UDC 616.25-003.219-021.3-089.819.3-089.168-036.82 https://doi.org/10.26641/2307-0404.2024.4.319308

V.V. Tkalich [1] *, ***Yu.V. Nedilia*** [1], ***V.I. Borysova*** [1], ***O.V. Galiiev*** [1], ***S.I. Savoliuk*** [2]

SPONTANEOUS PNEUMOTHORAX: INTUBATED OR NON-INTUBATED SURGERY?

Kyiv City Hospital No. 17 [1]
Laboratornyi side str., 20, Kyiv, 01133, Ukraine
Shupyk National Healthcare University of Ukraine [2]
Dorohozhytska str., 9, Kyiv, 04112, Ukraine
Київська міська клінічна лікарня № 17 [1]
пров. Лабораторний, 20, Київ, 01133, Україна
Національний університет охорони здоров'я України ім. П.Л. Шупика [2]
вул. Дорогожицька, 9, Київ, 04112, Україна
e-mail: airmj23@ukr.net

Цитування: Медичні перспективи. 2024. Т. 29, № 4. С. 117-125
Cited: Medicni perspektivi. 2024;29(4):117-125

Key words: *catamenial pneumothorax, diaphragm endometriosis, spontaneous pneumothorax, non-intubated video-assisted thoracic surgery, video-assisted thoracoscopic surgery, enhanced recovery after surgery*
Ключові слова: *катаменіальний пневмоторакс, ендометріоз діафрагми, спонтанний пневмоторакс, неінтубована відеоасистована торакальна хірургія, відеоасистована торакоскопічна хірургія, прискорене відновлення після операції*

Abstract. Spontaneous pneumothorax: intubated or non-intubated surgery? Tkalich V.V., Nedilia Yu.V., Borysova V.I., Galiiev O.V., Savoliuk S.I. *The aim of our clinical study was to justify and implement non-intubated video assisted thoracic surgery as a part of enhanced recovery after surgery pathway in treatment of spontaneous pneumothorax. Data of 150 patients who underwent surgical treatment were retrospectively analyzed. Among them group 1 of 75 patients underwent video-assisted thoracoscopic surgery (VATS) and group 2 of 75 patients underwent non-intubated VATS surgical treatment. All patients underwent atypical resection of the lung and pleural abrasion, diaphragm augmentation with mesh if diaphragm endometriosis was suspected. The perioperative data, short-term outcomes and recurrence rates of these two groups were compared. The two groups had comparable demographic, perioperative investigations, fluid infusions during surgery, the volume of surgery intraoperatively, blood loss, time for chest drain removal, length of stay in the hospital and the rate of complications. There were no conversions to thoracotomy or intubated general anaesthesia, no mortality. The peak end-tidal carbon dioxide was significantly higher in the non-intubated group than in the intubated group (mean: 48±8.6 vs 34±6.2 mmHg, p<0.001). The mean follow-up was 20.2±3.9 months in the non-intubated group and 24.7±4.2 months in the intubated group (p>0.05). Chest tube duration was 4.11 days in group 1 and 3.76 days in group 2. The recurrence rate of pneumothorax after surgery was 4% in both groups. Nnon-intubated video-assisted thoracic surgery for spontaneous pneumothorax could be considered a feasible, safe and effective method of treatment, even with mesh diaphragm augmentation, in cases of catamenial pneumothorax and can be a part of Enhanced Recovery After Surgery pathway. Continious follow-up and additional clinical investigations are supposed to validate the profits of the suggested approach.*

Реферат. Спонтанний пневмоторакс: хірургічне лікування з інтубацією чи без? Ткаліч В.В., Неділя Ю.В., Борисова В.І., Галієв О.В., Саволюк С.І. *Мета нашого клінічного дослідження полягала в тому, щоб обгрунтувати та імплементувати неінтубовану відеоасистовану торакальну як частину концепції покращеного відновлення після операції при лікуванні спонтанного пневмотораксу. Дані 150 пацієнтів, які перенесли хірургічне лікування, було ретроспективно проаналізовано. З них у 1 групі із 75 хворих виконано відеоасистовану торакальну хірургію і в 2 групі із 75 пацієнтів проведено неінтубовану відеоасистовану торакальну хірургію. Усім хворим виконана атипова резекція легені та абразія плеври, аугментація діафрагми сіткою при підозрі на ендометріоз діафрагми. Періопераційні дані, короткострокові результати та частота рецидивів у двох групах зіставні. Дві групи мали порівняльні демографічні профілі, передопераційні обстеження, об'єм інфузійної терапії інтраопераційно, об'єм хірургічних втручань інтраопераційно, крововтрату, терміни видалення дренажів, тривалість перебування в стаціонарі та рівні ускладнень. Не відмічено конверсії до торакотомії чи інтубаційної анестезії, смертності. Піковий рівень вуглекислого газу наприкінці дихання в неінтубованій групі був значно вищим, ніж в інтубованій групі (середнє значення: 48±8,6 проти 34±6,2 мм рт. ст., p<0,001).*

Середній термін спостереження становив 20,2±3,9 місяця в групі без інтубації та 24,7±4,2 місяця в групі інтубації (p>0,05). Тривалість знаходження торакального дренажу 4,11 дня в 1 групі, 3,76 дня в 2 групі. Частота рецидивів пневмотораксу після хірургічного лікування становила 4% в обох групах. Неінтубована відеоасистована торакальна хірургія спонтанного пневмотораксу може вважатися здійсненним, безпечним та ефективним методом лікування, навіть при укріпленні діафрагми сіткою, у випадках катаменіального пневмотораксу та може бути частиною концепції прискореного відновлення після операції. Для підтвердження переваг запропонованого підходу необхідні тривале спостереження та подальші клінічні дослідження.

