REVIEW ARTICLE

Heimlich Valve as an Ambulation Management of Persistent Pneumothorax or Fluidopneumothorax

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ABSTRACT

Pneumothorax or fluidopneumothorax is a critical condition when there is some air or/and fluid in the plural cavity. The symptoms may include shortness of breath, chest pain, blue discoloration of the skin or lips, increased heart rate, and loss of consciousness. Pleural cavity drainage is management therapy with the concept of Water Seal Drainage (WSD), which requires a long hospital stay. Heimlich valve is a non-return valve that allows fluid and air to exit the thoracic cavity (on inspiration) and prevents fluid and air from re-entering (during expiration). Heimlich valve is a viable, inexpensive, convenient, safe, effective, and efficient alternative in the management of ambulation of patients requiring prolonged pleural cavity drainage. The use of Heimlich valve is an alternative option for patients with persistent pneumothorax or fluidopneumothorax. It can shorten the time of treatment in the hospital, lowering treatment costs, and minimize the presence of nosocomial infections. Relative contraindications include fluidopneumothorax with massive pleural effusion or empyema. The risks and complications are dislodgement or improper reattachment, leaking valve, adhesion, and blockage, thus becoming tension pneumothorax or pleural cavity infection. Currently the latest innovation also improves the patient's convenience, like Thoracic Vent, Pneumostat, or Mini Mobile Dry Seal Drain.

INTRODUCTION

Pleural cavity drainage has been performed since the early 5th century BC by Hippocrates. There are two kinds of drainage, open and closed drainage, which have been debated for centuries by respective surgeons on both sides. In 1873, Playfair first introduced the concept of Water Seal Drainage (WSD) to treat thoracic empyema in a child.[1]

The concept of WSD is still used in various hospitals to treat cases of pleural effusion, pneumothorax, or fluidopneumothorax. The shape and design of the WSD device are developing and become modern. WSD not only has advantages but also several disadvantages. This drainage system needs more management. The level of water in the WSD tube needs to be maintained at the correct level to expel air from the pleural cavity. Nurses and other health workers need to have the knowledge and skills regarding the procedures for treating, cleaning, and sterilizing drainage equipment. The weight of the WSD bottle or device causes an increase in the length of stay for patients, thus increasing health care costs. In cases which require long-term care, WSD limits the patient's ambulation.[2]

A smaller, portable pleural cavity drainage device was created to facilitate the patient to ambulate more quickly. In 1968, Henry Heimlich introduced a flutter valve chest drainage, namely "Heimlich Chest Drain Valve". It is a one-way valve for handling pneumothorax.[3]

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Heimlich valve is a non-return valve that allows fluid and air to exit the thoracic cavity (on inspiration) and prevents fluid and air from re-entering (during expiration).[4] Heimlich valve is used for patients who still need drainage of the thoracic cavity but no longer require hospitalization. Patients can be outpatient with a Heimlich valve but still within special care. Patients can walk and resume their activities by storing the Heimlich valve and drainage bag inside the shirt thus it will not be visible from the outside. Heimlich valve can continue to be used until the excess fluid or air in the thoracic cavity is depleted and the lungs can expand again. Studies have proven that it is safe, relatively simple, efficient, and provides good results in the treatment of primary pneumothorax and secondary pneumothorax in patients with Pneumonocystis carinii, AIDS, cystic fibrosis, pulmonary metastases, and any others.[5]

History of Heimlich Valve

In 1962, Judah Henry Heimlich, an American thoracic surgeon and medical researcher discovered a flutter valve chest drain (Heimlich valve). Heimlich valve was made based on Heimlich's inspiration when he saw a Chinese soldier died on the operating table from a gunshot wound to the chest during World War II in 1945. In his essay "One Can Make a Difference", Dr. Heimlich stated that lungs can collapse due to compressed air, blood, or other material in the thoracic cavity. This can occur from gunshot wounds, stab wounds, or injuries during chest wall surgery. Therefore, it is necessary to insert a chest tube and connect it with a suction device (regulated suction). This aims to drain the blood, fluid, and air out of the thoracic cavity. The collapsed lung is expected to expand again, thus the person is safe. Chest drainage and suction devices were limited in number on the battlefield, resulting in the death of thousands of soldiers. Dr. Heimlich created a small, portable valve, which can drain air and other fluids from the thoracic cavity, but prevents air or fluids from entering from the outside.[3,5]

