MULTICENTER STUDY OF OPTIMAL MANAGEMENT STRATEGY IN SEVERE MULTIPLE TRAUMA

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The aim of the study. The development of a triage system to implement proper treatment based on severity of injury.
Material and methods. The study is based on material from three Polish Universities’ trauma departments: Cracow, Lublin, and Gdańsk. Using trauma scales, 300 of the most severely injured multiple trauma (MT) patients from 2000-2004 have been chosen for this study. Medical documentation was carefully analysed, particularly the time and extent of the surgical procedures performed as well as their potential to influence later results.
Results. There are three groups of patients:
1 – critically injured, with an ISS>50, LSO>15, RTS 3 pts, two body cavity involvement, multiple long bone and/or pelvis fractures. Only damage control was allowed and the definitive treatment necessary was within 48 hours.
2 – severely injured, with an unstable ISS 35-50, LSO 10-15, RTS 4-10 pts, one body cavity involvement, multiple long bone and/or pelvis fractures. Life-saving operations were possible with orthopaedic management (within 48 hours) provided using the “2+2 rule” (less than 2 hours of operation and no more than 2 units of blood transfused).
3 – moderately injured, with a stable ISS<35, LSO<10, RTS>10 pts, one body cavity involvement, a long bone or pelvis fracture. Classic surgical and orthopaedic management occurred within 48 hours.
Conclusions. The history and course of post-traumatic syndrome from metabolic, immune and endocrine viewpoints requires a special strategy for repairing life-threatening trauma injuries at the right time, in proper sequence, and with limited surgical activity in more severe cases.
Key words: multiple trauma, damage control, inflammatory response, emergency thoracotomy, abbreviated laparotomy

Despite considerable progress in medical sciences and profound changes in the organization of emergency services within the past quarter of a century, severe multiple trauma continues to be a major problem in traumatology with the associated mortality rates exceeding 10% in the best centers worldwide. According to recent reports, the most common causes of posttraumatic deaths in hospitals (>30-50% of all fatal outcomes) are late complications of a severe traumas and post-traumatic shock, including septic complications and multi-organ failure (MOF). Severe primary injuries of the central nervous system and exsanguinations continue to be the main causes of death (50-70%), at the site of the accident, in an ambulance (i.e. in the pre-hospital period), and during the first hours of hospitalization (1).

Thus, we are witnessing continued progress in reaching the injured victims as quickly as
possible and transporting them to an appropriate trauma center and to ensuring from the very beginning of medical care the highest competence in emergency and surgical teams (ever-improving procedures and standards, highly-specialized emergency and trauma centers) (2-7).

For years, diagnostic methods have been improving by aiming to identify and stop bleeding as quickly, as possible. This begins with a diagnostic peritoneal lavage or thoracocentesis. Then ultrasonography (8, 9) or angiography are performed, ending with recently developed CT analysis if necessary (20). New surgical procedures have been introduced and old ones have been improved in order to establish bleeding control within a short time (11, 12, 13). The most recent achievements in this field are the newly-rediscovered “damage control” (14-24) and more effective interventional radiology procedures (25-28).

Although a surgeon or a radiologist is capable of stopping the bleeding from major vessels, in many cases interstitial hemorrhage in particular organs, muscles, and investments continues. In some patients such bleeding contributes to early death, and in others it results in late severe metabolic and infectious complications. The problem is significant as the ever-increasing force of trauma (e.g. the growing velocity of bullets or vehicles) increasingly results in the formation of previously undetectable areas of destruction around the obvious injuries to various organs that today are easily identifiable. In these cases, traumatology may be assisted by modern pharmacology (29, 30, 31).

Based on retrospective analysis of our patients with severe multiple and multi-organ injuries, an attempt has been made both to evaluate and to determine an optimal time for therapeutic interventions and admissible range of necessary operations.

