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Research Article

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Comparative Evaluation of General and Regional Anesthesia Methods in Trauma Surgeries

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ABSTRACT The risk of complications of anaesthesia is significantly increased in some circumstances specific to emergency patients with pelvic and lower limb injuries. Therefore, in recent years, anaesthesiologists have given preference to regional anaesthesia in operations on pelvic organs and lower extremities.

AIM OF THE STUDY Comparative evaluation of the methods of general and regional anaesthesia in operations for pelvic and lower limb injuries.

MATERIAL AND METHODS The data of 101 patients aged from 21 to 78 years, operated in the early posttraumatic period, were included in the study. In group 1 (27 patients) multicomponent endotracheal anaesthesia was used, patients of group 2 (16 patients) were operated under epidural anaesthesia. Patients of the 3rd group (36 patients) underwent surgical intervention under subarachnoid anaesthesia. Group 4 (22 patients) included patients operated under spinal anaesthesia — bupivacaine combined with morphine hydrochloride in a dose of 0.07–0.08 mg.

RESULTS The most adequate method of postoperative analgesia was the method used in patients of group 4. A single injection of bupivacaine 10–15 mg in combination with morphine (0.08–0.1 mg/kg) provided rapid-onset, adequate, long-lasting (24–72 hours) analgesia without hemodynamic depression. Respiration and SpO_2 were adequate, patients were in a light sedation (level II) and a state of emotional calm and comfort.

CONCLUSION Spinal anaesthesia with bupivacaine combined with morphine hydrochloride at a dose of 0.07–0.08 mg is the method of choice of anaesthetic aid in orthopedic trauma surgeries, which provides good analgesia and hemodynamic stability with adequate spontaneous breathing of the patient during surgery.

Keywords: subarachnoid anesthesia, analgesia, bupivacaine, morphine hydrochloride, regional anesthesia, anesthetic aids, orthopedic trauma surgeries

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BP — blood pressure
BPdiast — diastolic blood pressure
BPmean — mean blood pressure
BPsyst — systolic blood pressure
CHD — coronary heart disease
HR — heart rate
NSAIDs — non-steroidal anti-inflammatory drugs
RA — regional anesthesia
RR — respiratory rate
TP — trauma patients

INTRODUCTION

Recently, indications for surgical interventions in trauma patients (TP) in the early post-shock period have been expanded [1, 2]. In particular, the elimination of functioning foci of the pathological process by osteosynthesis and other surgical procedures becomes a necessary condition determining the success of further treatment of traumatic disease [3,4,5]. In the first day after surgery, patients experience intense pain syndrome, accompanied by emotional discomfort, hemodynamic and respiratory disorders [6, 7, 8]. In this regard, the adequacy of early postoperative pain relief is associated with a reduction in the overall number of complications, both in the early and late postoperative periods.

In some circumstances typical for emergency patients, the risk of complications from anesthesia increases significantly, and may even exceed the anesthetic risk of the operation itself [9, 10, 11]. Therefore, in recent years, anesthesiologists have given preference to regional anesthesia (RA) during operations on the pelvic organs and lower extremities. The possibilities of modern anesthesiology, technical and medicamental support, and the improvement of modern RA make it possible to solve these problems to one degree or another.

Aim: comparative evaluation of general and regional anesthesia methods in surgeries for pelvic and lower extremity injuries.

MATERIAL AND METHODS

The study included 101 patients who were treated in the Traumatology Department of the Andijan Branch of the Republican Research Centre of Emergency Medicine (AB RRCEM) from 2020 to 2024. The patients underwent trauma surgeries in the pelvic area and lower extremities.

Among those operated on, the elderly and senile age group predominated (from 61 to 78 years old - 54.9%, the age group from 36 to 60 years old was 40.7%). Young patients (from 21 to 35 years old) were encountered in only 4.4% of cases from the total number.

Most patients had concomitant somatic pathology. The most common were cardiovascular diseases: coronary heart disease — CHD (18), postinfarction cardiosclerosis (8), cardiac rhythm disturbances (13), hypertension (45); 17 patients suffered from chronic obstructive pulmonary diseases. The patients also had such types of pathology as obesity (15), rheumatoid polyarthritis (2), diabetes mellitus (6), and anemia (18).

