ORIGINAL ARTICLE

Complications and Technical Errors of Tube Thoracostomy and its Underwater Seal System

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ABSTRACT

Objective — *To find out the complications and technical errors of tube thoracostomy and its underwater seal system in a tertiary care hospital.*

Study design — *Descriptive case series.*

Place & Duration of study — *Department of Thoracic Surgery Jinnah Postgraduate Medical Centre Karachi, from March 2010 to January 2012.*

Methodology — *All patients above the age of 12 year who were admitted directly or those referred from other centres were included in this study. Indications of chest tube insertion included both traumatic and non traumatic conditions. Data collection included both technical errors as well as complications related to the procedure.*

Results — *There were total of 144 patients managed during study period. This include 102 (70.8%) males and 42 (29.9%) females. The mean age of the patients was 32.2 year. Of total patients, 123 (85.45%) were referred from other hospitals while 21 (14.5%) were admitted directly in the ward. The most common complication related to insertion of chest tube was lung injury, (n=19, 13.19%) which resulted from the use of trocar or due to inadequate separation of the lung from the chest wall. Diaphragm injury occurred in 4 (2.78%) patients. The technical error frequently encountered was kinking of chest tube (n=25, 17.36%), followed by use of small chest tube (n=15, 10.41%).*

Conclusions — *Tube thoracostomy resulted in number of complications of which lung injury was most common. This occurred mainly due to trocar used for insertion. Kinking of tube was the most common technical error in the series.*

Key words — *Tube thoracostomy, Chest tube, Empyema thoracis.*

INTRODUCTION:

Tube thoracostomy is among the most commonly performed surgical procedures. Unfortunately this life saving procedure also continues to be a significant source of preventable morbidity.[1] As a consequence of its clinical utility, chest tube insertion has been classified as a mandatory skill for all physicians involved in care of injured patients, including general surgeons, intensivists and emergency medicine specialists.[2,3]

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While the ultimate goal of draining the pleural cavity remains constant, the actual technique of chest tube thoracostomy has changed considerably since its initial description by Hippocrates.[4] The first documented description of a closed tube drainage system for the drainage of empyema thoracis was by Hewett in 1867.[5] However during the second world war, the experience gained in military and civilian hospitals, contributed to the development of tube thoracostomy in chest trauma management. At the time of the Vietnam War, it had become the standard of care for management of chest trauma.[6]

In 1992, Lilienthal reported the postoperative use of chest tube following lung resection for suppurative diseases of the lung.[7] Tube thoracostomy is an invasive procedure and complications can result due to inadequate knowledge of thoracic anatomy or

inadequate training and experience. Trocar technique is by far associated with a highest rate of complications.[8] This study aimed at documenting all the possible and frequently encountered errors resulting in complications following tube thoracostomy and its underwater seal system with the view to address shortcoming of the procedure performed.

METHODOLOGY:

A descriptive case study was conducted at the Department of Thoracic Surgery Jinnah Postgraduate Medical Centre (JPMC) Karachi, from March 2010 to January 2012. All patients above the age of 12 year of either sex were included. Patients operated for tube thoracostomy in the ward as well as those referred from other centres after tube thoracostomy were included in the study. Patients who had tube thoracostomy during major operation (thoracotomy) were excluded. Patients who had chest tube for trauma as well as infective pathologies were recruited.

Data was collected using predesigned forms. Variables studied included profile of patients, indication of thoracostomy, site, technique used, complications of the procedure, and technical errors of tube thoracostomy and its underwater seal system. Chest x rays performed pre and postoperatively were collected. The chest tube and its drainage system were monitored on daily basis till its removal. Any complication or error related to the procedure and management provided was also documented. Data was collected on Microsoft Excel and frequency was expressed in percentages.

RESULTS:

A total of 144 patients studied. This included 21 patients operated at our hospital while 123 were referred from other institutions. Indications of tube thoracostomy is given in table I. Chest tube complications were noted among 10 patients of the JPMC while technical errors was recorded among 11 patients of the same group. Similarly 39 of the referred patients had complications related to the chest tube, while 68 had technical errors of the water seal system (table II).

Lung injury was the most commonly encountered complication (n=19, 13.19%), noted in both JPMC (n=3 , 2.1%) as well as the referred patients (n=16, 11.10%) in this study. It was followed by the diaphragmatic injury in (n=4, 2.78%). Second most frequent complication in JPMC patients after lung injury was empyema thoracis. Details are given in table II. Technical errors in referred patients and those from JPMC are shown in table III.

DISCUSSION:

Chest tube thoracostomy is often lifesaving in the treatment of severely injured patients. It serves to monitor thoracic blood loss, evacuate blood in the pleural cavity, prevent tension pneumothoraces and increase lung re-expansion, thereby tamponading low-pressure pulmonary vessels and improving respiratory compromise.[9,10] Unfortunately, this

Table I: Indications for Tube Thoracostomy

Indications	Number (Percentage)
Hemothorax secondary to Trauma	53 (42%)
Empyema Thoracis/ Pleural Effusion	35 (28%)
Pneumothorax secondary to Trauma	23 (18%)
Spontaneous Pneumothorax	14 (11%)

