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Diaphragmatic Eventration After COVID-19 Disease: Evaluation of Plication via VATS and Changes in Respiratory Functions

COVID-19 Hastalığı Sonrası Diyafram Eventrasyonu: VATS Aracılığıyla Plikasyonun Değerlendirilmesi Ve Solunum Fonksiyonlarındaki Değişiklikler

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ABSTRACT

Objective: Diaphragmatic eventration after COVID-19 infection is a rare condition that can seriously and adversely affect respiratory functions and requires surgical intervention. This research aimed to elucidate whether VATS diaphragm plication is an effective treatment option for improving pulmonary functions in patients with diaphragmatic eventration developed secondary to COVID-19.
Method: This prospective research enrolled 54 patients who underwent diaphragm plication via VATS procedure. demographic and anthropometric measurements such as weight, age, and BMI were recorded before and after surgery. All patients underwent preoperative and postoperative pulmonary function tests (PFTs). These tests included standard pulmonary function tests such as spirometry, peak expiratory flow (PEF), and forced expiratory volume in the first second (FEV1). An experienced respiratory physiotherapist performed the tests.
Results: There was a statistically significant difference between the patients' preoperative FEV1 measurement and postoperative FEV1 measurement ($p < 0.05$). The FEV1 value of the patients increased in the postoperative period. Postoperative pulmonary function tests showed a significant improvement in all patients. FEV1 values of all patients increased postoperatively by an average of 23% ($p < 0.05$). Similarly, significant improvements were observed in other pulmonary function parameters.
Conclusion: VATS diaphragm plication may be an effective treatment option in improving pulmonary functions and alleviating clinical symptoms in patients with diaphragmatic eventration developed after the COVID-19 infection.

Keywords: Diaphragm Plication, Diaphragm Eventration, Video-Assisted Thoracic Surgery (VATS), COVID-19, Pulmonary Functions.

ÖZET

Amaç: COVID-19 enfeksiyonundan sonra diyafram evantrasyonu, solunum fonksiyonlarını ciddi ve olumsuz etkileyebilen ve cerrahi müdahale gerektiren nadir bir durumdur. Bu araştırma, VATS diyafram plikasyonunun COVID-19'a ikincil olarak gelişen diyafram evantrasyonu olan hastalarda pulmoner fonksiyonları iyileştirmek için etkili bir tedavi seçeneği olup olmadığını açıklamayı amaçlamaktadır.
Yöntem: Bu prospektif araştırmaya, VATS prosedürü ile diyafram plikasyonu uygulanan 54 hasta dahil edildi. Kilo, yaş ve BMI gibi demografik ve antropometrik ölçümler ameliyattan önce ve sonra kaydedildi. Tüm hastalara ameliyat öncesi ve sonrası pulmoner fonksiyon testleri (PFT) uygulandı. Bu testler, spirometri, pik ekspiratuar akım (PEF) ve birinci saniyedeki zorlu ekspiratuar hacim (FEV1) gibi standart pulmoner fonksiyon testlerini içeriyordu. Testler deneyimli bir solunum fizyoterapisti tarafından gerçekleştirildi.
Bulgular: Hastaların ameliyat öncesi FEV1 ölçümü ile ameliyat sonrası FEV1 ölçümü arasında istatistiksel olarak anlamlı bir fark vardı ($p<0,05$). Hastaların FEV1 değerleri postoperatif dönemde arttı. Postoperatif pulmoner fonksiyon testleri tüm hastalarda anlamlı bir iyileşme gösterdi. Tüm hastaların FEV1 değerleri postoperatif ortalama %23 arttı ($p<0,05$). Benzer şekilde diğer pulmoner fonksiyon parametrelerinde de anlamlı iyileşmeler gözlendi.
Sonuç: VATS diyafram plikasyonu, COVID-19 enfeksiyonundan sonra gelişen diyafram evantrasyonu olan hastalarda pulmoner fonksiyonları iyileştirmede ve klinik semptomları hafifletmede etkili bir tedavi seçeneği olabilir.

