Review Article

Non-intubated anesthesia in thoracic surgery—technical issues

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Abstract: Performing awake thoracic surgery (ATS) is technically more challenging than thoracic surgery under general anesthesia (GA), but it can result in a greater benefit for the patient. Local wound infiltration and lidocaine administration in the pleural space can be considered for ATS. More invasive techniques are local wound infiltration with wound catheter insertion, thoracic wall blocks, selective intercostal nerve blockade, thoracic paravertebral blockade and thoracic epidural analgesia, offering the advantage of a catheter placement which can also be continued for postoperative analgesia.

Keywords: Awake thoracic surgery (ATS); awake video-assisted thoracoscopic surgery; thoracic epidural anesthesia (TEA); serratus anterior plane block; thoracic paravertebral blockade

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Authors' introduction:

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Figure 1 Dr. Gabor Kiss.

Introduction

Performing awake thoracic surgery (ATS) is technically more challenging than thoracic surgery under general anesthesia (GA), but it can result in a greater benefit for the patient due to avoidance of complications of intubation and prolonged mechanical ventilation, while providing better hemodynamics (1-10) and possibly superior postoperative analgesia.

The absence of GA and its side effects may explain faster postoperative recovery, lower complication rates, reduced stress hormones, and comparable or even reduced morbidity and mortality with comparable surgical results as opposed

Figure 2 Dr. Maria Castillo.

to GA (1,7,11-16).

However, thorough preparation of the patient is an essential part of the anesthetic management and must come before considering the local or regional anesthetic technique. The medical team must know the typical anesthetic complications which could arise during ATS and how to avoid them, and be prepared for conversion to GA and emergency intubation at any time during surgery.

Strict coordination and vigilance are the keys to successful patient management for ATS.

Comparison of each regional anesthesia technique for ATS

The following local and regional anesthetic techniques can be considered for ATS: local wound infiltration (with or without wound catheter insertion), serratus anterior plane (SAP) block, selective intercostal nerve blockade, thoracic paravertebral blockade (PVB) with or without catheter placement, thoracic epidural analgesia (TEA) and lidocaine administration in the pleural space.

Awake video-assisted thoracoscopic surgery has been performed with intercostal blocks and lidocaine infiltration only at the incision site (17-20). Local or wound infiltration proved to be safe but duration of action was limited and depended on the pharmacodynamics of the local anaesthetic agent used (21).

Local anesthesia can also be combined with thoracic epidural anesthesia (TEA) as reported by Mukaida and colleagues for patients with secondary hemothorax undergoing VATS (22).

Administration of lidocaine into the pleural space was used as an anesthetic technique in 34 patients with spontaneous pneumothoraces undergoing awake VATS by Nezu and coworkers (23).

More invasive techniques are SAP block, intercostal nerve blockade, thoracic PVB and TEA, offering the advantage of a catheter placement which can also be continued for postoperative analgesia.

The local anesthesia technique described by Diego Gonzalez-Rivas and coworkers

Single-port thoracoscopic lobectomy in a nonintubated patient was described by Gonzalez-Rivas and coworkers as a technique to reduce surgical access trauma more than in a standard VATS surgical approach. The authors emphasize that with the single-incision VATS technique in a nonintubated patient there is no need for epidural or vagus blockade and no lidocaine spray was used on the surface of the lung.

Thirty minutes before anaesthesia before anesthesia, the patient received intramuscular midazolam and atropine. No epidural catheter, no central venous catheter and no urinary catheter were placed. A laryngeal mask was used to control the airway and for inhalation of oxygen and sevoflurane. A continued target-controlled infusion of remifentanil was administered in order to achieve sedation under spontaneous respiration and avoid excessive patient hyper-reactivity, apnoea or carbon dioxide retention.

Only one intercostal space is opened which explains why the use of local anaesthesia and blockade of a single intercostal space is sufficient for pain control at the beginning and during the surgery. The intercostal space was infiltrated with 5 mL of levobupivacaine (5 mg/mL) which is a long-acting anesthetic agent. Using VATS approach through a single 2.5-cm incision, middle lobectomy and lymph node dissection was completed. Gonzalez-Rivas and coworkers use no trocar and try to avoid pressure on the intercostal nerve during instrumentation in order to reduce the risk of intercostal bundle injury (24,25). With this technique, the total surgical time was 80 min. Postoperatively, the chest tube was removed within the next 16 h and the patient was discharged from hospital after 36 h.

