

Anesthesiological care for donor nephrectomy and possibilities of its optimization

V.D. Babaev¹, A.V. Kuligin², A.N. Rossolovsky², R.S. Prokhorov¹,
A.V. Lushnikov², A.E. Gaidarov², E.E. Zeulina^{✉2}

¹*University Clinical Hospital No. 1 n.a. S.R. Mirotvortsev, Saratov State
Medical University n.a. V.I. Razumovsky,*

137 Bolshaya Sadovaya St., Saratov 410054 Russia;

²*Saratov State Medical University n.a. V.I. Razumovsky,
112 Bolshaya Kazachya St., Saratov 410012 Russia*

✉Corresponding author: Ekaterina E. Zeulina, Assoc. Prof., Cand. Sci. (Med.), Associate Professor of the Department of Emergency, Anesthesiology and Intensive Care, and Simulation Technologies in Medicine, Saratov State Medical University n.a. V.I. Razumovsky, zeulina@list.ru

Abstract

Background. *Living related donor (LRD) kidney transplantation is the most effective strategy of renal replacement therapy for patients with stage 5 chronic kidney disease. LRD organs are used due to the shortage of organs from deceased donors. One of the key problems still remained is the anesthetic management of laparoscopic donor nephrectomy (LDNE) and its impact on the graft condition.*

Objective. *Analysis and generalization of the results obtained in the studies of anesthetic management of LDNE and its impact on the graft condition.*

Material and methods. *The literature search was performed in the PubMed, eLibrary, The Cochrane Library, MedLine, EMBASE databases using the search queries: "laparoscopic donor nephrectomy",*

"nephrectomy", "anesthesia for donor nephrectomy and kidney transplantation", "renal graft condition during anesthesia", which made it possible to find and analyze 445 works published in foreign and Russian journals from 2020 to 2025. As a result of the selection, 51 publications were included in the review, including 10 randomized clinical trials, 1 experimental study, 16 observational studies, 2 meta-analyses, 10 systematic reviews, 1 single-center retrospective controlled study, 5 single-center prospective controlled studies, 4 clinical guidelines, 2 clinical case reports.

Conclusion. In the world literature over the recent five years, we have hardly found a large number of reports covering the issue of perioperative anesthetic management of LDNE. The available data indicate that general, combined and regional anesthesia are of interest and can be effectively used in LDNE.

Keywords: laparoscopic donor nephrectomy, anesthesia for donor nephrectomy and kidney transplantation, the state of the kidney graft during anesthesia

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AKI, acute kidney injury

DNE, donor nephrectomy

IRI, ischemic and reperfusion injury

KIM-1, kidney injury molecule-1

LDNE, laparoscopic donor nephrectomy

LRD, living related donor

RA, regional anesthesia

RCT, randomized clinical trial

TIA, total intravenous anesthesia
TIMP-2, tissue inhibitor of metalloproteinases 2

Introduction

Living related-donor (LRD) kidney transplantation is recognized as an effective strategy for renal replacement therapy in patients with 5th-stage chronic kidney disease [1, 2]. This method demonstrates better results in graft survival compared to the use of organs from deceased donors [3, 4]. Based on the statistical data of the registry of the All-Russian Public Organization of Transplantologists "Russian Transplantation Society" for 2023, deceased kidney donation in Russia exceeds living donation by approximately 10 times [5–7]. Acute shortage of donor organs, as well as the dilemma associated with anesthetic and perioperative management of donors, remain pressing interdisciplinary problems of surgery, transplantation, anesthesiology and resuscitation [8, 9].

The problem of choosing an optimal anesthesia method for laparoscopic donor nephrectomy (LDN) and its impact on the graft condition arises due to the initial severe condition of recipients, a high risk of surgical and anesthetic complications and the range of tasks that transplantation poses to the anesthesiology and resuscitation service [10–12]. Current achievements in transplant anesthesiology and resuscitation due to the development and implementation of innovative technologies help to reduce the length of the lung mechanical ventilation of both donors and recipients through the use of modern anesthetic drugs and improved perioperative monitoring of the functions of vital body systems. This reduces the risk of anesthesiology and resuscitation complications, promotes early ambulation and rehabilitation of patients and reduces the length of hospital stay [11–13]. In addition, these achievements have become possible due to a systematic interdisciplinary approach and great improvements in training of highly qualified specialists [3, 4, 10].