The treatment of spontaneous pneumothorax in some cases is challenging and requires multidisciplinary approach. A retrospective and prospective study was done and included 150 patients with spontaneous pneumothorax to define the clinical peculiarities, the efficacy of surgical treatment and recurrence rates. By means of our retrospective study, we estimated the implementability and safeness of non-intubated treatment of spontaneous pneumothorax (SP) under thoracic epidural anesthesia with sedation and spontaneous ventilation. In this study, we compare peri- and postoperative periods and complications with different types of anesthesia – with sedation without intubation with thoracoscopic bullectomy and with traditional general anesthesia with double-lumen intubation and mechanical ventilation. Non-intubated thoracic surgery can be a part of Enhanced Recovery After Surgery pathway.

MATERIALS AND METHODS OF RESEARCH

This is a retrospective study which was done in Kyiv City Hospital No. 17, polytrauma department from a period of 2016-2022 years. 150 patients with spontaneous pneumothorax were included in study. Group 1 (75 patients) was treated with video-assisted thoracoscopic surgery (VATS) technique, Group 2 (75 patients) was treated with non-intubated video-assisted thoracic surgery (NIVATS) technique. Patients in 2 groups were comparable for age, gender, indications for surgery, anesthesia profile, surgical technique, complications and results.

The inclusion criteria were age > 18 years, incidence of spontaneous pneumothorax (1st episode or recurrence).

The research was conducted in accordance with the principles of bioethics set out in the WMA Declaration of Helsinki – "Ethical principles for medical research involving human subjects" and "Universal Declaration on Bioethics and Human Rights" (UNESCO) and written consent was obtained from patients.

Statistical analysis was performed using both parametric and non-parametric methods. Continuous variables were presented as mean ± standard deviation. Abandoning among the "Non-intubated" and "Intubated" groups for continuous variables were made using the independent samples t-test for normally distributed data.

Categorical variables were compared using the Chi-square (χ^2) test. In cases where the expected frequencies were less than 5, the Fisher's exact test was used.

Additionally, the Odds Ratio (OR) and Relative Risk (RR) with 95% confidence intervals (CI) were calculated to assess the risk between groups for categorical variables.

A p-value of less than 0.05 was considered statistically significant.

All statistical analyses were conducted using SPSS version 25.0 (IBM Corp., Armonk, NY) or equivalent statistical software.

RESULTS AND DISCUSSION

VATS bullectomy was performed in 150 patients aged 14 to 69 years (VATS: n=75.50%; NIVATS: n=75.50%). All patients had a confirmation of pneumothorax on chest X-ray (CXR) or computer tomography (CT). The aim of thoracoscopy, performed under local anesthesia, was to examine the lung, diaphragm and reveal any adhesions and changes on tendinous part of the diaphragm doubtful for endometriosis. CT of the chest and abdomen (in woman) were performed before the operation. 2 patients underwent bilateral VATS (1 in 2 different operations, 1 during one operation). Before surgery, all patients were examined by an anesthesiologist to determine their physical status, Mallampati airway assessment, and ASA anesthetic risk for surgery. The protocol of anesthesia was explained to participants prior to informed consent. Demographic and clinical patient characteristics are summarized in Table 1.

In 9 cases non-intubated VATS was performed as initial and definitive procedure. 72 patients were operated with epidural anesthesia, except 2 patients who had contraindications for epidural anesthesia (1 continuous use of clopidogrel, 1 had epidural less than 2 weeks before) and 1 patient refused epidural anesthesia. 1 patient was with spontaneous pneumohemothorax (3000 ml blood in pleural cavity).

Surgical techniques.

Surgical technique in NIVATS group. All patients (except 1 with simultaneous bilateral pneumothorax) were operated on the lateral decubitus position, applying a combination of TEA, intravenous anesthesia and preserving spontaneous ventilation. Iatrogenic pneumothorax was put on due

to chest tube disconnection. In earlier cases we used a 2-port approach. In later cases a uniportal approach was applied in 4th -5th intercostal space. After making a 3 cm incision the wound protector SurgiSleeve XS (Covidien, USA) is inserted. The chest cavity (chest wall, mediastinum, diaphragm, lung) is examined with 10 mm 30° video thoracoscope (Hopkins II, Storz). Apical wedge resection was performed and all macroscopically suspicious areas for endometrial implants on the visceral pleura were resected with universal stapler Endo GIA (Covidien, USA) with purple Tri-Staple or Green-loading units. Diaphragm fenestrations were resected and tendinous part of the diaphragm was reinforced with Parietex mesh (Covidien, USA), sewn by 4-5 interrupted sutures with 2-0 Surgipro (Covidien, USA). Pleural abrasion with a help of tip cleaner was accomplished from the apex downwards to the diaphragm. Macroscopically doubtful deposits on parietal pleura were biopsied for histopathology for endometriosis. At the end of surgery 18 Fr chest tube was positioned under direct camera control. Lung was passively expanded and placed on passive underwater suction – 5 cm H_2O. In one patient who was operated simultaneously with bilateral pneumothoraxes the patient was lay in the back with arms abducted to 90 degrees. Two port approach was used in 4th and 7th intercostal spaces. After finishing the operation at one side, the lung was passively reexpanded and only after that the operation at another side was started.

