Clinical Anesthesia

Anesthesia for Emergency Surgery

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Chapter 1

General Considerations in Anesthesia for Emergency Surgery

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The principles involved in the anesthetic management of various types of surgical and obstetrical emergencies are cogently described in detail in subsequent chapters. This chapter emphasizes certain general considerations which pertain to the subject as a whole and certain clinical situations which may occur but which are not mentioned elsewhere in this monograph.

The first and perhaps the most important principle is that true surgical emergencies requiring *immediate* operation are rare. In fact, probably more patients are endangered by ill-advised emergency management of subacute situations than are endangered by delayed treatment of true emergencies. The vast majority of cases listed as "emergencies" are in reality urgent or emergent and as such benefit by a certain amount of time devoted preoperatively to full evaluation of the patient's condition, to institution of corrective and supportive measures, and to the organization of an appropriately skilled operative team with a rational plan of action calmly thought out in advance of surgery. The majority of true emergencies are either obstetrical in nature (Chapter 10) or involve either the cardiovascular system (Chapter 5) or patency of the airway (Chapter 9). Other "emergencies" usually benefit from less than immediate and often frenetic treatment.

A second principle in the anesthetic management of emergency surgical cases is that true patient safety is based upon well-established physiological and pharmacological facts. It is not based upon the ability to "get away with" a calculated risk. The mere fact that one has successfully assumed a calculated risk a certain number of times is in itself no criterion of true safety. This principle is true in all anesthesia but perhaps nowhere does it assume such importance as in the management of emergencies. The management of the full stomach is but one example of this, though perhaps the most frequently encountered. Administering thiopental to a patient with a full stomach for the closed reduction of a Colles' fracture is inherently and irrevocably unsound. The mere fact that it has been successfully done 100 or even 200 times in a row indicates nothing except perhaps a basic lack of self-confidence on the part of the anesthetist in his ability to provide conduction anesthesia. Such a past record is also of no consolation to the widow of the 201st case. In this regard, clinical impressions based upon the notorious inadequacies of human memory are an anathema in all areas of medicine but are especially so in anesthesia where statistically valid data are always required (but seldom available) to support a particular anesthetic technique.

A not infrequently encountered clinical situation which is not discussed in subsequent chapters but which often poses a problem to anesthetist and surgeon alike is determination of the optimal time for anesthesia and surgery in a patient actively bleeding internally to such an extent that blood replacement can keep up with blood loss but never exceed it with the result that the patient remains in hemorrhagic shock despite massive transfusions. On the one hand, one hesitates to anesthetize a patient in hemorrhagic shock for fear of so altering an already precarious cardiovascular status that cardiac arrest develops. On the other hand, continued but futile transfusions leave the patient in shock while exposing him to all the risks of repeated transfusions, to say nothing of depleting the blood-bank. The best data on the management of this difficult problem are those obtained by Beecher in his study of severely wounded military personnel.[1] These data indicate that enough blood should be replaced to cause either the blood pressure to start to rise or the pulse rate to start to slow. This is the moment which is most propitious for the start of anesthesia and surgery. To give less blood than this entails the danger of immediate cardiac arrest. To give more blood is often futile because as long as bleeding persists the blood pressure and pulse rate can never be returned to normal values regardless of the amount of blood transfused.

Another frequently encountered emergency which can put the anesthetist on the horns of a dilemma is the management of the patient with a post-operative dehiscence of an abdominal wound severe enough to result in essentially an evisceration. Here the anesthetist would like to provide profound muscular relaxation to facilitate wound closure but he would like to do so without having the patient strain or cough and so making the evisceration worse. The anesthetist's problems are further accentuated by, as is usually the case, the presence of a full stomach. His problems are even further added to if the original incision had been closed with wire stay sutures which remain in place, ready to lacerate and perforate bowel if any straining or coughing occurs. In such cases the presence of a Scultetus binder to contain the evisceration impedes or even prohibits spinal or peridural anesthesia. In such a situation there is no solution which is ideal from all points of view, and all anesthetic techniques have theoretical disadvantages. By and large, spinal or peridural anesthesia is best, especially if the disrupted wound is in the lower abdomen and if the Scultetus binder can temporarily be removed. If such is not possible, general anesthesia induced with thiopental is often the next best solution, preceded by preliminary denitrogenation with 100 per cent oxygen, given while the patient is awake, and followed by prompt endotracheal intubation with a relaxant other than succinylcholine. The fasciculations resulting from the use of decamethonium-like compounds are often dangerous in such a situation.

