Trauma Management

Volume I

Abdominal Trauma

Edited by

F. William Blaisdell, M.D.   Donald D. Trunkey, M.D.

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1982
Thieme-Stratton Inc. • New York
Georg Thieme Verlag • Stuttgart • New York

Publisher: Thieme-Stratton Inc.
381 Park Avenue South
New York, New York

Illustrations by Marsha Dohrmann
Cover by Leslie H.P. Hurley

TRAUMA MANAGEMENT
VOLUME I: ABDOMINAL TRAUMA

TSI ISBN 0-86577-011-5
GTV ISBN 3-13-598901-1

Library of Congress catalog number 81-65553.

Last digit is print number 5 4 3 2 1

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Foreword

As academic surgeons, our interest in trauma developed for multiple reasons. Our discipline, surgery, through the act of operation itself inflicts trauma. Thus the study of trauma provides insight into surgical illness and recovery from operation. The pursuit of trauma involves the need to investigate basic mechanisms of wound healing, immunology, biochemistry and physiology. Trauma is, and will remain, the most secure of all surgical disciplines since the treatment of injury will not be resolved by medical measures as is potentially true of cardiovascular disease, cancer, and biliary and gastrointestinal disorders. Finally, despite increasing specialization, the trauma surgeon must remain a generalist since under emergency circumstances he must be prepared to deal with unexpected problems in any area involving any body cavity.

In the process of developing trauma surgery as a distinct discipline in our university settings, we have acquired colleagues with similar interests. Thus we have accumulated a large clinical experience and a uniform approach to trauma that seems to merit collection in a treatise on trauma rather than remain as a large number of articles scattered throughout the medical literature in journals and in book chapters. We are bringing together from the respective staffs of our two institutions—the University of California, San Francisco at San Francisco General Hospital and the University of California, Davis—a coordinated and united approach to trauma.

In order to make the material more manageable and to permit subsequent revision and expansion of particular areas in which changes are the most rapid, we have elected rather than to incorporate our work into a single volume to organize it into a series of monographs. Our first, *Abdominal Trauma*, should be of the widest general interest and set the tone for the next two monographs on *Cervicothoracic Trauma* and *Initial Management and Resuscitation*. Subsequently we plan monographs on the major specialty areas: orthopedics, neurosurgery, plastic and maxillofacial surgery, burns and eventually the full spectrum of trauma.

The orientation of our trauma monographs will be toward the senior surgical resident and general surgeons who treat trauma in their private practice. We believe our orientation will be both practical and conservative, aimed toward saving the maximum number of lives with minimum morbidity.

After careful consideration of many options we have selected Thieme-Stratton Inc. as our publisher. We believe that this aggressive young publishing company will provide the resources to ensure a high quality series of volumes, which we hope will enhance the libraries of many of our colleagues in surgery.

F. William Blaisdell, M.D.

Donald D. Trunkey, M.D.

Preface

This monograph, *Abdominal Trauma*, is designed as the first of a series of treatises on trauma. It is fitting that *Abdominal Trauma* be the first since the abdomen is the focal point of the evaluation of injury in the multiply injured patient. Abdominal injury is the most subtle of all the injuries to the body, and is the most likely to tax the diagnostic skills of the trauma surgeon. Autopsy studies repeatedly confirm that abdominal injury is the most frequent cause of readily preventable death. Our philosophic approach to trauma, which may seem conservative to some, is to recommend exploratory laparotomy if there is doubt concerning the presence of abdominal injury. There are no statistics available that support the contention that patients die from complications secondary to exploratory laparotomy, whereas it is relatively easy to prove that patients die of delays in the diagnosis of abdominal trauma and that many patients die in sophisticated hospitals of readily treatable injuries without having been subjected to operation at all. We remain surprised at the reluctance of surgeons to explore the abdomen of a traumatized patient and at the same time readily accept a negative exploration rate of 20 to 30 percent for appendicitis as representing good practice.

Although new diagnostic techniques such as peritoneal lavage and CT scanning have provided valuable assistance in making a prompt diagnosis of abdominal injury, there is no substitute for clinical judgment since all ancillary diagnostic methods have inherent false negative rates. That for peritoneal lavage, for example, varies from 1 to 5 percent, but most likely is closer to the higher figure in medical centers that see and treat trauma only occasionally. The tragedy of one preventable death in a previously healthy young person may have permanent impact on the unfortunate surgeon responsible for treatment.

