Epidemiology of Abdominal Trauma

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Abstract

Traumas are a major health care concern owing to their frequency and potential seriousness because they occur in relatively young subjects. Mortality rates of abdominal traumas are estimated to range between 10 and 30%. Hemorrhagic shock is considered to be a therapeutic emergency when it occurs following abdominal traumas. Over the past 30 years, computed tomodensitometry has become the reference examination for the initial management and the follow-up of patients with abdominal traumas. At the same time, the surgical indications have decreased in favor of an "armed surveillance", including a combination of reanimation procedures, surgical interventions, and interventional radiology procedures.

1 Introduction

Traumas are a major health care concern owing to their frequency and potential seriousness because they occur in relatively young subjects. Mortality rates of abdominal traumas are estimated to range between 10 and 30%. Hemorrhagic shock is considered to be a therapeutic emergency when it occurs following abdominal traumas. Over the past 30 years, computed tomodensitometry (CT) has become the reference examination for the initial management and the follow-up of patients with abdominal traumas. At the same time, the surgical indications have decreased in favor of an "armed surveillance", including a combination of reanimation procedures, surgical interventions, and interventional radiology procedures.

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2 Epidemiology

2.1 General Traumatology

Traumas are the third most frequent cause of death in the general population, after cardiovascular disease and cancer. In the subgroup of adult patients under 40 years of age, traumas are the main cause of death (Tentillier and Masson 2000).

In the USA, the number of trauma victims is estimated at 57 million each year, resulting in two million hospitalizations and 150,000 deaths (Elliott and Rodriguez 1996).

In an industrialized country such as France, the incidence of traumas related to daily life accidents is 7.5 for 100 inhabitants, and the incidence of traumas due to public road accidents is 0.3 for 100 inhabitants (Tentillier and Masson 2000). Although the mortality due to public road accidents has been decreasing over the past few years, in France, more than 40,000 subjects were hospitalized for severe traumas in 2006, with 4,709 accident-related deaths (Traffic Accident Statistics 2006) (Table 1).

In public road accidents, the car is the main cause of death (Table 2); however, among subjects under 20 years of age, two-wheeled vehicles are the main cause of death.

Rates of chronic alcohol abuse are estimated at 50–60% among trauma victims (Jenkins 2000). Acute alcoholic intoxication is responsible for 10% of all accidents, and, notably, for 50% of all accident-related deaths. Studies conducted in North America have revealed that 40% of injured patients test positive for one or more illegal drugs (Soderstrom et al. 1988; Sloan et al. 1989; Jurkovich et al. 1992). A population case–control study was conducted in France from October 2001 to September 2003 on 10,748 car drivers involved in a fatal car accident, with known blood alcohol and drug levels. This study revealed that driving after using cannabis significantly increased the risk of a driver being involved in a car accident in a dose-dependent manner (odds ratio 3.32; 95% confidence interval 2.63–4.18), although in France the fraction of car accidents attributable to cannabis use is significantly lower than that due to positive blood alcohol levels (2.5% vs. 28.6%) (Laumon et al. 2005).

The economic burden of trauma is significant: it is estimated that trauma mortality is responsible for 26% of lost years of life (first cause), and for more than half of the number of lost productive life years (Tentillier and Masson 2000). In the USA, acute health care costs due to trauma were evaluated at 16 billion dollars in 1992, and the costs stemming from follow-up care, disabilities, and tax deficits were estimated at 150 billion dollars (Elliott and Rodriguez 1996).

Following a traffic accident or a fall, it is estimated that abdominal trauma is seen in 7–20% of hospitalized patients (Cayten 1984). In Quebec, Bergeron et al. (2007) found a 16% rate of thoracic or abdominal trauma in a population of 16,430 patients hospitalized for blunt trauma [Abbreviated Injury Score (AIS) 2 or greater].

In traumatology, a trimodal distribution of death is noted: 50% of deaths are estimated to occur at the scene of the accident, mainly due to severe vessel lesions and cerebral injuries. Approximately 30% of deaths take place within the first 24 h, secondary to hemorrhagic shock or severe cranial trauma. Finally, 20% of deaths occur in the following days or weeks, due to infections or multiple organ failure (MOF) (Trunkey 1991; ATLS 1994).

Although hemorrhagic shock constitutes the major therapeutic challenge in the management of the patient during the first hours following an abdominal trauma, mortality may vary owing to a variety of factors:

- The cause of the abdominal lesion, with a mortality rate estimated to range from 10 to 30% for abdominal contusions, from 5 to 15% for injuries caused by firearms, and from 1 to 2% for cold-weapon injuries (Cayten 1984).
- The type of organ involved, the severity of the lesion, and the number of intra-abdominal organs affected, with mortality rates estimated at 6% for isolated liver traumas, 15% for three-organ involvement, and 50 and 70% for four- and five-organ involvement, respectively (Carretier et al. 1991).
- The coexistence of extra-abdominal lesions. The most commonly accepted definition of a polytraumatized patient is that of a severely injured patient presenting with two or more traumatic lesions, with at least one being life-threatening. This concept of polytraumatism is an independent prognostic factor of mortality.
- The patient's age and medical history.

