	PIHI	Men	Women	BMI, kg/m^2	Age, years
SA1 (n=119)	SA	< 0,5	54 (45,4 %)	65 (54,6 %)	25,3±2,6	46,5±9,7
SA2 (n=25)		> 0,5	18 (72,0 %)	7 (28,0 %)	31,6±1,9	35,9±8,5
TIVA 1 (n=88)	GIA	< 0,5	48 (54,5 %)	40 (45,5 %)	25,5±2,5	49,8±12,9
TIVA 2 (n=22)		> 0,5	10 (45,5 %)	12 (54,5 %)	33,8±2,5	37,6±9,3

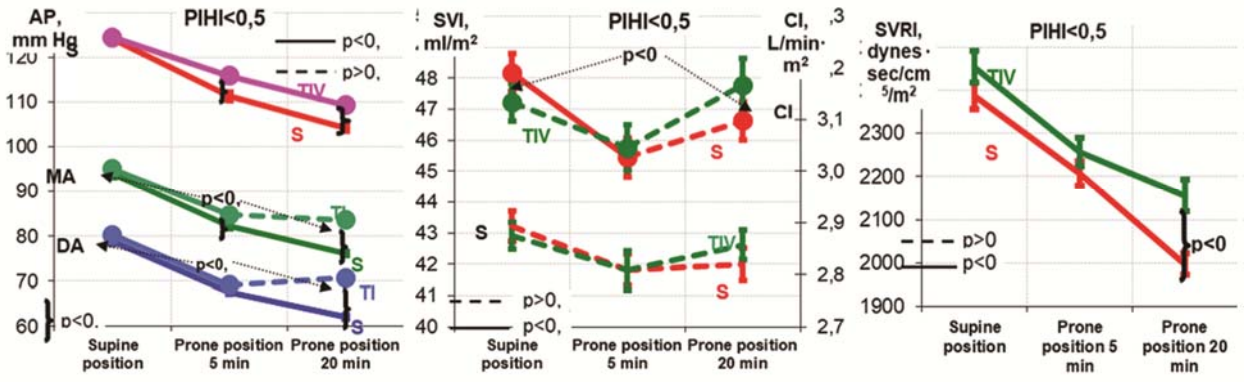

Fig. 1. Hemodynamic indicators of SA1 and TIVA 1 groups

No patient in both groups needed the correction of hemodynamics with α1-adrenomimetics. Thus, with a stable blood circulation regime (PIHI <0.5), despite the fact that SA has a more significant effect on hemodynamics than based on propofol TIVA, circulatory decompensation does not develop when the patient turns to prone position.

The course of SA and TIVA with initially labile blood circulation (PIHI>0.5). The baseline hemodynamic parameters of patients in SA2 and TIVA2 groups also did not differ significantly (**Fig. 2**), but there were significant differences between SA1 and TIVA1 groups, on the one hand, and the SA2 and TIVA2 groups, on the other (**Table 2**). The data presented in **Table 2** indicate that patients with PIHI> 0.5 had an increased tone of the sympathoadrenal system, manifested primarily in the elevated level of SPVR. Naturally, such a situation requires an increase in the strength of heart contractions to maintain a satisfactory cardiac output, which is manifested in increase of SAP. Even at rest (lying on the back without anesthesia), an increase in blood pressure did not allow achieving the same CI level as in patients with PIHI<0.5, although this level was sufficient to maintain oxygen transport (clinical signs of circulatory failure and hypoxia were not observed). However, the impact of such aggressive factors as surgery and anesthesia, imposed increased demands on the circulatory system, and the fulfillment of these requirements was not least determined by the initial blood circulation regime and the type of anesthesia.

