Журнал «Перспективи та інновації науки»
(Серія «Педагогіка», Серія «Психологія», Серія «Медицина»)
№ 10(56) 2025

UDC 616.24-002.2-089

https://doi.org/10.52058/2786-4952-2025-10(56)-2301-2309

Shevchuk Yuriy Hryhorovych Doctor of Medical Sciences, Professor of the Department of Operative Surgery and Clinical Anatomy, National Pirogov Memorial Medical University, Vinnytsia, https://orcid.org/0000-0002-1069-9287

Mitiuk Bohdan Oleksiyovych PhD, assistant of the Department of Surgery and Urology, National Pirogov Memorial Medical University, Vinnytsia, https://orcid.org/0000-0002-6115-1932

MODERN APPROACHES TO THE TREATMENT OF PNEUMOTHORAX

Abstract. Pneumothorax is a serious pathological condition accompanied by a violation of negative pressure in the pleural cavity, which leads to partial or complete collapse of the lung. The relevance of this problem is due to the high risk of developing acute respiratory failure, especially in cases of tension pneumothorax or in the presence of concomitant lung lesions. With an increase in the number of invasive procedures and the frequency of recurrence of pneumothorax in young patients, there is a need to improve treatment approaches. The purpose of the study is to analyze modern literary sources on methods of surgical treatment of various forms of pneumothorax. Materials and methods - a review of scientific publications by keywords in the Scopus, PubMed and Google Scholar databases, which do not exceed a 10-year publication period, was carried out. Results. Modern guidelines emphasize the obsolescence of protocols, which do not sufficiently take into account the possibilities of video-assisted thoracoscopy (VATS), outpatient drainage and selective pleurodesis. The study by Brown et al. showed that in uncomplicated primary spontaneous pneumothorax, conservative treatment is effective, with complete lung expansion in 94% of patients. In catamenial pneumothorax, the best results are obtained with VATS combined with hormonal therapy, while no correction leads to recurrence in 50% of cases. VATS with bullectomy and pleurodesis (mechanical or chemical) results in recurrence in only 5.3% of cases, compared with >30% after drainage alone. In 86% of young patients without comorbidities, simple observation was sufficient for recovery without drainage. In cases of secondary pneumothorax, especially in COPD, surgery is associated with longer recovery and higher risks, but remains necessary for recurrent episodes. In elderly patients, VATS has also been shown to be safer than thoracotomy with proper preoperative evaluation. Newer approaches include outpatient techniques (Heimlich maneuver drainage) that avoid hospitalization, as well as adapted strategies for pregnant women with multidisciplinary involvement. Conclusions. Modern treatment of pneumothorax is based on risk stratification, taking into account the

clinical condition, type of lesion and individual characteristics of the patient. The trend towards a minimally invasive, evidence-based and patient-centered approach is confirmed by both research results and updated clinical guidelines.

Keywords: pneumothorax, pulmonary pathology, pleural cavity drainage, thoracic surgery, modern treatment methods.

Шевчук Юрій Григорович д.мед.н., професор кафедри оперативної хірургії та клінічної анатомії, Вінницький національний медичний університет ім. М. І. Пирогова, м. Вінниця, https://orcid.org/0000-0002-1069-9287.

Мітюк Богдан Олексійович PhD, асистент кафедри хірургії та урології, Вінницький національний медичний університет ім. М. І. Пирогова, м. Вінниця, https://orcid.org/0000-0002-6115-1932