Table 1 Evolution of morbidity/mortality in public road accidents (Traffic Accident Statistics, France)

	2000	2002	2004	2006
Physical injury	121,223	105,470	85,390	80,309
Slightly injured (not hospitalized)	134,710	113,748	91,292	61,463
Seriously injured (hospitalized on day 6)	27,407	24,091	17,435	40,662
Dead on day 30	8,079	7,741	5,593	4,709

Table 2 Distribution of transportation means involved in road accident mortality in 2006 (Traffic Accident Statistics)

	Frequency of involvement (%)
Car	55.8
Pedestrians	11.4
Motorcycle	16.3
Moped	6.7
Bicycle	3.8
Heavy truck	1.8
Others (commercial vehicle, public transport, tractor, etc.)	4.2

- The rapidity and the quality of the patient's diagnostic and therapeutic management. Several studies have investigated the causes of death in the field of traumatology, with a subgroup analysis of evitable deaths. Shackford et al. (1993) performed a chronological analysis of 623 cases of trauma-induced death to determine whether death could have been avoided by an optimal environment. This evaluation was based on the severity of lesions, the moment of death, the principal cause of death, and factors contributing to death. The evaluation was carried out according to the chronology of events: accident prevention, discovery of the injured person, pre-hospital management, occurrence of secondary lesions, and medical and paramedical errors. From the study results, it appears that three quarters of all deaths could have been prevented, which, in North America, would have resulted in a gain of 20,817 life years and 9,255 productivity years. Although, in most cases, trauma prevention would have saved the patient's life, 151 deaths were accounted for by a management error during the hospital phase.

In a study involving 246 polytraumatized patients who eventually died, the major cause of avoidable death during the hospital phase was the lack of surgical intervention or delay in the surgical decision-making process (Kreis et al. 1986) (Table 3).

Table 3 Causes of preventable deaths (from Kreis et al. 1986)

Preventable causes of death	Number (percentage)
Decision for surgery not taken	25 (48)
Time lapse before surgery too long	21 (40)
Resuscitation error	5 (10)
Undiagnosed lesion	4 (8)

The total exceeds 100% as several causes may coexist in the same patient.

2.2 Abdominal Traumas

Abdominal traumas are defined as traumas involving the area between the diaphragm above and the pelvis below. They are classified into two types: blunt traumas or abdominal contusions, and penetrating traumas or abdominal wounds.

2.2.1 Blunt Traumas

In Europe, blunt abdominal traumas have always been more common, representing approximately 80% of all abdominal traumas. In three quarters of the cases, a traffic road accident is responsible for the trauma, and the abdominal trauma involves a polytraumatized patient (Lorgeron et al. 1983; Orliaguet and Cohen 1991). Falls represent the second most common cause of abdominal contusions (Cayten 1984). They are mainly due to suicide attempts with defenestration (two thirds of cases), work-related accidents, and sport accidents. Other causes associated with crushing (work accidents, fights) are less common.

In the USA, although penetrating traumas due to firearms or cold weapons were the main cause of hepatic lesions during the period between 1945 and 1975, blunt traumas are presently the principal etiological causes of liver and spleen lesions (Richardson 2005).

2.2.2 Penetrating Traumas

Penetrating traumas or abdominal wounds represent 20% of abdominal traumas, with a cold weapon as an injuring agent in two thirds of cases. Firearms of different calibers are used in the other cases.

2.2.3 Lesionel Mechanisms and Organ Lesions

Blunt Traumas

Following abdominal contusions, the intra-abdominal lesions depend on both the physical features of the initial mechanism and the organ affected, such as its anatomical relations, solid or hollow feature, fixed or mobile status, and whether it is in a state of repletion. Different mechanisms may be individualized when considering blunt traumas, but they are mostly associated in the case of traffic road accidents or falls:

- Direct shock responsible for compression crushing of the organs between the external force and the posterior plane. The standard example is the crushing of the pancreatic isthmus against vertebral body L1 by the steering wheel.
- A brutal increase in intra-abdominal pressure may lead to organ rupture away from the site of impact. This is the predominant mechanism involved in the traumatic rupture of the diaphragm.
- A sudden horizontal deceleration (brutal collision of a vehicle moving at great speed) or vertical deceleration (fall from a high place) causes stretching of the fixing structures of organs such as the vascular pedicles, bracketing areas, and ligaments. This mechanism may cause lesions of the organ itself at the insertion areas, but may also damage the vascular pedicles, leading to hemorrhages or ischemia. The rupture of sushepatic veins following a sagittal fracture of the hepatic dome is a standard example of this mechanism (Fingerhut and Trunkey 2000).
- Tangent forces on the abdominal wall may result in a separation of superficial layers, with vascular involvement. In the case of concomitantly increased intra-abdominal pressure, the muscular aponeurotic wall may split, without any cutaneous lesions (Balkan et al. 1999).