Heimlich valves were provided to American soldiers in the Vietnam War. This discovery is claimed to have saved the lives of hundreds of soldiers who were shot in the chest during the war. Heimlich valve is not only used in the emergency treatment of pneumothorax on the battle front. This tool is widely applied in the world of health. Heimlich valve becomes very popular today in the ambulation management of patients with prolonged pneumothorax due to various causes.[3]

Structure of Heimlich Valve

Heimlich valve is a small tube with a non-return valve inside which is sterile and for single-use. It is about 13 cm (5 inches) in size and weighs 22.5 grams.[5] The small tube is a single transparent chamber made from PVC (Polyvinyl chloride). The transparent material makes it easy to observe valve motion. The valve is a rubber sleeve, the distal part is compressed and flat. It is used to control the flow of air, where the air can pass from the proximal part but not the other way around. The two ends of the tube are pointed, functioning as connectors. The end of the proximal tube (inlet nozzle) is the part that is directly connected to the valve on the inside. This connector will be connected to the chest tube that leads to the thoracic cavity. The distal tube (outlet nozzle), is not directly connected to the valve on the inside. This connector will be attached to the drainage bag.[6,7]

Action Mechanism of Heimlich Valve

Heimlich valve works as a one-way valve. During expiration, air or/and fluid from the pleural cavity enters the inlet nozzle and passes through a rubber valve. The air will pass and flow through the outlet nozzle to the environment. During inspiration, the free end of the rubber valve has a lower pressure, thus it closes and prevents the air from entering the pleural cavity.[5,7]

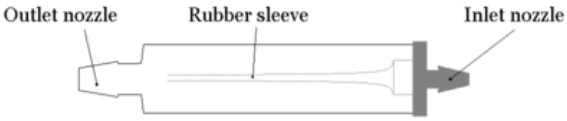

Figure 1. Structure of Heimlich valve[7]

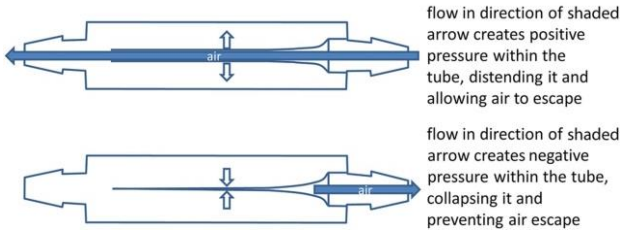

Figure 2. Action mechanism of Heimlich valve[7]

Figure 3. A patient's mobility with Heimlich valve.[9]

The inlet nozzle and the outlet nozzle should be open and unobstructed. Movement of the rubber valve is a sign of flowing air when breathing. This ensures that the Heimlich valve is functioning properly. The absence of rubber valve movement indicates that no air is passing through the valve, this indicates a resolution of the pneumothorax (the lung has expanded) or may indicate a possible blockage. Therefore, it is necessary to monitor the patient's clinical condition periodically as well as supporting radiological examinations.[5]

The Advantages of Heimlich Valve

Heimlich valve has several advantages over other drainage devices. It has a small size, lightweight, and portability, allowing the patient to ambulate more quickly. It is safe, simple, efficient, and easy to use. Its function and workings are not difficult for both health workers and the patients to understand. The production cost of Heimlich valve is relatively small, making it possible to become a single-use device without the need for re-sterilization. The tool is sterilized before packaging, stored in a sterile package, and is immediately ready for use.[8]

Patients with a Heimlich valve can feel more comfortable and have faster mobility. Patients can walk around the hospital ward by hiding the device under their clothes. This allows for early recovery of pulmonary function, increases motivation and the patient's independence, and avoids the stigma associated with chest tubes.[2] Patients can be discharged early from the hospital, o reduce treatment costs, and avoid nosocomial infections. Heimlich valve can also be used in various positions and does not need to be clamped. It is not limited to just below the patient's chest.[4]

