ABDOMINAL TRAUMA AND BRAIN INJURY– DIFFICULT CONDITION, FREQUENT ASSOCIATION, SPECIFIC CONSEQUENCES FOR EMERGENCY MEDICAL PREHOSPITAL TEAM

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Abstract

Background: Brain injury provides a significant percentage of, preventable deaths " in trauma, makes threaten in the highest degree the survival chance leads to definitive impairment of the brain functions, generates traumatic disability and concomitant lesion associations.

Purpose of the paper is to highlight specific diagnosis but also management and evolution medical issues that each of the two lesion types generates and which can lead to misdiagnosis symptoms and signs.

We focused on the specific ways trough abdominal and brain injury interacts each other to produce a traumatic complex evolving and adding secondary traumatic effects

In the same time we aimed to distinguish very particular emergency approach standards to minimize the risks of worsening evolution

The method of study: We analyzed 398 patients assisted by the prehospital teams related to ED County Hospital Craiova (2009 – 2012) with different association of multiple trauma lesions but significant abdominal and brain trauma association

Conclusions:

1. Clinical examination data are difficult to analyze in the presence of altered mental status and paraclinically resources must be widespread or systematic used.
2. Cervical spine lesions or spinal shock hide most significantly clinical abdominal signs.
3. Neurogenic shock can create confusion in the hemorrhagic shock interpretation.
4. Secondary brain injury is maintained or worsening by the presence of shock, but overcorrection of those to.
5. General anesthesia should be early considered in tactics, techniques and means custom, which has undeniable benefits in combating shock and brain protection
6. Temperature control should be considered

Keywords: multiple trauma, abdominal trauma, head trauma, traumatic brain injury, hemorrhagic shock, neurogenic shock, “golden hour”
Introduction

Head and spine trauma is a highly expanded chapter in traumatology, on the one hand due to frequency and association with other types of trauma, the consequences of mortality, morbidity and posttraumatic sequelae, enormous financial and material cost and complexity management to control the many physiopathological disorders generated by it. At the same time, abdominal injuries frequently occur as lesional associations in polytraumas, and abdominal pelvine combination creates difficulties of interpretation, evaluation and management of these patients.

Materials and Methods

We analyzed over 4 years, between 2009 - 2012 398 polytraumatized with head trauma and abdominal trauma assisted in ED Craiova, brought in, from outside the hospital by first aid and medical prehospital emergency teams of different levels of competency or by the relatives. A significant part of the assisted polytrauma presented an association of the abdominal trauma component (including of thoracoabdominal or abdominopelvine border) with brain injury. We have grouped these patients by the lesional mechanisms that generated the context of traumatic lesion, then analyzed the frequency of abdominal trauma and head trauma & cervical spine lesions association.

Occurrence circumstances and mechanisms of trauma resulting from the types of accidents of which they victims resulted from were:

- Road accidents - 303 cases, of which 178 patients were passengers in vehicles, 81 were pedestrians hit by vehicles, 19 were motorcyclists injured and 25 were cyclists.
- Work / home/ sport accidents - 39 patients, (12 pitfalls, 6 car or motor crush, 2 assault, 9 electrocutions.
- Suicide attempts - 14 cases, among which the most common mechanism the precipitating (12 cases), stabbing (2)
- Aggressions - 29 - 9 by blunt body attacks, 11 stab wounds, 4 caused by firearm, animal aggression - 5
- Various other situations - 19 – blast (11 victims), structures collapsing (6 victims), accidental falls or stinging into sharp objects (2 victims)

On the studied group, out of the bilesional associations with trauma score (TS) less than or equal to 4, head injuries are 6 out of 9, in the trilesional association group, the head trauma appears in 28 out of the 30 cases and in all cases with cvadri regional association and trauma score below. This leads to a strong argument for the need of advanced management before the worsening indicators becomes clinical obvious, proactive brain injury approach even since the accident scene and alternative, reliable solutions for the precise abdominal damage confirmation under these conditions.

We calculated the trauma score (TS) of each patient on admission to the ER and we grouped the trauma patients according to scores (Figure 1).

