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Features of Anesthesia in Minimally Invasive Surgery

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Authors' contributions

This work was carried out in collaboration among all authors. Author DM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KAE and TAR managed the analyses of the study. Authors ISM, OVK, VVG managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Minimally invasive surgery is usually performed due to various benefits, such as reduced postoperative pain, faster recovery, and reduced postoperative pulmonary complications. Combining different surgical interventions into one group on the principle of technological generality, and not depending on the etiopathogenesis of the patient or the operated organ from the point of view of the anesthesiologist is quite justified, since it allows us to develop a single methodological approach to intraoperative protection of the patient. This approach is formed on the basis of taking into account both general anaesthetic and specific requirements for this type of operation. At the same time, the procedure should be painless and comfortably tolerated by the patient, as well as anesthesia should contribute to the fastest possible rehabilitation of the patient

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and his social rehabilitation.
Naturally, the implementation of the above requirements should not be at the expense of the effectiveness, safety and reliability of anesthetic during the perioperative period.
The purpose of the work is to consider the features of anesthesia in minimally invasive surgery.

Keywords: Minimally invasive surgery; anesthesia; intra operative protection.

1. INTRODUCTION

Minimally invasive surgical technologies today represent the optimal choice for the treatment of a number of different diseases. These technologies are adopted by specialists of various medical industries, such as surgeons, oncologists, X-ray surgeons, etc. [1]. The relevance of the issues under consideration is determined, on the one hand, by the current tendency to minimize surgical trauma during operations, and on the other – by the constant development and improvement of hardware and instrumental support of modern surgical clinics.

Minimally invasive surgery also provides a special approach to the organization of anesthesia, since it is necessary to ensure, on the one hand, the necessary level of painlessness of the procedure, on the other hand, the anesthesiologist should use optimal approaches to ensure the effectiveness of subsequent rehabilitation of patients. Accordingly, the aim of the work is to study the features of anesthesia in minimally invasive surgery.

2. MATERIALS AND METHODS

The paper uses the analysis of special literature, as well as the comparative method, the method of generalization of the obtained data

3. RESULTS AND DISCUSSION

The study of the features of the use of anesthesia in minimally invasive surgical interventions should be carried out on the basis of various surgical manipulations of this type. Let us first consider the features of the use of anesthesia in minimally invasive pelvic and abdominal surgery.

1. Features of the use of anesthesia in minimally invasive pelvic and abdominal surgery.

With the development of surgical and anesthetic techniques, minimally invasive surgery is increasingly being offered to high-risk patients. The shorter recovery period and lower complication rate are balanced by perioperative problems in patients with reduced physiological reserve, including the effects of extreme position and longer duration of the procedure. In the light of the many methods of minimally invasive surgery, an individual approach to preoperative examination should be based on the proposed surgical procedure and concomitant diseases specific to the patient, with an emphasis on those systems affected by pneumoperitoneum. The potential need to switch to an open operation should be taken into account [2].

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However, there are a number of pre-existing conditions in which minimally invasive surgery is considered a contraindication, when cardiovascular changes caused by an increase in intra-abdominal pressure, the patient's position, or both, may be unacceptable. These include severe right ventricular or biventricular failure (in which ventricular output may decrease as a result of increased vascular resistance), right-to-left cardiac bypass (which may increase with increased pressure in the right ventricle), hypovolemic shock (further reduction in venous contraction. it can cause a sharp decrease in CO and blood pressure), as well as retinal detachment and an increase in intracranial pressure, which can lead to a noticeable decrease in perfusion pressure [3].

In robotic surgery, tracheal intubation is required using an oral tracheal tube with cuffs. Since the increased airway pressure is a result of the pneumoperitoneum and the location, the tracheal tube provides careful ventilation control and provides protection to the lungs from pulmonary aspiration of gastric contents. However, there is evidence that describes the safe use of second-generation epiglottis devices for some laparoscopic operations.

Some studies show no difference in gastric distension between them and tracheal intubation, with the LMA ProSeal laryngeal mask being an effective alternative to tracheal intubation without increasing complications.

Care should also be taken to prevent air from entering the stomach during ventilation with the bag mask, as this can make it difficult to view the surgical procedure and may require decompression of the stomach, which may be inconvenient to perform during surgery.

The patient's position may impair ventilation with increased inhalation pressure, hypercapnia, and the risk of barotrauma. It may be possible to correct hypercapnia by increasing minute alveolar ventilation, but this may put the patient at risk of further barotrauma as a result of increased airway pressure, and a small degree of permissive hypercapnia may be allowed as a compromise.

