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Review article

Paravertebral blockade using a catheter implanted under visual control during thoracosurgical procedure as an ideal expedient for treating postoperative pain

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ABSTRACT

Introduction: Postoperative pain is a natural occurrence after surgery, and its severity significantly affects the overall condition and likely recovery time of the patient. Because postoperative thoracic pain is one of the most severe postoperative, the physician must repeatedly administer medication from all levels of painkillers. Use may involve potential risks of further complications.

Aim: The aim is to describe some pathophysiological aspects of pain, some methods of pain therapy, anatomy of paravertebral space (PVS) and methods of performing a paravertebral blockade, especially the implementation of a catheter to the PVS, during operation from lateroposterial access.

Material and methods: This work was based on the available literature and the experience of the authors.

Results and discussion: This method was implemented on 38 patients over a 10 month span. On 3 of the patients, the analgesic effect was not obtained. In the author's opinion this was due to the intercostal being opened too wide with the same PVS resulting in the administered medication reaching the pleura, hence not making the desired impact. On the remaining patients the analgesic effect was obtained at a level of 3–5 PVS, without the necessity of administrating opioids in the case of breakthrough pain. After the first 24 h following surgical procedure the patients showed positive signs of recovery and were able to start rehabilitation.

Conclusions: Intraoperatively implanting a catheter to the PVS following thoracosurgical procedure in order to conduct continuous, regional postoperative anaesthesia is a safe and effective method of treating postoperative pain in thoracic surgery.

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1. INTRODUCTION

Postoperative pain is a natural occurrence following surgical procedures and its severity substantially influences the overall condition and likely recovery time of the patient. As pain intensifies following a thoracosurgical procedure, the physician is forced to repeatedly administer medication from all levels of analgesics. The application of which may be associated with a potential risk of further complications.

This thesis introduces a method of pain therapy based on the administration of drugs to the paravertebral space (PVS) under visual control through an intraoperatively placed catheter. Based on both the author's personal experience and published research, this process is considered an effective and safety method of alleviating postoperative pain. Considered as an alternative to epidural anaesthesia commonly used in many branches of thoracic surgery, the process simultaneously avoids the complications related to the use of opioids and non-steroidal anti-inflammatory drugs.

2. AIM

The aim of this paper is to describe some pathophysiological aspects of pain, some methods of pain therapy, anatomy of PVS and methods of performing a paravertebral blockade (PVB), especially the implementation of a catheter to the PVS, during operation from lateroposterial access.

3. MATERIAL AND METHODS

This work is based on the available literature and the experience of the authors.

4. RESULTS AND DISCUSSION

Postoperative pain is caused by an intraoperative trauma to the tissues and organs and its intensity is proportional to the type, extent and duration of the surgical procedure. In the instance of a planned surgical procedure, the physiological role of pain and the benefits resulting from short-term pain stimulation after contingent injuries no longer apply. Postoperative pain merely evokes phenomena unfavorable to the patient and maintaining long-termed pain stimulation develops a cascade of unfavorable pathophysiological processes, even causing neuroplastic changes to the central nervous system (CNS) leading to chronic pain syndrome. This causes an increase of sensitivity in the spinal cord and brain during the synthesis and activation of various receptor systems (i.e. NMDA) and also the formation of various compounds modifying pain perception. If the peripheral stimulus is strong enough or repeated – as in the instance of inflammatory pain or protracted pain – the pain transduction in the spinal cord becomes complex. During the release of endogenous substances, whose purpose it is to inhibit the pain stimulus, the same stimulus is simultaneously being 'intensified' and 'fixed.'[1] The modulation of reactivity in the CNS clinically manifests itself in a long lasting *hyperalgesia allodynia*, which can last longer than the nociceptive stimulation (receptor) and the healing process of the wound. It is believed that the 'plastic' reactivity of the CNS determines the formation of the central sensitization, which lasts 10–200 times longer than the flow of information from the peripheral receptors. The process of central sensitization is probably the cause of secondary hyperalgesia, referred pain, pain memory and 'second pain' (tied to the emergence of a series of offloading in neighboring neurons).[2] Back pain also postoperative, is a major health problem and a leading cause of disability. It generates work absenteeism and great costs for the society.[3]

Thoracosurgical procedures are part of a group of procedures causing the highest level of discomfort regarding postoperative pain. Following a thoracotomy, pain which limits chest movement leads to respiratory system dysfunctions. These are based on: vital lung capacity reduction, a limiting in coughing and a less effective removal of secretions. Thoracosurgical procedures can also cause arterial hypoxemia, atelectasis and pneumonia.[4]

The general administration of opioids represents the traditional method of treating postoperative pain in thoracic surgery – that they are most effective when administered intravenously, preferably through a patient-controlled analgesia (PCA) pump. Due to ineffectiveness, non-steroidal anti-inflammatory drugs (NSAIDs) used in monotherapy do not apply in thoracic surgery. They have a different target than opioid drugs; therefore it is possible and even indicated to combine medication from the two mentioned groups.

