

The Role of Carrying Out Combined Unilateral Spinal and Epidural Anesthesia Using Low Doses of Local Anesthetics in Elderly Patients in Lower Limb Joint Arthroplasty

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Annotation. Endoprosthetics of the joints of the lower limb is a very traumatic intervention. The relevance of this issue is due to the intensive development and introduction of the latest technologies in modern surgical interventions, including joint replacement, and a significant expansion of indications for surgical treatment. In connection with the above, anesthesia should correspond to the nature of this intervention: completely block nociceptive impulses, maximally reduce perioperative blood loss and the need for donor blood components, the likelihood of developing thromboembolic complications in the postoperative period, and the severity of postoperative pain syndrome.

Key words: patient, endoprosthetic, endoprosthesis replacement, operated.

All these requirements are met to the maximum extent by the methods of central segmental blockades. For the correct administration of anesthesia, it is necessary to have proper knowledge about possible complications and, above all, from the side of vital organs, adequate preparation before surgery, intraoperative management with minimal physical disturbances and side effects.

Rationale

Of the methods of anesthesia for endoprosthesis replacement of the joints of the lower limb, various options for regional anesthesia (SA, EA, combined SEA, conduction [1,2,3] and, to a lesser extent, general anesthesia [4,5,6,] are most widely used).

Traditional general anesthesia, eliminating the perception of pain, does not interfere with nociceptive stimulation of the central structures, which leads to the release of neuropeptides and excitatory amino acids, which, in turn, cause sensitization of the dorsal horns of the spinal cord, followed by their persistent depolarization and the development of a deficit in inhibitory control, which leads to the occurrence of postoperative pain syndrome [7]. One cannot but agree with A.M. Ovechkin that modern powerful inhalation anesthetics create only the illusion of adequate anesthesia during surgery, as they affect the most proximal link in the formation of acute pain syndrome.

With regard to arthroplasty of the joints of the lower limb, general anesthesia with tracheal intubation, mechanical ventilation in the elderly and senile people is associated with an increase in blood loss [8,9,10] an increased risk of postoperative thrombosis and pulmonary embolism [11,12] and other postoperative complications [13].

Materials and methods.

40 patients operated on under conditions of combined unilateral spinal-epidural anesthesia were studied. Inclusion criteria were: age at least 75 years old with a physical status according to ASA-III, IV Charlson comorbidity index more than 6 points.

All patients in this group underwent cement arthroplasty of the joints of the lower extremities (30 – THA, 13 – TKA) under conditions of unilateral SA and combined unilateral EA. Patients of this group, we carried out a two-level blockade. The studies were carried out at the TMA multidisciplinary clinic from 2018 to 2021. The main indications for surgical intervention were: hip fracture, coxarthrosis, gonarthrosis.

In addition to routine clinical and biochemical studies in terms of assessing the effectiveness of anesthesia in the perioperative period, we studied the following parameters of systemic and central hemodynamics, monitoring them:

- heart rate monitoring
- non-invasive determination of blood pressure
- SBP monitoring
- non-invasive monitoring of CG parameters by impedance cardiography (USU module).
- registration and automatic recording of arrhythmia.
- measurement of the degree of oxygen saturation of capillary blood (pulse oximetry)
- ECG registration and monitoring.

All of these studies were carried out by us using the "Resuscitation and Surgical Monitor" UM 300 (OOO of the company YUTAS, Ukraine), designed for continuous monitoring of the patient's vital functions, displaying them on the display, signaling deviations in controlled parameters.

In addition to these parameters, mean arterial pressure (MAP) was calculated in all patients using the formula:

$$\text{MAP mm Hg} = (\text{syst BP} + 2 \text{ diastBP}) / 3$$

For a more in-depth analysis of the changes taking place in the circulatory system of patients, in addition to the actual values of TPVR, we calculated the proper values of this indicator using the formula:

$$e\text{TPVR} = (\text{SBP due} * 80) / (\text{MOC fact}), \text{ where}$$

eTPVT – expected TPVR, dyn* [cm]⁽⁻⁵⁾

MAP - mean blood pressure mm Hg.

MBV fact - actual minute blood volume, l / min.

