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Video assisted thoracoscopic surgery vs thoracotomy in management of post traumatic retained hemothorax: a randomized study

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Abstract

Background Retained hemothorax is a serious problem that can lead to empyema or fibro-thorax. Evacuation of the retained hemothorax is commonly performed via open thoracotomy. This randomized study was conducted to represent our center's expertise with this issue, we compared the outcomes of video-assisted thoracoscopic surgery (VATS) against open thoracotomy in managing post-traumatic retained clotted hemothorax.

Methods This prospective randomized research was conducted on sixty cases with posttraumatic remaining clots of at least 500 ml or at least one-third of haemothorax that cannot be evacuated by a chest tube after 72 h of first intervention, as detected by computed tomography imaging who underwent open thoracotomy or VATS in the management of posttraumatic retained clotted hemothorax. Cases were allocated to equal groups; group A: cases who underwent VATS and group B: cases who underwent open thoracotomy.

Results Preoperative intercostal chest tube (ICT) placement period was insignificantly different between the two groups. Group A had a significantly lesser post-operative amount of ICT drainage, and ICT was removed after significantly fewer days than in group B (*P* value < 0.001). Post-operatively, the numerical rating scale (NRS) was significantly higher at post-extubation and 6 h after extubation in group B than group A (*P* value < 0.05) and was insignificantly different between both groups the next morning, after chest tube removal and before discharge. group A had statistically better NRS versus group B (*P* value < 0.001). Wound infection incidence was significantly less in group A compared to group B (*P* value = 0.025); the incidence of air leak was insignificantly different between both groups. Group A has significantly shorter hospitalization than group B (*P* value < 0.001). Wound infection and empyema in outcases were insignificantly different between both groups (*P* value = 0.492). Cases in group A returned to normal activity earlier than group B (*P* value < 0.001).

Conclusions VATS in managing posttraumatic retained hemothorax was a more effective, well-tolerated, and reliable intervention that can be easily utilized for managing posttraumatic retained hemothorax in comparison to open thoracotomy.

Keywords Video-assisted thoracoscopy, Open thoracotomy, Clotted hemothorax

Background

Post traumatic hemothorax is a serious problem characterized by presence of blood collections, fibrous adhesions [1] and increased risk of development of empyema [2].

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Early evacuation of hemothorax by the intercostal tube is an important step in management of hemothorax to avoid development of fibrous adhesion or empyema [3].

Retained hemothorax is recognized as remaining clots of at least 500 ml or at least one-third of haemothorax that cannot be evacuated by a chest tube after 72 h of first intervention, as detected by computed tomography (CT) imaging [4, 5].

Evacuation of this retained hemothorax is commonly performed via open thoracotomy [6–8]. Therefore, in this randomized trial, we compared the outcome after using video-assisted thoracoscopic surgery (VATS) against open thoracotomy in managing post-traumatic retained clotted hemothorax to reflect our center experience in this topic.

Methods

This prospective randomized research was conducted on sixty cases with posttraumatic remaining clots of at least 500 ml or at least one-third of haemothorax that cannot be evacuated by a chest tube after 72 h of first intervention, as detected by CT imaging who underwent open thoracotomy or VATS in the management of posttraumatic retained clotted hemothorax at Cardiothoracic Surgery Department at Tanta University Hospital from March 2021 to November 2022.

The research Ethics Committee Review Report of the Faculty of Medicine of Tanta University authorized the research (34,844/8/21). Each participant's Consent was acquired.

Inclusion criteria

Patients with posttraumatic residual clots at least 500 ml, or at least one-third of the blood in the pleural space in which a chest tube could not be utilized to drain it after 72 h of the first treatment revealed by CT scan.

Exclusion criteria

Case with hemodynamic instability that necessitated emergent open thoracotomy (massive pericardial effusion, great vessel injury, esophageal perforation, tracheal injury, diaphragmatic rupture with herniation of abdominal content), case with severe chronic obstructive pulmonary disease who did not tolerate single lung ventilation, case who refused to provide a written informed consent.

Randomization

Computer-generated randomization numbers were used to randomly allocate cases into two equal groups. Group A: cases who underwent VATS and Group B: cases who underwent open thoracotomy.

