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SEPAR Guidelines

Guidelines for the Diagnosis and Treatment of Thoracic Traumatism

Normativa sobre diagnóstico y tratamiento de los traumatismos torácicos

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Introduction

Thoracic trauma (TT) is a frequent problem in our setting, derived from the high incidence of traffic, domestic and work-related accidents. Other aggressions and accidents are also frequent, such as sports-related. There is an approximate associated mortality rate of 10%, in many cases after the patient has been admitted to hospital. In the United States, where the data are more reliable, trauma is calculated to cause around 100,000 deaths a year, out of which closed chest trauma are directly responsible for 20-25% and are an important contribution in another 50%. On most occasions, simple diagnostic and treatment measures can prevent extremely serious situations and even patient death. A small percent of cases require thoracotomy, not usually exceeding 10-20% of all TT.[1,2]

Types of Chest Trauma

Chest Wall Trauma

Rib Fractures

Rib fractures (RF) are the most frequent injuries after TT, and they are considered an important indicator of severity, as they reflect a great quantity of energy absorbed by the chest wall.[3] RF are more frequent between the 3rd and 9th ribs.[2] In the lower ones (lower than the 8th rib), the associated lesions may be situated at the abdominal level. Those of the first three ribs generally indicate serious TT with possible associated mediastinal, neurological, vascular or extrathoracic lesions.

With three RF or more, the associated extrathoracic lesions, the rate of complications and mortality increase significantly, therefore this number of lesions is considered an indicator for hospitalization. This rate increases in multiple and in bilateral RF,[3-5] and in these cases it is recommended that the patient be admitted to an Intensive Care Unit (ICU). Nevertheless, there are no randomized clinical studies (RCS) that clearly demonstrate the benefit of hospitalization versus protocol actions in the outpatient setting. Mortality can reach 15% in cases of more than 6 RF.[6]

In young patients, RF are predominantly the result of traffic, work-related or sports accidents, whereas in the elderly they are predominantly caused by accidental falls, where the impact is usually more moderate. This explains why some series have reported less mortality in this population group.[3] However, in the specific RF analysis, age is a determinant factor. A moderate TT in a senior can cause multiples fractures, and comorbidities increase with age, especially those of respiratory origin.

Radiologic diagnosis of isolated RF is done by simple chest radiograph. The current availability of CT has promoted its routine use in patients with severe TT, as it has been demonstrated to be superior in the diagnosis of associated lesions and in the evolution of the RF themselves.[7]

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Pain relief is transcendental, as it allows for proper ventilation, effective cough and adequate respiratory physiotherapy. The intravenous use of non-steroid and non-opiate anti-inflammatory drugs is quite widespread, although their side-effects are their main drawback. Loco-regional techniques include intercostal nerve block, epidural analgesics vs. opiates (fentanyl, morphine and buprenorphine), local anesthetics (bupivacaine, ropivacaine) or a combination of both, thoracic paravertebral block and, much less frequently, intrathecal opioids. For the treatment of severe chronic pain, transcutaneous electrical stimulation has also been used. The most controversial and studied aspect is the use of epidural analgesia compared with intravenous opiates in patients with multiple RF. In the RCS published in the last 20 years, there is a benefit of epidural analgesia when evaluating the degree of pain control,[8] the appearance of nosocomial pneumonia,[9] mean ICU and hospital stay,[10] and in the number of days with mechanical ventilation (MV).[9,10] The only confirmed benefit in a meta-analysis was the reduction in the number of days with MV when local anesthesia is used instead of epidural opiates. A significant increase has also been detected in hypotension, with no clinical implications. The use of epidural analgesia is limited due to the high number of patients with associated lesions in other organs, fundamentally lesions of the central nervous system and the spinal column, and it is likely that this is the explanation for the small sample sizes presented in studies.[9-12]

Establishing a specific recommendation for choosing an analgesic method is complicated. Probably, a multimodal analgesia adapted to the needs of each patient and specific center is the most efficient option, but studies are needed in this respect.

Fractures of the Sternum and Scapula

These are usually a consequence of a direct trauma. They can be found at the heart of a serious TT as these bones are usually fractured by high-intensity impacts. Unless there is important displacement, they do not require specific treatment.[1]

Flail Chest

Flail chest is a peculiar and infrequent situation in which there are two or more multiple RF with two or more foci and/or fractures that involve the chondrocostal junction, resulting in a fragment of the chest wall being isolated from the rest. Paradoxically, breathing is characterized by an inverse movement of the affected segment compared to the rest of the thorax. The normal respiratory dynamics are noticeably altered, and there are usually important lung lesions, generally pulmonary contusion or severe mediastinal lesions. Its presence is indicative of a high-energy trauma, and in more than half of cases it results in a situation of respiratory insufficiency that requires ventilatory support.[13] However, a small percentage of patients may have a flail chest with no associated lesions and evolve satisfactorily with analgesia and physiotherapy.