MATERIAL AND METHODS

The study is based on materials from three Polish university trauma departments from 2002 to 2004: Gdańsk, Cracow, and Lublin. Using digital trauma scales, we have chosen 300 severely injured trauma patients. Patients chosen had an ISS (Injury Severity Score) value equal or greater than 20 points. Detailed medical data have been carefully analyzed with special attention to the timing of the implemented surgical procedures and their potential influence on final results. Among polytraumatized patients 3 sub-groups have been distinguished regarding the severity of injuries: I – critically injured (ISS=50-75 pts, two body cavity involvement, multiple fractures), II – severely injured (ISS= 35-49 pts, one body cavity involvement, fractures) and III – moderately injured (ISS= 20-34 pts), one body cavity involvement, fractures).

The analysis included the mechanism of trauma, time of arrival, localization of injuries, diagnostic and therapeutic measures. Incidence of complications and final results of the implemented management have also been evaluated. In all fatalities, clinical diagnosis has been verified on the basis of post-mortem examinations; autopsies were performed at the departments of forensic medicine. Preventability of post-traumatic deaths and PDR – Preventable Death Rate have been evaluated by an audit committee that decided after a panel discussion whether the death was preventable or not.

Statistical analysis was achieved using MS Office tools (average, standard deviation, t-Student’s test, $\chi^2$). Generally accepted medical and anatomical nomenclature was used to define injuries and document accompanied illnesses, complications, and operations.

RESULTS

In the investigated group of 300 trauma victims, males predominated ($n = 223; 74.33\%$). The age of the patients ranged from 14 to 91 years and the mean age was $42.45 \pm 19.76$. Among the victims women ($46.62 \pm 22.79$ years) were significantly older than men ($40.99 \pm 18.89$ years with $p < 0.05$).

Patients injured inside a motor vehicle accounted for almost a half of all the patients (44%), pedestrians struck by cars were 27%, and motorcyclists were 3%. Falls from heights constituted 16%, assault accounted for 6% and other accidents were 4%. Almost 64% of the patients were admitted within 1 hour of the accident and 12% of them within 2 hours. The majority of all the analyzed victims (54.33%) were initially treated in intensive care units due to profound shock, respiratory and cardiac insufficiency, or deep unconsciousness. The severity of these multiple injuries measured
by the ISS ranged from 20 to 75 pts (mean value 39.47 ± 15.36). These patients sustained a total number of 897 injuries (3 traumatized body regions per patient on the average). The anatomical distribution of all the injuries is presented in tab. 1.

The most frequent and severe injuries involved the chest and the head. Half of the victims sustained injuries to the lower extremities and 1/3 had injuries in the abdomen and pelvis. Injuries within the chest, abdomen, and head were characterized by high AIS values.

A total number of 257 multiple-injury patients (85.67%) were submitted to surgical operations; a number of 515 major surgical procedures were performed on the patients (excluding sutures of the wounds), and 329 (63,88%) of these operations were performed during the first 24 hours of admission. A list of the procedures is presented in tab. 2.

77 patients (25.67%) died, half of whom (39) died during the first 24 hours of admission. Most of them died from shock or central nervous system trauma.

We have distinguished 3 subgroups of patients among the studied 300 multiple-injury patients: I. Critically injured, II. Severely injured, and III. Moderately injured (tab. 3).

Critically injured subgroup (I) consists of 80 patients determined by an ISS score ranging from 50 to 75 points with two body cavity

<table>
<thead>
<tr>
<th>Okolica uszkodzenia / Region involved</th>
<th>Number of patients</th>
<th>Percentage</th>
<th>Mean AIS* score (range 1-6 pts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>239</td>
<td>79.67%</td>
<td>4.05 ± 2.21</td>
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<tr>
<td>Chest</td>
<td>166</td>
<td>55.33%</td>
<td>4.48 ± 1.40</td>
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<tr>
<td>Abdomen</td>
<td>106</td>
<td>35.33%</td>
<td>4.45 ± 1.17</td>
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<tr>
<td>Pelvis and pelvic organs</td>
<td>98</td>
<td>32.67%</td>
<td>3.36 ± 1.29</td>
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<tr>
<td>Spine</td>
<td>33</td>
<td>11%</td>
<td>3.21 ± 1.11</td>
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<tr>
<td>Upper extremity</td>
<td>102</td>
<td>34%</td>
<td>2.90 ± 0.85</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>153</td>
<td>51%</td>
<td>3.88 ± 1</td>
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* AIS – abbreviated injury scale