All cases were subjected to the following:

Preoperative evaluation which included: full history taking, complete clinical examination, general examination, local examination, full routine laboratory tests, radiological investigations (CT, ultrasound), Electrocardiogram and Echocardiography.

Cases underwent one of the following operative techniques: Video-Assisted Thoracoscopy or open thoracotomy. Operative data was recorded.

Operative technique

Video-Assisted Thoracoscopy (Fig. 1)

The full collapse of the lung on the afflicted side is an essential precondition for VATS surgery. In the operating room, under general anaesthesia, using a double lumen endotracheal tube, VATS was conducted. The insertion of a double lumen endotracheal tube was verified using a flexible bronchoscope.

The case was positioned in lateral decubitus with the operated side facing up. Standard thoracoscopy hardware (KARL STORZ SE & Co. KG) was utilised, consisting of a scope with a 10-mm opening at a 30-degree angle, a light source, and a single high-resolution video-monitor. We usually started as uniportal VATS through introducing thoracoscope through the opening of previous thoracostomy tube as uniportal VATS. Removal of soft adhesions, confirming lung collapse, amount and site of clots were assessed then aspiration of fluid contents was done (Fig. 2).

Clots were removed using ovum or ring forceps through the ports, washed with warm saline was done then aspirated (Fig. 3).

Twenty-two cases were surgically operated with using one port only as a uniportal VATS, while eight cases were operated using another second port at level of seventh

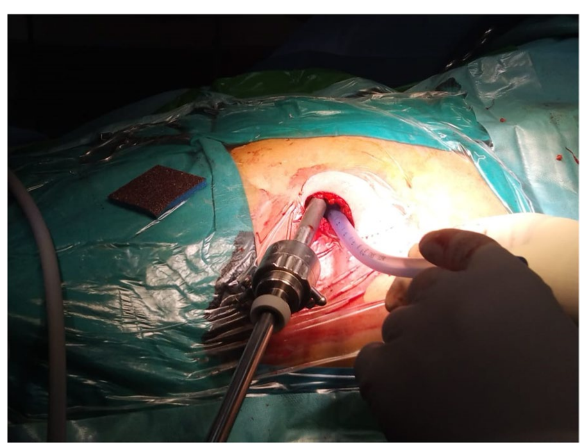

Fig. 1 Chest tube insertion camera guided at the end of VATS surgery

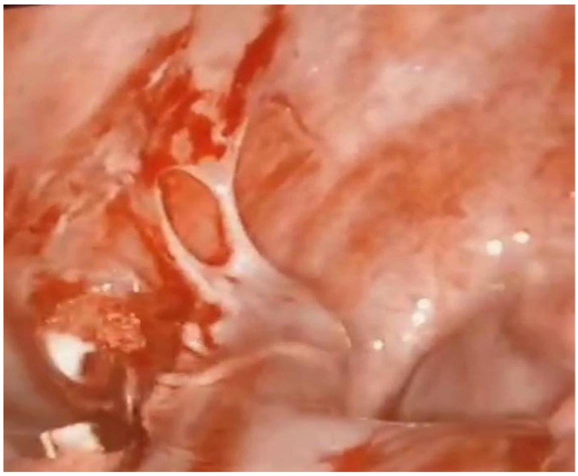

Fig. 2 Pleural adhesion seen during evacuation of clotted hemothorax

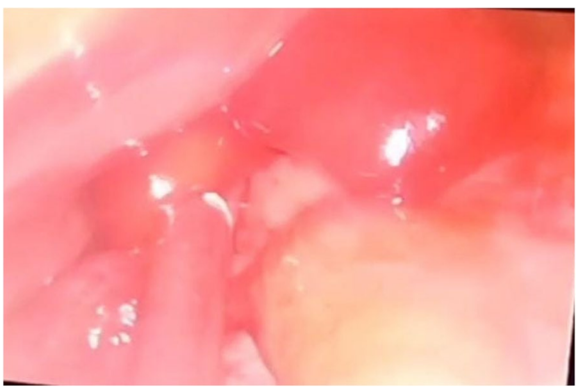

Fig. 3 Blood clots which were seen intraoperative during VATS surgery

intercostal space midaxillary line as a 2 ports VATS. Three cases from 2 ports VATS were converted to open thoracotomy due to dense pleural adhesions. Dry, sterilised ribbon gauze was inserted into the pleural space, dislodging and entrapping the adherent clots, and then extracting them, was successful in eliminating adherent clots that could not be evacuated by the above-mentioned procedures. A thorough search for further injuries, such as diaphragmatic rupture or intercostal vascular bleeding, was done. At the end of operation, one 32 Fr chest tube was placed and connected to under water seal.