Following blunt abdominal traumas, the lesions involve mainly solid organs, particularly the spleen and the liver, and may cause a hemoperitoneum (McAnena et al. 1990) (Table 4).

Table 4 Incidence of organ lesions in the case of abdominal contusions (from McAnena et al. 1990)

Organs	Incidence (%)
Spleen	46
Liver	33
Mesentery	10
Kidney–bladder	9
Small intestine	8
Colon	7
Duodenum–pancreas	5
Vessels	4
Stomach	2
Gallbladder	2

Table 5 Incidence of organ lesions in the case of open abdominal traumas (from Nicholas et al. 2003)

Organs	Percentage of patients with organ lesions
Small intestine	48
Colon	36.4
Liver	34.4
Spleen	9.2
Stomach	17.6
Kidney	14
Bladder	6.4
Rectum	5.2
Duodenum–pancreas	7.2
Vessels	30
Diaphragm	22.8

Penetrating Traumas

The penetrating feature of an abdominal wound is based on a break in the parietal peritoneal wall. Should this occur, the injuring agent may cause damage to any intra-abdominal organ. Cold weapons are responsible for direct lesions of the organs involved, whereas firearms cause damage not only to the trajectory of the projectile but also at a distance, depending on the caliber and type of projectile used. Thus, a distinction is made between small-caliber arms with slow kinetics (.22 Long Rifle; 6.35 mm) and high-caliber arms with rapid kinetics (9–11.43 mm, military weapons). The importance of the attrition chamber depends on both the characteristic features of the projectile (speed, mass, and instability) and those of the tissues shot through (Pailler et al. 1990). Identifying the entrance and exit orifices allows the physician to reconstitute the projectile's trajectory, enabling him or her to target the organs that are potentially involved, whether intra-abdominal or in other parts of the body (thoracic, retroperitoneal, or pelvic).

Penetrating abdominal traumas cause major damage to hollow organs. A US study conducted between 1997 and 2001 on 250 patients injured by either firearms (two thirds) or cold weapons (one third) found a lesion of the small intestine in half of the patients. This is the organ most commonly involved, followed by the colon (Nicholas et al. 2003) (Table 5).

Lesion Classification

The following different mechanisms may cause various organ lesions: intraparenchymal hematomas or subcapsular hematomas, fractures, channel lesions, vessel lesions, or parietal lesions. For each organ, there are descriptive lesion schemes classifying lesions according to their degree of severity. The most common classification system in international publications is that of the American Association for the Surgery of Trauma (AAST) (Moore et al. 1990).

In 2008, an analysis based on US trauma registry data involving 54,148 registered patients with a lesion code for spleen, liver, and kidney, of which 35,897 patients presented with an isolated solid organ lesion, validated the correlation between lesion severity established using the AAST classification and the patient outcomes. In the case of an isolated solid organ lesion, the evaluation parameters (mortality, duration of hospital stay, length of intensive care unit stay, specific intervention rate, and hospital costs) significantly increased with the lesion grade (Tinkoff et al. 2008).

2.2.4 Management of Abdominal Traumas

Physiopathology

For abdominal traumas, hemorrhagic shock and MOF are the principal causes of mortality. Hemorrhagic shock refers to acute tissue hypoperfusion caused by a decrease in circulating blood volume, resulting in an imbalance between oxygen supply and cellular oxygen needs (Duranteau 1995). Prolonged hypoperfusion is associated with anaerobic cellular metabolism, causing lactic acid production. The degree and particularly the persistence of the negative oxygen balance are major risk factors for acute respiratory distress syndrome and MOF (Rixen and Siegel 2000). Clinical and biological signs, reflecting decompensated shock, may be observed: hypothermia, acidosis, and coagulation disorders. These three elements work together and reinforce each other, rapidly leading to a vicious cycle, which may be fatal for the patient ("bloody vicious cycle") (Moore et al. 1998) (Fig. 1).

Hypothermia, defined by a temperature below 35°C, may be accounted for by hemorrhagic shock or by multiple other causes occurring in a polytraumatized patient (meteorological conditions at the accident site, freeing of the victim, vascular filling, laparotomy, etc.). Hypothermia has proven to be an independent risk factor of morbidity and mortality (Gentilello et al. 1997). Acidosis is defined by a pH below 7.36. The degree of acidosis and the clearance of lactates have also been shown to be independent prognostic factors of morbidity and mortality (Burch et al. 1997). Hypothermia and acidosis, along with hemodilution and coagulation factor consumption caused by the hemorrhage, reinforce each other, resulting in the development of acute posttraumatic coagulopathy (Eddy et al. 2000).

In this context, from a therapeutic viewpoint, the first-line emergency treatment consists of performing surgical hemostasis, in association with the correction of metabolic disorders, hypothermia, and coagulopathy. Abbreviated laparotomy is a necessary response to these physiological and clinical observations.

MOF may be described as an autodestructive process during which circulating factors have a deleterious impact on organs that were not affected by the initial aggression. It is associated with the progressive development of multiple organ deficiencies, resulting in the patient's death in 30–70% of cases (Carlet 1993). The factor time is of paramount importance in the initial patient management, so as to prevent the development of snowballing events comprising inflammatory responses associated with decompensated hemorrhagic shock. The second line of treatment consists of establishing an early diagnosis and initiating therapy for secondary complications such as infections, which may be a second risk factor for MOF (Fig. 2).

