

# DAMAGE CONTROL FOR SKELETAL INJURIES IN POLYTRAUMA PATIENTS – EDUCATIONAL CHALLENGE FOR ORTHOPAEDIC SURGEONS

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**Abstract:** Polytrauma patients need special therapeutic algorithms as their pathophysiology has particular features; two main elements must be taken into consideration- the complex systemic reaction with a dominant inflammatory component, and the necessity to prevent the “Second Hit” phenomenon, thus generating supplementary rules to be followed adjacent to those addressed to each separate injury. When considering the skeletal trauma, certain landmarks must guide the treatment, such as: proper evaluation of the systemic impact of the skeletal injury, multidisciplinary approach of the patient and flexible monitoring and treatment of all injuries generating haemodynamical instability. Due to high mortality and morbidity in polytrauma patients, optimal treatment is crucial first of all for their survival, therefore the particular principles of treating skeletal injuries in polytrauma must represent a distinct component of training in orthopaedic surgery. Using the tools provided by the ERASMUS + research programme 2015-1-RO01-KA202-015230 « Collaborative learning for enhancing practical skills for patient-focused interventions in gait rehabilitation after orthopaedic surgery” (COR- skills), the authors underline which are the main aspects to be approached by modern orthopaedic training so as to improve the treatment of skeletal injuries in polytrauma patients.

## INTRODUCTION

Although a consensus upon the definition of polytrauma has not yet been reached, most of the authors agree that:

- Injuries of several organs, from which at least one is vital and;
- Injury Severity Score (ISS) >16 is the most relevant element for defining a polytrauma.

Regardless the definition used, it has been demonstrated that the unique feature of these patients is the systemic impact of the initial injury; it is well known today that each injury has a systemic impact and generates a Systemic Post-Aggressive Reaction (SPAR); the impact and the intensity of the initial SPAR depends on the traumatic energy and on the reaction capacity of the patient and afterwards on the type of treatment. In polytrauma, the SPAR is in fact a complex and severe multi-path response, with two major and opponent components: Systemic inflammatory Response Syndrome (SIRS) – mediated by cells and substances, especially cytokines, SIRS is responsible for the most severe complications in polytrauma, since it may evolve to sepsis or to Multiple System and Organ Failure (MSOF), potentially lethal.

Compensatory Anti-inflammatory Response Syndrome (CARS) opposes to SIRS, but it should not overwhelm it, since CARS can depress immune reaction generated by inflammation, therefore decreasing the host defence.

The two above described processes are complex, involve several pathways, but the main feature is that they can finally affect organs and systems which were not initially damaged by trauma; this aspect is similar with that of a

“cascade”, with subsequent and auto-enhancing reactions, requiring an adequate multilateral therapeutic approach; the balance between SIRS, CARS and the host is unstable and it can rapidly change, thus careful monitoring and flexible adapted treatment are mandatory for the patient’s survival, since it can be destabilized by any interference with the response mechanisms, phenomenon which is currently described under the name of “Second Hit”.

Since any therapeutic manoeuvre (and especially surgery) can become a “Second Hit”, it is mandatory to adapt the treatment to the status of the patient so as to get the maximum of benefit with a minimal risk, this representing the core of the “Damage Control” concept, which must apply to all the injuries in polytrauma. From the point of view of the skeletal injuries, this requires a proper decision and execution process, so as the orthopaedic surgeon to harmonize with the rest of the team, addressing to the limb injury not as to an isolated one, but considering how to avoid the “second hit”. These goals can only be reached if orthopaedic surgeons are trained so as to integrate the principles of skeletal trauma with the pathophysiology of polytrauma, meaning that a special chapter dedicated to these situations must be included into the educational framework of orthopaedic surgeons. The authors analyse in this paper which could be the potential design of the curricular chapter dedicated to skeletal injuries in polytrauma, based on the outputs of the ERASMUS + research programme 2015-1-RO01-KA202-015230 “Collaborative learning for enhancing practical skills for patient-focused interventions in gait rehabilitation after orthopaedic surgery” (COR- skills); addressed to orthopaedic surgeons and rehabilitation physicians, this project uses e-learning as an interactive tool to deliver information and

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perform testing reflecting an interdisciplinary approach of orthopaedic and trauma pathology. Within this project, the experience of a Level 1 Trauma Centre was used to reveal which are the situations that most frequently require special skills including orthopaedic treatment in polytrauma and how these situations were approached.

