CURRENT THERAPY OF TRAUMA 1984-1985

TRUNKEY · LEWIS

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PREFACE

In 1984 trauma remains the most important health and social issue in the United States. More people between the ages of one and forty die traumatically than from any other cause; and for every death there are at least two disabilities resulting from traumatic injury. The staggering health care costs in administering to trauma victims exceeds the combined costs of treating patients with heart disease and those with cancer.

An entire literature is devoted to efforts aimed at reducing trauma or minimizing its toll. Our focus in this volume is entirely on therapy, and our purpose is to provide the surgeon with practical, proven guidelines for managing trauma. The work is based solely on the authors' experience at the San Francisco General Hospital. It is neither a review of trauma surgery nor an eclectic look at a variety of approaches to management. We have eschewed alternative treatments in favor of current practices which in our hands have produced good results over time.

Unlike other trauma management books, we have waived the use of illustrations. Few if any wholly new procedures or techniques are described herein; we assume the reader has access to the periodical and book literature that abounds with illustration. Instead, we provide the nuances of care—patient selection, timing of therapy, medical care, follow-up treatment—that influence greatly the outcome of trauma surgery. Also conspicuous by their absence are reference citations in support of the text. We do not expect the reader to accept our every statement as *ex cathedra*; rather, we have looked inward upon our own practices in putting the work together, and we feel a bibliography citing principally our own publications would be fatuous. Please do not brand us self-indulgent for the result; our objective is the most direct means of describing our approach to trauma management.

We gratefully acknowledge the cooperation and forbearance of the publisher in bringing this book to fruition. We wish to thank our coauthors, who are colleagues and members of the "trauma team"; they have been willing collaborators both in the production of this book and in the care of patients over several years. Particular thanks are due the many surgical residents with whom we have worked. Not only do they provide most of the direct care involved in managing severely injured patients at our institutions, they also lead us to improved therapy by questioning and scepticism of established practices.

Donald D. Trunkey, M.D.
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PREHOSPITAL TRAUMA CARE

Frank R. Lewis, M.D.

Views regarding the appropriate level of care for traumatized patients in the prehospital setting are currently in a state of ferment, with considerable debate and controversy regarding what is effective and justifiable. There is no uniform set of practices in the different states, and in California, which has evolved a system with autonomy at the county rather than the state level, practices are markedly variable even within the State. The controversy that prevails is a result of the nearly total lack of clinically relevant studies regarding paramedic practices in trauma. There is virtually no advanced life-support modality advocated for care of the trauma patient—field stabilization, intravenous lines, MAST suits, endotracheal intubation, esophageal obturator airways (EOA), McSwain darts, or any of the myriad drugs—for which a study exists showing the overall efficacy of that modality. There is no area of medicine which is practiced today on a less scientific basis than prehospital care for trauma. It seems that most advanced life-support (ALS) practices have been adopted with the faith that doing something to the patient is better than doing nothing, and that even if they are ineffective, most interventions are at least not harmful. In light of recent experience, both of these assumptions have to be questioned.

Prehospital care for cardiac arrest victims is fortunately on firmer ground, and there have been excellent studies from the greater Seattle area as well as elsewhere which document the advantages of advanced life-support practices for cardiac arrest or major arrhythmias. The most recent data from the Seattle area show that paramedic field care improves net survival after cardiac arrest from 8 percent to 18 percent. Because of the demonstrated value of paramedic services for cardiac patients, a tacit assumption seems to have been made that comparable benefit will obtain for trauma victims. As a result, similar practices have evolved, and field assessment, at-the-scene stabilization, and multiple interventions have become the standard. In the last 2 years, articles have begun to appear questioning the value of these practices and, in some instances, documenting poorer outcomes in trauma patients when paramedic interventions are attempted. It is not that the interventions themselves are normally harmful, although that is certainly possible for some, but rather that the time taken to provide them results in clinical deterioration. Exsanguination is the most common cause of preventable mortality in the first 2 hours after traumatic injury, and it is rare that it can be controlled in the field. Therefore, time works strongly against the paramedic, as it will be difficult for him to do anything for the exsanguinating patient that will compensate for the additional blood loss that occurs with prolonged field time.