Proper values of mean blood pressure depend on age. The proper value of SBP in the geriatric group of patients, which includes all the patients we studied, is as follows: in the elderly (60-75 years old) 95 mm Hg for men, 100 mm Hg for women

In persons of senile age (> 75 years), it is equal, respectively

100 and 110 mm Hg

In conditions of neuraxial blockades, especially in elderly people, in our opinion, the determination of the tone of the autonomic nervous system, which characterizes the autonomic regulation of the systemic circulation, is of particular interest. Therefore, when calculating the integral indicators of the cardiovascular system, we calculated the "vegetative index" of Kerdo according to the formula:

$$\text{VI} = (1 - \text{DBP} / \text{HR}) * 100, \text{ where}$$

VI - vegetative index;

DBP - diastolic blood pressure mm Hg

HR is the heart rate per minute.

With vegetative balance in the regulation of blood circulation, VI is 0.

After identifying the epidural space, the opening of the 18 G epidural needle was oriented towards the intended operation by turning it 45 degrees down. The catheter was inserted in this position without advancing it in the cranial direction. The needle was removed without changing the location of the catheter and fixed to the skin. The duration of unilateral EA was 2–3 days, after which the catheter was removed.

The adequacy of anesthesia was assessed intraoperatively, and postoperative analgesia, its effectiveness was assessed after 6, 24, 48 hours according to VAS at rest and during flexion in the operated joints, while walking.

As part of the concept of multimodal analgesia against the background of EA, all patients in this group received NSAIDs (ketoprofen 200 mg/day). Preoperative preparation of patients in this group did not differ from the previous ones. Pre-infusion in the operating room was carried out with crystalloid-colloidal solutions (25-27 ml/kg) with the obligatory addition of vasopressors (5-7 mg) and corticosteroids (prednisolone 1-2 mg/kg or dexamethasone - 0.07 mc/kg) administered with infusion pumps.

The main hemodynamic parameters were recorded every 5 minutes during the first 30 minutes after intrathecal administration of bupivacaine with fentanyl, and then every 10 minutes until the end of the operation.

Results

The table below shows the demographics of patients in this group operated under conditions of unilateral combined spinal-epidural anesthesia.

Table No. 1. Demographic and clinical characteristics of patients in this group (n = 43).

Indicators	Value
Age, years	78,2 ± 3,0
Gender, male/female, n %	17/26
BMI	23,9 ± 1,4
Side of the operation, l/r, n %	24/19
Comorbidity index	
3 or less, n %	19 (47,5)
4 and more, n %	24 (52,5)
ASA: II, n %	18 (35)
III, n %	25 (65)

A feature of patients in this group was senile age with a high comorbidity index (100%) and physical status ASA (62.5%) and class III (37.5%).

Concomitant diseases in patients of this group were hypertension, coronary cardiosclerosis suffered by IM (2), chronic myocardial insufficiency, varicose veins of the lower extremities, severe pain syndrome.

The initial values of peripheral blood, hemostasis and their changes during the operation practically did not differ from those in the previous groups. Moderate hypovolemia, hemoconcentration and activation of the blood coagulation system, signs of a systemic inflammatory (aseptic) response to the underlying pathology (dystrophic-degenerative changes in the joints (7), fracture of the femoral neck (5), aseptic necrosis of the femoral head (2) were still noted), rheumatoid arthritis (1) In 30 patients, venous access was peripheral, 13 patients had a central vein catheterized (subclavian according to Seldinger).

Table No. 2. Indicators of systemic hemodynamics in patients of this group at the stages of surgery and after it (n = 43).

