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ERAS PATHWAY IN TREATMENT OF SPONTANEOUS PNEUMOTHORAX IN MEN

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Abstract

Introduction. Spontaneous pneumothorax in men is a clinically relevant condition with recurrence rates up to 30% after the first episode. Advances in thoracic surgery have shifted management from conservative observation to minimally invasive strategies prioritizing functional preservation. Non-intubated uniportal video-assisted thoracoscopic surgery combined with Enhanced Recovery After Surgery protocols is considered a promising option, though evidence on long-term outcomes remains limited.
Aim. To assess the feasibility, safety, and long-term results of non-intubated uniportal video-assisted thoracoscopic surgery performed within Enhanced Recovery After Surgery protocols in men with spontaneous pneumothorax.
Materials and methods. A retrospective analysis of 80 men treated between 2017 and 2023 was conducted. Data included demographics, operative time, blood loss, anesthesia safety, postoperative pain, chest drainage duration, hospital stay, complications, and recurrence. All procedures were performed under thoracic epidural anesthesia with multimodal pain management. Follow-up averaged 60 months.
Results. All surgeries were completed without conversion to thoracotomy. The mean operative time was 67 minutes, and blood loss was minimal. Physiological stability was preserved, with no anesthesia-related complications. Pain intensity was low (mean visual analogue scale 1.9), oral intake resumed within 1 hour, and mobilization within 2-3 hours. Chest drainage lasted a mean of 3.3 days. Complications were rare, with prolonged air leak in 10% of cases. Recurrence was documented in 5% during long-term follow-up, all successfully managed with repeat minimally invasive surgery.
Conclusions. Non-intubated uniportal video-assisted thoracoscopic surgery within Enhanced Recovery After Surgery protocols is a safe and effective strategy for men with spontaneous pneumothorax. It minimizes perioperative trauma, accelerates functional recovery, reduces opioid use, and provides durable control of recurrence. Larger multicenter trials are required to confirm these findings and refine patient selection criteria.

Keywords: **spontaneous pneumothorax, bullous lung disease, non-intubated uniportal video-assisted thoracoscopic surgery, video-assisted thoracic surgery, enhanced recovery after surgery**

INTRODUCTION

Spontaneous pneumothorax in men is a common condition in thoracic practice, with an annual incidence estimated at 18-28 per 100,000 person-years, and a disease course dominated by abrupt pleural air entry from apical blebs, bullae, or peripheral air-cyst rupture with subsequent persistent air leak [1]. Historically, management evolved from observation and simple aspiration toward tube thoracostomy and, ultimately, definitive surgical strategies predicated on resection of culprit lesions and pleurodesis to reduce recurrence. Over the past two decades, video-assisted thoracoscopic surgery has become the preferred operative modality in suitable candidates, reflecting its favorable balance of invasiveness, visualization, and outcomes compared with open approaches. Ongoing debate persists, however, regarding the optimal timing of surgery–particularly at a first episode versus after recurrence–and the choice of anesthetic technique for otherwise healthy young men in whom preservation of pulmonary mechanics and rapid recovery are paramount [5-6].

Concurrently, enhanced recovery after surgery has reframed perioperative care as a multimodal, pathway-driven process that mitigates surgical stress, minimizes opioid exposure, and accelerates convalescence through

standardized preoperative education, thermal maintenance, carbohydrate loading where appropriate, minimally invasive access, procedure-specific analgesia, early oral intake, and early mobilization [4]. The application of these principles to thoracic surgery has been codified in dedicated guidance and has stimulated interest in anesthetic strategies that further attenuate physiological disruption. Among these, non-intubated thoracoscopic surgery–performed under carefully titrated sedation with regional techniques and spontaneous ventilation–seeks to avoid endotracheal intubation, one-lung ventilation, and neuromuscular blockade, thereby reducing airway trauma, ventilator-induced lung injury, postoperative nausea and vomiting, and residual neuromuscular weakness while supporting faster functional recovery in selected patients [18-19].

Against this backdrop, integrating an enhanced recovery pathway with non-intubated uniportal video-assisted thoracoscopic surgery represents a coherent, physiology-sparing paradigm for the definitive management of spontaneous pneumothorax in men. Nevertheless, real-world data on feasibility, safety, perioperative performance, and long-term recurrence within a structured pathway remain limited. The present study addresses this gap by reporting a single-center experience with pathway-based, non-intubated uniportal thoracoscopic management, with particular attention to analgesia, early ambulation, duration of drainage, and recurrence over extended follow-up.