Skepticism is also developing regarding the effectiveness of many of the modalities that are routinely used. In the last year, studies of EOA use in the field have shown that it does not provide effective ventilation for as many as 70 percent of patients in whom it is used. Pneumatic antishock garment (PASG) usage has shown that old beliefs regarding its autotransfusion effect are invalid, and that it raises blood pressure principally by increasing cardiac afterload, because perfusion is interrupted to the lower half of the body. Harmful effects of PASG usage have been well documented, and somewhat belatedly we have realized that there is no study in the literature showing that, overall, PASG usage has net beneficial effects. In San Francisco, we attempted such a study during the last 2 years, and after examining 250 traumatized patients randomly treated with or without the PASG, we could show no effect on patient outcome, despite the fact that patients were stratified objectively according to severity of injury. We point this out not because we are convinced that the PASG has been proved to have no value, but rather to let the reader understand how barren this area is in regard to clinical studies. It is a triumph of politics over science that approximately one-third of the states have legislation requiring PASGs to be carried by ambulances where there are as yet no studies available documenting their benefit.

As a result of this paucity of data in the area of prehospital care for trauma, few measures can be said to have proven benefit. This chapter must therefore present my opinions, based on my experience and analysis of the problem. In the next few years, however, as additional studies are done, this field is likely to change rapidly. It should be clearly understood that the points to be made are not held unanimously among emergency physicians and trauma surgeons, nor even perhaps among a majority.

BASIC SKILLS

The skills for which there is seemingly no disagreement are those that are simplest, quickest, and most effective—extrication, spinal protection, splinting, control of external bleeding, and basic cardiopulmonary resuscitation. We will briefly touch on each of these.

Extrication is a complex subject, requiring a variety of devices and techniques and considerable ingenuity in the face of unpredictable situations. Most of the heavy equipment used in automobile extrication is provided by fire departments, which respond jointly with paramedics to accident scenes. The area of specific paramedic expertise is in the handling of the patient. The principal objectives during extrication are to provoke as little extraneous movement as possible and to provide immobilization of extremities and spine until fractures are defined. Whenever possible, rigid immobilizing devices, such as short or long spine boards, should be used, and the patient should be either fastened to these in situ, or moved as gently as possible onto them. During any movement careful attention should be paid to extremities, to keep them in anatomic positions and prevent any flailing or distortion.

Spinal protection has been heavily emphasized in paramedic training, because of the disastrous and irreversible consequences if an unstable fracture, particularly of the cervical spine, produces spinal cord injury which was not already present. The actual frequency with which this might occur is not well documented. One might intuitively think that cord injury would be most likely at the moment of impact, when the fracture actually occurs. It would seem that the forces and displacement of the fracture site would be greatest at this moment, and that subsequent displacement would normally be slight by comparison. The literature tends to show that this is indeed correct, and that most cord damage does occur at the time of the injury. Nevertheless, there are well-documented cases in which cord damage was clearly not present initially, but was produced by patient movement either in the ambulance or in the hospital before adequate immobilization was provided. Although rare, such cases have emphasized the tremendous hazard of this injury and have made most paramedics and emergency physicians extremely careful in their handling of patients prior to obtaining spinal radiographs. This caution is generally appropriate, but the paranoia regarding possible cervical spine injury has reached such proportions that other more life-threatening injuries are often treated inadequately rather than risk cervical spine movement. Many deaths have unquestionably resulted, and in my opinion, the pendulum needs to swing back a bit the other way. If the patient has an obstructed airway, for example, and is becoming asphyxiated in spite of the usual attempts to treat it, it makes no sense to prohibit cervical spine extension to open the airway because of the possibility of a cervical injury. It should be recognized that statistically the chance of damaging the spine is slight, and that it is far more important to treat immediately life-threatening airway problems in the most effective manner, rather than let the patient arrest from hypoxia. Although no good data have been presented on this point, it is my impression that airway obstruction is at least 100 times more common than cervical spine injury as a cause of death or major disability. Treating the greatest threat to life at each moment should therefore be the governing principle. Under nearly all circumstances, this will allow appropriate spinal protection to be given, but occasionally it must be ignored.

The actual means of spinal immobilization for cervical fractures has been debated extensively, and it appears that the best method is to use a spinal board or other rigid device, with the head and thorax secured to it. When the patient is on a stretcher, sandbags on each side of the head may be used, with tape across the forehead, secured to each side of the sandbags. Cervical collars alone are of little value and do not effectively stabilize the neck. As soon as possible, of course, the patient with a cervical fracture should be placed in axial traction, using a halo and tong arrangement secured to the skull.

Immobilization of extremities for possible fracture is a time-honored principle and continues to be one of the most important field treatments. Effective immobilization will prevent further damage to vessels, nerves, and soft tissues, and is thought by some to reduce the extent of hemorrhage surrounding a fracture. Fractures of the forearm and of the leg below the knee can be effectively splinted either with inflatable tubular splints, which are commonly available today, or with splints made of a rigid material and secured to the extremity by wrapping with gauze or other soft material. For fractures of the femur, the most effective immobilization is via a Thomas splint or equivalent with distal traction applied to the ankle and foot. Convenient mechanized splints (Hare traction splint) are commercially available today to accomplish this. Obviously, one must ascertain that lower leg fractures are not present before applying traction to the ankle for a femur fracture. Fractures of the upper arm are best splinted by strapping the arm to the trunk with circumferential wrapping, with sling support of the forearm, so that the elbow is at approximately 90°.