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<tr>
<th>Surgical procedures performed</th>
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<tbody>
<tr>
<td>Neurosurgery</td>
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<tr>
<td>Thoracic surgery</td>
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<tr>
<td>Thoracic suction</td>
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<tr>
<td>Abdominal surgery</td>
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<td>Angiosurgery</td>
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<tr>
<th>Table 3. Characterization of the polytraumatized patients in subgroups distinguished on the basis of the severity of injuries</th>
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<tr>
<td>Critically injured ISS 50-75</td>
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<tr>
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<tr>
<td>Main injuries</td>
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<tr>
<td>No of patients</td>
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<tr>
<td>ISS (mean)</td>
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<tr>
<td>No of deaths (%)</td>
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<td>Sominating cause of death</td>
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* ARDS: adult respiratory distress syndrome, MOC – multi organ failure
Multicenter study of optimal management strategy in severe multiple trauma

Involvement combined with fractures of pelvis and long bones. Within this subgroup, 21 people sustained injuries characterized by the maximal value of the ISS (75 pts). Ultimately, 51 patients died (63.75%) and 29 survived (36.25%). According to the ISS criteria, injuries in 18 of the fatalities were regarded as critical and definitely unsurvivable, mainly due to cerebral injuries (in 14 persons). From among 62 trauma victims profound shock resulting from massive hemorrhage was found as the leading cause of death in 17 patients. MOF and sepsis was the cause in 10 people and cerebral complications for the remaining 6. Severity of injuries as measured by the ISS were similar in nonsurvivors and survivors (58.36 ± 8.23 vs 55.69 ± 6.31 ISS pts), while age was significantly higher for nonsurvivors (49.36 ± 17.18 vs 35.83 ± 18.48 years; p <0.05).

 Severely injured subgroup (II) consists of 56 patients was determined by ISS scores ranging from 35 to 49 points, one body cavity involvement, and fractures of pelvis and long bones. They were younger then the previous group (38.68 ± 18.21 years). In this group, 14 patients (25%) died as a result of trauma. In two cases, the cause of death was complications of head trauma and in another two cases shock as a result of abdominal trauma. Nine consecutive patients died from late complications of trauma (ARDS, MOF, gastrointestinal bleeding) and another one, a 74-year-old male died from circulatory insufficiency. One patient underwent abbreviated laparotomy with was unfortunately ineffective. In the four next cases, 5 extensive orthopedic procedures were performed and one patient was treated conservatively for his femur fracture. Among survivors, 11 were treated by extensive orthopedic surgery (with 17 total fractures repaired among them) and 5 patients sustained various complications (with 13 total fractures repaired using 16 abbreviated procedures according to “2+2 rule”). In this last group complications were observed only in one patient. Additionally, three of these patients had successful external stabilizations of fractured pelvises.

The moderately-injured subgroup (III) consisted of 164 persons. A mean value of the ISS in this subgroup was equal to 28.04 ± 4.09 and an average age was equal to 43.75 ± 20.91 years. Among these patients 12 people (7.32%) died. The main causes were late circulatory failure (4), pulmonary thrombo-embolism (2 – since typical anticoagulative therapy), and late complications of traumatic brain injury (2). Two old patients died as a result of retroperitoneal hemorrhage, another one from ruptured spleen and septic complications (a common outcome for a ruptured spleen) and one from infection in open fractures. The age of these patients ranged from 41 to 89 years and the average was almost 69 years.

