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Complications of Tube Thoracostomy- How Well Are We Training our junior Doctors?

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Abstract

Objective: This study aims to explore the common causative factors of dysfunctional closed chest drainage unit, their relative frequency and to give recommendations for its prevention.

Study Design:

Retrospective study

Place and Duration of study:

Department of Thoracic surgery, Nishter Medical University, Multan, between February 2015 and January 2017

Method:

139 patients were included in whom tube thoracostomy had been performed but it had failed in draining the pleural collection. Detailed history and thorough physical examination were carried out, Chest x-ray and where necessary chest CT scan were done to evaluate placement of chest tube and to work out the causative factor of dysfunctional closed chest drainage unit.

Results:

Out of the 139 study cases, 36(25.9%) were females while 103(74.1%) were male patients. Mean age of our study cases was 37.2 ±14.5 years (minimum age was 12 while maximum age was 65 years). A wrong connection of CDU was the most common cause of dysfunctional closed CDU. It was found in 24 cases (17.3%).Where as inadequate prime fluid, loose connections, kinked tubes; over full bottles were the other common problems.

Conclusion:

Dysfunctional closed chest drainage unit is a common but serious clinical problem which results in significant rise in morbidity, prolonged hospital stay and economic burden. It can be prevented by adopting proper protocol of tube thoracostomy.

Keywords: Dysfunctional chest drainage unit, Faulty chest tubes, Non-functioning tube thoracostomy, Failure of chest drainage system.

Abbreviations:

Chest drainage unit-CDU, tube thoracostomy-TT

Introduction

Tube thoracostomy is a commonly performed surgical procedure. It is performed on bed-side as well as in operative room, indicated in life threatening emergencies as well as for post-operative chest drainage in elective surgery [1]. It is a life saving technique, in many situations there is no alternative to TT [2]. However, despite of all these potential benefits procedure of TT placement is associated with life threatening complications such as laceration of thoracic and abdominal viscera, injury to great vessels and bronchopleural fistula etc[3-8]. The cumulative rate of these various complications is about 3-22 % [1, 3, 9]. Sometimes an 'apparently' perfectly placed TT can also be non-functioning due to disturbed negative pressure within the CDU. The basic design principle of these CDUs is to generate and maintain the negative pressure by preventing air entry within the pleural space for constant and effective drainage of any pleural collection [10]. So any factor causing impairment of negative pressure in CDU will result in its dysfunction. This dysfunctional CDU is a commonly encountered clinical problem. This article focuses on the factors causing dysfunctional CDU, with recommendation to prevent them.

Methodology

This retrospective study was conducted at Department of Thoracic Surgery, Nishter Medical University, Multan, between February 2015 and January 2017. A total of 139 patients were included. Inclusion criteria were:

A) Persistent air leak and failure of lung to re-expand following insertion of one or more TT

b) Failure in drainage of intrapleural fluid or blood in patients with empyema or hemothorax despite placement of one or two TT.

c) The timeline for determining if the TT has failed was 7 days.

Patients with loculated empyema, bronchopleural fistula and dislodged TT were not included. In case of "loculated" empyema, there is a probability of unresolved/un-drained pleural collection due to presence of loculation, and not because of faulty TT. So we excluded the cases of loculated empyema. In Bronchopleural fistula, there may be persistent air leak due to fistula and not because of faulty TT, so this air leak could be mistakenly attributed to dysfunctional CDU. The reason behind the exclusion of dislodged TT was our purpose to work out the causes of system failure in "an apparently perfectly placed TT" i.e. surgeon believes TT is placed

perfectly. But still it is not working properly. So dislodged TT does not fit in this criterion, hence we excluded it. Patient's demographic data was recorded and informed consent was taken. All selected cases were evaluated by detailed history and physical examination (including assessment of CDU from insertion site back to under-water seal bottle).Chest x-ray and where necessary chest CT scan were used to evaluate placement of TT and also to assess lung pathologies like loculated empyema and bullous diseases of lungs. We assessed these patients to explore factors causing dysfunctional closed CDU and documented all possible complications and mistakes related to chest tube insertion and care of its system.

Data were analyzed by using computer program SPSS 19 version. Descriptive statistics were used to calculate mean ± SD for age of the patients. Frequencies and percentages were calculated for factors causing dysfunctional closed CDU.