All patients were examined in the preoperative period and divided into four groups.

In group 1 (27 patients), multicomponent endotracheal anesthesia was used: induction with fentanyl, barbiturates in generally accepted calculated doses. Maintenance of anesthesia: seduxen — 0.3–0.6 mg/kg, fentanyl — 4–6 mcg/kg, droperidol (0.25% solution in standard doses), ketamine 1–3 mg/kg. Myoplegia was performed with arduan 0.06–0.1 mg/kg. Ventilation was performed with a mixture of oxygen and nitrous oxide in a ratio of 1:2. At the end of the surgical intervention, ventilation was performed until awakening and restoration of independent adequate breathing. For postoperative pain relief, 2% promedol - 20 mg, ketonal - 30 mg, 1% diphenhydramine - 10 mg, seduxen - 10 mg were administered parenterally.

Patients of group 2 (16 patients) were operated under epidural anesthesia (puncture of the epidural space at the level of LII–LIII, LIV–LV, with G18 Portex disposable sets followed by catheterization of the epidural space in the cranial direction by 4 cm). Test dose — 0.5% bupivacaine solution — 5 ml (25 mg). The main anesthetic used was 0.5% bupivacaine solution at a dose of 100 mg. In the early postoperative period, analgesia was achieved by epidural administration of 5 ml (25 mg) of 0.5% bupivacaine solution through a catheter.

In patients of group 3 (36 patients), the surgical intervention was performed under subarachnoid anesthesia. Lumbar puncture was performed at the level of LIII–LIV using a G-22-25 Portex needle. Spinal 0.5% bupivacaine was used intrathecally — 3–

4 ml (15–20 mg). An adequate spinal block developed in 5-8 minutes. For pain relief in the postoperative period, parenteral administration of narcotic analgesics in combination with nonsteroidal anti-inflammatory drugs (NSAIDs), antihistamines, and sedatives (2% promedol - 1 ml (20 mg), ketorol - 30 mg, 1% diphenhydramine - 1 ml (10 mg), seduxen - 10 mg) were used.

Group 4 (22 patients) included patients operated under spinal anesthesia - bupivacaine in combination with morphine hydrochloride at a dose of 0.07-0.08 mg (a narcotic analgesic used to potentiate the analgesic effect of a local anesthetic).

If necessary and required, additional pain relief medications, sedatives were used (in patients of groups 2, 3, and 4). The adequacy of intraoperative anesthesia was assessed using a set of clinical criteria and monitoring of systolic (BPsyst), diastolic (BPdiast), mean (BPmean) blood pressure, changes in heart rate (HR), pulse oximetry (SPO2), and thermometry.

All the patients after surgery were admitted to the intensive care unit and were under dynamic monitoring. The patients' condition and the quality of postoperative pain relief were assessed using a set of clinical criteria and monitoring of the level of consciousness. The level of sedation was assessed using the Ramsay sedation scale: Level I — the patient is agitated, impatient; Level II — the patient is awake, calm, oriented, and cooperates with the physician; Level III — the patient is conscious but responds only to commands; Level IV — the patient is dozing, but responds to touch or loud sounds; Level V — the patient is asleep, responds slowly and sluggishly to tactile stimuli or loud sounds; Level VI — the patient is asleep and does not respond to stimuli. The intensity of postoperative pain in dynamics was assessed using the Verbal Rating Scale (VRS) in points: 0 - no pain; 1 - mild pain during movement, absent at rest; 2 - moderate pain during movement, mild at rest; 3 - severe pain during movement, moderate at rest; 4 - unbearable pain.

All of the above indicators were recorded on the eve of the operation (stage I), during anesthesia (stage II), at the beginning of the operation (stage III), during the main stage of the operation (stage IV), and at the end of the operation (stage V).

