

# The chest drainage system

AK K A Mihiran, P Pitigala, D V T Harischandra, G Piyasiri

Teaching Hospital Karapitiya, Galle, Sri Lanka

**Correspondence** : Dr Amila Mihiran; mihiranmed@gmail.com

**Competing interests** : None declared

**Key words** : chest drainage system, underwater seal drainage

The chest tube is a flexible tube inserted into the pleural or pericardial cavity to remove air or fluid when present. The distal end of the tube connects to a drainage system through an underwater seal.

## Physiology

In inspiration, the intra thoracic pressure will decrease below the atmospheric pressure. The intrapleural pressure is always negative and during inspiration it becomes even more negative ( $-8\text{cm H}_2\text{O}$ ); during expiration it becomes less negative ( $-4\text{cm H}_2\text{O}$ ). A loss of this negative intra-pleural pressure due to any reason (such as when there is air or fluid in the pleural cavity) will lead to lung collapse.

A chest drainage system consists of a chest tube and chambers with an under-water seal, sometimes with added suction. The chest drainage system should be able to remove the fluid and/or air from the intrathoracic cavity, prevent the drained air and fluid from re-entering the pleural space and restore the negative pressure in the pleural space to re-expand the lung (1).

The distal end of the chest drain tube should be submerged 2cm under the surface level of water (or collection) in the drainage chamber. This creates a hydrostatic column of  $+2\text{cm H}_2\text{O}$  at the distal end of the drain tube.

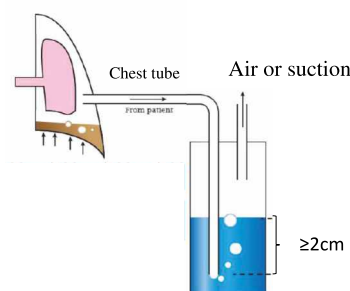
When air or fluid enters the pleural space, the intra-pleural pressure rises. If it rises sufficiently such that it starts to compress and displace the intrathoracic organs and diaphragm it becomes tensioned (tension

pneumo/ hydro /haemothorax). When the intra-pleural pressure is greater than  $+2\text{cmH}_2\text{O}$ , the air is eliminated from the pleural space into the drainage chamber along a pressure gradient. This aids the air filled in the pleura to be expelled out of the tube into the chamber and produces air bubbles. These air bubbles cannot re-enter into the tube because of the hydrostatic pressure  $\geq 2\text{cmH}_2\text{O}$  at the distal end of the tube. When the chamber is filled  $\geq 2/3$ , it produces a great hydrostatic column and therefore resistance at the distal end of the tube resulting in difficulty in removal of air from the pleura. So when the chamber becomes  $\geq 2/3$  filled, it should be changed or otherwise a suction should be applied.

The drainage chamber has a vent which allows the air to escape from the chamber, and not accumulate within the chamber. Fluids are drained by gravity through the chest tube into the drainage chamber. To prevent fluid re-entering into the pleural space, the chamber should always be kept at least 45 cm below the level of the patient's chest.

There are different types of chest drain bottles depending on the number of chambers.

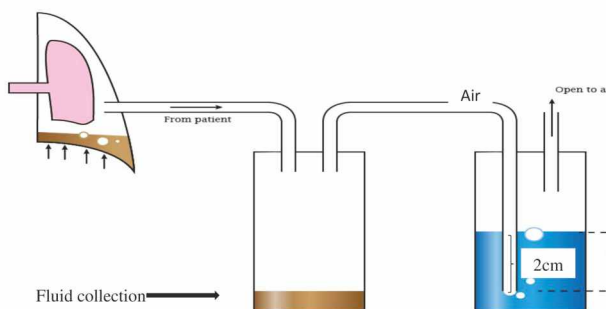
## Single chamber underwater seal drainage



**Fig 1** : Single chamber underwater seal drainage

In the single chamber underwater seal drainage system, the distal end of the chest tube connects to a rigid straw which is immersed into the bottle. Its tip is located 2cm below the water level and the vent tube is opened to the atmosphere to decompress the pressure from the air leak (fig 1). This is the simplest and most common configuration and is best for simple pneumothoraces. However, it is not ideal for drainage of fluid such as pleural effusions because as there is a risk of fluid returning into the pleural space if the chamber is inadvertently raised to a level above the chest. In the case of both air and fluid drainage, when a significant quantity of liquid is drained from the pleural cavity of the patient, the liquid level will rise, thus requiring a greater pressure on the rigid straw to remove additional air from the pleural cavity to the bottle effectively.