But in all emergencies, the anesthetist should be prepared in advance for any eventuality. He should never be induced into starting an anesthesia, regardless of how extreme the emergency, without having all his equipment immediately at hand and in functioning order. To do otherwise is to court disaster, for inevitably subsequent events will occur at such a pace that the patient "gets ahead of the anesthetist."

Reference

1. Beecher, H. K.: *Resuscitation and Anesthesia for Wounded Men.* Charles C Thomas, Springfield, Illinois, 1949.

Chapter 2

Anesthesia for Thoracic Emergencies

Donald W. Benson, M.D.

Injuries involving the chest wall and lung parenchyma are becoming more frequent as transportation speeds increase and safety engineering fails to keep pace. At the same time, lifesaving surgical intervention has been extended to patients for conditions previously considered unsalvable. The place of the anesthesiologist in both resuscitation and the anesthetic management for operative procedures in these emergencies has become increasingly important.[6] An accurate comprehension of the practical physiology involved in respiration is absolutely necessary for the proper care of these patients.

PHYSIOLOGICAL CONSIDERATIONS

A review of pertinent physiology may cover points so rudimentary that one perhaps ought to apologize for presenting it. Critical situations may arise so acutely, however, that a thoughtful, reasonable approach may be impossible. The anesthesiologist may have to step into a totally unfamiliar situation and perform tasks far from the ordinary. Only previously thought-out approaches and a complete grasp of the underlying physiological principles can save the day. This urgency justifies frequent review of these principles.

Functionally, the thorax and the respiratory contents may be divided into three major groupings: (1) the airways or conducting system; (2) the lung substance, including the alveoli and blood supply, both nutritional and respiratory; and (3) the thoracic wall, including the diaphragm. These three components work together to move sufficient air in and out of the lung and to ventilate blood passing through the lung from the right side of the heart to the left side for distribution. The gross function of air movement depends upon the increase in thoracic volume by downward motion of the diaphragm and outward motion of the chest wall by the familiar parallelogram action of the rib cage. This creates a decrease in pressure (an increase in negative pressure) in the potential space between the visceral and parietal plurae where a slightly less than atmospheric pressure already exists. The lungs expand to fill the void created by the expanding chest wall and thereby reduce the pressure in the air passages to less than atmospheric; whereupon air from the outside moves in to balance the pressures. When the appropriate inhaled air volume has been reached, the intercostal muscles and diaphragm relax and the elastic properties of the lung and chest wall, occasionally aided by muscular activity during forced breathing, bring the components back to their resting state and squeeze out some of the contained air. After a suitable resting time, this cycle repeats itself. The air in the alveoli is changed during the cycle so that fresh gases are presented to the capillary blood flowing through the alveolar walls.

The integrity of this beautifully constructed system is the major concern in emergencies surrounding the respiratory system, whether resulting from trauma or intrinsic disease. Maintenance of ventilation is vital to the functioning of the other body systems and must assume precedence in emergency therapy. The obvious exception is, of course, cardiac arrest wherein both systems must be artificially maintained at the same time. Let us consider then the patho-physiology of the three components of the respiratory mechanism with an eye towards understanding their treatment in resuscitation, anesthesia, and long-term maintenance.

The Airway

The air passageways are constructed to provide optimum distribution of gases with minimum effort. Disease and trauma can defeat this purpose by wholly or partially obstructing the airway with foreign bodies, tumors, edema, secretions, or blood. Intrinsic changes within the walls of the air passages, such as smooth-muscle spasm or collapse, can cause increased resistance to air flow because of decreased cross-sectional area. High respiratory obstruction lowers ventilatory efficiency as tidal volume decreases. This leads in turn to decreased alveolar ventilation with carbon dioxide retention and hypoxia. The respiratory drive increases and causes more muscular activity. Greater negative pressures within the thoracic cage improve air flow through the obstruction. But, as the pressure differential to move air increases, the effective resistance also increases. The increased workload eventually causes muscle fatigue and decreased alveolar ventilation. The stage is set for a catastrophe. If the obstruction can be removed or by-passed, ventilation will return to normal. Increasing the concentration of oxygen inhaled will help to relieve the hypoxia but will do nothing for the hypercarbia. Oxygen should be given as a temporary measure until the obstruction itself can be treated.