Statistical data processing was performed using the Microsoft Office Excel 2010 (Microsoft Corp., USA) and Statistica 6.0 (StatSoftInc., USA) software packages. Data are presented as mean (M) and standard deviation of the mean (m). Categorical data are described as frequency, n (%). The significance of differences between the stages depending on the type of data was assessed using Student's t-test or Mann–Whitney U-test or Fisher's exact test with a critical significance level (p) of less than 0.05.

RESULTS

The identified changes in hemodynamic parameters of patients in the different groups are presented in Tables 1–4. When analyzing the obtained data, similar trends were noted in all the study groups.

Table 1

Hemodynamic parameters at the stages of endotracheal anesthesia in patients of group 1 (M±m)

Parameter	Stage				
	I	II	III	IV	V
BPsyst, mmHg	141±3.41	132±3.23	124±3.11	92±4.24*	97±3.42*
BPdiast, mmHg	89±2.62	72±2.21	73±2.24	59±2.35*	54±2.13*
BPmean, mmHg	104±3.33	92±3.21	90±3.15	70±3.25*	68±2.75*
Heart rate, bpm	82±3.43	76±2.32	72±3.65	68±3.13*	63±2.14*
SpO_2	94±1.63	96±0.81	96±0.72	96±0.84	96±0.42
Respiratory rate, beats/min	14±0.12	13±0.41	13±0.92	12±0.53	14±0.32

Notes: BPsyst — systolic pressure; BPdiast — diastolic pressure; BPmean — mean arterial pressure; * — p<0.05 compared to baseline values

Table 2

Hemodynamic parameters at the stages of epidural anesthesia in patients of group 2 (M±m)

Parameter	Stage				
	I	II	III	IV	V
BPsyst, mmHg	144 ±3.24	123±3.32*	124±3.36*	104±3.46*	87±3.72*
BPdiast, mmHg	87±2.42	70±1.84*	71±2.37*	55±2.26*	48±2.31*
BPmean, mmHg	106±3.81	87±3.05*	88±3.82*	71±3.79*	61±3.49*
Heart rate, bpm	82±3.74	71±3.42*	68±2.63*	76±2.85*	64±2.62*
SpO_2	94±1.12	96±0.73	96±0.92	94±1.34	96±0.83
Respiratory rate, beats/min	14±0.43	15±0.16	12±1.21	11±0.31	11±0.93

Notes: BPsyst — systolic pressure; BPdiast — diastolic pressure; BPmean — mean arterial pressure; * — p<0.05 compared to baseline values

Table 3

Hemodynamic parameters at the stages of spinal anesthesia in patients of group 3 (M±m)

Parameter	Stage				
	I	II	II	IV	V
BPsyst, mmHg	139 ±3.21	125±3.25	122±2.43*	118±3.38*	81±3.83*
BPdiast, mmHg	82±3.62	74±2.27	67±3.82*	68±2.77*	56±2.64*
BPmean, mmHg	101±2.89	91±2.68	85±3.12*	84±2.36*	64±2.64*
Heart rate, bpm	78±3.44	71±3.34	68±3.24*	68±3.35*	59±3.31*
SpO_2	94±0.16	96±0.37	96±0.21	96±0.62	95±0.16
Respiratory rate, beats/min	14±0.28	16±0.65	14±0.41	13±0.74	16±0.37

Notes. BPsyst — systolic pressure; BPdiast — diastolic pressure; BPmean — mean arterial pressure; * — p<0.05 compared to baseline values

Table 4

Hemodynamic parameters at the stages of spinal anesthesia with morphine in patients of group 4 (M±m)

Parameter	Stage				
	I	II	II	IV	V
BPsyst, mmHg	152 ±3.84	133±3.82*	122±3.34*	121±1.23*	122±2.35*
BPdiast, mmHg	88±3.73	73±3.84*	64±3.64*	62±3.55*	66±3.14*
BPmean, mmHg	109±3.24	93±3.31*	83±3.95*	81±2.35*	84±3.24*
Heart rate, bpm	81±3.95	78±3.22	73±3.61*	71±3.42*	72±2.56*
SpO_2	94±1.52	96±0.87	97±0.63*	97±0.52*	97±0.63*
Respiratory rate, beats/min	14±0.38	14±0.25	14±0.32	14±0.16	13±0.34

Notes: BPsyst — systolic pressure; BPdiast — diastolic pressure; BPmean — mean arterial pressure; * — p<0.05 compared to baseline values

The method of general anesthesia as an anesthetic aid for patients of group 1 was used in cases where conduction methods were contraindicated. The dangers and complications of general anesthesia with mechanical ventilation in elderly and senile patients are well known, and limit the possibilities of choosing this method of anesthesia in patients of older age groups and somatically burdened patients [12]. Table 1 presents hemodynamic parameters at the stages of surgical intervention in patients of group 1.