СУЧАСНІ ПІДХОДИ ДО ЛІКУВАННЯ ПНЕВМОТОРАКСУ

Анотація. Пневмоторакс – це серйозний патологічний стан, що супроводжується порушенням негативного тиску в плевральній порожнині, що призводить до часткового або повного колапсу легені. Актуальність цієї проблеми зумовлена високим ризиком розвитку гострої дихальної недостатності, особливо у випадках напруженого пневмотораксу або за наявності супутніх уражень легень. Зі збільшенням кількості інвазивних процедур та частоти рецидивів пневмотораксу у молодих пацієнтів виникає потреба в удосконаленні підходів до лікування. Метою дослідження є аналіз сучасних літературних джерел щодо методів хірургічного лікування різних форм пневмотораксу. Матеріали та методи – проведено огляд наукових публікацій за ключовими словами в базах даних Scopus, PubMed та Google Scholar, які не перевищують 10-річного періоду публікацій. Результати. Сучасні рекомендації підкреслюють застарілість протоколів, які недостатньо враховують можливості відеоасистованої торакоскопії (ВАТС), амбулаторного дренування та селективного плевродезу. Дослідження Брауна та ін. показало, що при неускладненому первинному спонтанному пневмотораксі консервативне лікування є ефективним, з повним розширенням легень у 94% пацієнтів. При катаменіальному пневмотораксі найкращі результати отримують за допомогою ВАТС у поєднанні з гормональною терапією, тоді як відсутність корекції призводить до рецидиву у 50% випадків. ВАТС з булектомією та плевродезом (механічним або хімічним) призводить до рецидиву лише у 5,3% випадків, порівняно з >30% після лише дренування. У 86% молодих пацієнтів без супутніх захворювань простого спостереження було достатньо для одужання без дренування. У випадках вторинного пневмотораксу, особливо при ХОЗЛ, хірургічне втручання пов'язане з тривалішим одужанням та вищими ризиками, але залишається необхідним при рецидивуючих епізодах. У літніх пацієнтів ВАТС також виявилася безпечнішою,

Журнал «Перспективи та інновації науки»
(Серія «Педагогіка», Серія «Психологія», Серія «Медицина»)
№ 10(56) 2025

ніж торакотомія, за умови належної передопераційної оцінки. Новіші підходи включають амбулаторні методи (дренаж за маневром Геймліха), що дозволяють уникнути госпіталізації, а також адаптовані стратегії для вагітних жінок з участю різних спеціалістів. Висновки. Сучасне лікування пневмотораксу базується на стратифікації ризику з урахуванням клінічного стану, типу ураження та індивідуальних особливостей пацієнта. Тенденція до малоінвазивного, заснованого на доказах та орієнтованого на пацієнта підтверджена як результатами досліджень, так і оновленими клінічними рекомендаціями..

Ключові слова: пневмоторакс, легенева патологія, дренування плевральної порожнини, торакальна хірургія, сучасні методи лікування.

Statement of the problem. Pulmonary air leaks which occur while breathing can cause the lung to collapse, a condition known as pneumothorax (PTX), due to negative pressure being disrupted. Its clinical importance is because of its course towards respiratory failure within a short period of time, particularly with tension PTX or in the presence of concomitant lung lesions [1]. Spontaneous, traumatic and iatrogenic are the 3 primary categories of pneuomothorax. Spontaneous, in turn is categorixed to primary – when its appears in patients with normal anatomy of lungs and secondary – if there are abnormalities of the structure of lung [2]. The pathogenesis of pneumothorax is broad: it ranges from rupture of subpleural bullae that commonly causes primary spontaneous pneumothorax to traumatic chest injury or complication during invasive procedure, especially central venous catheterization, lung biopsy and mechanical ventilation [2]. Anatomic or physiological conditions, such as towering stature, slenderness and smoking were found to be associated with a significant predisposition of PSP, which is more pronounced in young male patients [3].

From an epidemiological standpoint, the incidence of primary spontaneous pneumothorax is 17-24 cases per 100,000 males and 1-6 cases per 100,000 females annually [4]. In Germany, for the period 2011-2015, a frequency of 8.7 cases per 100,000 inhabitants was found with a male predominance (more than 80% of all cases) [5]. In some other countries, like Iran approximately 70% of cases of pneumothorax have been reported to be primary spontaneous with the mean age around 30 years [6].

A 12-year national cohort study conducted in South Korea revealed an annual incidence of 14.6/100,000, and men were predisposed to spontaneous pneumothorax three times more than women [2]. The recurrence rate in this group of patients is up to 32% in the first year [7]. A British report covering a period of 48 years from 1968 to 2016 showed that the incidence was relatively constant and trending toward an increase in the past decade among inpatients, mainly elderly patients [8]. These overall epidemiological data are endorsed by UpToDate, which describes an escalating incidence of iatrogenic pneumothorax that can be ascribed to the growing number of invasive procedures in modern medicine [9].