Open thoracotomy (Fig. 4)

Cases were positioned as we made in VATS operation in lateral decubitus with the operated posterolateral thoracotomy at 5th intercostal space. Removal of soft adhesions, amount, and site of clots was assessed then aspiration of fluid contents was done. Clots were removed, washed with warm saline then aspirated. We excluded any other injury like diaphragmatic rupture or bleeding from intercostal vessels. Test for the lung expansion post evacuation of the retained blood clots, then pleural cavity irrigation, and two chest tubes of 32 Fr. were introduced.

Wound infection was defined by culture and sensitivity (C/S).

A routine indwelling precise intravenous analgesia pump was used. The capacity of the pump was 300 mL, including 250 μg sufentanil, 250 mg flurbiprofen axetil, 4 mL/h continuous dosage, and 4 mL/h bolus dosage (the longest lasting time was 72 h).

The numerical rating scale (NRS) ranges from '0' representing (no pain), and '10' representing the "worst pain imaginable" that was measured post-extubation, 6 h after extubation, next day morning, after chest tube removal, before discharge. Postoperative ward analgesia program: for an NRS ≤ 3, the bolus dosage button was pressed before coughing activity, and the dosage of the analgesia pump was then added. For an NRS 4–6: the bolus dosage button was pressed, and the dosage of the analgesia pump was then added (with reassessment after 5 min). If this was ineffective in relieving pain, flurbiprofen axetil 50 mg or morphine 2 mg slow intravenous injection was administered (with reassessment after 5–10 min). For NRS > 6: the acute pain services (APS) physician and anesthesiologist were contacted for a consultation to aid in adjusting the analgesic program; the above adjustments are recorded.

Post-operative in hospital follow-up was done including post-operative drainage (amount and duration in days), case clinical state (hemodynamic stability, temperature daily measure), timing of chest tube removal (days).

Criteria for Hospital discharge included hemodynamic stability with controlled arrhythmias, independent in ambulation and feeding, afebrile with no obvious infections and wound clean, normal voiding and bowel movements, tolerating full oral diet, and pain controlled on oral medication.

The chest drain was removed when drainage was clear and less than 50 ml/12 h with no air leaks, wound infection, length of hospitalization (days) and pain score numeric rating scale (NRS). Post-operative out cases follow-up (1–3 months) was done which included returned to normal activity (weeks) and wound infection.

Primary outcome was postoperative pain score, and secondary outcomes were wound infection, hospital stay, and return to normal activity.