High airway obstruction of any severity cannot be tolerated for long because it involves the whole lung. Low airway obstruction on the other hand may involve only parts of the lung so that signs of impairment will depend on the degree of involvement and may take some time to develop. Unventilated or collapsed portions of lung through which blood is still flowing make an effectual shunt from the right to the left side of the heart. This will usually result in some unsaturation of arterial blood and perhaps some cyanosis. Hyperventilation of normal parts of the lung usually compensates for carbon dioxide retention in the non-ventilated portion. As more alveoli are involved, both hypoxia and hypercarbia progress and the picture begins to resemble that of partial high obstruction.

Lung Substance

There is, of course, no clear-cut division between the lower airways and the lung proper in their pathological physiology. For example, lung contusion may cause excessive secretions and bleeding. This results in obstruction of air passages as well as blocked diffusion across alveolar membranes. The excessive secretions and internal bleeding of the contused lung were recognized as the "wet lung" syndrome in World War II.[4] Aggressive removal of secretions from the bronchi and bronchioles by suctioning and adequate coughing was vital in the saving of many of the patients having the wet lung syndrome.

Fluid in the alveolar sacs acts as an obstruction since blood continues to flow in the capillary bed but has no opportunity for gas exchange. This fluid barrier exists in clinical conditions such as pneumonia, either bacterial or chemical, and in pulmonary edema. The latter, when severe, can also behave as an obstruction. Disease processes can involve the tissue separating the capillary blood and the alveolar gases thereby hindering gaseous diffusion. Where there is such a diffusion barrier a high partial pressure of inhaled oxygen may improve diffusion of oxygen into blood by increasing the gradient across the dividing membranes but will have little effect on improving the rate of diffusion of carbon dioxide out of the blood into alveoli.

Acute pulmonary embolus presents a reversed set of circumstances. The embolus stops the pulmonary blood flow through the involved lung and although alveolar ventilation may be adequate there is no blood to be oxygenated. Furthermore, there is an increased resistance to flow from the right to the left side of the heart and a pulmonary hypertension results which may go on to produce heart failure. Complex reflex activity also occurs with the production of shock and dyspnea. When the embolus is large and is located at or near the bifurcation of the pulmonary artery it can be removed. Through the years the procedure for its removal has been attended by extremely high mortality but, with the advent of cardiopulmonary by-pass and diagnostic techniques capable of locating the embolus, more patients have been saved. The entire procedure is one of heroic proportions and should only be attempted by those well versed in the techniques of heart-lung by-pass.[10]

Atelectasis can be caused not only by obstructing processes within the lung but also by forces acting from without. The lung remains expanded by virtue of the slightly sub-atmospheric pressure surrounding it within the thorax. The presence of a pneumothorax, a hemothorax, or a hydrothorax causes collapse of lung tissue. If enough collapse occurs, some of the blood passing through the pulmonary circuit will be inadequately ventilated. This is most apparent when collapse is acute. When it is chronic the blood flow through the unaerated lung decreases or stops, thus reducing the shunt. The removal of air or fluid by whatever means allows the lung to expand and improves ventilation.

The special situation of tension pneumothorax is one of the most serious emergencies encountered in medicine. This usually begins with a lung leak which may be produced by a laceration from a sharp instrument, fractured rib, or a simple rupture of an emphysematous bleb. Air enters the pleural space causing symptoms of a pneumothorax. This results in dyspnea with increased negative pressure within the pleural space as the patient struggles to improve ventilation. More air is pulled into the area of pneumothorax and cannot escape. The amount of air in the pneumothorax increases, especially during the forced exhalation of labored breathing, and eventually builds up a sizable head of pressure. The positive pressure within the pneumothorax causes greater lung collapse, thereby setting up a vicious cycle. The displacement can be so great that the contents of the mediastinum are pushed into the uninvolved side. The hydrodynamic effects on the cardiovascular system are serious resulting in severe obstruction to venous return. Unless the air is vented and the normal negativity established, the situation can deteriorate with catastrophic results.

