

Tube Thoracostomy: The Struggle to the “Standard of Care”

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Tube thoracostomy for thoracic injuries has been standard for only the last 40 years. Its theoretic roots trace back to World War II, where the goal of treatment was restoration of intrathoracic organ function. Thoracentesis was used to evacuate the hemopneumothorax resulting from chest trauma and that compromised pulmonary function. Experience gained in military and civilian hospitals contributed to the development of tube thoracostomy as an alternative treatment for patients with chest

trauma. Progress stalled due to technologic problems and unacceptable complications associated with tube thoracostomy use during the Korean War. Technology improved, however, as did the success of thoracostomy, and it eventually became the standard of care, first in the civilian community and, ultimately, in the Vietnam War.

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It has oft been said that great advances in trauma care evolve from lessons learned on the battlefield. One has only to mention such names as Paré, Larréy, Cushing, Debakey, Spencer, and Shires to conjure up images of battlefield innovation with far-reaching consequences. Perhaps it is the large number of casualties in a relatively brief space of time that gives rise to new approaches to age-old problems. Perhaps it is the austere environment that necessitates alternative technology. Perhaps it is the relative youth of those rendering care, with relatively youthful supervision, to relatively youthful patients in the prime of health. Perhaps it is because the wounded soldier inspires the greatest commitment of resources, both physical and emotional. Whatever the explanation, war and its toll in human trauma have been well-described contributions to advances in the surgical care of the wounded, as well as the training of those who render such care.

Somewhat surprising then is a review of the history of tube thoracostomy and chest trauma. Although we all agree most victims of penetrating injury—even blunt injury—to the chest respond to chest tube alone, this consensus was not derived from experience gained in armed conflict. On the contrary, military experience, much to the surprise of most surgeons, retarded the acceptance of tube thoracostomy for the initial, usually definitive, management of combat casualties with chest trauma. The conflict responsible for this delay in accepting tube thoracostomy as the standard of care was the Korean War (1950 to 1953). During that war, tens of thousands of United States military personnel died, and hundreds of thousands were wounded [1]. Next to the

head, the chest was the most common anatomic location of fatal wounds [2]. Appropriate use of chest tubes could have lessened those numbers.

The need to evacuate the hemothorax that resulted from a penetrating wound of the chest was recognized by Boerhaave in the early 18th century. He advocated use of “. . . a blunt-tipped flexible tube, perforated laterally . . .” inserted into the pleural cavity and to which suction was applied [3]. Although thoracostomy had been used by surgeons, such as Guy de Chauliac, in the 14th century for the management of chest trauma, without anesthesia, such procedures were rare. The introduction of ether anesthesia and radiography in the 19th century, in addition to endotracheal intubation [4] and blood transfusion in the 20th century, set the stage for potential major advances in the management of the penetrating chest wound encountered in World War (WW) I (1914 to 1918). These wounds, however, would be more life-threatening than those encountered in earlier wars.

Thoracic surgery was in its infancy when WW I was raging. Casualty figures on both sides were in the millions [1]. An estimated 70% of wounds were caused by high velocity missiles from modern rifles and machine guns as well as from high explosives caused by artillery, mortars, mines, and bombs [5], not unlike those inflicted throughout the 20th and into the 21st centuries. Not surprising, among those sustaining chest injuries in WW I (6% of wounded), mortality was 56% [3]. Treatment consisted of needle aspiration of hemothorax (paracentesis thoracis), wound débridement, “wound thoracotomy” for removal of foreign body, and suture closure of open pneumothorax. Formal thoracotomy, through a separate incision, was largely reserved for treatment of tension pneumothorax, hemorrhage, and diaphragmatic injuries or late complications such as empyema or pulmonary entrapment and with cautious decortication. (The latter procedure, pulmonary decortication, did not become widely accepted until WW II [5, 6].)

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The use of drainage tubes to evacuate the pleural cavity of air and blood after thoracotomy was initially condemned; however, by the end of WW I, evacuation of pleural fluid by thoracentesis or a drainage tube was acknowledged as being essential to minimize subsequent infection. Improvised “flutter valves” assured unidirectional movement of air within the tube. Underwater drainage was in its infancy as WW I ended [5].

Despite large numbers of casualties and the initially staggering mortality from penetrating wounds of the chest, the wars of the first half of the 20th century witnessed little improvement in the surgical management of such injuries. Between the two world wars, major advances were made in the logistics of combat casualty care. Endotracheal anesthesia and antibiotics were introduced; blood transfusion was refined. These advances accounted for the dramatic drop in mortality (cited below) among those with chest wounds; however, their optimal surgical treatment, as we know it today, was still several wars away, and further major advancements would be found in the civilian community.