Anahtar Kelimeler: Diyafram Plikasyonu, Diyafram Evantrasyonu, Video Yardımlı Torasik Cerrahi (VATS), COVID-19, Pulmoner Fonksiyonlar.

INTRODUCTION

The COVID-19 pandemic has caused severe health problems and severely and adversely impacted healthcare systems worldwide. In addition to respiratory infections, rarely-seen respiratory complications of the pandemic have also been reported. Among them, diaphragmatic eventration developed after the onset of COVID-19 disease conveys critical importance (1).

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Diaphragmatic paralysis and eventration are rare. It is a clinical picture that can sometimes be encountered incidentally while being examined for another reason, is often on the left, and can be easily diagnosed. In the presence of unilateral diaphragmatic paralysis or eventration, adult patients may be minimally symptomatic or asymptomatic in terms of breathing. In contrast, surgical plication is indicated in adult patients only when symptoms are present (2). Plication is a surgical method used for paralysis and eventration of the diaphragm, and in all cases, diaphragm eventration is repaired surgically. Surgical plication prevents paradoxical movement during inspiration by tightening and stabilising the atrophic, thin, loose and elevated diaphragm (3). In patients with symptomatic unilateral diaphragmatic paralysis or eventration, plication prevents the abdominal organs from shifting to the ipsilateral thorax during inspiration. Thus, intrathoracic negative pressure is sufficient to inflate the contralateral lung. Atelectasis and intrapulmonary shunts improve. The patient gains better exercise performance and lung function (4).

Diaphragmatic eventration after COVID-19 infection is a rare condition that can seriously and adversely affect respiratory functions. The diaphragm acts as the primary muscle of respiration and ensures the regular functioning of respiratory functions. Therefore, any deformation or dysfunction of the diaphragm can lead to severe consequences, such as respiratory failure (5). During the COVID-19 pandemic, an increase in the incidence rates of diaphragmatic eventration in respiratory infections, especially pneumonia, was observed. In COVID-19 patients, the prolonged intensive care processes and the necessity of mechanical ventilation may trigger this complication by increasing the stress imposed on the diaphragm (6).

In this context, the diagnosis and treatment of diaphragmatic eventration developed after the onset of COVID-19 disease have become critical issues. Surgical intervention may be required in patients who do not respond to medical treatment and whose respiratory functions are severely affected. In this study, we investigated the efficacy of video-assisted thoracic surgery (VATS) diaphragm plication and postoperative changes in pulmonary functions in patients with diaphragmatic eventration after the onset of COVID-19 disease (7).

Within the scope of this research, we aimed to elucidate whether VATS diaphragm plication is an effective treatment option for improving pulmonary functions in patients with diaphragmatic eventration developed secondary to COVID-19. The evaluation and subsequent use of this technique might be an important step in improving patients' quality of life and long-term health outcomes.

METHOD

A total of 54 patients who underwent diaphragm plication via VATS procedure were enrolled in this prospective research. Seventeen patients were excluded because they had diaphragm plication after coronary artery bypass graft (CABG). Among the remaining 37 patients, 14 individuals were excluded as they did not have a confirmed diagnosis of COVID-19. Of the 23 patients with a history of COVID-19, nine patients had a history of trauma, and 3 patients were excluded from our study because previous radiological images were not available. The study was conducted on 11 male patients diagnosed with diaphragmatic eventration that developed during the COVID-19 epidemic.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Our institution has granted ethics committee approval on protocol number 4029, and informed consent has been obtained from all participants.

The patient's preoperative and postoperative clinical parameters were recorded. These parameters included dyspnea, chest pain, cough, amnestic disorders, myalgia, and dysesthesia. In addition, demographic and anthropometric measurements such as weight, age, and BMI were recorded before and after surgery. All patients underwent preoperative and postoperative pulmonary function tests (PFTs). These tests included standard pulmonary function tests such as spirometry, peak expiratory flow (PEF),

and forced expiratory volume in the first second (FEV1). An experienced respiratory physiotherapist performed the tests.

