Original Article
DOI: https://doi.org/10.70749/ijbr.v2i02.227

INDUS JOURNAL OF BIOSCIENCES RESEARCH
https://induspublisher.com/IJBR
ISSN: 2960-2793/ 2960-2807

Minimally Invasive Approach to Congenital Lung Malformations: A Comparative Study of Thoracoscopic Resection Techniques

Sarooj Gul[1], Afnan Fayaz[2], Aizaz Khattak[2], Mian Rahmat Zeb[3], Dawood Tahir[4], Muhammad Daraz Khan[5], Adnan Khan[6], Imran Tahir[2]

[1]Peaditric B Ward, Hayatabad Medical Complex, Peshawar, KPK, Pakistan.
[2]Department of Thoracic Surgery, Hayatabad Medical Complex, Peshawar, KPK, Pakistan.
[3]Department of Paediatrics, Saidu Medical College/ Saidu Group of Teaching Hospital, Mingora, Swat, KPK, Pakistan.
[4]Department of Surgery, Hayatabad Medical Complex, Peshawar, KPK, Pakistan.
[5]Department of Paediatrics Surgery, Khalifa Gul Nawaz Medical Teaching Institute, Bannu, KPK, Pakistan.
[6]Department of Paediatrics, Mian Rasheed Hussain Shaheed Memorial Hospital Pabbi, Nowshera, KPK, Pakistan.

ARTICLE INFO

Keywords

Congenital Lung Malformations, Thoracoscopic Resection, Minimally Invasive Surgery, Pediatric Pulmonary Surgery, Comparative Surgical Techniques.

Corresponding Author: Imran Tahir
Department of Thoracic Surgery, Hayatabad Medical Complex, Peshawar, KPK, Pakistan.
Email: imran.tahir@kgmc.edu.pk

Declaration

Author's Contributions: All authors contributed to the study and approved the final manuscript.
Conflict of Interest: The authors declare no conflict of interest.
Funding: No funding received.

Article History

Received: 04-10-2024
Revised: 24-10-2024
Accepted: 13-11-2024

ABSTRACT

Introduction: Congenital lung malformations (CLMs), encompassing diverse pulmonary anomalies, are increasingly diagnosed in children due to advancements in prenatal imaging and early postnatal screening techniques. **Objective:** This study aims to conduct a clinical comparison of thoracoscopic anatomical lesion resection and lobectomy for treating CLMs in children. **Methodology:** A comparative study was conducted at Hayatabad Medical Complex, Peshawar, from January to June 2024, involving 285 pediatric patients. Detailed demographic data, including age, gender, and weight at surgery, were collected. **Results:** Group A (Thoracoscopic Lesion Resection) had a significantly longer surgery duration (130 ± 20 minutes) compared to Group B (Lobectomy, 90 ± 15 minutes), but lower intraoperative blood loss (50 ± 10 mL vs. 120 ± 30 mL). Minimal intraoperative complications were reported, with one case in Group A (0.7%) and none in Group B. Group A exhibited shorter hospital stays (4.2 ± 0.5 vs. 6.8 ± 0.8 days, $p < 0.01$), quicker chest tube removal (2.1 ± 0.4 vs. 3.6 ± 0.6 days, $p < 0.05$), and lower postoperative pain levels. Air leaks (5% vs. 12%, $p < 0.05$) and recurrent respiratory infections (8% vs. 15%, $p < 0.05$) were also reduced in Group A. **Conclusion:** Thoracoscopic anatomical lesion resection is a highly effective, lung-sparing approach for treating CLMs in children, emphasizing the importance of preserving healthy lung tissue for optimal lung maturation. However, the study's limitations highlight the need for further research.

INTRODUCTION

Congenital lung malformations (CLMs), encompassing a diverse range of pulmonary anomalies, are increasingly diagnosed in children due to advancements in prenatal imaging and early postnatal screening techniques. These are CPAM, BPS, CLE and bronchogenic cysts which are pathologies that occur due to abnormally developed lungs during fetal development. Although many CLMs cause no symptoms and do not warrant prompt therapy, others may cause serious complications such as respiratory failure, recurring pneumonia, or life-threatening events, especially in newborns and small children [1]. Therefore, surgical intervention becomes