Indicators	Stages of study						
	Initial	Beginnin g of the operation	Implantati on	End of the operation	30 mins after	60 minutes after	120 mins after
BP syst	149,9 ± 6,0	136,7±5,3	145,5±5,4	140,7±3,7	132,4±4,1	138,4±4, 8	143,4±5, 5
BP diast	83,4 ± 3,9	80,1±4,4	82,7±3,8	80,7±2,9	76,9±4,3	80,7±5,2	81,2±4,9
MAP	105,5 ± 4,3	98,9±4,7	103,6±4,2	100,7±3,4	95,4±4,1	100,0±4, 9	102,0±5, 2

HR	94,7 ± 4,9	89,4±2,6	82,1±2,6	77,6±2,3	88,9±2,3	88,5±2,7	86,4±4,0
CVP	6,3 ± 1,7	7,2±0,9	7,1±1,2	8,4±1,3	8,4±1,6	8,9±0,5	9,2±1,0
SPO2, %	92,4 ± 0,9	94,0±1,3	93,7±1,4	92,8±0,9	93,1±1,2	92,6±0,9	92,4±1,3

Note: x - p < 0.05 relative to the initial values:

The presented data demonstrate rather stable indicators of systemic hemodynamics at all stages of the operation and the immediate postoperative period. There was only one episode of some decrease in blood pressure and MAP by the beginning of the operation. However, this episode was short-lived and not statistically significant, and this hypotension was only 8.8% lower than baseline systolic BP values. Diastolic BP and MAP decreased by 4% and 6.3%, respectively (p>0.05).

The second episode of lowering blood pressure and MAP was in response to the introduction of 2.5 mg of bupivacaine into the epidural space by 80-90 minutes. operating period, due to the weakening of the sensory block in the operated limb. But here, too, the maximum decrease in blood pressure and MAP was within 11.7%, 7.8% and 9.6%, respectively.

With regard to heart rate, there were no episodes of severe tachycardia or bradycardia during the entire study period. During the operation, there was a tendency to increase CVP. However, the CVP indicators remained within the physiological range, which indicates an increase in the return of blood to the heart without an overload reaction from the cardiovascular system.

Pulse oximetry indicators improved somewhat during the operation when oxygen was supplied through the mask, then returned to the original values again.

We analyzed changes in BP and MAP immediately after administration of intrathecal 5 mg bupivacaine with 20 µg fentanyl for 30 min.

Table No. 3. Indicators of systemic hemodynamics after performing unilateral spinal-epidural anesthesia before surgery (n = 43).

Time	BP syst	BP diast	MAP	HR
0	149,9 ± 6,0	83,4 ± 3,9	105,5 ± 4,3	88,7 ± 4,9
5	141,6 ± 5,4	80,1 ± 2,7	100,6 ± 4,9	89,2 ± 5,0
10	136,6 ± 4,7*	78,3 ± 4,2	97,5 ± 3,8	82,5 ± 4,7
15	136,3 ± 4,3*	77,9 ± 3,9	97,3 ± 4,1	78,2 ± 4,0
20	137,7 ± 5,0	78,8 ± 4,1	98,4 ± 4,5	86,4 ± 2,7
25	138,6 ± 3,9	81,2 ± 3,3	100,3 ± 3,7	88,3 ± 4,2
30	137,4 ± 4,8	83,3 ± 4,1	101,3 ± 4,4	86,9 ± 5,1

In general, hemodynamics is relatively stable. In this group, we see one episode of a decrease in blood pressure and MAP associated with the interthecal administration of bupivacaine with fentanyl, in response to which systolic, diastolic blood pressure and MAP decreased by a maximum of 10-15 minutes by 9.3%, 6.6% and 4.7%, respectively, the decrease by 10-15 minutes of systolic blood pressure was statistically significant, but it did not exceed 10%.

As for the heart rate, its maximum decrease by 15 minutes was 11.9% relative to the 0-value (p < 0.05). We attributed this to the action of fentanyl. In no case in this group, we noted arterial hypotension exceeding 20%.

The vascular load in this group was 1869.4 ± 278.4 ml.

Table No. 4 Dynamics of CH parameters at the stages of surgery and postoperative period in the studied patients of this group (n = 43).

Indication	Stages of study						
	I	II	III	IV	V	VI	VII
SI, ml/m ²	25,7±0,6	22,6±0,7x	22,9±0,5x	23,8±0,7	24,0±0,6	24,9±0,8	25,6±0,5
HI, l/m ²	2,28±0,4	1,89±0,3x	1,83±0,3x	1,88±0,5x	1,86±0,3xx	1,95±0,5x	2,01±0,6x
TPVR	2058,1±267,0	2457,1±209,9	2550,1±248,8	2433,8±306,7	2578,4±215,1	2279,2±196,6	2260,3±246,4

Note: x - p < 0.05 relative to the initial data: xx - P < 0.05 relative to the previous values.