## MATERIALS AND METHODS

A prospective study including polytrauma patients treated in a level 1 Trauma Centre (Clinical Emergency Hospital Bucharest) between 01.01.2016-01.01.2017 was performed in order to identify the skeletal injuries which required damage control and their treatment; the analysis was performed using the following criteria: demography, type of injury, type of treatment, outcome.

Due to the outstanding variety of the skeletal injuries which can occur in polytrauma, the treatment is guided according to the systemic impact of the injury; from this point of view, the ATLS criteria are usually used and the injuries are classified into:

- Life threatening, which are included into the primary survey step, immediately after the vital manoeuvres; these were represented by fractures with massive haemorrhage, such as pelvic injuries generating hemodynamically incoercible instability and mangled extremity;
- Injuries to be approached into the secondary phase of stabilisation, included into the „urgent surgery procedures “these also include the limb threatening injuries;
- Injuries that can be approached in the later phases of treatment.

Since Damage Control addresses to unstable patients, the first two categories from the above described were analysed; therefore, the inclusion criteria referred to:

- Haemodynamically unstable pelvic injuries;
- Positionally unstable pelvic injuries;
- Compartment syndrome;
- Higher degree open fractures (type III);
- Fractures involving serious soft tissue injury – mangled extremity, crushing mechanism;
- Femoral fractures, as injuries which significantly impact the haemodynamical stability of the patient, therefore needing urgent treatment.

For these categories, the treatment was analysed in order to establish the necessary step which should be included into orthopaedic training, as they definitely influence the patient outcome, according to the goal of our research project

## RESULTS AND DISCUSSIONS

From the 285 patients diagnosed as polytrauma during this interval, only 265 had complete medical records and were included in this study.

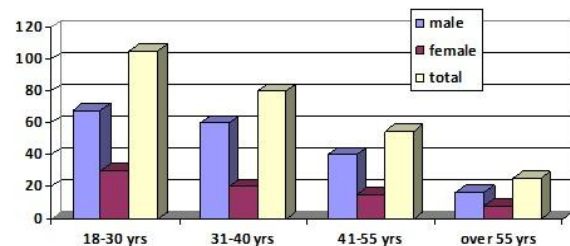
The study group included 185 males and 80 females, and the demographic analysis showed (figure no. 1) that most of the patients were young, active, thus demonstrating the importance of a valid therapeutic algorithm able to ensure the patients' survival and rehabilitation.

Considering the type of injuries, it must be underlined that, from the 265 polytrauma, 220 had at least one of the injuries mentioned above; more than that, in many cases, the injuries were associated, thus increasing the systemic impact of these injuries.

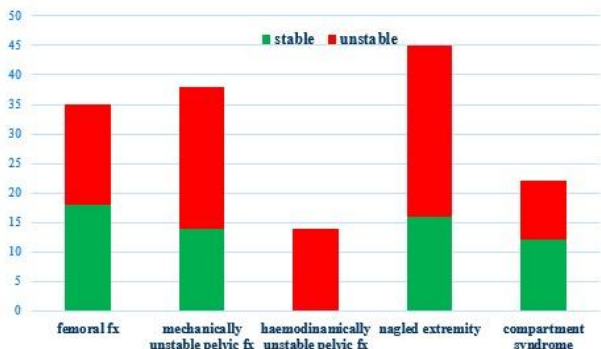
As for the treatment, it had three major components, which were not consecutive, but coexisting; one of the main characteristics of treatment in polytrauma patients being flexibility, in all these cases the patients were repeatedly re-

evaluated during their treatment, so as to adapt the algorithm to the local and general status, which could change in any time, due to the complex pathogeny of polytrauma. In all these patients, the first step was that of the general assessment, which must be performed by a multidisciplinary team, aiming to determine the status of the patient, who will be characterised as stable, unstable, borderline and in extremis. In our study group, the injuries and the hemodynamic stability of the patients are represented in figure no. 2.

**Figure no. 1. Demographic structure of the study group**



**Figure no. 2. The injuries and the hemodynamic stability of the patients in the study group**



For the femoral fractures (35), the treatment consisted in:

- Multiplane ExFix (External Fixation) for the unstable and borderline patients (17 patients);
- Early Total Care (ETC) for the stable patients (18 patients).