NSAIDs exhibit a ceiling effect. Exceeding the recommended dose does not enhance the therapeutic effects, but instead can possibly result in unwanted side effects. Therefore combining two NSAIDs is not recommended. Through reduction in the production of prostaglandins in the CNS, non-opioid analgesics (paracetamol and metamizole) have an analgesic and antipyretic effect. They do not have anti-inflammatory characteristics and due to the effect they have on different areas; they can be associated with 'typical' NSAIDs. A combined administration with opioids is again recommended.

A thoracotomy is an immense injury linked to a strong stimulation of the sympathetic nervous system. The most effective way to avoid adverse reactions is through the use of multimodal analgesia adopting the techniques associated with conduction anaesthesia.[5]

Over the years, an epidural was considered the 'golden standard' in pain therapy following thoracosurgical procedures due to its excellent, early analgesic effect.[6] However on considering the method's limitations and possibilities, its unsuitability is easily seen.

According to current guidelines outlined by a committee of experts concerning the treatment of postoperative pain, continuous paravertebral analgesia (PVB) is the recommended technique following surgical procedures within the chest. In comparison to an epidural it guarantees; effective control of pain both during coughing and at a rest, a

reduced need for opioids, improved ventilation, less chance of developing postoperative nausea and vomiting, and stable blood pressure. Prescribing anticoagulants after implanting an epidural catheter is contraindicated, whereas being harmless when applied after PVB.[7]

In a meta-analysis performed on 520 patients including 10 comparative theses between thoracic epidural analgesia (TEA) and PBV, Davies et al. conclude both methods' analgesic equivalence, but with a significantly lower amount of complications arising with PBV.[8]

In a more recent meta-analysis released in 2014 – including 12 trials and a group of 542 patients who had undergone a thoracosurgical procedure – Baidya et al. came to a similar conclusion, qualifying both methods (TEA and PVB) as equally effective in treating postoperative pain, with a smaller amount of side effects and complications in favour of PVB.[9] Also in 2014, Ding published a meta-analysis based on 18 independent theses – where 777 patients were taken into treatment - comparing the analgesic effects of TEA and PVB after a thoracotomy, concluding that while being comparable (VPS; 4-6), the frequency of occurring nausea, vomiting and incontinency after PVB was lower, with a smaller percentage of ineffective anaesthesia.[10]

4.1. Anatomy of the PVS

The PVS is a cuneal formation in the chest area lacking definition within anatomy textbooks. Located on both sides of the spine, it is filled with loose connective tissue. It is limited at the front by parietal pleura and on the medial side by the vertebral body, and both the intervertebral disc and foramen (neural exit). Finally it is bound at the back by the superior costotransverse ligament (*ligamentum costotransversarium superius*) and the intercostal membrane. The lack of an upper and lower wall favours the communication between the areas located directly above and below the PVS. It is however assumed that the level Th12 serves as the lower, axial border, paravertebrally limited by m. psoas major.[11]

Due to the lack of solid boundaries on the sides, it reaches intercostal spaces. The endothoracic fascia (*fascia endothoracica*) divides the paravertebral area into the extra pleural and subendothoracic compartment, whose purposes are not explained.[12]

The extra pleural (front) compartment contains the sympathetic ganglion, and the subendothoracic (rear) compartment the spinal nerve. The identification of the endothoracic fascia dividing the sympathetic and rear ganglion plus the compartments can be helpful in understanding the blockade's spread and common diversity.[13]

Administrating an anaesthetic to PVB consequently causes its spread; sideways into the endothoracic fascia, medially into the intervertebral foramen and epidural space, and upwards and downwards into neighboring paravertebral parts. On the level of the thoracic vertebrae this area contains: the spinal nerve (endothoracic, lacking a myelin sheath in the paravertebral section), the intercostal nerve's dorsal branches, connective branches (white and grey) and the sympathetic trunk (in the front part) (Figure 1).[14]

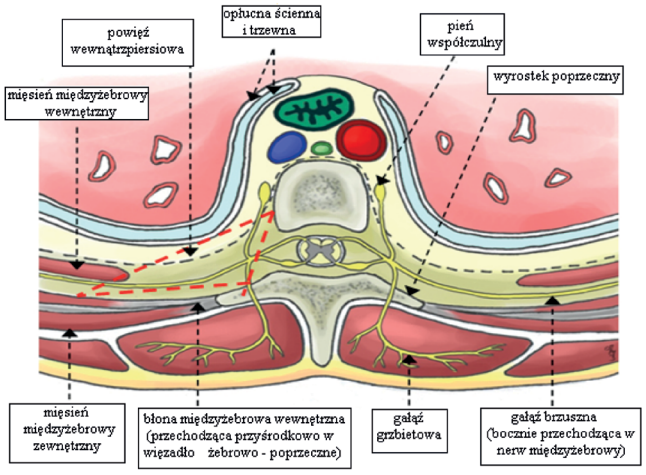

Figure 1. Anatomy of the endothoracic fascia.[15]

