

EVACUATION HOSPITAL EXPERIENCES WITH WAR WOUNDS AND INJURIES OF THE CHEST

A PRELIMINARY REPORT

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THE CASES which form the basis of this report were all seen in one Evacuation Hospital over a period extending from November 8, 1942, to August 2, 1944. During this time the hospital was at varying distances from the front lines in the North African and Italian campaigns. In most situations casualties were admitted 2 to 12 hours after injury. At Anzio, when the hospital was only a few miles from the front line and well within artillery range of the enemy, many casualties were received within a few minutes after being wounded. In all, 1,210 patients with wounds and injuries of the chest were treated, this number constituted 6.9 per cent of the total battle casualties and injuries admitted to this hospital. The experience gained in the management of these cases has led to the development of certain policies in regard to preoperative, operative and postoperative care of the patients who have suffered wounds of the chest. It is not our purpose to discuss in detail all the problems of the surgery of thoracic wounds. However, certain fundamental concepts may well be emphasized in this preliminary report. The various types of wounds of the chest will be discussed separately, giving some statistics and, in most instances, illustrating methods of management by case reports.

The rôle we play in a forward installation in respect to chest lesions is to: (1) Save lives. (2) Be conservative. (3) Evacuate patient to Base Hospital when transportable.

GENERAL MANAGEMENT OF CHEST CASES

The patient is propped up to a semisitting position if he is not in profound shock or unconscious. All clothing is removed from the chest and abdomen to permit an adequate examination. Immediate attention is given to shock and hemorrhage by starting replacement therapy, preferably with whole blood. The normal relationship of the intrathoracic organs is promptly restored, inasmuch as disturbances here may be responsible for shock. This may be attained, first, by adequately covering open chest wounds, if they exist; and second, by aspiration of blood and air from the pleural cavity. Thoracentesis for blood can be done nicely by using a transfusion vacuum bottle (Fig. 1). Blood so withdrawn is used for autotransfusion; though if an abdominal injury is suspected, the blood is not to be given until thoracotomy has proven the absence of contamination with gastric or intestinal contents. If pressure pneumothorax exists, a trocar-thoracotomy is done, placing the catheter in the 2nd interspace anteriorly in midclavicular line. The catheter is connected to a water-seal bottle.

All chest wounds, or chest wall injuries, with pain, receive intercostal nerve block (4 to 6 cc. of 1 per cent novocaine) two segments above and below the lesion. Paravertebral sympathetic block is occasionally substituted when

the lesion is far posterior. If morphine has not been given previously, $\frac{1}{6}$ gr. and atropine sulfate 1/100 gr. are given intravenously.

Excessive secretions and blood in the trachea and bronchi are aspirated by tracheal catheter suction. Occasionally bronchoscopic aspiration is necessary. Oxygen therapy is often useful in combating shock and anoxemia. The measures outlined above will render most patients with wounds of the chest good operative risks. Roentgenograms in two planes are always taken prior to operation. As soon as all indicated measures are carried out, necessary surgery is performed.

Anesthesia of choice in all suspected sucking wounds of the chest is gas-oxygen-ether, with intratracheal tube in position. This is necessary as all penetrating and perforating wounds of the chest are potentially sucking wounds and usually do suck when the débridement of the chest wall is complete. If the positive pressure anesthesia machine is not available, local anesthesia is then used. Open drop-ether and sodium pentothal anesthesia should never be used in the management of these wounds.

Débridement of all chest wall wounds must be thorough, which entails removing all devitalized tissue and loose rib fragments. Following débridement sucking wounds are closed by approximating muscle and fascia layers, thus, occluding the defect in the pleura. The skin is also closed when necessary to assure an air-tight closure. It should be emphasized that the pleura itself need not be sutured. Every effort is made to secure and maintain complete expansion of the lung, using positive pressure anesthesia and aspirating any residual air by needle. At the close of operation repeat the intercostal nerve block. Hemothoraces are aspirated without air replacement every 24 to 48 hours until the pleural cavity is free of fluid. Intratracheal catheter is used as indicated in the postoperative period.

PENETRATING AND PERFORATING WOUNDS OF THE CHEST

Penetrating and perforating wounds of the chest, with no indication for emergency thoracotomy, comprise the vast majority of the cases in this series. These cases, for the most part, require only simple débridement of the chest wall wound. The preoperative and postoperative care of these patients is most important.

These cases frequently have an accompanying hemopneumothorax, with associated severe pain (chest wall). Such factors may produce symptoms of shock and definitely aggravate shock when present. Thus, the problem of correcting this pathophysiologic condition should be undertaken immediately and vigorously by: (1) Aspiration of the hemopneumothorax (using blood for autotransfusion). (2) Doing an intercostal nerve block. This allows the patient to breathe deeply and cough painlessly so as to drain the bronchial tree of excessive bronchial secretion that seemingly accompanies chest wall and pulmonary trauma.

The following is an example of a perforating wound of the chest which was treated conservatively:

Case 1.—This patient suffered a perforating wound of the left chest from a 32-caliber bullet. He was admitted to the hospital shortly thereafter in moderate shock, and with some dyspnea. There was no hemoptysis and no gross bleeding. The wound of entrance was one centimeter in diameter at the level of the fourth rib anteriorly in the midclavicular line; the wound of exit was small and just beneath the inferior angle of the right scapula. The wounds were not sucking. No evidence of hemothorax or pneumothorax existed. An intercostal nerve block was done. Attempted aspiration of the chest yielded no blood or air. The patient was readily stabilized without replacement therapy. Under local anesthesia, the wounds were débrided, and no evidence of sucking found. The wound surfaces were powdered with sulfanilamide and vaselined gauze dressings were applied. On the first postoperative day 100 cc. of blood was aspirated from the left chest cavity. On the fifth postoperative day the patient was sitting up, breathing comfortably and had no complaints. He was evacuated to the rear on the sixth postoperative day.

