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Value of Using One-Way (Heimlich) Valve after Esophagectomy: A Retrospective Cohort Study

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1. Abstract

This is an observational study of the value of one-way flutter (Heimlich) valve in the patients undergoing hybrid minimally invasive esophagectomy. The study is aiming to establish the efficacy of the Heimlich valve drainage bag system as a safe alternative to a conventional underwater seal drainage bottle

1.1. Background: The aim of this study is to establish the efficacy of Heimlich valve drainage bag system as a safe alternative to conventional underwater seal drainage bottle in the management of post esophagectomy pleural collections.

1.2. Methods: Heimlich valve was introduced gradually to a total of 119 patients in a phased manner over 11 years.

1.3. Findings: 98% of patients successfully mobilised on POD 1. 94% of patients have their drain removed by POD 4. Overall pulmonary complications occurred in 8.4% of the patients with 4.2 % developed pneumonia, 1.7% had respiratory failure, 1.7% had pleural effusion and 0.8% developed lung consolidation. Ninety-day mortality was 3% and overall morbidity was 21%. The median of length of hospital stay was 6 days.

1.4. Conclusion: The Heimlich valve connected to drainage bag is an effective and safe alternative to the standard underwater seal drainage bottle in the management of post esophagectomy pleural effusion.

2. Introduction

Esophagectomy is one of the mainstays of treatment for esophageal cancer [1]. The operation involves thoracic dissection, either through thoracotomy or thoracoscopically. Dissection in the chest stimulates the production of effusion fluid postoperatively [2]. In addition, sterile water is frequently used for wash-out at the end of surgery to check for anastomotic leaks [3].

Chest drain(s) are routinely inserted at the end of esophagectomy to drain collected effusion, possible leaking chyle and any residual air. Due to the negative pressure inside the chest cavity, chest drains are connected to under-water seal bottles, and this should always remain below the patient's chest level [4, 5].

Under-water seal bottles are bulky and cause significant hindrance to mobilisation as they need to be carried below chest level by another person during the mobilisation of patients [4, 5]. Among other factors, the connection to under-water seal bottles contributes to the limited mobilisation of esophagectomy patients in the early post-operative period. This usually translates to a higher incidence of post-operative pulmonary complications [6-8].

This has prompted us to search for safe alternatives to under-water seal bottles. We became aware of the one-way Heimlich valve [5].

Heimlich valve was first described in 1968 by Henry Heimlich as an alternative to bulky under-water seal bottles for use after spontaneous pneumothorax, post-operative following thoracotomy for heart, lung, oesophagus or mediastinal surgery, pleural effusion and traumatic hemopneumothorax. Though there were concerns about clots occluding the valve in the immediate post operative period, he described its use after over 100 surgeries with no complications due to the clot. The US Army used these valves during the Vietnam war as they proved to be 'life-saving items. Despite the apparent benefits of the Heimlich valve, they have only found

limited use in thoracic surgery after pneumonectomy and by respiratory physicians to manage pneumothorax and pleural effusion. We are unaware of the use of the Heimlich valve after oesophageal surgery, and this is the first publication in literature describing its use after esophagectomy.

We introduced the Heimlich valve cautiously and gradually after esophagectomy. When we confirmed its safety and efficacy, we started using it as part of our standard protocol for esophagectomy patients. We review and share our experience of Heimlich valve use after esophagectomy in the last thirteen years.

3. Presentation

The Heimlich valve (Figure 1): The valve consists of a plastic cylindrical tube with two graduated rubber ends on each end of the cylinder, and they connect to the chest drain on one end and a collection bag on the other end (Figure 2). Inside the cylindrical tube, there is a unique rubber tube which normally has collapsed walls, but it is kept open on the end connecting to the chest drain to allow the flow of fluids through it. The collapsed walls on the other end prevent the regurgitation of fluids back to the chest. An arrow is drawn on the cylindrical tube to indicate the correct direction of the connection. In our series, we used two versions of the Heimlich valve type tubes. They are similar but differ in two minor things. The first tube has a rigid plastic cylinder and one blue rubber end connected to the chest drain. The other tube consists of a squeezable plastic cylinder, and the two rubber ends are similar and not coloured.

This study was conducted at Princess of Wales Hospital in Bridgend, Wales, UK. The study included all patients who underwent hybrid minimally invasive esophagectomy from January 2009 to July 2020.

We introduced the use of the Heimlich valve in 3 phases over two years, and once the efficacy was established it became a part of standard practice after 2010.

