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Effect of Artificial Pneumothorax on Operating Time for Video Assisted Thoracoscopic (VATS) Thymectomy

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ABSTRACT

Objective: To evaluate the effect of artificial pneumothorax on operating time for Video Assisted Thoracoscopic (VATS) Thymectomy

Study Design: Quasi-experimental study

Duration and Place of Study: Department of Thoracic Surgery, Combined Military Hospital Multan, Pakistan from Mar 2022 to Apr 2024.

Methodology: One hundred and ten patients aged between 18-65 years with different Thymic pathologies were included in this study. Patients were divided randomly into two groups; Group-O and Group-P. Group-O was subjected to one lung ventilation without artificial pneumothorax whereas Group-P was subjected to one lung ventilation with artificial pneumothorax. The operating time was noted from the time of incision till closure of the skin.

. There were 62(56.36%) females and 48 (43.64%) males. The overall mean operating time was 132.34±13.23 minutes. The mean operating time was significantly less 126.04±12.65 minutes in artificial pneumothorax than the group without artificial pneumothorax 138.41±10.78 minutes with very significant *p*-value ($p<0.001$).

Conclusion: The use of artificial pneumothorax for VATS thymectomy is associated with a notable decrease in the operating time without an increase in postoperative complications.

Keywords: Artificial Pneumothorax, Operative Time, One-Lung Ventilation, Thymectomy, VATS.

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INTRODUCTION

Thymus gland lies in the anterior mediastinum, it plays important role in development of immune system. Indications for thymectomy are Myasthenia gravis, Thymoma, Malignant tumors, thymic cysts, ectopic parathyroid glands. A key component of the therapy of many thymic illnesses, especially Thymoma and myasthenia gravis (MG) is thymectomy or the surgical removal of the thymus gland. By providing less-invasive methods over open surgeries, video-assisted thoracoscopic surgery (VATS) has revolutionized thymectomy.[1] With its improved results and fewer postoperative problems, VATS has become an alternative to thoracotomy in a variety of procedures, such as lobectomy and pneumothorax management.[2] Apart from conventional open surgery and minimally invasive procedure like VATS, Robotic thymectomy is a recent development in minimally invasive surgery for Thymectomy which makes use of a high-definition monitor, a two-channel endoscopic camera and a console which generates virtual 3D images of the field of operation.[3] Though it is superior but at the same time it expensive and requires longer operative time than VATS.[4,5]

VATS thymectomy has several advantages over the traditional open surgery including shorter recovery time, hospital stay, early return to work and lesser post-operative pain. However, the limited space in the thoracic cavity and rigid thoracic cage poses challenges during the procedure. The use of artificial pneumothorax, which includes inflating carbon dioxide to collapse the lung and provide work field, is a debatable feature of VATS thymectomy. Some researchers found the insufflation of thorax with carbon dioxide very beneficial and effective as it keeps surgeon comfortable plus doesn't pose much hemodynamic instability to the patient.[6,7] Contrary to this, some have opposed the technique on the same ground as they consider it does cause hemodynamic

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instability in patients.[8,9] Despite all this, VATS with single lung ventilation or double lung ventilation with or without artificial pneumothorax with carbon dioxide as medium is being used for minimally invasive surgeries.

Through the analysis of several intraoperative and postoperative parameters, this study aims to compare the operating time for VATS thymectomy; in patients who underwent VATS thymectomy with and without the use of artificial pneumothorax. This study explores the operating time recorded in minutes, from the time of skin incision to the time of closure.

METHODOLOGY

This single center Quasi-experimental study was conducted at Department of Thoracic Surgery Combined Military Hospital Multan, Pakistan for duration of 24 months from March 2022 to April 2024. The ethical approval was obtained from Institutional Ethical Committee (Certificate Number: 50/2024) before commencement of study. Using a Raosoft sample size calculator, keeping population size of 110 and a response distribution of 50%, sample size came to be 86. To make this study reliable and comprehensive, we took more patients than sample size. The informed consent was taken from patients after explaining the purpose of the study. Continuous consecutive sampling technique was used.