The objective of this review is to analyze and generalize the results of the studies on anesthetic management for laparoscopic donor nephrectomy and its impact on the graft condition.

Material and methods

The literature search included the PubMed, eLibrary, The Cochrane Library, MedLine, EMBASE databases using the following search queries: "laparoscopic donor nephrectomy", "nephrectomy", "anesthesia for donor nephrectomy and kidney transplantation", "renal graft condition under anesthesia", which enabled to find and analyze 445 papers published in foreign and Russian journals from 2020 to 2025. The selection of sources was carried out according to the following inclusion criteria:

1) design (publications had to present pre-clinical and clinical studies in all published foreign and Russian journals, without language and national restrictions, covering the issues of donor nephrectomy (DNE), methods of anesthetic management for DNE and kidney transplantation, the impact of anesthetic care on the graft condition);

2) subjects (adult kidney donors and recipients). Articles that examined methods of anesthetic management of pediatric DNE and kidney transplantation were excluded from the analysis.

In addition, a search was conducted through the reference lists of the selected publications, which made it possible to identify additional sources that met the specified criteria (n=132). As a result of the search, 51 publications were included in this review, 10 of which were randomized clinical trials (RCTs), 1 experimental study, 16 observational studies, 2 meta-analyses, 10 systematic reviews, 1 single-center retrospective controlled trial, 5 single-center prospective controlled studies, 4 clinical recommendations, 2 clinical case reports (Fig. 1).

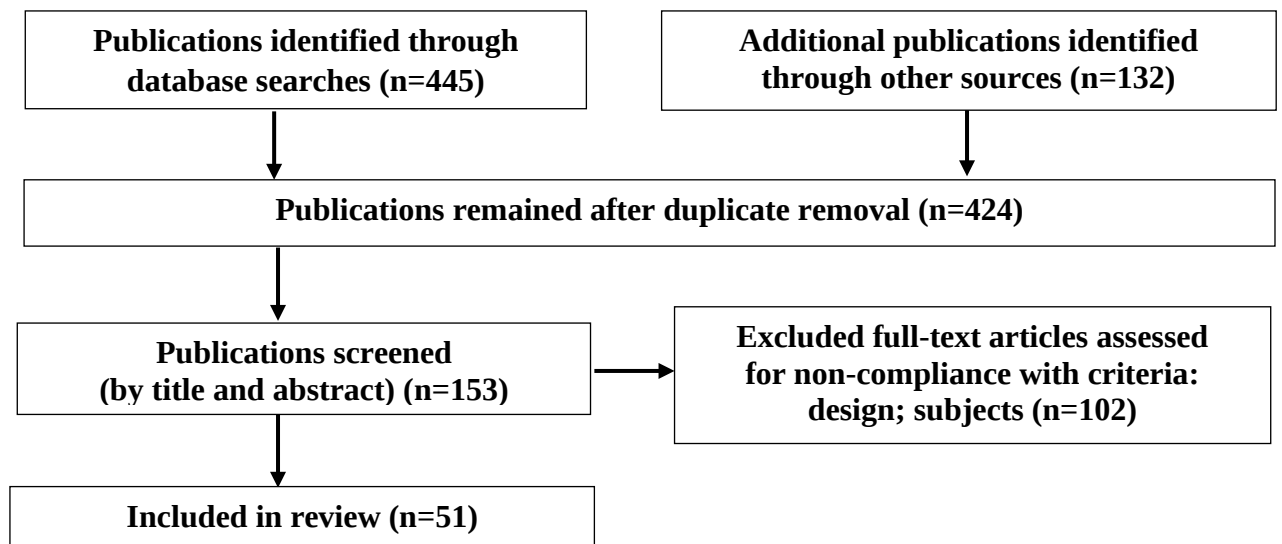


Fig. 1. Flow chart for searching and selecting articles for inclusion in the review