Statistical Analysis

Patient data collected within the scope of the study were analysed with the IBM Statistical Package for the Social Sciences (SPSS) for Windows 26.0 (IBM Corp., Armonk, NY) package program. Frequency and percentage for categorical data and mean and standard deviation for continuous data were given as descriptive values. For comparisons between groups, the "Independent Sample T–test" was used for two groups, and the "Pearson Chi-Square Test" was used to compare categorical variables. The results were considered statistically significant when the p-value was less than 0.05.

RESULTS

Eleven male patients aged between 23 and 35, with a mean age of 28, were included in this prospective research. The mean weight was 80±13 kg, and the mean body mass index (BMI) was 27±4 kg/m^2. All patients had been diagnosed with COVID-19 infection, as confirmed by RT–PCR results. The smoking rate was 54.5% (n=6). While diabetes, hypertension, and trauma were not observed in any of the patients, 90.9% (n=10) had shortness of breath and chest pain, 45.5% (n=5) had cough, and one patient had asthma/allergy. The preoperative clinical parameters of the patients were focused on symptoms such as dyspnea, chest pain, cough, amnestic disorders, myalgia and dysesthesia. Preoperative symptoms were tabulated, and the distribution of patients for each symptom was analysed in detail. Demographic and clinical characteristics of the patients are presented in (Table 1).

Table 1. Distribution of Demographic and Clinical Findings of Patients

Variables (n=11)	n (%)	Mean±SD	Median (Min-Max)
Gender			
Male	11 (100)		
Age		27.5±3.3	27 (23-35)
BMI		26±2.1	26 (23-31)
Smoking	6 (54.5)		
PA Ac X-ray COVID-19 Duration (months)		2.4±0.9	2 (1-4)
CT Findings (months)		2.8±1.1	3 (1-5)
Diabetes	0 (0)		
Hypertension	0 (0)		
Breath	10 (90.9)		
Cough	5 (45.5)		
Chest pain	10 (90.9)		
Trauma	0 (0)		
Asthma/Allergy	1 (9.1)		
Surgery	1 (9.1)		
Covid	11 (100)		
Direction			
Right	1 (9.1)		
Sun	10 (90.9)		

SD: standard deviation; PA: postero-anterior.

The distribution of the patients' first-second forced expiratory volume (FEV1) values measured before and after the operation is denoted in Table 2. When the table was examined, it was determined that there was a statistically significant difference between the patients' preoperative FEV1 measurement and postoperative FEV1 measurement ($p<0.05$). The FEV1 value of the patients increased in the postoperative period.

Table 2. Evaluation of Patients' Pre- and Post-Operative FEV1 Measurements

Variable	Before the operation	After the operation	p-value
FEV1			**<0.001**
Mean±SD	**55.7±2**	**68.4±2.1**	
Median (Min-Max)	**55 (52-58)**	**68 (65-72)**	

SD: standard deviation.

Postoperative pulmonary function tests showed a significant improvement in all patients. FEV1 values of all patients increased postoperatively by an average of 23% ($p<0.05$). Similarly, significant improvements were observed in other pulmonary function parameters.

Figure 1. Postoperative chest radiogram of the bilaterally expanded lungs.

Figure 3. Chest radiogram of the patient demonstrating consolidated areas with diffuse ground-glass opacities consistent with viral pneumonia.

Figure 2. Pre-COVID-19: Normal chest radiogram demonstrating expanded lungs with patent pulmonary sinuses.

Figure 4. Chest radiogram obtained 6 months after onset of COVID-19 disease that demonstrates left diaphragmatic eventration.

