

Current trends in polytrauma management Diagnostic and therapeutic algorithms operational in the Trauma Center of Cesena, Italy



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INTRODUCTION: *The purpose of this paper is to present the most recent revision of diagnostic therapeutic protocols regarding polytrauma that are operational in the Trauma Center of Cesena, and to check what impact the progressive implementation and review of these algorithms has had on predefined indicators of results and utilization of diagnostic and therapeutic resources. Finally for the purpose of comparing the results obtained in a subgroup of patients treated in the Trauma Center of Cesena, with those obtained in a group homogeneous for ISS and year of hospitalization stored in the RRG (Registro Regionale Grandi Traumi - Regional Major Trauma Registry).*

MATERIALS AND METHODS: *Through a retrospective study we analyzed a population of 21,704 patients hospitalized for trauma in our Trauma Center from 2001 to November 2009, 40.1% females and 59.9% males, aged between 0 and 105 years, who were treated with the protocols developed in the Trauma Service. Indicators of results and of diagnostic and therapeutic resource utilization were analyzed. All patients enrolled in the study were divided by year of admission to assess the performance of these indicators over the years. An ISS homogeneous subgroup including only patients hospitalized in the year 2007 was also created for comparison with the report of RRG (Regional Major Trauma Registry). Emergency Department code yellow or red patients were divided into 3 groups based on the hemodynamic response after primary assessment. Group A included patients that were hemodynamically stable (ATLS criteria); Group B included patients that were hemodynamically stabilized; Group C included patients that were hemodynamically unstable. Each group of patients was treated according to precise diagnostic and therapeutic protocols.*

RESULTS: *The overall hospital mortality was 2.4%. Mortality at discharge from intensive care was 11.6% while at discharge from the Emergency Surgery was 0.2%. The total average hospital stay was 10.1 days. ICU stay was 7.8 days, while in Emergency Surgery was 12.4 days. 79.4% of the patients were discharged home. Overall, the percentage of patients undergoing surgery was 64.3%. Patients undergoing diagnostic level II with multislice CT were 19.3%; those undergoing CT of the chest and / or abdomen were 5%. A total 0.8% of patients underwent angiography, and 0.2% underwent embolization. The overall percentage of patients transfused with packed red blood cell was 3.9%.*

CONCLUSIONS: *The hemodynamic response of patients after primary assessment determines the subsequent diagnostic and therapeutic procedures. The protocols that we utilized had a positive impact on the mortality of patients hospitalized in the intensive care and on the average intensive care stay, and were also associated with an increase in the number of angiography and arterial embolizations performed in sicker patients and those with relevant surgical lesions. The decrease in mortality is also observed in comparison with the RRG data. We believe therefore that these protocols can provide a valuable and effective aid for those involved in the care of trauma victims, allowing them to always be able to quickly decide what to do, when to do, how to do, and where to do what needs to be done.*

KEY WORDS: Hemodynamic Response, Non Polytrauma management, Trauma Registry.

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Introduction

The implementation of the Hub & Spoke Network in the Integrated Trauma Support System (SIAT), operational in the Region of Emilia Romagna for about 8

years, has effectively centralized the 3 major trauma Centers of the Emilia-Romagna (Cesena, Bologna and Parma), and has resulted in a high concentration of cases that making possible to acquire specialized experience in managing extensive multiple injuries. Thanks to the improvement of pre-hospital emergency care patients who use to die at the scene of the accident, or during transport by ambulance, now survive until arrival at Shock Room. It has long been known that the main cause of death of these patients is due to bleeding. Any delay in the control of the bleeding causes a massive loss of blood resulting hypothermia, coagulopathy, and an inescapably grim prognosis. It is also known that in these cases the mortality is related to the duration of the changes in physiological parameters resulting from the trauma, rather than from the non definitive repair of the injuries. The complex pathophysiology of the polytraumatized patients requires effective and rapid treatment of massive bleeding from parenchymatous organ injuries, as well as control of contamination from ruptured hollow organs. These actions are necessary to prevent, and protect the patient from, the deadly spiral of severe systemic complications, such as those caused by a prolonged state of hemorrhagic shock, Systemic Inflammatory Response Syndrome (SIRS), and Multiple Organ Failure Syndrome (MODS). The multidisciplinary team involved in the care of the polytrauma victim must aim to stabilize the patient as soon as possible, utilizing codified and shared guidelines and protocols that allow the trauma team and its leader to know at any given time, what to do, when to do, how to do, and where to do what needs to be done. The Trauma Service of our Trauma Center makes these protocols available, reviews them and updates them. The primary purpose of this paper is to present the most recent revision of diagnostic and therapeutic algorithms for extensive thoraco-abdominal and pelvic injuries, operational in the Trauma Center in Cesena. Secondly, to see if, and how, the experience acquired over the years impacted predefined diagnostic and therapeutic indicators of outcome and resource utilization. Finally to compare the results obtained in a homogeneous subgroup of patients treated in the Trauma Center of Cesena, with those of the Severe Trauma Regional Registry.

Materials and Methods

The Trauma Center (TC) of Cesena works within the context of an Integrated System for Trauma Care (SIAT), which covers a population of approximately 1,200,000 inhabitants with an estimate of 500 expected major traumas per year. The operation of the SIAT is based on an integrated network of hospitals according to a Hub & Spoke model in which the TC Cesena acts as Hub for the centralization of polytrauma victims transported by helicopter and by ambulance with an estimated tra-

vel no longer than 20 minutes (Primary Transportation). Multiple traumata (after transitional hemodynamic stabilization) and spinal trauma are also centralized in a Spoke center, (secondary transport). From October 2006, the Severe Trauma Regional Registry ((RRTG) became officially operational; the Registry collects data on trauma patients identified as having at least one of the following characteristics from across the region:

- ISS > 15
 - Placed in Intensive Therapy
 - Death in the Emergency Department
- Data on patients who do not go to intensive care are not sent to the trauma registry. The report containing the data for the year 2007, which is the first important benchmark, was published in November 2008. Through a retrospective analysis we analyzed a population of patients hospitalized for trauma in our TC from 2001 to November 2009 who were managed utilizing the internal protocols developed by our Trauma Service. Therefore the following specific indicators were created:

Result indicators:

- Overall hospital mortality
- Mortality at discharge from intensive care
- Mortality at discharge from Emergency Surgery Department
- Average total length of stay in the hospital
- Average length of stay in intensive care
- Average length of stay in Emergency Surgery Department
- Percentage of home discharges

Indicators of resource utilization:

- percentage of patients undergoing surgery;
- percentage of patients undergoing multislice CT;
- percentage of patients undergoing chest and / or abdomen CT;
- percentage of patients undergoing angiography;
- percentage of patients undergoing angio-embolization;
- overall percentage of patients transfused with packed red cells and / or plasma.

All patients evaluated in this study were subdivided by year of admission to assess the trends of these indicators over the years. A homogeneous subgroup for ISS > 15, comparable with the report of RRTG, containing only patients hospitalized in 2007 was created to assess the deviation of our indicators from the ones of the RRTG. For this retrospective study we analyzed a population of 21,704 patients hospitalized for trauma between 2001 and November 2009; 13,011 (59.9%) were males and 8,693 (40.1 %) females, aged between 0 and 105 years, (98.3% closed traumas).