External bleeding may be arterial or venous, the source usually being indicated by the pressure and color of the blood. In either case, direct compression over the bleeding site is the best method of control. This is usually done with sterile gauze placed directly over the wound and the fingers or palm applied firmly over it. Occasionally, when the bleeding is from a relatively proximal artery, control is difficult and pressure must be more focal or intense. Tourniquets are rarely necessary and should be avoided if at all possible. If they are used, they must be released at least hourly to allow reperfusion of the extremity for a few minutes. Pressure dressings often are utilized, with either gauze rolls or elastic rolls wrapped around the extremity to generate pressure over the wound. Although these can be effective in some cases, direct manual pressure is usually more effective and should be used preferentially. Inflatable tubular splints or the legs of the pneumatic antishock garment (PASG) can also be used to tamponade extremity bleeding, particularly if it is coming from a large area, as with an extensively avulsed skin flap. They are most effective with venous bleeding, but if inflated above arterial pressure, they may be used to control that as well. The same precautions as with tourniquets apply if such high pressures are used.

The final basic skills which should be discussed involve cardiopulmonary resuscitation. Of the two elements involved—ventilation and cardiac massage—ventilation is by far the more valuable one to emphasize in trauma victims. External cardiac massage in the hypovolemic patient who has arrested due to exsanguination is ineffective and rarely successful. Ventilation, however, is frequently compromised and can be effectively treated, particularly in cases of head injury and coma, or of aspiration. A knowledge of how to clear the oropharynx, open the airway, and provide effective ventilation, either by mouth-to-mouth or bag and mask techniques, should be essential skills for all EMTs, from the most basic level to paramedics. Objective assessment suggests that this frequently is not the case, and that this fundamental skill deserves greater emphasis, training, and testing in most programs. External cardiac massage should also be attempted in all trauma patients in cardiac arrest, but should never delay transport, unlike myocardial infarct and arrhythmia victims. Unless the arrest is due to hypoxia which has been corrected, or the patient in arrest can be delivered within 5 to 10 minutes to a facility where definitive care is provided, survival is unlikely. Patients who arrest in the field after blunt trauma are virtually never resuscitatable. Those who arrest after penetrating trauma have salvage rates as high as 40 percent with emergency room thoracotomy, but only when transport is extremely rapid and definitive care is immediately available on arrival at the hospital.

ADVANCED SKILLS

The items to be discussed here encompass the ALS skills which have already been mentioned in the introduction, but rather than basing the discussion around each of the skills, we would like to present a different perspective. If prehospital trauma care is to save lives, it must specifically address the causes of early mortality in trauma victims and provide effective treatment for these.

Trauma patients, for purposes of analysis, may be divided retrospectively into three categories of severity: (1) rapidly fatal, (2) urgent and life-threatening, and (3) stable. The first group encompasses injuries in which rapid exsanguination, massive head injury, cervical cord transection, or major airway disruption are present and produce inevitable death in less than 10 minutes. Approximately 5 percent of all injuries and 50 percent of trauma deaths fall into this category. For the foreseeable future, we have no way of improving salvage in this group, other than through prevention or environmental modification.

The third group, which accounts for 80 percent of all trauma, includes those in whom injuries are minor and those whose injuries are confined to soft tissues or isolated extremity fractures. Rarely does this group have major injury within the thorax or abdomen. For this group, urgent treatment is not essential, as they will survive without significant disability, even with a delay in treatment of 2 hours or more.

We wish to focus on the second group—those who are potentially salvageable if the medical care system is operating competently and efficiently—and to examine the specific paramedic skills that may affect survival.

Three types of injury account for most prehospital trauma mortality. Direct cerebral and high spinal cord injuries cause approximately 50 to 55 percent of deaths. Exsanguination due to thoracic, abdominal, and major vascular injuries, or severe pelvic and long bone fractures, accounts for 30 to 40 percent of deaths. Airway obstruction, open or tension pneumothorax, and hypoxia from other causes account for 10 to 15 percent of the total. Obviously, many of these injuries fall into the first group described and are unsalvageable with present therapies. The remainder, however, fall into group 2. How can they be benefited by advanced life-support skills?