The management of intravenous fluids remains a key area of anesthesia in major surgical procedures, preventing fluid overload, as well as supporting the perfusion of vital organs. Modern surgical practice, especially in the framework of accelerated recovery programs after surgery, usually leads to the fact that patients entering the operating rooms are in a relatively euvolemic state due to carbohydrate load, insufficient bowel preparation and avoidance of prolonged liquid fasting [4].

Fluid volume reduction is recommended in patients undergoing cystectomy to reduce volume overload and the frequency of kidney damage if there is a significant delay between ureteral compression and reimplantation.

Special attention should be paid to patients who have undergone long-term operations in the Trendelenburg position, such as cystectomy. This situation may expose such patients to the risk of cerebral edema, which can be aggravated by excessive intravenous fluid administration. Monitoring of hyperkalemia is important, especially when the ureters have been surgically clamped before urine is withdrawn (either through the iliac canal or through the formation of a neo-bladder).

After minimally invasive surgery, many of the patients may drink in the early postoperative period, and prolonged postoperative intravenous infusions are usually not necessary. An exception is cystectomy, in which postoperative intestinal obstruction is often found. In addition, a certain degree of permissive oliguria is allowed, and it is not treated with intravenous fluids in the absence of other signs of hypovolemia.

The degree of follow-up is usually determined by the patient's comorbidities, the expected blood loss, and the duration and complexity of the operation. Many use intra-arterial access to provide reliable blood pressure monitoring and regular blood gas analysis. For any laparoscopic surgery (and in particular robotic surgery), access to the patient is extremely limited. Care should be taken with any lines and control devices so that they do not bend or shift when installing the operating table or robot.

Some patients (for example, the elderly and patients who have undergone a cystectomy or prostatectomy) are at risk of significant postoperative cognitive dysfunction, and it may be useful to use EEG monitoring, such as a bispectral index to monitor depth of anesthesia, to avoid excessively deep anesthesia.

The main purpose of providing perioperative analgesia for patients who have undergone abdominal and pelvic operations with minimally invasive intervention is the use of multimodal opioid-sparing drugs. High doses of opioids are undesirable and are associated with nausea, vomiting, slower recovery of gastrointestinal function, respiratory depression and cough suppression, and the possibility of abuse after surgery [5].

Epidural analgesia for extensive open abdominal and pelvic surgery has been considered the gold standard for many years, but the main advantage of MIS is the reduced incision size and associated tissue damage, resulting in relatively modest postoperative analgesia requirements. Although epidural analgesia has been used for MIS, it has been found that it is not necessary and may lead to serious problems after surgery.

Compared to patients who received spinal anesthesia or ACP with intravenous administration.

With reduced epidural analgesia, the logical alternative was spinal anesthesia to treat immediate postoperative pain, also providing rapid mobilization and restoration of function (without side effects such as intestinal obstruction, impaired mobility, or hypotension). This method has been widely and successfully used for both laparoscopic and robotic operations. A popular method is to use intrathecal diamorphine to reduce the need for systemic opioids at doses ranging from 250 mcg to 1 mg, depending on the type and duration of surgery, associated comorbidities, and the location of postoperative care.

There are very few studies that can provide a comprehensive guide to pain management techniques. Local anesthesia techniques, such as transverse abdominal muscle blockage, can reduce opioid use, especially if the blockage is performed prior to surgery. Some practitioners have used remifentanil infusions to suppress some physiological responses to surgery, but there are concerns about acute tolerance and hyperalgesia caused by opioids.

If there are no contraindications, regular postoperative systemic analgesia with paracetamol and NSAIDs should be used, as well as opioids designed to relieve acute pain. Less commonly, anticonvulsants such as pregabalin and high-dose intravenous steroids are used. Second-line analgesics, including lidocaine and ketamine intravenously, are also recommended.

Recently, much attention has been paid to lidocaine, and a meta-analysis has demonstrated that it reduces the need for opioids, PONV, and the time before resuming the diet. However, there is a large heterogeneity in the time, dose, and duration of lidocaine infusion, and only a few researchers have measured lidocaine concentrations [6].