Verified population-based studies, especially that of Denmark, have demonstrated a primary spontaneous pneumothorax incidence of 12.3 per 100,000

Журнал «Перспективи та інновації науки»
(Серія «Педагогіка», Серія «Психологія», Серія «Медицина»)
№ 10(56) 2025

individuals with the risk expected to be even higher in smokers and those with family history positivity [10, 11]. Therefore, pneumothorax is still a critical disease variety not only with its multifactorial characteristics and evident gender as well as age specificity but also requires better methods in clinical study and treatment.

The purpose of the article – to perform an analysis of literary sources relating to contemporary approaches to the surgical treatment of various types of pneumothorax.

Research objects and methods. An analysis of literary sources obtained by searching for keywords was performed. The scientometric databases Scopus, PubMed, and Google Academy were used to search for publications. The keywords used for the search included: pneumothorax, pulmonary pathology, pleural cavity drainage, thoracic surgery, modern treatment methods, types of pneumothorax. Only publications no older than 10 years were taken for review.

Presentation of the main material.

Research results and their discussion. The necessity for such guidelines to be revised within the current setting of thoracic surgery is discussed. Hallifax and Janssen stress that the updated guidelines are for the most part out of date and certain essential aspects of care do not reflect new technical possibilities as well clinical attitude. Especially the introduction of VATS, ambulant drainage and selective pleurodesis is not yet adequately implemented in protocols. According to the authors, taking into account the growing rate of outpatient case load and patient preference for minimally invasive treatment options it is increasingly important to stratify patients according to clinical risk and not just according to size of pneumothorax [12].

The study by Brown et al. at one of the largest in assessing conservative management. In a randomized controlled trial, it has been demonstrated that primary spontaneous pneumothorax patients with no respiratory failure do not need drainage. In the conservative group, lung expansion was complete in 94 per cent of patients and the recurrence rate of pneumothorax did not differ from that of the surgical group. This paves the way for a less aggressive strategy in young patients with uncomplicated infection [13].

The rare catamenial pneumothorax is an interesting and significant subgroup. In a systematic review, Gil and Tulandi have proved that the best outcomes are obtained with a combinatory approach of surgical treatment and hormonal therapy. Without correction of gynecological hormonal background, the frequency of relapses is 50%. VATS examination of the right-sided diaphragm in women of reproductive age is mandatory, as this is where holes as a result of endometriosis are most commonly found [14].

The optimal therapy for primary spontaneous pneumothorax is VATS with bullectomy and mechanical or chemical pleurodesis, as indicated by the meta-analysis of Muhetaer et al. After this 5.3% recurrence occurs versus a >30% rate after isolated drainage. Moreover, it has less postoperative complications and shorter hospital stay. This supports the advantages of minimally invasive surgery compared with conventional surgery [15].

Meanwhile the obser-vation and regular monitoring along with determination of patient complaints were effective in uncomplicated primary pneumotorax as well (Balta, Kuzucuoglu). 86% of patients in their study experienced full recovery without drainage. This is particularly crucial in young patients without comorbidities who want to evade hospitalisation or surgery. So still today, in some cases it is feasible to prevent invasive treatment [16].

Secondary spontaneous pneumothorax, however, has a different situation. Ichinose et al. demonstrated that the outcome of surgical management in comorbid lung disease (e.g., COPD) is less favorable. They have higher return rates and longer rehabilitation time after surgery. In these patients the balance of risk and benefit for surgery should be considered in a careful manner, not delay surgery if needed [17].

In the German S3-Guideline, therapy levels were differentiated by clinical entities of pneumothorax. Drainage should be considered in cases of hemodynamic instability, high volume collapse and recurrence. VATS is the procedure of choice for recurrent pneumothorax, bullous disease or tension variety. The authors also point out the superiority of mechanical pleurodesis compared with chemical pleurodesis in terms of durability [18].

The meta-analysis of Sudduth and coworkers affirms that the lowest recurrence rate (3–6%) is achieved by a combination with bullectomy but also mechanical abrasion or talc pleurodesis. In this situation, there is no increase in complication rate or length of hospital stay. Electrocoagulation alone, without pleuroplasty factored in, has higher recurrence rates. This implies the effectiveness of combining treatments even at a first line setting [19].