These patients were managed according to multidisciplinary protocols designed by the Trauma Service, established in 2001, in the TC of Cesena. This organization is responsible to make diagnostic and therapeutic protocols and internal guidelines based on studies, analysis, comparisons and review of the literature, make

them known to the operators, monitor their implementation and revise them through audit procedures and clinical cases reviews. In these years, two revisions of the Trauma Service Document have been drafted, and placed in the internal network of the TC, which represents the container where all agreed procedures, updated and shared, are available to the people involved with the care of trauma victims. Patients were classified into 3 groups in relation to the hemodynamic response to resuscitation maneuvers carried out during the primary survey (Fig. 1). To define the types of hemodynamic response (Fig. 2), we considered the criteria of ATLS. Group A included the patients that were hemodynamically stable (Fig 3).

These patients were managed conservatively according to the criteria of inclusion and exclusion of the NOT (Non Operative Treatment). More particularly, the criteria of exclusion were:

- hemodynamic response type B or C;
- suspected presence of intra-abdominal lesions with signs of peritonitis;

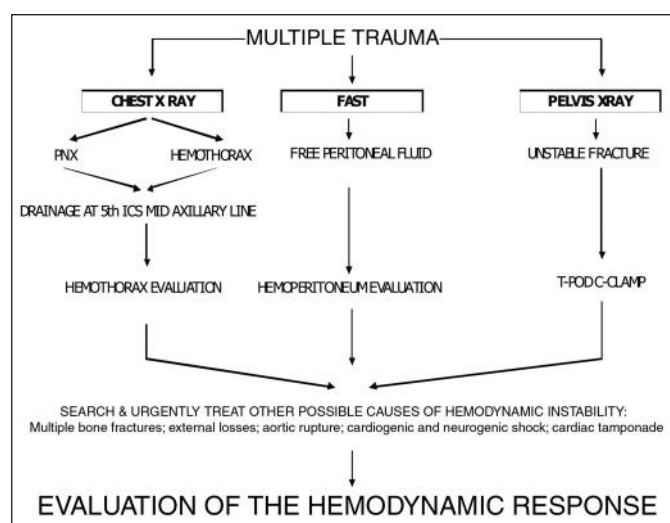


Fig. 1: Emergency room.

ATLS	Response type A	Response type B	Response type C
Vital signs	Back to normal	Transient improvement followed by BP & HR ↑	Remain abnormal
Estimated blood loss	Minimal (10-20%)	Moderate and persistent (20-40%)	Severe (>40%)
Need of additional fluid infusion	Low	High	High
Need of blood transfusion	Low	Moderate to high	Immediate
Type of blood needed	Typed & cross-matched blood	Specific blood type	Emergency blood
Early surgical presence	Yes	Yes	Yes

Response to the initial infusion of 2000 ml of Ringer in adults and 20 ml/kg in children

Fig. 2: Evaluation of the hemodynamic response.

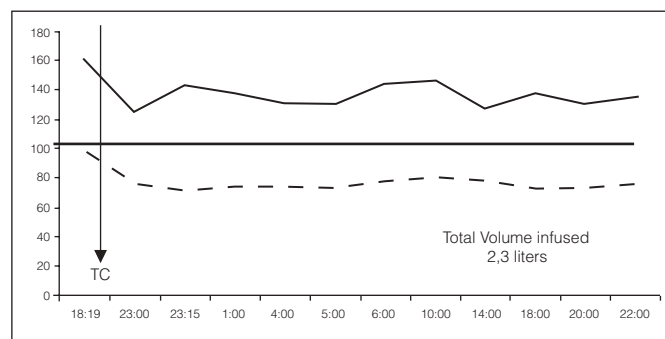


Fig. 3: Hemodynamics in the first 24 hours.

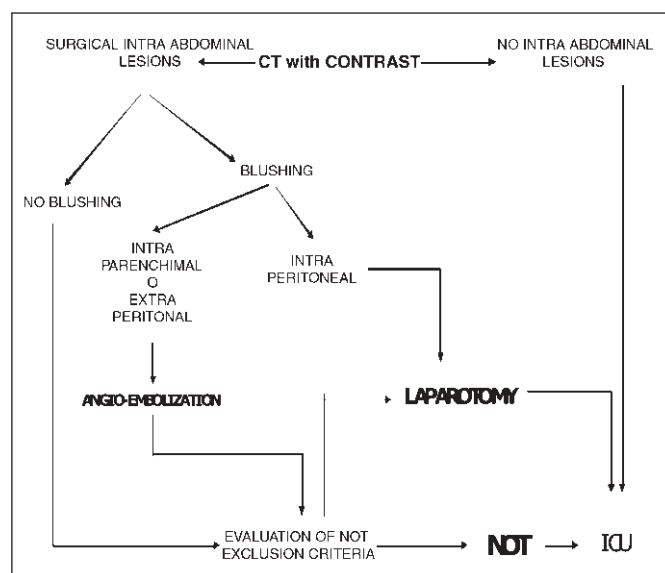


Fig. 4: Hemodynamics response type A

- presence of extra-abdominal lesions requiring surgery;
- impossibility to continuously monitor labs or tests for any reason;
- impossibility to perform immediate surgery in case of not failure;
- need blood transfusions over 4 units of packed cells or activation of the massive transfusion protocol.

Hemodynamically stable patients have been treated according to the algorithm illustrated in Fig. 4.

In agreement with the radiologists, we have created internal guidelines for defining the minimal level of information necessary for the assignment and monitoring of the patients in NOT (Fig. 5).

Likewise, we created a protocol for in-hospital monitoring of these patients, utilizing contrast echography (Fig 6). The main advantage offered by this modality is its ability to better define the contused areas and the presence of active bleeding.

The indication to discontinue NOT have been coded and are listed in Fig. 7.

The patients with hemodynamic response type B have been the most challenging (Fig. 8), because they were

MINIMAL INFORMATION AT THE FIRST CT	
>Integrity of the capsule (Liver and Spleen)	
>Size of the hemoperitoneum (> or < 1000 ml)	
>Evidence of active increase	
>Type of increase (arterial/venous)	
>Evidence of vascular lesions	
>Evidence of additional intra-abdominal lesion	
MINIMAL INFORMATION DURING ECHOGRAPHIC MONITORING	
>Hemoperitoneum size increased or not increased	
>Organ size increase present or not present	
>Lesion evolution (abscess, bilioma, etc.)	
MINIMAL INFORMATION DURING ECHOGRAPHIC FOLLOW UP	
>Lesion evolution (abscess, bilioma etc.)	

Fig. 5: Internal not guidelines.