The information available about this type of TT comes mostly from observational retrospective studies and some prospective studies that try to evaluate different types of therapeutic intervention. It is estimated that flail chest occurs in between 1.5 and 10% of TT,[5] with a mortality rate that varies from 12.5 to 33%, partly produced by the severity of the concomitant lesions.[14] In fact, there has been an increase observed in the frequency of associated injuries (pulmonary contusion, pleural occupation), in the incidence of respiratory complications and in mean ICU stay.[13] Thus, in most cases, MV is needed unless there are no associated lesions and the fragment with respiration is paradoxically small in size.

The basic treatment objectives are to supply oxygen, analgesia and an adequate cleaning of the trachea-bronchial tree, using bronchoscopy if necessary. There is not enough scientific evidence on the use of thoracic compression methods in order to endorse their use, and they may aggravate the situation of loss of vital capacity and contribute to the formation of atelectasis by altering the respiratory mechanics.

Standard treatment consists of MV, also known as "internal fixation". With it, the chest wall is stabilized until perilesional fibrosis develops, which usually occurs during the first three weeks after TT. In some patients with flail chest and respiratory insufficiency, non-invasive MV in CPAP mode has been shown to have less complications and mortality than conventional MV.[14] Nevertheless, more studies are needed to establish a clear recommendation of the type of patients that would benefit from this type of treatment.

The immediate benefit of surgical fixation is modest in terms of morbidity, mortality and functional recuperation.[15,16] The patients who benefit the most from intervention are those with anterolateral lesions and those in whom prolonged intubation can give rise to more complications. The intervention is recommended in those cases in which the only cause for maintaining MV is flail chest, as well as in those that need surgery for other causes and in those cases with major rib destruction, also known as "trauma thoracoplasty".[17]

Lung Trauma

A pulmonary laceration is a rupture of the parenchyma that creates an air space with different degrees of hemorrhage and can be simple or multiple. It is more frequent after a penetrating trauma, although in the last few decades an increase has been observed in the number of cases in which it has been necessary to establish an indication for surgery after high-energy closed chest traumas.[18]

Most lacerations are located in the external third of the lung surface, and they are resolved when proper lung expansion is achieved. The most central injuries can compromise higher caliber vessels and bronchi or affect a wide area and constitute a blast lung, requiring thoracotomy.[19] Simple sutures and atypical resection are standard techniques for treating peripheral lesions, especially secondary to stab wounds. For deeper lesions that compromise larger caliber vessels and bronchi or hilar vessels, lobectomy, and even pneumonectomy, may be necessary. Tractotomy is a technique designed for the lesions situated in the deepest part of the lobe, based on the concept of "lung damage control" which allows for quick access to the causes of hemorrhage or air leak (diagnostic tractotomy). If in doing so the damage is controlled, the need for lobectomy may be avoided.

Operatory mortality is situated between 25 and 30%, and it increases with the amount of parenchyma that is resected.[18-20] The severity of the associated lesions is a great influence. Factors reported to negatively affect mortality include: closed chest trauma, high severity index, the need for concomitant laparotomy, the need for transfusion and the number of transfused units, and physiological parameters such as low blood pressure upon admittance and low body temperature.[19] The most commonly used approach is anterolateral thoracotomy, as it allows for quick access to the hilum. To avoid the passage of blood to the healthy lung, a bronchial blocker is useful when placed through an orotracheal tube. The control of the pulmonary hilum by clamping, even manually, may be necessary in deep lacerations.[18]

Parenchymatous bleeding can evolve into a pulmonary hematoma which does not usually interfere with gas exchange, but which can become infected, leading to pulmonary abscess. The exact incidence is not known because in many cases it goes unnoticed or develops from foci of pulmonary contusions. It is not usually visible on radiography until between 24 and 72 hours after the trauma. CT is more precise for diagnosis. The natural evolution of the hematoma leads to reabsorption in 3-4 weeks, although in some cases encapsulation and fibrosis are produced.[21]

Pulmonary contusion is the most frequent associated lesion in TT, and is more common in closed chest trauma. It can also have an isolated presentation. Hemorrhage and later alveolar edema are

reflected in the existence of crepitant rales on auscultation, hypoxemia and impaired compliance, which can lead to respiratory insufficiency. CT reveals patchy infiltrates that tend towards coalescence in the first few days.[22] Mortality can reach 24% when there are associated lesions,[23] increasing the risk of developing respiratory distress. These factors make admittance advisable in order to maintain adequate oxygenation, fluidification of the secretions and ventilation, and even non-invasive MV has been used.[22] The use of antibiotics as prophylaxis and corticosteroids has not demonstrated any effectiveness

Accumulations in the Pleural Space

Traumatic Pneumothorax

Many patients that have suffered TT develop pneumothorax or hemo-pneumothorax, representing up to 20% of cases.[3] It may be present in the initial evaluation or it may develop later. The symptomatic spectrum is ample according to the degree and the tolerance of the patient to lung collapse. Traumatic pneumothorax treatment is, in theory, pleural drainage (PD).