According to the committee’s judgement, 13 preventable deaths have been identified among 77 fatalities (16.88%). The following shortcomings in the management have been pointed out: missed injuries (n=3), improper sequence of surgical procedures (n=3), delay or absence of orthopedic operations (n=3), faulty intraoperative decision (n=2), delayed pre-hospital time which resulted in delayed operation (1) and 1 due to invasive and premature orthopedic procedures.

In the group of deceased patients, one person only was operated on by “abbreviated laparotomy” procedure. Alternatively, in the group of survivors three “abbreviated laparotomies” were performed and three patients were initially treated by orthopedic damage control for long bones fractures. Inadequate intraoperative diagnosis and decisions occurred during dramatic emergency procedures. In general patients were operated on earlier in this group. For example, 10 of 14 chest drains in the first hour after admission were given to surviving patients, whereas in the deceased the insertion of tubes was delayed and only 9 of 16 received them within 24 hours. Also, 12 of 17 laparotomies in the first hour after admission were performed in survivors while only 13 of 23 were performed quickly in nonsurvivors. Furthermore, 11 of 15 patients passed necessary orthopedic procedures during first 72 hours versus 4 of 7 in deceased group. Both external stabilizations of fractured pelvises in survivors were done 2 hours after admission as opposed to 3 of 5 done being delayed several days in the deceased group.

**DISCUSSION**

The presented material includes the most severely injured patients with multiple and multi-organ trauma. It is evident that in this group the main, preventable cause of death is hemorrhage and late complications of shock.
constituted the principal cause of death (32). Thus, the control of bleeding by any means necessary, appears to be the basic and most important element of the management in these patients (33, 34). Trauma surgeon should be aware that hemorrhage is not always a result of extensive organ or large vessel injuries (35). The simple imaging diagnostic measures like ultrasound (or CT, if possible), should be implemented so that earlier hemorrhage detection is possible or adequate emergency procedures of a different type (i.e. diagnostic peritoneal lavage or thoracocentesis) (36-41) and more widespread implementation of other methods such as intravascular embolization or stenting may be useful to stop bleeding (42-46).

The focus of managing polytraumatized patients should be limiting the consequences of severe trauma such as hypothermia, acidosis, hypoxia, acute renal insufficiency, ARDS, SIRS (systemic inflammatory response syndrome), MOF, prolonged occult hypoperfusion, reperfusion, compartment syndromes, and other causes which may contribute to the “second hit” (47-57). Timing of surgical interventions is of paramount value in this respect. Moreover, our results seem to support the approach that trauma surgery introducing “damage control” procedures and staged management may be helpful in improvement of the final results of treatment in these patients (58-67). Particularly, this refers to orthopedic damage control (68, 69, 70).

Late complications of trauma (ARDS, MOF, gastrointestinal bleeding) have been identified as important causes of death in severely injured subgroup. So definitive surgery of major internal injuries should be combined with a limited range of orthopedics procedures. In this respect, the “2+2 rule” (not longer than 2 hours of operation and not more than 2 units of blood) seems the optimal strategy to save lives and to diminish the rate and degree of disability in these patients.

Analysis of results in the third group seems suggest the traumatized patients’ age and concomitant illnesses have a similar impact on the final result of treatment as the severity of injuries (71). At last 13 preventable deaths have been identified among 77 fatalities (16.88%). This result is comparable to that of other authors (72, 73, 74). So, we recommend a strategy which aims to first repair life-threatening injuries at the right time, in proper sequence with limited surgical activity in severely injured patients, and to implement definitive surgical treatment in later stages (75-78).

CONCLUSIONS

1. Massive hemorrhage is still of paramount importance in patients following multiple trauma.
2. Strategy of resuscitation and surgical management should be adjusted to the severity and extensivity of injuries and to the age and preexisting diseases of the patient.
3. Priorities and range of surgical interventions should be adjusted to different subgroups of polytraumatized victims.

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