Administrating a local anaesthetic to PVS causes a direct effect on the nervous structures mentioned above. The anaesthetic effect is a combination of a somatic, physical and sensory blockade, as well as a one-sided sympathetic blockade in a number of contiguous dermatomes. The anaesthesia's extent depends on its volume and concentration.[16]

Eason and Wyatt deemed that 15 mL of 0.375% bupivacain should desensitize at least 4 neighboring dermatomes. Today it is assumed that 15 mL of 0.5% bupivacain injected in the PVS space inhibits somatic nerves on a range of more than 5 dermatomes (1–9), while a sympathetic blockade affects more than 8 (6–10).[17]

In accordance with many authors, a continuous postoperative infusion should be at 0.1 mL/kg per hour.[18]

4.2. Methods of performing a PVB

Various methods of performing a PVB are described in clinical practice. These include methods based on: identification with the help of losing resistance, recognition of anatomical points, help of a neurostimulator, using ultrasonography, the opening of the chest during surgical procedures.

According to Davies, the implementation of a catheter to the PVS by the operating surgeon represents the most logical procedure in thoracic surgery, allowing the avoidance of complications and the anaesthetic's administration to the desired place.[8] Other authors[19] also suggest this solution because possible complications are few and far between. Yet, and for no apparent reason, it is a rarely practiced method deserving of more propagation due to its easy execution, slim chance of causing serious complications, and vast analgesic efficiency.

The procedure is based on the insertion of a Touhy needle (most commonly a 16G) to the front of the thoraxes closure and the area surrounding the wound's paraspinal pole after finishing the surgical procedure on the same level or one intercostal above (Figure 2).

Through this needle, the catheter for the permanent local anaesthesia is induced cranially at a distance of several centimeters and placed under visual control below the pari-

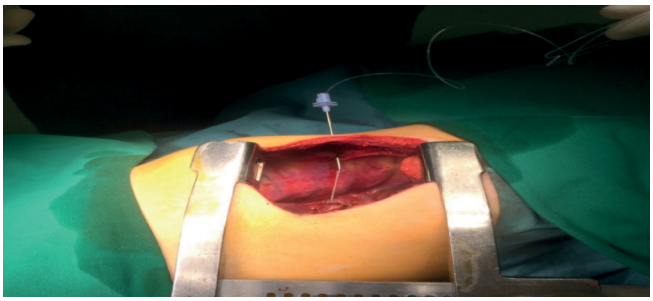

Figure 2. Catheter 16G inserted through a Touhy needle into the postoperative wound's paraspinal pole.

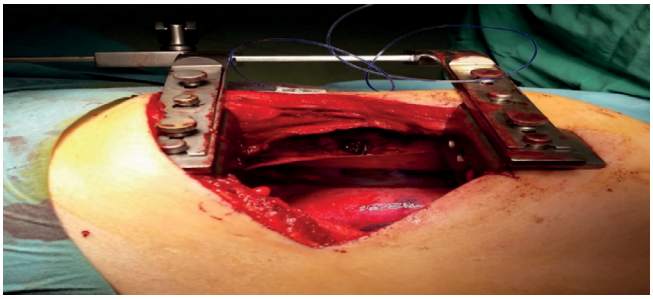

Figure 3. State after the catheter's implantation to the PVS, colored with a methylene blue solution for a better visualization.

etal pleura in the PVS. Berrisford and Sebanathan recommend the paraspinal section to be at least 10 cm long.[20]

To avoid undesired movement, the subpleural section is being tunneled subcutaneously. After installing the filter at the end of the catheter, a solution of physiological salt can be administered ensuring its proper localization and the liquid's spread below the parietal pleura (Figures 3 and 4).

For the purpose of teaching given to the paravertebral methylene blue solution (Figure 4).

A major intercostal opening at the posteolateral access can be a particular problem, touching the parietal pleura too closely in the paraspinal area, which can result in the anaesthesia pouring through the emerged wound into the pleural cavity. The closure of the intercostal at least results in partial sealing and an effective anaesthesia, as evidenced by the author's experience.

The correctness of catheter insertion to PVS, can be checked postoperatively providing water contrast agent through the catheter (Figure 5).

