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Anesthetic features in the surgical treatment of idiopathic scoliosis in adolescents

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Keypoints

Epidural blockade, when used as a component of general anesthesia, prevents the stress-surgical response and provides a significant blood-saving effect, reducing blood loss by 50%.

Abstract

Globally, there is a noticeable increase in spinal diseases, with scoliosis being one of the most prevalent. Reconstructive spinal surgeries for scoliosis treatment present challenges for effective anesthetic management. Apart from general anesthesia, a combination of general anesthesia with regional blockade is also employed for dorsal correction in adolescent patients. Despite numerous meta-analyses, there is still no consensus on the impact of regional anesthesia on the outcomes of traumatic spinal surgery. As a part of general anesthesia, epidural blockade suppresses the stress-surgical response and provides a substantial blood-saving effect, reducing blood loss by up to 50%. Incorporating epidural anesthesia into general anesthesia enables a swift and predictable recovery from anesthesia, thereby improving the safety of the early postoperative period.

Keywords

idiopathic scoliosis, transpedicular fixation, general anesthesia.

Introduction

Currently, a global trend exhibits a consistent increase in spinal diseases, with scoliosis constituting one of the most prevalent pathologies. Scoliosis affects up to 1.5% of the population, its incidence amongst adolescents ranging from 5-40%. The treatment of scoliosis remains one of the most formidable challenges in the field of orthopedics. If left untreated, scoliosis persistently progresses, with changes in the cardiovascular and respiratory systems becoming increasingly severe. The surgical treatment of advanced scoliosis is currently the only viable method to prevent the progression of disorders affecting essential organs, reestablish physical activity, and improve the mental health of patients. However, surgical correction of scoliosis is a protracted and highly invasive procedure, which incurs significant blood loss and thus, elicits a complex set of responses at the level of neuroendocrine stress, metabolism intensification, and significant deviations in oxygen delivery. It is imperative to note that surgical correction of scoliotic spinal deformities in adolescents carries a high risk of severe iatrogenic neurological complications. As such, the issue of intraoperative monitoring of spinal cord functions - characterized by the urgent awakening of the patient on the operating table after the stage of spinal distraction, referred to as the "Wake up test" - remains highly pertinent. The success of an urgent awakening of the patient at a specific stage of the surgery, in order to promptly diagnose potential neurological disorders, hinges on the ease of controlling the depth of drug-induced sleep and neuromuscular block

while maintaining effective analgesia. This necessitates particular requirements for all elements of anesthetic management, specifically the hypnotic and muscle relaxant used. These agents must facilitate a rapid loss of consciousness and the onset of a neuromuscular block, exhibit a short or medium duration of action, not be associated with a cumulative effect, and demonstrate clinical safety.

The surgical correction of severe forms of scoliosis (with a curvature arc exceeding 60º) is the solitary method to halt the progression of dysfunctions of the internal organs. Presently, surgical interventions employing a posterior approach are broadly utilized. Concurrently, one of the most traumatic phases of the procedure is the stage of separating the muscle masses from the spine - its skeletonization, which is accompanied by a considerable layer of paravertebral muscles and periosteum. During the decortication of the vertebrae, the bone marrow becomes exposed, leading to persistent venous bleeding. Another traumatic phase of the operation is the correction of the deformity (spinal traction, spinal osteotomy, derotation maneuver), during which the risk of neurological complications significantly escalates. Reconstructive surgeries on the spine for the treatment of scoliosis pose challenges for adequate anesthetic management. In addition to general anesthesia for dorsal correction of the spine in adolescents, a combination of general anesthesia with regional blockade is also employed.

Given the aforementioned, surgical procedures for the treatment of scoliosis denote a high risk of vertebrological operations and precondition high requirements for anesthetic support. The choice of anesthesia is further determined considering the patient's unique characteristics, including the degree of dysfunction of the thoracic organs and the surgical intervention method. Anesthesia should be sufficiently profound, manageable, ensure the maintenance of standard gas exchange and hemodynamics, as well as facilitate a swift transition of the patient to spontaneous breathing. When examining the problem of surgical treatment of scoliosis from an anesthesiologist-resuscitator perspective, spinal surgeries are characterized by high trauma, considerable blood loss volumes, and a significant frequency of postoperative complications.

An analysis of numerous literature sources reveals that the anesthetic management of corrective spinal surgeries represents one of the most challenging issues in contemporary vertebrosurgery and anesthesiology. The necessity for these interventions varies from 5% of children to 15% of the adult population. Simultaneously, extensive traumatic operations are accompanied by an unacceptably high complication and mortality rate worldwide.