The contributions to this and successive volumes all come from our colleagues with whom we practice, as we believe the value of this work is that it provides a uniform approach to trauma. In the experience of the authors this represents an optimal approach for us as we deal with thousands of trauma victims each year in our combined environments. We believe the guidelines for patient management that we have laid down should be of assistance to those who deal with trauma less frequently as well.

We the editors are grateful to our secretaries who have assisted us with the manuscript preparation by turning out draft after draft. We are indebted to our surgery residents, many of whom have initiated or assisted us with statistical evaluation of our results which have led to numerous papers and manuscripts. Moreover, their suggestions regarding patient management have led to new concepts of patient care and operative management. We are proud of our artist, Marsha Dohrmann, who has been selected to provide consistency for our illustrative material. We in particular are indebted to our long suffering wives and children who have tolerated our emergency commitments so well and in so doing have helped our surgical careers.

Contents

Chapter One

GENERAL ASSESSMENT, RESUSCITATION AND EXPLORATION OF PENETRATING AND BLUNT ABDOMINAL TRAUMA

F. WILLIAM BLAISDELL

INTRODUCTION

Definitive surgical treatment for abdominal injuries for all practical purposes has developed only in this century. Previously, survival was more dependent upon the individual's inherent ability to recuperate rather than on the medical care he received.

Historically, King William, the Conqueror of England, was one of the unfortunate victims of blunt abdominal trauma. In 1087, he was faced with a revolt of his son, Robert, and the treason of his half-brother, Odo. King Philip of France was in open rebellion. William and his army crossed the channel and attacked the French with a viciousness that he had not previously displayed. With a large force, he harried the countryside up to Mantes and fell upon the city in a surprise attack, during which terrible destruction ensued. The city was so completely burned that today it is hard to find traces of eleventh century buildings in the town. As the king rode through the burning streets, his horse, frightened by burning embers, threw the corpulent king against the high pommel of the saddle with such force that he was lethally ruptured. He was taken initially to the Priory of Saint-Gervais where he lived an additional three weeks with great suffering and then died of intra-abdominal sepsis on September 8, 1087. His body was removed to Caen where the final insult occurred. The attendants, who were trying to force his body into the stone coffin, ruptured the abdomen and an incredible stench filled the church. The tomb was destroyed in 1562 by the Calvinists. Only a single thigh bone survived as a remnant

Table 1–1 CAUSE OF DEATH IN 425 TRAUMA CASES (SAN FRANCISCO GENERAL AUTOPSY STUDY)

Type of Injury	Percentage
Head injury	45%
Burns	11%
Heart injury	10.5%
Lung injury	8%
Liver injury	6.5%
Aortic injury	4%
Hemorrhage	4%
Pelvic fracture	2.5%
Miscellaneous	3.0%
Hospital related*	6.5%

*primarily sepsis and respiratory failure

of the king, but this too was lost during the revolutionary riots of 1793. Today a simple stone slab is all that marks the grave of William the Conqueror.

During the nineteenth century, several surgeons attempted laparotomy for gunshot wounds of the abdomen with mixed success. However, mortality for an abdominal wound was 98 percent during the American Civil War. During the Boer War in 1899, there were isolated reports of successful surgical treatment of major abdominal trauma but more patients died after operative intervention than survived.[21]

World War I brought improvements in surgical techniques and perioperative care such that mortality following gunshot wounds to the abdomen dropped to 45 percent. This was further reduced to 25 percent during World War II, to 12 percent during the Korean conflict, and to 8.5 percent in Viet Nam. During the same period, the civilian mortality rate was 55 percent. This has dropped to less than 5 percent today. Much of this resulted from putting into practice lessons learned during the management of military wounds since World War II.[2,7,12,13,15,19,21,26,28,31]

Autopsy studies of injury show that head and chest trauma are the primary killers in present day society (Table 1-1). Nonetheless, abdominal injuries are responsible for approximately 10 percent of deaths following penetrating and blunt trauma. Isolated major blunt abdominal trauma that results in fatality is relatively rare since pelvic, chest, and head injury are found in association with most abdominally induced fatalities. Penetrating injuries most often cause fatalities secondary to major vascular injury or from septic complications of bowel injury.[16,17,26,34]