Results and discussion

Based on the analysis of the scientific literature over the recent 5 years, which touched on the topic of DNE, methods of its anesthetic managements and kidney transplantation, the impact of anesthetic management on the graft condition, we have revealed that issues of providing anesthesia and resuscitation to LRD and the LDNE surgical methods have been poorly studied areas [14], while the kidney transplantation aspects from an in-depth analysis of complications [15] to a comparison of various perioperative pain relief options for the recipient have been studied quite thoroughly [16, 17]. The anesthetic management for DNE plays an important role, since the LRD is a healthy person and the task of the doctor, an anesthesiologist-resuscitator, is to ensure the safety of the interventions performed, minimize the surgical and anesthetic risk, and achieve a speedy recovery after surgery [5-7]. In this regard, the choice of anesthetics for pain relief in DNE requires a careful approach, which should be based on the assessment of the functional operability of the donor, indications and contraindications for certain types of anesthesia, the impact of the latter on the graft condition, rather

than on the surgical anesthesia methods adopted in a particular hospital. According to R. Malyala et al. [18], the priority tasks of the anesthesiologist-resuscitator participating in organ procurement are to ensure and maintain effective antinociceptive protection, hemodynamic and metabolic stability, and create optimal conditions for the renal graft functioning.

Laparoscopic donor nephrectomy

Currently, the following methods are widely used in LDNE:

- 1) General anesthesia in the form of total intravenous anesthesia (TIA) using propofol, sodium thiopental, dexmedetomidine;
- 2) Inhalation anesthesia using volatile anesthetics (sevoflurane, desflurane, isoflurane).

These anesthetics are also effective in kidney transplantation.

In a RCT by S. Han et al. (2020), they showed that in LRDs from the group in which anesthesia was performed with propofol, nausea and vomiting occurred less frequently than in donors who received sevoflurane, but postoperative analgesia with opioids was similar in both groups [19]. In another foreign RCT [20] studying the comparative characteristics of anesthesia with propofol and sevoflurane in LRDs with LDNE, it was concluded that TIA with propofol contributed to a more rapid postoperative recovery of donors than inhalation anesthesia with sevoflurane. The study [21] did not reveal differences between the donors under propofol and sevoflurane anesthesia in short-term postoperative changes in the acute kidney injury (AKI) biomarkers: kidney injury molecule-1 (KIM-1), interleukin-18 (IL-18) and tissue inhibitor of metalloproteinase-2 (TIMP-2), as well in the differences in the dynamics of postoperative daily diuresis and glomerular filtration rate. The authors concluded that in the short term, the renal function in patients who underwent LDNE under propofol anesthesia is

similar to that in donors who underwent surgery under sevoflurane anesthesia. In the RCT by S. Milani et al. (2021) no impact of anesthetics on the graft function was noted in donor-recipient groups where anesthesia was performed either with isoflurane (n=38) or with propofol (n=22). Meanwhile, the kidney warm ischemia time in the group of patients receiving propofol was 2 minutes longer than in the group of patients who received inhalation anesthesia with isoflurane. In addition, the postoperative hospital stay of patients in the propofol group was significantly shorter than in the isoflurane group. Thus, anesthesia with propofol, in opinion of Milani et al., the preferred anesthesia option for kidney transplantation from LRD [22].

In the experimental study, B. Büyük et al. investigated the kidney excretory and metabolic functions, as well as the pathomorphology of the kidney in Wistar line female albino rats that underwent nephrectomy under TIA with sodium thiopental (n=20) and ketamine (n=20). As a result, the authors found that histopathological damage to the kidneys in terms of tubular necrosis, vacuolization and expansion of the Bowman-A.M. Shumlyansky capsule was lower in a group of animals receiving sodium thiopental. The authors suggested that sodium thiopental provides protection of renal tissue during cold ischemia by reducing apoptotic death of renal tissue cells [23]. It is worth noting that RCTs studying the nephroprotective effect of sodium thiopental were not found in the literature we analyzed, despite the fact that sodium thiopental is included in the TIA regimens both for LDNE and for kidney transplantation.