5 minutes after turning to prone position blood pressure in patients of both groups (SA2 and TIVA2), decreased significantly due to both SAP and DAP. Moreover, all blood pressure indicators were significantly lower in SA2 group (**Fig. 2**). The SPVR at this stage also decreased significantly in both groups, but there were no differences between the groups. This situation identified a significantly lower CI in SA2 group. The SI in this group was also lower, but not significantly, that is, in group TIVA2, a higher CI was achieved due to compensatory tachycardia, and the SA depressed this reaction. 20 minutes after turning to prone position, the differences in the blood pressure indexes worsened; SPVR and SVI became significant, and the patients of SA2 group were injected with phenylephrine at a rate of 0.071 ± 0.011 mg / kg / min. The nature of the difference in CI preserved, but it ceased to be reliable due to the large variation of values in different patients. This can probably be explained by the instability of the blood circulation in patients of this group. Nevertheless, the obtained results allow us to conclude that with initially insufficiently stable blood circulation regime, TIVA based on propofol violates the regulation of blood circulation to a lesser extent than SA. In a recent meta-analysis [8], general and spinal anesthesia was compared during operations on the lumbar spine in prone position. The authors detected a greater incidence of intraoperative hypertension and tachycardia in the group with general anesthesia. However, the frequency of hypotension and bradycardia was the same in both groups.

Table 2 – Baseline hemodynamic parameters depending on the blood circulation regime

Group	SAP, mm Hg.	DAP, mm Hg.	MAP, mm Hg.	SVI, ml/m^2	CI, l/min·m^2	SPVR, dynes sec/cm5/m2
SA1	124,2±12,7	78,9±8,1	94,0±9,2	43,2±5,4	3,19±0,40	2386±330
SA2	138,2±16,6*	86,6±9,9*	103,8±11,8*	35,8±5,9*	2,84±0,42*	2968±494*
GIA 1	124,5±10,6	80,3±7,8	95,1±7,9	42,9±4,0	3,13±0,34	2455±339
GIA 2	139,7±15,3*	86,8±6,6*	104,4±8,9*	38,1±2,3*	2,96±0,38*	2871±451*

Note: * –p <0.05 between groups 1 and 2.

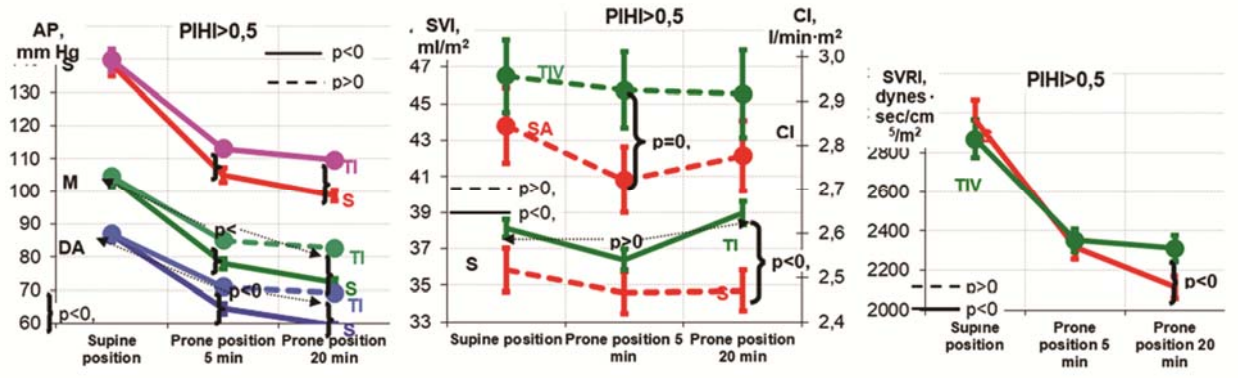

Fig. 2. Hemodynamic indicators of SA2 and TIVA2 groups

According to our research results, elderly patients are less likely to have labile hemodynamics; and spinal anesthesia can be safely administered to such patients. Our data are supported by the study [4], which demonstrates the greater hemodynamic stability of SA in elderly patients. However, the study of the hemodynamic status of patients in the preoperative period and the response to turning to prone position is an important predictive data for choosing anesthesia method.

Conclusions. In some patients who are elected to undergo surgery for spinal degenerative diseases in prone position, there is a labile blood circulation pattern, manifested by a tendency to arterial hypertension, increased SPVR and high tone of the sympathoadrenal system. Subarachnoid anesthesia, to a greater extent than propofol-based intravenous anesthesia, inhibits the effects of the sympathoadrenal system, which in a labile blood circulation regime leads to destabilization of hemodynamics and necessitates the administration of α1-adrenomimetics.

Before performing an operation in prone position in patients with degenerative diseases of the spine, it is advisable to determine the initial blood circulation regime by calculating the prognostic index of hemodynamic instability. If its value is less than 0.5, it is better to use intravenous anesthesia based on propofol than subarachnoid anesthesia.