Evolution of Management

Over the past 30 years, the therapeutic strategies for blunt abdominal traumas have progressed toward a

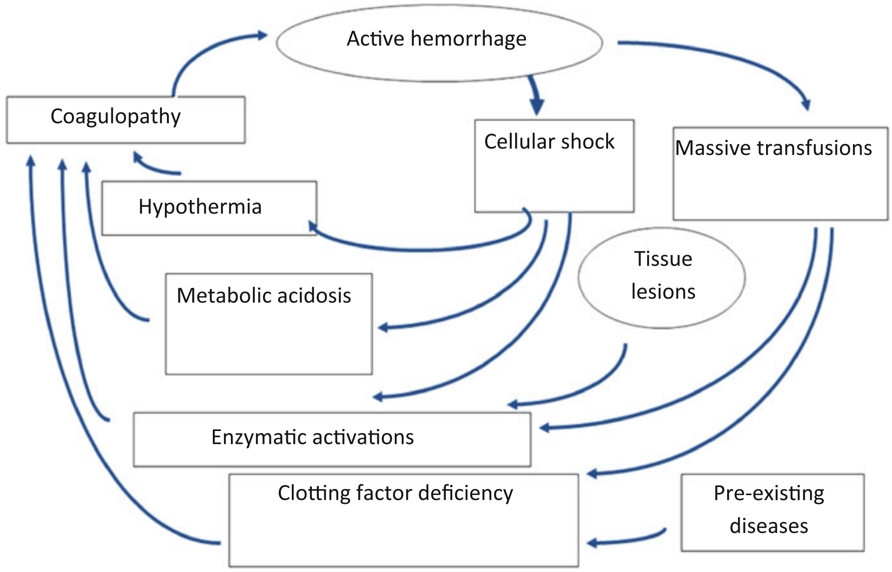

Fig. 1 The bloody vicious cycle

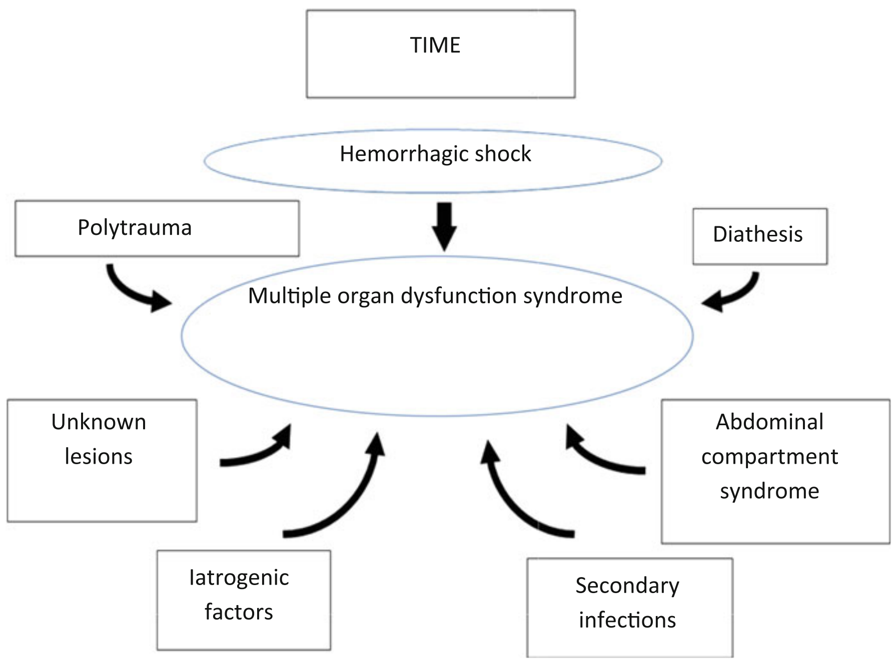

Fig. 2 Origin of the multiple organ dysfunction syndrome (MOF)

decrease in surgical indications, based on both the diagnostic reliability of the CT scan and the therapeutic possibilities of interventional radiology. Currently, 70–80% of splenic traumas and 80–90% of hepatic traumas are treated nonsurgically. Our better understanding of the pathophysiological changes of hemorrhagic shock has allowed us to further develop reanimation, surgical, and interventional radiology procedures, as illustrated by the standard concept of abbreviated laparotomy in the case of hepatic trauma.

Potential lesion progression requires frequent and complete evaluations of the injured patient's status, particularly at the early stages, with continuous adaptations of diagnostic and therapeutic measures. Repeated imaging is an essential part of patient management.