2. Features of anesthesia in minimally invasive surgical operations for esophagectomy.

It is also necessary to consider the features of anesthesia in minimally invasive surgical operations for esophagectomy. Esophagectomy is a high-risk surgical procedure that is associated with significant morbidity and mortality. Open esophagectomy results in significant access trauma, causes a significant systemic inflammatory response, and is associated with significant postoperative pain and decreased postoperative mobilization.

Although esophagectomy remains the main treatment for patients with non-metastatic esophageal cancer, the results are unsatisfactory. Hospital mortality of 5% and severe morbidity of 25% are typical, and even after successful resection of the tumor, only 20-25% of patients will be alive in 5 years. Open esophagectomy significantly affects the quality of life. Quality of life may sometimes never return to pre-operative levels, and at best it may take up to 6 months to achieve this. Given the significant incidence of this disease, significant advances have been made in laparoscopic and thoracoscopic equipment, skills, and methods over the past decade. Less traumatic surgical techniques using minimally invasive techniques are now used for more complex surgical procedures [7].

Esophageal cancer often manifests late and manifests as dysphagia, pain, and weight loss. Although dysphagia is a common symptom, current practice of preoperative neoadjuvant chemotherapy may improve this symptom. As a result, many patients are able to swallow normally and maintain oral nutrition by the time of surgery. Anesthesiologists, however, should always be vigilant about the presence of dysphagia and the potential risk of reflux, and take appropriate measures when inducing anesthesia and extubating the trachea. Although neoadjuvant chemotherapy has been shown to improve the survival of patients with esophageal carcinoma, it is important to identify complications of recent chemotherapy, including bone marrow suppression and infection.

All patients undergoing minimally invasive surgery should undergo a thorough health and nutritional assessment, including an assessment of respiratory and cardiac function. Echocardiography, although usually performed, does not accurately predict the perioperative risk. Cardiopulmonary exercise tests can provide more objective and valuable information about functional capabilities and perioperative risk.

There are a number of problems common to all methods of minimally invasive intervention:

- long operation time;

- long period of ventilation of one lung;
- difficulties in assessing fluid status and possible pulmonary complications associated with fluid overload;
- complications of extraperitoneal CO2 (brain, capnomediastinum, and surgical emphysema);
- providing effective postoperative analgesia [8].

Minimally invasive surgery in the case of esophagectomy is a long procedure that can take more than 8 hours, especially if it is performed by surgeons who are not familiar with this technique. Such a long operation increases the risk of hypothermia. Perioperative hypothermia has many detrimental effects, including reduced oxygen delivery, increased myocardial function, increased stress response, and increased postoperative infection. Appropriate measures should be taken to maintain normothermy. If the MIS operation was performed without complications and the patient has normothermia by the end of the operation, there are no indications for postoperative ventilation, and patients should be woken up and extubated.

Balanced anesthesia with an inhalation approach or an infusion with targeted propofol control in combination with an infusion of remifentanil can contribute to a speedy recovery after such an operation. Inhaled anesthesia may be beneficial, since it has recently been shown that volatile anesthetics have an immunomodulatory effect on the inflammatory response of the lungs to anesthesia of one lung [9].

Compared to intravenous propofol anesthesia, inhaled sevoflurane anesthesia can lead to a decrease in the formation of inflammatory mediators during a single ventilation of the lungs, as well as to a decrease in adverse postoperative events.

Remifentanil infusion lends itself to MIS because of its short half-life and because MIS usually results in periods of significant stimulation, especially during the laparoscopic stage, which can lead to tachycardia and hypertension.

The intense analgesia provided by remifentanil, along with the ability to quickly titrate the dosage, can help counteract these episodes and promote rapid recovery after prolonged surgery.

Minimally invasive intervention requires a period of ventilation of one lung during the mobilization of the thoracic esophagus. Inadequately managed lung isolation has been shown to contribute to mortality and morbidity after esophagectomy. 7 Esophageal immobilization is usually performed in the right part of the chest when the patient is in the left lying position or on his stomach [10].

Since the operation is performed thoracoscopically, retraction of an insufficiently destroyed lung or lobe is more difficult than with open surgery, and this is important when choosing the method used to achieve lung isolation. Isolation of the lungs can be provided through a left or right two-light tube or a single-light tracheal tube and a bronchial blocker.

Right-sided two-light tubes are considered less reliable than left-sided ones, because there is a greater chance of blockage of the opening in the upper lobe of the right bronchus, which occurs at a shorter distance from the keel than the left one. Intubation of the bronchus on the opposite side of the operation can reduce the likelihood of intraoperative displacement of the tube, and since most methods of minimally invasive intervention involve access to the right chest, it is preferable to use a left-sided two-light tube.