Prospects for further research. We plan to create an algorithm for a clinically grounded choice of anesthesia for patients with vertebral surgical interventions in prone position.

References

1. Лизогуб М.В., Георгіянц М.А., Висоцька О.В., Порван А.П., Лизогуб К.І. Спосіб прогнозування несприятливих змін гемодинаміки на фоні спінальної анестезії. Патент України на корисну модель № 131991 A61B 5/02. – Заявл. № u 2018 08333 від 30.07.2018; Опубл. 11.02.2019, Бюл.№3.Bible J, Mirza M, Knaub M. Blood-loss Management in Spine Surgery. *Journal of the American Academy of Orthopaedic Surgeons*. 2018; 26(2); 35–44. PMID: 29303921. DOI: 10.5435/JAAOS-D-16-00184
2. Chinachoti T, Tritrakarn T. Prospective study of hypotension and bradycardia during spinal anesthesia with bupivacaine: incidence and risk factors, part two. *J Med Assoc Thai.* 2007; 90(3); 492–501. PMID: 17427526
3. Finsterwald M, Muster M, Farshad M, Saporito A, Brada M, Aguirre J. Spinal versus general anesthesia for lumbar spine surgery in high risk patients: Perioperative hemodynamic stability, complications and costs. *J Clin Anesth*. 2018; 46: 3-7. PMID: 29316474. Doi: 10.1016/j.jclinane.2018.01.004
4. Kim DH, Shin S, Kim JY, Kim SH, Jo M, Choi YS. Pulse pressure variation and pleth variability index as predictors of fluid responsiveness in patients undergoing spinal surgery in the prone position. *Ther Clin Risk Manag*. 2018; 6(14): 1175-83. PMID: 30013353. PMCID: PMC6038863. DOI:10.2147/TCRM.S170395
5. Leslie K, Wu CY, Bjorksten AR, Williams DL, Ludbrook G, Williamson E. Cardiac output and propofol concentrations in prone surgical patients. *Anaesth Intensive Care*. 2011; 39(5): 868–74. PMID: 21970131. DOI: 10.1177/0310057X1103900511
6. Ławicka M, Małek A, Antczak D, Wajlonis A, Owczuk R. Non-invasive haemodynamic measurements with Nexfin predict the risk of hypotension following spinal anaesthesia. *Anaesthesiol Intensive Ther*. 2015; 47(4): 303-8. Doi: 10.5603/A1T.2015.0048
7. Meng T, Zhong Z, Meng L. Impact of spinal anaesthesia vs. general anaesthesia on peri-operative outcome in lumbar spine surgery: a systematic review and meta-analysis of randomised, controlled trials. *Anaesthesia*. 2016; 72(3): 391–401. PMID: 27770448. doi:10.1111/anae.13702
8. Willner D, Spennati V, Stohl S, Tosti G, Aloisio S, Bilotta F. Spine Surgery and Blood Loss: Systematic Review of Clinical Evidence. *Anesthesia&Analgesia*. 2016; 123(5): 1307–15. PMID: 27749350. DOI:10.1213/ANE.0000000000001485

9. Wu CY, Lee TS, Chan KC, Jeng CS, Cheng YJ. Does targeted pre-load optimization by stroke volume variation attenuate a reduction in cardiac output in the prone position. *Anesthesia.* 2012; 67(7): 760–4. PMID: 22452326. DOI: 10.1111/j.1365-2044.2012.07116.x

УДК 616-089.5-083.94

ГЕМОДИНАМІКА ПРИ РІЗНИХ ВИДАХ АНЕСТЕЗІЇ В ЗАЛЕЖНОСТІ ВІД ВИХІДНОГО РЕЖИМУ КРОВООБІГУ ПРИ ВЕРТЕБРОЛОГІЧНИХ ОПЕРАЦІЯХ В ПОЛОЖЕННІ НА ЖИВОТІ

Лизогуб М. В.