PATHOPHYSIOLOGY AND ETIOLOGY

Stab wounds are relatively benign injuries unless a major blood vessel has been lacerated or unless a particularly vital structure has been injured. Rarely do these result in much morbidity. Gunshot wounds, on the other hand, may cause devastating abdominal injury particularly if they are from high-velocity weapons or close-range shotguns (Table 1-2 lists common handguns and weapons with their respective muzzle velocities).[36]

Terminal ballistics, the amount of energy imparted to tissues by the missle, largely determines the injury and killing power (Figure 1-1). Although not all authorities agree, the most widely accepted terminal ballistic theory is the kinetic energy theory. The kinetic energy theory states that kinetic energy released to tissues

Table 1–2 EXAMPLES OF MUZZLE VELOCITY

Weapon		Velocity (ft/sec)
.22	Long rifle	1335
.22	Magnum	2000
.220	Swift	2800
.270	Winchester	3580
.357	Magnum	1550
.38	Colt	730
.44	Magnum	1850
.45	ACP	850

equals mass times velocity squared, divided by two times the gravity, KE $mV^2/2g$. This is thought to provide the best estimate of wounding capacity and it thus follows that modest increases in velocity will result in tremendous increases in the kinetic energy of the missle and resultant killing and wounding power. Simple calculations using this formula demonstrates that a .22 Magnum is capable of eight times the energy release of a .38 revolver. Generally, those weapons capable of generating a missle velocity in excess of 2000 ft/sec are said to be high-velocity.[36]

The amount of energy imparted to the tissue is estimated to be the kinetic energy upon impact minus kinetic energy upon exit. Thus, bullet design becomes important and ideally, a bullet should dissipate all of its energy to the tissue with no residual exit energy. This has led to the development of missiles which disintegrate upon impact, such as soft point and hollow nose bullets. Increased muzzle velocity and disintegrating missles can cause extensive tissue damage creating for example, a

Figure 1–1 Close range shotgun injury of the lower chest and right upper quadrant of the abdomen.

Table 1–3 FREQUENCY OF INJURIES IN TRAFFIC ACCIDENT VICTIMS

	57 Pedestrians	64 Auto Occupants	6 Motorcycle or Bicycle
Head	35 (22)*	43 (30)	6 (6)
Chest	17 (4)	31 (12)	3
Abdomen	14 (2)	24 (10)	–
Spine	4 (2)	4 (1)	–
Upper Extremity	14 (0)	17 (0)	1
Pelvis and lower extremity	40 (16)	27 (2)	2
Genitourinary	5 (0)	4 (1)	–

*The number of times that each injury was the primary cause of death is indicated in parentheses (from Perry and McClellen).

temporary cavity 30 times the size of the entering bullet. This is dependent on ballistics, type of bullet, and the tissue that is transgressed. The damage produced can be worsened by secondary missiles or fragments of disintegrating bone and other tissue.

Close-range shotgun blasts undoubtedly cause the most devastating injuries of any weapon to which civilians are normally exposed. Sherman and Parrish have classified shotgun wounds into three categories: Type I shotgun injuries, sustained at long range (greater than seven yards); Type II shotgun injuries, sustained at close range (three to seven yards); and Type III shotgun injuries, sustained at very close range (less than three yards); illustrated in Figure 1-1.[29] Type I injuries usually present as scatter types and may not even penetrate visceral cavities from distances greater than 40 yards. At 20 yards, penetration is increased and yet expectant management may sometimes be warranted. Type II injuries usually involve damage to deep structures and require more aggressive management. Type III wounds produce massive tissue injury and carry a very high mortality rate (85-90 percent).

Blunt injury can be caused by direct impact, deacceleration, rotary forces, and shear forces. Direct impact may cause significant injury and the severity can be estimated by knowing the force and duration of impact as well as the mass of the patient contact area. Table 1-3 demonstrates the most common sites of injury from motor vehicle accidents. Ejection, steering assembly impact, windshield impact, instrument panel impact, and rear collision account for the majority of these.

Deacceleration injuries are most often associated with high-speed motor vehicle accidents and falls from heights. As the body impacts, the organs continue to move forward at the terminal velocity, tearing vessels and tissues from points of attachment. Rotary forces also tend to cause tearing injuries from a tumbling type of action.

