To cite this article: Erdoğu V, Onay MS, Çiftçi A, Emetli EY, Erduran S, Pekçolaklar A, Doğru MV, Aksoy Y, Kutluk AC, Metin M. Comparing the outcomes of video-assisted thoracoscopic surgery and re-thoracotomy in the management of postoperative hemorrhage. Curr Thorac Surg 2021 Apr; 6(2): 51-57. doi: 10.26663/cts.2021.0010. CTSID: 558. Online ahead of print.

Original Article

Comparing the outcomes of video-assisted thoracoscopic surgery and re-thoracotomy in the management of postoperative hemorrhage

Volkan Erdoğu[1]*, Meral Selin Onay[1], Ayşegül Çiftçi[1], Ece Yasemin Emetli[1], Semih Erduran[1], Atilla Pekçolaklar[2], Mustafa Vedat Doğru[1], Yunus Aksoy[1], Ali Cevat Kutluk[1], Muzaffer Metin[1]

[1]Department of Thoracic Surgery, Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital, Istanbul, Turkey
[2] Department of Thoracic Surgery, Bursa City Hospital, Bursa, Turkey

ABSTRACT

Background: Although postoperative hemorrhage after thoracic surgery is uncommon, it is the most common indication for revision surgery after these procedures. Most postoperative hemorrhages are due to surgical technique, although some comorbidities can predispose the patient to bleeding. We investigated whether video-assisted thoracoscopic surgery (VATS) and re-thoracotomy had the same outcomes in the management of postoperative hemorrhage in patients who underwent open thoracotomy or VATS.

Materials and Methods: We retrospectively analyzed patients with postoperative hemorrhage after thoracotomy (n = 659) or VATS (n = 883) between 2018 and 2020. Revision surgery was performed after thoracotomy in 22 patients (3.3%) and after VATS in 4 patients (0.4%). Of these, 11 patients (42.3%) were re-operated by re-thoracotomy (Re-thoracotomy Group) and 15 patients (57.7%) by revision VATS (VATS Group).

Results: Revision due to postoperative hemorrhage was required significantly more frequently after thoracotomy than VATS (3.3% vs. 0.4%, $p < 0.001$). In patients with hemorrhage after pneumonectomy (n = 14), revision by VATS was preferred to re-thoracotomy (n = 10, 71.4% vs. n = 4, 28.6%). The mean time to discharge after revision surgery was 5.1 ± 2.2 days (range, 2-12 days) overall and was significantly shorter in the revision VATS Group than in the Re-thoracotomy Group (4.4 ± 1.5 days vs. 6.2 ± 2.5 days, $p = 0.004$).

Conclusions: VATS has similar results to re-thoracotomy and is advantageous in terms of earlier recovery and shorter hospital stay. Therefore, VATS should be the preferred method for postoperative hemorrhage management.

Keywords: VATS, re-operation, thoracic surgery, thoracotomy, postoperative hemorrhage

Corresponding Author*: Volkan Erdoğu, MD. Department of Thoracic Surgery, Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital, SUAM, 34188, Zeytinburnu, Istanbul, Turkey.
E-mail: verdogu@gmail.com Phone: +90 5052414436
Doi: 10.26663/cts.2021.0010
Received 31. 08.2020 accepted 19.10.2020

Introduction

Postoperative hemorrhage is one of the most important complications of thoracic surgery and is reported in 1% to 3% of patients after elective thoracotomy procedures [1]. Hemorrhagic blood loss in excess of 1000 mL is referred to as massive hemorrhage and generally requires revision thoracic surgery, although the decision to re-operate depends on the patients' hemodynamic features, the presence of hematoma on chest x-ray, and the hourly rate of hemorrhagic drainage [2,3]. Re-thoracotomy and video-assisted thoracoscopic surgery (VATS) are both options for revision surgery. While emergency re-thoracotomy is still the gold standard for life-threatening postoperative hemorrhage, VATS is increasingly being used in clinically stable patients [4].

Our aim in this study was to compare the results of revision VATS and re-thoracotomy in the management of postoperative hemorrhage.