General anesthetic dexmedetomidine, known for its sedative, anxiolytic, hypnotic, analgesic, sympatholytic, anti-inflammatory effects, in addition to cardioprotective and cerebroprotective effects, also has a nephroprotective effect [24]. The nephroprotective properties of dexmedetomidine are predetermined by the stimulation of renal blood flow and diuresis, inhibition of vasoconstriction, reduction in the

secretion of renin and arginine vasopressin, and an increase in glomerular filtration rate [25]. This property was also demonstrated in RCT by X.S. Shan et al. (2022). The authors showed that perioperative administration dexmedetomidine reduces the risk of AKI and, accordingly, primary graft dysfunction in kidney recipients. However, we have not found similar studies on the use of dexmedetomidine as a general anesthetic in LDNE [26]. In their observational study, Z. Liu et al. (2022) also found that dexmedetomidine in kidney transplantation reduced the level of AKI markers, the risk of perioperative hemodynamic changes caused by surgical stress [27].

Data from Russian prospective single-center controlled studies on the optimization of anesthetic management in kidney transplantation by comparing the nephroprotective effects of inhalation anesthetics (sevoflurane/desflurane/isoflurane) showed similar conclusions: S.V. Zhuravel et al. (2020) showed that the primary graft function was significantly more common in the group receiving desflurane than in the group of patients receiving sevoflurane or isoflurane. This was confirmed by the lowest numbers of renal replacement therapy sessions, hospital readmissions associated with graft dysfunction, and by the absence of transplantectomies. In this regard, the authors believe that desflurane is the optimal inhalation anesthetic for kidney transplantation [28]. At the same time, N.K. Kuznetsova and her colleagues (2020), when assessing the intraoperative hemodynamics, recorded the most episodes of its instability in the group of patients receiving isoflurane, and the most stable statistically significant parameters were observed in the sevoflurane anesthesia group, while desflurane, according to their assessment, took intermediate position [29].

Thus, the review of publications demonstrated that the majority of studies were devoted to comparative aspects of the impact of general and

inhalation anesthetics on the initial graft function after kidney transplantation, while similar studies on LDNE were not found. Along with this, the interest of the authors of this review was attracted by the RCT conducted by A. Chutipongtanate et al. (2020), who assessed the effect of desflurane and sevoflurane on the induction of peripheral blood T-regulatory cells in LRD kidney recipients. Desflurane caused a significant increase in peripheral blood T-regulatory cells after 24 hours of exposure, which may be useful in kidney transplantation, thus, the choice of desflurane as an anesthetic in kidney transplantation may have additional benefits for the long-term graft function, in particular for preventing a graft rejection [30].

In turn, combined anesthesia is a method of anesthetic management that combines the advantages of general and regional anesthesia (RA). This approach could be considered for LDNE, since it can provide an effective pain relief, reduce the body's stress response and become a predictor of faster donor recovery after surgery. In particular, when a local anesthetic is administered into the epidural space, the sympathetic nerve impulses are blocked at the level of the corresponding dermatomes. In the sympathetic blockade zone, the dilation of arteries and arterioles develops with their decreased resistance to blood flow [31]. Based on this, A.V. Kuligin et al. (2023) [32] and H. Kim et al. (2024) [33] came to similar conclusions that epidural anesthesia in both donors and recipients affects renal vasculature by blocking sympathetic innervation from the Th_X –L_I spinal cord segments, resulting in vasodilation and increased renal blood flow. In a clinical case report described by A. Nawabi et al. (2020) [34], kidney transplantation was performed under spinal anesthesia, meanwhile the authors emphasized the existing comorbidity of the recipient and a new coronavirus infection pandemic, in which a surgical intervention under TIA had a high risk of pulmonary and septic

complications. Based on their work, the authors indicated that the advantage of performing kidney transplantation under spinal anesthesia was the anticipated control over pain intensity in the postoperative period, which required further study.