![Figure 1 – Initial trauma scores groups sorted by lesion profile](image-url)
Abdominal trauma and brain injury—difficult condition, frequent association, specific consequences for emergency medical prehospital team

We divided the patients according to the level of competence of the crew that took the patient from the accident side (first aid, medical with GP / medical with nurse, resuscitation team or ground/HEMS ICU prehospital medical team), or as the case of bystanders intervention - with management complexity initially established and possible difficulties, problems or complications occurred. We followed later in the dynamic evolution of trauma scores throughout the golden hour "in each of these classes of patients (graphs 1-4)

Primary and secondary survey to these patients represented every time a challenge, establishing investigative strategy and management priorities, to find the optimum compromise for meeting specific management objectives for each of these lesion combinations and time setting for their final decision, as well as surgical gestures hierarchy within some emergency and trauma team accomplish their competency.

I thought it appropriate to consider all these difficulties in interpretation and management encountered not only the ED assistance but also during the subsequent management strategies of these patients, of the possible causes of confusion or omission of injuries and of the factors can avoid the production of such issues.

Results & Discussions

The following are detailed categories of patients enrolled in different classes of scores oft trauma and posttraumatic lesion associations and the developments of trauma scores for each working group and the original score during the golden hour trauma.

Graph 1 - trauma score dynamic to TS group 4-6

Graph 2 - Evolution of the trauma score in patients group with initial TS 7-10
Studying the collected data in these graphs some outstanding issues are revealed:

- as small was the initial trauma score, as faster dynamic deterioration$^{[2,3]}$ was to the patients group brought by lay rescuers: more than that, the worsened condition still remain out of possibility of compensation by the emergency medical teams after admission to ER (on average, the last 20 minutes of the „golden hour”), so trauma score continued to remain low, or decrease throughout, the „golden hour”

- to the patients assisted by mobile advanced teams in trauma resuscitation, trauma scores increased more abrupt and early to the patients that the medical team took$^{[2-5]}$ over the operation from the beginning than with patients who were extracted from the place of the accident by the bystanders, even if they were assisted after that by a specialized team. We always must keep in mind that after induction of general anesthesia, trauma score decrease due to the neurological component (GLASGOW COMA SCORE reduced according to the type and depth of general anesthesia protocol). Even so, there is a substantial improvement in scores of trauma patients assisted by pre-hospital resuscitation team vs. others patient category$^{[6]}$ (brought by unspecialized ambulance, to which the changes in the trauma score are induced directly from natural real evolution its.

- the category of trauma patients with initial trauma score 11 - 14 is a particularly interesting category to be considered...
carefully because on one hand, the initial score does not always indicate at first glance a major imminent risk, but on the conditions of only bystanders / ordinary ambulances assistance, the rapid deterioration in trauma score level in the first 20 - 30 minutes may place these patients at high risk patient group. This is the category of "avoidable deaths in trauma", or of the patients that, talk and die\textsuperscript{[7]} since quality intervention may actually be saving without being particularly complicated but extremely proactive and more safety measures. In this category fall the mild head injuries, GCS 9-13\textsuperscript{[2-4]}. The patient’s presents late quantitative or qualitative alterations of consciousness lasting for hours after impact associated with autonomic reactional phenomenon, focal neurologic signs, suggesting for increased intracranial tension. Significant mortality and residual disability\textsuperscript{[7-9]}, significant rate of positive CT/MRI\textsuperscript{[10]} and required neurosurgical interventions consistent especially when previously special condition such as the risk for intracranial bleeding, therefore, these patients required army expectative, early management of vital functions - especially of the airway despite controversies\textsuperscript{[11]} and ventilation before clinical impairment, adequate sedation, neurosurgical advisory for transfer / admission / observation.

From this perspective, the long term benefits brought by this approach, based on the physiological peculiarities of this special joint lesion, are much higher in real terms than those reflected by differences in the absolute values of scores compared to previous trauma.

The two categories of factors incriminated into the pathophysiological changes in brain trauma consists in primary brain injury generated by trauma, defined as diffuse or focal primary brain lesions and the secondary brain injury mainly resulting from hypoxia, hypercapnia, hypovolemia. It accepts also be incriminated: hypo / hyperglycemia, hyperthermia, seizures and not least hyperoxia / iatrogenic hypocapnia.