The local anesthetic technique by Hung *et al.*

This is similar to the approach of Gonzalez-Rivas and coworkers and was recently published as a series of cases using only infiltration of several intercostal spaces (from T3 to T8) instead of using an epidural catheter (26).

Thoracic paravertebral anaesthesia for awake video-assisted thoracoscopic surgery

According to a meta-analysis by Davies RG and coworkers, thoracic PVB and epidural analgesia provide comparable pain relief after thoracic surgery. However, PVB has a better side-effect profile (27).

PVB offers the advantage of a unilateral block without bilateral sympathectomy, and a lower incidence of hypotension, urinary retention, and pulmonary complications. PVB can be useful if thoracic anesthesia is contraindicated as in cases of sepsis, coagulation disorders, neurological disorders, or difficult vertebral anatomy where epidural is difficult to perform (28).

Compared to TEA, PVB is relatively easy to learn (28,29). It can be performed using the commonly practiced loss of resistance technique (28), with the assistance of ultrasound (30) or using a nerve simulator (31).

The first description of the use of thoracic PVB as the sole anesthetic for video-assisted thoracoscopy was presented in a paper by Piccioni et al. They described two cases where patients had ATS with PVB without sedation (28). They explained their technique as follows: the patient is in the sitting position. The superior aspects of spinous processes of T3–T6 were marked and after skin anaesthesia with a total of 7 mL lidocaine 1%, needle insertions was performed 2.5 cm laterally to the superior aspects of spinous processes of T3–T6 using a 70-mm, 22-G insulated stimulating needle and peripheral nerve stimulator. The needle was directed to the transverse process, then 'walked' cranially and advanced 1.5-2 cm with the nerve stimulator current set at 2.5 mA (0.3 ms duration and 1 Hz) until the intercostal muscle or sensitive response could still be obtained with a current of 0.5 mA. After aspiration, they administered in one patient 5 mL ropivacaine 1% per segment at four segments and in another patient 4 mL ropivacaine 0.75% at six levels. In general, their blocks took 10-15 min to perform. In both patients the onset of sensory loss to pinprick occurred approximately 15 min after injections and there were no signs of bilateral blockade.

In the operating room patients were placed in the lateral position for surgery and supplemental oxygen was administered at 10 L per minute (28).

A potential complication of thoracic PVB is pneumothorax, however, the incidence is low at 0.5% (32,33). In addition, this is less of a problem if thoracoscopy or thoracotomy with chest tube placement is planned.

Piccioni and coworkers conclude that the use of thoracic PVB as the sole anaesthetic for video-assisted thoracoscopy resulted in adequate unilateral anaesthesia, stable hemodynamics with no complications, and a high level of patient satisfaction (28).

Epidural anesthesia

Complications of epidural anaesthesia include dural puncture, neurological injury and paraplegia. Therefore, PVB is an effective alternative with fewer contra-indications (28). However, if longer duration of surgery should be expected, a thoracic epidural should be the first choice for ATS. In addition, as with the PVB, TEA has the advantage of providing postoperative pain relief for a longer period with boluses or a continuous infusion of local anesthetics compared to an analgesic technique with a single injection. In one paper, TEA provided pain-free surgery for a total operation time of 219 min (5).

Puncture level of the epidural block depends on the surgical incision site but is usually between T3 and T7 and should be discussed with the surgeons. The volume of local anesthesia is titrated to achieve somatosensory anaesthesia between T2 to T12, but depends on the size of the incision and varies with the patient's size and weight.

The choice of the molecule for local anesthesia depends on whether the onset of the TEA block should be rapid, which can be achieved with lidocaine 20 mg/mL. In contrast, ropivacaine 7.5 mg/mL has a slow onset but a much longer half-life. Low concentration LA solutions run the risk that the sensory block is less dense than required and that the patient might feel intrathoracic surgical manipulation, eventually leading to pain or panic attacks (5). In contrast, highly concentrated anesthetics could lead to a motor block of the intercostal muscle and thereby decrease tidal volume. However, as described in a paper by Gruber and coworkers, 0.25% bupivacaine administered in a TEA did not adversely affect ventilatory mechanics and gas exchange and was well tolerated even in severe COPD patients (34).

It is necessary to test the epidural analgesic block either with ice cubes or with a maximal painful tetanic stimulus which can be produced by a neurostimulator before the operation, and surgery should only be allowed once the skin area defined for surgical incision is completely anaesthetized.