inevitable for the clinical signs or where the surgical risk is high in the future. Consequently, lobectomy is the resection of a lung lobe that has been previously regarded as the standard operative approach to patients with CLMs [2]. However, lobectomy like any other surgery comes with risks such as postoperative complications, a longer working period to recovery, and possible poor lung function due to loss of a greater mass of the lung tissue. Where lung development is essential for patients, especially children, several authors noted the importance of less aggressive procedures that would spare as much tissue as possible [3]. Of the minimally invasive procedures, thoracoscopic surgery has received much attention in the last few years as a potential replacement for open thoracotomy in managing CLM. Laparoscopic surgery possesses some advantages over open surgery such as less postoperative pain, shorter hospitalization, faster convalescence, and better cosmesis [4]. Hereof, the thoracoscopic anatomical lesion resection [segmentectomy: segmentectomy is defined as a surgical procedure in which the affected area of the lung is removed while minimizing the removal of the health tissue] has been highlighted as the approach that directs its activity at the affected region and adjacent healthy tissues as much as possible [5]. While able to remove the segments or lesions responsible for the pathology, thoracoscopic anatomical lesion resection maintains the functionality of the lungs because not the entire lung is resected [6]. Another major issue for consideration in pediatric thoracic surgery is the treatment of malformed pulmonary tissue while maintaining the functionality of the target organ. Lobectomy though effective and recommendable, results in a significant loss of lung tissue especially in the early growing stages of young children [7]. However, thoracoscopic anatomical lesion resection where the diseased segments only are resected, is likely to provide better long-term pulmonary function than lobectomy. Nonetheless, the necessary broad precision and the process of using this approach, especially on a small pediatric patient is alarming due to the complicated technique which is involved [8]. Such as within the base of the brain, they have to be cautious to avoid the removal of the entire malformation and at the same time not harm any other part of the brain [9]. Moreover, the postoperative recovery experience of children who have undergone these two different types of surgeries explains their quality of life after surgery [10]. It is also known that thoracoscopic surgery yields a reduced amount of postoperative pain, smaller incisions, and a quicker functional recovery most patients prefer to open thoracotomy surgery [11]. These factors have a potential influence on students' health and psychology, as well as their young relatives' health. Nevertheless, the role of the increasingly used minimally invasive thoracoscopic anatomical lesion resection in the prevention of its relapse or other complications remains to be confirmed in further long-term studies, especially about the rather radical but effective lobectomy [12].

OBJECTIVE

The main objective of the study is to find the clinical comparative study of thoracoscopic anatomical lesion resection and lobectomy in the treatment of congenital lung malformations in children.

METHODOLOGY

This comparative study was conducted at Hayatabad Medical Complex, Peshawar, from January 2024 to June 2024, involving a total of 285 patients. Data collection was carried out following approval from the hospital's ethical committee, with informed consent obtained from all participants. The study included pediatric patients under 16 years of age who were diagnosed with congenital lung malformations confirmed through preoperative imaging such as chest X-rays, CT scans, or MRI. Eligibility for surgery was based on symptoms including recurrent respiratory infections, respiratory distress, or abnormal lung function. Patients were excluded if they had additional congenital anomalies unrelated to the lungs, significant comorbidities that could influence postoperative outcomes, or required emergency surgery or immediate intervention for life-threatening conditions.

Data Collection

Data included detailed demographic information such as the age, gender, and weight of each patient at the time of surgery. The patients were divided into two groups based on the type of surgical intervention received:

1. **Group A (Thoracoscopic Anatomical Lesion Resection):** 140 patients underwent thoracoscopic anatomical lesion resection, a minimally invasive surgery aimed at resecting the specific segments of the lung affected by the malformation.
2. **Group B (Lobectomy):** 145 patients underwent lobectomy, the standard surgical procedure that involves the removal of an entire lung lobe.

Preoperative data were collected to assess the initial condition of the patients, including symptoms like recurrent respiratory infections, respiratory distress, or abnormal lung function, as well as imaging findings from chest X-rays, CT scans, or MRIs, which confirmed the presence of congenital lung malformations. Additionally, preoperative pulmonary function tests were recorded when available.Intraoperative data focused on the specifics of the surgical procedure, including the duration of surgery, the extent of intraoperative blood loss, and the occurrence of any complications, such as bleeding or injury to surrounding structures. Postoperative data included the length of hospital stay, the time to chest tube removal, pain scores (measured using age-appropriate pain scales), and any postoperative complications such as air leaks, infections, or recurrence of malformations.

