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Novel Chest Tube Design to Alleviate Clogging and Facilitate Video-Assisted Thoracoscopic Surgery

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Chest tubes are one of the most common devices used in thoracic surgery and in treating victims of trauma. This flexible catheter is used to alleviate pneumothoraces and evacuate pleural fluids.^{1,2} Current commercially available chest tubes may commonly develop intraluminal clot after placement. Though a variety of clogging mechanisms exist, a common means of catheter blockage is by thrombus or debris. This may cause the chest tube to malfunction or completely stop draining, which may lead infections and accumulation of pleural fluid. Karimov et al.¹ reported a cohort of 100 patients with 234 chest tubes post cardiac surgery and reported a 36% clogging rate. In that series, more than 80% of the thrombus formation (assessed at removal) in the chest tube was seen in the internal portion of the tube, making bedside visualization impossible.¹ In a survey that included 106 cardiothoracic surgeons, all respondents (106/106; 100%) confirmed encountering problems with clogged chest tubes and 87% reported adverse patient outcomes related to a clogged chest tube. 51% of the surgeons confirmed not being satisfied with currently available tubes.² Clogging of the tube can become life threatening in cases where intrathoracic bleeding will occur, accumulating around the heart and lung. Some believe that the commonly used stripping maneuver to try and declot clogged catheters may introduce negative intrathoracic pressure, leading to increased bleeding events.²

The novel chest tube design proposed by the authors (Figures 1 and 2) aims to address issues with clogging with inlets for thoracoscopic instrumentation. The chest tube is paired with a

specialized thoracoscopy instrument and large-lumen stopcock. Additionally, the novel chest tube can function by itself, such as bedside placement for a trauma-associated pneumothorax. The novel accompanying thoracoscopy instrument and stopcock can facilitate VATS and declogging maneuvers. The chest tube has large sideholes to facilitate drainage along with visualization and passage of a paired thoracoscopy instrument. The three-way valve is attachable to the end of the catheter and is comprised of a chamber with a nearly spherical inner surface, branch-tubes extending from it, and a rod-shaped operating part with a guide hole linking the inner surface of the chamber to the outside. The large inputs of the stopcock allow drained material and thoracoscopy instrument insertion. A sterilizable and reusable thoracoscopy device designed to work with the novel chest tube and is equipped with a camera paired with a suction-irrigator and biopsy probe. This camera facilitates direct visualization, allowing the operator to unclog the tube, reposition it, deliver drugs and contrast, perform interventional radiology procedures and pleurodesis, and obtain microbiology and histopathology specimens from the lung, pleura, and mediastinum.

Flow within catheters is governed by Poiseuille's law lumen size with catheter lumen size representing the most important factor, as the effect of the radius is raised to the fourth power in Poiseuille's law. The large valves of the stopcock does not decrease the lumen size of the catheter, which has been shown in prior studies to impede flow.³ Our design aims to make chest tubes more efficient in placing, durable, and salvageable from clogging. This could spare patients from multiple procedures, reduce the risk of infection and operation time, and make the detection of the tube malfunction and catheter tip position change easier. The lumen of the novel chest tube could be used as a port of entry for VATS, facilitating a single-incision (or reduced incision) procedure. Prior studies have shown that single incision VATS decreases postoperative pain and results in a higher patient satisfaction compared with the conventional three-port VATS.⁴ The novel chest tube described in the current work could function as a port, which may spare patients from extra ports.

Disclosures:

The authors hold intellectual property relative to the device described in this work issued as US patent application US20170304508 (patent assignment in process) and US patent #10,137,293. This was entered as in a 2015 invention contest; the entry is available at: <https://contest.techbriefs.com/2015/entries/medical/5318>. Dr. Ballard receives salary support from National Institutes of Health TOP-TIER grant T32-EB021955.

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Figure 1.
Schematic drawing of the chest tube device including a novel large bore three-way valve.

Figure 2. Schematic drawing of the thoracic catheter device system, wherein the thoracoscopy device is inserted in the three-way valve and through the chest tube and extends out a terminal hole in the distal end of the chest tube.