If a bronchial blocker is selected, it must be placed on the right side, as the right lung must be destroyed; however, the blocking cuff may cover the opening in the right upper lobe, making it difficult to compress. Although sometimes a bronchial blocker may be required (for example, in cases of difficult intubation), our experience shows that minimally invasive intervention is probably best performed using a left-sided two-light tube. Whichever method of lung isolation is chosen, a fiberoptic bronchoscope should be used to check the correct position both after intubation and after moving the patient before surgery [11].

Acute lung injury is a complication of esophagectomy. Features associated with this risk were identified, including the duration of ventilation of one lung and perioperative cardiorespiratory instability, including periods of hypoxia and high airway pressure. Although the duration of ventilation of one lung is mainly determined by surgical factors, insufficient isolation of the lungs can prolong this period of time. Therefore, it is imperative that anesthesiologists have the skills to correctly position the two-light tube, limit the respiratory volume to 5-6 ml kg^{-1} during ventilation of one lung, and use strategies to avoid hypoxia and high airway pressure.

Controlled-pressure ventilation reduces the peak airway pressure during single-lung ventilation compared to controlled-volume ventilation. This strategy has the potential to reduce the risk of barotrauma in ventilators, but is unlikely to improve arterial oxygenation.

Even with reduced access trauma, MIS can cause significant postoperative pain if optimal multimodal analgesia is not used. Effective analgesia is necessary for rapid extubation, rapid recovery, and early mobilization.

In addition to the usual postoperative simple analgesia, paravertebral or epidural analgesia is used. It has recently been determined that paravertebral block provides analgesia comparable to thoracic epidural anesthesia after thoracotomy, but may be associated with a reduction in the frequency of failed blockages and a reduction in side effects, including hypotension and urinary retention [12].

In addition, pulmonary complications may occur more frequently in patients treated with thoracic epidural anesthesia rather than paravertebral nerve block. This increase in lung problems can be attributed to sympathetic block caused by thoracic epidural anesthesia, which leads to additional fluid injection to correct hypotension caused by epidural anesthesia.

3. Anesthesia in video-assisted surgery

Anesthesia in video-assisted surgery is similar in many ways to anesthesia in open thoracic surgery. Protective ventilation and reasonable fluid administration are necessary to minimize postoperative pulmonary complications. However, there are a number of key differences.

The anesthesia will depend on the procedure performed. Small procedures can be performed with peripheral IV access, non-invasive blood pressure monitoring, and short-acting medications. Longer or more serious procedures will require larger-diameter intravenous access and intra-arterial cannulation for monitoring and sampling.

As with open surgery, the position is often performed in a supine position on the side. The operating table is adapted to provide extreme lateral flexion, opening the intercostal spaces and improving surgical access. This means that it is necessary to ensure that the patient is attached to the operating table; a combination of back and arm supports is described, as well as a "bean suction bag". Whichever method is chosen, the priorities are to make sure that there is no room for movement, that the pressure points are effectively covered by pillows, and that the head and neck have adequate support for a potentially lengthy procedure. Care must be taken not to displace the airway devices, vascular cannulas, and monitors at this stage [13].

The choice of anesthesia for a closed brain biopsy depends on the surgical technique, patient characteristics, and position. Precordial Doppler imaging can be used to detect venous air embolism in a semi-sitting position.

Neuron navigation procedures require high accuracy and patient immobility. This is easily achieved with the help of general and, therefore, this method is preferable to local anesthesia and sedatives [14].

Unlike the usual practice of neuroanesthesia, when brain lethargy is desired, brain shift due to brain "lethargy" can lead to a loss of reliability of the navigation system.

If local anesthesia is selected and the sedative effect is controlled, regional nerve blockades may be used. A sedative effect may be required, which is achieved with the use of propofol or remifentanil. Continuous recording of blood pressure results is also necessary to track unexpected peaks in blood pressure that may contribute to bleeding.

4. CONCLUSIONS

Minimally invasive surgical techniques can reduce postoperative pain, improve recovery, and accelerate patients' return to a normal quality of life. Minimally invasive interventions present a number of problems associated with anesthesia, some of which are unique to the procedure, and require understanding the specific surgical steps taken and recognizing the potential complications of single-lung anesthesia and extraperitoneal spread of carbon dioxide.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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