Igai et al. reviewed outcomes of VATS in elderly patients with secondary pneumothorax. Despite a relatively higher rate of complications with surgery in this group (up to 21%), the overall functional result of these patients is good following adequate preoperative planning. Respiratory function, comorbidities, and nutritional state need to be evaluated in the elderly. VATS is much better tolerated than thoracotomy in these situations [20].

Olesen et al., in a randomized trial, compared surgery and drainage to treat primary spontaneous pneumothorax. The recurrence rate after surgery was 8.1% and after drainage was 24.2%. Nevertheless, surgery was correlated with increases in LOS and costs suggesting the necessity of a tailored treatment decision [21].

In catamenial pneumothorax, Ichiki et al. advise that the diaphragm be inspected during VATS and, if any defect is found, to suture. Excision of pleural endometriosis nodules is also recommended. Without correction of these abnormalities, relapse is virtually inevitable within 1 year. These women need additional gynecological surveillance [22].

Pathak et al further note that if a diaphragmatic defect is identified, mesh repair or resection of the involved tissue may be indicated. Eighty-eight percent of women without repair suffered a recurrence. Consequently, most of us now believe that the diaphragmatic element in catamenial pneumothoraxes can no longer be overlooked. Complete eradication of it is crucial for the treatment [23].

Журнал «Перспективи та інновації науки»
(Серія «Педагогіка», Серія «Психологія», Серія «Медицина»)
№ 10(56) 2025

Novel pneumothorax therapy options by use of outpatient techniques. Harnedy et al. point to the safety of using small-boari type drainage catheters with a Heimlich valve in the mild cases. This enables patients to circumvent hospitalization and meanwhile manage the resorption of air. These types of technologies may have an important impact on the future treatment of primary pneumothoraces [24].

It is a delicate condition: pneumothorax during pregnancy. Agrafiotis et al. suggest that surgery should not be performed in the first trimester, but that VATS is a feasible option in the second and third trimesters if indicated. Patient management needs to be interdisciplinary – obstetricians, thoracic surgeons and anesthesiologists. Gestational protocols should also be adaptable, considering fetal safety [25].

At last, the recent French clinical recommendations SPLF/SFAR provide updated risk stratification of primary pneumothorax. They acknowledge the benefit of ambulatory drainage, discard systematic pleurodesis after initial episode and suggest VATS in case of recurrent pneumothorax. It is also mentioned that the indication for treatment has to be clinical stability and not only percentage of collapse. This suggests move toward the evidence-based and more patient-friendly approach in treatment of pneumothorax [26].

Conclusions. At present, pneumothorax management follows the paradigm of clinical risk stratification, rather than anatomical collapse volume. It has been demonstrated that conservative treatment is effective in primary spontaneous pneumothorax not accompanied with respiratory failure and that surgery is indicated for the recurrence form, secondary type or catamenial type. Video-assisted thoracoscopy (VATS) with bullectomy and pleurodesis is associated with the lowest recurrence rate, as well a short hospital stay and less complications. However, in other cases – pregnancy and young patients who have no related diseases – inpatient individualized approaches are suitable. In recent guidelines the trend to less aggressive, evidence-based and patient-centred pneumothorax therapy is reflected.

References

1. Imran, J. B., & Eastman, A. L. (2017). Pneumothorax. *Jama*, *318*(10), 974-974.

2. Huan, N. C., Sidhu, C., & Thomas, R. (2021). Pneumothorax: classification and etiology. *Clinics in chest medicine*, *42*(4), 711-727.

3. Bobbio, A., Dechartres, A., Bouam, S., Damotte, D., Rabbat, A., Régnard, J. F., ... & Alifano, M. (2015). Epidemiology of spontaneous pneumothorax: gender-related differences. *Thorax*, *70*(7), 653-658.

4. Mendogni, P., Vannucci, J., Ghisalberti, M., Anile, M., Aramini, B., Congedo, M. T., ... & Russo, E. (2020). Epidemiology and management of primary spontaneous pneumothorax: a systematic review. *Interactive cardiovascular and thoracic surgery*, *30*(3), 337-345.

5. Schnell, J., Koryllos, A., Lopez-Pastorini, A., Lefering, R., & Stoelben, E. (2017). Spontaneous pneumothorax: epidemiology and treatment in Germany between 2011 and 2015. *Deutsches Ärzteblatt International*, *114*(44), 739.