COMMENT: In this case the relief of pain by intercostal nerve block brought an apparently ill patient into a comfortable state. While it is true that blood and fluid do not always produce marked symptoms, time and experience has demonstrated that patients are able to return to duty sooner when the pleural cavity is kept dry and the lung is allowed to reexpand.

SUCKING WOUNDS OF THE CHEST

Large sucking wounds of the chest demand prompt attention and may present some difficulty in closure. When a wound is large and the chest open, fluid and clots should be aspirated through the wound; furthermore, one should endeavor to be certain that hemorrhage has stopped and that there has been no injury to the diaphragm. Intrapleural foreign bodies and only readily accessible fragments in the lung should be removed; occasionally it is necessary and expedient to enlarge the wound to do this, as exemplified in the following cases:

Case 2.—This patient had a perforating gunshot wound of the left chest, with wound of entrance anterior in the region of the third rib and the wound of exit through the scapula just above the angle. An hemopneumothorax existed and there was also a perforating wound of the left hand. Six hours after being wounded an intercostal nerve block was done, and 400 cc. of blood was aspirated from the left pleural cavity; this blood was autotransfused. (Prior to the nerve block and aspiration atropine sulfate gr. 1/100 and morphine sulfate gr. 1/4 were administered). The blood pressure was 108/70. Ten hours following the wound, operation was performed under endotracheal positive pressure anesthesia. The chest wound was found to be gaping and air and blood were spluttering therefrom. A perforation of the lung lay directly beneath the chest wall perforation and the air was seen to be coming from this wound in the lung. The chest wall wound was enlarged and the three-inch laceration of the lung, containing a bronchial fistula, was closed with interrupted silk sutures. Closure of the chest wall wound was done in anatomic layers with catgut, and the skin was closed with silk sutures. A small catheter was placed in the third interspace in the midclavicular line. The posterior wound was then débrided and also the wound of the right hand. At the end of the procedure the blood pressure was 104/78. The patient was given penicillin 25,000 units intramuscularly every three hours. On the second postoperative day good breath sounds were heard throughout the posterior chest. The anterior catheter which had been connected with a water-seal bottle immediately postoperatively had ceased to drain four days postoperatively; it was removed at that time. On the fifth postoperative

day the patient had a temperature of 103° F., and signs of fluid posteriorly, 1,000 cc. of thin bloody fluid was aspirated from the left chest. The patient was evacuated in good condition, with the note that further thoracentesis might be necessary.

COMMENT: Too much dependence was placed on the anterior catheter to drain the chest cavity. The patient's position had been changed to effect fluid drainage, but without success. If daily thoracentesis had been done he should have been relatively dry at the time of evacuation.

Case 3.—This soldier was wounded by a machine gun bullet, and was admitted to the hospital in severe shock, with a blood pressure of 40/0 and shallow respirations (30 per minute). The wound of entrance was in the left chest at the lateral border of the left scapula at the level of the fourth rib. The foreign body could be palpated in an hematoma the size of a golf ball in the right chest wall in the posterior axillary line at the level of the fourth rib. Three and one-half hours after being wounded (0800 hours) an intercostal nerve block was done. At 1245 hours atropine sulfate gr. 1/100 was administered intravenously and 1,300 cc. of blood was aspirated from the left pleural cavity and given as autotransfusion in addition to 600 cc. of whole blood and 250 cc. of plasma. The blood pressure then became stable at 100/60. The patient vomited and coughed up a blood-tinged milk-like substance. The presence of chyle from a thoracic duct wound or sulfathiazole from an esophageal wound was considered. The patient was given a small amount of barium for roentgenologic examination, but no lesion in the esophagus could be demonstrated.

At 1330 hours of the same day, under oxygen-ether intratracheal anesthesia, the wound was débrided. It was found to extend through the scapula and it was necessary to reflect the scapula through a regular thoracoplasty incision to complete the débridement. The lower border of the fourth rib and the fourth intercostal bundle were found to be destroyed and a sucking wound 4 cm. in length was found. Two hundred cubic centimeters of blood were aspirated from the left pleural cavity. The patient's condition did not warrant further exploration of the chest cavity. The sucking wound was closed by approximation of muscle and fascia over it. The machine gun bullet was then removed from the right chest wall. Six hundred cubic centimeters of additional blood was given during operation. The patient was returned to ward in good condition. Twenty-five thousand units of penicillin was administered intramuscularly every three hours. He was evacuated to the rear on the third postoperative day, with a dry chest.

Case 4.—This patient was wounded by artillery fire. Dyspnea, weakness and pain in the abdomen developed immediately. He was admitted to the hospital one hour and forty-five minutes after being wounded, and was in fairly good condition. The abdomen was spastic, but there was no rebound tenderness. There was a penetrating wound 2 cm. in diameter in the left posterior scapular line at the level of the ninth interspace. There were two small perforating wounds in the left arm. There were signs of a large hemothorax, but no blood could be obtained by aspiration. The intercostal nerves in the region of the wound were blocked. Then, under oxygen-ether anesthesia, with intratracheal tube in place, the wound of the left posterior chest wall was excised. There was much destruction of the muscle and the tenth rib. With débridement of the wound a large clotted hemothorax was revealed. Approximately 1,800 cc. of clotted blood were evacuated from the left pleural cavity. A puncture-like laceration was found in the lingula of the left upper lobe. This laceration was 5 cm. in diameter, and was bleeding freely and bubbling air. The lacerated lung was repaired with interrupted silk sutures. The diaphragm was not involved. A catheter was placed in the eighth interspace in the posterior axillary line. Sixty thousand units of penicillin was introduced intrapleurally. The incision was closed in anatomic layers with catgut sutures. Six hundred cubic centimeters of blood and 250 cc. of plasma were given during operation. The patient returned to ward in good condition. Penicillin therapy was

continued by the intramuscular route, and the catheter was removed 48 hours post-operatively. There were some signs of fluid at the base, but only 20 cc. of thin fluid could be aspirated. Breath sounds were present anteriorly and posteriorly. The patient was evacuated to the Base on the sixth postoperative day.