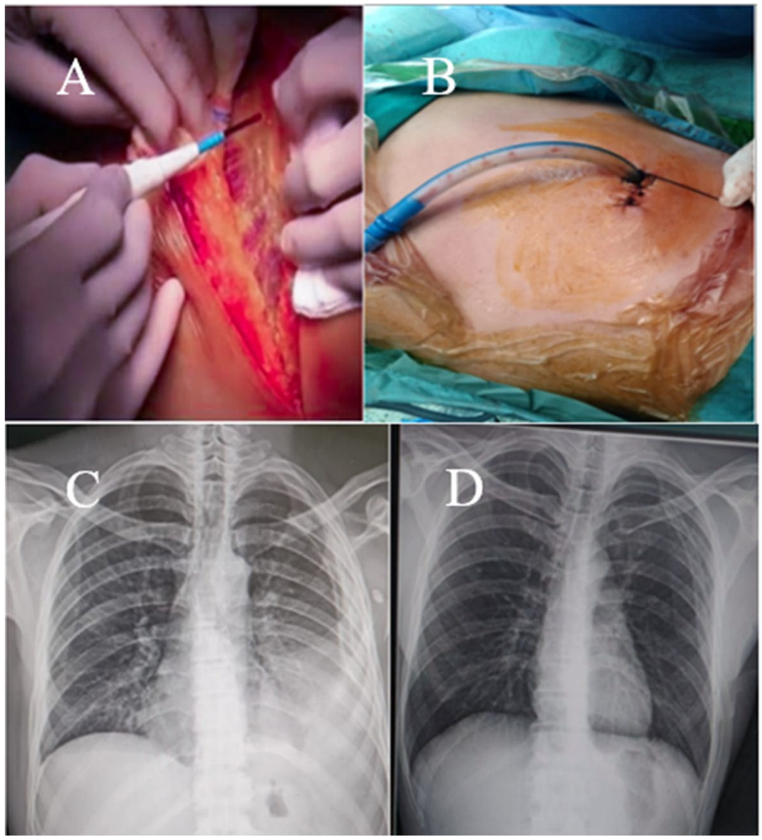

Fig. 4 **A** Thoracotomy wound incision, **B** uniportal VATS incision with chest tube insertion at the end of operation, **C** preoperative chest x-ray showed left sided retained hemothorax with chest tube seen in situ, **D** post-operative VATS surgery chest x-ray showed complete evacuation of left side retained hemothorax and complete lung expansion

Sample size calculation

The sample size calculation was done by G*Power 3.1.9.2 (Universitat Kiel, Germany). According to a previous study [9], the mean ± SD of postoperative pain (the primary outcome) was 3.53 ± 1.88 in VATS group and 4.90 ± 1.84 in thoracotomy group. The sample size was based on the following considerations: 0.745 effect size, 95% confidence limit, 80% power of the study, group ratio 1:1. We recruited 30 patients in each group.

Statistical analysis

Version 26 of the SPSS (Statistical Package for the Social Sciences) was used for statistical analysis (IBM Inc., Chicago, IL, USA). Using the Shapiro-Wilks normality test and histograms, quantitative data distribution was examined to identify the appropriate statistical test: parametric or nonparametric. The unpaired T-test was utilized to compare variables that were reported as mean and standard deviation (SD), such as age. Categorical variables (such as gender) were reported as frequencies and percentages and examined statistically using the Chi-square test or fisher exact test as appropriate. A two-tailed *P* value ≤ 0.05 was considered statistically significant.

Results

Cases eligible for participation in the research are shown in Fig. 5.

Demographic characteristics (age, sex, body mass index, temperature), type of trauma, side of affection, and oxygen need were significantly different between both groups (Table 1).

Preoperative **i**ntercostal drainage tube period was insignificantly different between the two groups. (*P* = 0.221). The post-operative amount of ICT drainage, and ICT was removed after significantly fewer days than in group B (Thoracotomy) (*P* value < 0.001) (Table 2).

Operation findings are demonstrated in Table 3. Duration of operation was significantly shorter in group A (VATS) than in group B (Thoracotomy) (*P* value < 0.001). post-operative extubation time was comparable between both groups.

Post-operatively, NRS was significantly higher in group B compared to group A post-extubation and 6 h after