6. Aghajanzadeh, M., Asgary, M. R., Delshad, M. S. E., & Khotbehsora, M. H. (2018). Data on the epidemiology, diagnosis, and treatment of patients with pneumothorax. *Data in brief*, *20*, 1053.

7. Kim, D., Jung, B., Jang, B. H., Chung, S. H., Lee, Y. J., & Ha, I. H. (2019). Epidemiology and medical service use for spontaneous pneumothorax: a 12-year study using nationwide cohort data in Korea. *BMJ open*, *9*(10), e028624.

8. Hallifax, R. J., Goldacre, R., Landray, M. J., Rahman, N. M., & Goldacre, M. J. (2018). Trends in the incidence and recurrence of inpatient-treated spontaneous pneumothorax, 1968-2016. *Jama*, *320*(14), 1471-1480.

9. Lee, Y. G. (2024). Pneumothorax in adults: Epidemiology and etiology. *UpToDate [Internet]*, *23*, 261-275.

10. Hallifax, R. J., & Rahman, N. M. (2015). Epidemiology of pneumothorax–finally something solid out of thin air. *Thorax*, *70*(10), 921-922.

11. Olesen, W. H., Titlestad, I. L., Andersen, P. E., Lindahl-Jacobsen, R., & Licht, P. B. (2019). Incidence of primary spontaneous pneumothorax: a validated, register-based nationwide study. *ERJ open research*, *5*(2).

12. Hallifax, R., & Janssen, J. P. (2019, June). Pneumothorax—time for new guidelines?. In *Seminars in respiratory and critical care medicine* (Vol. 40, No. 03, pp. 314-322). Thieme Medical Publishers.

13. Brown, S. G., Ball, E. L., Perrin, K., Asha, S. E., Braithwaite, I., Egerton-Warburton, D., ... & Beasley, R. (2020). Conservative versus interventional treatment for spontaneous pneumothorax. *New England Journal of Medicine*, *382*(5), 405-415.

14. Gil, Y., & Tulandi, T. (2020). Diagnosis and treatment of catamenial pneumothorax: a systematic review. *Journal of minimally invasive gynecology*, *27*(1), 48-53.

15. Muhetaer, M., Paerhati, K., Sun, Q., Li, D., Zong, L., Zhang, H., & Zhang, L. (2022). Effects of different treatment regimens on primary spontaneous pneumothorax: a systematic review and network meta-analysis. *Annals of thoracic and cardiovascular surgery*, *28*(6), 389-402.

16. Balta, C., & Kuzucuoglu, M. (2020). Conservative treatment approach in primary spontaneous pneumothorax. *J Coll Physicians Surg Pak*, *30*(2), 168-171.

17. Ichinose, J., Nagayama, K., Hino, H., Nitadori, J. I., Anraku, M., Murakawa, T., & Nakajima, J. (2016). Results of surgical treatment for secondary spontaneous pneumothorax according to underlying diseases. *European Journal of Cardio-thoracic Surgery*, *49*(4), 1132-1136.

18. Schnell, J., Beer, M., Eggeling, S., Gesierich, W., Gottlieb, J., Herth, F., ... & Stoelben, E. (2018). Management of spontaneous pneumothorax and postinterventional pneumothorax: German S3-guideline. *Zentralblatt für Chirurgie-Zeitschrift für Allgemeine, Viszeral-, Thorax-und Gefäßchirurgie*, *143*(S 01), S12-S43.

19. Sudduth, C. L., Shinnick, J. K., Geng, Z., McCracken, C. E., Clifton, M. S., & Raval, M. V. (2017). Optimal surgical technique in spontaneous pneumothorax: a systematic review and meta-analysis. *Journal of Surgical Research*, *210*, 32-46.

20. Igai, H., Kamiyoshihara, M., Ibe, T., Kawatani, N., & Shimizu, K. (2016). Surgical treatment for elderly patients with secondary spontaneous pneumothorax. *General thoracic and cardiovascular surgery*, *64*(5), 267-272.