COMMENT: The size of the wound after adequate débridement of the chest-wall permitted evacuation of a large clotted hemothorax, repair of a laceration of the lung and a bronchial fistula, and inspection of the diaphragm.

The above cases represent most of the common problems encountered in the sucking chest wound and illustrate the usual method of handling them. When there is extensive destruction of muscle and ribs, proper débridement of the wounds ordinarily opens the pleural cavity; then an estimation of the intrathoracic damage is made. Frequently, any necessary repair can be effected by enlarging the wound slightly.

THORACOTOMY INDICATIONS AND APPROACH

There are not many indications for formal emergency thoracotomies in Forward Hospitals. In fact, we believe there are only four, namely: (1) Cases with continued gross bleeding. (2) Uncontrolled bronchopleural fistulae (such as lacerated bronchi). (3) Suspected and known thoraco-abdominal lesions (which will be discussed separately). (4) Suspected and known esophageal wounds.

Under sucking wounds certain indications were mentioned for enlarging those wounds and such enlargements are properly thoracotomies, but we ordinarily think of them as extensive débridements; of these and formal thoracotomies there were 110 cases (which constituted 10 per cent of the group), not including the thoracoceliotomies.

The elective removal of foreign bodies and decortication of organized hemothorax are not performed routinely in an Evacuation Hospital, but in situations where Base Hospitals have been far removed, it has been expedient to retain these patients for definitive surgery.

When thoracotomies are indicated, in some instances they may be done through the wound of the chest wall, provided the lesion is in the site of the elective incision (*i.e.*, posterolateral area). This requires enlargement of the débrided wound. Against this procedure is the fact that these wounds frequently break down from infection. For this reason, when a large thoracotomy incision must be made, it should, whenever possible, be kept away from the original wound. Indications for thoracotomy will be demonstrated by illustrative cases.

HEMORRHAGE FROM LARGE INTRATHORACIC BLOOD VESSEL

When there is evidence of bleeding from a large intrathoracic blood vessel (this largely determined by route taken by missile—usually through the neck and supraclavicular region—and by the fact the hemothorax is clotted), the case should be explored as soon as the blood pressure becomes stabilized. Procrastination in such cases, in our experience, has been disastrous, as illustrated in the following two cases:

Case 5.—This patient was wounded by shell fragments. He received a penetrating wound of the left chest with the entrance wound in the left neck, and also penetrating wounds of the right upper arm and the left hip. He was admitted to the hospital with a large hemothorax five hours after having been wounded. After several unsuccessful attempts to aspirate this hemothorax it was decided the blood was clotted. The wound of the neck was débrided, and the tract partially explored where it ran superior to the first rib. The wound was powdered with sulfanilamide and covered with a vaselined gauze dressing. The first three days postoperatively no aspiration of the chest was attempted; 400 to 500 cc. of blood were aspirated daily from the left chest for the next five days. The patient was supported by numerous blood transfusions. On the eleventh postoperative day 900 cc. of thin bloody fluid were aspirated. On the twelfth postoperative day the patient suddenly went into severe shock; the radial pulse was imperceptible and no blood pressure reading could be obtained. Respiration was slightly labored, and the skin was cold and clammy. The breath sounds on the left were distant. The patient was given 1,000 cc. of blood, and he rallied satisfactorily. Attempted aspiration was unsuccessful. The following day his pulse was 148. Four hundred cubic centimeters of blood-tinged fluid was aspirated. Under oxygen-ether-intratracheal anesthesia a sickle-shaped incision was made from the middle third of the clavicle to the fifth costosternal junction. The first rib was excised at the sternocartilaginous junction. As the pleural cavity was entered copious quantities of blood poured out. Rapidly, the second, third and fourth ribs were severed at the sternocartilaginous junction. A finger was used to compress a rent in a bleeding vessel at the apex of the chest. The bleeding was from the region of the subclavian artery and innominate vein. Apparently, local infection had completed the laceration of these vessels. The bleeding was controlled eventually by gross clamping and mass sutures at the apex of the chest. The chest wall closure was effected with catgut sutures for muscle and fascia and silk sutures for the skin. A catheter was placed in the eighth intercostal space. The patient's blood pressure was imperceptible through much of the operation, although intravenous blood was started prior to operation in both ankles and the right arm; 3,000 cc. of blood were given during operation and 750 cc. immediately following operation. One hour postoperatively the blood pressure was 100/60, and four hours postoperatively it was 102/80. Oxygen was discontinued one hour after the operation.

The postoperative course was uneventful the first 13 days. When the hospital blew down in a snow storm this patient, with 700 others, was evacuated to another hospital. The catheter was not draining at this time. He was transferred to a General Hospital four days later. On admission there the following note was made: "Dyspneic, distressed, with intercostal catheter not draining. On the twenty-first postoperative day a large tube was inserted in the eighth rib bed; the pus which drained was putrid. There was no bronchial fistula and the anterior wound was nicely healed. Steady improvement followed this procedure."

COMMENT: The direction taken by the missile and the early clotting of blood indicated the possibility of a large vessel laceration. However, in the absence of shock and other evidence of gross bleeding, thoracotomy seemed contraindicated at the time. Subsequent events suggest that it would have been the better procedure. Intravenous fluids started in three veins before surgery unquestionably saved this patient's life.

Case 6.—This patient was admitted to the hospital two hours after sustaining shell fragment wounds; one of which was a 3- x 2-cm. penetrating wound in midline of the neck above the thyroid cartilage and the other a 1- x 2-cm. penetrating wound in the right lateral portion of the neck in the same plane. On admission, he was not in shock or experiencing any respiratory distress. Attempted aspiration was unproductive. Five hours after having been wounded, under intratracheal oxygen-ether anesthesia, a thy-

roidectomy-type incision was made and the right sternocleidomastoid muscle divided. Diffuse bleeding, which was thought to be coming from the right innominate vein, was in evidence beneath the right clavicle. Bleeding was controlled by a gauze pack, which was left in place. At completion of this débridement blood pressure was 92/68. Eighty cubic centimeters of blood was aspirated from the right chest; however, more blood remained, which was clotted and unaspirable. One hour postoperatively the patient went into profound shock and he expired ten minutes later.