Резюме. При операціях в положенні на животі гемодинаміка пацієнта знаходиться під впливом двох важливих факторів – анестезії та операційного положення – та прогнозування цих змін одночасно мало вивчено у сучасній літературі. Метою дослідження було обґрунтування вибору методу анестезії при операціях на поперековому відділі хребта в положенні на животі. Було обстежено 254 пацієнта, яким виконані планові оперативні втручання з приводу дегенеративних захворювань хребта у віці від 16 до 77 років (45,8±11,7), чоловіків 130 (51,2%), жінок 124 (48,8%). Напередодні операції досліджували зміни системи кровообігу при повороті на живіт та виділяли пацієнтів із лабільною реакцією. Інтраопераційно проводили порівняння реакції гемодинаміки при повороті на живіт на фоні спінальної анестезії (СА) та загальної внутрішньовенної анестезії на основі пропофолу та фентанілу (ВА). При початково стабільному режимі кровообігу поворот пацієнтів на живіт призводив до більш значущих змін гемодинаміки у групі СА, ніж у групі ВА, проте дані зміни не потребували корекції симпатоміметиками. При лабільному режимі кровообігу в групі СА у 16 % пацієнтів потребувалась корекція гемодинаміки фенілефрином, чого не спостерігалося у групі ВА. Таким чином, клінічна оцінка гемодинаміки при зміні положення тіла у передопераційному періоді дозволяє виявити пацієнтів з лабільними реакціями, що проявляються тенденцією до артеріальної гіпертензії та підвищенню периферичного судинного опору. СА у більшій мірі, ніж ВА на основі пропофолу гальмує вплив симпатоадреналової системи, що при лабільному режимі кровообігу призводить до дестабілізації гемодинаміки та викликає необхідність введення α_1-адреноміметиків.

Ключові слова: гемодинаміка, вертебрологічні операції, спінальна анестезія, внутрішньовенна анестезія, положення на животі.

УДК 616-089.5-083.94

ГЕМОДИНАМИКА ПРИ РАЗНЫХ ВИДАХ АНЕСТЕЗИИ В ЗАВИСИМОСТИ ОТ ИСХОДНОГО РЕЖИМА КРОВООБРАЩЕНИЯ ПРИ ВЕРТЕБРОЛОГИЧЕСКИХ ОПЕРАЦИЯХ В ПОЛОЖЕНИИ НА ЖИВОТЕ

Лизогуб Н. В.

Резюме. При операциях в положении на животе гемодинамика пациента находится под влиянием двух серьезных факторов – анестезии и операционного положения – и прогнозирование этих изменений одновременно мало изучено в современной литературе. Целью исследования явилось обоснование выбора метода анестезии при операциях на поясничном отделе позвоночника в положении на животе. Было обследовано 254 пациента, которым выполнены плановые операции по поводу дегенеративных заболеваний позвоночника возрастом от 16 до 77 лет (45,8±11,7), мужчин – 130 (51,2%), женщин – 124 (48,8%). Накануне операции исследовали изменения гемодинамики на поворот на живот и выделяли пациентов с лабильной реакцией. Интраоперационно проводили сравнение реакции гемодинамики при повороте на живот при спинальной анестезии (СА) и общей внутривенной анестезии на основе пропофола и фентанила (ВА). При исходно стабильном режиме кровообращения поворот пациентов на живот приводил к более значимым изменениям гемодинамики в группе СА, чем в группе ВА, однако данные изменения не потребовали коррекции симпатомиметиками. При лабильном режиме кровообращения в группе СА у 16% пациентов потребовалась коррекция гемодинамики фенилэфрином, чего не наблюдалось в группе ВА. Таким образом, клиническая оценка гемодинамики при изменении положения тела в предоперационном периоде позволяет выявить пациентов с лабильными реакциями, проявляющимися тенденцией к артериальной гипертензии и повышению периферического сосудистого сопротивления. СА в большей степени, чем ВА на основе пропофола, тормозит влияния симпатоадреналовой системы, что при лабильном режиме кровообращения приводит к дестабилизации гемодинамики и вызывает необходимость введения α_1-адреномиметиков.

Ключевые слова: гемодинамика, вертебрологические операции, спинальная анестезия, внутривенная анестезия, положение на животе.

The authors of this study confirm that the research and publication of the results were not associated with any conflicts regarding commercial or financial relations, relations with organizations and/or individuals who may have been related to the study, and interrelations of coauthors of the article.

Стаття надійшла 12.06.2019 р.
Рекомендована до друку на засіданні редакційної колегії після рецензування