Results

In 139 cases, 36 (25.9%) were females while 103 (74.1%) were male patients. Mean age of our study cases was 37.2 ±14.5 years (minimum age was 12 while maximum age was 65 years). A wrong connection of CDU was the most common cause of dysfunctional closed CDU. It was found in 24 cases (17.3%). Whereas odd underwater seal, inadequate prime fluid, loose connections, kinked tubes, over full bottles were the other common problems.

Table-I. Demographic characteristics in all patients

Characteristics	Total(n=139)
Age(Years)	37.2 ±14.5
Gender	
Male	103
Female	36

Table II. Relative Frequency of different causes in patients

Causes	**Frequency**	**Percentage**
Wrong Connections	24	17.3%
Odd Under Water Seal	19	13.7%
Inadequate Prime Fluid	15	10.8%
Loose Connections	15	10.8%
Over Full Bottles	12	8.6%
Kinked Tubes	10	7.2%
Clamping	7	5.0%
Holes in Tubes	7	5.0%
Sealed off Vent	7	5.0%
Faulty Suction	5	3.6%
Eyelet out of Pleural Space	5	3.6%
Bottle above Level of Chest	5	3.6%
Absent Drainage Bottle	2	1.4%
Subcutaneous Chest Tube	2	1.4%
Odd Chest Tube	2	1.4%
Stitch Cutting through the tube	2	1.4%
Total	139	100%

Discussion

Dysfunctional closed CDU is a common condition which can lead to grave consequences if not managed in time. In the literature various causes of CDU system failure are described as shown in table III.

Table III. Frequency of causative factors of dysfunctional CDU as described in literature

Serial Number	Causative factor	Relative frequency
1	Ectopic TT	23-53% [4, 5, 11]
2	Clamping	9.1% [6]
3	Faulty suction system	6.8% [6]
4	Loose connections	4.4% [6]
5	Tube blockage	0.6- 3.5 % [12, 13]
6	Sealed –off Vent	3.2% [6]
7	Intra thoracic tube kinking	2.7-3.9% [6, 14]
8	Subcutaneous emphysema	1-1.8% [12, 13]
9	Improper filling of the under-water seal bottles	0.3% [6]
10	Subcutaneous placement of tube	1% [15]

But In this study, we found that faulty connection of tubing of CDU is the most frequent cause of dysfunctional CDU's. Whereas in other studies; ectopic TT and clamping of TT were the most common pitfalls in TT placement [4-6]. A faulty connection can defeat the purpose of TT and results in pneumothorax. *When tube from the patient's chest is connected to the vent and the bottle system is sealed off, then patient may have tension pneumothorax because air coming from patient's chest has nowhere to vent. But if the bottle system is not sealed off, then the patient is practically in open pneumothorax because end of the tube coming from patient's chest is in free communication with the environment* [10, 16-18]. An appropriate under-water seal drainage bottle is essential component of CDU to maintain negative pressure and prevent air entry into the pleural space . During this study it was observed that empty bottles of IV fluids, ordinary drainage bags (with no Heimlich valve), even balloons and plastic shopper bags were used as drainage bottle. In two cases no drainage bottle was present at all and chest tube was open to air. These conditions lead to system failure. The loose connections of the tubing at junction point of the CDU are potential source of persistent air leak. In our study their percentage was very high (10.8%) as compared to a study of Jordan in which their percentage was 4.4% [6]. In this study, by Al- Tarshihi et al, the percentage of improper filling of bottles was 0.3 % which is quite low as compared to our study. A kinked or angulated tube impairs the efficacy of TT, and is responsible for poor drainage, discomfort and trauma on removal, hence leads to un-drained pleural collection [19]. In a study conducted by Adame N et al. its percentage is 3.9% which is significantly lower than our study [14]. On the other, in the study by Al- Tarshihi et al, percentage of clamped chest tubes was 9.1% which is much higher than our results [6]. Similarly in our study percentage of improper handling of suction system was considerably less (3.6%) as compared to 6.8% in above mentioned study. However sub-cutaneous placement of TT was present in 1.4% of cases, which is comparable to a European study in which its incidence was 1–1.8% [15]. These observations show an alarming situation. Even in a tertiary level hospital the knowledge and training of medical staff are not up to the mark and numerous serious problems result due to these pitfalls in TT placement and management of CDU's. So the nurses and residents should be properly trained regarding management of chest drains to avoid lethal complications.