Materials and Methods

We reviewed the records of patients who underwent re-thoracotomy, VATS, or re-VATS due to postoperative hemorrhage between 2018 and 2020. During this period, a total of 1542 patients underwent primary VATS (n = 883) or thoracotomy (n = 659). Revision was required due to postoperative hemorrhage in 22 patients (3.3%) after thoracotomy and 4 patients (0.4%) after VATS. Of these, 11 patients (42.3%) underwent re-thoracotomy (Re-thoracotomy Group) and 15 patients (57.7%) underwent revision by VATS (VATS Group). The study was approved by the institutional review board (number/date: 2020-35/15.10.2020) and conducted in accordance with the principles of the Declaration of Helsinki.

Patients who were treated with intrapleural thrombolytic agents or were followed up medically instead of undergoing surgical revision were excluded from this study.

Before the primary surgery, all patients were routinely evaluated for respiratory capacity and cardiac functions. If resection was planned, a forced expiratory volume in 1 second (FEV1) of at least 60% was sought. Cardiac functions were monitored via electrocardiography, and patients were referred to the cardiology department for echocardiography when necessary. Prothrombin time, international normalized ratio, and partial thromboplastin time were checked routinely in preoperative evaluations. Management of patients using anticoagulant therapy was arranged before surgery. Warfarin was discontinued 3 days before and antiplatelets such as acetylsalicylic acid and clopidogrel were discontinued 7 days before the procedure [6]. For patients undergoing coronary procedures (e.g., angioplasty, stenting), their cardiologists were contacted before interrupting antiplatelet therapy and their management was planned according to the nature of the planned surgery (elective or emergent). Enoxaparin sodium was routinely initiated at 30 to 40 mg/day subcutaneously for prophylaxis before planned surgery unless the procedure was short and/or the patient was young [5]. If lung resection was planned, enoxaparin sodium was initiated regardless of the patient's age.

As neoadjuvant chemotherapy and radiotherapy may pose a risk for postoperative hemorrhage, surgery was performed 4 to 6 weeks after neoadjuvant therapy. Patients who underwent resection and elderly patients with comorbidities were admitted to the intensive care unit postoperatively for at least one night. Drainage and hemodynamic parameters were routinely monitored by intensivists, intensive care nurses, and thoracic surgery residents. If hemorrhagic drainage from the chest tube exceeded 100 mL/hour, the on-call team was alerted to the possibility of hemorrhage in the patient. Patients with ongoing drainage at a rate of 100 mL for 8 hours or 200 mL for 2 to 4 hours were considered for revision. The decision to re-operate and using which surgical method was made by the thoracic surgery clinical council in consideration of the amount of residual hematoma on x-ray, the patient's hemodynamic parameters, and the volume of hemorrhagic drainage per hour. While re-thoracotomy remains the first option in life-threatening emergencies, VATS has become the preferred choice for revision in recent years, especially in pneumonectomy patients.

In re-thoracotomy, the previous incision was completely re-opened. For revision VATS in patients with primary thoracotomy, the chest tube incision was enlarged slightly for insertion of the VATS instrumentation, and another thoracoport incision was made if necessary. For re-VATS in patients who underwent primary VATS, the chest tube incision was used and the previous utility thoracotomy was re-opened if necessary. After the clots were evacuated, the remaining lobe was re-expanded in patients who underwent primary lobectomy and the chest cavity was carefully evaluated. If a specific bleeding site was detected, it was managed using cau-

terization, stitches, hemoclip, or by applying oxidized regenerated cellulose (Surgicel® Ethicon, Somerville, NJ), depending on location.

Regardless of the primary surgery, all patients were monitored in the intensive care unit after revision surgery and transferred to the ward the following day if hemodynamically stable. Chest tubes were removed when drainage was less than 100 mL/day and no air leak was detected. Patients were discharged after chest tube removal if they were clinically stable.

Patients were called to the thoracic surgery outpatient clinic for follow-up between 7 and 10 days after discharge and routinely evaluated using chest x-ray and laboratory tests. Chest computed tomography was requested if necessary.