In potentially salvageable patients with head injuries who die, the usual cause of death is airway obstruction or aspiration causing acute hypoxia. This is true, of course, only when prompt neurosurgical care is provided, so that avoidable neurologic death does not occur. Patients with massive cerebral injury or brain stem herniation in the first hour or two are generally not salvageable, unless an acute epidural or subdural hematoma is present and can be decompressed. In the potentially salvageable group, cerebral edema causing significant elevation in intracranial pressure usually does not occur for at least 30 to 60 minutes, if not longer. Preventable death in the field is therefore mostly due to airway problems that occur with unconsciousness, not to the head injury directly. The most essential skill the paramedic can provide is therefore endotracheal intubation, which at once provides ventilation and airway protection. The neurologic lesion itself cannot be treated in the field and is best handled by rapid transport to definitive neurosurgical care. Spinal protection, in appropriate cases, is also an essential maneuver which can be quickly accomplished in patients requiring it. Since edema does not usually develop for 30 to 60 minutes, mannitol given in the field is unlikely to be of benefit and might aggravate coexisting hypovolemia.

The second most common cause of death is exsanguination. What can the paramedic offer? For isolated sources of external bleeding, direct pressure to control it is the obvious answer. The majority of patients who exsanguinate, however, do so from internal bleeding, which is not controllable without surgical intervention. The only treatments that are potentially beneficial are the establishment of an intravenous (IV) line with rapid fluid administration and the use of the pneumatic antishock garment (PASG). At first, each of these would seem to be noncontroversial. However, when the time taken for establishment of an IV is considered, it is more questionable. There are minimal data on the success rate or the realistic time it takes to start an IV in the field in trauma patients. In a study of 100 arrested patients by McSwain et al., the average time for starting an IV was 11 minutes. Given the suboptimal conditions under which the paramedic is working, this seems like an appropriate figure.

In a patient who will potentially exsanguinate in 15 to 40 minutes, the bleeding rate is in the range of 60 to 200 ml/minute, as it requires a loss of 40 to 50 percent of the blood volume to cause hypovolemic arrest. An average delay of 11 minutes to start an IV (plus an unknown failure rate, but probably at least 20 to 30 percent) will therefore lead to blood loss of 700 to 1800 ml while the attempt is being made, plus additional losses before and after. Given the fact that the paramedic cannot normally infuse more than 1,000 to 2,000 ml of IV solution in the usual 10 to 20 minutes between establishment of the IV and arrival at a hospital, it seems that the trade-off is not a good one. Under the best of circumstances, the loss of blood will have been offset by an equal volume of asanguineous, non-oxygen-carrying solution. Under more usual circumstances, the replacement volume will not even equal the lost volume. When one further considers that the balanced salt solutions normally used for IV administration have only one-third the intravascular filling effect of a comparable volume of blood, the trade-off is further worsened. The patient threatened with exsanguination in less than 40 minutes therefore loses more circulating blood volume during the average IV attempt than can be given subsequently to make up for it. If the failure rate involved in starting field IVs is considered, it only tips the balance further in favor of not starting the IV.

One might argue that the IV does not have to be started prior to transport and could be attempted en route. This is theoretically true, but the additional practical problem of starting an IV in a moving, bouncing ambulance are well known to paramedics, and they are prone to delay transport until the IV is established.

If total field times in excess of 40 to 60 minutes are encountered, the foregoing analysis does not apply, and the benefits of an IV might outweigh its disadvantages. This would occur with prolonged extrication or long transport distances; in the average urban setting where paramedic services are provided, these are not common problems. Where transport times of 5 to 20 minutes are more usual, it is clear that starting IVs in trauma patients is illogical: Patients who are bleeding rapidly and urgently need volume replacement will be harmed by the delay in starting the IV, and those who are not bleeding rapidly do not need the volume replacement.

What of the pneumatic antishock garment, which has enjoyed widespread usage in civilian systems since its introduction in Vietnam? It is clear that arterial hypotension can often be partially corrected by pneumatic antishock garment application. Originally this was thought to be due to autotransfusion of blood from the legs and lower abdomen. More recently it has been shown that only 200 ml of blood is autotransfused and that the major effects are due to increased peripheral resistance due to the tourniquet effect below the waist.

The beneficial effects of the pneumatic antishock garment are a rise in proximal aortic pressure, and potential tamponade of bleeding sources which lie within the garment itself, such as a badly fractured pelvis. Potential negative effects are increased bleeding from sources above the level of garment application, compromise of ventilation due to restriction of rib cage expansion and elevation of the diaphragm, and ischemic damage to tissues within the garment if it is kept inflated too long. In addition, there is a profound hypotensive effect when the PASG is deflated, which has been responsible for precipitating many cardiac arrests in emergency departments, and a concurrent washout of lactic acid from ischemic tissues analogous to that which occurs with aortic declamping.