*Surgical technique in VATS group.*_After the establishment of DLT the patient was positioned in lateral decubitus position. Surgical manipulations were the same as in NIVATS group.

Chest tube removal criteria were no air leak, amount of fluid less than 200 ml/24h, normal picture on chest X-ray. The next day was the date of discharge.

Anesthesia.

After come in the operating room, monitors were placed on all patients. In both group standard monitoring included an ECG, a pulse oximeter, an automated noninvasive pressure device, measurement of respiratory rate, and capnography. In group NIVATS (group 2) we used bispectral index (BIS) to monitor the depth of anesthesia.

In the VATS group (group 1) anesthetic management was represented by general anesthesia, including inhaled anesthesia with Sevoran, intravenous fentanyl, and one-lung ventilation (OLV). A 35- or 37- Fr left-sided DLT was inserted after induction with propofol, fentanyl, and neuromuscular blockade. Protective ventilation strategy was commenced with tidal volumes 5-6 mL/kg and positive end-expiratory pressure 5 cm H_2O, with peak pressure of under 30 cm H_2O. The average dose of fentanyl used during surgery was 8,91 mcg/kg/h (±1.6), and muscle relaxation was used to suppress cough. Patients were usually extubated in the operating room or sometimes remained intubated for up to 30 minutes, and then were transferred to the intensive care unit (ICU). Postoperative analgesia included the use of paracetamol and dexketoprofen, and with severe pain, additional administration of opioids. We additionally used thoracic epidural anesthesia intra- and postoperatively only in the last three cases. We want to note that in these cases, the average dose of intraoperative administration of fentanyl was 3.3 mcg/kg/h, but so far we can't put it into a separate subgroup because of the small number of cases, but we want to note that relief of postoperative pain by TEA was enough. The time spent in intensive care from 4 to 16 hours (an average of 7.75±2.26).

Anesthetic protocol in our study of non-intubated (group 2) surgery was done applying a combination of intravenous and epidural anesthesia with spontaneous breathing.

In the sitting position after established intravenous rehydration T5-T7 interspace was choosed to perform TEA. After that 40 mg of lidocaine infused as a test dose and continuous pumping of bupivacaine hydrochloride 0.25% with a rate of 8-10 ml/h.

This provides additional anesthesia at the level of T2-T10 and assists to preserve spontaneous breathing. Patient oxygenation is put through non-rebreathing mask with oxygen flow 7-10 L/min and FiO_2 0.5-0.7.

The last step before starting the surgery is positioning patient in the lateral decubitus position.

In group 2, we administered a loading dose of dexmedetomidine immediately after placing the epidural catheter and returning the patient to a horizontal position at a dose of 1 mcg/kg for 20 minutes followed by a maintenance dose of 0.7 mcg/kg/h. In this case, the induction doses of propofol and fentanyl averaged 1. 52±0.48 and 1.34±0.37, respectively. During anesthesia, propofol infusion was at an average dose of 3.1±1.33 mg/kg/h, and fentanyl – 1.82±0.71 mcg/kg/h.

In NIVATS group intrapleural injection of 20 ml of 0.25% bupivacaine by surgeons was an additional way to suppress the cough reflex during lung manipulations. Postoperative analgesia was a prolonged TEA of 0.125% bupivacaine, the rate of administration of which was controlled by patients depending on the intensity of the pain syndrome. If necessary, in some cases, TEA was supplemented with single injections of dexketoprofen. There was no need for opioid administration.

Surgical and anesthetic results.

Patient data and features are summarized in Table 1, 2.

Table 1

Demographic and clinical patient characteristics, M±m

Variable	Non-intubated (n=75)	Intubated (n=75)	p	OR (95% CI)	RR (95% CI)
Age (years)	39.86±13.62	38.33±11.18	0.447	-	-
Weight (kg)	60.2±9.6	58.7±6.1	0.895	-	-
Height (cm)	170.31±5.46	173.25±7.96	0.586	-	-
BMI	21.21±2.93	20.17±2.03	0.746	-	-
Gender					
Male	59 (78.7%)	61 (81.3%)	0.548	0.831 (0.39-1.77)	0.968 (0.67-1.38)
Female	16 (21.3%)	14 (18.7%)		0.831 (0.39-1.77)	0.968 (0.67-1.38)
Mallampati score:					
class 1	72 (96.0%)	70 (93.3%)	0.682	1.72 (0.35-8.37)	1.03 (0.95-1.11)
class 2	3 (4.0%)	5 (6.7%)			
ASA anesthetic risk for surgery:					
ASA I	58 (77.3%)	53 (70.7%)	0.103	2.3 (0.87-6.11)	1.09 (0.97-1.22)
ASA II	8 (10.7%)	21 (28%)			
ASA III	9 (12%)	1 (1.3%)			

Table 2

Indications for surgery

Indication	Non-intubated (n=75)	Intubated (n=75)	p	OR (95% CI)	RR (95% CI)
1st episode, thoracoscopic or CT findings	58	10	<0.001	37.7 (14.4-98.6)	5.8 (3.1-11.1)
Ipsilateral recurrence	15	65	<0.001	0.026 (0.01-0.07)	0.23 (0.14-0.36)
Bilateral simultaneous recurrence	2	-	-	-	-

Between July 2016 and September 2022, 150 patients underwent VATS for SP. The surgical and anesthetic results are given in Table 3. The conversion rate to thoracotomy or intubation in both groups wasn't observed in our study. The mortality rate is zero in each group.