And in this group of patients, we register the initial hypodynamic regime of blood circulation with a decrease in one-time and minute productivity of the heart and relatively increased values of TPVR. And here we see two episodes of SI and HI decrease. One of them was in the course of the operation - at the III stage of the operation, the HI and SI decreased by 10.9% and 19.8%, respectively. In both cases p < 0.05. In response to the decrease in these indicators, there was a trend towards an increase in TPVR (by 20.1%). The second episode of decrease in SI and SI by 6.7% and 18.5%, respectively (p < 0.05) was associated with patients' complaints of pain in the postoperative wound before the introduction of bupivacaine into the epidural space, TPVR during this period increased by 21.9 % (p < 0.05).

In the group of patients, the initial values of TPVR exceeded the due values of this indicator by 5.5%, indicating the prevalence of spastic processes in the system of low circulatory pressure due to the overwhelming influence of the sympathetic nervous system. This was also evidenced by the vegetative Kerdo index and the level of cortisol in the blood at stages I and V of the study.

VI at the indicated stages of the study was +12 and +14, and the level of cortisol in patients of this group (n=8) upon admission to the clinic was elevated (594.7 ± 21.9 n mol/l), but did not exceed the reference limit. 60 minutes after the operation, a significant decrease (399.8 ± 36.8 nmol/l) was noted - by 32.8% relative to the initial values, which corresponded to adequate analgesia during this period.

Table 5. Indicators of sensory and motor blocks and total consumption of bupivacaine and fentanyl in the perioperative period in patients of this group (n = 43).

Indicator	Value
Sensory block	
Block start, sec	57,1 ± 6,3

Block peak, min	7,08 ± 0,9
Time to reach the block up to Th 10, min	6,34 ± 0,87
Block duration, min	112,5±6,1
Block regression time, minutes	92,7 ± 9,9
Motor block	
Block start, min	6,4 ± 2,1
Block duration, min	129,9 ± 12,8
Block peak, min	7,22 ± 1,9

Analyzing the presented values, it can be indicated that in this group with unilateral spinal-epidural anesthesia with small doses (5 mg of bupivacaine), the timing of the onset of blocks and the time to reach the sensory block to the level of Th10 are slightly prolonged, relative to those with high doses of local anesthetic (in the previous group) . Attention is drawn to the decrease in the duration of the sensory block and the regression time, relative to the same indicators in the previous group by 14.5% and 19.4%, respectively, which we associated exclusively with a decrease in the dose of bupivacaine, since the dosage of intrathecal adjuvant administration in both groups was the same (20 mcg fentanyl).

As for the motor block, its duration was sufficient for such an operation, and it was regulated by the introduction of bupivacaine into the epidural space without opioids and other adjuvants. Despite many similarities between spinal and epidural anesthesia, their physiological and pharmacological effects differ. One of the advantages of EA over SA is the creation of a segmental sensory block and control of sensory and motor block.

Sensory blockade of the operated limb to the zones of innervation of the hip and knee joints (Th10 - Th11 and L5 - L4, respectively) was achieved in 100% of cases within 30 - 35 minutes with unilateral spinal epidural anesthesia.

In all patients of this group, by 30-35 minutes after the start of the unilateral anesthesia procedure, a motor block of the pathological limb developed, towards which the epidural catheter was oriented. Moreover, motor blockade was 3 - 4 points on the Bromage scale.

By the beginning of the operation in one patient in this group (6.6%), we registered motor blockade (1-2 points) of the contralateral limb. The development of motor blockade of the healthy leg in 2 patients in the postoperative period could be evidence of displacement of the tip of the epidural catheter in the central direction; this was also evidenced by the fact that a decrease in the dose and rate of administration of bupivacaine into the epidural space did not lead to the termination of the motor block of the contralateral limb. In the postoperative period, in addition to CPA, no additional anesthesia was performed by introducing bupivacaine into the epidural catheter.

Table No. 6. Surgical blood loss and perioperative time parameters in patients operated on under conditions of unilateral spinal-epidural anesthesia (n = 43).