Secondary brain injury determinism is therefore multifactorial, evolutionary, worse by the inadequate / submaximal / late management, conditioning the complexity and sequence of management, generating dynamic consequential effects and, finally, affecting the neurological outcome \textsuperscript{[3-6]}. In this direction, the tumtable in generating secondary brain injury is represented by the cerebral perfusion flow related to the intracranial pressure. Increased intracranial pressure leads to decreased cerebral perfusion pressure, unless the median arterial systemic pressure increases, an effect limited by the development of cerebral edema. This means that any procedures to reduce intracranial pressure tend to increase cerebral perfusion pressure, and factors that lead to low blood pressure (hypovolemia in this case) tend to compromise cerebral flow. In the same time, any condition leading to increased metabolic brain rate tend to compromise the balance between brain metabolic supply vs. dept, extending and aggravating secondary brain injury, often with more important repercussions on the outcome than the primary one.

In case of severe myelic lesions, affecting sympathetic system, neurogenic shock, resulting in installation of maldistribution and manifested by lowering BP, bradycardia and absence of signs of hemodynamic compensation, may be not only an additional element of brain suffering but also a risk of masking other sources of hypovolemic shock like hemorrhagic is\textsuperscript{[12,13]}. In the same way, the evolution of primary and secondary brain injury, of the side effects of head trauma, the effects of removal, modification of pain threshold and alteration of sensitivity, all of them can all hide behind an impressive injury or very
painful one, as a broken column with dramatic consequences (the myth of ,,occult cervical fracture'') as well as an originally myelic section screen may actually show as a spinal shock with a real chance of remission if adequate approach established.

Special issues that may augment the severity and prognosis strike, when myelic lesion really exists, proved to be hiding signs of peritonitis related to altered perception of pain, loss of muscle tone, confusion between neurogenic and hemorrhagic shock - misleading behavior, minimizing neurological symptoms of primary brain injury in head trauma with cerebral transient component or other factors that alter consciousness, meaning secondary brain injury. It is also possible that the presence of several injuries in the same anatomical region may cause overlooking the cervical lesions [12, 13].

It is rarely observed that as the early stages of shock (adrenergic reaction) are masked in the presence of severe brain injury with the development of Cushing's triad, bradycardia and hypertension may divert attention from abdominal trauma. Likewise, the myelic section at the cervical level or installation of a spinal shock in a myelic contusion by affecting the cervical sympathetic, not only mask tachycardia, but trough generating vasodilatation, cancels any compensation possibility of hemorrhage, while perception of pain and signs of peritoneal irritation also abolished, make impossible the patient’s signaling (even consciously) of any alert sign of a possible intra-abdominal injury [14].

This is why FAST examination performed systematically in the resuscitation area, or even in prehospital if available, in any patient with brain trauma is mandatory with particular advantages in certain circumstances over CT [15], although not sufficient, since the retroperitoneum offers little space access for this investigation and the previous presence of poured ascites cancel the benefits, forcing the practice of a CT with iv. Contrast or angiography (with therapeutic benefits in case of treatable lesions discovered).

All these are strong reasons to approach the obvious head and spinal trauma patient with all the resources for a major injury not only limited to these segments, especially with high probability of existence of abdominal visceral injuries (nature visceral pain- softer, more diffuse and difficult to appreciate by a patient with multiple sources of somatic pain) until proven otherwise.

On the other hand, if patients with intraperitoneal lesions have proven relatively easy to layer, in the case of retroperitoneal lesions, the suspicion has been clinically the most valuable component. Both renal lesions and those of the ureter and not least the bladder requiring serial FAST examinations and CT with repeted IV. Contrast confirmed in 3 cases to specify the location and type of lesion, and in four cases a cystoscopy was immediate necessary. Important genital lesions such as massive metrorrhagia due to cervical body dezinsertion of the uterus from the vagina (abdominopelvine trauma by pelvis crushing) and retroplacentary hematoma in 2 situations of abdominal trauma in third trimester pregnant women have raised important problems to highlight the lesion, including radiological investigation in pregnancy and of therapeutic solution. Not last, the contusion of the sigmoid and respectively its penetrated wound through the bone dodge from the iliac wing complex fracture – in a shooting case - the requiring immediate rectoscopy followed by left iliac external anus.