Autopsy revealed intrathoracic laceration of the right subclavian artery and innominate vein; the right thoracic cavity was filled with clotted blood. Massive hemorrhage was the immediate cause of death.

COMMENT: This patient should have had a formal thoracotomy, and an attempt made to ligate the lacerated vessels. In cases such as these, it is advisable to start blood and plasma in every available arm and leg prior to operation.

LACERATED BRONCHI WITH BRONCHOPLEURAL FISTULA

Any case with pressure pneumothorax which cannot be controlled by needle aspiration or by a large catheter in the anterior chest should have an immediate thoracotomy.

We think it is noteworthy to report these two cases of lacerations of main stem bronchi, with large defects, because it is only in rare instances that such patients live to be evacuated from the battle field. At the Anzio Beachhead, hospitals occupied a peculiar position, in that they were part of the battle field, and patients were injured on or adjoining the hospital area. These are the only cases of main-stem bronchi defects, to our knowledge, to reach a hospital alive. Most certainly, such cases deserve emergency thoracotomies.

Case 7.—The patient was received at this hospital one hour after sustaining a shell fragment wound of the right chest, eighth interspace, posteriorly. Presumably, he was in a prone position when wounded. He immediately became aware of a sucking wound of the chest and inability to move his lower extremities. Dyspnea followed. On admission, he was in shock and suffering profound respiratory embarrassment. Complete paralysis below the eighth dorsal segment existed. A large 5- to 6-cm. diameter wound in the eighth interspace posteriorly was sucking air, draining blood and was filled with clothes and bone fragments. The sucking was stopped with a vaselined gauze pack to the wound. A paravertebral nerve block of the sixth to tenth intercostal nerves improved the respirations and the patient began to cough up a large amount of blood. Twenty-five grams of serum albumin elevated the blood pressure to 96/52, and the chest was immediately aspirated of 800 cc. of blood, which was given as an auto-transfusion. Insertion of an intercostal tube relieved the developing pressure hemothorax. The patient became fairly well stabilized nine hours after injury, when suddenly pneumothorax increased, and operation then became an emergency. Under intratracheal oxygen-ether anesthesia the wound in the region of the eighth rib was excised and a posterolateral thoracotomy incision in the right eighth interspace was made. A large ragged bullet-shaped shell fragment, 12 cm. in length, was found penetrating a main-stem bronchus from which air and blood was flowing freely. The azygos vein was found to be lacerated and was sutured, but not completely occluded. There was an irregular 2.5-cm. defect in the posterolateral wall of the right main-stem bronchus just distal to the bifurcation of the trachea. This defect was approximated, after considerable difficulty, with interrupted silk sutures and reinforced with muscle. The repair was water-tested and no leakage experienced. A 12- to 14-cm. long transverse laceration of

the upper lobe was closed with interrupted silk sutures. The lung was then reexpanded, except for a portion of the upper lobe in the region of the lacerated area. The closure of the incision was done in anatomic layers with catgut sutures for deep layers and silk sutures for skin. The patient was in fair condition at termination of the operation. He had received 1,000 cc. of blood and 250 cc. of plasma during the procedure.

The patient underwent a stormy postoperative course, with abdominal distention and the accompanying sequelae of a cord transection. Seven days postoperatively a suprapubic cystostomy was performed and a hip spica applied to insure the patient's

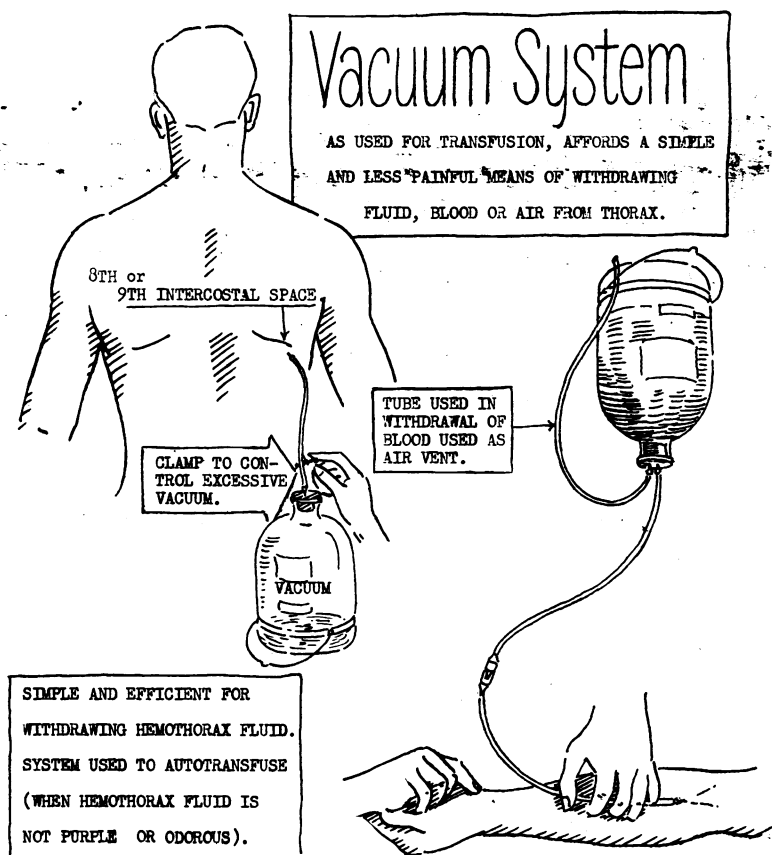


FIG. 1

comfort and to facilitate his handling in evacuation to the rear. Although the right lung remained expanded, on the twelfth postoperative day an infection of the incision developed at the site which included the original wound (experiences such as this illustrate the inadvisability of including the wounded area in the thoracotomy incision). An empyema ensued. Four days later he was sufficiently stabilized for evacuation to the rear. It should be noted that he had received 25,000 units of penicillin intramuscularly every three hours for ten days postoperatively. No sulfonamides were given (when penicillin is available, sulfonamides are never used). Reports a month later stated there was an empyema cavity of 200 to 300 cc. remaining, and there was some return of sensation in the extremities. A progress note four months later recorded progress as "excellent."