MONITOR OF MAJOR HEPATIC TRAUMA IN TNO

If not already present at arrival:

1. Place two # 16G venous access cannulae
2. Insert a urinary bladder catheter
3. Make sure that 4 units of blood are available

TIME FROM ADMISSION	0 – 24 hrs	24 – 48 hrs	48 – 72 hrs	III -VII day	VIII day	DISCHARGE
VITAL SIGNS	CONTINUOUS MONITOR (BP, HR, O2 Sat)			EVERY 6 HRS	EVERY 12 HRS	YES
ABDOMINAL ECHO	EVERY 6 HRS	EVERY 12 HRS	EVERY 24 HRS	ECHO WITH MDC A 72 H	YES	ECHO WITH MDC
TC	NO	NO	NO	NO	NO	NO***
CBC	EVERY 4 HRS UNTIL STABLE	EVERY 12 HRS	EVERY 24 HRS	EVERY 48 HRS	YES	YES
CLOTTING PROFILE	YES	NO				
SGOT SGPT	NO	EVERY 24 HRS		EVERY 48 HRS	YES	YES
URINE OUTPUT PER HR	YES			Remove BILLY CATHETER	NO	
INTAKE AND OUTPUT	YES			NO		
MOBILIZATION	NO				YES	
DVT PROPHYLAXIS	ELASTIC STOCKINGS			ELASTIC STOCKINGS + EBPM*		EBPM*
ANTIBIOTICS	NO			AUGMENTIN (PER OS) 1 GR. X 2 IF FEBRILE		
DIET	FASTING			LIQUID	LIGHT	REGULAR

* Dose per protocol schedule
 *** Only if requested by radiologist
 *FOLLOW UP AT 30-60 DAYS WITH MDC OR UNTIL COMPLETELY RECOVERED

Fig. 6: Monitor of major hepatic trauma in TNO.

- Onset of Hypotension, tachycardia and oligo-anuria during monitoring
- Drop in Hematocrit associated with echographic evidence of progressive increase in the size of the hemoperitoneum (in particular if located around the spleen, the liver and the space of Douglas)
- More than 4 units of blood needed in the first 24 hours to maintain stable vital signs

Fig. 7: Indications for discontinuing NOT.

patients with an ongoing bleeding and needed to be kept stable during the diagnostic phase with multislice CT. Per protocol, NOT was not pursued in patients with surgical lesions, due to their unstable hemodynamic status.

The decision to perform surgery was not made based on the morphofogy or the severity of the possible parenchymal organ lesion, but rather on the presence, or

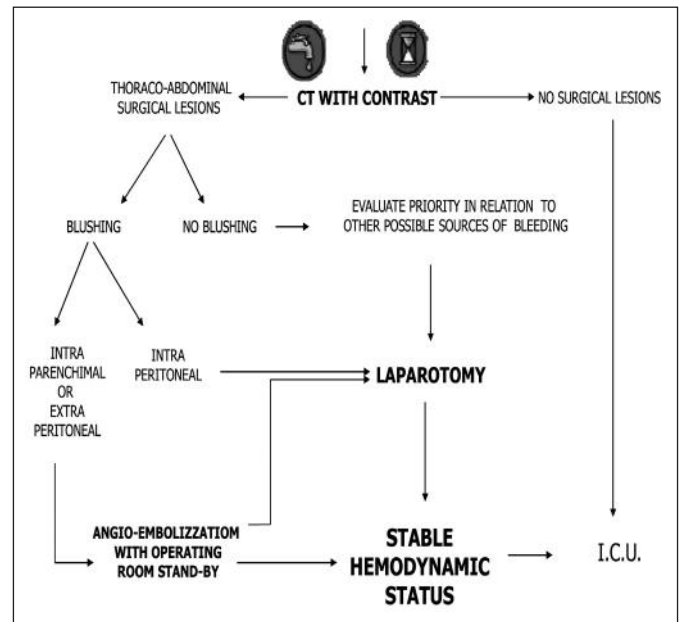


Fig. 8: Hemodynamic response type B.

- GRADE I** : pooling of contrast directly in the peritoneal space necessitating surgical intervention in **100%** of the cases

→ **GRADE II** : pooling of contrast around the lesion in the parenchyma and in the in peritoneal necessitating surgical intervention in **66%** of the cases ←

- GRADE III** : pooling of contrast only in the parenchyma and/or around the lesions successfully treated with TNO in **100%** of the cases

Fang (World J. Surg 2001)

Fig. 9: Contrast pooling.

absence of an active enlargement of contrast pooling in a given the location (Fig. 9).

In this group of patient, when the decision was made to proceed with angio-embolization, an operating room was made available on stand-by to perform surgery in case of hemodynamic deterioration due to failure of the endovascular procedure to control the bleeding within a maximum of 90 minutes.

The group of patients with hemodynamic response Type C were hemodynamically unstable and unresponsive to fluids replacement and intensive therapy. These patients are extremely ill and do not have time for a level II diagnostic phase and must be brought to the operating room to control the bleeding as quickly as possible. The level I diagnostics obtained in the in Shock Room as part of the Primary Survey, are focused exclusively to provide information on the site where the bleeding is primarily taking place (abdomen, chest). Multiple trauma victims cannot be dealt with in a conventional sur-

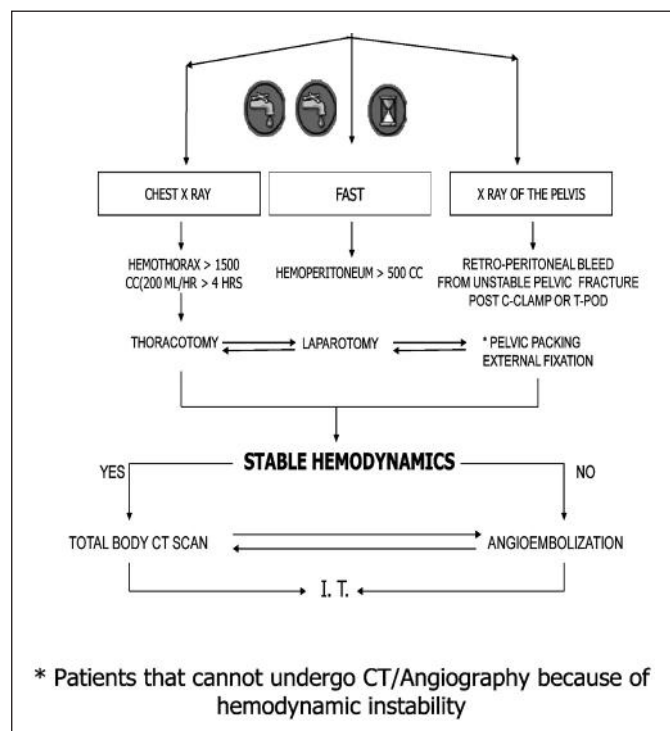


Fig. 10: Hemodynamic response type C.

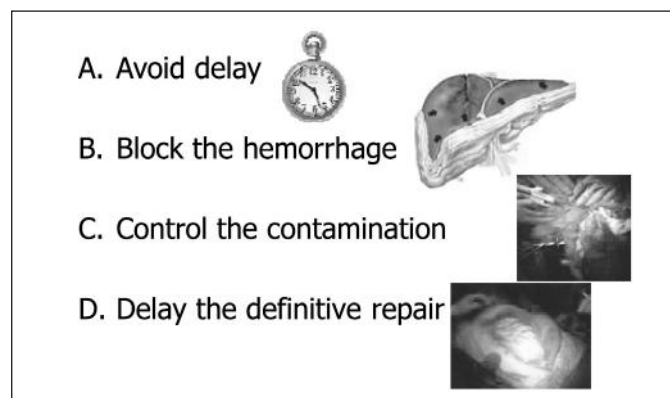


Fig. 11: Principles.

gical manner. The approach has been, by necessity more aggressive, with time being of the essence and finalized to life saving manouvers; based on the principle of Damage Control (Fig. 11), the definitive repairs are deferred to a time when the physiologic parameters are corrected.