By far the retroperitoneal hematoma was the most challenging diagnostic and therapeutic the poverty of the clinical signs.
even in patients aware and cooperative, the difficulty of examination, the poverty of the investigation means (basically just CT \[15\] iv contrast agent with benefits, and in 4 cases selective arteriography), difficulties in assessing the blood loss, especially therapeutic intervention opportunities and difficulties in tactical decisions making \[8\]. Complex pelvic injuries were the causes of these situations in 83% of cases and isolated abdominal trauma in only 11%, all the rest being generated by lumbar trauma. This obviously raises the issue of intra-abdominal injuries caused by sub sequential impact on adjacent areas, which frequently leads to underestimation of intra-abdominal injuries, especially retroperitoneal.

Multiple sources of different types of shock coexistence were another serious problem. In 46.35% of cases the patients had more than 2 sources of hemorrhagic shock (external bleeding and haemoperitoneum), 18.11% had three or more sources of hemorrhagic shock (haemoperitoneum, external bleeding, retroperitoneal hematoma, complex fractures the cob or basin) and to 31% the mechanisms of the shock were different (both hemorrhagic and neurogenic). All that leads to conclude that the right initial decision have to be to start initial fluid resuscitation for hemorrhagic shock \[16, 17\].

As another matter of fact, it is to be discussed the impact of certain therapeutic decisions absolutely necessary in abdominal trauma in neurological traumatic impairment context and equally the impact of some standard treatment strategies on monitoring, diagnosis and management of abdominal injuries. Thus a number of tactical measures should be harmonized, implemented and prioritize as follows:

- Quick vascular refill vs. antiedematous therapy - the balance point is represented by the identification as early as possible and removing all sources of bleeding.

Deciding early if the blood transfusion is the most profitable method of vascular refilling up \[15-17\] to the admission in the operating room and satisfying the desire to supplementary oxygen transporter and thus improve the hematos, and also the clotting factors if associated with fresh plasma \[18\]. Worsening condition is thus avoided in term of controlling ICP, limiting ischemic secondary anemic brain injury or coagulation factors dilution.

- Antiedematous agents should be used with caution in hemorrhagic or hypotensive patient, so elevated ICP control is more profitable to be achieved by general anesthesia, adapted hyperventilation and temperature control, except, of course, the neurosurgery intervention.

- Anesthesia and sedation procedures in particular, are both means of controlling intracranial pressure optimization of cerebral metabolism, brain and systemic oxygen consumption by increasing the seizure threshold and thus limiting brain injury and overall the pain control, which is the most important factor for the initiation and maintenance of shock. It is essential that the trauma team understand that the pain is in no way an important clinical indicator for diagnosis or management orientation and thus its cropping does not bring any harm to this directory and but has positive consequences invaluable in optimizing the patient’s condition, pain management with all means available, tailored obviously to the patient’s profile becomes an absolute standard of management.

- General anesthesia, facilitating the establishment of controlled ventilation leads to optimize oxygenation beneficial in all hemorrhagic shock. The impact of general anesthesia established in relation
“Abdominal trauma and brain injury—difficult condition, frequent association, specific consequences for emergency medical prehospital team”

to its generic indications or not established in circumstances that would have required it, is clear from the evolution of the scores of trauma patients. Real benefits of general anesthesia, resulting in increased survival of about 8.5% - expressed on three categories of patients:

Severe brain injury category of patients - the main element of the combination, crush induction supported on barbiturate pivot followed by mechanical ventilation - IPPV (17, 19) with ICP control increased survival by 5.2% compared to patients who received only sedation variants without neuromuscular block and associated with assisted ventilation only. The issue of EEPP (end expiratory positive pressure) is equally important to decide, because of the impact both on the ICP and venous return, and trough that on the cardiac output and hemodynamic balancing. In the same direction the association of pulmonary contusion and cardiac contusion must be disclosed because of the relationship with the ventilation and anesthetic protocol (19, 20).

