

Post pull pneumothorax following cardiac surgery

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Keywords - chest tube, chest tube removal, post pull pneumothorax, cardiac surgery

Abstract

Background: Mediastinal and pleural tubes are routinely employed following cardiac surgery to prevent accumulation of blood and fluids in the mediastinum or the pleural cavities. Recurrent pneumothorax is the most significant complication after chest tube discontinuation. We reviewed the occurrence of post pull pneumothorax after adult cardiac surgical procedures in our hospital. **Methods:** A retrospective study of patients undergoing various cardiac surgical procedures over a five year period was performed. The principle outcome was recurrent pneumothorax after chest tube discontinuation. **Results:** 8900 patients underwent cardiac surgical procedures in the five-year study period. There were 6236 males and 2542 women with a mean age of 66,5 years. One hundred and twenty-two patients suffered postoperative pneumothorax for an overall incidence of 1,4%. Twenty-one of 122 patients developed a pneumothorax of variable size following chest tube removal for an overall incidence of 0,23%. Sixteen patients of 21 need chest drain reinsertion. **Conclusions:** Incidence of postoperative and post pull pneumothorax following cardiac surgery is very low. However, postoperative pneumothorax is associated with longer ICU length of stay and longer hospital length of stay. Patients suffering post pull pneumothorax have shorter time to drain removal, so premature drain removal can be a cause of post pull pneumothorax.

Introduction

Mediastinal and pleural chest tubes are routinely employed following cardiac surgery to prevent accumulation of blood and fluids in the mediastinum or the pleural cavities. The most significant complication after chest tube discontinuation is recurrent pneumothorax, called post pull pneumothorax. A post pull pneumothorax is defined as the presence of air in the hemithorax on post pull chest imaging. It can be associated with premature chest tube removal (i.e. before full lung re-expansion), an occult air leak, or air entering the pleural

space during removal.^[1] Post pull pneumothorax results in increased patient morbidity and hospital stay.^[2] We reviewed the occurrence of post pull pneumothorax after adult cardiac surgical procedures in our hospital.

Clinical scenario

A 28-year-old man underwent an aortic valve replacement. After leaving the operating room he was haemodynamically and respiratorily stable. He did not require any support and he



Figure 1. Postoperative X-ray

had good gas exchange. He had three chest tubes in situ with minimal output (<10 ml/hour) for the past eight hours. His chest tubes were removed the first day postoperatively. A routine chest X-ray was taken afterwards and showed a complete left-sided pneumothorax. The postoperative X-rays of this patient are shown (in figure 1 and 2).



Figure 2. X-ray after chest tube removal

Materials and methods

A five-year retrospective study of adult cardiac surgical procedures performed between January 2010 and December 2015 at the Catharina Hospital was conducted.

Demographic data regarding age, sex, type of cardiac procedure, evidence of postoperative air leak from the chest tubes and development of probable post pull pneumothorax were collected from the electronic complication registration database. A post pull pneumothorax is defined as the presence of air in the hemithorax on chest imaging after chest tube removal. Data such as the existence of post pull pneumothorax, opening the pleura during surgery, side of pneumothorax, reintervention or time to drain removal were collected manually by chart review. The chest tubes were removed by the nursing staff if there was less than 20 ml drainage in two consecutive hours and no visible air leak. All chest tubes were removed at the end of inspiration, while the patient was asked to perform a Valsalva manoeuvre. Chest X-rays were performed in all patients the first day postoperatively, but follow-up chest X-ray was not routinely obtained after chest tube removal. Patients were clinically monitored for development of any respiratory difficulties; patients with respiratory symptoms underwent a post pull CXR. The X-rays were evaluated for presence of a pneumothorax. Data were analysed using IBM SPSS statistics

22. Student's t-tests, chi-square analysis and Mann-Whitney tests were used to analyse the data. Mean and SD were used for continuous variables with a normal distribution. Median and interquartile range were used for continuous variables without normal distribution. Categorical variables were described as fraction and percentage.

Results

Tables 1 and 2 demonstrate the differences between groups by demographics and clinical characteristics.