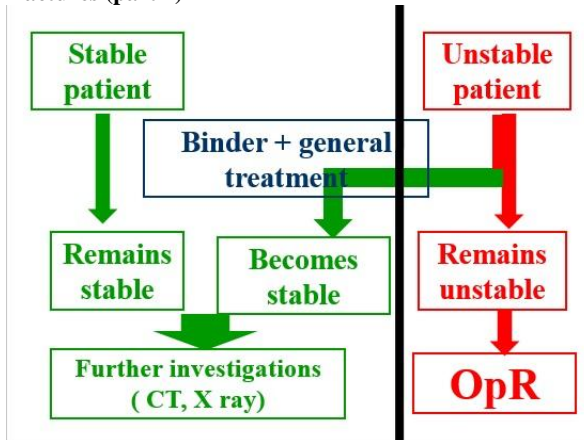
For the pelvic fractures, two different elements were used in order to decide the type of treatment:

- The haemodynamic stability of the patients;
- The mechanical stability of the fracture, thus generating four types of patients, who were defined as:
  - Haemodynamically stable, with a stable pelvic fracture- in this situation, there was no surgical indication;
  - Haemodynamically stable, with an unstable pelvic fracture (14 patients) - in this situation, the treatment was surgical, by ETC 12 patients) and ExFix in 2 patients, due to skin injuries or Morell –Lavallee injuries;
  - Haemodynamically unstable, with a stable pelvic fracture (2 patients)- in this situation, the source of instability was not the bone fragments, but the venous plexus, needing packing (1 case) and the superior gluteal artery (in 1 case, which needed an embolization);
  - Haemodynamically unstable, with an unstable pelvic fracture (12 patients), needing external stabilization (by ExFix) followed by internal fixation after the

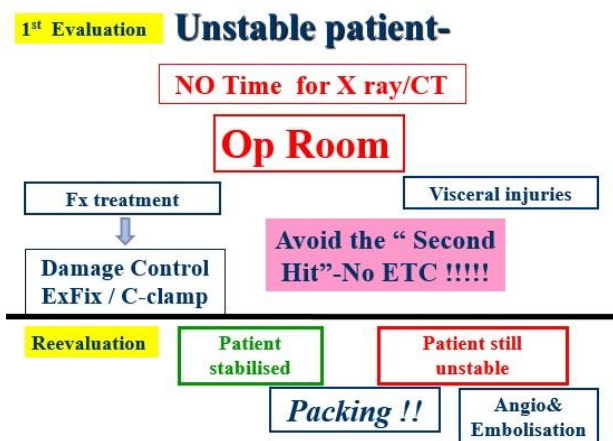
## CLINICAL ASPECTS

remission of SIRS. The algorithm for the pelvic fractures is presented in figures no. 3 and 4.

**Figure no. 3. Treatment for polytrauma patients with pelvic fractures (part 1)**



**Figure no. 4. Treatment for polytrauma patients with pelvic fractures (part 2)**



When CS (Compartment Syndrome) occurred (22 patients), the mandatory aspects were represented by:

- Fracture stabilization by ExFix;
- Fasciotomy;
- Lavage and Debridement.

In polytrauma patients with Acute Peripheral ischaemia (API), the algorithm was:

- Rapid stable fracture fixation;
- Arterial Restoration;
- Soft tissue –debridement, lavage, Haemostasis;
- Fasciotomy for Reperfusion Syndrome prophylaxis.

In complex trauma with Mangled Extremities (45 patients), the treatment included the following steps in all the cases:

- Explore the vitality of the segment and decide the MESS (Mangled Extremity Severity Score) - by fasciotomy and thorough evaluation;
- Decide salvage vs. amputation;
- If salvage is decided, surgery must include:
  - Thorough debridement;
  - Lavage, Haemostasis;
  - Fracture fixation.
- If amputation is decided, the level must be definitely into healthy tissue; thorough debridement, lavage and secondary coverage are mandatory.

In the most difficult cases, these types of injuries were associated, thus considerably increasing the severity and the systemic impact, as well as the lethal potential of the injuries, as in the case that will be presented: a 45 yrs. old male who suffered a traffic accident (driver) was brought to the hospital with haemodynamic instability, painful inferior abdomen, bleeding at the urinary meatus, perineal ecchymosis and clinical signs of:

- Open left femoral fracture;
- Pelvic fracture;
- Crushing of the left inferior limb with open fractures of the femoral shaft, and left tibia fracture (figure no. 5).