Indications for Heimlich Valve Installation

Patients with pneumothorax or fluido-pneumothorax require special hospital care. Air, fluid, or blood in the pleural cavity causes the lung to collapse and even deviation of the mediastinal structures may occur. This condition can cause shortness of breath, which in certain conditions can cause life-threatening tension.[1] The procedure for expelling air, fluids, or blood is performed by placing a chest tube. During hospitalization, the chest tube will be connected to WSD. In certain conditions, lungs have not been able to fully expand and thus require longer treatment. This certainly increases the cost of hospitalization and makes the patients uncomfortable. The use of Heimlich valve is an alternative option for patients with persistent pneumothorax or fluidopneumothorax.[5]

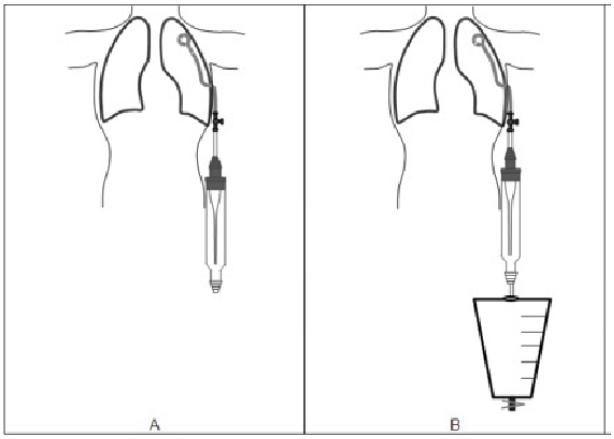

Figure 4. A. Chest tubes and Heimlich valve on persistent pneumothorax ; B. Chest tubes, Heimlich valves, and drainage bags in persistent fluidopneumothorax[10]

In patients with persistent pneumothorax whose lung reserves are poor, surgery is not possible. Treatment with chest tubes is required in the long term. Therefore, Heimlich valve is used to drain air from the pleural cavity while being outpatient. In fluidopneumothorax patients, the outlet nozzle is connected to a drainage bag. If being trained properly, measuring and draining can be performed quite safely by the patient or the family. It can also be connected to a negative pressure device if needed.[5,10]

Contraindications of Heimlich Valve Installation

No specific contraindications to the use of Heimlich valve in the literature. Relative contraindications include fluidopneumothorax with a large volume of fluid (massive pleural effusion) or thick pleural fluid secretion (empyema). Thick pleural fluid/empyema increases the risk of adhesions/ blockages, which can lead to tension pneumothorax.[5,7,10]

Installation Technique of Heimlich Valve

The installation procedure is started by the insertion of a chest tube. The chest tube used consists of several sizes. In the case of primary spontaneous pneumothorax, Heimlich valve can be connected to a small (8 Fr) chest tube.[11,12] This can minimize the possibility of bleeding and will reduce pain. The chest tube is connected to the inlet nozzle of the Heimlich valve. Meanwhile, the outlet nozzle of the Heimlich valve does not need to be connected to a drainage bag in pneumothorax or connected to the drainage bag in fluido-pneumothorax.[10,13]

Before the patient is being discharged from the hospital, it is necessary to recheck the sutures in the chest tube insertion. If you feel that the sutures are not strong enough or loose, it can be sutured again with a non-absorbable suture. Make sure gauze and plaster are securely attached to prevent accidental dislodgement.[2]

Patient Care with Heimlich Valve

Patient care using Heimlich valve should observe the wounds of the chest tube insertion, each part and the connecting part of the drainage system, and the drainage bag. The wound should be covered with a clean, dry, and firm gauze which is changed every day. If the gauze is wet, it should be changed immediately to prevent it from a possible source of infection. If the gauze is loose or being lifted from the skin, it should also be replaced to prevent the discharge of the chest tube spontaneously. The connections between the parts of the drainage system must always be evaluated. The addition of adhesive aims to prevent accidental dislodgement.[13]

In fluidopneumothorax patients, Heimlich valve is connected to a drainage bag to accommodate the discharge fluid. The liquid collected in the drainage bag needs to be removed periodically and recorded to monitor its progress, about the amount and any changes in liquid color. An increase in the amount of fluid or a change in color can be a sign that further examination is needed. Drainage bags also need to be replaced with new ones regularly, thus they will not become a source of infection.[10]