Shear forces have a tendency to produce degloving types of injuries such as are apt to occur when the patient is run over by a large vehicle. As the vehicle passes over the body, the skin and subcutaneous tissues are pushed ahead tearing nutrient blood supply from its muscular sources below. Subsequent extensive soft tissue loss is common following such injury.

ASSESSMENT

The *definitive evaluation* of both blunt and penetrating trauma consists of history, physical, and laboratory assessment. Although the physical examination is a key to the diagnosis of the nature and type of trauma, the *history* should not be neglected (Table 1-4). If not obtainable from the patient, it is often available from

Table 1–4 HISTORY

Mechanism of injury
Time of injury
Status at the scene
Level of consciousness
Shock
Complaints
Previous state of health

the ambulance attendants, police, friends, relatives, or bystanders. It is important to obtain information about the mechanism of injury. Was penetrating trauma part of a fight and was there a possibility of blunt trauma as well? Was the injury caused by an auto accident, an auto versus pedestrian accident or a fall? And, in particular, when did the injury occur relative to the patient's admission to the emergency department? This history can be obtained by a nurse or a physician associate while the physical examination is being carried out so that it does not necessarily result in a delay in evaluation. Knowing whether the patient was awake and alert at the scene of the accident and knowing that he is now comatose may well change the priorities of management. What were the patient's complaints at the scene of the accident? What are they now? What was his previous state of health?

Physical examination can be carried out in a relatively short period of time (Table 1-5). One of the areas that is often neglected in the initial physical examination is the backside of the patient. All too often, in a matter of moments, he is tied down by intravenous lines, catheters, and splints. When first seen, the patient can be log-rolled, with someone supporting his head and neck while the back, flanks, buttocks, and posterior aspects of the thigh and neck are inspected. All of this should not take more than a few minutes to accomplish.

The *first priority* overall, in assessment, is the *respiratory system*. If the patient is conscious, he should be asked to take a deep breath. The ability to take deep inspiration without discomfort rules out most thoracic injuries. If the patient is unable to take a deep breath or if he splints with respiration, thoracic wall injury should be assumed. If the patient is comatose and has lost gag, cough, and swallowing reflex, he is at risk for aspiration, and endotracheal intubation should be carried out promptly. If ventilation is rapid and shallow then once again there is presumption of respiratory injury. In all instances in which there is evidence of chest injury, a chest x-ray should be obtained as rapidly as possible and arterial blood gases drawn from the femoral artery and sent for analysis.

Blunt traumatic injuries to the lower six ribs or penetrating trauma through the sixth interspace or below implies the possibility of abdominal injury. Since the

Table 1–5 PHYSICAL EXAMINATION

Back of patient
Ventilation adequacy
Perfusion adequacy
CNS status
Abdominal evaluation
Rectal examination
Extremity evaluation
Repeat PE—any change from above?

diaphragm rises with normal ventilation to the sixth interspace, penetrating trauma at this level may well penetrate the abdominal cavity. Similarly, very little lung tissue lies below the lower six ribs and so, blunt injuries associated with rib fractures may injure an underlying viscus such as liver, spleen, stomach, or kidney.

The *cardiovascular system* should be the *second priority* in assessment. The blood pressure and pulse should be noted. Most patients with discomfort from injury have a rapid pulse. Young patients, by vasoconstricting, can maintain a relatively good blood pressure even though considerable volume has been lost. Assessment of peripheral perfusion, urinary output, and cardiac cerebral function are appropriate to define the level of shock. Warm extremities, good peripheral perfusion, and good urinary output provide assurance that the cardiovascular system is intact.

The *third priority* in assessment is the *central nervous system*. Comatose patients should have their necks splinted until cervical films can be carried out. They should be inspected for evidence of blunt head trauma and for scalp lacerations and the level of consciousness should be noted. A progressive fall in the level of consciousness is the primary indication of increasing intracranial pressure and this dictates the need for early cerebral decompression. An awake, conscious patient obviously has a good margin for safety. If the patient is conscious and moves his head without discomfort, the probability of cervical fracture is minimal. If he is unconscious or reports cervical discomfort, the head and neck should be splinted with sand bags until cervical films can be obtained.