Table 1. Demographic and clinical characteristics

	No pneumothorax	Pneumothorax	p value
Patients (total)	8778 (98.6%)	122 (1.4%)	
Age (mean ± SD)	66.5 ± 10.3	66.32 ± 11.2	NS
Sex	6236 (71%) male	88 (72.1%) male	NS
Euroscore (median, IQR)	3.74 (1.95-7.42)	4.92 (2.58-10.53)	0.001
COPD	713 (8.1%)	13 (10.7%)	NS
Cardiac procedures			
• CABG alone	4847 (55.2%)	54 (44.3%)	NS
• CABG + valve	1236 (14.1%)	21 (17.2%)	NS
• CABG + others	8 (0.1%)	0 (0%)	NS
• AVR	1068 (12.2%)	17 (13.9%)	NS
• AVR + MVR	128 (1.5%)	1 (0.8%)	NS
• MVR + MVP	506 (5.8%)	13 (10.7%)	NS
• TV surgery	16 (0.2%)	0 (0%)	NS
• Redo procedures	73 (0.8%)	3 (2.5%)	NS
• Others	896 (10.2%)	13 (10.7%)	NS
ICU length of stay (hours) (median, IQR)	22 (9-45)	52.5 (25-123)	<0.001
Hospital length of stay (hours) Median (IQR)	170 (122-244)	238 (143.3-456)	<0.001
Mortality during hospitalisation	266 (3.0%)	8 (6.6%)	NS

SD = standard deviation; IQR = interquartile range; COPD = chronic obstructive pulmonary disease; CABG = coronary artery bypass graft; AVR = aortic valve replacement; MVR = mitral valve replacement; MVP = mitral valve repair; TV = tricuspid valve; NS = non-significant.

A total of 8900 patients underwent cardiac surgical procedures in the five-year study period. Of these, 6236 (71%) were men and 2542 (29%) were women. Age ranged from 16 to 92 with a mean of 66.5 years. Operative procedures included coronary artery bypass grafting (CABG) in 6166 patients (69.3%), valve replacement in 1749 patients (19.7%), redo-procedures in 76 patients (0.86%) and other procedures in 909 patients (10.2%).

Table 2. Demographic and clinical characteristics of patients suffering pneumothorax

	Post pull pneumothorax	Pneumothorax not related to chest tube removal	
Patients (total)	21 (17%)	101 (83%)	
Age (median, IQR)	68 (58.5-75)	68 (60.5-74)	NS
Sex	14 male (66.7 %)	74 male (73.3%)	NS
Euroscore (median, IQR)	5.93 (3.75-16.50)	4.76 (2.32-10.46)	
COPD	3 (14.3%)	10 (9.9%)	NS
Reintervention	16 (76.2%)	58 (57.4 %)	NS
Right pneumothorax	18 (85.7%)	69 (68.3%)	NS
Pleural cavity breached			
• Right	4 (19%)	7 (6.9%)	p=0.08
• Left	2 (9.5%)	15 (14.9%)	NS
• Both	1 (4.8)	5 (5%)	NS
• Closed	2 (9.5%)	13 (12.9%)	NS
Drain removal on ICU	20 (95.2%)	52 (51.5%)	p<0.001
Median drain removal time (hours)	24 (24-36)	48 (48-96)	p<0.001
Cardiac procedures			NS
• CABG alone	7 (33.3%)	47 (46.5%)	
• CABG + valve	6 (28.6%)	15 (14.9%)	
• AVR	3 (14.3%)	14 (13.9%)	
• AVR + MVR	0 (0%)	1 (1%)	
• MVR + MVP	3 (14.3%)	10 (9.9%)	
• Redo procedures	0 (0%)	3 (3.0%)	
• Others	2 (9.5%)	11 (10.9%)	
ICU length of stay (hours) (median, IQR)	95 (47-159.5)	49 (24-121)	NS
Hospital length of stay (hours) (median, IQR)	315 (241.5-496)	242.5 (170-442.5)	p=0.08
Mortality during hospitalisation	2 (9.5%)	6 (5.9%)	NS

SD = standard deviation; IQR = interquartile range; COPD = chronic obstructive pulmonary disease; CABG = coronary artery bypass graft; AVR = aortic valve replacement; MVR = mitral valve replacement; MVP = mitral valve repair; TV = tricuspid valve; NS = non-significant

Altogether 122 patients suffered postoperative pneumothorax for an incidence of 1.4%. Patients with a postoperative pneumothorax have a significant higher logistic Euroscore, they have a significant higher ICU length of stay a significant higher hospital length of stay.

Of 122 cases of postoperative pneumothorax, 21 patients developed a pneumothorax of variable size following chest tube removal at the end of full inspiration. A post pull pneumothorax occurred 18 times on the right side and twice on the left. One patient developed a post pull pneumothorax at both sides. A chest tube was inserted in 16 patients with a moderate size post pull pneumothorax. Patients suffering post pull pneumothorax had a significant shorter time until chest tube removal. Chest tubes were removed on average after 24 hours (24-36 hours) in patients who developed post pull pneumothorax (p<0.001). In 20 patients with a post pull pneumothorax, chest tubes were removed at the intensive care unit (p<0.001). Pleural cavity was opened in 7 patients suffering post pull pneumothorax (33.3%) and in 28 patients (26.8%) suffering normal postoperative pneumothorax. Unfortunately, 59.8% of these data are missing.