Recommendations

I. Connections of tubing should be done vigilantly and should be cross checked by a senior team member.
II. After finishing the TT placement, the proper functioning of CDU system should be confirmed. It can be done by observing the "swinging" of water column with respiration [2].
III. At least 4cm of tube length coming from the patient's chest should be immersed under-water to protect against end of tube coming out of the water in case of bottle tilt [17].
IV. A standard, properly designed CDU system should be used. Manufacturer's instructions should be closely followed in setting up the CDU system.
V. Multiple connections should be avoided.Ends of connection pieces should be serrated / stepped. No connection of CDU should ever be covered with an adhesive tape [17]. Appropriate level (4-5 cm) of prime fluid should be maintained in the bottle of CDU. It should not be allowed to build up beyond 15 cm. If it is higher than 15 cm, then a status of relative tension builds up in the system, and at level higher than 25 cm, features of tension pneumothorax can appear if there is air-leak from the lung [18].
VI. Mac technique should be implemented while performing a TT placement. It comprises of grasping the external portion of the TT, turning it clockwise at 180 degree and then releasing the tube. If the tube restitutes back to its original position, the test is considered positive and the tube is considered to be kinked. If the tube does not spin back and stays in its position upon release, the test is considered negative [14, 20]. Another course of action is to use blunt malleable sterile stylet inside the tube at the time of insertion. It is inserted into the chest tube so that it does not protrude beyond the tube and is actually 1 cm short of the tip, to avoid visceral injury by the stylet [21].

VII. Unnecessary repeated clamping of the tubing should be avoided. If a clamp is applied at all, then on removal of the clamp, careful examination of the tube should be done to rule out any structural damage to the tube at the site of clamping [22]. Use of rubber tipped or padded clamps are less likely to cause structural damage to the tube. It should be assured that suction system is functioning properly. When suction is no longer needed, it should be detached from the bottle of CDU [17].

VIII. Patient and the family should be properly educated regarding handling of CDU and to keep them below the level of patient's chest. Flutter valve systems may be used in patients who are stable, with mild air and fluid leak from the TT [23]. Only simple, sterile 0.9% saline solution should be used as prime fluid in the under-water seal bottles. Anti-septic solutions should never be added to prime fluid because these are highly irritant and their retrograde flow can result in chemical pleuritis.

IX. To avoid shallow insertion of TT, the approximate length of the TT to be inserted into the pleural cavity should be measured before insertion. There should be a distance of at least 5cm between the last eyelet of chest drain and entry point of chest drain into chest wall *[24]*. In general no extra holes should be created into the chest drain. If it is necessary to create extra holes, then distal most holes should be created across the radiopaque line. The fixation stitch on the tube should be tied with patients arm in adduction *[25]*. If chest tube is fixated with patient's arm in full abduction (especially in obese patients) and after fixation patient adducts the arm, the fixation stitch moves caudally with the folds of skin, it pulls the tube down as well which may lead to last eye coming out of pleural space . To prevent sub-cutaneous placement adequately sized incision will allow full dissection through subcutaneous tissue and intercostal muscles. Prior to entering the pleural space, sterile gloved finger should be passed through the dissected tract to confirm that pleural space has been entered.

X. Never pass the fixation stitch through the chest tube as it creates a tiny communication through the hole between the negative intra pleural and the atmospheric pressure. Odd and inappropriate chest tubes i.e. Foley catheter, NG tube and IV infusion set should never be used in place of standard chest drains.

Conclusion

Dysfunctional closed chest drainage unit is a common but serious clinical problem. It mostly results due to wrong connections of CDU system. Whereas inadequate prime fluid, loose connections, kinked tubes and over full bottles are the other major causative factors of dysfunctional CDUs. We believe that, these mistakes in handling with the TT and CDU system are mainly being practiced by the residents and the nurses. It is because of their inadequate knowledge and poor experience. Therefore, training courses for both the residents and the nurses are mandatory in any hospital dealing with thoracic patients. The authors suggest that only standard, specifically designed chest tubes and CDUs should be used. Furthermore, the residents and paramedical staff should be educated and trained in how to follow the proper protocol of tube thoracostomy and management of chest drainage unit system. In this way, we can prevent this life threatening and disastrous condition.

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