In the study by V.Kh. Sharipova et al. (2024), the authors discussed the combined effect of TIA (Group 1), the blockade of the transverse abdominis muscle space (Group 2), and the blockade of the erector spinae muscle space (Group 3) in patients, the kidney transplant recipients, on the postoperative need for pain relief with narcotic analgesics. The pain intensity in Group 1 was more significant than in the other two, in Group 2 it was 12.8% higher compared to Group 3. The pain sensations in Group 2 was 65.3% more intense compared to Group 3. The mean dose of narcotic analgesic equivalent to morphine in the 1st group was 18.5% higher than in patients of the 2nd group, and in the 3rd group it was 47% lower compared to the 1st group and 34.7% lower compared to the 2nd group. Adequacy of pain relief against a low consumption of narcotic analgesics contributed to the absence of postoperative nausea and vomiting and early restoration of intestinal motility. Thus, the authors concluded that the combined use of TIA and the blockade of the space of the muscle straightening the back (planar block of *musculus erector spinae*), may be recommended in patients, the renal transplant recipients, in the perioperative period [35]. In a single-center retrospective controlled study by a group of authors led by A.V. Shabunin (2024), they assessed the pain intensity by using a visual analogue scale at 1 and 24 hours after surgery, the daily need for opioids, and the incidence of adverse events from the gastrointestinal tract (nausea, vomiting, intestinal paresis) in the postoperative period in kidney transplant recipients who underwent transverse abdominal space block. The results demonstrated clinically significant reductions in the need for opioid analgesics, in the incidence

of adverse events from the gastrointestinal tract, and an early ambulation of patients after surgery [36]. We should note that we did not find a large number of publications on the use of RA in kidney donors in the perioperative period, which also requires further study. For example, in a systematic review, M. Ander et al. (2024) analyzed studies that included generally accepted advantages and disadvantages of RA techniques: combined spinal-epidural anesthesia, transverse abdominus plane block, continuous thoracic paravertebral block, catheterization of the space of the erector spinal muscle in kidney donors and recipients, as well as the dynamics of patient recovery after anesthesia, technical difficulties of RA techniques, overall results (length of stay in the intensive care unit and in clinic), complications (cases of anaphylaxis, systemic toxicity of local anesthetics, etc.). Based on the analysis, the authors stated that these RA techniques in LDNE and kidney transplantation could be effectively used in both donors and recipients due to ensuring controlled stability of intraoperative hemodynamics with low anesthesia requirements and reduced morphine consumption in the first day after surgery [37].

S. Mittal et al., the authors of RCT (2024) dedicated to assessing the impact of RA methods on the need for fentanyl and additional analgesics in the postoperative period in kidney recipients, where the patients were divided into two groups (intrathecal morphine injection (group 1), and *muscle erector spinae block (group 2)*), revealed that the pain scores at rest and during coughing were significantly lower in the 1st group than in the 2nd one. The mean time till the first use of analgesic was longer in the 1st group. No significant differences were shown in the postoperative consumption of total fentanyl and the use of auxiliary analgesia in both groups. In addition, there were more adverse events – cases of nausea, vomiting and skin itching in the 1st group [38]. Whereas in their RCT, Ö. Özkalayci et al. (2024) did not reveal any differences between the

LRD groups, in particular in the group of patients who underwent *musculus block erector spinae* for postoperative pain relief of hand-assisted LDNE; the amount of fentanyl administered via patient-controlled analgesia over 24 hours, in postoperative opioid consumption, and pain assessment during a 7-day follow-up period. Based on the data obtained, it was concluded that *musculus erector spinae* block was not an effective strategy for postoperative analgesia in LRD undergoing manual assisted LDNE [39]. In addition, the limitations of using the *muscle erector spinae* block technique related to the presence of confident ultrasound navigation skills in the anesthesiologist-resuscitator, the shortage of free ultrasound equipment in the operating room, and the inappropriateness of its use in emergency surgery urge the investigators to search for the most effective RA methods in LRD undergoing LDNE.