For those that occur in the context of moderate TT that are small in volume, with no clinical repercussions and no need for MV, there is the possibility of keeping the patient under observation. This posture is supported by studies referring the need for PD in at least 10% of cases.[24] Indication for surgery is limited to prolonged air leaks and lung expansion deficit, and can be performed via video-assisted thoracoscopy.[25]

Tension pneumothorax is produced by a pulmonary injury with unidirectional valvular component causing air to penetrate into the pleural cavity without any possibility to be evacuated. This produces mediastinal and contralateral lung compression. It can be caused by the TT itself or by MV, especially if positive pressure is established. Diagnosis can be easily determined given acute dyspnea, thoracic pain, tachycardia, hypotension and even jugular ingurgitation. Physical examination confirms the diagnosis with simple percussion (tympanic) and auscultation (absence of vesicular murmur). Treatment should be immediate, without waiting for radiological confirmation. A pleural drain should be inserted, or if none is available, a large-caliber needle to allow for decompression.

Open pneumothorax is produced by a solution de continuity of the chest wall that allows air to pass into the interior in order to balance the atmospheric pressure if the lesion is important (two-thirds of the diameter of the trachea). Ventilation is seriously affected, leading to hypoxia and hypercapnia. Initially, the closure of the defect must be ensured, and this may be done provisionally with an occlusive bandage. A PD should also be inserted. These lesions always require surgical reparation. Pneumothorax can coexist with subcutaneous emphysema, although the latter can also have an isolated presentation. It can be secondary to an airway or lung injury, or by explosion. Subcutaneous emphysema does not require treatment, except in cases in which it is very important and progressive, and in these cases a PD may be inserted.[1]

Hemothorax

The presence of hemothorax, either isolated or in the form of hemopneumothorax, is very frequent in TT. Lesions affecting the heart and large blood vessels as well as large lacerations can produce massive hemothorax. Others usually produce smaller volumes of blood or continuous bleeding. In general series, the percentage of hemithorax is less than 25% of cases,[3,26] although it may be higher if there are more than two RF.[5]

Chest radiography is the initial test for diagnosis, although physical examination has a negative predictive value and a sensitivity of 100%.[27] Thoracic ultrasound, a very accessible test, can detect hemothorax with higher sensitivity and specificity than chest radiograph.[28] The indiscriminate use of CT in moderate TT has lead to an increase in the diagnosis of occult hemothorax, whose clinical impact has still yet to be determined. Nevertheless, it may be important in the evaluation of retained hemothorax or in late-appearing hemothorax.

In up to 80-90% of cases, hemothorax is resolved with the placement of a PD.[3,5] In the remainder, surgery is necessary. The indications for emergency thoracotomy are based on the initial volume of drained blood, on the pace of blood loss and on the hemodynamics of the patient. Emergency surgery is indicated when the volume of initial bleeding is greater than 1,000-1,500 cc or lesser volumes that produce hemodynamic affectation or a continuous drainage greater than 200-300 cc/ hour in the first three or four hours. A risk of death three times greater has been reported in total bleeding in the first 24 hours of 1,400 cc when compared with another of 500 cc.[29] Video-assisted thoracoscopy can be indicated in cases of persistent hemothorax in hemodynamically-stable patients. Algorithms have been proposed to serve as a starting point in evaluating this type of situation.[30] The time passed from the trauma to the diagnosis, hemodynamic tolerance to blood loss and comorbidities are also important when contemplating surgery.

In the case of retained hemothorax, video-assisted thoracoscopy performed early on can reduce the days of drainage, hospital stay and hospital costs.[31] It could also avoid the development of a pleural empyema (PE), but there are no studies that specifically evaluate this result. To date, the moment when the intervention should take place has not been clarified, although within the first ten days after the trauma seems to be a reasonable limit.[31] The use of fibrinolytics in retained hemothorax has not been sufficiently studied and the advantages of its use have not been contrasted.

Traumatic Chylothorax

Traumatic rupture of the thoracic duct is rare. It has been described associated with clavicle fractures, esophageal trauma and spinal column trauma. It is usually resolved spontaneously two or three weeks after the accident. Treatment is based on PD and nutritional support with the abstention of long-chain triglycerides.[32] Ligation of the thoracic duct is the solution in cases with no response to conservative treatment. Talc pleurodesis is an alternative en patients who are not candidates for surgery.[2]

Airway Trauma

Iatrogenic lesions of the airway can be produced after orotracheal intubation, tracheostomy or endoscopic procedures. Those that are traumatic in origin can occur more frequently after closed chest trauma with an incidence that varies between 0.5% and 3%.[33] In our setting, trauma caused by stabbing or shooting are quite rare.