As provided for by the Damage Control strategy, after the initial surgery accomplished temporary hemostasis (packing) and control of contamination (resections without restoration of intestinal continuity), the patients were tranferred directly to Intensive Care (Fig. 12).

In instances where the hemodynamic instability persisted after packing, the hemostasis was improved with arterial embolization prior to transfer to Intensive Care.

As a general rule, the maximum time expected for the shortened laparotomy (the first phase of the Damage

PHASE 1

- Shortened Laparotomy
- Laparotomy
- Possible arterial embolization

PHASE 2

- Transfer to Intensive Care for correction of physiologic parameters

PHASE 3

- Re-operation for hemostasis and repair of the lesions
- Laparotomy closure

Fig. 12: Damage control phases.

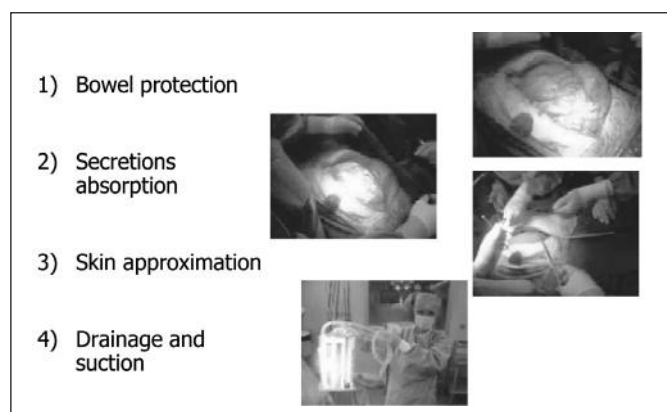


Fig. 13: Phase 1: laparostomy.

- Possibly in the temporal window before the occurrence of the SIRS, at the time of completion of the resuscitative phase.
- Lactate < 4 mmol/l associated with a BE lower than -4 mmol/l are the indexes that best reflect the return of normal perfusion
- These end points are normally reached within 36 hours in the Intensive Care Unit of the Trauma Center
- The timing of the second operation is therefore between 24 to 48 hours and within a maximum of 96 hours

Fig. 14: Phase 2: timing of the second operation.

Control) has not exceeded 90 minutes. As driven by the protocol, the first surgical stage has been completed with a laparostomy. The type of laparostomy utilized has changed over time; the one presently used is characterized by simplicity, speed, efficacy, and low cost. It is based on 4 basic principles (Fig. 13).

The time frame between the first laparotomy and the re-operation has been between 24 and 72 hours, more frequently around 36 hours. The quality and quantity of the losses through the laparostomy have been routinely monitored in the Intensive Care Unit and correlated to the hemodynamic status of the patient. At the same time, appropriate measures were taken for correction of abnormal coagulation and arterial blood gases

- A. There is a significant mortality increase (70%) in instances of early, unplanned re-operations
- B. At re-operation, it is of paramount importance to perform only procedures that the patient can tolerate
- C. After removal of the packing a systematic inspection of the abdominal cavity is performed to exclude the presence of lesions not detected at the time of the initial surgery
- D. Vascular shunts must be replaced with grafts as soon as possible to prevent thrombo-embolic events when the coagulation parameters are normalized

Fig. 15: Phase 3: strategies and principles.

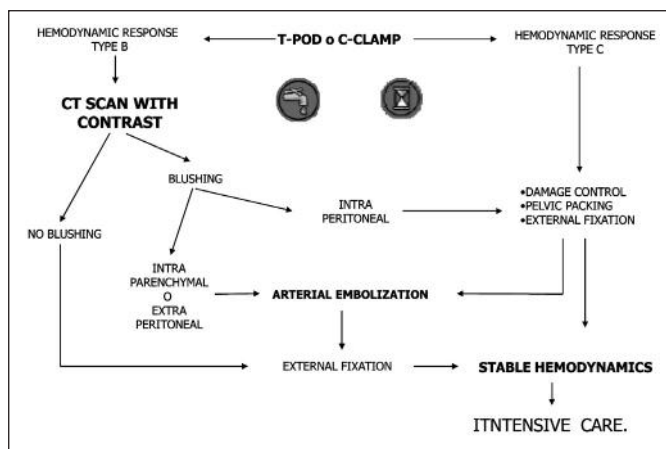


Fig. 16: Abdominal-pelvic trauma.

parameters and correction of hypothermia as quickly as possible.

Some arterial blood gas parameters (Fig. 14) have been utilized to determine the timing of the second operation.

The re-operation has been carried out for the definitive control of the hemostasis after removal of the packing and for restoration of intestinal continuity (Fig. 15). When indicated, a jejunostomy is performed for nutritional support.

During this phase a systematic exploration of the peritoneal cavity was carried out to detect lesions that could have been possibly missed at the time of the initial operation. Re-packing with relaparostomy were deemed necessary in few cases.

In the majority of cases the laparostomy has been closed without utilizing alloplastic materials. The closure technique has been designed to accomplish two important goals: approximation of the edematous tissues, and prevention of the compartmental abdominal syndrome. This has required extensive mobilization of the subcutaneous layers obtained by performing long relaxing incisions on the anterior rectus abdominis sheet, for better approximation without tension. Often, additional skin

relaxing incisions have been required, particular attention being paid to preserve the peri-umbilical vascular anastomotic circulation.

Abdominal-pelvic polytrauma patients with pelvic fractures associated with hemodynamic instability deserve special consideration (Fig. 16).

In these patients, early fixation of the pelvis associated with arterial embolization are the most effective measures to obtain hemodynamic Stability. These are the only patients in which we obtained a multislice CT and angiography, inspite of their hemodynamic instability. In a very limited group of patients that could not be hemodynamically stabilized, we proceeded with immediate external fixation of the pelvis and abdominal and pelvic packing prior to angiographic embolization, paying a high mortality price.

Results

The overall hospital mortality has been 2,4%. (Tab. I). The mortality at the time of discharge from Intensive care was 11,6% while the mortality at the time of discharge from Urgent Surgery was 0,2%. The overall average hospital stay was 10.1 days; it was 7.1 days in the Intensive Care, and 12.44 days in Urgent Surgery. 79,4% were discharged home. The percent of patients that underwent surgery was 64,3%.

19,3% of the patients underwent multislice CT; CT of the Chest and/or abdomen were obtained in 5% of the

TABLE I - Trauma center of Cesena

Patients hospitalized for trauma	21.704	
Average hospital stay	10,1	
Hospital mortality	519	2,4%
Patients undergoing surgery	13.958	64,3%
Patients undergoing multislice CT	4.188	19,3%
Patients undergoing CT of Chest and/or abdomen	1.095	5%
Patients undergoing angiography	176	0,8%
Patients undergoing angio-embolization	50	0,2%
Patients transfused Plasma with RBCs and/or	856	3,9%

TABLE II - Intensive care.