21. Olesen, W. H., Katballe, N., Sindby, J. E., Titlestad, I. L., Andersen, P. E., Lindahl-Jacobsen, R., & Licht, P. B. (2018). Surgical treatment versus conventional chest tube drainage in primary spontaneous pneumothorax: a randomized controlled trial. *European Journal of Cardio-Thoracic Surgery*, *54*(1), 113-121.

22. Ichiki, Y., Nagashima, A., Yasuda, M., Takenoyama, M., & Toyoshima, S. (2015). Surgical treatment of catamenial pneumothorax: Report of three cases. *Asian Journal of Surgery*, *38*(3), 180-185.

23. Pathak, S., Caruana, E., & Chowdhry, F. (2019). Should surgical treatment of catamenial pneumothorax include diaphragmatic repair?. *Interactive CardioVascular and Thoracic Surgery*, *29*(6), 906-910.

24. Harnedy, F., Foley, E., & Fitzgerald, D. B. (2025). New strategies in the management of pneumothorax. *Breathe*, *21*(3).

25. Agrafiotis, A. C., Assouad, J., Lardinois, I., & Markou, G. A. (2021). Pneumothorax and pregnancy: a systematic review of the current literature and proposal of treatment recommendations. *The Thoracic and Cardiovascular Surgeon*, *69*(01), 095-100.

26. Jouneau, S., Ricard, J. D., Seguin-Givelet, A., Bigé, N., Contou, D., Desmettre, T., ... & Martinez, M. (2023). SPLF/SMFU/SRLF/SFAR/SFCTCV Guidelines for the management of patients with primary spontaneous pneumothorax. *Annals of Intensive Care*, *13*(1), 88.

Література

1. Imran, J. B., & Eastman, A. L. (2017). Pneumothorax. *Jama*, *318*(10), 974-974.

2. Huan, N. C., Sidhu, C., & Thomas, R. (2021). Pneumothorax: classification and etiology. *Clinics in chest medicine*, *42*(4), 711-727.

3. Bobbio, A., Dechartres, A., Bouam, S., Damotte, D., Rabbat, A., Régnard, J. F., ... & Alifano, M. (2015). Epidemiology of spontaneous pneumothorax: gender-related differences. *Thorax*, *70*(7), 653-658.

4. Mendogni, P., Vannucci, J., Ghisalberti, M., Anile, M., Aramini, B., Congedo, M. T., ... & Russo, E. (2020). Epidemiology and management of primary spontaneous pneumothorax: a systematic review. *Interactive cardiovascular and thoracic surgery*, *30*(3), 337-345.

5. Schnell, J., Koryllos, A., Lopez-Pastorini, A., Lefering, R., & Stoelben, E. (2017). Spontaneous pneumothorax: epidemiology and treatment in Germany between 2011 and 2015. *Deutsches Ärzteblatt International*, *114*(44), 739.

6. Aghajanzadeh, M., Asgary, M. R., Delshad, M. S. E., & Khotbehsora, M. H. (2018). Data on the epidemiology, diagnosis, and treatment of patients with pneumothorax. *Data in brief*, *20*, 1053.

7. Kim, D., Jung, B., Jang, B. H., Chung, S. H., Lee, Y. J., & Ha, I. H. (2019). Epidemiology and medical service use for spontaneous pneumothorax: a 12-year study using nationwide cohort data in Korea. *BMJ open*, *9*(10), e028624.

8. Hallifax, R. J., Goldacre, R., Landray, M. J., Rahman, N. M., & Goldacre, M. J. (2018). Trends in the incidence and recurrence of inpatient-treated spontaneous pneumothorax, 1968-2016. *Jama*, *320*(14), 1471-1480.

9. Lee, Y. G. (2024). Pneumothorax in adults: Epidemiology and etiology. *UpToDate [Internet]*, *23*, 261-275.

10. Hallifax, R. J., & Rahman, N. M. (2015). Epidemiology of pneumothorax–finally something solid out of thin air. *Thorax*, *70*(10), 921-922.

11. Olesen, W. H., Titlestad, I. L., Andersen, P. E., Lindahl-Jacobsen, R., & Licht, P. B. (2019). Incidence of primary spontaneous pneumothorax: a validated, register-based nationwide study. *ERJ open research*, *5*(2).