Case 8.—This soldier was admitted to a hospital one hour and 50 minutes after receiving multiple penetrating shell fragment wounds, most notable of which was a large sucking wound of the seventh interspace posteriorly that involved the seventh Dorsal vertebra. Complete paralysis existed from the eighth dorsal segment downwards. Being in moderate shock, he was sustained with serum albumin and transfusion until his blood pressure became stable. He was received at this hospital in a dyspneic state, with intercostal catheter working and with air and blood in the right thorax. His chest was very "wet" and copious quantities of bloody exudate were aspirated. Then, under intratracheal oxygen-ether anesthesia, two hours after admission here, the right pleural space was opened at a selected site in the fifth intercostal space; 700 cc. of blood were evacuated from the pleural cavity. Air was seen bubbling from the right main-stem bronchus. There was a 2-cm. defect in the anterior and left lateral wall where a piece of the bronchus had been torn out approximately 1.5 cm. from the bifurcation of the trachea. With considerable difficulty, three heavy silk sutures were placed to occlude the defect (water-tested) and a muscle graft was sutured over the area. There was profuse bleeding in the wound exit in the seventh intercostal space at the level of the transverse process. This wound extended to the spinal canal and the cord could be visualized, but no damage was apparent. Bleeding was controlled only by a pack which was brought out through the wound. The pleura was then closed and the ribs approximated. Sixty thousand units of penicillin were deposited intrathoracically. Two catheters were inserted; one in the eighth interspace posteriorly, the other in the second interspace in the midclavicular line anteriorly. The patient had received 1,200 cc. of blood and 1,000 cc. of glucose during operation. Penicillin therapy, 25,000 units intramuscularly every three hours, was instituted. Forty-eight hours postoperatively the patient became irrational, had a temperature elevation to 104° F., and developed a stiff neck with other signs and symptoms of meningitis. Seventy-two hours postoperatively the temperature remained elevated to 105° F., stiffness of neck persisted and the general condition became more critical. At this time the hospital was forced to move forward; the patient was left at a Holding Hospital, and placed on the "seriously ill" list. His lung remained completely aerated. The patient had been receiving 25,000 units of penicillin intramuscularly every three hours throughout his hospital stay.

POSTOPERATIVE CARE

After operation, intercostal nerve block should be repeated and residual air aspirated by suction bottle in the 2nd intercostal space in the mid-clavicular line. All thoracotomies are drained with a catheter in the 7th or 8th intercostal space in the posterior axillary line. Postoperatively, all patients are aspirated with a long catheter which is inserted through the endotracheal tube or are aspirated by means of a bronchoscope. It goes without saying that bronchoscopic aspiration is more complete although it entails prolonged anesthesia and consumes more time, which is a real factor when there is a large back-log of untreated wounded. In our experience the long catheter aspiration has proven satisfactory.

THORACO-ABDOMINAL WOUNDS

There were 103 cases with coexisting wounds of the chest and the abdominal cavity (two died prior to operation). In six of these cases the wounds were caused by two or more missiles without injury to the diaphragm. The injuries below the diaphragm were limited largely to the upper abdominal viscera. In the treatment of these cases attention was focused primarily on

the chest; measures to relieve respiratory difficulties were instituted promptly. These consisted chiefly of insuring that the dressing adequately occluded the chest wound, aspirating the hemopneumothoraces, autotransfusion, and novocaine block of intercostal nerves in areas of the chest wounds. Relief of respiratory difficulty and treatment of shock were carried on simultaneously. With improvement in the patient's general condition an appraisal of the chest and abdominal injuries was made. The choice of approach to abdominal injury was determined largely by the fancy or experience of the surgeon. From our experiences with this group of cases, after studying in detail their postoperative course and reviewing the mortality figures, the claims of those who strongly advocate one approach over the other cannot be dogmatically substantiated, though for those familiar with the chest, the thoracic approach is definitely preferable. Forty thoraco-abdominal wounds were treated by thoracoceliotomy (all work done through chest incision), with ten deaths (25 per cent). Fifty-four thoraco-abdominal wounds were treated primarily through the celiotomy incision, with 17 deaths (31 per cent). Six thoraco-abdominal wounds were treated through a combined approach, with two deaths (33 per cent). Major Pat R. Imes, in preparing a report on the abdominal wounds treated in this hospital, has noted the high mortality that accompanies multiple abdominal visceral wounds. His figures indicate that mortality is in direct proportion to the number of viscera involved. The superior statistics for the thoracic approach are seen to be more apparent than real when the following table is studied:

	Wound of:								
	Abdomen Negative			One Abdominal Viscus			Two or More Abdominal Viscera		
	Cases	Deaths	%	Cases	Deaths	%	Cases	Deaths	%
Celiotomy.....	4	0	0	26	3	11	24	14	58
Left thoracoceliotomy.....	4	0	0	15	4	27	8	4	50
Right thoracoceliotomy....	0	0	0	10	0	0	3	2	66
Total.....	8	0	0	51	7	14	35	20	57

One flank wound lacerated the diaphragm. Nephrectomy and repair of the diaphragm were accomplished through a kidney incision.

These mortality figures indicate a somewhat higher death rate than those from abdominal wounds without involvement of the chest. But on comparison with similar upper abdominal visceral injuries there is no remarkable difference. However, the fact remains that the chest wound must first be converted into a nonsucking wound and the physiology of the chest stabilized prior to a thoracoceliotomy or abdominalceliotomy.

A—THORACIC APPROACH, LEFT-SIDED
No. of Cases: 27 Deaths: 8

Thoracic approach on a left-sided lesion is quite adequate unless the missile is directed from below the umbilicus upwards; a rare condition.