It seems impossible in the abstract to weigh the negative and positive effects of the PASG application and decide whether there is net benefit; a randomized clinical trial is the only way we are going to learn if it is useful or not. We would advocate such a trial, preferably multicenter, to develop data as rapidly as possible. As noted in the opening paragraphs, we have done a preliminary study in San Francisco, and after examining 250 patients, we could find no difference in survival with or without PASG usage. A study to answer the question posed would therefore probably require 2,000 to 3,000 patients. In the interim, it seems reasonable to continue pneumatic antishock garment usage as is the current practice.

To summarize, in the patients who will potentially die of exsanguination in the first 40 minutes after injury, paramedics have little to offer other than direct control of bleeding where possible and rapid transport to a trauma center where definitive surgical care is available. Intravenous line placement appears to be counterproductive and pneumatic antishock garments will elevate blood pressure, but have not been proven to have more positive than negative effects.

Finally, what of the acute airway problems that are lethal? The great majority of these are effectively treated by endotracheal intubation, as it protects from aspiration and provides a closed pneumatic system for ventilation. It has been thought to the present time that the esophageal obturator airway (EOA) was an effective alternative to endotracheal intubation that did not require as high a level of skills training. It has now been shown in two different systems that the EOA does not function as well as thought, and that the incidence of inadequate ventilation when utilizing it is unacceptably high. It therefore appears that endotracheal intubation, though more demanding in training time and skill required, is sufficiently superior in results to justify this investment. When the benefits described earlier in comatose patients are also considered, the benefits seem overriding.

For the remainder of the acute, potentially lethal chest problems, there seems little that can be done in the field. Placement of McSwain darts for relief of pneumothorax has been advocated, but given the difficulty of making this diagnosis on clinical grounds, it seems unlikely that field use of these devices will ever be practical. The harm resulting from placement in a large number of patients with respiratory distress of other origin would almost certainly outstrip the benefits in the small number of patients with tension pneumothorax. Rapid transport is also again an essential factor in obtaining good results with major airway problems, since it is only in an emergency department or surgical suite that adequate facilities for diagnostic evaluation, tube thoracostomy placement, and possibly thoracotomy will be provided.

SUMMARY

Trauma patients are fundamentally different from cardiac arrest victims, who are customarily resuscitated and stabilized before transport. The difference is that cardiac patients already have an arrested circulation, and transport without resuscitation will only guarantee irreversibility. The trauma patient, in constrast, begins with a normal circulatory system and is progressively worsening with time. Attempts at "stabilization," other than for airway control and basic care, will only use up time and allow deterioration through progressive hypovolemia. Stabilization of the exsanguinating patient can only be achieved in an operating room by a surgeon trained to deal with traumatic injuries. In the patient who is bleeding rapidly enough to have his life threatened, time is critical, and wasting minutes in the field with ineffectual therapeutic maneuvers should not be tolerated.

The value of rapid transport has been shown in several studies, but seems not to have had the impact it should have had on paramedic practice. Military experience, from World War II through Vietnam, shows clearly that survival is inversely proportional to time of injury to effective treatment. McSwain has shown, in both trauma and cardiac arrest patients, that rapid transport leads to improved survival. Most recently, Gervin and Fischer have shown that delayed transport due to paramedic field interventions *decreases* survival in patients with cardiac injuries. The conclusion of all these studies is in agreement with my analysis.

It appears that a reorientation of paramedic field care for trauma patients needs to occur, and the skills and services that are actually beneficial need to be emphasized and taught. The overriding benefits will be from endotracheal intubation and rapid transport, with spinal and extremity immobilization when indicated. Intravenous lines seem counterproductive other than in prolonged transports or delayed extrication, and the pneumatic antishock garment is possibly useful, but needs to be objectively evaluated. Use of EOAs should probably be phased out and replaced by training for direct endotracheal intubation. Use of drugs is rarely, if ever, indicated. By focusing paramedic training on fewer skills which are truly beneficial, and ensuring that those skills are developed and maintained, the large investment in paramedic services will produce more effective benefits in the trauma patient than is currently the case.

EMERGENCY DEPARTMENT CARE

Frank R. Lewis, M.D.
Donald D. Trunkey, M.D.

The majority of trauma patients present to the Emergency Department without life-threatening injuries and may be assessed in the orderly manner to which physicians are traditionally accustomed. Roughly 10 percent of patients, however, will have life-threatening injuries; speed in assessment, diagnosis, and therapy becomes crucial to their survival. If the emergency physician or surgeon who initially sees such patients has not developed a logical and sequential plan for their management, then when confronted with the problem, he will almost surely function poorly and inefficiently. In contrast, the experienced physician who is able to quickly discern the critical areas of injury and deal with them appropriately can provide immediate treatment and can supervise and direct the multiple casualty situation with relatively inexperienced personnel. Disaster or triage situations only heighten the need for such expertise.