Postoperative views of incisions are represented in Figure.

Surgical complication profiles. Postoperative prolonged air leak (air leaks > 5 days) was 16% in NIVATS group and 17.3% in VATS group.

In NIVATS group we had 2 complications. In 1 case we had postoperative bleeding from adhesions. The patient was re-operated 6 h after operation (800 ml blood lose) in NIVATS technique: hemostasis was achieved due to additional coagulation of adhesions in the cupola of pleura near great vessels and put on SugriCell in that place. In case 2 the patient was operated in uniportal manner and Green reload on EndoGIA universal stapler was blocked on stapled lung and it was impossible to open the reload. The additional port in 7th intercostal space was placed and the lung was re resected under blocked reload. The next Green reload was opened during sewing and staple raws were in lung in open position and the lung began to bleed. The bleeding part was taken in a lung

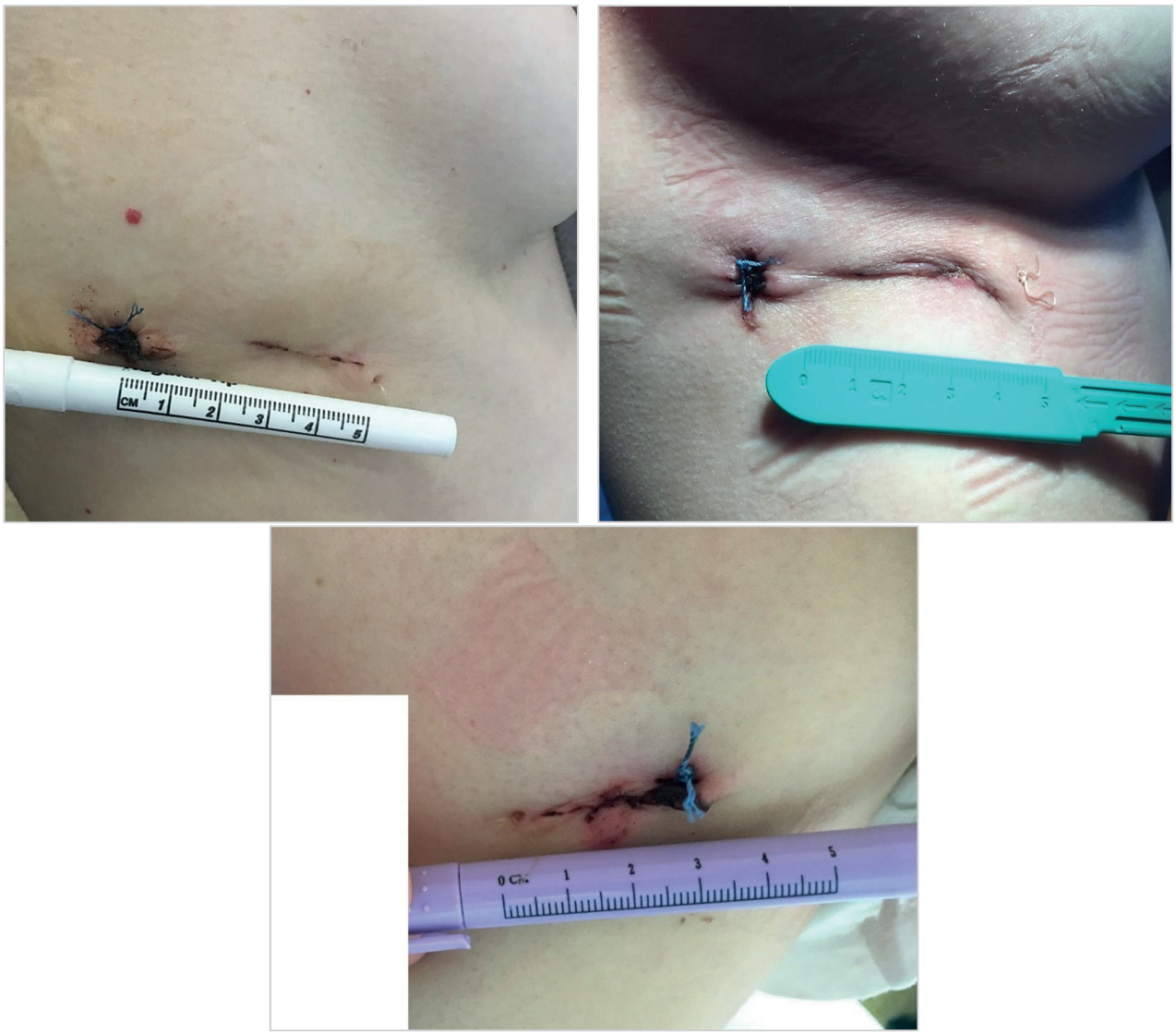
clamp, grasped up and resew with purple tri-staple reload with additional manual sew the part of the beginning of staple line.