Modern approaches to the treatment of spinal pathologies, inclusive of long-term multilevel stabilization through the incorporation of metal implants, are associated with high trauma, blood loss, and reflexogenicity. Consequently, these issues underscore the relevance of implementing the modern concept of multimodal anesthesia and analgesia, defined as a comprehensive yet differentiated approach to safeguarding organs and bodily systems from surgical stress. Additionally, major surgical interventions on the spine, encompassing simultaneous correction via an extensive posterior approach or staged anterior and posterior interventions within the same day, are attended by substantial, and sometimes massive, blood loss. Protecting the patient from the aftermath of a surgical stress response, both during the intraoperative and postoperative period amid major reconstructive spine surgeries, is a pressing issue in modern anesthesiology. Regional blockade as a component of multimodal anesthesia addresses this problem. Despite conducted meta-analyses, there is currently no consensus regarding the impact of regional anesthesia on the outcomes of traumatic spinal surgery. All the aforementioned determines the relevance of the problem from both a scientific and practical viewpoint, as well as the necessity to devise a differentiated approach to ascertaining indications for regional blockade and balanced anesthetic management of spinal surgery.

Purpose of the study: To develop an optimal method of anesthesia and postoperative analgesia for the dorsal correction of adolescent idiopathic scoliosis.

Material and Methods

The study was conducted at the surgical clinic of the AMU. It comprised 45 patients who underwent dorsal spine correction for idiopathic scoliosis, classified as class 2 according to the ASA classification. Based on the type of anesthesia, the patients were divided into three groups: Group I (n=15) - general anesthesia with epidural blockade using bupivacaine, Group II (n=15) - general anesthesia with epidural blockade using bupivacaine and fentanyl, and Group III (n=15) - general anesthesia. Traditional multi-component general anesthesia was administered with propofol or sevoflurane, fentanyl, and rocuronium bromide. In Group I, general anesthesia was combined with epidural blockade using bupivacaine at a dosage of 4 mg/kg; in Group II, epidural anesthesia was executed with bupivacaine at a dosage of 3 mg/kg and fentanyl 25 μg. Catheterization of the epidural space within the surgical wound was performed post metal structure installation. For surgeries involving one portion of the spine, one catheter was placed in the epidural space. Under aseptic conditions, the epidural space was punctured via a midline Tuohy needle and catheterization was carried out such that the tip of the epidural catheter was positioned above the apical vertebra. The puncture site of the epidural space was selected in each case based on the present spinal deformity. In operations involving two or more portions of the spine, to ensure segmental anesthesia in the postoperative period, catheterization of the epidural space was executed at two levels in the upper thoracic and lumbar spine.

The following anesthesia protocol was developed: induction into general anesthesia across all groups was accomplished by the intravenous administration of propofol (2.5-3.5 mg/kg) and fentanyl (2 μg/kg). Rocuronium bromide was utilized for myorelaxation at a dose of 0.6 mg/kg for tracheal intubation and 6 μg/kg/min for continuous infusion during surgery, evaluated via the TOF-Watch Organon monitor. In groups receiving epidural anesthesia, all patients slated for transpedicular spinal fixation (TPF) spanning 8-10 spinal segments underwent puncture and catheterization of the epidural space, 2-4 segments above the anticipated level of surgical intervention in the thoracic spine. Post administration of the test dose, a bolus of 0.5% bupivacaine solution was fractionally administered from 3-7 ml, followed by fentanyl 25 μg. Subsequently, an infusion of a mixture of 0.25% bupivacaine solution and fentanyl (1 μg/ml) commenced at a rate of 5-7 ml/hour. In the postoperative period, upon assessing the neurological status, patients in the EA group continued epidural analgesia with a 0.25% bupivacaine solution with fentanyl (1 μg/ml) at a rate of 5 ml/hour for 48 hours.

For the group of patients receiving only general anesthesia, inhalation anesthesia was performed with sevoflurane or TIVA was executed with a constant fentanyl infusion at a rate of 0.002 μg/kg/h and its bolus injection of 50-100 μg prior to incision and at the most traumatic points as needed. Postoperative analgesia was achieved through the administration of opioids.

The study was conducted in the following stages: Stage 1 - Preoperative; Stage 2 - Skin incision; Stage 3 - Traumatic moment of surgery; Stage 4 - Conclusion of surgery; Stage 5 - 1st postoperative day; Stage 6 - 3rd postoperative day. During the postoperative period, pain severity, assessment of pain, postoperative nausea, and vomiting were ascertained utilizing a visual analog scale (VAS) both at rest and during activation. Activation implied the patient turning on his side in bed on the first day, followed by ambulation within the ward on the subsequent day. Postoperative pain was assessed via VAS at rest and during activation, ranging from "0" (no pain) to "100" (worst conceivable pain). Pain intensity was recorded during rest, while turning in bed, standing, coughing, and walking. The intensity of the pain syndrome was documented in the patient's chart. If patients experienced pain, opioids were administered. All possible side effects of anesthesia, including urinary retention, nausea, and

vomiting were documented. Mandatory safety monitoring incorporated the registration of blood pressure, heart rate, ECG, SpO2, FiO2, ETCO2. The obtained clinical and laboratory data were subjected to statistical analysis using both parametric and non-parametric methods. The study outcomes were processed in accordance with the rules of variation statistics.