Although nothing can take the place of extensive experience in seeing and treating a variety of complex injuries, we have found that the following plan provides a framework which allows the most critical injuries to be dealt with first, but prevents minor injuries from being overlooked in the multiple trauma situation. With use, it becomes second nature whenever a trauma patient is encountered and rapidly allows the inexperienced physician to gain confidence.

In addition to expertise, it should perhaps be noted that the demeanor of the physician in charge of the resuscitation situation is also important. A calm and deliberate manner is essential, and instructions to other medical and paramedical personnel must be given clearly and unambiguously. Vacillation, indecision, and overt anxiety will alarm the patient, as well as everyone else in the vicinity.

The sequential steps in rapidly assessing and treating the patient are the following:

1. Airway and pulmonary evaluation
2. Estimation of blood volume loss and cardiac status
3. Brief history and physical
4. Initial treatment
5. Definitive diagnosis and care

In the following pages these will be discussed in detail. One should bear in mind that it should be possible to complete the first 3 items in the above list in less than three minutes. A relatively good picture of the patient's injuries, status, and prognosis will then be apparent, and one can return to any area that demands urgent attention or can proceed with diagnostic studies or surgical intervention, as indicated. It is absolutely essential that the responsible physician take the time to make this assessment when he first sees the patient, and not to take the word of anyone else for the findings that are present. We commonly see instances of over- and undertreatment of patients because this principle is ignored, and therapy is instituted for the most obvious injury without evaluating all systems. There is virtually never a reason not to take the brief time necessary for a thorough assessment.

AIRWAY AND PULMONARY EVALUATION

Airway obstruction is generally recognized as the most rapidly fatal problem seen in the emergency setting; not so well recognized are the injuries to the lung or chest wall, which impair ventilation almost as severely as an obstructed airway, and which can also be rapidly fatal: open pneumothorax (sucking chest wound), tension pneumothorax, and flail chest. These entities should always be considered in any patient with severe respiratory distress.

An initial look at the patient after he or she has been completely undressed should give the examiner several pieces of information about respiratory status: Is the patient making respiratory efforts? How strongly and how rapidly? Is he awake and able to protect his airway from aspiration? Is air actually exchanging via the nose and mouth? Is respiratory noise present—gasping, stridor, or wheezing? Is the chest wall moving symmetrically on both sides, or is there splinting or paradoxical movement? Are there any surface markings, wounds, abrasions, or ecchymoses indicative of the area and extent of trauma? Is the patient breathing easily, or are the accessory muscles being used? What are the relative durations of inspiration and expiration? Is the patient comfortable lying supine, or does he need to sit upright or in some other position to maximize ventilation?

If the foregoing assessment indicates that the patient is apneic, or if the airway is totally obstructed, immediate attention must be directed to it. One should first open the mouth and suction the back of the throat. If a "cafe coronary" is a possibility, and the patient is unconscious, insertion of two fingers over the tongue to the area of the glottis will usually disclose a foreign body if present and allow its easy removal. In the awake patient in respiratory distress, insertion of anything into the nose or mouth will usually exacerbate the distress and should be avoided unless a specific therapeutic maneuver, such as endotracheal intubation, is being carried out.

Once secretions or foreign body have been excluded, one should displace the jaw anteriorly, either by grasping the symphysis and lifting or by using both hands and lifting forward on the mandibular angles. If the airway can be opened, a well-fitting mask can then be used to ventilate the patient with positive pressure and 100 percent oxygen for 2 to 3 minutes. If it is not possible to establish ventilation with a mask, one should move immediately to intubate the patient via the oral route with either a No. 6 or No. 7 cuffed endotracheal tube. For the nonanesthetist physician who intubates patients infrequently, we prefer a large straight blade for the laryngoscope (Miller or Wisconsin blades) rather than the curved MacIntosh blade.

In more than 99 percent of patients, airway access via oral intubation of the trachea is successful in the emergency department. The occasional patient, however, because of severe maxillofacial injury, bleeding, distortion of anatomy, or foreign body, will require emergency tracheostomy. When necessary, a cricothyroidotomy should be done between the laryngeal cartilage and the cricoid, rather than a classic tracheostomy through the second or third tracheal rings. Access to the cricothyroid membrane is much faster and easier, as it lies nearer the surface and requires minimal retraction for exposure. Concern about subglottic stenosis or vocal cord dysfunction following this procedure has been shown in recent series not to be a significant problem. A transverse incision 2 to 3 cm long is made transversely directly over the cricothyroid membrane, with the patient's neck extended. The membrane is incised transversely over the anterior third of the tracheal circumference, and a curved clamp is inserted and spread to define the opening. A No. 5 to No. 7 curved (60°) tracheostomy tube is then inserted, and the cuff is inflated. The tube should be immediately secured around the neck with umbilical tape.