Patients with a ruptured diaphragm or chest wall as specific elements of seriousness to which the achievement of general anesthesia focused on one hand on facilitating the mechanical ventilation with negative intrathoracic time pressure cancellation and mediastinal balance and thus improving venous return and oxygenation

Patients with hemorrhagic shock - general anesthesia are improving oxygenation and decreasing agitation, muscle effort and rebalancing vital regional blood flows and oxygenation, additionally sustained by using suitable anesthetic drugs.

Some preconditions are necessary to these benefits occurrence such as:

- use of appropriate drug combinations pathophysiological according to the profile of the patient
- The most profitable scheme induction in patients with brain injury and hypovolemia proved to be deep sedation (combining etomidate (21) - benzodiazepine – fentanyl), almost in the same sequence as being used to classical rapid sequence induction (22, 23, 24). There is practically no difference in survival that can be attributed to the two types of induction, but the high quality of sedation and of ventilation remains mandatory for the prognosis. Compared with, using only some sequences of sedation either without assisting the airway, ventilation and circulation, or with weak medical standardization generated up to 35% lower survival rate than the same group of TS (9-11) patients for whom it was proceeded to correctly anesthetic induction for the same profile lesion. In lower TS groups the survival chance gap reaches up to 62%

- assisted/ controlled ventilation strategy (25) of the patient, impact volume ventilation regime, the pressure (including PEEP) or BiPAP, are recognized aspects with high impact on both the ventilation optimization and oxygenation but also with effects on ICP, intrathoracic pressure and through it of the venous return, thus of the telediastolic cardiac filling and blood pressure. Hypocapnia, made by hyperventilation, must be easy and just short at the beginning of the management, especially if high peak ICP suspected. It is important that the management of patients with severe trauma covers normoxia, normocapnia, normoglycemia and normo (optimally) or mild hypothermia of the head (if no contraindications, here we are talking
about hemorrhage at any location, but especially the surgical unmanageable, including intracranial one). Pressure-cycled ventilation is usually not beneficial if an intracranial haematoma suspected nor in case of hypotension, especially if it is generated by bleeding so BiPAP – were the most frequent chosen solution in these situations, especially for the 18 cases with pulmonary contusion. Using telemedicine transmission, especially video data transmission could assist lower competency prehospital teams to decision making or the dispatch center to send an higher mean of intervention to support them, always the goal being to maximize the management in minimum time as possible [26].

The implications of temperature control, in fact the issue of hypothermia [27] - accidental or controlled are management resources of primary and secondary brain injury. The use of these means can be beneficial if it is strictly particularized and accompanied by a very careful monitoring of the coagulant status and brain pressure and hemodynamic parameters (cardiac index), in order to effectively control the overloading in conditions of depression of the contraction force in hypothermia.

The use of controlled hypothermia of the head may be accepted in conditions of abdominal trauma coexistence situation only if PIC is high despite other means of control and there are no uncontrolled bleeding sources and the coagulant status is good, since the trauma team should expect a dilution coagulopathy given by both the fast filling and hypothermia.

In the cases observed in this study, mortality was - due to several factors whose control can and should be done in - an integrated management as follows.

Causes of deaths attributed to cerebral trauma
- External exsanguination added to other sources of hypovolemia
- Respiratory depression / cardiac caused by the severity of the brain damage
- Reduced cerebral perfusion due to mass effect, diffuse cerebral oedema

Causes of deaths attributed to spinal trauma
- Higher level of Cspine section (above the C4)
- Upward swelling of the brainstem
- Remote complications in the high level Cspine section
- Undervaluing other vital lesions in patients with myelic sections

Causes of deaths attributed to abdominal trauma
- Acute hypovolemia
- Disseminated intravascular coagulation (massive loss of fibrine) after massive blood losses
- Post-hemorrhagic acute anemia
- Toxicoseptic distance complications arising from abdominal injuries