The Chest Wall

Another type of wound that can produce inefficient respiration is the so-called "sucking wound" of the chest. Here a pneumothorax results but air moves back and forth at a rate dependent on the size of the hole. Simple closure of the hole and subsequent removal of the trapped air by tapping or underwater drainage rapidly improves the patient's condition.

This situation is well known to the anesthetist since it is similar to that encountered in a simple one-sided thoracotomy. Here the paradoxical movement of the lung on the open side (collapsing during inspiration and expanding during expiration) defeats the ventilatory effort. In surgery this is taken care of by assisting or controlling respiration with positive pressure in the airway during inhalation. It must be borne in mind, however, that the position and size of the hole may be such that air is trapped, causing lung collapse.

Some of the major thoracic emergencies of today are found in the so-called "closed injuries" involving the thoracic cage. Here there is no opening into the pleural space from the outside. There may be, however, pneumothorax, hemothorax, or a combination of the two as a result of lung trauma. These conditions have been discussed previously and will not be taken up here except to point out that they must be considered as complicating factors in closed chest injuries. The main difficulty is the inability of the chest wall to function as a unit, so that inadequate ventilation results. As there are degrees of injury, there are degrees of malfunction. There may be, for example, multiple rib fractures which do not result in paradoxical chest movement but which do cause pain of such intensity that the patient involuntarily splints the chest wall to the degree that hypoventilation occurs.

At the other end of the scale are multiple rib fractures which result in marked instability as the chest wall endeavors to make normal respiratory movements. This entity is sometimes called the "flail chest" and it is just that. As an inspiratory effort is made the chest wall moves inward with a paradoxical motion. Because the patient is frequently hypoxic and hypercarbic the respiratory movements are exaggerated and rapid. The chest tends to move in and out rapidly in a flailing manner which is inefficient for respiratory exchange. Minor degrees of instability can be tolerated but if the wounds are of any severity the respiratory inefficiency is intolerable and the course is usually downhill unless aggressive therapeutic measures are undertaken.

The remaining portion of the thorax, the diaphragm, can also contribute to emergency situations. Diaphragmatic hernias of all sorts, under the proper conditions, such as acute obstruction or dilatation of the stomach or gastrointestinal tract, can result in excessive lung collapse. Here the abdominal contents occupying space in the chest behave like a large hemothorax with similar signs and symptoms. This is especially true in the newly born and in the very young infant in whom diaphragmatic malformations may result in the filling of an entire hemithorax with bowel. Traumatic rupture of the diaphragm can result in much the same picture and cause severe hypoxia and hypercarbia.

CLINICAL CONSIDERATIONS

As has been implied in the introductory paragraphs, anesthesia for surgical intervention and resuscitation in thoracic emergencies is the application not so much of techniques as of the physiological understanding of the situation. A rapid diagnosis should be followed by measures *first* to provide ventilation of the pulmonary blood flow and *second*, as the situation allows, to carry out definitive therapy. In order that the physiological approach is maintained, let us look at some representative clinical problems in the same order as the patho-physiology was discussed.

The Airways

A cardinal rule in anesthesia in the presence of high airway obstruction is that the obstruction should be cleared by means of endotracheal intubation prior to anesthesia. Intubation accomplished while the patient is awake with the assurance of a clear airway takes away most of the danger involved in the resection of tumors high in the trachea or larynx. It should be remembered, however, that traumatic and unsuccessful attempts to pass an endotracheal tube beyond a partially obstructing tumor may result in rapid enlargement of the tumor with resultant complete obstruction.

It must be realized that temporary compromises must often be made. The endotracheal tube which can be passed beyond an obstruction will often be smaller than one's good judgment would consider desirable. For example, a tracheal fracture just above the carina in a young adult may stenose down until it will admit only a 23 or 26 French tube. To carry out controlled ventilation for an adult during thoracotomy through a tube of this size may be difficult. Adequate alveolar ventilation can be maintained through such an airway, however, if the lungs distal to the obstruction are in reasonably good condition and if lung and chest wall compliance are normal. A positive-negative type respirator is of great help in supplying pressures adequate to move the volumes of air rapidly enough in both directions. Once the trachea is opened the first tube is quickly removed and a large cuffed tube is passed, guided by the surgeon into the distal trachea. Such an operation obviously requires excellent cooperation and communication between surgeon and anesthetist. Any delay could prove fatal.