4.3. Used medication

There is a lack of an unequivocal and categorical algorithm determining the dosage of drugs that should be used in PVB. According to many authors, bupivacain at a concentration of either 0.25% or 0.5%, and ropivacain at a concentration 0.5% should be used alongside the occasional addition of adrenaline. Both drugs are dosed in a bolus of 10–20 mL and a subsequent, continuous infusion at the speed of 0.1 mL/kg per hour.[16,18,21]

The author uses a bolus of 0.5% bupivacain infused to the intraoperatively implanted catheter at the moment of

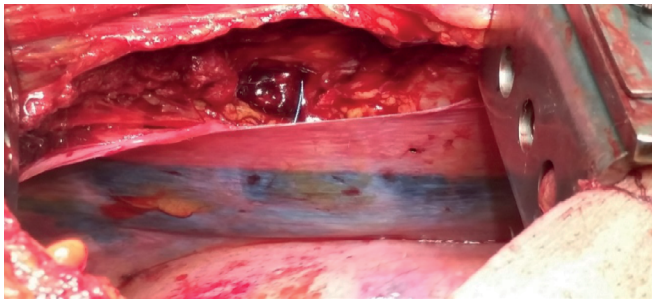

Figure 4. Paravertebral space colored in the distance of 4–5 intercostal.

closing the coating of the chest and a subsequent continuous infusion of 0.25% bupivacain by elastomeric pump at a speed of 5 mL/h, usually obtaining the analgesic effect on a level of 3–5 PVS. This removes the need to administrate opioids in the occurrence of breakthrough pain.

Pain intensity was assessed on the basis of VPS (visual pain score). Patients filled out Pain-Scale Questionnaire surveys on a 0–10 scale, in the first, 2nd, and 3rd postoperative days. Drug administration to PVS was continued 3 days after surgery (until the 3rd postoperative day). Complications of this method are rare. These include: infectious complications, hematoma, toxicity of topical anaesthetic subarachnoid or epidural anaesthesia, neurological complications, damage to nervous structures, puncture large vessels, haemorrhage, blood pressure drop. We have not experienced any complications during this postoperative pain treatment.

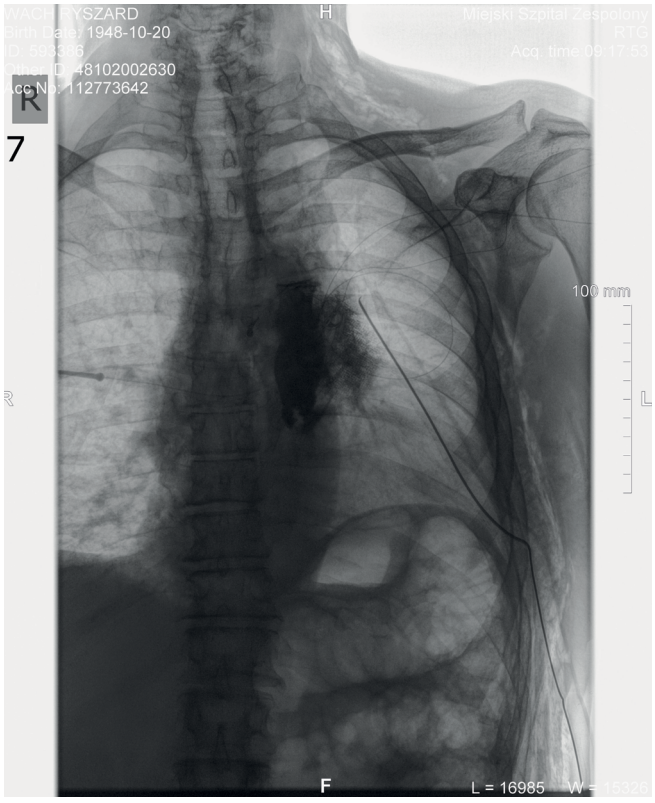

Figure 5. PVS contrasted with an Ultravist 350 solution, administered through the intraoperatively implanted catheter.

This method was implemented on 38 patients over a 10 month span. On 3 of the patients, the analgesic effect was not obtained. In the author's opinion and considering the intraoperative picture, this was due to the intercostal being opened too wide with the same PVS resulting in the administered medication reaching the pleura, hence not making the desired impact. On the remaining patients the analgesic effect was obtained at a level of 3–5 PVS, without the necessity of administrating opioids in the case of breakthrough pain. After the first 24 h following surgical procedure the patients showed positive signs of recovery and were able to start rehabilitation.

According to Richardson, the optimal solution is the use of 'pre-emptive analgesia' under multimodal therapy, using the dose of the anaesthetic infused to PVS before incision to the skin, supplemented by further proceedings as described above, decreasing postoperative pain to 0.5 cm on a scale of 0–10 cm.[18]

5. CONCLUSIONS

Intraoperatively implanting a catheter to the PVS following thoracosurgical procedure in order to conduct continuous, regional postoperative anaesthesia is a safe and effective method of treating postoperative pain in thoracic surgery.

Conflict of interest

None declared.

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