We are often asked whether endotracheal intubation or tracheostomy, both of which require neck extension, should be attempted in the unconscious patient when a cervical spine fracture is a possibility and x-ray studies have not been obtained. In such circumstances, one must decide which is the greater threat to the patient—the obstructed airway or the possible cervical spine fracture. In our opinion, the airway virtually always has priority, as the possibility of cervical cord injury is relatively remote. If circumstances allow, however, and the patient is not facing a life-threatening situation, cervical spine injury should certainly be excluded first.

We might parenthetically comment on the value of oxygen administration in the acutely traumatized patient with airway or pulmonary problems: it rarely provides significant benefit, as most of the life-threatening problems are due to inadequate ventilation of the alveoli, and are mechanical in nature. While increased inspired concentrations of oxygen are unlikely to be harmful, and should be used if readily available, one should not waste time in the acute emergency looking for a source of oxygen when what the patient really needs is effective definition and correction of his ventilatory inadequacy.

Let us return now to the completion of the pulmonary assessment, assuming that the degree of airway impairment is not such as to require immediate intervention. After a careful visual inspection, as already described, one should palpate the entire thorax for crepitus or rib instability, or (if the patient is awake) to see whether pressure in any area causes pain. This is most easily done by compression of the sternum toward the spine, followed by compression with the examiner's hands on each side of the chest. Rib fractures are the most common injury seen after blunt trauma, and their diagnosis is predominantly clinical. When a rib is fractured, there is point tenderness at the fracture site, and pressure on the rib at a distant location will reproduce the pain. X-ray examination should be used to define multiple rib fractures, but multiple views to rule out all possible fracture sites are not necessary. It should also be remembered that costochondral fractures do not show on x-ray films. The trachea should be palpated and its position relative to the sternal notch carefully noted. The clavicles and scapula should also be palpated for tenderness or deformity.

If respiratory distress is present, one should auscultate the chest to see whether breath sounds are reduced on one side. If the patient is not in any respiratory distress, we do not waste time with auscultation at this point in the assessment. It should be noted that although physical diagnosis books describe marked differences in breath sounds on the two sides as the diagnostic criteria for pneumothorax, the practical usefulness of this observation is limited. The differences may be quite subtle and, in a noisy trauma room, impossible to distinguish. Thus auscultation should be recognized as of limited value and should never be the sole determinant of treatment or of nontreatment of pneumothorax.

At this point one should have a fairly good idea of the thoracic pathology present, based on the examination and the mechanism of injury. If the trauma is penetrating, is it confined to one hemithorax, or does it cross the midline, with the concomitant risk of major vascular or cardiac injury and perforation of the esophagus or trachea? Is there subcutaneous emphysema, suggesting tracheal or bronchial disruption? Are there obvious rib fractures, and if so, approximately how extensive are they? Is there good reason to suspect that there is a pneumo- or hemothorax? The final decision on many of these points must often await the chest roentgenogram, as physical diagnosis is at best inexact. In the compromised patient, however, one may not have time to get the roentgenogram, and therapy must be undertaken on the basis of the physical findings and likely injury. The patient in severe respiratory distress, who is not relieved by tracheal intubation, should have chest tubes placed prior to any x-ray examination, as they may be lifesaving. If injuries appear confined to one side, then initially a unilateral chest tube should be placed; if lateralization is not possible, bilateral tubes should be inserted. The actual technique of insertion will be addressed later in this chapter.

ESTIMATION OF BLOOD VOLUME LOSS AND CARDIAC STATUS

The next priority is to assess the degree of shock and decide how much intravascular volume replacement the patient is likely to need, how rapidly, and what size and type of intravenous catheters are needed. A judgment about degree of shock must always be considered in light of the time since injury. If, for example, the injury occurred 15 minutes before and the patient is in profound shock, massive bleeding is occurring and several large-bore IV access lines are needed. Conversely, if the injury occurred 2 hours before and the degree of shock is mild, the rate of bleeding is not immediately life-threatening, and less aggressive volume restitution is called for.

The indicators that are commonly used for assessment of shock in the emergency setting are the following:

1. Blood pressure
2. Pulse rate
3. Skin perfusion (color, temperature, moisture)
4. Urine output
5. Mental status
6. Central venous pressure

We would like to discuss each of these and indicate its sensitivity and accuracy in the assessment of shock.