Meanwhile, there are a sufficient number of RCTs that summarize the data on anesthetic interventions for kidney recipients. Thus, in the American RCT, E.S. Schwenk et al. (2021) compared the efficacy of a continuous intravenous lidocaine infusion to a single unilateral transversus abdominis block in kidney transplant recipients based on opioid requirements during the first 24 hours after surgery. Lidocaine infusion was non-inferior to a single unilateral transversus abdominis block in providing postoperative analgesia after kidney transplantation. Continuous intravenous lidocaine infusion may be an effective alternative to a single unilateral transversus *abdominis block*, if it is contraindicated or when the necessary skills are not available [40].

Kidney transplant status

The analyzed sources provide ambiguous information on the pathogenetically substantiated choice of drugs for general and RA, aimed at preserving and supporting the functions of the renal graft through

pharmacological effects on renal microcirculation. The latter includes the glomerular and peritubular capillary systems, which ensure key processes: filtration, reabsorption, and maintenance of the osmotic gradient [3, 24, 41]. Due to the mechanism of autoregulation, the kidney is able to maintain stable blood flow and glomerular filtration rate even with fluctuations in arterial pressure within 85–200 mm Hg. The complexity of the microcirculatory bed structure emphasizes the importance of ensuring adequate perfusion, especially during kidney procurement and transplantation, when it is necessary to carefully monitor the blood supply to the graft to maintain its functional activity [10, 18, 24]. At the same time, the inflammatory reaction in the graft also has a negative effect on its initial and further function. Consequently, specific and non-specific factors that form ischemic and reperfusion injury (IRI) of the graft worsen its initial function and negatively affect the long-term results of transplantation [8, 9, 42].

Despite the fact that propofol is a routine drug used in anesthesiology practice for the induction and maintenance of general anesthesia of any duration in various surgical areas [43, 44], there are scant data on the LDNE effect on reducing the risk of developing transplant IRI. In particular, the RCT performed by J. Cai et al. (2025) found no difference between anesthesia with sevoflurane and with propofol in relation to intraoperative hemodynamics, AKI biomarker levels (TIMP-2, KIM-1, and IL-18) and biochemical homeostasis in donors who underwent LDNE [20]. Thus, further RCTs are required to evaluate the effect of propofol on the risk of developing graft IRI in LDNE.

In the cohort study of N. Jahn et al. (2022), sevoflurane and desflurane anesthesia demonstrated nephroprotective properties towards

the graft, thereby reducing the incidence of postoperative complications related to IRI compared to the isoflurane anesthesia group [45].

There are a number of RCTs on the effect of dexmedetomidine on the development of renal IRI. Thus, in one of them J. Chen et al. (2020) [46] noted that the expression of kidney injury molecule 1 (KIM-1) in urine in the dexmedetomidine group, as opposed to placebo, was lower at 2–72 hours after reperfusion, which was associated with the anti-inflammatory response of dexmedetomidine. However, despite the decrease in KIM-1 expression in urine, the authors did not find intergroup differences in azotemia and diuresis after transplantation. Long-term outcomes in patients who underwent surgery were assessed at days 30, 60, and 90. In the first 3 months, no differences were found between the groups in the level of urea, serum creatinine, and the dynamics of glomerular filtration rate, which was consistent with meta-analysis data [47]. In their RCT, Y.C. Wang et al. (2022) studied the effect of dexmedetomidine on the risk of developing IRI in the graft by means of sublingual monitoring of microcirculation in recipients. In this case, recipients from the dexmedetomidine group had better initial renal function, but the overall vessel density in the study and control groups did not differ significantly, moreover, 2 hours after surgery, microcirculation parameters in the sublingual region did not differ significantly from the group where dexmedetomidine was not used [48].