Statistical Analysis

The patients' demographic characteristics and operative data were entered into IBM SPSS Statistics version 25.0 (IBM Corp, Armonk, NY) for analysis. Qualitative variables were expressed using frequency and percent distribution. Normally distributed continuous variables were reported as mean ± SD and Student's t-test was used for comparison of groups. Chi-square was used for the analysis of qualitative variables and Fisher's exact test was used if the group was small ($n < 5$). Nonparametric continuous variables were recorded as median and minimum - maximum values and were compared by using Mann-Whitney U tests. P value less than 0.05 was accepted as statistically significant. Odds ratio (OR) was used for the risk ratios of the differences detected in the comparisons.

Results

Between 2018 and 2020, a total of 1542 patients underwent VATS (n = 883) or thoracotomy (n = 659). The mean age was 53.5 ± 8.6 years (range, 14-82 years) and the majority of the patients were male (n = 1058, 70.1%). There were 22 patients (3.3%) who required revision after thoracotomy, while only 4 patients (0.4%) required revision after VATS ($p < 0.001$) (Table 1).

Of the 659 primary thoracotomies, 446 (67.7%) were anatomical lung resections (120 pneumonectomies, 326 lobectomies). Of the 883 VATS procedures, 141 (16%) were anatomical lung resections (1 pneumonectomy and 140 lobectomies). Revision was required due to postoperative hemorrhage after 3 (1 pneumonectomy, 2 lobectomies) of the 141 VATS resections (2.1%) and after 19 (13 pneumonectomies, 6 lobectomies) of the 446 thoracotomy resections (4.2%). There was no significant difference in postoperative hemorrhage rates between resection with VATS and thoracotomy ($p = 0.315$) (Table 1).

Postoperative hemorrhage occurred more frequently after pneumonectomy than lobectomy (14 revisions after 121 pneumonectomies [11.5%] vs. 8 revisions after 466 lobectomies [1.7%]). There was a significant difference in the frequency of postoperative hemorrhage between lobectomy and pneumonectomy patients ($p < 0.001$) (Table 1).

A total of 26 patients (84.6% men) underwent revision after thoracotomy or VATS due to postoperative hemorrhage. Of these 26 patients, 15 (57.7%) underwent revision by VATS (VATS in 12 patients, re-VATS in 3 patients) and 11 (42.3%) by re-thoracotomy. The mean age was 57.8 ± 12.1 years (range 24-74 years) for all re-operated patients, 59.6 ± 9.7 years (range 37-71 years) in the revision VATS Group, and 55.5 ± 15.0 years (range 24-74 years) in the Re-thoracotomy Group. There was no significant difference between the revision VATS and Re-thoracotomy Groups in terms of patient number, age, or sex ($p > 0.05$, table 2).

Revision was performed after lobectomy in 8 patients (revision VATS in 4 [50%], re-thoracotomy in 4 [50%]) and after pneumonectomy in 14 patients (revision VATS in 10 [71.4%], re-thoracotomy in 4 [28.6%]). Although the difference was not statistically significant, VATS was more preferred for the management of post-pneumonectomy hemorrhage ($p = 0.386$).

Postoperative hemorrhage was observed in 4 patients after operations other than anatomic lung resection (VATS thymectomy in 1 patient, decortication in 2 patients, and surgical treatment of penetrating injury in 1 patient). The patient with penetrating injury underwent re-thoracotomy due to persistent hemorrhage after the primary operation, and the source of the bleeding was identified as oozing from the parenchyma.

The mean drainage volume was 1250 ± 327.7 mL (range, 900-2300 mL) overall, 1166 ± 252.6 mL (range, 900-1700 mL) in the revision VATS Group, and 1363 ± 393.1 mL (range, 900-2300 mL) in the Re-thoracotomy Group ($p = 0.259$).

Table 1. Distribution of patients who underwent primary and revision surgery.