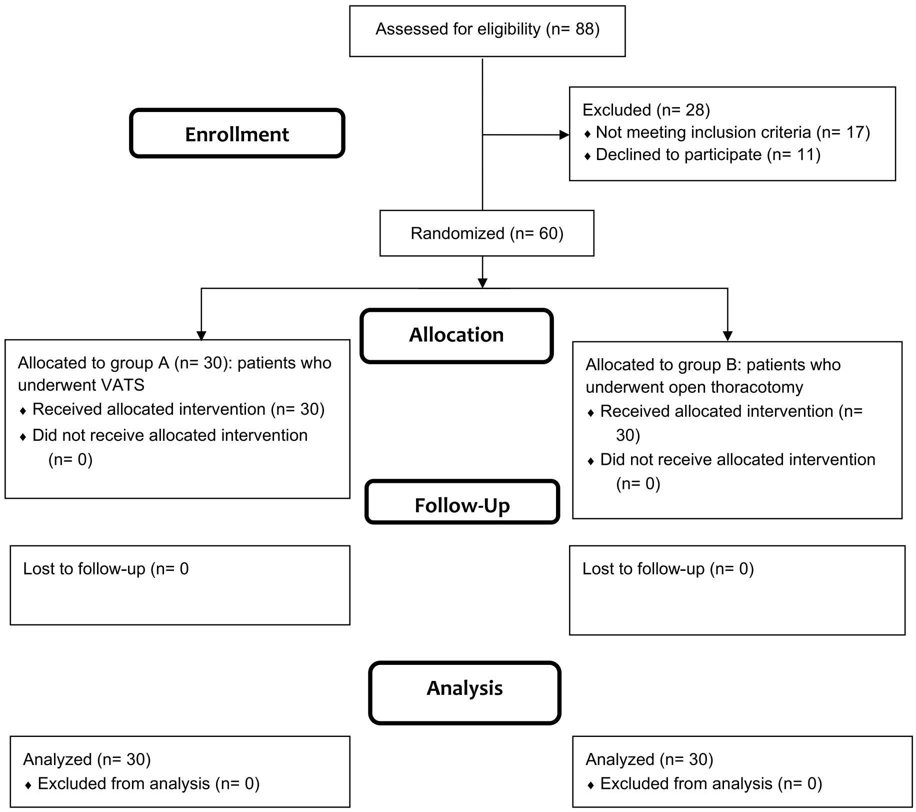

Fig. 5 Consort flow chart of the studied groups

Table 1 Demographic characteristics, type of trauma, side of affection and oxygen need of both groups

	Group A ($n=30$)	Group B ($n=30$)	*P* value
Age (years)	47.9 ± 10.32	42.8 ± 12.72	0.094
Gender			
Male	19 (63.33%)	17 (56.67%)	0.792
Female	11 (36.67%)	13 (43.33%)	
BMI (kg/m^2)	26.9 ± 2.91	26.6 ± 2.79	0.751
Temperature (°C)	36.5 ± 0.37	36.5 ± 0.26	0.687
Type of trauma			
Blunt	25 (83.33%)	27 (90%)	0.706
Penetrating	5 (16.67%)	3 (10%)	
Side of affection			
Right	13 (43.33%)	18 (60%)	0.301
Left	17 (56.67%)	12 (40.00%)	
Oxygen need	3 (10%)	7 (23.33%)	0.299

Data are presented as mean ± SD or frequency (%)

BMI Body mass index

extubation (*P* value 0.007 and 0.041, respectively) with no significant difference between groups next day morning, after chest tube removal and before discharge (Table 4).

Wound infection was defined by culture and sensitivity (C/S), there was serious oozing from the wound, swab was taken for culture and sensitivity, group A was negative for c/s and responds to broad spectrum antibiotics.

Table 2 Preoperative ICT period, post-operative ICT drainage and ICT removal (days) of the studied groups

	Group A ($n=30$)	Group B ($n=30$)	P value
Preoperative ICT period (days)	5.35 ± 1.16	5.9 ± 1.3	0.221
Amount of post-operative ICT drainage	83.33 ± 30.32	153.33 ± 47.22	< 0.001*
ICT removal (days)	1.4 ± 0.5	2.8 ± 0.83	< 0.001*

Data are presented as mean ± SD

* significant as P value ≤ 0.05. ICT: Intercostal chest tube

Table 4 Numeric rating scale (NRS) of the studied groups

	Group A ($n=30$)	Group B ($n=30$)	P value
Post-extubation	1 (1—2)	2 (1—3)	**0.007***
6 h after extubation	3 (2—4)	3.5 (2—5)	**0.041***
Next day morning	2 (2—4)	3 (2.25—5)	0.070
After chest tube removal	2.5 (1—4)	3 (2.25—4)	0.239
Before discharge	4 (3—4.75)	5 (3—6)	0.066

Data are presented as median (IRQ)

NRS Numerical rating scale, *significant as P value ≤ 0.05

Figure 6 The incidence of wound infection was significantly less in group A than in group B (P value = 0.025).

The incidence of air leak was insignificantly different between both groups. Hospitalization duration was significantly shorter in group A than in group B (P value < 0.001). Wound infection and empyema in follow-up outcases were insignificantly different between both groups (P value = 0.492). Cases in group A returned to normal activity earlier than group B (P value < 0.001) (Table 5).