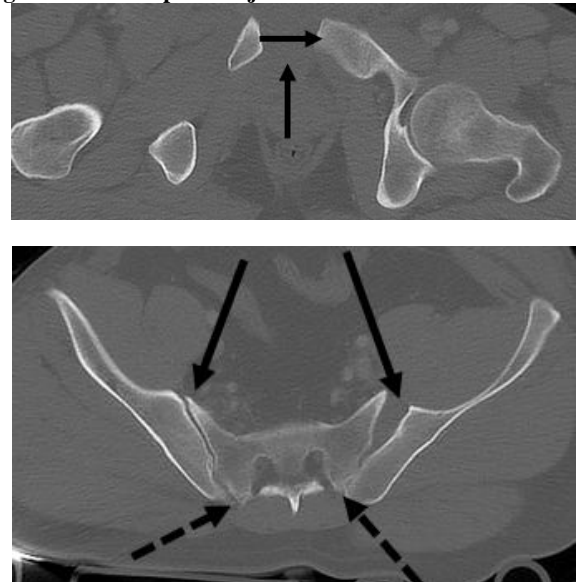
Following the X-rays, the pelvic, femoral and tibia fractures were confirmed; a urinary catheter was introduced with haematuric aspect of the urinary flow, thus suspecting a visceral injury; in this situation, an abdomino-pelvic CT was performed, showing:

- Haematoma of the inferior wall of the urinary bladder, extended in the adjacent structures;
- Fracture of the right sacral ala, complete left sacro-iliac dislocation, pubic dislocation (5 cm), (figure no. 6), with the vesical injury considered as a complication of the pelvic injury.

**Figure no. 5. The aspect of the left lower limb with multiple open injuries**



**Figure no. 6. The pelvic injuries seen on the CT**

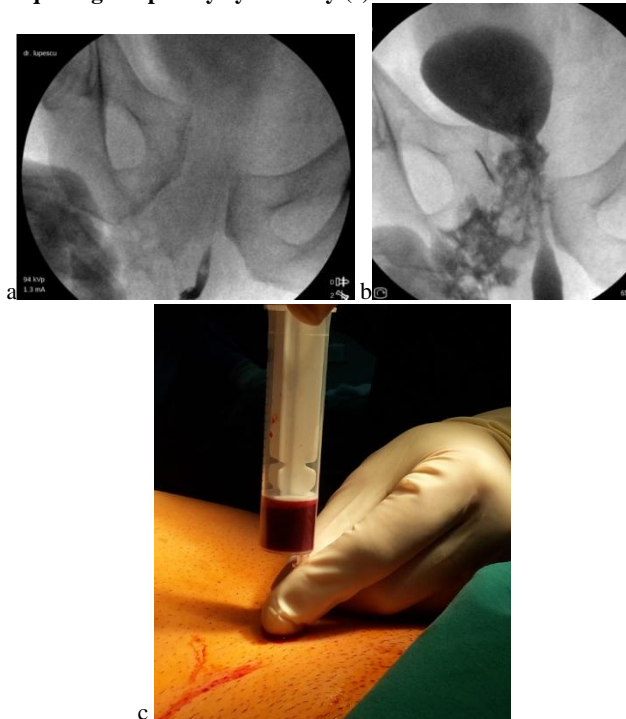


According to the Tile classification, this is a type C2 unstable injury, considering the injury is complete on the left side, and incomplete on the right side. Due to a high energy trauma, the anterior and the posterior arches are affected, generating the rotational and the vertical instability of the hemipelvis. Due to these aspects, the injury is included into the "vertical shear" type according to the Young-Burgess classification.



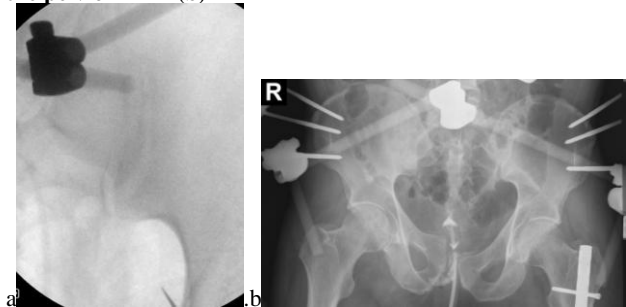
During the evaluation steps, the patient became haemodynamically unstable for several times, requiring specific treatment; considering this, as well as the paraclinic results, the patient was considered to be a “borderline” type, and the Damage Control treatment was the method of choice, in order to prevent the “Second Hit” phenomenon; due to the systemic impact of the femoral and pelvic fractures, their urgent stabilization was indicated, accompanied by surgical treatment for the injuries produce by crushing of the soft tissues of the lower limb. The retrograde cystography (figure no. 7a, b) confirmed the vesical injury, so a temporary cystostomy was performed (figure no. 7c)

**Figure no. 7. Vesical injury (a,b) retrograde cystography-requiring temporary cystostomy (c)**



It must be underlined that the rotationally and vertically unstable pelvic injury was responsible for the vesical injury, therefore fracture stabilization was also considered to be protective for the visceral injury; an ExFix at the level of the iliac crest was inserted after reduction, controlled at the level of the sacro-iliac joint (figure no. 8a).

