



Editorial

Determining the patient at risk – are scoring systems helpful to develop individualized concepts for safe definitive fracture fixation and damage control techniques?



The complication rates in patients with multiple injuries have decreased over the last 2 decades, especially in most western societies [1,2]. The causes may lie in the improvement of safety issues, both for motor vehicle passengers [3–5] and for pedestrians involved in motor-vehicle-accidents (MVs) [6]. Apart from these road safety issues [2,7], transportation modes appear to have improved and might be helpful especially for at risk patients, such as the growing population of elderly patients [8]. Further numerous changes have been made in the clinical management as follows:

Identification of high risk patients

A more precise identification of the patient at risk of complications in the early stages after trauma [9–12] and the awareness of life threatening complications [13–16] has improved. The availability of numerous clinical parameters and biomarkers for the prediction of clinical complications has also been a major step ahead [17,18]. A combination of factors is required for any surgical clearance procedure [19–22]. In general, prediction of outcomes after injury has traditionally incorporated measures of injury severity, recently associated with physiologic and shock measures, in order to improve accuracy of anatomic-based models. Likewise, a single-institution study described a mortality predictive equation [$f(x) = 3.48 - .22(\text{GCS}) - .08(\text{BE}) + .08(\text{Tx}) + .05(\text{ISS}) + .04(\text{Age})$], where GCS is Glasgow Coma Score, BE is base excess, Tx is transfusion requirement, and ISS is Injury Severity Score, which had 63% sensitivity, 94% specificity, (receiver operating characteristic [ROC] 0.96) [23]. With new options of determining patients, we are better able to assess patients even early after injury. Interleukins have been used for a long time in selected level I trauma centers and their value – along with other parameters, appear to be still increasing today [24,25]. Moreover, a recent meta-analysis has reconfirmed the value of proinflammatory cytokines for predicting the risk of general complications [26].

Reinforcing diagnostic procedures in chest trauma

Chest trauma belongs to the most important factors in determining the complication rate in these patients and the recent literature has reconfirmed this issue [27–29]. A recent review demonstrated that especially the management of chest

trauma patients requires expertise in this field and a team approach is required. Multiple investigations have demonstrated incentive spirometry to be an important screening tool to identify high-risk rib fracture patients who could benefit from aggressive, multidisciplinary pulmonary complication prevention strategies. Thus, as screening tool to determine whether surgical fixation is required in rib fractures, or patients with flail chest appears to be a reasonable approach [30].

Is a single parameter sufficient to determine high risk patients?

Balogh et al. rightfully stressed the fact use of a single parameter alone has failed to prove effective in predicting the course of a multiply injured patient [31]. It is evident that a single parameter may be influenced by other interactions and its sensitivity may not be sufficient, or influenced by other factors, such as volume treatment, infusion of medications that affect coagulation and others. He indicates that “*Measuring interleukins from batched samples of polytrauma patients' sera and retrospectively correlating with the already recovered or dead individuals' outcomes has not lead to any targeted or patient specific therapy*”. This applies as well for any scoring systems used in the past, if relying on a single parameter.

The use of lactate appears to be a perfect example: Acid base changes are a direct response to injury and the clearance of lactate can occur within hours. The development of the calculation of lactate clearance has been tremendous. In 1961, improved lactate values were calculated: $([\text{IL} - \text{DL}] / \text{IL}) \times 100$ (expressed as %) [32]. In 2012, Régnier et al. added a time correction and developed the description of a percentage of initial lactate cleared per hour [33]. Billeter et al. separated four categories based on lactate level evolution: $\text{IL and DL} \leq 2.5$; $\text{IL} > 2.5$ and $\text{DL} \leq 2.5$; $\text{IL} \leq 2.5$ and $\text{DL} > 2.5$; $\text{IL} + \text{DL} > 2.5$ mmol/L [34]. Our group has recently demonstrated that admission lactate levels and/or lactate clearance is able to determine early death from hemorrhage, but fails to predict later complications, such as Sepsis, MOF or late death. In our series of 3668 polytrauma patients, the ones with early elevated lactate levels died from uncontrolled hemorrhage and some of them could never be cleared for any orthopedic operation [35]. Finally, it was previously pointed out that “*it is well known that some diseases (such as chronic renal failure) lead to sustained changes in the acid–base system, namely lactate levels*” [36].

Table 1

Comparison of scoring systems and scales that deal with recommendation for the stratification of multiple injured patients and timing of fracture fixation.