The *fourth priority* is the *abdominal contents - the gastrointestinal and genitourinary systems*. This begins with assessment of the integrity of the chest wall, since the lower six ribs overlie the abdominal cavity. The screening maneuver of asking the patient to take a deep breath is a reliable way of ruling out chest wall injury. If the comatose patient responds to stimuli, gentle pressure over the lower ribs establishes whether or not rib fractures are present. The contour of the abdomen should be noted. The normal fasting abdomen is scaphoid. The abdomen may be relatively flat after a full meal and, of course, the contour of the abdomen of the obese patient may be convex rather than scaphoid. Gentle palpation of the abdomen should be carried out initially by laying the hand on the abdominal wall. This permits assessment of local areas of increased tone which may suggest underlying injury. The presence or absence of penetrating wounds should be noted. Bullet holes and knife wounds should be described and should be marked with a paper clip or radiopaque object so as to permit localization on abdominal film when this is obtained. The bullet wounds should be matched up with the information about the number of shots fired. Two holes may mean either two bullets or a through and through injury. An odd number of holes implies the presence of a foreign body inside the patient and it is mandatory that the bullet be located by x-ray so its exact path can be determined. Failure to locate a foreign body such as a bullet can have serious consequences. When the wounding object is radiopaque, it must be located by x-ray, since major cardiac and vascular injury may lead to embolism of the wounding object to a remote site and early location of the wounding object may be the key to prompt recognition of these potentially lethal injuries.

Deeper palpation should be carried out to elicit guarding, tenderness, and rebound. The flanks should be palpated and the iliac crest and symphysis pubis compressed, to establish the possibility of a pelvic fracture. Inspection of the genitalia should follow. Blood coming from the urethra is diagnostic of urethral injury. If the patient can void, a urine specimen should be obtained promptly. Hematuria requires urinary tract evaluation for renal or bladder injury.

Rectal examination should be carried out. Fullness in the pelvis is diagnostic of retroperitoneal hematoma and pelvic fracture. Blood on the examining glove suggest lower gastrointestinal injury. Pelvic fractures may be associated with perineal lacerations. These compound fractures are extremely serious since they are invariably associated with extensive soft tissue injury and have high mortality.

As *final priority* the *extremities* should be examined. If the patient is awake and can move both lower extremities without discomfort, the probability of fracture is low. Passive motion of the limbs should also be carried out. If the patient is unable to cooperate then pain on motion of the extremity points to a site of probable injury. Instability, of course, is diagnostic of fracture or dislocation. The upper extremity should be examined in a similar fashion, and both upper and lower extremities carefully palpated for pulses, evidence of hematomas, and sites of tenderness which may be associated with fracture or ligamentous injury.

Following the completion of the physical examination, which rarely should take more than a few minutes, the appropriate *laboratory studies*, if not already initiated, should be carried out (Table 1-6). Blood should be sent for typing and crossmatch. Minimal examination should consist of CBC, urinalysis, chest x-ray—upright if possible, and if there is any evidence of abdominal injury, abdominal films consisting of AP and supine and upright or left lateral decubitus films (Table 1-7). Suspected bone injuries should be x-rayed. Hematuria or penetrating trauma that is presumed to pass in the vicinity of the kidneys, ureter, or bladder are indications for radiologic assessment of the urinary tract. This involves urethrograms, cystograms and/or intravenous pyelography (see Chapter 2). It is important to note that disruption of the renal pedicle can occur without the injury being reflected in the urine. The value of an intravenous pyelogram in this instance is that it not only provides information about the renal injury but, even more importantly, it also documents the status of the opposite kidney. If there is a thoracic injury or any question regarding the adequacy of pulmonary function, arterial blood should be drawn for arterial blood gases. If there is evidence of major injury, routine obtaining of an SMA-12 is appropriate. Additional specialized laboratory procedures will be dictated by the specific injuries that are suspected (see subsequent chapters). We have found it useful

Table 1–6 LABORATORY ASSESSMENT

Blood for type and cross match
Hct and WBC
Urinalysis
Arterial blood gases?
Amylase?
SMA–12?
Toxicology?
Blood alcohol?

Table 1–7 X-RAY ASSESSMENT

Chest x-ray—upright if possible
Abdominal film—KUB
Fracture sites
IVP?
CT CNS scan?

to save 10 cc of clotted blood from most patients and send the sample for toxicology, blood alcohol, or other tests, as indicated.

Repeated physical examinations are extremely helpful to the clinician in less obvious cases as are repeated vital signs and laboratory data such as the hematocrit and white count. Serum amylase may assist in diagnosing pancreatic injury.[25] The indications for peritoneal lavage will be discussed in Chapter 3.