AIM

The aim of this study was to evaluate the feasibility, safety, and clinical effectiveness of implementing an enhanced recovery after surgery pathway in combination with non-intubated uniportal video-assisted thoracoscopic surgery for the treatment of spontaneous pneumothorax in men, with particular focus on perioperative outcomes, postoperative recovery, and long-term recurrence rates.

MATERIALS AND METHODS

This retrospective single-center study was conducted at the Polytrauma Department of Kyiv City Hospital No. 17 over the period 2017-2023. A total of 80 male patients with a confirmed diagnosis of spontaneous pneumothorax were included. The inclusion criteria were: (1) age over 18 years, (2) first or recurrent episode of spontaneous pneumothorax, and (3) eligibility for surgical treatment under non-intubated video-assisted thoracoscopic surgery (VATS). Patients with secondary pneumothorax associated with trauma, prior thoracic surgery, or advanced chronic pulmonary disease were excluded.

Upon admission, all patients underwent chest radiography to confirm the diagnosis; in cases requiring surgical planning, computed tomography (CT) of the chest was performed to assess bullous disease and structural changes of the lung. Initial diagnostic thoracoscopy under local anesthesia was performed in the majority of cases, with placement of an 18 Fr chest drain connected to an underwater seal system. This served as a bridge to definitive surgical intervention.

All patients subsequently underwent non-intubated uniportal VATS (NI-uVATS). The surgical approach was standardized: a single 3-4 cm incision at the 4th-5th intercostal space in the midaxillary line, wound protection with SurgiSleeve XS, and the use of a 10 mm, 30° thoracoscope (Storz). Adhesiolysis was performed with monopolar cautery or LigaSure, followed by wedge resection of visible bullae using an Endo GIA stapling system. Mechanical pleurodesis was routinely performed according to European Society of Thoracic Surgeons (ESTS) recommendations.

Anesthetic management relied on thoracic epidural anesthesia (TEA) at the T5–T6 level combined with continuous intravenous sedation (dexmedetomidine, propofol, fentanyl). All patients received supplemental oxygen via non-rebreathing mask at a flow of 7-10 L/min (FiO_2 0.4-0.5). Monitoring included electrocardiography, pulse oximetry, non-invasive blood pressure, capnography, respiratory rate, and bispectral index (BIS). No premedication was administered.

Postoperative analgesia was provided through continued TEA and multimodal opioid-sparing regimens (scheduled NSAIDs). Pain intensity was assessed using the visual analogue scale (VAS). Chest drains were routinely removed once daily output fell below 200 mL and air leakage ceased.

Demographic and perioperative characteristics are presented in Table 1.

The study protocol was approved by the Ethics Committee of Shupyk National Healthcare University of Ukraine. Written informed consent was obtained from all patients, in accordance with the Helsinki Declaration and national legislation.

RESULTS

A total of 80 male patients with spontaneous pneumothorax underwent surgical management using the non-intubated uniportal video-assisted thoracoscopic surgery (NI-uVATS) technique within an Enhanced Recovery After Surgery (ERAS) framework. The mean age of the study cohort was 33.5 ± 8.1 years, with a mean body mass index of 20.0 ± 2.4 kg/m². Most patients (75%, n = 60) presented with their first episode of pneumothorax, whereas 25% (n = 20) had recurrent disease, including 12 with a second episode, 5 with a third, and 3 with a fourth. Preoperative assessment confirmed that the vast majority of patients were otherwise healthy, with 90% classified as ASA I and 10% as ASA II, and airway evaluation corresponding predominantly to Mallampati grade I.