**Figure no. 8. Reduction of the sacro-iliac dislocation (a) and the pelvic ExFix (b)**



As demonstrated in figure no. 8b, performed 3 months after the initial trauma, the pubic symphysis was not anatomically reduced, because the patient's status did not allow any other invasive manoeuvres. The haemodynamic instability restricted the orthopaedic treatment to Damage Control, but the

patient survived; in this type of patients, survival is the main goal, and the treatment must be adapted to it.

**Figure no. 9. Minimal skin damages (a), contrasting with the crushing soft tissue injuries (b)**



After the pelvic injury was stabilized, the lower limb was evaluated, considering that the initial trauma was produced by a high energy crushing mechanism. Although the wounds were not extensive, their real aspect was suggested by the subcutaneous extension (figure no. 9a), so extrenal fixation was performed after debridement (figure no. 9b). Fracture stanilization (both for femoral and tibial shaft) was performed using and ExFix, with minimal blood loss, so that not to enhance the consequences of initial trauma.

An extended posterior degloving was revealed at the level of the shank (figure no. 10), but it was not incised from the beginning, due to the instability of the patient; the concept of avoiding the “Second Hit” phenomeon was applied, thus diminishing the risk of producing a supplimentary imbalance at a systemic level; therefore, extended incisions were avoided, so were other invasive procedures.

**Figure no. 10. Extended posterior degloving**



The outcome of the patient, as demonstrated in table no. 1, was favourable, with increasing values of haemoglobine and progressive remission of the inflammatory syndrome.

## CLINICAL ASPECTS

**Table no. 1. Paraclinical evaluations**

Data	Hb	Leu	Neu x10 <sup>3</sup>	PLT	INR	APTT	PT	Fibrinogen	CK
02.03.2016	14.2	31.840	24.12	316.000	0.92	25.9	11.1	-	395
02.03.2016 20:00	9.3	13.700	11.9	137.000	1.06	24.9	12.8	126	1.459 CK MB 30
03.03.2016	8.1	10.500	8.6	106.000	1.21	29.1	14.7	160	2772
04.03.2016	6.3	6.300	4.5	68.000	1.22	28.2	14.8	389	6775
04.03.2016 18:30	7.8	6.700	4.6	70.000	1.15	27.4	13.9	468	12.576
05.03.2016	9.6	7.400	4.7	114.000	1.06	27.7	12.8	-	9.838 CK MB 70
06.03.2016	10.2	8.700	6.4	103.000	1.04	28.6	12.6	659	10.831
07.03.2016	8.1	9.900	7.1	385.000	-	-	-	750	227CK MB 3
08.03.2016	9.8	8.500	5.7	148.000	1.06	28	12.8	-	-
09.03.2016	9.7	10.300	6.4	215.000	1.03	29.1	12.5	679	-
10.03.2016	9.5	9.400	5.8	272.000	1.02	29.7	12.4	-	-
11.03.2016	9	12.600	8.6	404.000	1.02	29.3	12.3	-	975

### CONCLUSIONS

The specific feature of polytrauma patients as an intense systemic reaction, with two components- SIRS and CARS; both of them have positive effects under basic conditions, but when they are abnormally stimulated, the resulting process can significantly impair the healing mechanisms; the systemic reaction affects not only the systems and organs which were initially traumatised, but also some other organs and systems, not affected by the traumatic agents, but by the Systemic Post-Aggressive Reaction.

Under these circumstances, not only that the injuries must be completely identified and their treatment established according to survival requirements, but the method of treatment must ensure maximal efficacy with minimal systemic damage; this is the so called "Damage Control" principle which allows the injured body to sustain therapeutic interventions without damaging the fragile systemic balance

Another principle which must be respected for these patients is that of avoiding the "Second Hit" phenomenon, referring to the request that, for polytrauma patients, any intervention must be protective enough so as not to act as "Second Hit". This paper illustrates these ideas for the most frequent severe type of injuries of the pelvic and lower limb described in polytrauma patients and with the most difficult treatment. Complete thorough and repeated multidisciplinary evaluation of the patients is mandatory, as their status can rapidly change, and must result in a flexible treatment adapted to the priorities, starting with survival of the patient

Due to the importance of a proper treatment in polytrauma patients, these aspects must be applied by all specialists involved, who must be properly trained from the point of view of the theoretical knowledge and that of practical skills, as well.

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