Generally, the principle for use of lavage is that if the injury is limited to the abdomen, clinical criteria and not lavage should dictate the need for laparotomy. When there are multiple injuries, and when there is bleeding from other areas so that the hematocrit is an unreliable indication of intraabdominal bleeding, then peritoneal lavage may be an appropriate diagnostic maneuver.[8] It is of particular value when there is an associated head injury or where a history is unobtainable, as when the patient does not respond to examination so that the reliability of the abdominal examination is questionable. Other means of assessing trauma include laparoscopy, sonography, scintillation, and CT scans.[11] These all have serious limitations and will be dealt with in more detail in Chapter 2.

RESUSCITATION

The *first principle* of resuscitation involves *ensuring* an *adequate airway* (Table 1-8). This is more apt to be a problem in a patient with multiple blunt traumatic injuries than with penetrating trauma. When thoracic penetration is present or when there have been rib fractures, there is always the probability that associated lung laceration may be present. When positive pressure ventilation is initiated as part of resuscitation or when anesthesia is induced for the surgical treatment of other injuries, a minor lung laceration can produce lethal tension pneumothorax as air is forced out of the laceration due to increased atmospheric pressure in the airway (Figure 1-2). For this reason, chest tubes are used liberally as part of initial resuscitation, particularly if the unstable condition of the patient contraindicates immediate chext x-ray. In the stable patient, chest tube insertion can await indications based on chest x-ray. However, if the patient with thoracic penetration is going to require immediate abdominal surgery, then prophylactic chest tube insertion may be judicious when there has been thoracic penetration or evidence of rib fractures despite the absence of hemo- or pneumothorax.

Another mechanism for collapse with introduction of mechanical ventilation is air embolism. This results when air enters a pulmonary vessel with resultant coronary air embolism.[32] This is most apt to occur in the presence of shock when pulmonary vascular pressures are low. One indication for endotracheal intubation is altered consciousness with loss of gag, cough, and swallowing reflexes so that the patient is at risk for aspiration; major maxillofacial injury that produces bleeding into the upper airway is another. Whenever the patient has altered ventilation as manifested

Table 1–8 PRIORITIES OF MANAGEMENT

1. Airway
2. Cardiovascular
3. Central nervous system
4. Gastrointestinal and genitourinary
5. Orthopedic and plastic

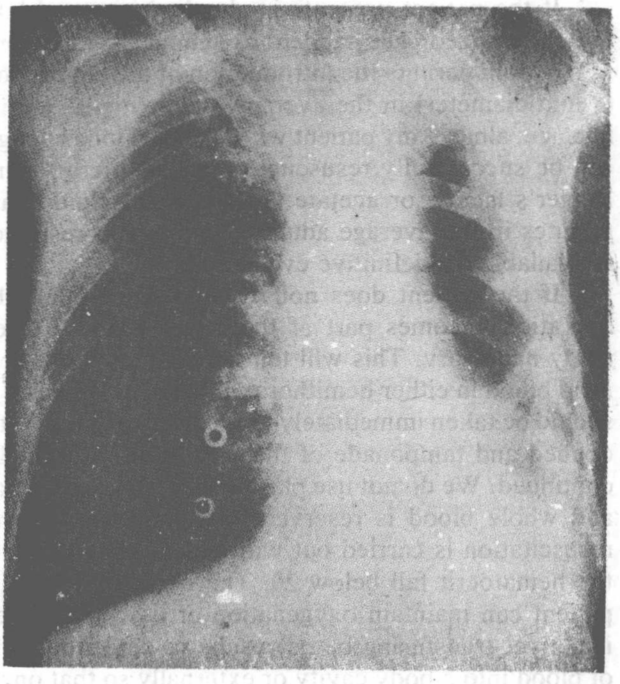

Figure 1–2 Right tension pneumothorax. The mediastinum is shifted to the left with compromise of function of the good lung.

by difficulty taking a deep breath, rapid respirations (over 30-35 per minute), and evidence of abnormalities of arterial blood gases, such as the PO2 level below 60 in a previously healthy patient or a PCO2 level below 30 or above 50, intubation is indicated.