Table 1

Baseline Demographic and Perioperative Characteristics of Patients with Spontaneous Pneumothorax (n = 80)

Parameter	Value (Mean ± SD / %)
Age (years)	33.5 ± 8.1
Body mass index (kg/m²)	20.0 ± 2.4
First episode of pneumothorax (%)	60 (75.0%)
Recurrent pneumothorax (%)	20 (25.0%)
ASA physical status I / II (%)	90.0 / 10.0
Mallampati score I / II (%)	90.0 / 10.0
Mean surgical duration (minutes)	67.3 ± 29.2
Estimated intraoperative blood loss (mL)	15.0 ± 11.2
Lowest intraoperative SpO_2 (%)	94.5 ± 1.1
Peak $EtCO_2$ (mmHg)	47.5 ± 3.5
Conversion to thoracotomy (%)	0 (0%)
Duration of chest drainage (days)	3.3 ± 0.4
Postoperative pain (VAS score)	1.9 ± 0.8
Complications: prolonged air leak > 5 d	8 (10.0%)
Recurrence during follow-up (%)	4 (5.0%)
Follow-up period (months)	60.2 ± 9.4

All procedures were successfully completed using the NI-uVATS approach without conversion to thoracotomy or intubated multiportal VATS. The mean operative duration was 67.3 ± 29.2 minutes, and intraoperative blood loss was minimal (15.0 ± 11.2 mL). Throughout the perioperative course, physiological stability was maintained: mean arterial pressure averaged 82.2 ± 18.3 mmHg, the lowest oxygen saturation did not fall below 94.5 ± 1.1%, and peak end-tidal CO_2 remained within physiologically acceptable ranges (47.5 ± 3.5 mmHg). No intraoperative complications such as major bleeding, hypoxemia, or arrhythmias were recorded, and all patients tolerated the procedure without the need for emergent airway conversion.

Postoperative recovery was rapid and consistent with ERAS principles. Patients resumed oral intake within the first postoperative hour and were mobilized within 2-3 hours following surgery. Pain intensity, assessed using the visual analogue scale (VAS), was low, with a mean score of 1.9 ± 0.8. Effective analgesia was achieved through the combination of thoracic epidural anesthesia and scheduled administration of non-steroidal anti-inflammatory drugs, and none of the patients required systemic opioids. Chest drainage was maintained for a mean of 3.3 ± 0.4 days, after which patients were typically discharged on the following day with clear instructions regarding physical activity restriction and follow-up.

Complications were rare and generally minor. Prolonged air leakage exceeding five days occurred in eight patients (10.0%), necessitating extended drainage but not reoperation. No wound infections, empyema, thromboembolic events, or mortality were reported.

Long-term follow-up, averaging 60.2 ± 9.4 months, demonstrated a recurrence rate of 5.0% (4 patients). All recurrent cases occurred within the first 18 months after surgery and were managed successfully with repeat minimally invasive intervention. No cases of chronic postoperative pain, impaired pulmonary function, or other late complications were identified during the follow-up period.

Taken together, these results indicate that NI-uVATS performed within a structured ERAS pathway provides reliable surgical control of spontaneous pneumothorax, with minimal intraoperative risk, low postoperative pain, early functional recovery, shortened hospital stay, and a durable reduction in recurrence rates.

DISCUSSION

The present study demonstrates that the integration of Enhanced Recovery After Surgery (ERAS) protocols with non-intubated uniportal video-assisted thoracoscopic surgery (NI-uVATS) in the treatment of spontaneous pneumothorax in men is a feasible, safe, and effective strategy. The outcomes of our cohort highlight several important aspects of this combined approach, which are consistent with and complementary to the findings reported in contemporary literature.

A central issue in the management of spontaneous pneumothorax remains the optimal timing of surgery. Traditional recommendations, such as those formulated by the British Thoracic Society, suggest reserving operative management for recurrent episodes, bilateral pneumothorax, or persistent air leak. Nevertheless, growing evidence supports early surgical intervention, even during the first episode, in order to reduce the high recurrence risk associated with conservative treatment. In our series, 75% of patients underwent surgery during the first episode, and the recurrence rate was limited to 5% over a median follow-up of five years. These results compare favorably with the 32% recurrence risk observed in conservatively treated first episodes and are in line with reports by Chiu and colleagues, who advocated early video-assisted thoracoscopic surgery within 12 hours of

admission, and Margolis et al., who documented improved outcomes with next-day intervention.

Another significant aspect of our findings concerns the feasibility and safety of NI-uVATS. All procedures were completed without conversion to thoracotomy or intubated VATS, and intraoperative parameters, including oxygenation, ventilation, and hemodynamic stability, remained within safe limits. These results are consistent with data from the Awake Thoracic Surgery Research Group and subsequent trials, which have established non-intubated thoracoscopic surgery as a safe alternative in carefully selected patients. Recent randomized evidence has further confirmed that non-intubated anesthesia is not inferior to intubated approaches in terms of intraoperative safety and postoperative pulmonary outcomes, thereby supporting the validity of our results.