There is the rare occasion in partial high airway obstruction, however, when general anesthesia without a tube is necessary or desirable and when relaxation is extremely helpful. An excellent example of this is the removal of a large foreign body trapped just below the glottis in a large child in whom the involuntary movements of the larynx may damage the vocal cord during removal. In this and like instances some test of adequacy of the airway should be made before anesthesia is attempted. Adequacy of the airway can be assessed by ventilating the patient with a bag and mask and making certain that air can move freely enough to allow adequate or near adequate ventilation if the patient is paralyzed. To carry out an apneic technique for foreign body removal, denitrogenation of the lung is first accomplished by non-rebreathing of oxygen. Then anesthesia is induced with an intravenous anesthetic agent, followed by a dose of succinylcholine adequate to produce total relaxation. Hyperventilation for carbon dioxide removal is carried out if possible and then followed by endoscopy and removal of the foreign body. The approximate length of time that apnea can be allowed depends on the degree of denitrogenation, the amount of carbon dioxide blown off, and the amount of oxygen sucked from the lung by bronchoscopic equipment. This is usually four to six minutes. Clinical judgment should prevail, however, and if signs of hypoxia and hypercarbia develop, such as rising blood pressure, irregular or slow pulse, or cyanosis, the procedure should be stopped and ventilation taken over.

There are fortunately few emergency operations which must be carried out for obstruction of the lower airways. Lower airway obstruction, unless it exists throughout the lungs, allows for enough ventilation so that immediate intervention is not necessary. Although some sort of definitive therapy such as bronchoscopic removal of obstructing substances or surgical removal of an affected portion of lung must be carried out within a reasonable time, a planned approach to the problem can usually be made.

There are acute occasions, however, such as persistent intra-pulmonic bleeding which can be frightening both in appearance and portent. The usual therapy is sedation of the patient to put the lung at rest in the hope that the bleeding will stop. Small amounts of blood can usually be coughed up and if the patient can be kept quiet the bleeding may stop. If it persists, however, obstructing clot formation will take place in an increasing amount. Bronchoscopic examination can usually reveal which side and sometimes which lobe is the source of bleeding. It is unlikely that surgery will be attempted unless there is a very good idea of the source of the bleeding.

Endobronchial anesthesia, a Carlen's tube or a technique described by Bonica being employed, can be of real value in this situation,[2, 3] allowing ventilation to be carried out by the uninvolved lung and protecting the normal lung from spill-over bleeding. If either the equipment or the experience for these techniques is lacking a large, well-placed endotracheal tube and proper positioning will suffice. The Overholt table or similar adaptations, with the use of the Overholt positions, will allow good drainage. Most operating rooms do not have such devices, however, and must rely on regular operating tables. Steep Trendelenburg position, with the patient on his unaffected side and slightly face down, coupled with frequent suction, is the best compromise. The steepest head-down position is required when the left side is recumbent to allow for the greater angulation of the left main-stem bronchus. Whatever technique is used, speed is essential. Everything and everybody should be completely ready before rapid entry is made into the chest. Personal experience suggests that intubation is best done with relaxation and an apneic technique so that good visualization of the larynx can be made. Even in expert hands, intubation made while the patient is awake frequently is difficult because of the spray of blood being coughed out. Light general anesthesia allowing the retention of some cough reflex will minimize the spread of blood to normal lung.

Once definitive surgery has been carried out, the aftercare may still be mainly airway management. Removal of retained blood and tracheobronchial toilet are important. Tracheotomy should be considered together with high humidity and instillation of clot-dissolving enzyme preparations. All these and excellent tracheotomy care are necessary for survival.

The techniques suggested for the management of intra-pulmonic bleeding can be extended to a number of other secretory obstructive problems both acute and semi-acute, such as the actual or potential rupture of fluid-containing lung cysts.

In summary, the principal requirements are: (1) complete preparedness for rapid induction of anesthesia, positioning of the patient, and entry into the chest; (2) isolation of the affected area by an endobronchial technique, if feasible; (3) regular intubation with appropriate positioning; (4) vigorous and meticulous aftercare.

Intra-pleural Air and Blood

Most pneumothoraces, hemothoraces, and combinations thereof are handled by catheter drainage with an underwater seal or continuous suc-