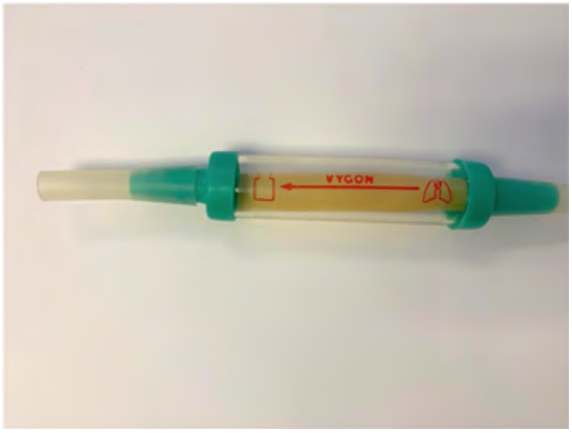

Figure 1: Heimlich valve

Figure 2: Heimlich valve connected to Bile Bag

3.1. First Phase

Under-water seal bottles were replaced for the Heimlich valve on day three after esophagectomy. Chest drain was clamped during the change, the tube connecting the chest drain to the under-water seal bottle was removed, and the top end of the Heimlich valve was connected directly to the chest drain. The bottom end of the valve was connected to an ordinary bile bag. This phase continued for six months, and during this period, active monitoring of the output was implemented. Chest X-ray was ordered 24 hours after connection to the Heimlich valve to assess for residual effusion not drained through the Heimlich valve.

3.2. Second Phase

This also continued for six months, and the valve inserted as described above on day two post-esophagectomy. Active monitoring of the chest output was maintained, and a chest X-ray was performed 48 hours after the valve placement to check for residual non-drained effusion.

3.3. Third Phase

After the first and second phases, confidence with the use of the valve was achieved and therefore, the Heimlich valve was inserted on the first post-operative day. The output was closely monitored, and this phase continued for another twelve months.

3.4. Established Practice

Since August 2010, we have inserted the Heimlich valve straight at the end of esophagectomy operations.

The study did not need ethical approval, as it just replaced the traditional water-seal drainage system with a more portable and patient-compliant Heimlich valve-bag collection system after a Hybrid Minimally Invasive esophagectomy.

Regarding contraindication to the use of the Heimlich valve: It is not practical to use the valve in the presence of significant pneumothorax and pleural efflux. The accumulated air distends the drainage system and would need frequent deflation, which is not convenient. The relatively common minor pneumothorax was not a contraindication to using the Heimlich valve-bag system.

3.5. Change of the Valve

The Heimlich valve was replaced with another valve when we noticed that the cylinder was full of debris and sediments/clots as this could impair free drainage. Also, the Heimlich valve was replaced with an under-water seal bottle when patients had significant pneumothorax manifesting itself in a ballooning of the connected bag. The chest drain was clamped during the process of replacement of the valves.

Chest drains with the Heimlich valve were removed when the daily output was less than 250 ml and contained no chyle or gastric fluid.

This study was done in line with the STROCSS criteria and registered with Research Registry. The registration ID is: researchregistry8108 which is accessible using the link https://www.researchregistry.com/browse-the-registry#home/ [9].

4. Results

One hundred nineteen consecutive esophagectomy patients were managed using the Heimlich valve instead of the under-water seal bottles. All patients had hybrid minimally invasive esophagectomy (HMIO) with laparoscopic abdominal part and right thoracotomy.

The median number of Heimlich valves used per patient was two valves and ranged from one to three. In the group of 98 patients where the Heimlich valve was connected at the end of the surgery, two patients had the valve initially removed and the chest drain connected to under-water seal bottles because of significantly associated pneumothorax. The Heimlich valve was reinserted in these two patients on day one in the first patient and on day two on the other when the pneumothorax spontaneously resolved. A total of 24 chest x-rays performed on 21 patients in the initial two-year period. None of these chest x-rays has revealed significant residual effusion, which was not drained through the Heimlich valve.

The recorded amounts of drained chest fluids were comparable to the pattern and quantity of drained chest fluids post esophagectomy prior to the use of Heimlich valve. None of the patients in this cohort suffered clinical shortness of breath or difficulty breathing due to residual effusions not drained through the Heimlich valve. Delayed pleural effusion after removal of chest drains and home discharge occurred in three patients. One patient was found to have Chyle leak which was treated by thoracotomy and ligation of the thoracic duct. The other two patients were treated by needle aspiration, and there was no need for reinsertion of chest drains. Three anastomotic leaks and two chyle leaks occurred in this series. One of the patients with chyle leak was diagnosed after the patient discharged home and presented ten days later with shortness of breath. The other chyle leak and the three anastomotic leaks were recognised when chyle and gastric contents were present in the drainage bag. The presence of the Heimlich valve did not obstruct the flow of these thickened fluids.