In lesions of iatrogenic origin, airway trauma is usually seen in the form of lacerations of the membranous face of the cervical trachea. When the cause is TT, there are usually cartilaginous, irregular or circumferential ruptures. Lesions of the right main bronchus are more frequent.[33]

They can cause refractory respiratory insufficiencies or difficulty in oxygenation in patients on MV. There is almost always pneumomediastinum and subcutaneous emphysema. The presence of pneumothorax is also frequent, with a characteristic absence of pulmonary expansion and important air leak after the placement of a PD. In iatrogenic lesions, the image of a balloon of the intubation tube outside the limit of the trachea is pathognomonic.[34] In some patients, the lesion can go unnoticed due to the few signs and symptoms that it provokes, and leads to healing by secondary intention. In these cases, obstructive complications can arise in the mid- or long-term.

The basic diagnostic test is bronchoscopy, which locates and evaluates the lesion and aids in guiding the placement of the endotracheal tube and guarantee the airway. This is the basic

maneuver in the initial treatment, although tracheotomy may be necessary in laryngotracheal ruptures.

Multi-cut CT is able to rule out or evaluate this type of lesions, especially in cases of late presentation.[35] It is contraindicated in patients with hemodynamic instability and without airway control.

If surgical indication exists, surgery should not be delayed. Whatever the method of treatment, the use of prophylactic antibiotics seems reasonable to avoid mediastinitis. Conservative medical treatment is an effective alternative in some cases, especially in iatrogenic lesions of the membrane of less than 3 cm.[35] The secondary cases of TT usually present more important symptoms that indicate the need for surgery.[33] Cervicotomy allows for high tracheal lesions to be repaired, whereas rupture near the tracheal carina or the main bronchi are more frequently approached with right thoracotomy. Primary suture of the lesion or termino-terminal anastomosis to refresh the edges of the rupture are usually sufficient. In the isolated ruptures of the airways, it is quite rare that it is necessary to resect parenchyma, except in the cases of gun-shot wounds that affect the pulmonary hilum and have vascular affectation.[36]

The results of surgery are variable, with a mortality that varies from 6 to 19%, being greater in closed chest trauma and in those cases of delayed surgery.[36] Cicatricial stenosis is present in 2-3% of the patients who are operated, and it may be necessary to apply treatments such as dilatations, endoprosthesis, laser and surgical reconstruction.

Mediastinal Trauma

Cardiac Trauma

Cardiac contusion is the most frequent closed cardiac trauma. It usually originates in the right ventricle due to its proximity to the anterior thoracic cage. Valvular lesions usually affect the tendinous chords and the papillary muscles of the subvalvular apparatus and it is the aortic valve which is more often injured. Myocardial rupture represents the most serious lesion and can be the cause of immediate death or cause cardiac tamponade. Rupture of the interventricular septum is less frequent and can usually be treated at the hospital.[37]

Valve and interventricular septum ruptures cause acute cardiac insufficiency. Contusions can be asymptomatic and go unnoticed or present an anginoid-type pain that worsens upon breathing. The circulating levels of troponin-I and troponin-T have low sensitivity, although normal levels in absence of alterations on electrocardiogram can have a negative predictive value of 100%.[37,38] The value of the serial determinations in the stratification of risk for complications still has not been established. There is no specific electrocardiographic pattern.

Simple chest radiography can demonstrate widening of the cardiac silhouette and sternal fracture, images that rule out cardiac injury. Doppler ultrasound is the diagnostic procedure of choice as it is easy to perform and is highly cost-effective.[39] Transesophageal ultrasound is a valid alternative.

Cardiac contusion with few clinical repercussions merely requires observation. If arrhythmias appear, treatment is indicated. If there is hemodynamic instability, venous and pulmonary artery pressure should be monitored, while cardiac output should be controlled when administering fluids and inotropics. In some circumstances, an intra-aortic counterpulsation balloon may be necessary. Anti-coagulation is reserved for those cases with intraventricular thrombi or if surgery with bypass circulation is necessary.

Indications for surgery are hemopericardium, due to cardiac rupture or of a coronary artery, and serious valvular lesions or interventricular fistulas that provoke uncontrollable hemodynamic instability.

Penetrating cardiac trauma caused by stabbing are the most frequent in our setting. They can also be secondary to firearm wounds or iatrogenic (cardiac catheter, pacemakers, thoracic trocar, etc). Right ventricular affectation is most frequent. Patients who do not die before being taken to the hospital have a high survival rate. The most frequent manifestations are cardiac tamponade and hypovolemic shock due to massive blood loss.[37]

Table 1
Diagnosis of cardiac tamponade

Elevated central venous pressure*
Decreased arterial pressure*
Paradoxical pulse**
Kussmaul's sign
Electrical activity without pulse (absence of hypotension and tension pneumothorax)
Electrocardiogram (electrical alternance, especially if P wave and QRS are combined)
Echocardiogram (pericardial effusion, right ventricular wall collapse, left auricle collapse, specific for tamponade)
Doppler study (alteration of the "E" wave for transmitral flow, 25% less on inspiration than on expiration)

*Beck's triad with together with muffled heart sounds.
**Reduction in systolic blood pressure of more than 10 mmHg during spontaneous breathing.
Source: Committee on Trauma.[1]

Median sternotomy is the standard access to the heart, but left submammary anterolateral thoracotomy offers faster and more comfortable access. After the opening of the pericardium, the myocardial injury is sutured with monofilament supported by a patch made of bioprosthetic material. Distal coronary affectation can be resolved with a ligature to avoid bleeding.