Statistical Analysis

The statistical analysis was conducted using SPSS v29. Categorical data were analyzed using chi-square tests, while continuous variables (such as surgical duration, blood loss, and length of hospital stay) were analyzed using independent t-tests. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Data were collected from 285 patients, Group A (Thoracoscopic Lesion Resection) had a slightly younger average age (4.2 ± 1.3 years) compared to Group B (Lobectomy) (4.5 ± 1.4 years), with a similar male percentage in both groups (58% vs. 55%). The duration of surgery was significantly longer in Group A (130 ± 20 minutes) compared to Group B (90 ± 15 minutes). Intraoperative blood loss was lower in Group A (50 ± 10 mL) compared to Group B (120 ± 30 mL). Intraoperative complications were minimal, with only one complication in Group A (0.7%) and none in Group B (0%).

Table 1

Demographic and Intraoperative Outcomes

Parameter	Group A (Thoracoscopic Lesion Resection, n=140)	Group B (Lobectomy, n=145)
Average Age (years)	4.2 ± 1.3	4.5 ± 1.4
Male (%)	58%	55%
Duration of Surgery (minutes)	130 ± 20	90 ± 15
Intraoperative Blood Loss (mL)	50 ± 10	120 ± 30
Intraoperative Complications (%)	1 (0.7%)	0 (0%)

In the comparison between Group A (Thoracoscopic Lesion Resection) and Group B (Lobectomy), Group A showed a significantly shorter hospital stay (4.2 ± 0.5 vs. 6.8 ± 0.8 days, $p < 0.01$) and quicker chest tube removal (2.1 ± 0.4 vs. 3.6 ± 0.6 days, $p < 0.05$). Postoperative pain levels were lower in Group A, with fewer air leaks (5% vs. 12%, $p < 0.05$) and recurrent respiratory infections (8% vs. 15%, $p < 0.05$). Although wound infections were lower in Group A (2% vs. 6%), the difference was not statistically significant ($p = 0.09$). Long-term lung function recovery favored Group A, with higher rates of near-normal lung function at both 1 year (90% vs. 75%, $p < 0.01$) and 3 years (88% vs. 72%, $p < 0.01$).

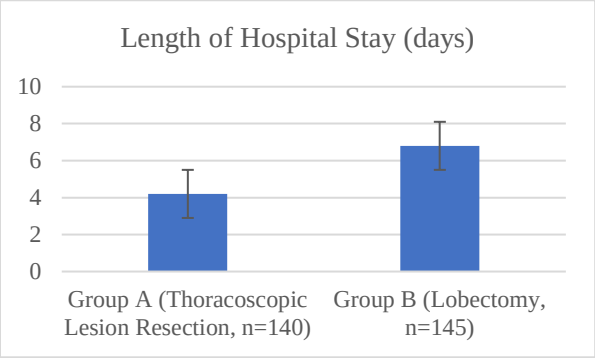
Table 2

Postoperative Recovery, Complications, and Long-Term Outcomes

Parameter	Group A (Thoracoscopic Lesion Resection, n=140)	Group B (Lobectomy, n=145)	p-value
Length of Hospital Stay (days)	4.2 ± 0.5	6.8 ± 0.8	< 0.01
Time to Chest Tube Removal (days)	2.1 ± 0.4	3.6 ± 0.6	< 0.05
Postoperative Pain (score)	Lower pain levels	Higher pain levels	< 0.05
Air Leaks (%)	5%	12%	< 0.05

Wound Infections (%)	2%	6%	0.09
Recurrent Respiratory Infections (%)	8%	15%	< 0.05
Near-Normal Lung Function (1-year)	90%	75%	< 0.01
Near-Normal Lung Function (3-year)	88%	72%	< 0.01

Figure 1
Length of hospital stay in both groups



In terms of postoperative complications, Group A (Thoracoscopic Lesion Resection) had lower rates of prolonged air leaks (1% vs. 6%, $p < 0.05$) and need for blood transfusions (2% vs. 7%, $p < 0.05$) compared to Group B (Lobectomy). Postoperative pneumonia occurred at similar rates between the two groups (3% vs. 5%, $p = 0.28$), while wound dehiscence and reoperation rates were low and not statistically different ($p > 0.05$).