Pazienti hospitalized for trauma	2.042	
Average Intensive Care stay	7,6	
Average hospital stay	20,7	
Intensive Care Mortality	236	11,6%
Hospital Mortality	268	13,1%
Patients undergoing surgery	1.564	76,6%
Patients undergoing multislice CT	686	33,6%
Patients undergoing CT of Chest and/or abdomen	311	15,2%
Patients undergoing angiography	115	5,6%
Patients undergoing angio-embolization	37	1,8%
Patients transfused Plasma with RBCs and/or	158	7,7%

TABLE III - Emergency surgery department

Pazienti hospitalized for trauma	565	
Average Emergency Surgery stay	5,8	
Average hospital stay	12,4	
Mortality in Emergency Surgery	1	0,2%
Hospital mortality	6	1,1%
Patients undergoing surgery	258	45,7%
Patients undergoing multislice CT	200	35,4%
Patients undergoing CT of Chest and/or abdomen	213	37,7%
Patients undergoing angiography	14	2,5%
Patients undergoing angio-embolization	8	1,4%
Patients transfused Plasma with RBCs and/or	40	7,1%

TABLE IV

	RRGT	TC Cesena
Number	1254	257
Closed Trauma	98,2%	98,1%
Open Trauma	1,8%	1,9%
Hospital Mortality	13%	10,1%
ICU Mortality	11%	8,9%
Average Hospital stay	27gg	22,1gg
Average ICU stay	9gg	7,3gg
Surgical Interventions	70%	77,4%
Multislice CT	44%	37%
CT Chest/Abdomen	54%	18,7%
Total Angiographies	5%	8,2%
Total RBC transfusions	26%	6,6%

patients. 0.8% of the patients underwent angiography; 0.2% underwent angio-embolization. The total percentage of patients that received packed RBCs was 3,9%. Patients undergoing Level II diagnostic studies with multislice CT were 19.3%; tables II and III show the total data related to the trauma patients in the Intensive Care and Urgent Surgery.

Table IV illustrates the data of the homogeneous subgroup with ISS>15 of TC Cesena compared to the Regional Trauma Registry (RRGT).

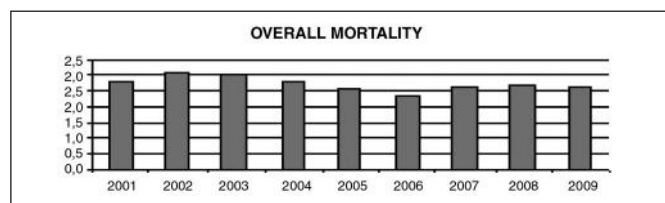
Table V of page 89 illustrates the data concerning the indicators analyzed in the corresponding years.

Discussion

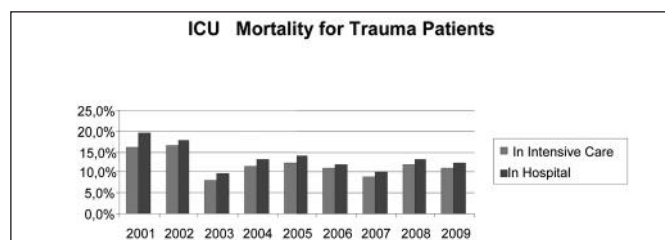
The indicators analyzed in this study show that the mortality of patients hospitalized for trauma has not significantly changed through the years (Graphic A).

Graphic B illustrates that there is a significant decrease in mortality of Intensive Care patients.

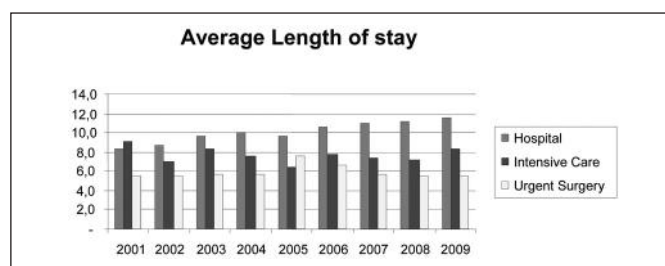
These results are comparable to the ones reported by Scalea,¹ in a retrospective analysis of a 12 years period. The average length of stay has shown a different pattern: the overall length of stay has increased, but the ICU and Urgent Surgery Department length of stay has decreased. (Graphic C).



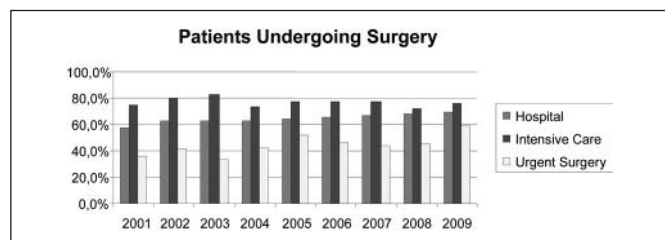
Graphic A



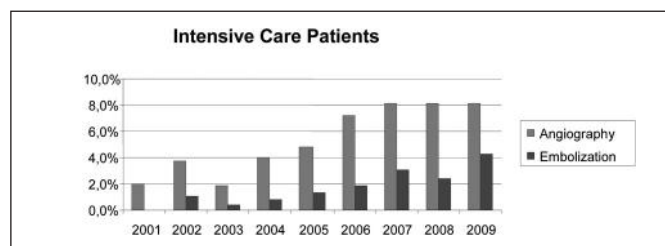
Graphic B



Graphic C



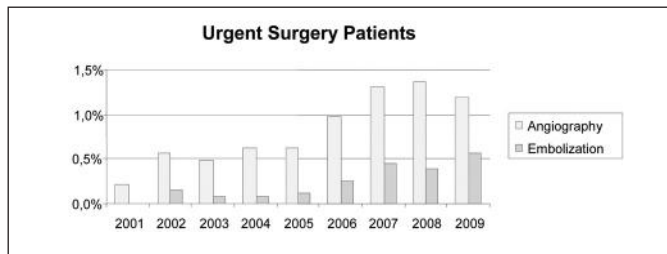
Graphic D



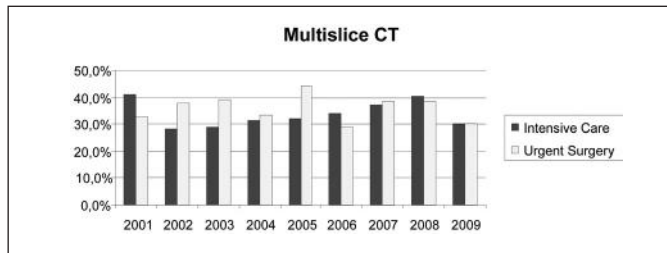
Graphic E

The overall percentage of patients undergoing surgery has not changed in the study period, except for a slight increase in the more severely ill Intensive Care patients. (Graphic D).

As far as Angiographies and Angio-embolizations are concerned, the data show that their utilization is steadily and clearly increasing in the Intensive Care and Urgent Surgery patients. (Graphics E; F).