Author (year)	Name	Deviation Mode	Validation	Evidence Level	Categories			
					Coagulation	Acid-Base	Temperature	Soft Tissue
Pape (2005)	CGS	Review	No	IV	X	X	X	X
Dienstknecht (2013)	CS	Multi Center (n=165)	No	II				X
Vallier (2014)	EAC	Single Center (n=1443)	No	II		X		
Nahm (2014)	mCGS	Modified from Pape 2005	No	IV	X	X	X	X
Hildebrand (2015)	PTGS	Multi Center (11436)	No	II	X	X		X

Scoring systems and scales

Attempts to classify multiple injured patients can be found in several scoring systems that try to stratify patients according their clinical status. In 2005, a group of European Surgeons from three major level I trauma centres summarised parameters indicative of different types of pathogenetic changes on the basis of previous author's suggestions, and known pathogenetic pathways, namely the triad of death [16]. End points of resuscitation, and requirement of blood transfusions appear to be valid [37]. The clinical grading system represents a summary of multiple publications and lists parameters indicative of four different pathogenetic pathways, namely acid base changes, coagulopathy, body temperature and various soft tissue injuries [16]. Of note, multiple isolated factors were included as well, such as factor V, fibrinogen, platelet count and the Advanced Trauma Life Support (ATLS) classification. We omitted D-dimer levels, urine output, thoracic trauma score, and the oxygenation ratio (PaO₂/FIO₂). All recommendations rely on studies prior to 2005.

Subsequently, numerous approaches were described to facilitate this complex approach: One author modified the recommendations from 2005 by downgrading the importance of chest injury and the early requirement of blood transfusion [38]. Another protocol focuses on parameters indicative of the acid base system. The authors use a dichotomous approach to separate high risk and low risk groups prior to major surgery [39]. A further approach used data from an existing prospective study and searched for parameters to separate stable from borderline patients. A thoracic AIS > 2, ventilation >48 h, and GCS < 9 on admission appeared to be valid indicators of a borderline condition [40]. Data from a nationwide trauma registry was used to develop another scoring system for patient grading, focusing on the patient in borderline condition. Parameters indicative of the borderline trauma patient were admission blood pressure <90 mmHg; Base deficit 8–10 INR < 2 NISS >35–39 and pBRC >3–14 [41].

The resulting scores are described in detail below:

Modified clinical grading system (mCGS) [38]

The mCGS represents - modification of the recommendations from - encompassed the following further changes: "Parameters omitted from the CGS included factor II and V, fibrinogen, D-dimer, Advanced Trauma Life Support classification, urine output, PaO₂/FIO₂, and thoracic trauma score because of limitations in data availability. The transfusion parameter was modified from blood units (2 h) to number of PRBCs transfused on the day of injury. Suggested parameter values associated with all criteria except platelet count overlapped and were modified so that patients could be clearly assigned to a clinical grade".

Early appropriate care protocol (EAC) [38]

The early appropriate care protocol has been developed based on data from 1443 adult patients treated between 1999 and 2006 in a level I trauma center. The mean ISS was 24.7 (range: 9–57),

thus including isolated fractures. The aim of the development was to facilitate the clearance of patients for definitive surgeries by orthopedic surgeons, after assessment by general surgery and neurosurgical clearance. The database encompasses fractures of the pelvis (n = 291), acetabulum (n = 399), spine (n = 102), and/or proximal or the femur shaft (n = 851). It foresees the use of lactate, pH and base excess and utilizes a dichotomous approach that divides between low risk and high risk patients [21]. According to the authors, definitive surgery of all of these fractures is recommended when patients fall into the low risk group. Of note, there were patients who had provisional external fixation of their femur or pelvis followed by later conversion to internal techniques. These patients were grouped into the late fixation group.

Polytrauma grading score (PTGS) [41]

The Polytrauma grading score (PTGS) was calculated on the basis of a nationwide trauma registry. Its results are calculated from data of 11,436 multiply injured patients treated in multiple trauma centers between 1994 and 2012. The following inclusion criteria were applied: age > 16 years, Abbreviated Injury Score (AIS) ≥ 3 points and treatment in an intensive care unit, or Injury Severity Score (ISS) ≥ 16 points; none of these patients had isolated major fractures.

The specifics and the differences of these scoring systems and the number of categories are listed in Table 1.

To date, it is unclear if any of these grading scales are superior to each other, as none of the scores has been validated and submitted to a separate patient group to determine its efficacy. While the mCGS has been discussed to be less effective than the EAC protocol, this assumption cannot be maintained for the original publication, as too many factors had been changed. The PTGS may suffer from a lack of indications towards the patient with questionable risk, e.g. the borderline patient, as the indicators are associated with a tremendously increased risk of mortality.

In summary, the optimal and clinically feasible classification of the multiple injured patient still remains in evolution. As far as the current recommendations are concerned, the use of multiple parameters, ideally covering different pathogenetic pathways appear to be safe. Due to the dynamic nature of the injuries, there should be multiple assessments of trauma patients, ideally before the decision making process towards surgery. Even according to the most recent recommendations, the following approach has been suggested: If a patient is stable, or the values improve, safe definitive surgery is recommended – if in doubt, a damage control approach is favored [42].

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