Case 9.—This soldier was admitted to the hospital with a severe perforating gunshot wound of the chest, with lacerations of the diaphragm, spleen, left lower lobe of lung and herniation into the chest of the stomach, spleen, colon and small bowel. Three hours after being wounded, under endotracheal ether anesthesia, a left-sided thoracotomy was performed with resection of eight inches of the ninth rib. The chest cavity was found to contain the entire stomach, tremendously dilated, the omentum and transverse colon with splenic flexure and a portion of the jejunum. The badly lacerated spleen was removed, and a stomach tube reduced the stomach 60 per cent in size. The left gastro-epiploic artery which was torn near its termination was ligated. The kidney, colon, stomach and bowel were found to be intact. The torn lesser omentum was repaired, and the diaphragm was closed in two layers with silk sutures. The tip of the lower lobe of the left lung, which was badly torn and bleeding, was resected and sutured with swaged catgut. A catheter was inserted intercostally, and closure was effected with paracostal sutures and suture of the muscle layers. Twelve days post-operatively the patient was evacuated to a Base Hospital.

COMMENT: This case rather typifies left thoraco-abdominal lesions, and illustrates the proximity of all left upper quadrant organs to the chest cavity and their accessibility through this approach. When the diaphragm is opened these organs actually ooze into the chest cavity.

Case 10.—In this instance a soldier received a shell fragment wound which penetrated the tenth interspace in the posterior axillary line. At a Forward Field Hospital exploration of the wound was done and a perforation of the diaphragm sutured. The wound was then hurriedly closed, apparently because the hospital was under shell fire. On admission to this hospital, 24 hours after being wounded, the patient was suffering severe abdominal pain, with distention. Accompanying the patient was a note by the surgeon stating that "he thought a celiotomy should be performed." Through a left rectus incision the abdomen was opened, and the peritoneal cavity found to contain clean blood although all viscera appeared intact. Thirty-six hours after operation the thoracotomy wound became edematous; crepitation and a foul odor were present. Upon exploration of the wound, the superficial muscle was found to be necrotic and characteristic gas gangrene was seen to exist. The patient expired 48 hours postoperatively. Findings at the autopsy revealed gas gangrene of the chest wall, and a perforation of the splenic flexure of the colon.

COMMENT: This case represents an injury to the retroperitoneal portion of the splenic flexure that was not identified through a celiotomy. This could have been handled simply, and easily, through a thoracotomy approach. That the lesion was not recognized is not the fault of the thoracic approach.

B—THORACIC APPROACH, RIGHT-SIDED

No. of Cases: 13

Deaths: 2

Thoracic approach for a right-sided thoraco-abdominal lesion is usually the procedure of choice.

Case 11.—After having sustained a penetrating wound of the right lower chest region the patient was admitted to the hospital shortly thereafter, with a rigid abdomen. The tenth right rib was resected and a laceration of the lower lobe of the lung sutured. The diaphragm was found to be perforated and the foreign body to lie in a tear in the liver. Inspection of the hepatic flexure, duodenum and kidney disclosed no injury, nor were other intra-abdominal viscera injured. The liver was drained subdiaphragmatically and the diaphragm closed in two layers with interrupted silk sutures. The patient was evacuated to the rear six days later in good condition.

COMMENT: In the 17 cases where right thoraco-abdominal lesions existed it was necessary to make an additional abdominal incision in only five instances.

C—ABDOMINAL APPROACH

*No. of Cases: 54**Deaths: 17*

Case 12.—This patient was admitted to the hospital, with a blood pressure of 90/50 and pulse of 140, after having experienced a gunshot wound of the left chest and abdomen. Prior to admission here he had received 500 cc. of plasma. Upon arrival at this installation no respiratory difficulty was apparent and breath sounds were present, though diminished on the left. The abdomen appeared somewhat spastic and moderately tender. The patient complained of suprapubic pain. A perforating wound of the left chest existed with a wound of entry 1.5 cm. in diameter, in the seventh interspace anteriorly, two inches from the midline, and a ragged wound of exit, 7.5 cm. in diameter, in the ninth interspace, just medial to the posterior axillary line. Twenty-five to 30 cc. of blood and a small amount of air were aspirated from the left pleural cavity; 500 cc. of plasma administered and a blood transfusion was begun prior to operation. Then, under ether-oxygen anesthesia, a subcostal incision was made. The peritoneal cavity was found to contain approximately 800 cc. of blood, which was mixed with gastric contents. Exploration disclosed lacerations of the spleen, diaphragm and stomach, which was distended. Entry and exit wounds in the cardia of the stomach were closed and inverted in two layers with chromic catgut. The lesser peritoneal cavity was not involved. The spleen was then delivered and a 6-cm. sucking laceration of the posterior portion of the diaphragm presented itself. The spleen was removed. A large laceration of the diaphragm was closed with difficulty, while another nonsucking laceration of the anterior diaphragm was easily repaired. The closure of the abdomen was done in layers. The patient's condition was not satisfactory during the entire operative procedure, and he expired on the operating table while the skin sutures were being placed. The operation lasted 90 minutes, the greater part of which was consumed in effecting closure of the diaphragm. At no time did the patient's blood pressure exceed 90/60, and in spite of constant administration of blood there was a gradual fall in the blood pressure during the last 30 minutes of the procedure.

COMMENT: All patients with suspected perforations of the diaphragm should have an intratracheal tube in place. The sudden collapse of the left lung in an already shocked patient was directly conducive to the above fatality. The large sucking diaphragmatic perforation was not apparent until the lacerated spleen was delivered for removal. Upon the delivery of the spleen the tamponade of this organ to the perforation of the diaphragm was thus destroyed, and immediately a large sucking wound presented itself in an inaccessible position. The diaphragmatic laceration had to be more or less ignored, except for an ineffective gauze pack, until after the spleen was removed. Two things are apparent: This patient should have had an intratracheal tube, with facilities for maintaining positive intrapulmonic pressure present during operation. This case could have been handled very easily through a thoracic approach.