Graphic F



Graphic G

The diagnostic utilization of Multislice CT has been substantially unchanged over time (Graphic G).

The correct evaluation of the hemodynamic stability of the severely ill polytrauma victim is the most important factor. The patients who are hemodynamically stable favorably respond to the Infusion of crystalloids even at maintenance levels (Fig. 17). These patients may even present with a hemoperitoneum larger than 500 cc from the rupture of an intra-abdominal organ, and must be handled conservatively following the principles of the Non Operative Treatment. At present, over 70% of splenic lesions and almost 90% hepatic lesions can be successfully managed non operatively.

The practice management guidelines of the Eastern Association for the Surgery of Trauma(2003) ², have proposed three levels of recommendations.

Level I recommendations:

There are insufficient data to suggest nonoperative management as a Level I recommendation for the initial management of blunt injuries to the liver and/or spleen in the hemodynamically stable patient.

Level II recommendations:

- There are sufficient data to suggest that nonoperative management of blunt hepatic and/or splenic injuries in a hemodynamically stable patient is reasonable.
- The severity of hepatic or splenic injury (as suggested by CT grade or degree of hemoperitoneum), neurologic status, and/or the presence of associated injuries are not contraindications to non-operative management.
- Abdominal CT is the most reliable method to identify and assess the severity of the injury to the spleen or liver.

Level III recommendations:

- The clinical status of the patient should dictate the frequency of follow-up scans.
- Initial CT of the abdomen should be performed with oral and intravenous contrast to facilitate the diagnosis of hollow viscus injuries.
- Medical clearance to resume normal activity status should be based on evidence of healing.
- Angiographic embolization is an adjunct in the non operative management of the hemodynamically stable patient with hepatic and splenic injuries and evidence of ongoing bleeding.

The presence of contrast pooling on the CT scan, is more important than the morphology of the injury, or the size of the hemoperitoneum, in determining the success of NOT (non-operative management) because its presence increases the risk of failure of NOT ³.

In these cases, when the degree of contrast pooling is not 1 (that is, spillage of the contrast directly in the free peritoneal space), non-operative management candidates increase from 62 to 82%, with a concomitant increase of successful cases from 94 to 98%, in hemodynamically stable patients treated with angio-embolization ⁴⁻⁶.

Several papers report a success rate of 85 to 100% with non-operative management of liver injuries ⁷⁻¹⁰.

As far as the occurrence of complications a study of 337 patients with liver injuries followed for 40 months, has shown percentages so low that the Authors concluded that non-operative management was safe ¹¹.

A recent study involving pediatric patients, has demonstrated that the hemodynamic status of the patient, rather than the degree of the injury, must guide the modality of treatment ¹².

In particular it is restated that:

- patients with isolated splenic and hepatic injuries can be managed conservatively based on the hemodynamic status, regardless of the degree of injury, with resultant shortened hospital stay and reduced utilization of resources, in comparison with the present guidelines;
- normal activities of daily living can be safely and effectively resumed at the time of discharge (restrictions only for gymnastics and contact sports);
- return to full unrestricted activities is safe after echographic evidence that the injury is healed, which usually does not occur before 4 weeks, even for grade IV lesions.

An additional recent study ¹³, evaluated the support of angiography embolization, and concluded that:

- the failure rate of non-operative management without embolization is 34% (greater for AAST grade III-IV lesions);
- splenic artery embolization has brought the success rate of non-operative management to 97% (over 80% for high grade lesions).

The proximal embolization of the splenic artery offers the following advantages:

- failure rate less than (22% vs 33%);

TABLE V

INDICATORS	2001	2002	2003	2004	2005	2006	2007	2008	2009*
Total number of patients hospitalized for trauma	2.411	2.493	2.455	2.424	2.381	2.448	2.467	2.356	2.269
Overall mortality	2,8%	3%	3%	2,8%	2,5%	2,3%	2,6%	2,6%	2,6%
Overall hospital stay	8,3	8,7	9,7	10,1	9,6	10,7	11	11,2	11,5
Surgical procedures	57,8%	62,9%	62,6%	62,8%	63,5%	66,6%	66,6%	67,9%	69,5%
Multislice CT	17,8%	19,1%	19,5%	20,5%	19,2%	19,9%	20,2%	18,8%	18,6%
CT Chest and/or Abdomen	2,7%	3,5%	3,6%	4,6%	4,7%	5,9%	6,6%	7,9%	5,9%
Angiography	02%	0,6%	0,5%	0,6%	0,6%	1%	1,3%	1,4%	1,2%
Angio-embolization	0%	0,2%	0,1%	0,1%	0,1%	0,2%	0,4%	0,4%	0,6%
RBCs Transfusions	1,1%	2,2%	2,6%	2,3%	2,6%	3,3%	5,2%	7,9%	8,8%
Plasma Transfusions	0%	0,3%	0%	0,2%	0,3%	0%	0,1%	0,1%	0,2%
Discharged Home	80,1%	82,6%	80,4%	76,4%	79,3%	78,1%	79,7%	78,9%	79,6%
Total number of patients hospitalized in ICU for trauma	149	189	215	247	229	256	257	257	233
ICU Mortality	16,1%	16,4%	7,9%	11,3%	12,2%	10,9%	8,9%	11,7%	11,2%
Hospital Mortality	19,5%	18%	9,8%	13%	14%	11,7%	10,1%	13,2%	12,4%
Average ICU stay	9	7,1	8,3	7,5	6,4	7,8	7,3	7,3	8,2
Average hospital stay	19,2	19	23,5	18,7	18,8	22,6	22,1	20	21,4
Surgical procedures	75,2%	79,9%	82,3%	73,7%	76,9%	77,8%	77,4%	71,6%	75,5%
Multislice CT	40,9%	28%	28,8%	31,2%	32,3%	34,2%	37%	40,1%	30%
CT Chest and/or Abdomen	11,4%	11,1%	11,6%	12,6%	15,7%	19,2%	18,7%	26,1%	13,7%
Angiography	2%	3,7%	1,9%	4%	4,8%	7,1%	8,2%	8,2%	8,2%
Angio-embolization	0%	1,1%	0,5%	0,8%	1,3%	1,9%	3,1%	2,3%	4,3%
RBCs Transfusions	2%	7,9%	7%	7,7%	7,9%	4,9%	6,6%	8,9%	15%
Plasma Transfusions	0%	3,7%	0%	1,2%	2,2%	0	0,4%	0,4%	0,4%
Total number of patients hospitalized in Urgent Surgery Dept for trauma	58	53	36	30	27	55	109	94	103
Urgent Surgery Mortality	0%	0%	0%	3,3%	0%	0%	0%	0%	0%
Hospital Mortality	3,4%	1,9%	0%	3,3%	0%	0%	0,9%	0%	1%
Average Urgent Surgery stay	5,5	5,5	5,8	5,7	7,6	6,7	5,7	5,4	5,6
Average hospital stay	9,6	8,4	15,5	15,8	14	15,3	12,9	10,6	13,2
Surgical procedures	36,2%	41,5%	33,3%	43,3%	51,9%	47,3%	44%	44,7%	58,3%
Multislice CT	32,8%	37,7%	38,9%	33,3%	44,4%	29,1%	38,5%	38,3%	30,1%
CT Chest and/or Abdomen	27,6%	30,2%	36,1%	23,3%	51,9%	36,4%	51,4%	51,1%	37,9%
Angiography	0%	1,9%	2,8%	0%	0%	5,5%	3,7%	1,1%	3,9%
Angio-embolization	0%	0%	2,8%	0%	0%	1,8%	1,8%	1,1%	2,9%
RBCs Transfusions	6,9%	1,9%	2,8%	0%	11,1%	10,9%	7,3%	6,4%	10,7%
Plasma Transfusions	0%	0%	0%	0%	0%	0%	0%	0%	1%

– diminished incidence and size of splenic, infarcts in comparison with distal embolization, documented by CT scanning;

– the percentage of successful non-perative management increases with a second embolization, in cases of failed first embolization;

– the angio-embolization must be performed with operating room Stand-by.