Emergency submammary thoracotomy is reserved for patients presenting vital signs upon arrival at the emergency room in order to control the lesion, perform resuscitation maneuvers and transfer the patient to the operating room. Even so, survival is limited.[1,37,40]

Cardiac tamponade is a situation that usually occurs in stabbing injuries that penetrate the cardiac cavity, although it may also happen in cases of gunshot wounds and in closed chest trauma. Beck's triad and Kussmaul's sign are specific physical examination data, but they may not be present or difficult to find. In such instances, attention must be paid to objective data that can determine diagnosis (table 1).[1,40]

Pericardiocentesis is indicated in cases where there is no response to reanimation measures and when the suspicion for cardiac tamponade is high, as it is a very effective transitory measure. A subxiphoid pericardial window is a good alternative, but this should be performed in the operating room by an expert surgeon.[1]

The use of dobutamine to control hypotension and the volume overload should only be applied in hypovolemic patients, as in others it may aggravate tamponade. The definitive solution for cardio-pericardial injury is surgical intervention by thoracotomy or sternotomy for cardiac exploration. This should be done immediately if pericardiocentesis is either confirmed or strongly suspected.[41]

Trauma of the Large Mediastinal Vessels

This type of trauma is usually produced by high-speed traffic accidents, being run over, or falls from heights. The mechanisms by which they are produced are usually abrupt deceleration by shear force and compression against an object, especially the arterial ligament. In cases of vessel rupture, a massive hemorrhage is produced that ends the patient's life either at the accident scene or during the trip to the hospital. The cases which can be intervened are those of ruptures that are contained maintained by the adventitia.

Patients that arrive at the hospital with one of these TT usually have symptoms of hypotension that can be extreme due to a large hemorrhage. There may serious concomitant lesions, such as RF of the first costal arches and fractures of the sternum.

Table 2
Radiological signs suspecting aortic rupture

Mediastinal widening
Obliteration of the aortic button
Deviation of the trachea towards the right
Obliteration of the aortopulmonary window
Depression of the left main bronchus
Deviation of the esophagus
Widening of the paratracheal stripe
Widening of the paravertebral interface
Presence of an apical pleural cap
Left hemothorax
Fractures of the 1st and 2nd ribs and scapula

Source: Committee on Trauma.[1]

Simple chest radiography has a high negative predictive value in cases without radiologic signs of aortic rupture. CT has a 100% negative predictive value and a specificity of 83-99%.[42] Aortography is currently only used for surgical planning. Transesophageal ultrasound is useful for bedside diagnosis. The radiological findings most indicative of this type of lesion are compiled in table 2.[1]

As a temporary measure, the use of short-acting beta-blockers has been reported in order to maintain stable blood pressure. Some authors prefer stabilizing the patient and carrying out a programmed intervention. The classic treatment is primary reparation or resection of the affected area and the interposition of a substitutive prosthesis, with a mortality rate between 15 and 67%. Recently-published articles mention treatment with endovascular prosthesis. Its use seems to be very effective, significantly reducing the risk of spinal ischemic lesions and successfully replacing classic open surgery.[43]

Lesions of the large supra-aortic vessels can be repaired with conventional surgery using sutures or substitutive prosthesis. Trauma of the main pulmonary arteries or veins are, except for those in anterior situations, difficult to resolve and sometimes require pneumonectomy. Those of the peripheral pulmonary vessels are easier to resolve using conventional thoracotomy.

Venous vascular trauma (vena cava, vena azygos) also require immediate reparation as they can cause rapidly-evolving hypovolemic shock. Trauma of the vena cava can require bypass circulation.[1]

Diaphragm Trauma

Lacerations of the diaphragm have a variable clinical presentation depending on size, origin and location of the lesion. These are more frequent on the left side and after penetrating TT.[26,44,45] The main problem lies in their detection because they can go unnoticed as they are masked by other more serious lesions that require immediate attention. Smaller ruptures, especially secondary to penetrating wounds and affecting the right hemidiaphragm, are even more difficult to diagnose and are often detected years after TT. They should be highly suspected in penetrating wounds located under the breast and above the navel.[45] Given that the herniation of abdominal viscera can be absent in up to half of the cases, chest radiography may not initially be diagnostic. Nevertheless, chest radiography in which the diaphragm is not visualized has been associated as an independent risk factor for the presence of one of these lesions.[44] The placement of a PD may evidence a leak of digestive content or bilious liquid. Table 3 summarizes clinical and diagnostic data as well as the surgical approach used according to presentation.