The patients had relatively stable hemodynamics until the main stage of the operation. However, starting from the moment of induction of anesthesia, a tendency to decrease in blood pressure was observed. At the main stage of the operation, statistically significant, compared with the initial state, decrease in systolic blood pressure from 141±3.41 to 92±4.24 mm Hg and a decrease in heart rate from 82±3.43 to 68±3.13 were noted, which persisted for 1 minute until the end of the operation (p<0.05). The main disadvantages of general anesthesia in patients of this category were significant suppression of hemodynamics and severe pain syndrome against the background of post-anesthetic sedation in the early postoperative period. Relief of significant pain syndrome was achieved by administering narcotic analgesics, which required mandatory monitoring of respiration and hemodynamics.

In patients of group 2, operated under conditions of epidural block, general anxiety and agitation appeared after 5-7 minutes. In this regard, there was a need for intravenous addition of ketamine and dormicum. Against the background of additional administration of drugs for anesthesia, statistically significant changes in hemodynamics were observed with a tendency to relative hypotension at all stages of the operation. (Table 2).

In this group of patients, the changes in the parameters were more pronounced. At the main stage of the operation, a statistically significant, compared with the initial state, decrease in BPsyst by 35%, and a decrease in heart rate by 17% (p < 0.05) were observed; this trend persisted until the end of the operation. By the end of the intraoperative period, hypotension became pronounced. Hemodynamic changes were controlled by increasing the rate of infusion therapy and introducing vasoconstrictors. Increasing hypotension after 6–8 hours of using sedatives and analgesics also required an increase in the volume of infusion therapy.

As a result of the introduction of centrally acting drugs and deepening of anesthesia, 2 patients of the older age group developed respiratory disorders that required tracheal intubation and mechanical ventilation. Nausea and vomiting were observed in 3 patients.

The changes identified during the analysis of the course of anesthesia in patient group 3 are presented in Table 3.

All patients in group 3 maintained adequate sensorimotor block at all stages of the operation, which did not require additional administration of

analgesics. Although the above-mentioned tendency toward hypotension persisted in this group, hemodynamic parameters were fairly stable, and respiratory disorders were not observed.

In order to ensure comfort, sedation with dormicum was performed, the total consumption of which did not exceed 5 mg per operation. The intraoperative period proceeded with relatively stable hemodynamic parameters, but, as in the other groups, a significant decrease in blood pressure (from 15 to 39%) and a decrease in heart rate (by 18 - 20%) from baseline values were observed at all stages of the study ($p < 0.05$).

Analgesia with subarachnoid anesthesia at all stages of the operation was sufficient, but after the operation, the pain syndrome in patients of this group was pronounced. The treatment was carried out in the same way as in group 1 - with narcotic and non-narcotic analgesics in generally accepted doses. Ensuring adequate postoperative analgesia was quite difficult.

Patients of the 4th group underwent spinal anesthesia with bupivacaine in combination with morphine hydrochloride at a dose of 0.08–0.1 mg as an adjuvant. The spinal block developed and proceeded similarly to what occurred in patients of group 3; in order to create comfort for patients at the intraoperative stage, only intravenous superficial sedation with dormicum was performed, the consumption of which did not exceed 5 mg.