Table II: Complications

Complications	Percentage	Referred Patients	JPMC
Lung injury	19 (13.19%)	16 (11.1%)	3 (2.1%)
Intercostal vessel injury	1 (0.69%)	1 (0.69%)	0 (0.00%)
Diaphragmatic injury	4 (2.78%)	3 (2.08%)	1 (0.69%)
Liver injury	1 (0.69%)	1 (0.69%)	0 (0.00%)
Empyema thoracis	10 (6.94%)	8 (5.55%)	2 (1.39%)
Clotted hemothorax	7 (4.86%)	7 (4.86%)	0 (0.00%)

Table III: Technical Errors Observed in Studied Patients			
Technical Errors	**Percentage**	**Referred Patients**	**JPMC**
Clamping during transport	2 (1.38%)	2 (1.38%)	0 (0.00%)
Tube kinking	25 (17.36%)	19 (13.19%)	6 (4.16%)
Air vent covered	4 (2.77%)	3 (2.08%)	1 (0.69%)
Fenestrations outside	4 (4.77%)	3 (2.08%)	1 (0.69%)
Loose fixation	7 (4.86%)	6 (4.16%)	1 (0.69%)
Small sized tube	15 (10.41%)	15 (10.41%)	0 (0.00%)
Clogging of tube	7 (4.86%)	6 (4.16%)	1 (0.69%)
Improper water seal	5 (3.47%)	4 (2.77%)	1 (0.69%)
Wide wound of tube	10 (6.94%)	10 (9.80%)	0 (0.00%)
Improper insertion site	20 (13.88%)	16 (11.11%)	4 (2.77%)
Extrapleural placement	3 (2.08%)	3 (2.08%)	0 (0.00%)

procedure is also associated with significant morbidity and occasional mortality.[11] Same was observed in present study.

A sound knowledge of the anatomy of the thorax is important to avoid some complications of tube thoracostomy .The intercostal spaces are filled with intercostal muscles, the vein, artery, and nerve lying in the costal groove at inferior margin of the rib and situated between the second and the third layer of muscles. To avoid the neurovascular bundle, it is normally advocated that the drain be located in the interspace just superior to the rib. However, puncture done close to the inferior margin of the rib may lead to laceration of the intercostal vessels.[12]

British Thoracic Society (BTS) has recommended the triangle of safety as the site for insertion for intercostal drain.[13] This area is bordered by the anterior border of the latissimus dorsi, the lateral border of the pectoralis major muscle, a line superior to the horizontal level of the nipple, and an apex below the axilla. A survey on the conformity with the anatomical landmarks at the time when an intercostal drain is inserted revealed that 45% of the drains were placed outside the safe area of chest drain insertion. The most common error being a choice of insertion too low in 20% cases.[14]

The midaxillary line is the most commonly advocated position for tube thoracostomy. the innermost layer of intercostal muscle are poorly developed at this point, and comprises of thin intracostals, which blend with the internal intercostal layer except where separated by neurovascular bundles.[15] A more anterior position will lead to injury to the muscles and breast tissue while a more posterior position is more uncomfortable and has risk of drain leakage.[16] The long thoracic nerve lies behind the mid-axillary line on the surface of serratus anterior and deep to the fascia and segmentally supplies this muscle. These anatomical facts must be kept in mind when performing tube thoracostomy.

In full expiration, the two domes of diaphragm rise as high as the 4th dorsal intervertebral space on the right and 5th space on the left; hence, when a chest tube is placed too low, there is a high probability of abdominal placement under the diaphragm. Inferior placement of chest tubes will not only perforate the diaphragm but will also damage intra-abdominal organs. The same will also apply to other conditions that elevate the diaphragm, for example, late pregnancy, gross obesity, massive ascites, and intra-abdominal tumours.[14] Injury to diaphragm occurred in four patients in this series. Non-functional drain may be due to kinking, angulation, clot formation within the lumen, presence of debris, or lung tissue. Smaller drains tend to kink or clot easy than larger drains especially when used in the setting of trauma.[1] A cardinal sign of blocked chest tube drain is failure of fluid within the tube to fluctuate with respiration upon coughing. This ineffective drainage will result in un-drained or unresolved pleural collection. Tension pneumothorax can also result in cases of ongoing air leak. Milking or stripping can be used to unblock semisolid contents. However, this is controversial and debatable as the negative pressure created may damage lung tissue. Chest drain should be unkinked

in cases of kinking causing blockage. This error is noted in 25% patients in this series. This is avoidable and must not happen as it adds to morbidity with grave consequences.

The technique and level of expertise was not known in cases referred from outside. It was thus not assessed however, in our department, tube placement was performed in the safe triangle along the superior margin of the rib without a trocar, to prevent vessel and visceral injury. Finger sweep maneuver is important step and it is taught to the residents that before tube thoracostomy it is mandatory to separate any possible adhesions between the lung and pleura to avoid possible lung injury.

Tube placement quality was assessed with a chest x-ray. Minimal 32F or 36F tubes were used according to physique of the patient. Therefore clogging and small sized tube issues were not seen in our patients. Tube kinking in this study was managed by manipulation / re-tube thoracostomy in patients for effective drainage. In cases of improper anatomical site insertion, if drain was not working efficiently, it was removed, wound closed and re-insertion of tube was performed at correct site.

CONCLUSIONS:

Number of complications occurred following tube thoracostomy of which the lung injury was most common. This occurred mainly due to trocar used for insertion. Kinking of tube and improper size were other important preventable errors related to the procedure.

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