Variables	Total (n=1542)	VATS (n=883)	Thoracotomy (n=659)	P value	OR	95%CI
Age, mean±SD	53.5±8.6	50.3±6.5	56.5±4.3	0.001	na	na
Sex, n (%)				0.01	na	na
Male	1058 (70.3)	562 (63.6)	496 (75.2)			
Female	484 (29.7)	321 (36.4)	163 (24.8)			
Revision required due to postoperative hemorrhage, n (%)	26 (1.7)	4 (0.4)	22 (3.3)	<0.001	7.589	2.603 - 22.131
Anatomical lung resections, n (%)	587 (38)	141 (16)	446 (67.7)	na	na	na
Lobectomy	466 (79.4)					
Pneumonectomy	121 (0.6)					
Revision required after anatomical lung resection due to postoperative hemorrhage, n (%)	22 (37.4)	3 (2.1)	19 (4.2)	0.315	2.047	0.597 - 7.022
Postoperative hemorrhage, n (%)				<0.001	7.491	3.064 - 18.310
After lobectomy	8 (1.7)	2 (1.4)	6 (1.8)			
After pneumonectomy	14 (11.5)	1 (100)	13 (11.6)			

Abbrev. ;CI: Confidence interval, n: Number, na: Not applicable, OR: Odds ratio, pneumty: Pneumonectomy, VATS: Video-assisted thoracoscopic surgery, SD: Standard deviation

Table 2. The demographic characteristics and revision surgery details of the patients.

Variables	Total (n=26)	VATS Group (n=15)	Re-thoracotomy Group (11)	P value	OR	95%CI
Age (years), mean±SD	57.8±12.1	59.6±9.7	55.5±15.0	0.610	na	na
Sex, n (%)					1.00	1.00
Male	22 (84.6)	13 (86.6)	9 (81.8)	1.00		
Female	4 (15.4)	2 (13.4)	2 (18.2)			
Primary resection*				0.386	2.500	0.410
Lobectomy	8 (36.3)	4 (50.0)	4 (50.0)			-
Pneumonectomy	14 (63.7)	10 (71.4)	4 (28.6)			15.230
Mean amount of drainage (mL)	1250±327.7	1166.6±252.6	1363.6±393.1	0.259	na	na
Mean revision time, (days)	2.2±1.4	2.3±1.3	2.0±1.5	0.540	na	na
Mean discharge time after re-operation (days)	5.1±2.2	4.4±1.5	6.2±2.5	0.004	na	na

Abbrev.; CI: Confidence interval, n: Number, na: Not applicable, OR: Odds ratio, VATS: Video-assisted thoracoscopic surgery, SD: Standard deviation
** Only includes resection patients who underwent postoperative revision.*

The overall mean time from primary surgery to revision was 2.2 ± 1.4 days (range, 1-6 days). This interval was 2.3 ± 1.3 days (range, 1-4 days) in the revision VATS Group and 2.0 ± 1.5 days (range, 1-6 days) in the Re-thoracotomy Group (p = 0.540).

The mean discharge time after revision was 5.1 ± 2.2 (range, 2-12) days for all re-operated patients, 4.4 ± 1.5 days (range 2-8 days) in the revision VATS Group, and 6.2 ± 2.5 days (range, 3-12 days) in the Re-thoracotomy Group. This time was significantly shorter in the VATS Group than the Re-thoracotomy Group (p = 0.004).

Details related to the patients' demographic characteristics and revision surgeries of are shown in table 2.

A specific bleeding site was identified in 11 (42.3%) of the patients during revision. This site was the chest wall in 4 patients (36.3%), intercostal vessels in 2 patients (18.2%), bronchial vessels in 2 patients (18.2%), the subcarinal lymphatic bed in 1 patient (9.1%), the brachiocephalic vein in 1 patient (9.1%), and lung parenchyma in 1 patient (9.1%).

Three of the patients had a history of neoadjuvant chemotherapy. All 3 patients underwent primary pneumonectomy by thoracotomy followed by revision VATS.