The dynamics of the studied parameters is presented in Table 4. Hemodynamic parameters in patients of this group were also characterized by a decrease in blood pressure and heart rate, but the parameters did not go beyond the physiological norm and remained stable throughout the operation. When comparing the dynamics of blood pressure and heart rate between the groups, more pronounced hypotension was noted in patients of group 2. Blood pressure decreased by 27.8% at the main stage and by 39% at the end of the operation. Hypotension was not accompanied by compensatory tachycardia, which could be potentially dangerous for patients with concomitant pathology. Stability of hemodynamic parameters allowed us to reduce the volume of intraoperative infusion therapy.

When analyzing the course of the early postoperative period, the method used in patients of group 4 proved to be the most adequate method of postoperative pain relief (Table 5).

Table 5

Hemodynamic parameters in the early postoperative period (M±m)

Parameter	Group		
	2	3	4
BPsyst, mmHg	102±3.72	98±3.62*	119±33.84*,**
BPdiast, mmHg	55±2.85	58±2.56	83±2.22*,**
BPmean, mmHg	70±3.25	71±3.05	95±3.83*,**
Heart rate, bpm	78±3.94	90±4.82*	64±3.62*,**
Respiratory rate, beats/min	14±2.36	13±3.23	13±2.64
SpO_2	94±1.32	92±1.81	94±1.61
Level of sedation	II	IV	II
Frequency of analgesic administration	1–2 times anesthetic through an epidural catheter	2–3 times intramuscularly	Once
Verbal Rating Scale, points	1–2	2–3	0–1

Notes: * — p<0.05 compared to group 2, ** — p<0.05 compared to group 3; BPsyst — systolic pressure; BPdiast — diastolic pressure; BPmean — mean arterial pressure

A single injection of bupivacaine 10–15 mg in combination with morphine (0.08–0.1 mg) provided rapidly developing, adequate, prolonged (24–72 hours) analgesia without hemodynamic depression. Blood pressure and heart rate remained within normal values and were significantly different from similar indicators in patients of groups 1-3 (p<0.05). Respiration and SpO2 were adequate, the patients were in light sedation (level II) in a state of emotional calm and comfort. The Verbal Rating Scale indicated the absence of pain at this stage in patients of this group.

DISCUSSION OF RESULTS

Our studies have shown that combined general anesthesia does not provide hemodynamic stability during surgery, especially at the time of the main stage of the operation. General anesthesia is relatively contraindicated for patients with severe concomitant pathology of the cardiovascular and respiratory systems, and has such disadvantages in the early postoperative period as post-anesthesia depression and severe pain syndrome.

Many authors also note that the main disadvantage of conventional methods of combined

general anesthesia with mechanical ventilation is the slow awakening of patients and short-term analgesia in the early postoperative period [13]. In addition, postoperative pain relief with narcotic analgesics in patients operated under conditions of multicomponent anesthesia with mechanical ventilation often causes depression of respiration and consciousness [14].

The main complication of opioid use in elderly patients is respiratory arrest due to decreased drug clearance. Moreover, with age, against the background of sensitization of brain receptors, sensitivity to fentanyl increases. The pharmacokinetics of muscle relaxants may change towards an increase in the duration of their action due to a decrease in hepatic metabolism and renal excretory function [8].

Modern literature data indicate a clear advantage of regional anesthesia methods in lower limb surgeries [13, 15]. Our data confirm this.

Epidural anesthesia has an insufficient analgesic effect during surgery due to the peculiarities of the knee joint innervation and the different effects of local anesthetic on different types of sensory fibers (A, B and C) of the large nerves Lv–SI and SII [6]. In general, this type of anesthesia is quite effective, but requires the addition of sedatives. Our patients after epidural anesthesia experience pronounced sedation (level IV), associated with the prolonged action of the drugs administered for intraoperative potentiation. This also does not solve the safety issues.

One of the methods of anesthesia, widely used in surgical traumatology, is spinal anesthesia. However, it is not without its drawbacks. The main risks of spinal anesthesia are severe arterial hypotension, bradycardia with the development of high sympathetic block [15] and, as a consequence, possible decompensation of the cardiovascular system. Typically, the period of pain relief when using this method lasts no more than 11–13 hours and is achieved, among other things, through the use of adjuvants (clonidine, morphine) [8].