Case 13.—This soldier was admitted to the hospital nine hours after being wounded by shell fire. Examination disclosed a 1-cm. penetrating wound of the chest in the eighth interspace in the anterior axillary line, with a fragment lying posteriorly at the level of the first lumbar vertebra; also, a perforating wound of the left thigh, a penetrating wound of the right thigh, and a penetrating wound of the left testicle. On

arrival here the patient's blood pressure was 92/30. One thousand cubic centimeters of blood and atropine sulfate gr. 1/100 were administered intravenously. Chest aspiration produced 150 cc. of blood, but no air. (As chest pain was not a factor in this case, a nerve block was not indicated.) Nine hours after the wound was incurred, under intratracheal oxygen-ether anesthesia, the wounds of the chest were débrided and closed; a left subcostal incision was made; and the lacerated and bleeding spleen was removed. The kidney was also found to be torn. (Microscopic examination of the urine showed 8 to 12 red blood cells per high powered field.) A drain was inserted through the flank retroperitoneally. Examination of the stomach, colon and small intestine disclosed no injury. The perforation in the anterior portion of the diaphragm was repaired with catgut sutures and the abdominal incision closed with catgut and silk retention sutures. The wound of the left testicle was débrided and the left testicle removed. The perforating wound had entered the right compartment of the scrotum, but the right testicle was only slightly injured. A rubber drain was inserted through the lower portion of the scrotum. The wounds of the thighs were débrided and foreign bodies removed. Immediately following operation 1,000 cc. of air were aspirated from the left chest cavity. The patient had received 1,000 cc. of blood during operation. Postoperatively, he was placed on penicillin therapy, 25,000 units intramuscularly every three hours. On the second postoperative day an aspiration of the chest cavity yielded 200 cc. of bloody fluid. On the eleventh postoperative day the patient was evacuated to the rear in good condition.

COMMENT: This case was properly managed, as the chest wound was closed prior to celiotomy and the chest aspirated. These abdominal injuries could have been managed easily through a thoracic incision.

CHEST WALL WOUNDS

Chest wall wounds without intrapleural penetration and without contusion of the lung are handled as any other minor wounds. They do not constitute a large group of cases. The wound tract is excised, foreign bodies removed and the wound left open. One should not overlook intrathoracic disturbance merely because the superficial wound appears benign. There are some chest wall wounds without pleural penetration in which there is a varying degree of contusion or local blast injury to the underlying lung. These wounds may be quite serious and demand the same attention and care as intrathoracic wounds.

Case 14.—This patient stated that he was picked up by Aid men one to two hours after being struck by shell fragments in the right shoulder and the left knee. He arrived at the hospital 11 hours after sustaining his wounds, with a moderate hemothorax and "wet" lungs apparent. Many loud râles and rhonchi were heard. There existed a perforating wound of the right upper chest. Roentgenologic examination disclosed comminuted fractures of the posterior portion of the second, third and probably fourth ribs, with mild hemothorax on the right side; also an epiphyseal fracture of the left tibial tubercle. No foreign bodies were visible on either of the films. Fourteen hours after being wounded, under 1 per cent novocaine anesthesia, the 3-cm. wound of entrance just below the outer third of the right clavicle was excised. The tract entered and was traced below the pectoralis muscle, which was laid open. A small fractured piece of the clavicle was removed. The path of the fragment traveled posteriorly, anterior and superior to the axillary vessels and nerves and made a 3-cm. exit wound just medial to the posterior axillary line. The wound was widely excised and a large amount of clotted and liquid blood was evacuated. The tract led through the latissimus dorsi and

trapezius muscles but did not enter the chest cavity. Hemostasis was secured. Sulfanilamide was powdered over both the wounds and a vaselined gauze dressing was applied to the anterior wound. A paravertebral injection of 5 cc. of 1 per cent novocaine was done at levels of the cervical 7 thoracic 1, 2, 3 and 4 vertebrae. Five hundred cubic centimeters of blood were aspirated through the seventh intercostal space in the posterior axillary line and given as an autotransfusion, in addition to 500 cc. of normal saline. The wound of the left knee was then débrided. The patient's bronchial tree, which was filled with secretions, was sucked dry through a bronchoscope; he was returned to the ward in good condition. Four days postoperatively paravertebral block of the right dorsal 2, 3, 4 and 5 was done for relief of pain. No fluid was obtained on attempted aspiration. On the eighth postoperative day aspiration of the right thorax yielded 1,350 cc. of bloody fluid, and two days later 150 cc. of thin pink fluid was withdrawn. On the twelfth postoperative day aspiration of the right chest produced 725 cc. of thin pink fluid; thereafter the chest remained dry. On the twenty-second postoperative day the patient was ambulatory, but still had some loss of function of his right upper arm. He was evacuated to the rear with his chest in satisfactory condition.

FRACTURED RIBS

Of the large number of cases with simple and comminuted fractures of the ribs there were nine who had paradoxical breathing. Pain was controlled with intercostal nerve block. (In view of the fact that simple intercostal nerve block is so effective, we think it is most inadvisable to use adhesive tape to control pain in any chest injury.)

Case 15.—This patient was received at this hospital one hour after suffering injuries from a motorcycle accident which rendered him unconscious. Upon admission here he was dyspneic, cyanotic and experiencing extreme pain with paradoxical breathing. No chest perforation or sucking wound was apparent. There were fractures of the seventh, eighth, ninth, tenth and eleventh ribs, with hemothorax. One per cent novocaine injection of the seventh to eleventh intercostal nerves immediately relieved the pain, and stopped the paradoxical respirations. The patient was autotransfused with 500 cc. of blood on the first day following injury, 600 cc. on the fourth day and 250 cc. on the eleventh day, following which he was free of pain and evacuated to a convalescent hospital.

COMMENT: This case represents a simple, but gratifying means of treating a common injury, even in civilian life.