Research results

The dynamics of postoperative pain syndrome, according to the Visual Analog Scale (VAS), were statistically significantly different in groups with and without epidural analgesia, both at rest and during patient activation. In all groups where epidural analgesia (a mixture of bupivacaine and fentanyl) was used postoperatively, pain intensity was statistically significantly less and patients did not require additional administration of opioids. In the second group, where patients received epidural bupivacaine without fentanyl, the pain syndrome was notably less pronounced compared to the group without epidural analgesia (EA). Patients in the third group (only general anesthesia) occasionally complained of moderate pain at rest and severe pain during activation. They were unable to turn on their side or onto their stomach independently and rated the quality of pain relief on average as "satisfactory" by 3.7% ± 0.6 points.

The study showed that the consumption of drugs for general anesthesia and pain relief in patients in the group without EA was statistically significantly higher compared to other groups. For instance, the consumption of propofol was 1200±143 mg, and fentanyl was 1.2±0.1 mg. Intraoperative consumption of bupivacaine was 105.5±10.4 mg for single-stage operations and 153.7±15.3 mg for two-stage operations, respectively. The use of regional blockade during the operation resulted in a significant decrease in the consumption of narcotic analgesics, muscle relaxants, and inhalation anesthetics.

Epidural analgesia contributed to a significant reduction in both postoperative analgesia and sedation. Effective pain relief with minimal sedation, achieved in the epidural analgesia groups by reducing the daily requirement of opioids, was associated with early activation of patients with the restoration of the ability to walk, self-care, and effective coughing. This facilitates accelerated early activation of patients, which is currently considered one of the most crucial elements of the ERAS (Enhanced Recovery After Surgery) program and ensures the prevention of severe postoperative complications.

Investigation of standard markers of surgical stress, such as blood serum glucose levels at three stages of the study (during surgery), did not reveal statistically significant differences in the dynamics of glycemia in both groups (with and without EA), indicating adequate pain relief. However, by the end of the operation and by the first day, its serum level increased in the group with general anesthesia and exceeded normal values, unlike the groups with epidural analgesia. This supports the importance of adequate blockade of sympathetic adrenergic stimulation.

The study highlighted a significant blood-saving effect in groups with epidural analgesia (EA), particularly pronounced at the intraoperative stage, reaching up to 50%. This contributed to a substantial decrease in the volume of infusion-transfusion therapy. The main reason for such an effective reduction in blood loss during reconstructive spine operations is likely due to the redistribution of blood flow and a decrease in pressure in the vertebral bodies and epidural veins, where diffuse venous bleeding and a specific position on the abdomen are the main pathogenetic factors of blood loss. Accordingly, a reduction in perioperative blood loss was noted along with statistically significant and uniform changes in intraoperative infusion therapy. Infusion therapy, based on maintaining normovolemia and zero fluid balance, was utilized in all groups: the group with general anesthesia averaged 8.3±2.5 ml/kg/h of crystalloids, 5.3±0.5 ml/kg/h of colloids, respectively, and in groups with EA - 6 crystalloids, 5±1.1 ml/kg/h, colloids - 2.1±0.5 ml/kg/h, respectively.

Analysis of the results obtained in complex reconstructive spine operations for scoliosis suggested that the

significant decrease in perioperative blood loss during this operation was due to the effects of sympathicolysis during EA, the hemodynamic effect of EA, such as controlled hypotension, redistribution of blood flow in the venous system, and reduced pressure in epidural veins and low intraosseous pressure.

One of the most common serious complications identified was postoperative nosocomial pneumonia, with an incidence of 2.5% in the general anesthesia group. In all cases, pneumonia had an early onset on days 2-3 of the postoperative period and did not exceed the boundaries of one lobe of the lung. In groups with EA, patients with pneumonia were not observed. Surgical complications like suppuration or dehiscence of the surgical wound edges occurred in 2.1% of patients in the general anesthesia group. No such cases were registered in groups with EA. The most frequent complication in the postoperative period was dynamic intestinal paresis, which usually developed on days 2-3 and occurred in patients under general anesthesia.

More effective pain relief in the groups of patients with EA contributed to earlier patient activation and verticalization (by an average of 2 days) compared to patients without EA. Due to early patient activation, the frequency of observed undesirable critical incidents in the postoperative period was statistically significantly lower in groups of patients who used EA, especially respiratory ones, as well as intestinal paresis and the syndrome of postoperative nausea and vomiting, by 2-3 times compared with patients who underwent general anesthesia alone.

Conclusion

1. Epidural blockade, when used as a component of general anesthesia, prevents the stress-surgical response and provides a significant blood-saving effect, reducing blood loss by 50%.
2. The integration of epidural anesthesia into general anesthesia ensures a rapid and predictable awakening, thereby enhancing the safety of the early postoperative period.

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