Epidural anesthesia can have vasodilatory effects leading to hypotension. Therefore, when mean arterial pressure (MAP) falls below 65 mmHg and/or systolic arterial pressure below 90 mmHg, fluid administration should be started with or without vasoactive drugs. In paper with nine cases for ATS under TEA, phenylephrine or ephedrine was used in 50% of cases to maintain MAP above 65 mmHg and systolic arterial pressure above 90 mmHg (5). Norepinephrine can be used if phenylephrine requirements become elevated.

Serratus anterior plane block

Ultrasound-guided SAP block was first described by Blanco and coworkers in healthy volunteers who obtained an effective block from T2 to T9 lasting 750-840 min by blocking lateral branches of inter-costal nerves (21).

Based on the paper of Dr. Blanco and coworkers, Kunhabdulla NP and coworkers described SAP block with ultrasound guidance in patients with multiple rib fractures. SAP block was followed by catheter insertion for continuous infusion of local anesthetic (35). The authors describe this technique as follows:

The serratus anterior muscle was localized with a high frequency ultrasound probe positioned over the fifth rib in the posterior axillary line in vertical axis and then aligned along the long axis of the rib. The skin was anesthetized with 1% lignocaine and an 18 G Touhy needle was introduced on the surface of the rib under the serratus anterior muscle between the posterior and mid-axillary line. In order to confirm the position of the needle tip, hydro dissection was done with 3 mL of saline and this was followed by an injection of 20 mL of 0.125% bupivacaine. Then a 20 G epidural catheter was advanced through the epidural needle to a depth of 4 cm beyond the needle tip and tunneled subcutaneously to prevent displacement.

Postoperatively, Kunhabdulla and coworkers started a continuous infusion of 0.0625% bupivacaine with 1 mg/mL of fentanyl at 7 mL/h after 4 h (35).

Some clinicians avoid adding opioids in the continous infusion of local anesthetics because of fear of respiratory depression related to obstructive sleep apnea (36).

Supplemental and multimodal analgesia

At the end of surgery, additional analgesics should be given intravenously such as acetaminophen, paracetamol, or tramadol. In case the local anesthetic technique for ATS did not provide full analgesia, ketamine, NSAIDS and opioids can be supplemented depending on the comorbidities of the patient.

When ATS is performed with TEA, use of the epidural can be continued postoperatively as patient-controlled epidural analgesia (5).

Sedation during ATS

The use of short acting agents such as remifentanil administered by total intravenous anesthesia (TIVA) should be the first choice. The advantage of remifentanil is that it has an ultra-short context-sensitive half-time of 3 min. In addition, in case of apnea leading to rapid desaturation, remifentanil can be antagonized by naloxone.

Propofol TIVA can be titrated to the desired sedation level without compromising spontaneous respiration and airway responses. It can be given alone or in conjunction with remifentanil. In several papers, target controlled infusions (TCI) of propofol, TCI remifentanil, and combinations of both have been utilized as a light sedation, resulting in the patients being less anxious yet still remaining responsive during surgery (5).

Titrating levels of propofol plasma concentration can vary from one patient to another and also depends on the experience of the anesthesiologist. Therefore, it is difficult to make a recommendation for plasma concentration to obtain anxiolysis while keeping the patient spontaneously breathing during ATS. In an observational study, the range of propofol TCI plasma concentration in six patients was 0.5-2 μg/mL (Shneider) and remifentanil plasma concentration 0.5-3 ng/mL (Minto) including one patient who had remifentanil only. There was no significant impact on oxygen saturation (5).

Care must be taken in patients with severe COPD where sedation could contribute to or accentuate hypercapnia. If sedation is unavoidable in these patients, ketamine should be used preferentially as it is the only anesthetic that maintains functional residual capacity by preserving inspiratory muscle tone (37).

Finally, dexmedetomidine, an α2-adrenoceptor agonist, also could remain an option for sedation during ATS. It has been approved in the US for perioperative sedation in anesthesia but it has not yet been officially licensed for this use in Europe where its indication is limited to sedation in the Intensive Care Unit. Perioperatively, it decreases sympathetic, neuroendocrine, hemodynamic responses and also anesthetic and opioid requirements during surgery. It preserves respiratory and psychomotoric functions. Side effects consist of moderate cardiovascular depression, with decreases in blood pressure and heart rate (38,39).

Conclusions

Literature has shown that following local and regional anesthetic techniques can effectively be applied for ATS: local wound infiltration, SAP block, selective intercostal nerve blockade, PVB, TEA and lidocaine administration in the pleural space.

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