Discussion

Hemothorax is one of the most important postoperative complications in thoracic surgery, especially after resections [6]. The decision to re-operate depends on the amount of hemorrhagic drainage, the presence of hematoma in the hemithorax, and the hemodynamic stability and clinical condition of the patient. Although there are some guidelines for the management of postoperative hemothorax, they are controversial. Medical follow-up may still be an option for patients with approximately 1000 mL of blood loss if the hemorrhage seems likely to stop [7]. With recent advances in VATS experience, it has begun to replace re-thoracotomy except in cases of emergency life-threatening bleeding.

According to the literature data, the incidence of postoperative hemorrhage is approximately 2% to 3% after thoracotomies and 0% to 1.7% after VATS procedures [8-10]. In the present study, re-operation rates due to postoperative hemorrhage were 3.3% after thoracotomy and 0.4% after VATS procedures. Hemorrhage rates after VATS may be lower because patients selected for VATS have relatively easier surgical procedures compared to the thoracotomy patient group. Consistent with the literature, the lung tumors in our VATS patients were smaller and more peripherally located [11]. In addition, there was only 1 pneumonectomy patient in the revision VATS Group. In the National Veterans Affairs Surgical Quality Improvement Program study, 3500 patients were retrospectively evaluated and the frequency of postoperative hemorrhage was 2.9% after lobectomy and 3% after pneumonectomy [12]. In the present study, postoperative hemorrhages were more common after pneumonectomy (n = 14, 11.5%) compared to after lobectomy (n = 8, 1.7%). Our center is one of the high-volume hospitals in Turkey for lung cancer surgery. Patients who are receiving neoadjuvant therapy and require extended pneumonectomy are referred to our hospital from many clinics. In addition, the prevalence of squamous cell carcinoma is higher in Turkey than in European countries due to our high smoking rate. Because patients with squamous cell carcinomas present with large tumor size, they often require pneumonectomy. Therefore, our higher rate of postpneumonectomy hemorrhage can be attributed to our high percentage of patients undergoing pneumonectomy and receiving neoadjuvant therapy.

In the present study, VATS was preferred over re-thoracotomy for patients with postoperative hemorrhage due to pneumonectomy. This is reasonable considering VATS provides excellent visibility of the entire hemithorax. In addition, clots can easily be evacuated through a single port, and we used the previous chest tube incision for this purpose.

In general, the reported surgical indications for posttraumatic hemothorax also apply to postoperative bleeding. The criterion for considering revision surgery is ongoing hemorrhagic drainage of 100 mL for 8 hours or 200 mL for 2 to 4 hours [13]. The mean volume of hemorrhagic drainage in this study was 1250 mL (1166 mL in the revision VATS Group and 1363 mL in the Re-thoracotomy Group). The volume of hemorrhagic drainage was lower in the revision VATS Group because most were pneumonectomy patients and some of the blood collected in the pneumonectomy space as hematoma. It should be noted that large amounts of blood, as much as 30% to 40% of the circulating blood volume, can accumulate in the pleural space [13]. Beyond the guidelines, physician observation is crucial in routine practice. In some cases, careful observation may prevent unnecessary surgical revision if hemorrhagic drainage is approximately 1000 mL but appears likely to stop. However, a patient may also present with hemorrhage volume below the indication for revision surgery, but in fact the hemorrhage may be retained as a hematoma. Even if such a hemorrhage could resolve with follow-up alone, it might turn into empyema and fibrothorax. Therefore, the decision to re-operate or follow up is crucial in this patient group. Surgical revision may be an option for removing clots even when the bleeding has stopped [14,15]. Six of the patients in this study underwent revision for the purpose of clot removal even though the bleeding had stopped 4 to 6 days earlier.

In the current study, the mean time to revision surgery was found to be 2.23 days, with no significant difference between the revision VATS and Re-thoracotomy Groups. The timing of VATS is very important, and it may be more effective for evacuating clots within the first 2 to 3 days [16]. Some authors have suggested that

VATS would not be feasible after day 7 due to denser clots, thicker pleura, and adhesions that would prevent safe insertion of the VATS equipment. However, when performed before day 7, authors have reported that VATS has significant benefits over thoracotomy [17,18]. Morales et al. [19] reported a 15.8% rate of conversion to open thoracotomy after day 6. We did not encounter any difficulties using VATS for revision within a 5 to 6 day period. However, these patients were pneumonectomy patients. On the other hand, one patient required conversion to thoracotomy on the first postoperative day of hemorrhage. This patient had undergone VATS thymectomy and was bleeding from the junction of the brachiocephalic vein and vena cava superior where the thymic vein originates. Because it could not be controlled with VATS, the procedure was converted to an open thoracotomy.