Anesthetic profiles. During surgery the peak end-tidal carbon dioxide (Peak $EtCO_2$) in NIVATS group was significantly higher than that in IVATS group (mean: 51 vs 38 mmHg). PaCO2 values in the post-operative period did not vary significantly among the two groups. Lower rates of intraoperative oxygen saturation (SpO_2) were observed in group 2 than in group 1 (mean: 94 vs 98 mmHg), but did not exceed the permissible limits. In the postoperative period – SpO_2 there was no difference. Despite the fact that the intraoperative mean arterial pressure in both groups was comparable, the volume of fluid infusion to maintain it was significantly different and averaged 7. 8 ml/kg/h in the VATS group and 17.7 ml/kg/h in the NIVATS group. This is due to the use of NIVATS TEA and is confirmed by the absence of differences in infusion therapy in patients who performed NIVATS without TEA (8.3±3.6 ml/kg/h). In both groups, in cases of contraindications to infusion therapy with a significant occurrence of hypotension was a need for a single administration of vasopressors. The frequency of these cases in groups 1 and 2 was 2 (2.7%) and 3 (4%) respectively.

Table 3

Surgical and anesthetic results, M±m

Variable	Non-intubated (n=75)	Intubated (n=75)	p	OR (95% CI)	RR (95% CI)
Surgical duration (min)	79.7±32.3	78. 9±27.8	0.872	-	-
Peak $EtCO_2$ during operation (mmHg)	50.97±3.89	37.9±2.61	0.001	-	-
Peak $EtCO_2$ after operation (mmHg)	36.95±1.45	35.8±2.03	0.355	-	-
Lowest SpO_2 during operation (%)	94.2±1.30	97.9±1.5	0.045	-	-
Lowest SpO_2 after operation (%)	97.8±1.7	98.9±1.35	0.152	-	-
Conversion to thoracotomy (%)	0 (0%)	0 (0%)	-	-	-
Total blood loss (ml)	15.0±11.3	17.0±12.1	0.300	-	-
Intraoperative mean arterial pressure (mm Hg)	84.4±20.3	81.7±21.5	0.433	-	-
Volume of fluid administration (ml/kg/h)	17.7±7.5	7.8±4.2	0.001	-	-
Complication:					
Surgical bleeding	1 (1.3%)	0 (0%)	-	-	-
Cases of intraoperative hypotension requiring administration of vasopressors	3 (4%)	2 (2.7%)	0.649	1.52 (0.25-9.02)	1.33 (0.22-8.11)
Sore throat	-	33 (44)	0.001	-	-
Nausea and vomiting	-	11 (14.6%)	0.001	-	-
Associated with TEA	2 (2.6%)	-		-	-
Postoperative pain, VAS scale (0 – 10)	1.9±0.8	3.7±1.13	0.001	-	-
Cases of postoperative care of patients in ICU	12 (16%)	75 (100%)	0.155	-	-
Return to eating (hours)	0.5–1	2–4	0.152	-	-
Admission time of patients to normal activity (hours)	2–3	6–8	0.006	-	-
Chest drainage (days)	3.76±0.35	3.95±0.48	0.209	-	-
Air leak > 5 days	12 (16%)	13 (17.3%)	0.539	0.91 (0.38-2.19)	0.92 (0.42-2.03)
Mortality	0 (0%)	0 (0%)	-	-	-
Follow-up period (months)	20.2±3.9	24.7±4.2	0.102	-	-
Recurrence	3 (4%)	3 (4%)	1.000	-	-



Postoperative view of incisions

In the postoperative period, all patients of the VATS group were monitored in the ICU for 4-15 hours, which was associated with general anesthesia and artificial lung ventilation. In the NIVATS group, 12 (16%) patients were in ICU after surgery. These were mainly patients with ASA III and those who were operated at night. The recovery of the drinking regime and normal motor activity occurred much faster in the NIVATS group.

The main complications of the early postoperative period (up to 24 hours) in the VATS group were throat pain in 33 (44%) patients, which is associated with the use of DLT, as well as nausea and vomiting in 11 (14.6%) patients. These complaints were absent in patients of the NIVATS group.

In the NIVATS group, 2 (2.6%) patients had complications that we associated with TEA. In one case, this was a headache lasting about 24 hours – in this patient, during the placement of an epidural catheter, casual dura mater puncture was performed. In the second case, this was a collapse when the patient gets out of bed early, which was probably associated with a decreased vascular tone caused by TEA.

The intensity of postoperative pain was greater in group 1 (mean: 3.7 vs 1.9), which required repeated injections of NSAIDs and/or administration of opioids. In the NIVATS group, when the pain syndrome intensified, as a rule, only an increase in the rate of introduction of bupivacaine into the epidural catheter and / or single administration of NSAIDs was required.