Severity Evaluation and Prognostic Index

The evaluation of lesion severity is a necessary step in all the treatment phases in order to optimize therapeutic and diagnostic orientations and choices. This evaluation must be initiated during the prehospital phase. The Vittel criteria, which pertain to the severity of the lesion, are an objective and simple tool for grading trauma patients. They are based on the analysis of the elements surrounding the accident and take into account information relating to physiological parameters, lesion, reanimation, and patient history. The presence of a single criterion is sufficient to characterize the severity of the trauma, except for the terrain, which must be evaluated on a case-by-case basis. Among the criteria, some are considered serious because they are associated with very high mortality: systolic arterial pressure below 65 mmHg (mortality 65%), Glasgow Coma Scale score of 3 (mortality 62%), and O_2 saturation below 80% or not measurable (mortality 76%) (Riou et al. 2002) (Table 6).

Besides this classification index, there are prognostic indices that allow us to statistically predict the likelihood of survival, risks of sequelae, and the length of hospital stay. The most commonly used index is the Injury Severity Score (ISS), which takes into account the anatomical region, the organ involved, the severity of the lesion, as well as the lesion's penetrating feature (or not), but does not consider the terrain or physiological parameters. This score is based on the description of the lesions by means of the AIS (Baker et al. 1974), which provides for each organ an estimation of the lesion severity using a six-point scale as follows: 1 for minor lesion; 2 for moderate lesion; 3 for severe, non-life-threatening lesion; 4 for severe, life-threatening lesion; 5 for critical lesion with uncertain survival; 6 for non-viable lesion. The ISS takes into account the seriousness of all lesions in a polytraumatized patient. An ISS greater than 16 usually defines a set of serious traumatic lesions; if the ISS is above 25, the patient's vital prognosis is involved; with an ISS ranging from 40 to 75, the patient's survival is uncertain. Likewise, the physiological impact of the trauma may also be a source of seriousness. The Revised Trauma Score (RTS) is a simple means that allows this impact to be evaluated at the accident site or upon admission to the hospital (Moreau et al. 1985; Champion et al. 1989). This evaluation takes into account the most negative values of the Glasgow Coma Scale, systolic arterial pressure, and respiratory frequency (appendices). An RTS of less than 10 requires that the patient be admitted to an intensive care unit, without giving any indications on the length of hospitalization. The combination of ISS, RTS, and the patient's age (more or less than 55 years) is used to compute the probability of survival and the quality of the patient's management by a medical facility (TRISS method). Finally, the standard resuscitation scores (IGS II and

Table 6 Vittel criteria

Five assessment steps	Severity criteria
1. Psychological variables	Glasgow Coma Scale score below 13
	Systolic blood pressure below 90 mmHg, O_2 saturation below 90%
2. Kinetic variables	Occupant ejection
	Other passenger dead in the same vehicle
	Fall more than 6 m
	Victim thrown out of the vehicle or crushed
	Overall assessment (vehicle deformity, estimated speed, absence of helmet, absence of safety belt)
	Blast
3. Anatomical lesions	Penetrating trauma of the head, neck, thorax, abdomen, pelvis, arm, or thigh
	Flail chest
	Severe burn, smoke inhalation
	Pelvic fracture
	Suspicion of medullary injury
	Amputation at the level of the wrist, ankle, or above
	Acute limb ischemia
4. Prehospital resuscitation	Assisted ventilation
	Vascular filling with more than 1,000 mL of colloids
	Catecholamines
	Inflated medical antishock trousers
5. Diathesis (to be assessed)	Age more than 65 years
	Cardiac or coronary insufficiency
	Respiratory insufficiency
	Pregnancy (2nd and 3rd trimesters)
	Blood crasis disorders

Simplified Acute Physiology Score: SAPS II) (Bach and Frey 1971) are also widely used for trauma patients admitted for resuscitation. A trauma patient with an IGS II score greater than 30 is considered to present a significant vital risk.

The Principles of Initial Management

Any injured patient with abdominal trauma must be considered, a priori, as being a polytraumatized patient and should thus benefit from systematic and full treatment. Priority must be given to accurate diagnosis and treatment of immediately life threatening lesions. The goal of resuscitation is to restore and maintain optimal tissue oxygenation and perfusion by means of an adapted ventilation and volemic expansion, while preventing hypothermia. The next diagnostic and therapeutic measures depend on the resuscitation-induced hemodynamic responses.

If hemodynamic instability persists, the diagnosis of active intracavitary hemorrhage must be considered. At this stage, focused assessment with sonography for trauma (FAST) ultrasonography in the shock resuscitation unit may guide the diagnosis toward intrathoracic, intraperitoneal, or pelvic hemorrhages. In this case, a strict collaboration between surgeons, resuscitation physicians, and radiologists is necessary to direct the patient to the operation room or to the interventional radiology unit without any further delay, in order for the required hemostatic gestures (surgical measures and/or arterial embolization) to be performed immediately.

In this setting of decompensated hemorrhagic shock, abbreviated laparotomy may be a particularly adapted surgical response. Its primary goal is to achieve rapid control of all hemorrhagic sources in order to interrupt the vicious cycle of hemorrhages. Surgical hemostatic interventions include vascular ligatures, total splenectomy, and “packings”.