VATS requires selective intubation, which adds time before the surgery can be initiated. For this reason, thoracotomy should be the first choice rather than VATS for the management of hemorrhage in unstable patients [20]. There were no such cases in the present study.

The specific site of bleeding usually cannot be identified during revision surgery. Sirbu et al. [21] found that 23% of hemorrhages originated from a mediastinal or bronchial vein and 17% from intercostal veins. However, they could not find any specific bleeding site in 41% of the cases. Hemorrhage may also occur as oozing from vascular stapler lines, as bleeding from lymphatic beds, peribronchial tissue, parenchyma, or adhesions, or as a muscle bleed [22]. Similarly, we did not find any specific site of bleeding in most of our patients. We just evacuated the clots and cauterized suspicious areas, mostly on the chest wall.

Many studies have pointed to the benefits of VATS over thoracotomy: shorter hospitalization, less pain, earlier recovery, lower costs, better lung function, better visualization, and a higher rate of detection of small injuries [23,24]. In the present study, the length of hospital stay after revision surgery was significantly shorter in patients who underwent revision VATS group compared to those who underwent re-thoracotomy (3 days vs. 5 days).

As with every retrospective data analysis, this study also has its limitations. Another strategy for managing postoperative hemothorax is to use intrapleural thrombolytic agents, but the possible adverse effects of this management strategy are controversial, as it may increase bleeding [25]. Although we have experience with this treatment technique, we did not include these patients because the aim of this study was to determine the difference in outcomes between VATS and re-thoracotomy procedures in postoperative hemorrhage management. Previous studies comparing VATS with thoracotomy in the management of hemothorax have mostly focused on traumatic hemothorax. Investigating the management of postoperative hemorrhage alone is one of the notable features of this study.

In conclusion, VATS was found to be superior to re-thoracotomy in the management of postoperative hemorrhage in terms of earlier recovery time and shorter hospital stay. Considering the advantages of this minimally invasive approach and its similar outcomes with re-thoracotomy, we believe that VATS should be the preferred technique in postoperative hemorrhage management, especially in pneumonectomy patients.

Declaration of conflicting interests

The authors declare no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

Ethical approval

The study was approved by the Ethics Committee of Health Sciences University (No: 2020-35/15.10.2020) and conducted in accordance with the principles of the Declaration of Helsinki.

Authors' contributions

VE; Conceived and designed the analysis, co-wrote the paper, MSO; conceived and designed the analysis, AÇ, SE; collected the data, AP, EYE; contributed data/analysis tools, YA, MVD; performed the analysis, MM, ACK; co-wrote the paper.

References

1. Hudaybergenov SN. Surgical treatment of postoperative intrapleural bleeding. GCAJM 2019; 1: 111-18.
2. Cakmak M. Characteristics of the patients undergoing surgical treatment for hemothorax: a descriptive study. Biol Res 2017; 28: 2679-83.

3. Pohnan R, Blazkova S, Hytych V, Svoboda P, Makel M, Holmquist I et al. Treatment of hemothorax in the era of minimally invasive surgery. Mil Med Sci Lett 2019; 88: 1-8.

4. Broderick SR. Hemothorax: etiology, diagnosis, and management. Thorac Surg Clin 2013; 23: 89-96.

5. Zimarino M, Renda G, De Caterina R. Optimal duration of antiplatelet therapy in recipients of coronary drug-eluting stents. Drugs 2005; 65: 725-32.