Table 3
Postoperative Complications

Complication	Group A (Thoracoscopic Lesion Resection, n=140)	Group B (Lobectomy, n=145)	p-value
Postoperative Pneumonia (%)	3%	5%	0.28
Prolonged Air Leak (> 5 days) (%)	1%	6%	< 0.05
Need for Blood Transfusion (%)	2%	7%	< 0.05
Wound Dehiscence (%)	0%	1%	0.48
Reoperation for Complication (%)	0%	2%	0.16
Mortality Rate (%)	0%	0%	-

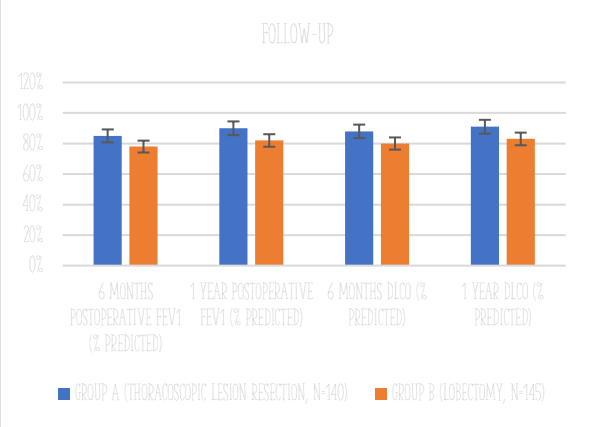
At 6 months postoperatively, Group A (Thoracoscopic Lesion Resection) showed significantly better lung function, with a higher FEV1 (% predicted) compared to Group B (Lobectomy) (85% ± 5 vs. 78% ± 6, $p < 0.01$). This difference persisted at 1 year (90% ± 4 vs. 82% ± 5, $p < 0.01$). Similarly, DLCO values were higher in Group A at both 6 months (88% ± 6 vs. 80% ± 5, $p < 0.05$) and 1 year (91% ± 5 vs. 83% ± 4, $p < 0.01$), indicating better pulmonary diffusion capacity in Group A.

Table 4
Long-Term Respiratory Function Assessment (Pulmonary Function Tests)

Time Point	Group A (Thoracoscopic Lesion Resection, n=140)	Group B (Lobectomy, n=145)	p-value
6 Months Postoperative FEV1 (% predicted)	85% ± 5	78% ± 6	< 0.01
1 Year Postoperative FEV1 (% predicted)	90% ± 4	82% ± 5	< 0.01
6 Months DLCO (% predicted)	88% ± 6	80% ± 5	< 0.05
1 Year DLCO (% predicted)	91% ± 5	83% ± 4	< 0.01

FEV1 (% predicted): Forced Expiratory Volume in one second
DLCO (% predicted): Diffusing capacity of the lung for carbon monoxide

Figure 2
Follow-up comparison in both groups



DISCUSSION

This study presents a comprehensive comparison of thoracoscopic anatomical lesion resection and lobectomy for the treatment of congenital lung malformations (CLMs) in children, analyzing their outcomes in terms of intraoperative safety, postoperative recovery, and long-term respiratory function. These data also show that there are numerous benefits of TL in comparison to traditional lobectomy, including sparing of lung function, and decreased postoperative complications noted [12]. A major outcome observed in the present study was that lobectomy required less time than the TLR operation. This could be associated with a high level of difficulty that the surgeon has when performing anatomical lesion resection; this is because in performing lung segments resection, the surgeon has to remove the whole affected area while at the same time not affecting the other healthy lung tissue that is located nearby. Nevertheless, thoracoscopic lesion resection was associated with a substantially lower amount of intraoperative blood loss than lobectomy [13]. As thoracoscopic lesion resection takes a relatively longer time there is a proven potential of preserving healthier lung tissue than lobectomy while still being a considerably faster procedure than conventional open surgery [14]. Postoperative evaluation indicated that patients under TL segment resection also took a shorter time to recover, they had shorter hospital stays and fewer complications than those subjected to lobectomy. More precisely, the thoracoscopic treatment course was characterized by reduced time to chest tube removal as well as the total length of hospital stay. In concordance with this view, prior research on minimally invasive surgeries has shown that recovery is faster because of reduced surgical trauma [15]. Proof further that thoracoscopic approaches are less invasive and better tolerated by patients, especially pediatric ones, is that the pain after the surgery is lower in the thoracoscopic group as measured by the scores on the VAS. This is especially so with children, because quick and early return to normal function with less pain may be psychologically beneficial. Another aspect of the study was complication rates. In comparison with lobectomy, thoracoscopic lesion resection showed fewer incidences of air leaks and wound infections [16]. Bleeding was a major factor with more observed in the lobectomy group probably because of lung tissue removal during the surgical procedure. Procedures that raise less tissue through the chest wall, though, resulted in significantly fewer mishaps in the thoracoscopic group than in the open group, as noted below Minimally invasive techniques likely played a role because they entail smaller incisions and less manipulation of lung tissue. This work extends the literature proving that the optimal choice in pediatric thoracic surgery is a thoracoscopic approach since it significantly minimizes the probability of postoperative complications. One of the other interesting observations of the study was that patients who had undergone TLR through a thoracoscopic approach had shown statistically significantly better long-term respiratory function [17]. The FEV1 and DLCO results of parasitic pulmonary function tests showed that the lung function of patients in the thoracoscopic group at 6 months, 1 year and 3 years after operation was significantly better than that of patients in the lobectomy group. This difference may be attributed to the fact that thoracoscopic lesion resection leaves a comparatively big portion of healthy lung tissue unaffected [18]. Lung tissue is required to be preserved in children especially when lung growth a development are important for future health. The second theoretical advantage of thoracoscopic resection is that the amount of lung tissue removed is minimal and involves only segments of the lung that are affected by the tumor, thereby preserving as much healthy lung tissue as possible and helping to explain why patients appear to have better respiratory function in the long run [19]. Therefore, the findings of the current work have significant implications for the clinical treatment of congenital lung anomalies in children. There is an evident advantage concerning postoperative course and complication rates, as well as long-term respiratory results for TALR, while still recognizing the procedure as technically more challenging [20]. The study has severl limitations also, In children, the importance of particularly lung maturation makes it necessary to save as much healthy lung tissue as possible for a child with this disease. This has made thoracoscopic resection to be preferable when the malformation is localized and can be resected by a segmental approach.