Controlling bacterial contamination is based on simple closure of openings in the digestive tract using clips or ligatures. At this stage, there is no indication to reestablish digestive continuity or to create stomas.

Parietal closure is restricted to simple skin closure or laparostomy, and the injured patient is left in the care of the resuscitation team for the control of physiological functions and the correction of metabolic disorders. It is at this stage that an arterial embolization may be performed, relatively early on, in order to complete the surgical intervention.

A secondary laparotomy is performed 36 h later, with the goal of performing reconstruction interventions, proceeding to the ablation of packing, completing surgical exploration, and carrying out the full parietal closure.

Abdominal compartment syndrome is a complication that must be checked in the case of an abbreviated laparotomy with packing. Should this complication occur, resumption of intraperitoneal or retroperitoneal hemorrhages must be considered. This syndrome is characterized by a significant increase in intra-abdominal pressure, resulting in a decrease of both cardiac output and thoracic compliance, along with an alteration of renal function. The diagnosis of this syndrome is based on the evolution of intravesical pressure measurements, which allows physicians to direct the patient to emergency surgical decompression via a laparotomy, as deemed necessary.

If the injured patient has a hemodynamic status that is stable or has been stabilized by resuscitation measures, complete and precise lesion screening must be performed, which is based on an abdominal CT scan, the reference examination which has become indispensable in managing polytraumatized patients. Its diagnostic accuracy has led to the development of various nonsurgical strategies for solid organ lesions.

The entire set of aforementioned data is instrumental in establishing decision algorithms (Figs. 3, 4). For blunt abdominal traumas, the strategy is systematized, whereas it is still being debated for penetrating abdominal traumas.

For open abdominal traumas, however, there is consensus on a certain number of rules. Immediate laparotomy is necessary in the case of noncontrolled hemorrhagic shock, flow of digestive fluid, or apparent peritoneal signs. Immediate laparotomy is also routinely performed in the case of a firearm wound affecting the anterolateral abdominal wall. Under these conditions, visceral lesions are present in 80% of cases (Cayten 1984). For cold-weapon wounds, the standard strategy included a laparotomy for every diagnosis of peritoneal rupture. Because it was later shown that 30% of these procedures turned out to be unnecessary, a more pragmatic attitude was taken, consisting of a repeated examination for hemorrhage or peritonitis signs before deciding on a surgical intervention. For some authors, performing a laparoscopy would represent an alternative to simple clinical surveillance. For all penetrating traumas, a CT