In two foreign publications, G.J. Nieuwenhuijs-Moeke et al. [49, 50] confirmed the fact that unstable intraoperative hemodynamics and inadequate graft perfusion at the stage of LDNE in posthumous donors worsened the organ condition, increased IRI due to acute tubular necrosis, vascular endothelial dysfunction, and thrombus formation, which negatively affected organ acceptance and long-term transplantation

results, while similar data on LRD were absent, which required further large-scale study.

Conclusion

Kidney transplantation remains one of the most effective methods of renal replacement therapy for patients with stage 5 chronic kidney disease. Living related donors are used for kidney transplantation due to a shortage of organs from deceased donors, despite the health risks of living related donors [3, 5, 6]. Thus, the risk of developing stage 5 chronic kidney disease in kidney donors over a 15-year period is 3.5–5.3 times higher compared to the general population [51]. One should noted that there is a shortage of deceased donors even in countries where donation has long existed, is cultivated, and is encouraged by government authorities and religious organizations. In most regions of Russia, with the exception of Moscow and several other regions, deceased donation currently remains at an extremely low level [5, 7].

In world literature over the recent five years, we have not found a large number of reports on perioperative anesthetic management of laparoscopic donor nephrectomy, while aspects of pain relief for patients undergoing kidney transplantation are covered sufficiently, but ambiguously. The available data indicate that general, combined and regional anesthesia are of interest and can be effectively used in laparoscopic donor nephrectomy due to their ability to reduce the body's stress response and improve postoperative recovery of donors. Despite some promising results, the number of randomized clinical trials remains limited, and existing studies have methodological limitations, small sample sizes and a high risk of systematic errors. Further large randomized clinical trials are required to draw final conclusions on the

optimization of anesthetic management of laparoscopic donor nephrectomy.

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Information about the authors

Valery D. Babaev, Physician Anesthesiologist-Intensivist of Anesthesiology and Intensive Care Department No. 1, S.R. Mirotvortsev Clinical Hospital No. 1, Saratov State Medical University n.a. V.I. Razumovsky, <https://orcid.org/0009-0008-2094-0573>

20%, study concept and design development, data analysis and interpretation

Alexander V. Kuligin, Assoc. Prof., Dr. Sci. (Med.), Head of the Department of Emergency Medicine, Anesthesiology and Intensive Care, and Simulation Technologies in Medicine, Saratov State Medical University n.a. V.I. Razumovsky, <https://orcid.org/0000-0001-5705-215X>

15%, editing the article text, preparing the conclusion, final approval for publication of the manuscript

Anton N. Rossolovsky, Assoc. Prof., Dr. Sci. (Med.), Associate Professor of the Department of Urology, Saratov State Medical University n.a. V.I. Razumovsky, <https://orcid.org/0000-0002-9810-4363>

10%, editing the text of the article, preparing the conclusion

Roman S. Prokhorov, Head of Critical Medicine and Intensive Care Department No. 1, S.R. Mirotvortsev Clinical Hospital No. 1, Saratov State Medical University n.a. V.I. Razumovsky, <https://orcid.org/0009-0005-3556-2438>

5%, processing of scientific literature

Alexander V. Lushnikov, Assoc. Prof., Cand. Sci. (Med.), Associate Professor of the Department of Emergency Medicine, Anesthesiology and Intensive Care, and Simulation Technologies in Medicine, Saratov State Medical University n.a. V.I. Razumovsky, <https://orcid.org/0000-0003-1615-6969>

5%, literature review

Alexey E. Gaidarov, Assistant of the Department of Emergency Medicine Anesthesiology and Intensive Care, and Simulation Technologies in Medicine, Saratov State Medical University n.a. V.I. Razumovsky, <https://orcid.org/0009-0005-3561-8534>

5%, literature review

Ekaterina E. Zeulina, Assoc. Prof., Cand. Sci. (Med.), Associate Professor of the Department of Emergency Medicine, Anesthesiology and Intensive Care, and Simulation Technologies in Medicine, Saratov State Medical University n.a. V.I. Razumovsky, <https://orcid.org/0000-0003-1297-5123>

40%, processing of scientific literature, writing conclusions, editing and formatting of the article text

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