Discussion

There was no variation in the preoperative ICT time between the research groups.

In their respective investigations, Lin et al. [10] found that early intervention "during the first three post-trauma days" using VATS reduces the post-operative hospital admission and comorbidities which conflicts with our results as we interfered after at least 5 days. Elkhayat et al., [11] observed that the preoperative ICT period was 5.4 days which runs in line with our results. Lee and his coworkers, [12] observed that they were doing VATS procedure after about 5.8 days after indwelling the ICT, which agrees with our research and this describes how intervention with VATS after 5 days was related with a reduced transition to thoracotomy, decreased incidence of empyema (0%), and a shorter hospitalization.

In the present research, the duration of operation was substantially shorter in the VATS than on open thoracotomy. In agreement with our findings, Rezk et al. [13] documented that the open thoracotomy had significant longer surgical duration (101.3 ± 18.6 min) compared to VATS (55.67 ± 8.98 min) ($p = 0.001$).

In disagreement with our findings Lee and his coworkers, [12] observed that the average VATS time was 139.7 min which disagrees with our results; and they explained this longer duration by the presence of multi-lesion and associated rib fixation.

In the present research, operation findings including lung laceration, pleural adhesion and lung free and post-operative extubation time were comparable between both groups (P value = 0.643, 1, 0.568, and 0.142 respectively). Our results agreed with Rezk et al. [13] who reported that operation findings including lung laceration, pleural adhesion, thick peel and lung free were similar in open thoracotomy and VATS ($p > 0.05$).

In the current research, NRS was significantly higher in group B compared to group A post-extubation and 6 h after extubation (P value 0.007 and 0.041, respectively). In agreement with our findings, Rezk et al. [13] revealed that open thoracotomy has more significant post-operative pain than in VATS ($p < 0.05$). In disagreement with our findings, Wildgaard and his colleagues [14] reported in their research that there was no difference between post-operative pain syndrome and cases were free of pain

Table 3 Duration of operation, operative findings and post-operative extubation time

			Group A ($n=30$)	Group B ($n=30$)	P value
Duration of operation (min)			73.7 ± 13.83	140.5 ± 22.9	< 0.001*
Operative findings	**Lung**	**Lung laceration**	2 (6.67%)	4 (13.33%)	0.643
		Pleural adhesion	5 (16.67%)	6 (20.0%)	1
		Lung free	23 (76.67%)	20 (66.66%)	0.568
	Rib fracture		4 (13.33%)	6 (20.0%)	0.730
Post-operative extubation time (min)			22.93 ± 5.21	24.80 ± 4.49	0.142

Data are presented as mean ± SD or frequency (%)

* significant as P value ≤ 0.05

Fig. 6 Wound infection after thoracotomy operation to evacuate clotted hemothorax

after VATS which was conflicting with our results; this was explained by using epidural analgesia.

In the present research, the amount of post-operative ICT drainage and duration of ICT removal were substantially less in the VATS than thoracotomy (P value < 0.001), and this was explained by less manipulation and good chest physiotherapy. In agreement with our findings, Rezk et al. [13] demonstrated that the amount of ICT drainage was significantly longer in open thoracotomy than in VATS (116.16 ± 27.8 vs. 50.33 ± 15.2; $p = 0.001$). They also reported a longer duration of ICT drainage in open thoracotomy versus VATS (2.2 ± 0.41 vs. 1.2 ± 0.41; $p = 0.021$). In agreement with our findings, Elkhayat et al. [11] reported a significantly longer drainage day in control group than in VATS, resulting sometimes from the improper position of chest tube and blood clots blocking the chest tube.

In disagreement with our findings, Alassal et al. [15] reported non-significant difference in the mean amount of drainage between open thoracotomy and VATS (795 ml, and 739 ml for both respectively) ($P = 0.083$). The amount of post-operative ICT drainage in our research was lesser than that obtained by Navsaria et al. [16], who reported that 650 ml of post-operative ICT drainage were evacuated thoracoscopically.