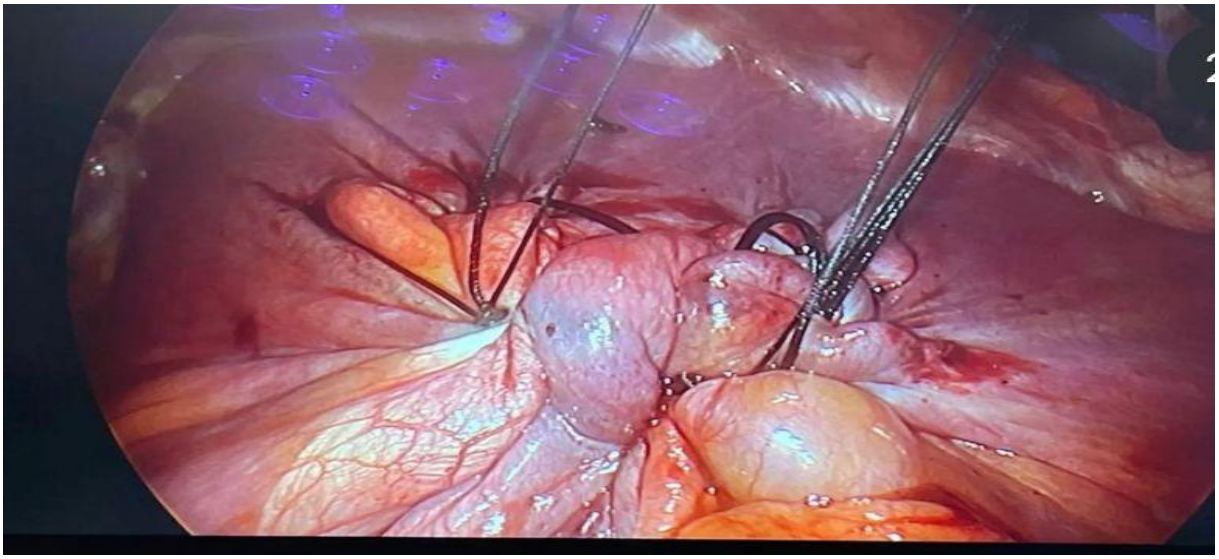

Figure 5. Perioperative photo taken during application of VATS diaphragm plication.

DISCUSSION

In diaphragmatic eventration, the diaphragm rises due to damage to the phrenic nerve for various reasons. Paradoxical movement is observed on the same side, and the diaphragm compresses the lung, causing atelectasis and dyspnea. Treatment is to prevent paradoxical movement and correct dyspnea by bringing the ascending diaphragm back into place and under tension (8).

The patient is taken into surgery in the posterolateral thoracotomy position, with the head preferably 30–45 degrees above. Before the operation, the stomach is decompressed by inserting a nasogastric tube. 2–4 points on the front armpit line to see a wider area of the diaphragm. A camera port is placed through the intercostal space. After examining the inside, a 4–5 cm incision is made in the 7–8 intercostal spaces, where plication can be most easily performed. Instruments are inserted through this incision, and plication is initiated. Sometimes, it may be necessary to make additional trocar holes. Plication is usually performed with non-absorbable suture materials. Multiple plication techniques can be utilised by placing 4–6 U-shaped sutures using number one silk and plegit. The knot pusher is used to knot the stitches. The knots in the peripheral part close to the incision site can also be tied by hand. After the procedure is completed, bleeding and diaphragmatic tension are checked, and a 24F or 28F chest tube is placed. The chest tube can be removed if there is no leakage, bleeding or excess fluid drainage on the first postoperative day (9–11).

The COVID-19 pandemic has led to the emergence of rarely-seen respiratory system complications. One of these complications is diaphragmatic eventration after COVID-19. This condition, which can affect respiratory functions, can seriously reduce patients' quality of life and lead to long-term health problems (12). In this study, we evaluated the efficacy of VATS diaphragm plication and postoperative changes in respiratory function in patients with diaphragmatic eventration after the onset of COVID-19 disease, which is a rare but important complication of the COVID-19 pandemic. The outcomes of this research indicated that the VATS diaphragm plication technique significantly improved pulmonary functions in these patients.