According to most researchers, subarachnoid (spinal) anesthesia provides adequate analgesia during surgery, but not in the immediate postoperative period. To relieve postoperative pain, it is necessary to use analgesics (narcotic and NSAIDs), which can cause respiratory and hemodynamic disorders in elderly patients [7].

A single injection of bupivacaine 10–15 mg in combination with morphine (0.08–0.1 mg) during spinal anesthesia in most cases met all the requirements for adequate pain relief during the intra- and postoperative period, was not accompanied by significant hemodynamic disturbances; and pain syndrome in the postoperative period was either absent or insignificant. Literature data show that prolonged analgesia is an effective method for relieving acute pain after surgery with a low risk of side effects and high quality of pain relief. This technique is absolutely indicated in patients with a high risk of developing cardiovascular complications after traumatic orthopedic surgeries [1, 8]. The use of local anesthetics in elderly patients does not increase the risk of adverse events, but systemic toxicity must be considered when choosing these drugs.

In order to improve the quality of postoperative pain relief without increasing the incidence of side effects, it is justified to add opioid analgesics to local anesthetics. Table 5 presents a comparative assessment of hemodynamic parameters in patients of the examined groups in the early postoperative period, from which it is evident that patients after spinal anesthesia have statistically significantly more pronounced hypotension and a decrease in SpO2, compared with epidural and spinal — bupivacaine in combination with morphine hydrochloride — anesthesia.

Our data indicate that the most favorable hemodynamic parameters were observed in patients of group 4 with level II sedation. This is confirmed by literary data [6].

Research is still underway to find optimal options for anesthetic support for operations in older patients, but the problem has not yet been fully resolved [2, 6]. More than 30% of patients in the older age group have from 3 to 5 diseases of various organs and body systems. Age-related decline in body functions is a natural process during aging, which, in turn, limits an adequate response to stress factors, which include surgical intervention, anesthesia, as well as preparation for them in the preoperative period [3].

Age-related changes in the heart include impaired diastolic function and left ventricular myocardial hypertrophy, decreased cardiomyocyte count, and focal muscle fiber dystrophy. In the

elderly, the sensitivity of baroreceptors decreases, susceptibility to angiotensin II changes, which makes it impossible to respond in a timely manner to intraoperative changes in blood pressure and hypovolemia. The stiffness of the walls of blood vessels increases, as this is associated with age-related destruction of collagen and elastin. A decrease in tolerance to stress can be considered an important point: at rest, the ejection fraction can be maintained, but under stress, the heart loses the ability to fully respond with an increase in rate and contractility depending on the end-diastolic volume (volemia), thereby increasing the risk of developing ischemic damage to organs and tissues [4, 6, 9].

CONCLUSION

None of the known methods of anesthesia is ideal in terms of safety. In our study, each of the four options for anesthesia showed both positive and negative aspects. Based on the comparative analysis, we believe that the method of choice for anesthesia in traumatic orthopedic surgeries is spinal anesthesia with bupivacaine in combination with morphine hydrochloride at a dose of 0.07–0.08 mg, which provides good analgesia and hemodynamic stability with adequate spontaneous breathing of the patient during surgery, as well as a stable course of the early postoperative period with an adequate analgesic component due to a local anesthetic in combination with a narcotic analgesic.

The main disadvantages of general anesthesia in patients during trauma surgeries were significant suppression of hemodynamics and severe pain syndrome against the background of post-anesthetic sedation in the early postoperative period, which was relieved by the administration of not only NSAIDs, but also narcotic analgesics.

FINDINGS

1. In the group of patients operated under conditions of epidural block and sedation, changes in hemodynamic parameters were more pronounced: a statistically significant, compared with the initial state, decrease in BPsyst by 35% and a decrease in heart rate by 17% ($p < 0.05$) were observed, this trend persisted until the end of the operation.

2. A single subarachnoid injection of 10–15 mg bupivacaine in combination with morphine (0.08–0.1 mg) provides rapidly developing, adequate, long-lasting (24–72 hours) analgesia without hemodynamic depression. Blood pressure and heart rate indicators remained within normal values and were statistically significantly different from similar indicators in patients of groups 1–3 ($p<0.05$).

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