Once diagnosed, diaphragmatic lacerations should be repaired. Given that in most cases there are also lesions in the abdomen, laparotomy is considered the indicated approach in an acute situation. Thoracotomy is reserved for cases with treatable lesions in the thorax, such as massive hemothorax or suspected cardiac injury. It is also useful in cases of rupture of the right hemidiaphragm, where the liver can complicate the reparation through the abdomen. Video-assisted thoracoscopy has been used for the confirmation of diagnosis in stable patients; in expert hands, it can also be therapeutic.[45]

Esophageal Trauma

TT with esophageal affectation are very rare and are usually secondary to penetrating lesions, with the neck being the most frequently affected area. Symptoms are usually non-specific, occasionally going unnoticed. Constant pain may not appear until some hours after the lesion is produced. Other clinical manifestations, such as dyspnea, cough and hematemesis can be confused in the center of a polytrauma. Simple radiography can be normal or find mediastinal and cervical emphysema. Helical CT is more specific for detecting mediastinal emphysema and can be completed with the oral administration of hydrosoluble contrast. Esophagogram is the diagnostic test of choice when there is high suspicion for perforation. Digestive endoscopy is only indicated if there are diagnostic doubts.

Surgical treatment within the first 24 hours after perforation is the best option. Within this timeframe, mean mortality rate is 20%, although it can reach more than 60% if left longer. Surgery consists of ample debridement and primary closure in two layers: mucosa and muscular, covered with a well-vascularized graft (pleura, intercostal muscle, etc.). Esophageal rest is achieved with an esophageal tube for aspiration above the suture and a double lumen percutaneous gastrojejunal tube to avoid vomiting and gastric reflux and allow for enteral nutrition through the jejunal tube.

More complicated perforations are treated by means of mediastinal debridement and drainage or fistulización directed with a Kehr's T tube. Another possibility is esophageal exclusion using automatic stapling with absorbable staples in the neck and cardia to later reestablish communication. In all cases there should be ample antibiotic coverage.[46]

Intra-Thoracic Foreign Bodies Secondary to Trauma

There may initially be foreign bodies impacted in the thorax secondary to TT. If they are large and if the patient is in an unstable situation, they should be extracted by means of thoracotomy. If the foreign bodies are buried in some part of the thorax and the acute moment has passed, their extraction depends on various factors. If they are large, located near the vital structures and cause symptoms, it is preferable to extract them using thoracotomy. This intervention should also be performed if they are located in an intravascular situation, due to the possibility of migration.[2]

Serious Thoracic Trauma

The systematic ATLS[1] is the main reference in the evaluation and treatment of polytrauma. In this protocol, there should be a primary examination, resuscitation of the vital functions, a secondary review and established definitive care (table 4).

The primary examination should begin with the airway, establishing the existence of injury or obstructions by foreign bodies. The oropharynx should be examined to check for laryngeal lesions. In the exploration of this type of lesions, it is important to check the quality of the patient's voice and to evaluate the presence of stridor. In cervicothoracic trauma, the neck and sternoclavicular articulation should be carefully examined as a later dislocation can obstruct the airway.

Another basic part of the primary review is breathing evaluation while examining the patient (respiratory movements, respiratory frequency, rhythm, presence of cyanosis) to rule out hypoxia.

The initial circulation evaluation entails taking the patient's pulse (frequency and regularity) and the inspection of peripheral circulation (skin coloration and temperature). It is important to check the neck

Table 3
Diagnosis and surgical approach of diaphragm rupture

Symptoms	Acute		Chronic	
	Non-specific	Specific	Non-specific	Specific
	Dyspnea Thoracic pain Epigastralgia	Omalgia IAS in thorax	Epigastralgia[a] Nausea/vomiting Gastric incarceration Dysphagia Regurgitation Non-distended abdomen IAS Intestinal obstruction[b]	Omalgia
Diagnosis	Chest Rx[c] Reduced lung volume Elevated right hemidiaphragm Atypical pleural effusion Air-fluid level Colon interposition CT Thoracoscopy[d] Laparoscopy[d]		Chest Rx[c] Barium contrast MRI/multi-cut CT	
Approach	Unstable Directed[e]	Stable Laparotomy Right thoracotomy	Thoracotomy Thoracoscopy[d] Laparoscopy[d]	