"BLAST LUNG" INJURIES

"Blast lung" injuries have been a relatively frequent finding, and a very discouraging condition. These cases typically present the following general points: (a) Proximity to a violent explosion such as a land mine; (b) multiple fractures; and (c) delayed respiratory-circulatory collapse, with marked pulmonary edema occurring two to three days after injury. No known therapy has been successfully employed in the treatment of these cases. Positive pressure oxygen therapy has been used with equivocal benefit. A case report, with pathologic findings is recorded below:

Case 16.—This patient was riding in the back seat of a command car when the rear wheel ran over a land mine. He recovered consciousness in a few minutes. He did not experience any dizziness, headache or blurring of vision, but did have difficulty in hearing in both ears. The latter might have been the result of a head injury which

caused a small puncture wound anterior to the left ear near the temporal artery. Speech and cerebation were not impaired. He was treated at a Collecting Station, and both legs and ankles were supported by wire splints extending above the knees. Under ether anesthesia, at a Field Hospital the wound of the right leg was débrided and plaster encasements were applied to both legs (the fracture of the left leg was not compound).

On admission to this hospital, 52 hours after injury, the patient was in good condition, with no complaints. The encasements on both legs were satisfactory, and the toes of both feet were warm. Four hours after admission the patient was conversing normally and rationally. His pupils were equal and regular. His pulse varied between 125 and 130. The following morning the pulse was 140, respirations 32, and blood pressure 98/50. Five hundred cubic centimeters of plasma were administered, after which the pulse was 120, respirations 40, and blood pressure 98/50. The patient had a temperature of 100.4° F., and was very drowsy, but mentally clear when aroused. There was no evidence of a head injury, except a small puncture wound above the left ear. Seven hundred and fifty cubic centimeters of plasma, 500 cc. of blood, and elevation of the foot of his bed brought the blood pressure up to 110 systolic. One and one-half hours later the blood pressure fell to 70 systolic. His respiratory distress was only moderate, although breath sounds were "spottedly" distant and coarse râles were heard throughout the entire chest. The patient was voiding involuntarily and spitting frothy blood.

The upper abdomen was distended, and no bruises or evidence of trauma to the abdominal wall were apparent. There was no peristalsis. Questionable consolidation of both bases with marked friction rub existed. A catheterized specimen of urine was clear. The same evening, at 1900 hours, the patient's condition became critical, with respiratory distress rapidly increasing. Two ampules of coramine and 500 cc. of blood were administered. Diminished breath sounds and tactile fremitus of the left chest with a loud to-and-fro friction rub was felt and heard. Dyspnea and slight cyanosis continued. Oxygen therapy was instituted. The blood pressure was 90/40, pulse 136, and respirations 26. There was a question of a pulmonary infarct. He expectorated frothy sputum with bright blood streaks, and breathed with difficulty and duress. He was lucid enough to attempt to answer questions. The abdomen was moderately distended. The patient struggled for breath (not obstructive type of dyspnea), then suddenly stopped breathing. Artificial respiration failed to revive him. He expired three days after sustaining injuries.

Autopsy revealed a clean peritoneum with no evidence of injury to the retroperitoneal tissues. The examination of the chest disclosed both pleural cavities intact, lungs expanded, grossly hemorrhagic, but crepitant in areas. There was some frothy serous fluid in the bronchial tubes on sectioning. There was no free blood in the pleural cavities. The pulmonary arteries contained thrombi, apparently postmortem. No injury to the thoracic cage was evident, nor was the diaphragm injured. The heart was grossly normal except for a questionable thrombosis in the auricle.

Pathologic Diagnoses.—*Gross:* (1) Compound fracture, right ankle. (2) Simple fracture, left ankle. (3) Blast injury, lungs (possible). (4) Thrombosis, pulmonary arteries (?). (5) Thrombosis, cardiac auricle (?).

Histologic Examination.—The lung shows extensive areas of intra-alveolar extravasations of red cells intermingled with varying numbers of pigmented macrophages. Occasional alveoli are filled with fluid containing a few red cells. The bronchial lumina contain large numbers of red cells. Interspersed with blood filled alveoli are occasional emphysematous alveoli, some with ruptured walls.

Pathologic Diagnoses.—*Microscopic:* (1) Pulmonary hemorrhage, severe, with ruptured alveoli. (2) Congestion of spleen. (3) Epicardial hemorrhage of the heart.

COMMENT: Some so-called "blast lungs" have had fat embolism. Characteristically, these patients also have had compound fractures, usually resulting from land mine traumatic amputations. Unfortunately, the special

fat stain was not used on this tissue. In view of the fact that there were ruptured alveoli we are obliged to classify this as a blast injury of the lungs.

SUMMARY

A preliminary report is made on the management of 1,210 cases of wounds and injuries of the chest. Illustrative case records are presented. The following points are emphasized:

A. Preoperative Recommendations:

1. Large occlusive vaselined gauze dressing over wound.
2. Whole blood for shock.
3. Immediate aspiration of hemothoraces (without air replacement).
4. Autotransfusion with thoracentesis blood.
5. Trocar-thoracotomy for pressure pneumothorax.
6. Intercostal nerve block.
7. Tracheal and bronchial aspiration.
8. Oxygen therapy.

B. Operative Recommendations:

1. Endotracheal anesthesia.
2. Intravenous fluids, preferably blood, flowing in one or two veins, during operation.
3. Permissible to enlarge débrided sucking wound for exploration of diaphragm or the control of hemorrhage.
4. Conservative surgery, minimizing the importance of foreign body removal, unless it is large, accessible, or in a vital organ.
5. Formal thoracotomy: (1) To control hemorrhage. (2) To close large, bronchopleural fistula. (3) In known or suspected thoraco-abdominal lesions. (4) In known or suspected esophageal lesions.

C. Postoperative Recommendations:

1. Bronchial aspiration (catheter or bronchoscopic).
2. Aspirate all air immediately postoperatively.
3. Repeat intercostal nerve block.
4. Continue nasal oxygen if dyspneic.
5. Penicillin 25,000 units every three hours intramuscularly.
6. Encourage cough, with breathing exercises.
7. Daily or necessary thoracenteses without air replacement.
8. Evacuate when transportable.

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