12. Hallifax, R., & Janssen, J. P. (2019, June). Pneumothorax—time for new guidelines?. In *Seminars in respiratory and critical care medicine* (Vol. 40, No. 03, pp. 314-322). Thieme Medical Publishers.

13. Brown, S. G., Ball, E. L., Perrin, K., Asha, S. E., Braithwaite, I., Egerton-Warburton, D., ... & Beasley, R. (2020). Conservative versus interventional treatment for spontaneous pneumothorax. *New England Journal of Medicine*, *382*(5), 405-415.

14. Gil, Y., & Tulandi, T. (2020). Diagnosis and treatment of catamenial pneumothorax: a systematic review. *Journal of minimally invasive gynecology*, *27*(1), 48-53.

15. Muhetaer, M., Paerhati, K., Sun, Q., Li, D., Zong, L., Zhang, H., & Zhang, L. (2022). Effects of different treatment regimens on primary spontaneous pneumothorax: a systematic review and network meta-analysis. *Annals of thoracic and cardiovascular surgery*, *28*(6), 389-402.

16. Balta, C., & Kuzucuoglu, M. (2020). Conservative treatment approach in primary spontaneous pneumothorax. *J Coll Physicians Surg Pak*, *30*(2), 168-171.

17. Ichinose, J., Nagayama, K., Hino, H., Nitadori, J. I., Anraku, M., Murakawa, T., & Nakajima, J. (2016). Results of surgical treatment for secondary spontaneous pneumothorax according to underlying diseases. *European Journal of Cardio-thoracic Surgery*, *49*(4), 1132-1136.

18. Schnell, J., Beer, M., Eggeling, S., Gesierich, W., Gottlieb, J., Herth, F., ... & Stoelben, E. (2018). Management of spontaneous pneumothorax and postinterventional pneumothorax: German S3-guideline. *Zentralblatt für Chirurgie-Zeitschrift für Allgemeine, Viszeral-, Thorax-und Gefäßchirurgie*, *143*(S 01), S12-S43.

19. Sudduth, C. L., Shinnick, J. K., Geng, Z., McCracken, C. E., Clifton, M. S., & Raval, M. V. (2017). Optimal surgical technique in spontaneous pneumothorax: a systematic review and meta-analysis. *Journal of Surgical Research*, *210*, 32-46.

20. Igai, H., Kamiyoshihara, M., Ibe, T., Kawatani, N., & Shimizu, K. (2016). Surgical treatment for elderly patients with secondary spontaneous pneumothorax. *General thoracic and cardiovascular surgery*, *64*(5), 267-272.

21. Olesen, W. H., Katballe, N., Sindby, J. E., Titlestad, I. L., Andersen, P. E., Lindahl-Jacobsen, R., & Licht, P. B. (2018). Surgical treatment versus conventional chest tube drainage in primary spontaneous pneumothorax: a randomized controlled trial. *European Journal of Cardio-Thoracic Surgery*, *54*(1), 113-121.

22. Ichiki, Y., Nagashima, A., Yasuda, M., Takenoyama, M., & Toyoshima, S. (2015). Surgical treatment of catamenial pneumothorax: Report of three cases. *Asian Journal of Surgery*, *38*(3), 180-185.

23. Pathak, S., Caruana, E., & Chowdhry, F. (2019). Should surgical treatment of catamenial pneumothorax include diaphragmatic repair?. *Interactive CardioVascular and Thoracic Surgery*, *29*(6), 906-910.

24. Harnedy, F., Foley, E., & Fitzgerald, D. B. (2025). New strategies in the management of pneumothorax. *Breathe*, *21*(3).

25. Agrafiotis, A. C., Assouad, J., Lardinois, I., & Markou, G. A. (2021). Pneumothorax and pregnancy: a systematic review of the current literature and proposal of treatment recommendations. *The Thoracic and Cardiovascular Surgeon*, *69*(01), 095-100.

26. Jouneau, S., Ricard, J. D., Seguin-Givelet, A., Bigé, N., Contou, D., Desmettre, T., ... & Martinez, M. (2023). SPLF/SMFU/SRLF/SFAR/SFCTCV Guidelines for the management of patients with primary spontaneous pneumothorax. *Annals of Intensive Care*, *13*(1), 88.