The *second priority* is resuscitation of the *cardiovascular system*. If the patient demonstrates blood loss as manifested by the previously described signs of shock, frequent assessment of skin perfusion and temperature is appropriate. A urinary catheter should be inserted for monitoring urinary output. If there is any evidence of significant blood loss, access to the vascular system via cutdown is essential. If evidence of shock is minimal, this can be accomplished using a cutdown on an accessible antecubital vein. A 5 mm diameter plastic catheter threaded up the basilic vein to an intra-thoracic position facilitates rapid administration of volume or central venous pressure assessment techniques. This and the appearance of neck veins are always important aspects of initial triage. Distended neck veins or a high CVP in the presence of shock means tension pneumothorax, or pericardial injury or tamponade. Once these possibilities are recognized, immediate appropriate steps to identify and deal with the pathology are essential. These can consist of chest tube placement or pericardiocentesis (Figure 1-3).

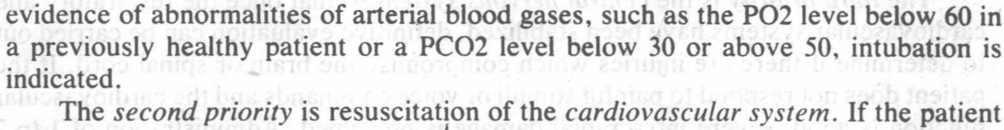

Figure 1–3 Neck Vein Triage Shock.

If the patient presents in shock, upper and lower extremity cutdowns should both be utilized. The saphenous vein at the ankle or at the saphenofemoral junction in the groin permits the introduction of the entire cross-section of intravenous tubing (8 mm diameter) in the average male patient. With saphenous and antecubital line in place, almost any patient who survived long enough to reach the Emergency Room can be successfully resuscitated, albeit briefly. Our resuscitation fluid of choice is Ringer's lactate or acetate. Two liters of fluid can be administered in two to five minutes in the average adult. If the patient responds and shock is alleviated, time is available for definitive evaluation.

If the patient does not respond or responds briefly to fluid infusion, urgent operation becomes part of the resuscitation.[23] Chest x-ray is the only diagnostic study necessary. This will tell the surgeon what body cavity to open first. If there is no blood in either hemithorax, the abdomen is the source of problems. The patient should be taken immediately to the operating room, the most appropriate body cavity opened and tamponade of the bleeding site carried out while fluid resuscitation is continued. We do not use plasma, albumin, or dextran as part of initial resuscitation, and whole blood is reserved for administration in the operating room; all initial resuscitation is carried out with balanced salt solution, even to the point of seeing the hematocrit fall below 20. The reason for this is that with adequate volume, a patient can maintain oxygenation of tissues despite a low hemoglobin. If bleeding is active, transfusing blood results in depletion of blood reserves through the loss of blood into a body cavity or externally so that once control of bleeding is obtained there may not be sufficient reserves of blood to restore the hematocrit to the optimal level of about 30.

The *third priority* is the *central nervous system* so that once the respiratory and cardiovascular systems have been stabilized, definitive evaluation can be carried out to determine if there are injuries which compromise the brain or spinal cord. If the patient does not respond to painful stimuli or voice commands and the cardiovascular function is good, severe intracranial damage is presumed. Administration of 1 to 2 units of mannitol or endotracheal intubation with hyperventilation will usually permit medical decompression of increased intracranial pressure so that time can be bought for obtaining definitive diagnostic procedures such as the CT scan. When the abdominal or thoracic injuries are extremely urgent, time may not permit obtaining definitive assessment of the neurological system. In these circumstances, the neurosurgeons may wish to place burr holes while thoracotomy or laparotomy is going on so that temporary decompression can be obtained. Later the patient can be taken for definitive scanning studies followed by reoperation as indicated to control intracranial bleeding and to evacuate intracerebral hematomas.

The *fourth priority* for resuscitation is the *gastrointestinal* and *genitourinary systems*. Generally, laparotomy should be carried out within six to eight hours, during the "golden period" of wounding. It is during this period of time that contamination such as that due to perforation of the intestine remains on the peritoneal surface so that local irrigation and debridement can be carried out and much of the risk of infection eliminated. After that so-called "golden period", the bacteria invade tissue so that the wound is not easily cleaned. It is for this reason that we do not observe stab wounds since we feel that prompt operation permits early recognition of injury and can avoid many of the infectious complications in the abdominal cavity and in the wounds and incisions.

The *final priority, orthopedic* and *maxillofacial injuries* and *plastic procedures*