Indicators	Value
The volume of surgical blood loss, ml	529,8 ± 56,5

ITT volume, ml	1869,4 ± 278,4
Volume of blood transfusion (er mass), ml	261,7 ± 40,4
Time to operation, min	51,8 ± 4,9
Duration of operation, min	119,7 ± 8,8
Time of stay of patients in the operating room after surgery, min	21,4 ± 2,9
Recovery time of cognitive functions, min	17,7 ± 3,0

The given data practically do not differ from the same indicators in the II group of patients. Such a long period of the beginning of the operation is explained by the complexity and duration of the procedure of unilateral spinal-epidural anesthesia, which had no effect on all other studied perioperative parameters.

We noted an earlier development of pain in the immediate postoperative period (by 30-40 minutes), when CPA was started. Satisfaction with this anesthesia technique for both patients and surgeons was positive in all cases.

We did not observe any intraoperative complications in this group of patients. In one patient (6.6%) 24-26 hours after the operation, a post-puncture syndrome (headache, nausea, vomiting, dizziness) was registered, which was associated with the outflow of CSF through a puncture of the dura mater. Double intravenous drip administration of 10% caffeine (200-300 mg each) and sealing of the epidural space with autologous blood stopped this syndrome. One patient had pruritus and urinary retention. Another patient noted moderate back pain, which stopped on its own. In the postoperative period, 2 cases of rhythm disruption were registered (extrasystole over the ventricular - 1) and paroxysmal tachyarrhythmia - 2). In 2 (5%) patients, significant sedation was registered in the immediate p/o period (40-60 min), but without clinically significant respiratory depression. Patients reported a desire to sleep and assessed their condition as intoxication. We associated this with the epidurally administered local anesthetic and the coincident administration of 100 mg of ketoprofen. Postoperative chills were not observed in any case.

Table No. 7. The total consumption of drugs in the perioperative period for each patient operated on under conditions of unilateral spinal-epidural anesthesia (n = 43).

Medicaton	Doses
Bupivacaine 0.5%, mg	7,5 ± 2,4
Fentanyl, mcg	22,4 ± 2,6
Propofol, mg	40,0
Diazepam, mg	15,0
Paracetamol, gr	2,0
Vasopressors, mg	22,4 ± 3,7

NSAIDs, (ketoprofen) mg	200,0
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From the presented data, it can be concluded that this method of pain relief has a significant opioid-sparing character, which is extremely important for geriatric patients undergoing such voluminous and traumatic interventions as major orthopedic surgeries.

We were looking for an answer to the question: did regional anesthesia reduce mortality, cardiovascular complications, DVT and PE, blood loss, duration of surgery, pain, opioid-related side effects, cognitive impairment, blood loss. To answer these questions, we conducted a systematic review of the current literature to compare our data on VCA and two optimized variants of unilateral SA combined with EA and unilateral spinal-epidural anesthesia in elderly patients who underwent total cement arthroplasty of the lower limb joints.

Summing up the analysis of this group, it should be noted that unilateral and spinal and epidural anesthesia with small doses of an intrathecally administered local anesthetic (0.5% bupivacaine 5 mg with 20 µg fentanyl) and additional unilateral epidural analgesia is a new, safe and effective method of pain relief for arthroplasty surgery of lower limb joints.

Conclusions

1. Our proposed method of unilateral and spinal and epidural anesthesia with low doses of intrathecally administered local anesthetic (5 mg of 0.5% hyperbaric solution of bupivacaine with 20 µg of fentanyl) and additionally introducing low doses of bupivacaine 2.5 mg into the epidural space allows achieving proper sensory-motor block necessary for the production of endoprosthesis replacement of the joints of the lower extremities.
2. The addition of fentanyl 20 µg to low doses of bupivacaine (5 mg) prolongs the duration of sensory block by 17.1% and the total duration of pain relief (by 19.8%) with lower doses of local anesthetic, without increasing the duration of motor block.
3. Unilateral spinal-epidural anesthesia is characterized by hemodynamic stability, adequate protection against operational stress, a small number of complications and side effects, and an opioid-sparing effect. It should find a niche for its use in elderly people with a high comorbidity index and physical status (II - III) ASA.

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