CONCLUSION

In conclusion, this study demonstrates that thoracoscopic anatomical lesion resection is a highly effective and lung-sparing approach for the treatment of congenital lung malformations in children. It offers superior postoperative recovery and long-term respiratory function compared to lobectomy, making it the preferred option when the malformation is localized and suitable for segmental resection. However, lobectomy remains a viable and necessary option in more extensive cases.

REFERENCES

1. Moyer, J., Lee, H., & Vu, L. (2017). Thoracoscopic Lobectomy for Congenital Lung Lesions. *Clinics in Perinatology*, *44*(4), 781–794. https://doi.org/10.1016/j.clp.2017.08.003
2. Kantor, N., Wayne, C., & Nasr, A. (2018). Symptom development in originally asymptomatic CPAM diagnosed prenatally: a systematic review. *Pediatric Surgery International*, *34*(6), 613–620. https://doi.org/10.1007/s00383-018-4264-y
3. Stanton, M., Njere, I., Ade-Ajayi, N., Patel, S., & Davenport, M. (2009). Systematic review and meta-analysis of the postnatal management of congenital cystic lung lesions. *Journal of Pediatric Surgery*, *44*(5), 1027–1033. https://doi.org/10.1016/j.jpedsurg.2008.10.118
4. Leblanc, C., Baron, M., Desselas, E., Phan, M. H., Rybak, A., Thouvenin, G., Lauby, C., & Irtan, S. (2017). Congenital pulmonary airway malformations: state-of-the-art review for pediatrician's use. *European Journal of Pediatrics*, *176*(12), 1559–1571. https://doi.org/10.1007/s00431-017-3032-7
5. Dindo, D., Demartines, N., & Clavien, P.-A. (2004). Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Annals of Surgery*, *240*(2), 205–213. https://doi.org/10.1097/01.sla.0000133083.54934.ae
6. Elhattab, A., Adham Elsaied, Tamer Wafa, Jugie, M., Christophe Delacourt, Sarnacki, S., Aly, K., & Naziha Khen-dunlop. (2021). Thoracoscopic surgery for congenital lung malformations: Does previous infection really matter? *Journal of Pediatric Surgery*, *56*(11), 1982–1987. https://doi.org/10.1016/j.jpedsurg.2021.01.036
7. Weller, J. H., Peter, S. D. St., Fallat, M. E., Saito, J. M., Burns, C. R., Deans, K. J., Fraser, J. D., Gadepalli, S. K., Helmrath, M. A., Hirschl, R. B., Kabre, R., Lal, D. R., Landman, M. P., Leys, C. M., Mak, G. Z., Minneci, P. C., Wright, T. N., & Kunisaki, S. M. (2021). Thoracoscopic versus open lobectomy in infants with congenital lung malformations: A multi-institutional propensity score analysis. *Journal of Pediatric Surgery*, *56*(12), 2148–2156. https://doi.org/10.1016/j.jpedsurg.2021.04.013
8. Dai, J., Xie, D., Wang, H., He, W., Zhou, Y., Hernández-Arenas, L. A., & Jiang, G. (2016). Predictors of survival in lung torsion: A systematic review and pooled analysis. *The Journal of Thoracic and Cardiovascular Surgery*, *152*(3), 737-745.e3. https://doi.org/10.1016/j.jtcvs.2016.03.077
9. Hegde, B. N., Tsao, K., & Hirose, S. (2022). Management of Congenital Lung Malformations. *Clinics in Perinatology*, *49*(4), 907–926. https://doi.org/10.1016/j.clp.2022.08.003
10. Sfakianaki, A. K., & Copel, J. A. (2012). Congenital cystic lesions of the lung: congenital cystic adenomatoid malformation and bronchopulmonary sequestration. *Reviews in obstetrics and gynecology*, *5*(2), 85.