Pneumothorax is classified by the cause or according to the underlying respiratory disease: primary (PSP) and secondary (SSP). In women, SSP can be caused by diseases such as endometriosis and lymphangioleiomyomatosis (LAM). These types of SSP are characterized by a high recurrence rate. In women with LAM pneumothorax occurs in 40-80% of them and has the highest rate of recurrence 70% among patients with

spontaneous pneumothorax. The side of recurrence is – unilateral (71%), contralateral (74%), bilateral (4%) [1]. Catamenial pneumothorax has recurrence rate of 40% according to the literature [2].

Incidence of PSP is 7-28/100.000/year in men and 1.2-6/100,000 per year in women [3]. The recurrence range is 25-50%, and most recurrences occur in the first year. Because of the effect of the preexisting lung disease, the management of SSP is potentially more difficult [4]. In our study we had 80 patients (53.3%) with recurrent pneumothorax.

The history of treatment of spontaneous pneumothorax started from conservative treatment (observation, aspiration), crossed to surgical in failure of conservative treatment (chest tube drainage, thoracotomy, VATS) and comes to less invasive surgical treatment at the 1st episode of pneumothorax (tubeless/non-intubated VATS).

When hunt for the best available surgical approach to spontaneous pneumothorax and confront VATS and thoracotomy, the answer seems ordinary and estimated – VATS approach [5,6,7]. A Randomized Controlled Trial the authors conclude that uniportal VATS approach is less painful besides being as efficient as 2- or 3-portal VATS approaches for spontaneous pneumothorax treatment [8]. In our study we use uniportal approach too. We found in more ergonomically comfortable for surgery but the main source of the pain is the intercostal space, where the chest drain is inserted and the sites of where trocars were put in. According to the review of Suraj Pathaka recurrence rates of catamenial pneumothorax after only hormonal treatment – 58.5%, only diaphragm repair – 33%, only surgery on the lung – 63.3%. The bottom line of this review is that management strategies for CP may include any combination of hormonal therapy, pleural symphysis, operative parenchymal resection and diaphragmatic excision/repair [9]. Ideally, bullectomy should be follow by some pleurodesis technique [10]. Mechanical pleurodesis is one of the most broadly used techniques as a part of surgery for SP. We also do mechanical pleurodesis according to the recommendations of European Society of Thoracic Surgeons with tip cleaner and found it sufficient enough for adhesion formation.

NIVATS method eliminates complications of general anesthesia with OLV such as ventilation-induced lung injury, intubation-associated respiratory trauma (sore throat, pain, hoarseness, tracheal laceration), residual neuromuscular blockade and minimizing the risks of postoperative nausea and vomiting.

All the mentioned above allowes to decrease painkillers use and the length of postoperative period [11]. We had no nausea and vomiting and sore throat in NIVATS group in compare to VATS group, where we observed nausea and vomiting in 14,6% of patients and sore throat in 44% of patients which is the same as in the literature.

The interest for NIVATS procedures has become more attractive and showed the same safeness to classic general anaesthesia over the last decade. In 1997 year the first series of minimally invasive pulmonary resections under local anesthesia showed a small rate of complications, shorter period of hospital stay and were published.

Patients with pneumothorax who had contraindications for general anesthesia were surgically treated under local anaesthesia and TEA by Mukaida et al. in 1998.

In 2007, in a small randomized trial, Pompeo and Mineo compared VATS bullectomy and pleural abrasion performed in awake patients with spontaneous pneumothorax and epidural anesthesia versus patients under general anesthesia with OLV. Results of this study have proposed that awake VATS bullectomy with pleural abrasion was probable and issued in decrease of hospital stay.

Bilateral spontaneous pneumothorax is rare and potentially life threatening condition. Jianxing He published a study of 15 patients with bilateral spontaneous pneumothoraxes successfully treated in non-intubated VATS manner [12]. Qingdong Cao published a study of 18 patients with bilateral spontaneous pneumothoraxes successfully treated in non-intubated subxiphoid VATS (SVATS) manner [13]. In our study we operated 2 patients in NIVATS group simultaneously.

NIVATS technique predispose to development of hypercapnia and hypoxemia as during OLV. Preserving hemidiaphragm contraction during NIVATS eliminates ventilation and perfusion mismatch in compare to intubated surgery with neuromuscular blockade [14].

“Permissive hypercapnia” which take place in NIVATS can be allowed as it’s well tolerated and is eliminated after lung expansion at the end of surgery. We react on the level of $PaCO_2$ more than 70 mm Hg with forced ventilation via a facemask for a short period of time [14, 15].

Minimally invasive surgical technique during NIVATS is shown to reduce stress hormones and pro-inflammatory mediators in more level than during surgeries with mechanical ventilation [16].

Such regional anesthetic techniques as paravertebral block, TEA, erector spine block ensure superior ventilation, preferable hemodynamic stability, reduced thrombotic complications and improve respiratory function in postoperative period are indispensable in non-intubated patients [17]. The predicted

risk of complications in TEA (unintentional high anesthetic block, epidural hematoma, injury of spinal cord) is estimated to be 0.07%. We used TEA for all patients in NIVATS group and it was the main tool for relieving postoperative pain, especially in patients with prolonged air leak.

There are patient exclusion criteria in NIVATS [15].

Conversion to intubated general anesthesia.