The after discharge follow up of the patients whose liver and/or spleen injuries were managed nonoperatively, is an issue still open to discussion. The indications to resume a completely normal life are not yet backed by specific supporting data. Studies are on the way to evaluate the usefulness of contrast echography for in-and-out of the hospital monitoring.

Approximately 5% of hemodynamically unstable multiple trauma patients do not respond to resuscitative measures, because of the severity of their injuries. The complex physiopathology of these multiple trauma victims requires rapid and effective treatment of massive bleeding from ruptured organs, as well as control of contamination from ruptured hollow viscera.

The goal is to prevent the spiral of death caused by the complications originating from the prolonged hemorrhagic shock, from the systemic multiorgan dysfunctional syndrome (MODS) ^{14,15}. The principles of surgical treatment are, therefore, based on the understanding of the physiopathologic mechanisms involved; to be effective, the surgical strategy must be able to correct the abnormalities as quickly as possible. The mortality is heavily

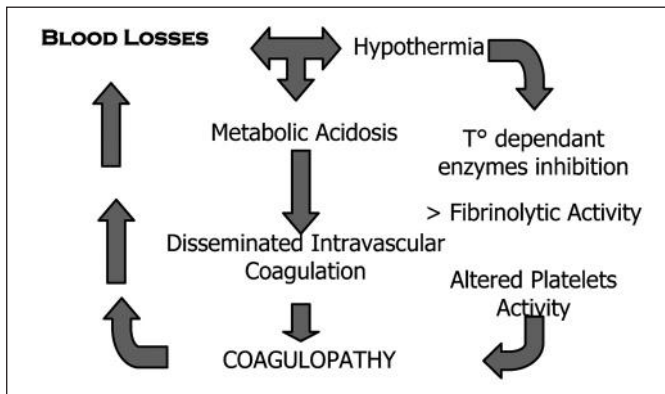


Fig. 17: Lethal triad.

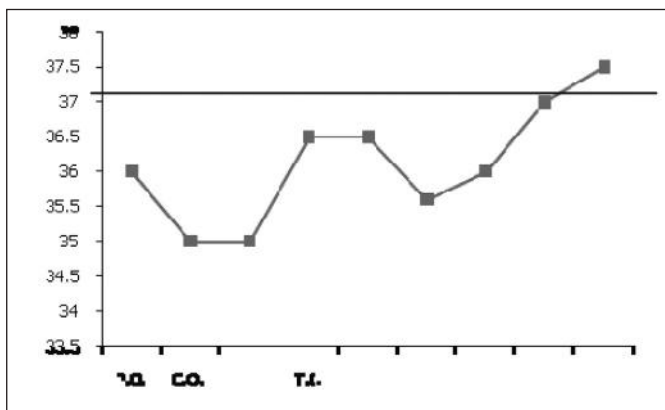


Fig. 18: Temperature.

influenced by the duration of these abnormalities. The polytrauma patient almost invariably presents a clinical picture marked by hypotension and hypothermia. Recent studies have shown that a temperature lower than 32 Centigrades in a multiple trauma patient is associated with a 100% mortality, and that any drop in temperature below 35 C is an unfavorable prognostic sign. It has been demonstrated that the thermic balance of a polytrauma patient in the operating room is critically controlled by the heat losses from the, exposed peritoneal surface (Fig. 18); a rapid closure of the abdomen results in a significant improvement of the hypothermia and, consequently, of the **coagulopathy**. It has also been demonstrated that **hypothermia** in association with the dilution of the clotting factors are the most common and preventable causes of coagulopathy (Fig. 19).

The dilution of the clotting factors is due to the massive amounts of fluids and/or transfusions that these hemodynamically unstable patients receive during the resuscitative phase. **The metabolic acidosis** (Fig. 20) that sets in under these circumstances due to the increased production of lactic acid under anaerobic metabolism, completes the vicious cycle of a worsening clinical picture with unfavorable outcome. Many authors have demonstrated that the degree of metabolic acidosis is an indicator of the total volume that needs to be infused

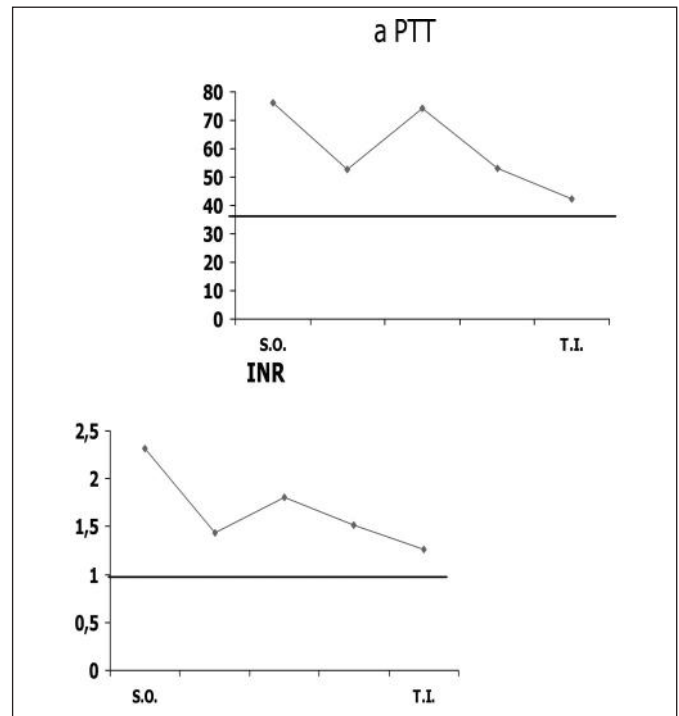


Fig. 19: Coagulation parameters.