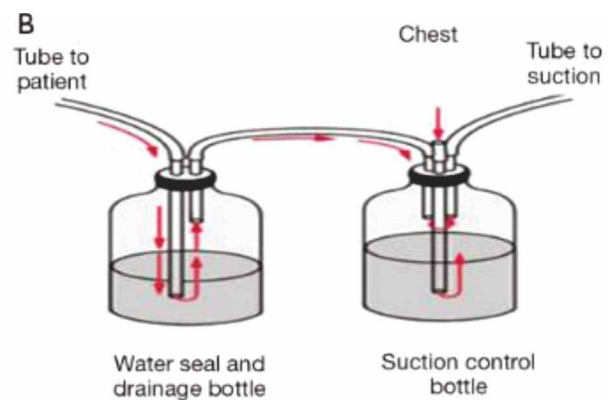
### Two chamber underwater seal drainage



**Fig 2 :** Two chamber underwater seal drainage

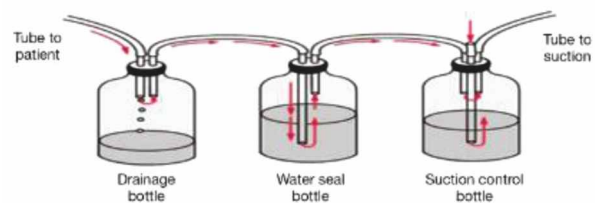
In the two chamber underwater seal drainage system, there is a separate chamber prior to the underwater seal chamber which is mainly for the collection of fluids from the chest tube (fig 2). As the fluid collects into a separate chamber, hydrostatic resistance at the distal end of the tube can be maintained at a near constant. This minimizes the effect on the air passage from the pleura to the atmosphere. This configuration is desirable for both pneumothoraces and pleural fluid collections but is less efficient for the draining of air. Both the one and two-bottle chest drainage systems rely on gravity to create a pressure gradient by which air and fluid leaves the chest. Keeping the drainage system below the level of the patient's chest enhances gravity drainage; additional pressure is created when the patient exhales or

coughs. Efficiency of drainage can be improved with application of suction and for that purpose, it can be further modified by introducing a suction controller (fig 3).



**Fig 3 :** Two chambers with suction controller

### Three chamber underwater seal drainage

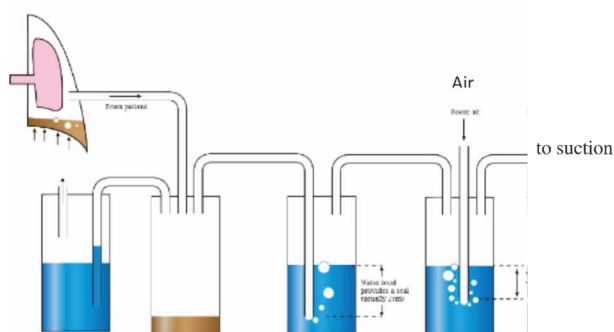


**Fig 4 :** Three chamber underwater seal drainage

In the three chamber underwater seal drainage system, the two chamber configuration is connected to a suction control chamber (fig 4) where the suction pressure can be maintained at a desirable level and the pleura will not be exposed to undesirable pressures. This is desirable for both pneumothoraces and pleural fluid collections. This configuration ensures that air expulsion is not affected by any changes in underwater resistance as it maintains a stable pressure in the suction control bottle.

There are certain disadvantages of this configuration such as continuous bubbling, complexity and not being a fail-safe arrangement for suction failures. As there are three chambers, if the pressure increases inadvertently in these chambers, a considerable amount of air will enter into the pleural space and may worsen the pneumothorax.

### Four chamber underwater seal drainage



**Fig 5 :** Four chamber underwater seal drainage

In the four chamber underwater seal drainage system, there is an additional underwater seal chamber which is connected to the fluid drainage chamber of the three chamber drainage system. It will act as a vent and the patient may be protected from a pneumothorax in a sudden suction failure.

Present day advanced chest drainage systems incorporate the above principals while being more compact and digitalized. They can provide regulated negative pressure close to the patient's chest, based on the patient's air leak. They can monitor the air leak

and are programmed to only apply the suction required to maintain the negative pressure prescribed. More advanced systems have digital displays providing objective data in real time and can provide a 24-hour historical graph of the air leak, which allows easy tracking of the progress of treatment.

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