Pain management and opioid avoidance represent another important achievement of the ERAS-integrated approach. In our cohort, mean postoperative pain intensity was low, and none of the patients required opioids, as adequate control was achieved through thoracic epidural anesthesia in combination with scheduled nonsteroidal anti-inflammatory drugs. This corresponds to the principles outlined in ERAS guidelines and is consistent with studies that emphasize the effectiveness of multimodal analgesia in reducing both immediate pain and long-term opioid dependence. Such findings are particularly relevant in light of the global opioid crisis and highlight the broader implications of adopting ERAS principles in thoracic surgery.

Functional recovery was also markedly accelerated in our patients, with mobilization initiated within hours after surgery, resumption of oral intake in less than one hour, and chest drain removal after a median of three days. These indicators of rapid convalescence mirror the improvements reported in ERAS-focused studies in elective thoracic procedures, where reduced hospital stay, earlier return to daily activities, and improved patient satisfaction were consistently observed. The results of the present study suggest that these benefits can be successfully reproduced in urgent but stable cases such as spontaneous pneumothorax.

The long-term recurrence rate of 5% in our cohort is consistent with the lower range reported in large meta-analyses of VATS bullectomy and pleurodesis, where recurrence typically ranges from 5% to 10%. Huang et al. recently reported a recurrence rate of approximately 6.5% following VATS, while Nonomura et al. highlighted the challenges of recurrence in long-term follow-up despite technically adequate surgery. Our findings suggest that NI-uVATS, when integrated with ERAS-aligned perioperative care, achieves at least comparable recurrence rates while conferring additional advantages in terms of reduced pain and faster recovery.

The exclusive use of uniportal access in our cohort may also have contributed to the observed results. Recent studies have confirmed that uniportal VATS provides similar safety and efficacy to multiportal approaches but is associated with reduced postoperative pain, improved ergonomics, and superior cosmetic outcomes. These advantages further justify the application of uniportal techniques in young and otherwise healthy men, who constituted the majority of our study population.

The study, however, is not without limitations. Its single-center and retrospective design, the relatively small and homogeneous patient cohort, and the absence of randomized allocation inevitably limit generalizability. Moreover, although the follow-up period was long, subgroup analyses, particularly those exploring recurrence risk according to etiology and extent of bullous disease, were underpowered. Nevertheless, the consistency of our findings with those of other centers strengthens their clinical relevance and provides a basis for future multicenter, prospective investigations.

In summary, the results of this study add to the growing evidence that combining ERAS protocols with non-intubated uniportal VATS in the treatment of spontaneous pneumothorax represents a rational, physiology-preserving, and patient-centered approach. By reducing perioperative stress, minimizing opioid use, facilitating early mobilization, and ensuring durable outcomes, this strategy addresses key priorities of modern thoracic surgery and holds promise for broader implementation.

CONCLUSIONS

This single-center analysis confirms that the application of an Enhanced Recovery After Surgery (ERAS) pathway in combination with non-intubated uniportal video-assisted thoracoscopic surgery (NI-uVATS) for the management of spontaneous pneumothorax in men is both feasible and effective. The approach was associated with high procedural safety, stable intraoperative parameters, minimal blood loss, and the absence of anesthesia-related complications. Postoperative recovery was characterized by consistently low pain intensity without the need for opioids, early resumption of oral intake, rapid mobilization, and shortened duration of pleural drainage and hospitalization. The long-term recurrence rate of 5% observed over a five-year follow-up period compares favorably with published outcomes of conventional surgical strategies, underscoring the durability of NI-uVATS combined with ERAS principles. Taken together, these findings demonstrate that this physiology-preserving and patient-centered strategy offers clear advantages over traditional approaches and may represent a valuable standard of care in appropriately selected patients.