Patients must be more careful in their activities. If the Heimlich valve accidentally disconnected between connectors, they must be reconnected immediately. The inlet nozzle of the Heimlich valve is connected to the chest tube, while the outlet nozzle is connected to the drainage bag. The patient is asked to cough to expel any extra air that may have entered the thoracic cavity when the plug of Heimlich valve disconnects.[13]

Patients should see a doctor every week to know the condition of the Heimlich valve and the progress of the disease. The clinician needs to evaluate for valve occlusion, valve leakage, discoloration of chest fluid secretions, and clinical signs of complications in the patient such as pneumothorax, infection, or subcutis emphysema.[1] Radiological investigations will be performed periodically to evaluate the patient's lung condition, whether it is an improvement or a worsening of the condition. Patients can come to the doctor outside their routine schedule if they experience high fever, intense feeling of tightness, chest pain, swelling of the neck or hands, pain that increases and does not go away by pain medication, the skin around the chest tube is red, swollen, or feels warm, painful to the touch, the amount of liquid from the collection bag increases, the liquid changes color or cloudy, and smells.[2,10,14]

Risks and Complications of Heimlich Valve Installation

The risks of installing Heimlich valve are dislodgement or improper reattachment, leakage, adhesion, or blockage of the Heimlich valve. Dislodgement is the disconnection between parts of the drainage system which usually occurs accidentally. Improper accidental reattachment is the reversal of the Heimlich valve which can cause the entry of free air into the pleural cavity. The pressure in the pleural cavity that is lower than free air causes the air to enter the cavity, especially during inspiration. During expiration, the valve that is inverted cannot open (because it is compressed). This can result in a tension pneumothorax. The risk of applying accidental dislodgement is prevented by additional adhesive to the joints between parts. The risk of reattachment can be prevented by applying a different color to the proximal and distal tube ends to avoid valve reversal.[13]

The poor condition of Heimlich valve or prolonged use can cause leakage. The rubber on the Heimlich valve does not work optimally, thus the one-way adjustment function is disturbed. Heimlich valve may develop adhesions or blockage. Thick pleural fluid secretions such as blood or empyema can cause clotting. This can cause valve occlusion and the airflow becomes

obstructed. Tension pneumothorax can happen, thus it needs to be connected using WSD.[15] Apart from pneumothorax, the patient may also develop complications of subcutis emphysema, which may require hospitalization again.[5]

Complications of pleural cavity infection can happen; if the chest tube and Heimlich valve installation are less sterile. The fluid from the pleural cavity may turn cloudy or have a foul odor, which is a feature of empyema. Poor care of the wound around the chest tube can also lead to local infection. When this happens, there is a very high risk of removal of the chest tube spontaneously. Complications of infection are prevented by performing sterile insertion procedures and administering antibiotics. There have been no reports of serious complications associated with the use of Heimlich valve documented. This shows that if used properly and informed correctly to health care workers and patients, Heimlich valve is a safe and efficient procedure.[5]

Indications for Heimlich Valve Removal

Indications for Heimlich valve removal is the drainage production of less than 100ml in 24 hours, drainage fluid is not an empyema, and there is an improvement in auscultation of breath sounds in pneumothorax.[8] An enlarged lung is characterized by immobilization of the valve during breathing and coughing. This needs to be confirmed by radiological examination. If improvement has been proven, the drainage system can be removed.[7]

The success of Heimlich valve in patients with pneumothorax or fluidopneumothorax is quite good. Complications are rare. In certain cases, further action is required. In a retrospective study at St. Mary's Mission Hospital Elementaita for 4 years, only 7% of the sample required surgery, because there were a localized pleural effusion and thickening visceral pleural. The timing for Heimlich valve removal is uncertain and varying in each case, depending on the cause of the disease, comorbid factors, and the patient's response. In a retrospective study at the same place within the same period of time, Heimlich valves were removed within an average of 6 days.[8] In a case report of a patient with a recurrent pneumothorax, the Heimlich valve was removed within 2 weeks.[2] In a case report of a patient with pneumothorax for cystic fibrosis, the Heimlich valve was removed within 2 months.[8]