Sometimes, intraoperative conversion to general anesthesia is inevitable and the surgical team must have a plan to minimize the risk to the patient. The overall conversion rate of NIVATS to general intubate anesthesia varies from <1% to 9% based on data provided from 15 centers in which more than 1,400 patients participated. [18] Situations requiring conversion included operations related to the operation itself, such as excessive adhesions (0.69%), bleeding (0.34%), poor lung collapse [19, 20, 21] And anesthetic problems, in which surgical intervention would be at increased risk of complications, such as mediastinal displacement (0.34%), hypoxemia (0.27%), non-suppressive cough (<0.1%), hypercapnia (<0.1%), inadequate control of pain [22]. In our study we didn't have a conversion to general anesthesia.

Studies by Noda and colleagues and Mineo also showed the clinical benefits of awake thoracoscopic surgery in patients with SSP, including a lower incidence of postoperative respiratory complications and reduced expression of stress hormones and systemic inflammatory markers [23]. Avoidance of neuromuscular blockade, which prevents atelectasis in the nonoperated dependent lung and lowers the risk of hypoxia and ventilator dependency, is another important consideration in nonintubated surgery. It maintains FRC and preserves the compliance of the dependent lung, thus maintaining adequate perfusion and preventing a V/Q mismatch. All of these effects are vital for patients with SSP. In such patients, the risk of hypoxemia and hypercapnia is also lower with non-intubated anesthesia than with intubated general anesthesia [24].

A minimally invasive approach was proved to be superior in shortening the in-hospital stay, relieving pain in postoperative period, improving lung function postoperatively and reducing overall morbidities after surgery.

CONCLUSIONS

1. Patients with primary spontaneous pneumothorax can be treated in non-intubated video-assisted thoracic surgery technique at the 1st episode of pneumothorax to reduce the recurrence rate (54.6% of patients were treated surgically after recurrence of pneumothorax).
2. Recurrence rate after video-assisted thoracoscopic surgery and non-intubated video-assisted thoracic surgery technique is the same 4%
3. Non-intubated video-assisted thoracic surgery technique can be a part of enhanced recovery after surgery in thoracic surgery in the treatment of primary spontaneous pneumothorax: doesn't have complications of intubated anesthesia (sore throat in 44% and nausea and vomiting in 14.6% in video-assisted thoracoscopic surgery group patients), early mobilization (2 hours after surgery),
4. The non-intubated procedures can be a part of Enhanced Recovery After Surgery pathway. They try to minimize the adverse effects of tracheal intubation and general anesthesia, reducing the incidence of perioperative complications leads to faster postoperative recovery, so patients can soon return to daily activities, increasing patient satisfaction with the treatment.

Contributors:

Tkalich V.V. – conceptualization, methodology, investigation, writing – review & editing, visualization;

Nedilia Yu.V. – methodology, investigation;

Borysova V.I. – conceptualization, writing – review & editing;

Galiiev O.V. – conceptualization, methodology;

Savoliuk S.I. – methodology, project administration.

Funding. This research received no external funding.

Conflict of interests. The authors declare no conflict of interest.

REFERENCES

1. McCarthy C, Gupta N, Johnson SR, Yu JJ, McCormack FX. Lymphangioleiomyomatosis: pathogenesis, clinical features, diagnosis, and management. Lancet Respir Med. 2021 Nov;9(11):1313-27. doi: https://doi.org/10.1016/S2213-2600(21)00228-9

2. Dos Santos VM, Dos Santos LAM. Catamenial pneumothorax: a rare condition. An Sist Sanit Navar. 2024 May 27;47(2):e1076. doi: https://doi.org/10.23938/ASSN.1076

3. Huan NC, Sidhu C, Thomas R. Pneumothorax: Classification and Etiology. Clin Chest Med. 2021 Dec;42(4):711-27. doi: https://doi.org/10.1016/j.ccm.2021.08.007

4. Chen PH, Hung WT, Chen JS. Nonintubated Video – Assisted Thoracic Surgery for the Management of Primary and Secondary Spontaneous Pneumothorax. Thorac Surg Clin. 2020 Feb;30(1):15-24. doi: https://doi.org/10.1016/j.thorsurg.2019.08.001

5. Shigenobu T, Ohtsuka T, Yoshizu A. Risk factors for the recurrence of primary spontaneous pneumothorax after video-assisted thoracoscopic surgery in patients younger than 40 years. J Thorac Dis. 2023 Jul 31;15(7):3783-90. doi: https://doi.org/10.21037/jtd-23-257

6. Opanasenko MS, Tereshkovych OV, Shalahai SM, Konik BM, Shestakova D, Kalenychenko MI, et al. [Application of video-assisted lung volume reduction operations in bullous emphysema of the lungs in clinical practice]. Asthma and allergy. 2023;3:58-64. Ukrainian. doi: https://doi.org/10.31655/2307-3373-2023-3-58-64

7. Boiko VV, Haft KL, Nakonechnyi YeV, Shylina MV. [Videotracoscopic interference with bullous emphysema complicated by spontaneous pneumothorax]. Kharkiv Surgical School. 2019;3-4(96-97):59-63. Ukrainian. doi: https://doi.org/10.37699/2308-7005.3-4.2019.11