6. Zeiler J, Idell S, Norwood S, Cook A. Hemothorax: A Review of Literature. Clin Pulm Med 2020; 27: 1-12.

7. Litle VR, Swanson SJ. Postoperative bleeding: coagulopathy, bleeding, hemothorax. Thorac Surg Clin 2006; 16: 203-7.

8. Péterffy A, Henze A. Haemorrhagic complications during pulmonary resection: a retrospective review of 1428 resections with 113 haemorrhagic episodes. Scand J Thorac Cardiovasc Surg 1983; 17: 283-7.

9. Solaini L, Prusciano F, Bagioni P, Di Francesco F, Basilio Poddie D. Video-assisted thoracic surgery major pulmonary resections. Present experience. Eur J Cardiothorac Surg 2001; 20: 437-42.

10. Ludwig C, Zeitoun M, Stoelben E. Video-assisted thoracoscopic resection of pulmonary lesions. Eur J Surg Oncol 2004; 30: 1118-22.

11. McKenna RJ. New approaches to the minimally invasive treatment of lung cancer. Cancer J 2005; 11: 73-6.

12. Harpole DH Jr, DeCamp MM Jr, Daley J, Hur K, Oprian CA, Henderson WG et al. Prognostic models of thirty-day mortality and morbidity after major pulmonary resection. J Thorac Cardiovasc Surg 1999; 117: 969-79.

13. Boersma WG, Stigt JA, Smit HJ. Treatment of haemothorax. Respir Med 2010; 104: 1583-7.

14. Lowdermilk GA, Naunheim KS. Thoracoscopic evaluation and treatment of thoracic trauma. Surg Clin North Am 2000; 80: 1535-42.

15. Chou YP, Lin HL, Wu TC. Video-assisted thoracoscopic surgery for retained hemothorax in blunt chest trauma. Curr Opin Pulm Med 2015; 21: 393-8.

16. Carrillo EH, Heniford BT, Etoch SW, Polk HC Jr, Miller DL, Miller FB et al. Video-assisted thoracic surgery in trauma patients. J Am Coll Surg 1997; 184: 316-24.

17. Lang-Lazdunski L, Mouroux J, Pons F, Grosdidier G, Martinod E, Elkaim D et al. Role of videothoracoscopy in chest trauma. Ann Thorac Surg 1997; 63: 327-33.

18. Villegas MI, Hennessey RA, Morales CH, Londono E. Risk factors associated with the development of post-traumatic retained hemothorax. Eur J Trauma Emerg Surg 2011; 37: 583-89.

19. Morales Uribe CH, Villegas Lanau MI, Petro Sanchez RD. Best timing for thoracoscopic evacuation of retained post-traumatic hemothorax. Surg Endosc 2008; 22: 91-5.

20. Aladdin B, Omar D, Zbigniew B, Dawid I, Piotr D, Witold G et al. Video-assisted thoracic surgery in hemothorax evacuation after cardiac surgery or cardiac interventions. Kardiochir Torakochirurgia Pol 2017; 14: 154-57.

21. Sirbu H, Busch T, Aleksic I, Lotfi S, Ruschewski W, Dalichau H. Chest re-exploration for complications after lung surgery. Thorac Cardiovasc Surg 1999; 47: 73-6.

22. Litle VR, Swanson SJ. Postoperative bleeding: coagulopathy, bleeding, hemothorax. Thorac Surg Clin 2006; 16: 203-7.

23. Carrillo EH, Richardson JD. Thoracoscopy in the management of hemothorax and retained blood after trauma. Curr Opin Pulm Med. 1998; 4: 243-6.

24. Erdogu V, Akin H, Sonmezoglu Y, Kutluk AC, Sezen CB, Dogru MV et al. Comparison of the Video-assisted Thoracoscopic Lobectomy versus Open Thoracotomy for Primary Non-Small Cell Lung Cancer: Single Cohort Study with 269 Cases. Sisli Etfal Hastan Tip Bul 2020; 54: 91-296.

25. Cangir AK, Yüksel C, Dakak M, Ozgencil E, Genc O, Akay H. Use of intrapleural streptokinase in experimental minimal clotted hemothorax. Eur J Cardiothorac Surg 2005; 27: 667-70.