In the current research, the incidence of wound infection was substantially less in the VATS than in thoracotomy (P value = 0.025); the incidence of air leak was insignificantly different between both groups. In agreement with our findings, Rezk et al. [13] documented that there was a significant increase in different post-operative comorbidities as wound infection in open thoracotomy versus VATS ($p = 0.021$). However, in contrast to our findings, they reported a significant increase in air leak in open thoracotomy than VATS. In agreement with our findings, Elkhayat et al. [11] observed that comorbidities in open thoracotomy were more common.

In the current research, hospitalization was substantially less in the VATS than in thoracotomy (P value < 0.001). VATS Cases returned to normal activity faster than open thoracotomy (P value < 0.001), due to less post-operative pain, shorter ICT drainage and chest physiotherapy, and lesser incidence of wound infection.

Fouly and his colleagues, [17] observed that the total post-operative hospitalization in thoracoscopy group was significantly shorter than open thoracotomy, which agreed with our results. In addition, Alassal et al. [15] reported that the mean post-operative hospitalization was significantly shorter in VATS than in open thoracotomy (7.32 ± 1.99 days vs. 10.77 ± 2.13 days; $p = 0.034$), this was explained by good chest physiotherapy, less pain and less drainage.

In the current research, after 1–3 months follow-up the VATS showed insignificant comorbidities in comparison to thoracotomy. Wound infection in follow up outcases was insignificantly different between both groups (P value = 0.492). On follow-up, none of the cases treated by VATS were presented with wound infection, which was similar to Elkhayat et al. [11]. Elkhayat et al. [11] observed that comorbidities (wound infection) in open

Table 5 Complications, hospitalization, and return to normal activity of the studied groups

Complications	Group A ($n = 30$)	Group B ($n = 30$)	P value
Post-operative wound infection	1 (3.33%)	8 (26.67%)	0.025*
Air leak (hours)	1 (3.33%)	3 (10%)	0.612
Hospitalizations (days)	3.90 ± 1.20	7.37 ± 1.85	< 0.001*
Outcase wound infection	0 (0%)	2 (6.67%)	0.492
Return to the normal activity. (wks.)	3.83 ± 1.15	7.67 ± 1.90	< 0.001*

Data are presented as mean ± SD or frequency (%)

* Significant as P value ≤ 0.05

thoracotomy were more common in follow-up outcases, which agreed with our results. In agreement with our findings, Rezk et al. [13] reported that VATS cases had shorter hospitalization durations in comparison with in open thoracotomy (3.03 ± 0.88 vs. 5.53 ± 0.86; $P=0.001$). Also, the team documented that VATS case returned rapidly to normal activity in comparison with open thoracotomy (1.03 ± 0.81 vs. 2.2 ± 0.71; $p=0.01$).

The study has some limitations as it was a single-center study, and the results may differ elsewhere. The sample size was relatively small, and the results can't be generalized. The study has raised some ethical issues regarding the fact that some patients underwent a thoracotomy whereas others underwent a less aggressive thoracoscopic exploration. Therefore, more studies with a larger sample size need to be conducted in comparing VATS with other modalities for treating clotted hemothorax.

Conclusions

VATS in managing posttraumatic retained clotted hemothorax was an effective intervention with shorter duration of operation, shorter pain score, lesser amount of post-operative ICT drainage, shorter removal duration of ICT, shorter hospitalizations, and lesser incidence of wound infection compared to open thoracotomy.

Abbreviations

VATS	Video-assisted thoracoscopic surgery
ICT	Intercostal chest tube
NRS	Numerical rating scale
CT	Computed tomography
SD	Standard deviation

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Not applicable.

Authors' contributions

AM and AA conceived and supervised the study; AK and AG were responsible for data collection. AK and AG analysed and interpreted the data. All authors provided comments on the manuscript at various stages of development. All authors read and approved the final manuscript.

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Availability of data and materials

Data and material are available on a reasonable request from the author.

Declarations

Ethics approval and consent to participate

The ethical committee of the Faculty of Medicine, Tanta University Hospital, Tanta, Egypt has approved the study. Before enrollment, informed written consent was taken from patients.

Consent for publication

All authors give their consent for publication in the journal.

Competing interests

The authors declare that they have no competing interests.

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