8. Kutluk AC, Kocaturk CI, Akin H, Erdogan S, Bilen S, Karapinar K, et al. Which is the best minimal invasive approach for the treatment of spontaneous pneumothorax? Uniport, two, or three ports: a prospective randomized trial. Thorac Cardiovasc Surg. 2018;66:589-94. doi: https://doi.org/10.1055/s-0038-1629909

9. Pathak S, Caruana E, Chowdhry F. Should surgical treatment of catamenial pneumothorax include diaphragmatic repair? Interact Cardiovasc Thorac Surg. 2019 Dec 1;29(6):906-10. doi: https://doi.org/10.1093/icvts/ivz205

10. Sesma J, Álvarez M, Gálvez , Bolufer S, Lirio F, Mafé JJ, et al. Non-intubated VATS for the management in primary spontaneous pneumothorax. Video-assist Thorac Surg. 2019;4:23. doi: https://doi.org/10.21037/vats.2019.09.02

11. Hwang J, Seung Shin JS, Son JH, Min TJ. Non-intubated thoracoscopic bullectomy under sedation is safe and comfortable in the perioperative period. J Thorac Dis. 2018;10(3):1703-10. doi: https://doi.org/10.21037/jtd.2018.02.10

12. Guo Z, Yin W, Zhang X, Xu X, Liu H, Shao W, et al. Primary spontaneous pneumothorax: simultaneous treatment by bilateral non-intubated videothoracoscopy. Interactive CardioVascular and Thoracic Surgery. 2016;1:6. doi: https://doi.org/10.1093/icvts/ivw123

13. Li X, Wang X, Zhang H, Cheng H, Cao Q. Unilateral single-port thoracoscopic surgery for bilateral pneumothorax or pulmonary bullae. Journal of Cardiothoracic Surgery. 2019;14:71. doi: https://doi.org/10.1186/s13019-019-0894-y

14. Koh LY, Hwang NC. Anesthesia for Nonintubated Video-Assisted Thoracoscopic Surgery. J Cardiothorac Vasc Anesth. 2023 Jul;37(7):1275-83. doi: https://doi.org/10.1053/j.jvca.2023.02.048

15. Gonzalez-Rivas D, Bonome C, Fieira E, Aymerich H, Fernandez R, Delgado M, et al. Non-intubated video-assisted thoracoscopic lung resections: the future of thoracic surgery? European Journal of Cardio-Thoracic Surgery. 2016;49:721-31. doi: https://doi.org/10.1093/ejcts/ezv136

16. Lantos J, Németh T, Barta Z, Szabó Z, Paróczai D, Varga E, et al. Pathophysiological Advantages of Spontaneous Ventilation. Front Surg. 2022 Mar 14:9:822560. doi: https://doi.org/10.3389/fsurg.2022.822560

17. Chen X. Efficacy of intraoperative thoracoscopic intercostal nerve blocks in nonintubated and intubated video-assisted thoracic surgery. J Formos Med Assoc. 2024 Aug;123(8):920. doi: https://doi.org/10.1016/j.jfma.2024.01.008

18. Chiang X-H, Lin M-W. Converting to Intubation During Non-intubated Thoracic Surgery: Incidence, Indication, Technique, and Prevention. Front Surg. 2021 Oct 26:8:769850. doi: https://doi.org/10.3389/fsurg.2021.769850

19. Fabo C, Oszlanyi A, Lantos J, Rarosi F, Horvath T, Barta Z, et al. Non-intubated Thoracoscopic Surgery-Tips and Tricks From Anesthesiological Aspects: A Mini Review. Front Surg. 2022 Feb 11;8:818456. doi: https://doi.org/10.3389/fsurg.2021.818456

20. Liu J, Cui F, Li S, Chen H, Shao W, Liang L, et al. Nonintubated video-assisted thoracoscopic surgery under epidural anesthesia compared with conventional anesthetic option: a randomized control study. Surg Innov. 2015;22:123-30. doi: https://doi.org/10.1177/1553350614531662

21. Anile M, Vannucci J, Ferrante F, Bruno K, De Paolo D, Bassi M, et al. Non-Intubated Thoracic Surgery: Standpoints and Perspectives. Front Surg. 2022 Jul 01:9:937633. doi: https://doi.org/10.3389/fsurg.2022.937633

22. Yanik F. Current overview of awake, non-intubated, video-assisted thoracic surgery. Wideochir Inne Tech Maloinwazyjne. 2023 Sep;18(3):445-52. doi: https://doi.org/10.5114/wiitm.2023.128070

23. Elkhouly AG, Karamustafaoglu YA, Galvez C, Rao M, Lerut P, Grimonprez A, et al. Nonintubated versus intubated thoracoscopic bullectomy for primary spontaneous pneumothorax: A multicenter propensity-matched analysis. Asian Cardiovasc Thorac Ann. 2022 Nov;30(9):1010-6. doi: https://doi.org/10.1177/02184923221129239

24. Kiss G. Technical Issues and Patient Safety in Nonintubated Thoracic Anesthesia. Thorac Surg Clin. 2020;30(1):1-13. doi: https://doi.org/10.1016/j.thorsurg.2019.09.001

Стаття надійшла до редакції 30.07.2024;
затверджена до публікації 20.11.2024