It is noteworthy that a number of these causes of death can be missed on a superficial evaluation due to the incomplete clinical picture, nonspecific or inconsistent due to the traumatic associations described with high visibility in the immediate perspective on the evolution of the patient (such as the shock not high lightened and treated in its "compensated" early stages, can have a dramatic evolution, sometimes irrecoverable). Others can cause chain pathophysiological alterations that can impede the development at distance of the patient, and thus may alter his chance of survival, such as hypothermia or crush syndrome that can have misleading appearances of gravity which make them invisible to an unsuspecting and untrained eyes [28].
Others generate over the functional outcome an echo which cannot be ignored since it can be devastating and irreversible - lesions of the cervical column, compartment or crush syndrome, acute traumatic ischemia of limb.

On the other hand, most of the complications are due to the inability of the medical team who took the patient to achieve maximal management of injuries and obvious clinical disorders, requiring tactical decisions and complex therapeutic gestures for which the training, experience and competence were binding, so that partial compromise solution were taken that only protected the patient for reduced time intervals and in various degrees.

Whatever the causes that generated the production of these accidents it is important to mention here that each of them had an impact not only on the functional prognosis but also on the vital prognosis, the patient being under a major risk, which often is unjustified and avoidable.

It is not be neglected in this chapter that the immediate mortality in patients with myelitic lesions of the cervical spine was 7% (due to lesion generated only at the myelitic level - under 24 hours). It is also particularly important that there have been two serious accidents in patients brought to the ER with trauma score 6 and 8, to whom the previous attempt to place the nasogastric tube in craniofacial trauma and abdominal conditions (with frequent vomiting) led to Mendelson syndrome and malposition of the tube respectively in the facial sinuses.

**Conclusions**

The combination of significant brain injury and abdominal trauma is over then 40% from observed patients, meaning that very significant part of the multiple trauma patients could have this association, could have risks that this association are involving, and could have beneficial proactive management assessment in sense to decrease survival chance and functional impairment due to consequences that this association leads to.

The “occult” lesions are missed diagnosis lesions caused by a multitude of effects of hidden of symptoms and signs from clinical syndromes, induced by altered mental status and decreasing level of sensibility, which may mask or complicate certain visceral abdominal injuries.

The survival chance is higher to the patients with medium TS level but medium management level protocol compared to inferior TS level but aggressive, anticipative and well conducted management strategy.

The therapeutic strategy, following a series of **golden standards** gives the expected results only if it is early, vigorous and accurate in algorithm, free from the temptation of the middle way. Beyond the false security of the induced gestures thought to be minimally invasive, there are usually lost benefits, lost time and wasted resources, with effects difficult or even impossible to recover in the patient's economy.

The precocity of the proactive management starting in prehospital phase of intervention with high competency medical emergency team, sometimes aggressive can earn benefits that otherwise the late conduct cannot recover, however powerful it may be (early immobilization of the column, early airway control, preventing secondary brain injury).

So early access to accident scene and concentration of highly specialized medical resources with advanced training for trauma and currently involved in a high level trauma center activity as well as pre-hospital care must be massive from the beginning for these types of injuries. More than that, dispatch center involvement are mandatory to choose the most appropriate means of intervention and in the same time the closest one, or to associate multiple means of
intervention from first aid to mobile prehospital ICU team to cover long distances with sequential levels of management.

The better satisfactory solution was to decide most often the emergency medical helicopter intervention directly in scene (sometimes prefaced by the closest first aid team). That solution has ensured the highest level of intervention, identical in complexity of decision, procedures and protocol with the trauma center one and in the same time to maintain all the intervention in „golden hour” real terms. The third advantage of this way of approach are the primary addressing the appropriate patient to the most appropriate trauma center, avoiding successively subsequent transfers between trauma centers to attain the goals of management.

The general final conclusion are that multiple trauma patient with particular significant both brain and abdominal injury define a picture with a background of strong colors that requires classical and well know attitudes, but a lots of shades that involves many much specific and specialized resources that utility, priority, complexity, risks and possibility of implementation should to be every time decided based on serious criteria panel to maximize benefits and minimize the misdiagnosis and avoidable deaths.

**Conflicts of Interest: Nil**

**References**


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