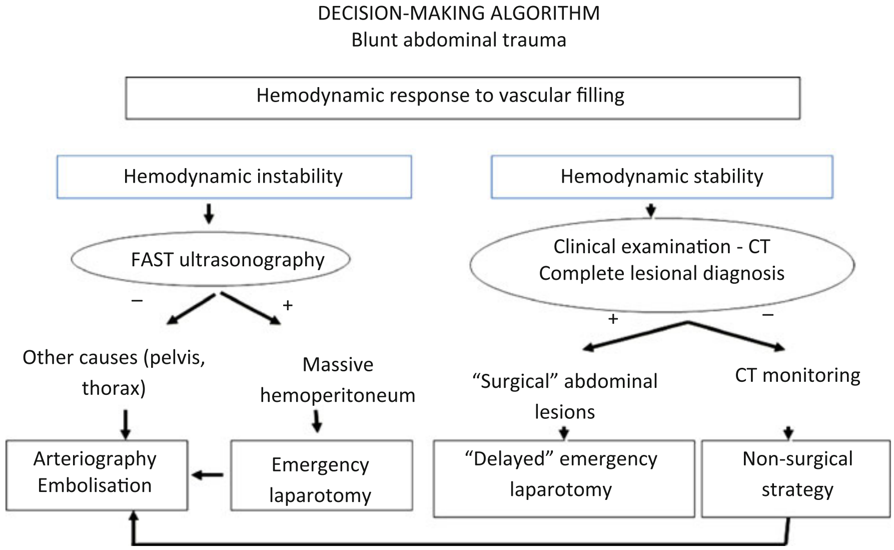

Fig. 3 Therapeutic strategy in the case of trauma

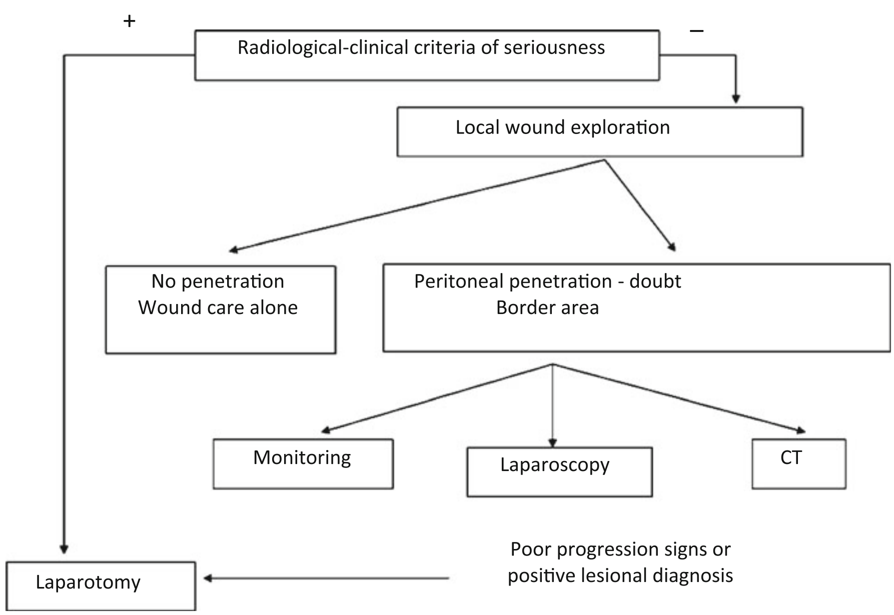

Fig. 4 Therapeutic strategy in the case of penetrating abdominal trauma

scan may be useful in the decision-making process when physicians are confronted with wounds involving borderline regions (thorax, retroperitoneum).

3 Specificities by Organs

3.1 Spleen

The spleen is the most commonly injured organ in blunt abdominal traumas. The current trend toward nonoperative management of splenic traumas is largely accounted for by the identification of immune functions that are specific to the spleen and the risk of fulminant infections following splenectomy. Only hemodynamic instability requires laparotomy, with total splenectomy carried out in most cases. On the basis of data in the American National Trauma Data Bank, the analysis of 23,532 cases of splenic contusions which occurred in 565 trauma centers over 5 years (1999–2004) revealed a 90% rate of initial nonoperative management, associated with an 80% success rate

Table 7 Efficacy of spleen embolization in abdominal traumas

Series	Number of patients	Preservation of spleen (%)	Morbidity (%)	Mortality (%)
Ekeh et al. (2005)	15	100	27	0
Haan et al. (2004)	143	87	16	0
Gaarder et al. (2006)	27	88	7	0
Bessoud et al. (2007)	37	97	3	0
Brugère et al. (2008)	22	91	27	0
Total	244	93	16	0

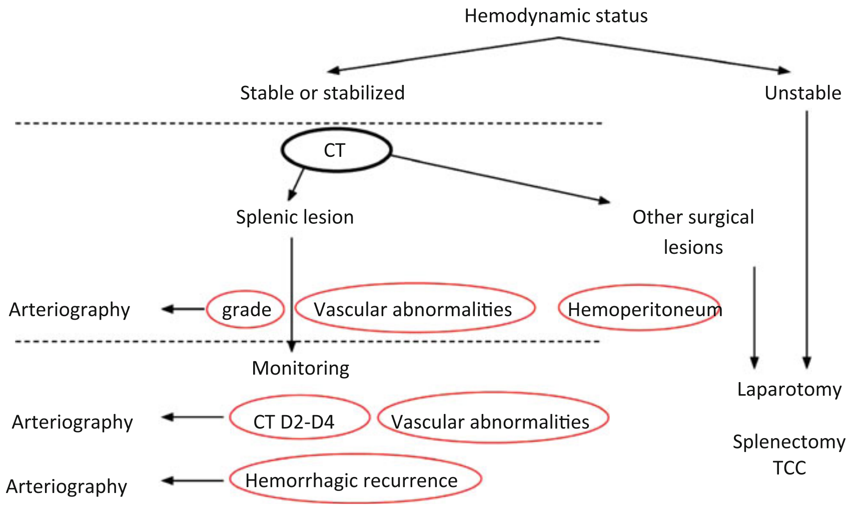

Fig. 5 Place of arteriography in the management of splenic traumas

(Smith et al. 2008). Identified factors of therapeutic success in the case of surgical abstention included hemodynamic stability, ISS below 15, Glasgow Coma Scale score above 12, lower than grade IV splenic lesion, and minor hemoperitoneum (perisplenic).

Splenic artery embolization is an additional therapeutic option among nonoperative strategies, which would result in an increased splenic preservation rate. Its therapeutic value is recognized in the clinical practice guidelines of the Eastern Association for the Surgery of Trauma (EAST; Eastern Association for the Surgery of Trauma 2003) and has been demonstrated in several published series (Table 7).

Morbidity arises from major complications and/or complications specific to embolization (persistent splenic hemorrhage, splenic infarction, abscess, and renal insufficiency).

However, the utilization level of splenic artery embolization in the decision-making algorithm for splenic traumas remains to be seen (Moore et al. 2008). One level corresponds to the prevention of secondary splenic hemorrhage. In this case, arteriography with embolization should be performed when the initial CT scan or systematic imaging examination during the first week following the trauma reveals grade III or higher lesions or vascular abnormalities. The other level corresponds to the treatment of subacute or chronic hemorrhages in a patient who is stable or has been stabilized during initial management or the monitoring period. Figure 5 summarizes the potential value of arteriography with embolization in the management of splenic traumas.