Inclusion Criteria: Patients between 18-65 years of age from either sex, who presented with different thymic pathologies requiring surgery, were included in this study.

Exclusion Criteria: Patients who had previous cardiac surgery, ischemic heart disease, previous thoracic surgery, uncontrolled hypertension, and ventilation/ perfusion mismatch disorders were excluded. Patients with absolute contraindication to VATS were also excluded.

Patients were divided into two groups: Group-O (n=55) and Group-P (n=55). Group-O included individuals who underwent VATS without artificial pneumothorax while Group-P included those who underwent VATS with artificial pneumothorax as shown in figure. The randomization among the groups was done using computer generated list. Relevant clinical history was taken. All the patients were admitted to the inpatient department where pre-anesthesia was done. Surgical technique used for all the VATS thymectomy was standard Right sided approach with one lung ventilation. In Group-O, VATS thymectomy was done without artificial pneumothorax whereas in Group-P artificial pneumothorax was created by carbon dioxide insufflation until 7- 10mmHg pressure was achieved. Time was recorded in minutes starting from the time on incision to the skin closure.

The Data was collected, entered and analyzed using SPSS version 25.0 (Statistical Package for Social Sciences). The normality of data for continuous variables was checked using the Shapiro Wilk test. The Mean±SD was calculated for qualitative variables. The independent samples t-test was used for statistical significance. The p-value<0.05 was considered as significant.

RESULTS

One hundred and ten (n=110) patients were included in the study. Mean age was 41.60±10.06 years. There were 62(56.36%) females and 48(43.64%) males. 55(50.00%) patients had myasthenia gravis while 35(31.8%) patients had Thymoma. The mean operating time was 132.34±13.23 minutes. Details are shown in Table-I.

Table-I: Demographic Characteristics of Study Groups (n=110)

Variable(s)	Total Population (n=110)	Video Assisted Thoracoscopic Thymectomy	
		Without Pneumomediastinum (n=56)	With Pneumomediastinum (n=54)
Age (years)	41.60±10.06	39.70±9.67	4.57±10.17
Gender			
Females	62 (56.36%)	34 (60.71%)	28 (51.85%)
Males	48 (43.64%)	22 (39.29%)	26 (48.15%)
Operative Time (minutes)	132.34±13.23	138.41±10.78	126.04±12.65
Reason of Surgery			
Myasthenia Gravis	55(50.00%)	33(58.93%)	22(40.74%)
Thymoma	35(31.82%)	17(30.36%)	18(33.33%)
Post Covid Myasthenia Gravis	20(18.18%)	6 (10.71%)	14(25.93%)

The mean operating time for VATS without pneumomediastinum was 138.41±10.78 minutes and for VATS with pneumomediastinum was 126.04±12.65, significantly (p<0.001) lower than the VATS without pneumomediastinum as shown in Table-II.

Table-II: Comparative Analysis of Operative Time Among Groups (n=110)

Variable	Video Assisted Thoracoscopic Thymectomy		*p*-value
	Without Pneumomediastinum (n=56)	With Pneumomediastinum (n=54)	
Operative Time	138.41±10.78	126.04±12.65	<0.001