Before removal, the Heimlich valve and chest tube were clamped for 24 hours. If the lungs continue to expand and the patient is not tight on radiological images 24 hours after closing, the chest tube can be removed.[9] When removing the Heimlich valve and chest tube, the patient is instructed to perform the valsalva maneuver or to hold their breath in a forced expiration prior to the removal of the chest tube. At the same time, the chest tube is removed quickly and smoothly then the sutures are tied back tightly. After the removal of the chest tube, it is necessary to observe for signs and symptoms of pneumothorax. These complications can occur hours to weeks after removal.[9]

Innovation based on Heimlich Valve

Over time, there are many innovation based on Heimlich valve. These devices were created to increase patients' safety and comfort.

1). Heimlich valve with a different color on both ends of the tube.

This product has a different color on both ends, which prevents reverse installation. The inlet nozzle which is connected to the chest tube is blue, while the outlet nozzle remains open or connected with a transparent drainage bag. The advantage of this tool when compared to the conventional ones is that it reduces the possibility of errors (inverted) in installing Heimlich valves.[8,9]

Figure 6. Heimlich valve with a different color of the two tube ends[8]

2). Tru-close Thoracic Vent (Thora-Vent)

Tru-close thoracic vent (Thora-Vent) is an air drainage tool in pneumothorax that allows the patient to ambulate early. The non-return valve inside causes air to escape but not re-entering the chest cavity. There is a red diaphragm that functions as an indicator of pneumothorax as reflected by intrapleural pressure. The advantages of this tool when compared to the conventional ones are that it is small, light, safe, and minimally invasive.[16]

Figure 7. Tru-close thoracic vent (Thora-Vent)[17]

3. Pneumostat Chest Drain Valve (pocket-sized Heimlich valve)

The pneumostat chest drain valve is an innovation that adopts the one-way Heimlich valve which immediately has a small drainage space.[1] The non-return valve is able to remove air leaks and prevent air from re-entering the thoracic cavity. The small drainage space can accommodate about 30 ml of liquid which can be removed through the end of the distal chamber (sample port) by suction using a syringe. Pneumostats can be connected to chest tubes of various sizes.[2] This appliance is simple, light, not too large, easy to carry, and easy to hide under clothes. The advantage of this tool when compared to the conventional ones is that there is only one connection, thus minimizing the possibility of error reattachment. [18,19]

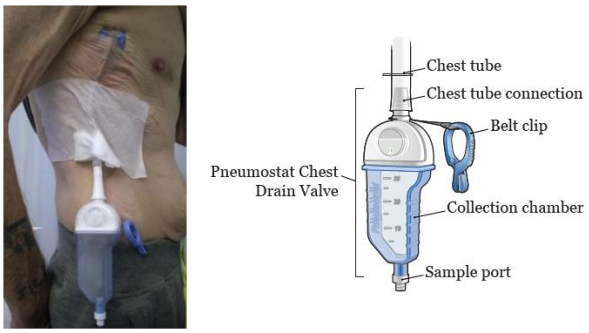

Figure 8. Pneumostat chest drain valve (pocket-sized Heimlich valve) [19,20]

4. Mini Mobile Dry Seal Drain

Mini Mobile Dry Seal Drain is a modified drainage unit using a one-way valve. This tool is often used to remove excess air and fluid in postoperative patients. The non-return valve allows air and fluid to escape but cannot re-enter the chest cavity. The advantage of this tool when compared to the conventional ones is that it is light but can accommodate up to 1,000 ml of liquid. Patients can ambulate early, thereby reducing the length of stay, minimizing the risk of nosocomial infections, and accelerating the patient's independence.[21]

Figure 9. Mini Mobile Dry Seal Drain[22]

SUMMARY

Heimlich valve is a one-way valve that allows fluid and air to exit the thoracic cavity (on inspiration) and prevents fluid and air from re-entering (on expiration). It is a viable, inexpensive, convenient, effective, and efficient alternative in the management of ambulation of patients requiring prolonged pleural cavity drainage. The high success rate, safety, and very low morbidity are strong reasons for using Heimlich valve in patients with persistent pneumothorax and fluidopneumothorax. Patients can ambulate faster to reduce treatment costs and minimize the presence of nosocomial infections.

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