Discussion

Urschel et al^[4] found an incidence of postoperative pneumothorax of 1.4%. Our study shows a similar incidence of 1.4% of postoperative pneumothorax. Although an incidence of 1.4% is quite low, postoperative pneumothorax can be a source of prolonged morbidity, require operative intervention and is potentially life threatening.^[4] Our study shows a significant longer length of ICU stay and hospital stay in patients suffering postoperative pneumothorax. Logistic euroscore^[11] was significantly higher in patients suffering postoperative pneumothorax as well. Although we did not identify single risk factors, it is likely that a combination of risk factors or a risk model such as Euroscore could contribute to a higher risk for developing post pull pneumothorax. Postoperative pneumothorax can be associated with iatrogenic lung injury, which may occur during central venous line insertion, sternotomy, internal mammary artery dissection or sternal closure.^[1] It can also be associated with emphysematous bullous rupture.^[1-4] However, in our study population there were no significant differences in incidence of COPD.

Khan et al.^[3] found 2% of patients suffering pneumothorax after drain removal following cardiac surgery. We found a lower incidence of 0.2% of patients suffering post pull pneumothorax. In the majority of cases, a specific cause of the pneumothorax could not be determined with certainty. Air leaking back into the pleural cavity during chest tube removal is a possible cause of this complication.^[1,3,4] Our study shows a significantly shorter time to chest tube removal in patients with post pull pneumothorax in comparison with normal postoperative pneumothorax. This may be associated with premature chest tube removal (i.e. before full lung re-expansion).

Using the correct technique for chest tube removal is critical for preventing recurrent pneumothorax. The removal of chest tubes is performed mainly at the end of full inspiration or at the end of full expiration. Most practitioners ask the patient

to perform a Valsalva manoeuvre during both techniques to create positive intrathoracic pressure.^[1] In our hospital, all chest tubes are always removed at the end of full inspiration, while the patient is asked to perform a Valsalva manoeuvre. As there are no previous studies performed to assess the method of chest tube removal in cardiac surgery patients, a comparison is made between different patient populations. Bell et al.^[2] evaluated the incidence of pneumothorax based on chest tube removal in 69 trauma patients. They found that removal of chest tubes at the end of inspiration or at the end of expiration is equally safe. The reason for insertion of chest tubes in the study of Bell et al.^[2] was because of blunt or penetrating thoracic trauma. Because of the different reasons for use of chest tubes, it is questionable if Bell's study outcome can be applied to patients who have undergone cardiac surgery. Cerfolio et al.^[5] evaluated which of these two techniques was more effective at reducing the incidence of pneumothorax after chest tube removal in patients who underwent pulmonary resection. Their study showed that removing a chest tube after pulmonary resection at the end of expiration while the patient performed a Valsalva manoeuvre has a lower incidence of non-clinically significant pneumothorax than removing the chest tubes while the patient performed a full inspiration. A clinically significant pneumothorax was defined as a new or increased pneumothorax that caused dyspnoea with decrease in oxygen saturation, the placement of a new chest tube or pleural catheter or delay in discharge because of the pneumothorax. No method has shown to be superior in preventing pneumothorax in trauma patients or patients after pulmonary resection. As our study was an observational study, further investigation is needed for the optimal chest tube removal technique in patients following cardiac surgery.

For the routine use of chest X-rays after removal of chest tubes is little evidence. Several studies have questioned the utility of routine postoperative and post chest tube removal chest X-rays. In our hospital routine postoperative chest X-rays are obtained the first day postoperatively, but there are no routine chest X-rays obtained after removal of chest tubes. However, a chest X-ray is always obtained before discharging from the hospital. So a pneumothorax will not be missed. Various studies have concluded that routine post chest tube removal chest X-rays provides no diagnostic or therapeutic advantage over clinically indicated chest radiography or simple clinical assessment.^[6-10]

This study has several limitations. Because of the retrospective design of the study there are a lot of missing data concerning operatively opening of the pleura and the time until chest tube removal in patients who did not suffer a pneumothorax. Another limitation is that the decision to replace a chest tube in the event of pneumothorax recurrence was at the discretion of the attending physician. It is unclear from the chart review whether the chest tubes were replaced because of respiratory dysfunction, size of pneumothorax or empirically. Because

of the observational character of this study, risk factors for developing post pull pneumothorax after cardiac surgery cannot be approved. Further research is needed to evaluate the best technique for chest drain removal in cardiac surgery patients.

In conclusion, this retrospective study shows a low incidence of postoperative and post pull pneumothorax. However, postoperative pneumothorax is associated with longer ICU length of stay and longer hospital length of stay. Patients suffering post pull pneumothorax have a shorter time to drain removal, so premature drain removal can be a cause of post pull pneumothorax.

Disclosures

All authors declare no conflicts of interest. No funding or financial support was received.

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