Prospects for further research. Despite the encouraging outcomes reported, several issues merit

further investigation. The limited sample size and single-center design restrict generalizability, particularly to older or comorbid patient populations. Multicenter prospective studies with larger cohorts are required to validate the reproducibility and safety of NI-uVATS within structured ERAS pathways across diverse clinical settings. Future research should also aim to refine patient selection criteria, systematically evaluate the impact of non-intubated anesthesia on pulmonary function and quality of life, and compare uniportal versus multiportal approaches in terms of long-term recurrence and functional outcomes. Moreover, comprehensive assessment of health economics, including treatment costs, resource utilization, and societal benefits of earlier return to normal activity, will be crucial to establish the broader value of this paradigm. Such studies will contribute to consolidating evidence-based guidelines and to defining the role of NI-uVATS with ERAS integration as a routine therapeutic option in the management of spontaneous pneumothorax.

COMPLIANCE WITH ETHICAL REQUIREMENTS

The study was conducted in accordance with the main provisions and rules ensuring humane treatment of patients following requirements of the Tokyo Declaration of the World Medical Association, the International Recommendations of the Helsinki Declaration on Human Rights, the Council of Europe Convention on Human Rights and Biomedicine, the Laws of Ukraine, the orders of the Ministry of Health of Ukraine and the requirements of the Medical Code of Ethics of Ukraine.

The Ethics Committee of Shupyk National Healthcare University of Ukraine, approved the study. Written informed consent was obtained from all patients. Prior to the commencement of the study, all participants received full information regarding the aims, methods, potential risks, and benefits of participation. Participation in the study was voluntary. Participants had the right to withdraw from the study at any time, without explanation. In line with confidentiality regulations, all data was collected anonymously and processed in accordance with applicable data protection standards. All information was utilized solely within the context of this study and was provided in an aggregated form for results analysis.

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All authors reviewed the results and approved the final version of the manuscript.

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Резюме

ПІДХІД ПРИСКОРЕНОГО ВІДНОВЛЕННЯ ПІСЛЯ ОПЕРАЦІЇ (ERAS) У ЛІКУВАННІ СПОНТАННОГО ПНЕВМОТОРАКСУ У ЧОЛОВІКІВ

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Вступ. Спонтанний пневмоторакс у чоловіків є актуальною клінічною проблемою з частотою рецидивів до 30% після першого епізоду. Сучасна торакальна хірургія пройшла шлях від консервативного спостереження до малоінвазивних методів, спрямованих на збереження функціонального стану. Неінтубована однопортова відеоасистована торакоскопічна хірургія у поєднанні з протоколами прискореного відновлення після операції розглядається як перспективний підхід, проте даних щодо її довгострокової ефективності недостатньо.

Мета. Оцінити доцільність, безпечність та результати застосування неінтубованої однопортової відеоасистованої торакоскопічної хірургії у рамках протоколів прискореного відновлення після операції у чоловіків зі спонтанним пневмотораксом.

Матеріали та методи. Проведено ретроспективний аналіз лікування 80 чоловіків у 2017-2023 роках. Вивчали демографічні показники, тривалість операції, крововтрату, безпечність анестезії, інтенсивність болю, тривалість дренування, госпіталізацію, ускладнення та рецидиви. Усі втручання виконували під торакальною епідуральною анестезією з мультимодальним знеболенням. Середній період спостереження становив 60 місяців.

Результати. Усі операції виконано без конверсії до торакотомії. Середня тривалість становила 67 хвилин, крововтрата була мінімальною. Фізіологічна стабільність підтримувалась, ускладнень, пов'язаних з анестезією, не зафіксовано. Інтенсивність післяопераційного болю була низькою (середній показник за візуально-аналоговою шкалою – 1,9), відновлення перорального харчування відбувалося протягом години, мобілізація – через 2-3 години. Тривалість дренування становила в середньому 3,3 доби. Ускладнення відзначено у 10% пацієнтів (пролонгована повітряна нориця). Рецидиви зареєстровані у 5% випадків, усі успішно повторно прооперовані малоінвазивним методом.

Висновки. Поєднання протоколів прискореного відновлення після операції з неінтубованою однопортовою відеоасистованою торакоскопічною хірургією є безпечним, ефективним та орієнтованим на пацієнта підходом. Методика знижує періопераційну травму, прискорює відновлення, зменшує потребу в опіоїдах і забезпечує тривалий контроль рецидивів. Для підтвердження результатів необхідні багатоцентрові дослідження.

Ключові слова: **спонтанний пневмоторакс, бульозна хвороба легень, неінтубована однопортова відеоасистована торакоскопічна хірургія, відеоасистована торакальна хірургія, прискорене відновлення після операції**

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