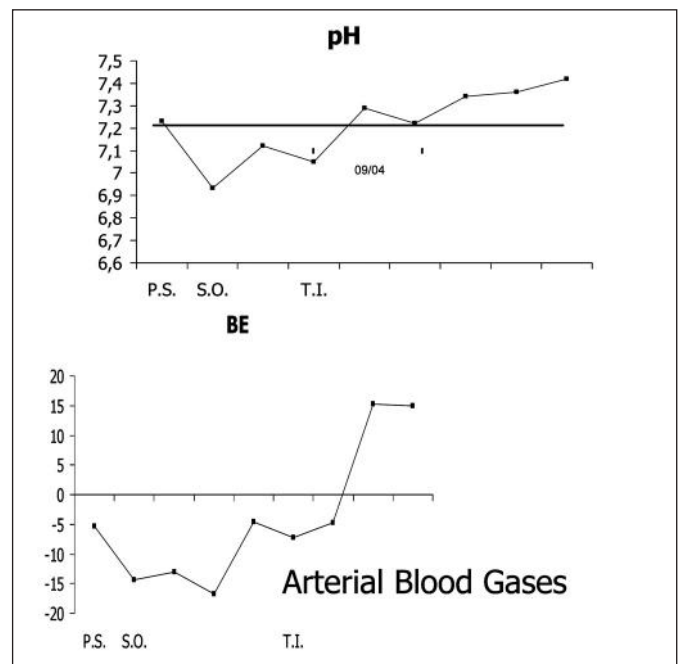


Fig. 20: Arterial blood gases.

during resuscitative maneuvers, as well as an indicator of the severity of the lesions and of the prognosis. Other authors have also demonstrated that persistent metabolic acidosis and base defect are unfavorable prognostic factors in multitrauma patients. Therefore, a laparotomy for Damage Control should afford the most effective control of bleeding and contamination within a time

	Penetrating Trauma	Closed Trauma
➤ Number	26	30
➤ Age	29,1	37,2
➤ ISS	30,1	38,4
➤ T°	34,5°	34,2°
➤ pH	7,23	7,17
➤ Blood Transfusions	18,7 U.I	22,7 U.I
➤ Survival	92%	57%

Scalea et Al. 2006

Fig. 21: Damage control mortality.

limit of 90 minutes. European guidelines state ¹⁶: «We recommended that the damage control surgery be employed in the severely injured patient presenting with deep haemorrhagic shock, signs of ongoing bleeding and coagulopathy...».

«Despite the lack of controlled randomised studies comparing damage control to traditional surgical management, a retrospective review by Stone et al. presents data in favour of damage control for the severely injured patient exhibiting signs of coagulopathy during surgery...».

The Damage Control mortality ¹⁷⁻²⁰ varies for closed and for penetrating trauma; the figures for penetrating trauma are better, as shown in Fig. 22, 23.

The Damage Control strategy, on one hand does improve the survival rate of critically ill patients, but on the other pays a significant morbidity price. In a recent publication ²¹ the study of 344 patients treated with Damage Control laparotomies demonstrated that the complications are fundamentally related to two variables:

- method utilized for the abdominal closure;
- timing of the closure.

Based on what relates to the closure of the abdomen during Phase III of Damage control, the patients can be categorized in three groups:

Group 1: Patients in which it is possible to obtain a fascial closure with or without relaxing incisions and mobilization of the various layers. They represent 65% of the total three groups. The fascial closure is performed within an average of 4 days, at the second or third operation.

Group 2: Patients in which the abdomen is closed utilizing only the skin layer, leaving the fascial plane open, or utilizing absorbable prosthetic materials. They represent 29% of the total three groups.

Group 3: Patients who undergo delayed closure (average 14 days) of the fascia utilizing non absorbable prosthetic materials. They represent 6% of the total three groups.

The patients that survived the abdominal closure (25% of the ones that underwent the procedure) experienced complications distributed as following: 9% in group 1, 53% in group 2, and 60% in group 3.

- **27%** Overall mortality during the first hospitalization in a group of 56 patients with 46% of penetrating trauma

Scalea et Al. 2006

- **10%** Overall mortality during the first hospitalization in a group of 21 patients with 100% of penetrating trauma

Johanson et Al. 2001

- **42%** Overall mortality during the first hospitalization in a group of 24 patients with 100% of penetrating trauma

Rotondo et Al. 1993

Fig. 22: Mortality.

The complications were:

1. Wound infection
2. Abscess
3. Entero-cutaneous fistulae.

The fistulae occurred with significantly lower incidence (3%) in group 1 where the fascia was directly closed, as compared to group 2 (30%). The average time of appearance of this complication has been of 21 days in both groups. In 3 cases the complication appeared after one year.

The incidence of complications significantly increases in patients that undergo laparotomy closure after more than 8 days from the first operation ²²⁻²⁸.

Only 12% of the subgroup of patients who underwent closure within 8 days experienced a complication, versus 52% of the ones closed after 8 days. The patients with primary closure of the fascia (group 1) were the only ones who showed a statistically significant reduction of complications, while no significant differences were noted in the patients of the other two groups. The outcome of the 17 patients that experienced complications shows that 6 died, and that 5 of the 6 died for causes related to their intra-abdominal pathology, as the result of the excessive tension, and subsequent necrosis of the tissues, resulting in abscess and fistulae formation. The infectious complications were more frequent in patients closed with both, absorbable and nonabsorbable prosthetic materials.

The 25% total incidence of complications observed when the abdominal packing was removed within 4 days, rose to 40% when the removal took place at a later date. Multiple closed thoraco-abdominal-pelvic trauma with severe pelvic fractures associated with hemodynamic instability are particularly challenging, because they need to undergo angioembolization while in critical conditions ²⁹⁻³³. Only a small percentage of these patients must undergo pelvic packing with fixation in the operating room prior to embolization.

Conclusions

The correct evaluation of the hemodynamic response according to codified criteria, after the primary survey, is the fundamental step necessary to determine the most appropriate diagnostic and therapeutic route for the polytrauma victim. There are three categories of hemodynamic response: patients hemodynamically stable, stabilized and unstabilized. Each of these categories must follow a completely different diagnostic and therapeutic route. Hemodynamically unstable closed trauma patients require a minimal diagnostic work up, for the sole purpose of providing information on the possible cause of the instability; treatment of the main source of hemorrhage must take place as quickly as possible considering that mortality has a 1% increase for every three minutes, after the first 30 minutes in the shock room. The Damage Control strategy is applied in 5% of the cases to guarantee the immediate survival of the critically ill patients who will subsequently undergo definitive repair of the lesion after hemodynamic stabilization. Multislice CT should not be added for diagnosis, as it is unnecessary and time consuming when the patient is hemodynamically unstable. Hemodynamically stable patients presenting with organ injuries should be managed non-operatively, regardless of the morphology of the lesion, taking advantage of arterial embolization. Hemodynamically stabilized patients (hemodynamic response type B) are a diagnostic and therapeutic decision challenge. The diagnostic-therapeutic protocols operational at the Trauma Center of Cesena have favorably effected the Intensive Care Unit and Hospital mortality, as well as the average length of stay in intensive care.

Our results are also related to the increase utilization of angiography (and multislice CT) not only for diagnostic, but also for therapeutic purposes in the non-operative management, or after the Damage Control Strategy. The positive impact on the results and diagnostic-therapeutic resources utilization indicators is confirmed by the comparison with the RRTG data. In consideration of all of the above, we feel that the proposed protocols are an adequate tool for those people involved with the care of multitrauma victims, where there is need to decide, as quickly and as effectively as possible, what to do, how to do, when to do, and where to do.

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