IAS: intestinal air-fluid sounds.
[a] Worse with meals.
[b] Symptoms vary depending on the level of incarcerated intestine.
[c] After inserting the nasogastric tube, it follows an ascending path after passing the level of the diaphragm, as seen within the thorax, which is considered pathognomonic.
[d] Can be done to diagnose cases of stable patients, undiagnosed by another method, in whom the suspicion of diaphragmatic rupture persists. For the reparation of the lesions by these techniques, a high degree of experience is required as the dissection can be especially difficult at the pericardial level.
[e] In most cases, the associated abdominal lesions make laparotomy the method of choice.

veins for distension (if there are hypovolemia and cardiac tamponade or tension pneumothorax, they may not be distended). Blood pressure and pulse should be measured with the corresponding monitoring methods. Trauma due to sudden deceleration and central thoracic trauma can entail myocardial lesions causing arrhythmia, especially if there are acidosis and hypoxia. Premature ventricular contractions and electric activity without pulse or electromechanical dissociation (rhythm on electrocardiogram but with absence of pulse) can be found in cardiac tamponade, hypertensive pneumothorax, hypovolemic shock and even in cardiac rupture.[1]

Evolution and Complications

Although there is a wide variety of complications associated with TT, respiratory insufficiency, pneumonia, respiratory distress and pleural infection are the most frequent.[47] They are directly related with the severity of the trauma and patient comorbidity.[3] The clinical situation sometimes mandates prolonged ICU care and MV, increasing the risk for nosocomial pneumonia.[48]

PE can complicate a hemothorax. It is produced by bacterial contamination of a PD or by associated lung infection. Its treatment is PD and, in case of persistence and loculation, it may be necessary to place another and even instill fibrinolytic substances or perform video-assisted thoracoscopy or thoracotomy and pulmonary decortication. Prevention entails adequate antiseptic coverage when placing the PD along with the prophylactic administration of antibiotics.[47]

Arrhythmia and defects of the cardiac conduction have been described, developing either immediately or a time after closed TT. Fibrillation and auricular flutter are the most common, while tachycardia and bradycardia have also been described. These arrhythmias may require prolonged anti-arrhythmic treatment.[49] Pericarditis is more frequent in cardiac wounds, and it purulent form is exceptional.

After-Effects

After-effects are later, established consequences of a TT. Fibrothorax secondary to a hemothorax or a PE can produce lung trapping and the retraction of the thoracic wall. Decortication is indicated in young patients with impaired respiratory capacity.[50]

There are some patients with sternal fractures in whom conservative treatment with analgesia and rest is not able to consolidate the focus of the fracture, accompanied by pain and instability, and surgical intervention is necessary for stabilization.[1]

Residual pain, many times as a consequence of RF, is a frequent after-effect that can cause great discomfort and the need for treatment in specialized chronic pain units.

Table 4
Systematic ATLS

Primary examination
Airway
Breathing
Tension pneumothorax
Open pneumothorax
Flail chest
Massive hemothorax
Circulation
(Evaluate emergency thoracotomy)
Massive hemothorax
Cardiac tamponade
Secondary review (thoracic injury that endanger life)
Simple pneumothorax
Pulmonary contusion
Tracheobronchial lesions
Closed cardiac injuries
Traumatic aorta ruptura
Traumatic diaphram injury
Lesiones crossing the mediastinum

Source: Committee on Trauma.[1]

Table 5
Classification of the recommendations and quality of scientific evidence according to the GRADE system[51]

Recommendation grade	Quality of evidence	Implications
1. Consistent recommendation[a] High quality of evidence	Well-done RCS or, as an exception, well-done OS	Apply in most patients under most circumstances
2. Consistent recommendation[a] Moderate quality of evidence	RCS with limitations or well-done OS with important effects	Apply in most patients under most circumstances
3. Consistent recommendation[a] Low quality of evidence	Evidence for at least one important result or OS or RCS with important major defects or indirect evidence	May change when the evidence becomes available
4. Consistent recommendation[a] Very low quality of evidence	Evidence for at least one important result of clinical observations, non-systematic or indirect evidence	May change when the more evidence becomes available
5. Weak recommendation[b] Moderate quality of evidence	Well-done RCS or, on exception, well-done OS	May differ depending on the circumstances or patients
6. Weak recommendation[b] Moderate quality of evidence	RCS with limitations or well-done OS with important effects	Other alternatives can be better for some patients under certain circumstances
7. Weak recommendation[c] Low quality of evidence	Evidence for at least one important result from OS or RCS with major important defects or indirect evidence	Other alternatives may be equally reasonable
8. Weak recommendation[d] Very low quality of evidence	Evidence for at least one important result from non-systemic clinical observations or very indirect evidence	Other alternatives can be equally reasonable

OS: observational studies; RCS: randomized control studies.
[a] The benefits clearly outweigh the drawbacks or vice-versa.
[b] The benefits are balanced with the drawbacks.
[c] Uncertainty in the estimation of the benefits or drawbacks; the benefits may be balanced with the drawbacks.
[d] Greater uncertainty in the estimation of the benefits or drawbacks; the benefits may or may not be balanced with the drawbacks.