3.2 Liver

Liver traumas mainly occur in the case of blunt abdominal traumas and represent the primary cause of death in these injuries. Poor prognosis of blunt liver traumas is predominantly attributable to the hemorrhagic nature of liver lesions, and to a lesser extent to their anatomical severity. Mortality rates have considerably decreased, from 25% in the 1970s, to a current rate 10–15%, with only 20–25% of cases being directly related to liver lesions (Malhotra et al. 2000; Richardson et al. 2000). Currently, nonoperative management of liver traumas is chosen as first-line therapy in more than 80% of cases, including initial accurate CT assessment and hepatic artery embolization for hemorrhagic lesion management.

This initial surgical abstention should not delay a secondary indication for laparotomy or laparoscopy if, during repeated monitoring, there is any suspicion of intra-abdominal surgical lesions, such as a hollow organ rupture. Surgical techniques for the treatment of active hemorrhagic liver lesions are currently conservative: safety procedures such as liver packing and abbreviated laparotomy are preferred over standard hepatic surgery procedures, such as vascular clamping and hepatic resection. Nonoperative management requires effective and early cooperation between the surgeon, the resuscitation physician, and the interventional radiologist (Létoublon and Arvieux 2003).

3.3 Gastrointestinal Tract

The incidence of gastrointestinal tract lesions is predominant in penetrating abdominal traumas. A study involving 85,643 injured subjects with abdominal contusion revealed a 2.9% incidence rate of small intestine lesions and a 0.7% incidence rate of lesions with perforation. This low rate contrasts with a 29% morbidity rate and a 15% mortality rate. Even in the case of an isolated small intestine wound, the mortality remains high, with an estimated 6% death rate. The major prognostic factor is the time delay until surgical intervention, with a rate multiplied by a factor of 4 if this period exceeds 24 h (Fakhry et al. 2003). The incidence rate of colic lesions caused by blunt trauma is only 0.3%, although this condition is associated with a 36% morbidity rate and 19% mortality rate. The presence of a colic lesion is an independent risk factor for longer hospital stay and higher morbidity (Williams et al. 2003). The incidence of digestive tract lesions is particularly significant in the case of penetrating abdominal traumas.

The detection at clinical examination of a seat belt mark on the abdominal wall is associated with a 2.4 times higher risk of small intestine wound and, more generally, with a 8 times higher risk of intra-abdominal lesions.

Early diagnosis and treatment of the intestinal lesions are thus essential prognostic factors. Initial clinical examination is difficult and unreliable as abdominal wall traumas are often associated with other traumas in a polytrauma context. Likewise, a CT scan is not always conclusive. In the EAST study, no pneumoperitoneum was visualized on the initial CT scan in 75% of the small intestine rupture cases, with CT scan findings considered “normal” in 13% of patients (Fakhry et al. 2003). Thus, CT examination must be repeated within the 12–24 h following the initial trauma.

Surgical management of small intestine wounds is straightforward and generally based on sutures and immediate resection–anastomoses. Surgical treatment of colic wounds is more controversial owing to the risk of sepsis and postoperative fistulae. A meta-analysis performed in 2003 based on five controlled randomized studies was in favor of immediate reconstructive surgery in the case of penetrating colon traumas (Nelson and Singer 2003). However, a strategy of avoiding immediately reestablishing digestive continuity must be considered under the following conditions: significant stercoral contamination, a more than 24 h delay prior to the surgical intervention, and prolonged hemorrhagic shock, as well as the presence of several abdominal lesions.

3.4 Pancreas

In the case of abdominal traumas, pancreatic lesions are rare, but their diagnosis is far from easy. Clinical examination is difficult owing to the organ’s retroperitoneal location. The diagnosis of pancreatic lesions should be considered in the case of abdominal traumas caused by bicycle handlebars or compression of the driver of a motor vehicle against the steering wheel. An increase in lipase levels upon repeated measurements presents a diagnostic value after the third hour following the accident (Takishima et al. 1997). The diagnosis of pancreatic lesions is essentially based on CT scan results; however, there is a 40% rate of false-negative test results if the scan is performed within the first 12 h after the accident.

The two main specific risk factors of pancreatic traumas are pancreatic duct lesions and delayed diagnosis of these lesions (more than 24 h) (Bach and Frey

1971; Heitsch et al. 1976; Bradley et al. 1998). Their diagnosis is currently based on retrograde cholangiopancreatography. The value of pancreatography using nuclear magnetic resonance for pancreatic duct screening still needs to be defined (Nirula et al. 1999; Fulcher et al. 2000). The management of these lesions depends on the integrity of the Wirsung channel, the degree of parenchymal involvement, and the exact location of the lesion. Should the diagnosis of channel rupture be confirmed, the preferred strategy consists of surgical intervention, such as simple external drainage or distal pancreatic resection.

4 Conclusion

The management of abdominal traumas represents a triple challenge:

- A therapeutic challenge due to the immediate seriousness of hemorrhages, which may be highly reversible among young adults, who are the most exposed to this risk, from an epidemiological point of view
- An organizational challenge, as this requires the implementation of a patient care chain, starting at the accident site and involving different health care teams and facilities
- A human challenge, as the care chain is unable to function without any effective, early, and continuing cooperation between the different actors

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