The improvement observed in postoperative pulmonary functions, especially an average improvement of 23% in FEV1 values, emphasises the effectiveness of VATS diaphragm plication. Similarly, significant improvements were observed in other pulmonary function parameters. These findings suggest that VATS diaphragm plication is an important treatment option to improve pulmonary functions in patients with diaphragmatic eventration developed after the onset of the COVID-19 pandemic.

In addition, a significant improvement in postoperative clinical symptoms was also observed. Reduction in dyspnea and chest pain scores, alleviation of cough symptoms and improvement in other clinical symptoms thanks to VATS diaphragm plication may contribute favourably to patients' quality of life.

The selection of treatment approaches for patients requiring surgical intervention is critical (13). In this study, patients who did not respond to medical treatment and whose respiratory functions were severely affected were treated with a minimally invasive VATS diaphragm plication procedure. This approach allows patients to recover faster in the postoperative period and shorten their hospital stay. Furthermore, minimal postoperative complications increase the safety of this procedure and improve patient satisfaction, quality of life, and health outcomes in the long term (14).

COVID-19 infection can lead to decreased muscular fibre structural integrity of the diaphragm, resulting in eventration. The long-term complications remain unknown. Severe acute respiratory syndrome coronavirus two infections are known to cause diaphragmatic weaknesses and paralysis. The increasing incidence of mechanical ventilator-induced respiratory dysfunction is also seen. Phrenic neuropathy due to SARS-CoV-2 infection can result in muscle fibre weakness and cause hemi-diaphragmatic eventration (15). COVID-19 infection leading to diaphragmatic dysfunction causing diaphragmatic eventration is a rare complication and is not widely reported. Unilateral presentations are more common on the left side, and right-sided eventration is rare (15, 16).

In conclusion, diaphragmatic eventration developed after the onset of COVID-19 is a rare but important complication. However, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has left the medical field in question in its wake. The complications, short-term as well as long-term prognosis, are still under research, and many rare complications, such as this case of right-sided hemi-diaphragmatic eventration, are reported very scarcely (17). However, further large-scale and prospective studies with longer follow-up periods performed on this issue may contribute to developing more effective and reliable treatment alternatives and confirm the long-term efficacy and safety of this treatment approach. A better definition of long-term outcomes and indications for surgical intervention may contribute to the effective management of patients during the treatment process and improve outcomes (18).

CONCLUSION

This study that evaluated the clinical course and treatment outcomes of patients with diaphragmatic eventration after COVID-19 and reviewed the available literature also assessed the efficacy of VATS diaphragm plication and postoperative changes in pulmonary functions in patients with diaphragmatic eventration developed after COVID-19 pandemic and suggested that VATS diaphragm plication may be an effective treatment option in improving pulmonary functions and alleviating clinical symptoms.

DESCRIPTIONS

No financial support.

No conflict of interest.

Abbreviations

BMI : Body mass index

CABG : Coronary artery bypass graft

FEV1 : Forced expiratory volume in the first second

PEF : Peak expiratory flow

PFT : Pulmonary function test

SARS-CoV-2 : Severe acute respiratory syndrome coronavirus 2

SPSS : Statistical Package for the Social Sciences

VATS : Video-assisted thoracic surgery

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REFERENCES

1. Alrosan S, Lem VM, Abu-Jeyyab M. A Bilateral Diaphragmatic Paralysis Post-COVID-19 Infection: A Case Report and a Review of the Literature. Cureus. 2023;15(3):e35791. doi:10.7759/cureus.35791

2. Agarwal AK, Lone NA. Diaphragm Eventration. In: StatPearls. Treasure Island (FL): StatPearls Publishing; July 24, 2023.