Although blood pressure is the time-honored parameter that is used to define volume loss, we feel it is less accurate and sensitive than items 2, 3, and 4 above. The response of the blood pressure to intravascular depletion is nonlinear, as compensatory mechanisms of increased cardiac rate and contractility, and venous and arteriolar vasoconstriction provide excellent compensation for the first 15 to 20 percent of intravascular volume loss in the healthy young adult. After about 20 percent volume loss, the blood pressure begins to decline, and in the average patient, it will be in the 60 to 80 mmHg range with 30 percent volume loss and the 30 to 50 mmHg range with 40 percent volume loss. As volume loss becomes more severe, therefore, the decline in blood pressure is more precipitous. In the elderly patient who cannot compensate as well by the aforementioned mechanisms, the decline in blood pressure begins at 10 to 15 percent volume loss and will proceed to the point of arrest by 40 percent loss. The nonlinear behavior of blood pressure has two disadvantages: Declines in blood pressure are a relatively insensitive sign of early shock, and in the infrequently monitored patient, blood pressure may appear stable for an initial period, and then rather suddenly appear to "crash." We often hear the inexperienced observer speculate about how a bleeding source must have suddenly appeared to explain this behavior; in reality the patient was bleeding all the time and finally reached the point of decompensation.

The other obvious deficiency with blood pressure monitoring is the lack of an absolute "normal." A patient who is normally hypertensive may be in profound shock when his systolic blood pressure is 120 mmHg, whereas the healthy young athlete may be entirely normal with a systolic pressure of 90 mmHg.

Pulse rate is the second commonly used indicator and, indeed, is more sensitive than blood pressure. Its value is significantly limited by its lack of specificity, as the emotionalism, pain, and excitement surrounding the usual trauma situation may result in tachycardia without hypovolemia. However, if tachycardia is sustained above levels of 120/min, it should be considered an indicator of hypovolemia until proven otherwise. In young patients, the heart rate may accelerate to 160 to 180/min with severe volume depletion. The older patient is unable to accelerate to this degree and rarely will sustain rates greater than 140/min.

Skin perfusion is, we feel, a greatly underappreciated indicator of hypovolemia, but it is the observation we place most confidence in when initially evaluating the patient. The early physiologic compensation to volume loss is to vasoconstrict vessels to the skin and muscle, and this is manifested by paleness and coolness of the skin, which develops quite rapidly. The release of epinephrine, which also accompanies hypovolemia, causes sweating, and on palpating the patient's trunk in such a situation one will be immediately struck by the coolness and moisture. The lower extremities are the first to manifest the vasoconstriction, and palpation over the kneecaps or the feet provides the best "early warning" of impending shock. We routinely use these findings with confidence in all age groups and all types of injuries, and have yet to find them unreliable.

The fourth indicator is urine output, and any patient with significant trauma should always have an indwelling urinary bladder catheter inserted as soon as possible to monitor urine volumes every 15 minutes. This is the second most reliable indicator of volume loss, after skin perfusion, and is only slightly less sensitive than that. The second level of compensation of the body to hypovolemia is visceral vasoconstriction, and this results in decreased flow to the gut, liver, and kidney. Urine output will immediately reflect decreases in renal blood flow; hence its value as an indicator. A minimally adequate urine volume is 0.5 ml/kg/hr, and resuscitative fluids should be administered rapidly until this level is reached. If urine output exceeds 1 ml/kg/hr, the fluid administration rate can be cut back. On an ongoing basis during resuscitation or surgery, the urine output is overall the best indicator of adequacy of volume restitution.

The fifth indicator of hypovolemia, alteration in mental status, is rarely seen because it is present only with preterminal degrees of hypovolemia. Compensatory mechanisms maintain flow to the myocardium and brain with great tenacity; hence one does not see cerebral hypoperfusion until blood pressure is in the 30 to 60 mmHg systolic range or below. The alteration usually seen is agitation and mental confusion, so that the patient becomes irrational, anxious, and uncooperative. Such states are also commonly produced by alcohol or other drugs in the emergency setting; hence it may be hard to distinguish alterations due to hypovolemia from those due to drugs, particularly when both may be present. There is no sure way to resolve this problem, other than to retain a high degree of suspicion and to be aware that the agitated patient must immediately be checked carefully to exclude hypovolemia as a cause for his behavior.

The last parameter, central venous pressure, is not a very good indicator of hypovolemia, since the normal levels of 3 to 8 mmHg are relatively hard to distinguish from hypovolemic levels of 0 to 5 mmHg, particularly when one is initially es-