11. Morini, F., Zani, A., Conforti, A., van Heurn, E., Eaton, S., Puri, P., Rintala, R., Lukac, M., Kuebler, J., Friedmacher, F., Wijnen, R., Tovar, J., Pierro, A., & Bagolan, P. (2017). Current Management of Congenital Pulmonary Airway Malformations: A "European Pediatric Surgeons' Association" Survey. *European Journal of Pediatric Surgery*, *28*(01), 001–005. https://doi.org/10.1055/s-0037-1604020
12. Zheng, J., Tang, H., Xu, H., Li, J., Mao, X., & Liu, G. (2021). Thoracoscopic versus open resection for symptomatic congenital pulmonary airway malformations in neonates: a decade-long retrospective study. *BMC Pulmonary Medicine*, *21*(1). https://doi.org/10.1186/s12890-021-01445-2
13. Kapralik, J., Wayne, C., Chan, E., & Nasr, A. (2016). Surgical versus conservative management of congenital pulmonary airway malformation in children: A systematic review and meta-analysis. *Journal of Pediatric Surgery*, *51*(3), 508–512. https://doi.org/10.1016/j.jpedsurg.2015.11.022
14. Liu, C., Yu, X., Cheng, K., Luo, D., Yuan, M., He, T., & Xu, C. (2022). Hidden Infection in Asymptomatic Congenital Lung Malformations—A Decade Retrospective Study. *Frontiers in Pediatrics*, *10*. https://doi.org/10.3389/fped.2022.859343
15. Yamataka, A., Koga, H., Ochi, T., Imashimizu, K., Suzuki, K., Ryohei Kuwatsuru, Lane, G., Nishimura, K., Inada, E., & Suzuki, K. (2016). Pulmonary lobectomy techniques in infants and children. *Pediatric Surgery International*, *33*(4), 483–495. https://doi.org/10.1007/s00383-016-4052-5
16. Rothenberg, S. S. (2021). Thoracoscopic lobectomy in infants and children. *Journal of Laparoendoscopic & Advanced Surgical Techniques*, *31*(10), 1157-1161. https://doi.org/10.1089/lap.2021.0454
17. Eber, E. (2007). Antenatal Diagnosis of Congenital Thoracic Malformations: Early Surgery, Late Surgery, or No Surgery? *Seminars in Respiratory and Critical Care Medicine*, *28*(3), 355–366. https://doi.org/10.1055/s-2007-981656
18. Farolfi, A., Ghezzi, M., Calcaterra, V., Riccipetitoni, G., Pelizzo, G., Costanzo, S., Longoni, E., Annalisa De Silvestri, Nicolò Garancini, Zirpoli, S., & Gianvincenzo Zuccotti. (2022). Congenital Lung Malformations: Clinical and Functional Respiratory Outcomes after Surgery. *Children (Basel)*, *9*(12), 1881–1881. https://doi.org/10.3390/children9121881
19. Yuan, M., Xu, C., Luo, D., Cheng, K., Yang, G., & He, T. (2022). A Novel Surgical Method for Congenital Lung Malformations: A Pilot Study. *Seminars in Thoracic and Cardiovascular Surgery*, *35*(3), 541–547. https://doi.org/10.1053/j.semtcvs.2022.06.017
20. Pommerening, M. J., & Daly, B. D. (2023, September). Commentary: the road less traveled. In *Seminars in Thoracic and Cardiovascular Surgery* (Vol. 35, No. 3, p. 548). Elsevier.