3. Beshay M, Abdel Bary M, Kösek V, Vordemvenne T, Mertzlufft F, Schulte Am Esch J. Minimally-Invasive Diaphragmatic Plication in Patients with Unilateral Diaphragmatic Paralysis. J Clin Med. 2023;12(16):5301. doi:10.3390/jcm12165301

4. Yongue C, Geraci TC, Chang SH. Management of Diaphragm Paralysis and Eventration. Thorac Surg Clin. 2024;34(2):179-187. doi:10.1016/j.thorsurg.2024.01.006

5. Boussuges A, Habert P, Chaumet G, et al. Diaphragm dysfunction after severe COVID-19: An ultrasound study. Front Med (Lausanne). 2022;9:949281. doi:10.3389/fmed.2022.949281

6. Medina-Pérez JJ, Balderas-Juárez JA, Vega-Rosas A, Ballesteros-Penedo PG, Coubert-Pelayo SG. Acute Phrenic Neuropathy and Diaphragmatic Dysfunction as a Complication of COVID-19: A Report of Four Cases. Cureus. 2023;15(1):e34419. doi:10.7759/cureus.34419

7. Law SM, Scott K, Alkarn A, et al. COVID-19 associated phrenic nerve mononeuritis: a case series. Thorax. 2022;77(8):834-838. doi:10.1136/thoraxjnl-2021-218257

8. Black MC, Joubert K, Seese L, et al. Innovative and Contemporary Interventions of Diaphragmatic Disorders. J Thorac Imaging. 2019;34(4):236-247. doi:10.1097/RTI.0000000000000416

9. Bin Asaf B, Kodaganur Gopinath S, Kumar A, Puri HV, Pulle MV, Bishnoi S. Robotic diaphragmatic plication for eventration: A retrospective analysis of efficacy, safety, and feasibility. Asian J Endosc Surg. 2021;14(1):70-76. doi:10.1111/ases.12833

10. Zhang G, Wang L, Wu Y, Shen G. Uniportal Video-Assisted Thoracoscopic Stapled Resection of Adult Diaphragmatic Eventration. Ann Thorac Surg. 2020;110(2):e135-e137. doi:10.1016/j.athoracsur.2020.03.023

11. Hill TM, Onugha O. Stapled Diaphragmatic Plication: Is It Better Than Suture Plication?. Surg Technol Int. 2020;36:270-273.

12. Hassanali F, Ahmadikia K, Mirenayat MS, Zahiri R, Fakharian A. COVID-19 Associated Unilateral Diaphragm Paralysis: A Case Report. Tanaffos. 2022;21(4):516-519.

13. Veerwal H, Preet K, Sood A, Singh H, Parmar M, Mittal BR. Incidentally detected diaphragmatic eventration as para-cardiac thoracic activity on myocardial perfusion imaging. J Nucl Cardiol. Published online January 30, 2024. doi:10.1016/j.nuclcard.2024.101817

14. Balamurugan G, Bhandarwar A, Wagh A, et al. Comparison of short-term outcomes of video-assisted thoracoscopic (VATS) plication of diaphragmatic eventration - a six-year prospective cohort study. Updates Surg. 2024;76(1):279-288. doi:10.1007/s13304-023-01583-8.

15. Baby BP, Mittal N. Right hemi diaphragmatic eventration - A rare post SARS-COV-2 infection complication. Lung India. 2023;40(5):462-464. doi:10.4103/lungindia.lungindia_92_23

16. Guarracino F, Vetrugno L, Forfori F, et al. Lung, Heart, Vascular, and Diaphragm Ultrasound Examination of COVID-19 Patients: A Comprehensive Approach. J Cardiothorac Vasc Anesth. 2021;35(6):1866-1874. doi:10.1053/j.jvca.2020.06.013

17. Govindasaami V. COVID-19 and diaphragmatic eventration - Coincidence is not causality. Lung India. 2024;41(1):76-77. doi:10.4103/lungindia.lungindia_459_23

18. Medina-Pérez JJ, Balderas-Juárez JA, Vega-Rosas A, Ballesteros-Penedo PG, Coubert-Pelayo SG. Acute Phrenic Neuropathy and Diaphragmatic Dysfunction as a Complication of COVID-19: A Report of Four Cases. Cureus. 2023;15(1):e34419. doi:10.7759/cureus.34419