Mishaps in connection of the Heimlich valve occurred in one patient when a surgical trainee connected the valve in opposite direction. Instead of connecting the opened rubber end to the chest drain, he connected the collapsed end to the chest drain. It was recognised after few hours when it was noted that there is no fluid collecting in the valve and the drainage bag. The valve was reinserted in the correct direction and no complications happened.

In the group where Heimlich valve was connected at end of surgery (98 patients), mobilisation and walking around the bed on post-operative day 1 was achieved in all but two patients (98%). The chest drains with the connected Heimlich valve were removed on post-operative day 3 or day 4 in 112 patients (94%). Ninety-day mortality was 3%, and overall morbidity was 21%. Overall pulmonary complications occurred in 10 patients (8.4%) where 5 patients developed pneumonia (4.2%), two patients had a respiratory failure (1.7%), two patients developed pleural effusion (1.7%) and one patient developed lung consolidation (0.8%). The median hospital length of stay was 6 days, but this was significantly reduced in the last five years with a median of 5 (4-7) days compared to 8 (7-11) days in the first seven years.

5. Discussion

After esophagectomy, blood, air and fluids in the thoracic cavity interfere with the negative pressure in the chest and could cause lung collapse [10]. Ventilation with positive pressure would prevent lung collapse but if the patient is breathing spontaneously, a vent (chest drain) is needed. The most used drainage system after esophagectomy is the chest drain connected to water-seal bottle. The water seal is an efficient drainage system but has few limitations which could impact on patients' outcome. It must be placed below the chest wall and works only in the upright position, and the tube must be clamped during the transportation of patients [4, 5].

The placement of the Heimlich valve and connection to the chest drain and the collecting bag is simple and easy. The outer tube is marked by an arrow to indicate which tend to be connected to the chest drain. Also, it is obvious from the opened end of the internal rubber that this should be connected to the chest drain. Although the upper end of the Heimlich valve was connected tightly with the chest drain, sometimes, for extra security, we reinforced the joint between the valve and chest drain with strong tape.

A similar ambulatory pleural drainage system Atrium Pneumostat (Atrium Medical Corp, Hudson, NH) is also commercially available as a one-way valve without the rubber tubing. However, we have no experience in this.

The main purpose of the water-seal drainage is to act as a unidirectional valve allowing drainage of the fluid and air out of the thoracic cavity and preventing air entry during the negative inspiratory phase. This allows for the re-expansion of the lungs and drainage of fluid. The chest drains also serve in the early detection

of complications like anastomotic leak and chyle leak. If there are no complications, then once re-expansion of lungs has been established the chest tubes can usually be removed.

The conventional underwater-seal chest drains are associated with significant morbidity and pain after an esophagectomy surgery and act as a significant deterrent in early ambulation of the patients, which hinders ERAS and may be associated with increased respiratory complications [6, 11]. Bearing this in mind, we introduced the novel concept of the Heimlich valve in oesophageal surgery. It has been used in thoracic surgery after pneumonectomy as part of fast-track surgery [12, 13]. We borrowed this concept and cautiously introduced this in a phased manner in esophagectomies at our centre. In our study we noticed that not only was this associated with better patient compliance, but it was also convenient to the nursing and physiotherapy staff. The patients were able to mobilise out of bed from day one after surgery which helped in early lung expansion and decreased respiratory complications as evidenced in our study. These drains, being smaller in size and not attached to any water-seal drains were associated with less pain, ease of understanding, and decreased length of stay. Heimlich valve has been used in outpatients' treatment of pneumothorax as safe, efficient and affordable option [14, 15], however in our study we did not explore this option.

There are a few case reports in the literature of the risk of tension pneumothorax if the outlet was blocked or if the valve was incorrectly connected [16]. Mishaps with the connection of the valve happened only in one patient where the opposite end of the valve was connected to the chest drain. It was recognised when it was noted few hours later that there was no drainage in the valve or the collecting bag. The valve was removed and reconnected in the correct position with no adverse effects on the patient.

It's well established that early mobilisation after esophagectomy reduces the risk of pulmonary complications, including chest infection [6-8]. The risk of pulmonary complications is usually between 20-40 % [17], and we reported a risk of 8.4% in our study. We strongly believe that the introduction of the Heimlich valve was a major contributor to improved outcomes in our cohort. However, we also altered our practice with other minor changes like an intercostal block over the epidural catheter and reduced reliance on opioid analgesia [18].

6. Conclusion

In summary, we believe in simplicity, and this was one of the various interventions which we used at our centre to uncomplicate recovery after major surgery and enable early recovery and improved patient compliance. This proved to be a safe, well-tolerated and efficient alternative to conventional under-water seal drainage. There is no RCT comparing the two-drainage system, and this could be a step further is establishing the efficacy.

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