Recommendations (Table 5)[51]

Rib Fractures

- Simple chest radiography should be routinely ordered to confirm clinical suspicion. In the case of multiple RF and in high-energy TT, the use of CT is justified to determine the presence and severity of the associated injuries (GR2).
- Hospitalization is recommended in the following situations: when three or more ribs are fractured; in the case of fracture of the first or second ribs; if there are serious injuries and associated complications; and in the cases of important comorbidity, especially in elderly patients (GR3).
- ICU observation is recommended in patients with multiple RF and serious comorbidity (GR3).
- In the cases of RF of the first two ribs, physical examination and studies are required to rule out associated vascular or nervous system lesions (GR4).
- Epidural analgesia is superior to the intravenous infusion of opiates for controlling pain in patients with multiple or bilateral RF (GR5).
- Respiratory physiotherapy is recommended for all patients with RF (expert consensus).
- In low RF, the presence of abdominal lesions should be ruled out (expert consensus).

Flail Chest

- Monitoring, radiological studies and arterial gasometry are recommended in patients with flail chest who do not require immediate intubation (expert consensus).
- Non-invasive MV is an alternative to intubation in patients with flail chest who develop respiratory insufficiency and have no lesions either in the lungs or in any other organs to indicate orotracheal intubation and MV (GR5).
- Generally, surgical fixation is only recommended in cases in which the only cause for maintained MV is flail chest, when a thoracotomy is necessary for other causes or when there is traumatic thoracoplasty (GR3).

Traumatic Lung Lesions

- Hospitalization is recommended for all patients affected with pulmonary contusion and its treatment with general measures, liquid restriction and respiratory physiotherapy (GR3).
- Simple suture is the best surgical option in pulmonary lacerations, avoiding large resections except in the case of massive blast lung (GR4).
- The treatment for non-complicated pulmonary hematoma is observation (GR4).

Traumatic Pneumothorax

- Traumatic pneumothorax is treated with PD except in the cases of minimal pneumothorax. Both tension pneumothorax and open pneumothorax constitute immediate surgical emergencies (expert consensus).
- Surgical indication for simple traumatic pneumothorax is limited to cases of maintained air leaks and when there is lack of lung expansion (expert consensus).

Traumatic Hemothorax

- Emergency surgery is recommended after an evaluation of age, comorbidity and coagulation alterations, considering the hemothorax to have possible indications for surgery in the following cases:
  - Patients in hypovolemic shock or with hemodynamic instability and suspected serious intra-thoracic lesion (expert consensus).
  - Persistent bleeding after an initial volume of drained blood of 1,000 cc (GR3).
  - Bleeding of more than 250 ml/h in the first three hours (GR3).
  - Suspected serious intra-thoracic lesion (expert consensus).
- Video-assisted thoracoscopy should be reserved for patients with persistent hemothorax with hemodynamic stability (GR4).
- Video-assisted thoracoscopy is indicated in cases of retained hemothorax, especially if PD and endopleural fibrinolysis have failed (expert consensus).

Airway Rupture

- Given the suspicion or diagnosis of tracheobronchial rupture, the first priority is to ensure the airway and the oxygenation of the patient (expert consensus).
- Diagnosis should be based on physical examination and simple chest radiography, reserving CT for doubtful lesions with torpid evolution (GR3).
- In cases of important subcutaneous emphysema, respiratory insufficiency and pneumothorax treated with PD in which there is

an absence of lung expansion, rupture of the main airway must be ruled out immediately (expert consensus).
- When tracheobronchial rupture is suspected, bronchoscopy should be performed. Patients with confirmed airway rupture and respiratory insufficiency should be treated surgically as soon as possible (expert consensus).
- Conservative treatment can be an alternative in small lesions, generally iatrogenic lesions that have no clinical repercussions or associated lesions in other intra-thoracic organs (GR4).

Cardiac Trauma of the Large Mediastinal Vessels

- Myocardial contusion is correctly diagnosed by CK-MB and troponin I enzyme determination. Except for complications, they do not require specific treatment (GR3).
- Cardiac tamponade secondary stabbing should be intervened as an immediate emergency. Pericardiocentesis should only be done as a transitory measure while waiting for surgery (GR6).
- Ruptures of the descending thoracic aorta can be treated by means of vascular endoprosthesis, which present fewer possibilities for medullar ischemic injuries (GR3).

Complications, Evolution and After-Effects

- Antiseptic coverage is recommended when inserting a PD. Likewise, prophylactic administration of antibiotics is recommended for preventing the formation of PE (GR2).
- Pleural decortication is indicated in young patients with impaired respiratory capacity as a consequence of posttraumatic fibrothorax (GR3).
- In non-consolidated sternal fractures accompanied by pain and instability, surgical treatment is indicated (GR3).
- Treatment in specialized chronic pain units is recommended for those patients with residual pain after TT (GR4).

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