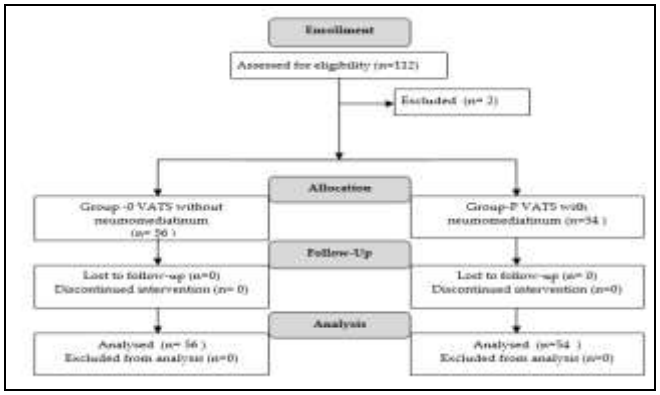

Figure: Patient Flow Diagram

DISCUSSION

In this study, the mean age was 41.60±10.06 years. 55(50.00%) patients were suffering with myasthenia gravis while 35(31.8%) patients had thymoma. The mean operating time was 132.34±13.23 minutes. The mean operating time for VATS without pneumomediastinum was 138.41±10.78 minutes and for VATS with pneumomediastinum was 126.04±12.65 minutes, significantly (p<0.001) lower than the VATS without pneumomediastinum. Postoperative outcomes such as hospital stay, and intraoperative complications are crucial considerations in evaluating surgical techniques. Decreased intraoperative blood loss, shorter hospital stay, lower overall complications were associated with VATS thymectomy by Qi *et al*.[10] Artificial pneumothorax facilitates a collapsed lung environment thus enhancing visualization of the thymic gland and associated structures. This makes the VATS thymectomy procedure more precise in terms of dissection and hemostasis prevention.[11] Regarding operative outcomes, studies have shown that VATS thymectomy with artificial pneumothorax being more advantageous in terms of improved visualization and accessibility, potentially leading to reduced operative times and intraoperative complications.[12] This finding is supported by our data, which demonstrated a statistically significant shorter mean operative time in the artificial pneumothorax group 126.04±12.65 minutes compared to the non-pneumothorax group 138.41±10.78 minutes with p<0.001. Reduced interference from lung movements may contribute to precise movements leading to quicker dissection and overall shorter operative durations.

VATS with artificial pneumothorax has been studied in various thoracic procedures including esophagectomy.[13,14] When assessing the long-term efficacy of VATS thymectomy, patient-reported outcomes like quality of life and satisfaction must be considered. Comparing minimally invasive procedures like VATS to open surgery, the former is typically linked to better patient satisfaction and a quicker recovery after surgery.[15] The researchers found two lung ventilation better and safer with artificial pneumothorax (CO2 as medium of insufflation). The CO2 insufflated two lung ventilation group had a smaller duration of surgery comparatively. In our study, we also found that the artificial pneumothorax group had lesser duration of surgery than the group without artificial pneumothorax.

These findings have clinical implications that highlight the significance of specialized surgical techniques in VATS thymectomy. While considering artificial pneumothorax, surgeons must consider the logistical difficulties and potential risks involved with lung deflation procedures as well as the potential benefits of improved intraoperative visualization and procedural efficiency. Several clinical considerations, including the patient's attributes, surgical experience, and institutional resources, must be carefully considered when deciding whether to execute a VATS thymectomy with or without artificial pneumothorax.[16-17]

Studies conducted by Ren *et al*., showed that there were changes in the levels of arterial blood gas, decrease in venous blood return, accompanied by a rise in $PaCO_2$ and a drop in pH after the establishment of CO2 artificial pneumothorax.[18] The cumulative effect of these alterations were hypercapnia ($PaCO_2$ >50mmHg) and respiratory acidosis which presented in seventy percent of the patients in the study. Furthermore, using artificial pneumothorax can elevate the intrathoracic pressure increasing the peak inspiratory pressure which is potentially capable of resulting in pulmonary alveoli damage due to stress.[19] However these adverse effects can be easily prevented by maintaining and monitoring the CO_2 insufflation pressure set at 8mmHg and if they persist, they can be

easily managed by quickly removing the CO_2 insufflation. Therefore, study done by Lin *et al*. suggest that use of artificial pneumothorax is safe with controlled CO_2 insufflation and by using standardized protocol.[20] The minimally invasive procedures like VATS thymectomy have certain limitations as well, sometimes the surgeons are not able to remove the tissue completely that might result in patients not receiving the full or little benefit from the surgery.[20] The complications of VATS thymectomy include bleeding, infection, damage to nearby structures (such the phrenic nerve or major arteries), and chronic air leakage, even in the absence of artificial pneumothorax.[21]

CONCLUSION

The creation of artificial pneumomediastinum significantly reduces the operative time hence reducing the post-operative complications related to prolonged one lung ventilation.

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Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

HS & FAM: Data acquisition, data analysis, drafting the manuscript, critical review, approval of the final version to be published.

AW & AR: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

MST & MAM & HH: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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