Wounds of the thorax in WW II were managed with one overriding goal in mind: restoration of lung function. Débridement of the wound was emphasized, as was drainage of the pleural cavity with “a number 15 or number 18 French catheter . . . however diligent aspiration of the chest with a needle was just as effective and being simpler, was preferable” [5]. If clotted blood resulted and could not be removed by needle aspiration, catheter drainage was necessitated to fragment the clot and permit pleural irrigation with saline. “An intercostal tube, however, seldom functioned more than 48 hours; aspiration then had to be employed.”

Indications for thoracotomy, in the management of chest wounds in WW II included otherwise uncontrollable hemorrhage, diaphragmatic or suspected mediastinal wounds, and large (>2.5 cm) foreign bodies, all evident through a wound of entrance or “traumatic thoracotomy” [5]. After closure of the chest, “a catheter was inserted into the eighth intercostal space.” In this reference [5], a chest tube, connected to two-bottle water seal suction is depicted. Among United States troops, 7.2% of wounds were to the chest, and only 8% of those died of their wounds [3].

Experience during the post-WW II period initially favored these principles of management already discussed. Penetrating chest trauma was treated with thoracentesis for evacuation of any blood that had accumulated during a 24-hour period after the injury, at which point a pulmonary laceration was presumed sealed [7]. Earlier aspiration was recommended only if the patient was cyanotic or dyspneic [8]. Use of a chest tube was reserved for persistent or continuous air leak and then for only a short interval (48 hours). Antibiotics—penicillin and streptomycin—were instilled into the pleural cavity. The goal was to prevent empyema by keeping the pleural cavity dry and hermetic. Pulmonary decortication, first successfully performed by Burford in 1943 [6], was indicated when pleural evacuation failed and empyema eventuated.

Subsequent reports by Maloney [9] and Gray [10], regarding civilian chest trauma management in the 1950s, include terminology such as “closed thoracotomy,” “thoracotomy tube,” “closed drainage,” and “thoracostomy.” These procedures shared equal favor with repeated thoracenteses to maintain the injured pleural cavity free of air, fluid, and blood. The goal remained: preservation of lung function and avoidance of empyema. In the aforementioned series, a pointed instrument was the most common cause of penetrating chest trauma. Thus, the stage was set for combat casualty care and application of tube thoracostomy in the management of penetrating chest trauma to be experienced in the Korean War (1950 to 1953).

In that conflict, however, the management of missile injuries of the chest, resulting in pneumothorax, hemothorax, and hemopneumothorax, would remain unchanged from that practiced in the preceding conflict, WW II. In King’s series of “405 major thoracic casualties from Korea” [11] treated in Japan, all had sustained pleural penetration, most by small arms projectiles. Thoracentesis was used in 31% and this procedure was performed, on average, almost three times per patient. Thoracotomy was required in 13% of patients. The average volume of pleural blood aspirated from each patient exceeded 900 mL.

King was critical of the care rendered these patients before evacuation from Korea. “On the basis of our own experience in the handling of cases of hemothorax, the number of patients and number of thoracenteses done on each patient, prior to arriving at Yokosuka, left much to be desired. On only 124 patients (30%) had chest aspiration been done and only two aspirations were done on each patient.”

King urged liberal, routine and regularly repeated pleural aspiration “at least once daily.” One patient received 60 thoracenteses during a 2-month period! Optimal therapy was considered to be aspiration within the first 24 hours after wounding. Days of delay decreased the chances of completely evacuating the pleural cavity, thus setting the stage for the dreaded empyema. The author reaffirmed the basic principle in avoidance of the latter, “rapid clearing of the pleural cavity . . . early and complete re-expansion of the lung.” With this technique he reported 85.6% success (full reexpansion, radiographically, over time). Conversely, “The use of thoracotomy tube drainage for treatment of hemothorax resulted in a high incidence of complications.” Nonetheless, the mortality for these 405 patients was only 1.9%; 80% were returned to duty within 90 days! Apparent therapeutic success favored continuance of contemporary therapy!

Valle reported an even larger series of similar patients, 1968 of whom had sustained “penetrating type” chest injuries [12]. Hemothorax was treated with thoracentesis, “repeated every 24 hours, or more often if indicated, until no fluid could be obtained and the chest appeared normal to physical and X-ray examination.” Penicillin and streptomycin were instilled in the pleural cavity. Eighty percent completely recovered; 68% were returned to duty. The author reported 254 decortications, 92% of

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