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Development of multiple organ dysfunction syndrome in older and young adult trauma patients

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ABSTRACT

Objective: We sought out to determine the correlation between the injury severity score (ISS) and multiple organ dysfunction syndrome (MODS) between severely injured young adults (18–54 years) and elderly (>55 years) patients.

Materials and Methods: This was a cross-sectional observational study. We included all adult cases (>18 years) diagnosed with trauma defined by the International Classification of Diseases, Ninth Revision. For significance testing, Chi-square test and odds ratio were used. Severe injuries were defined by an ISS >15. The presence of MODS was based on the definitions proposed by society for critical care medicine.

Results: A total of 469 young and 173 elderly patients were included in the study. Among the 469 young adults, 193 had ISS >15, whereas out of the 173 elderly patients, 88 had an ISS >15. Severely injured young and elderly groups were more likely to develop MODS compared with those with an ISS <15 ($P < 0.001$ and $P < 0.001$, respectively). The elderly had a higher likelihood of developing MODS ($P < 0.001$; odds ratio: 5.17; 95% confidence interval: 2.74–9.80).

Conclusion: This study demonstrated a direct relationship between an ISS >15 and the development of MODS. We also observed a five-fold increase in the development of MODS among severely injured elderly patients.

Key Words: Injury severity score, multiple organ dysfunction syndrome, trauma

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INTRODUCTION

Over the past decades, significant advances have been developed toward the care of critically injured trauma patients, but still trauma remains the leading cause of mortality among young individuals in productive age, having a significant socioeconomic impact in the United States and the world.[1,2]

Multiple organ dysfunction syndrome (MODS) is a life-threatening complication of severe trauma MODS, which is a major cause of mortality in the injured patient, representing a significant financial burden to the health-care system. In the severely injured patient, traumatic shock and blood loss result in inadequate tissue perfusion or inability to use oxygen at the cellular level, and aggressive resuscitation can lead to free radical washout from ischemic tissue. All of these lead to activation of host mechanisms such as inflammatory cascades, coagulation cascade, complement system, and the innate and specific immune responses.[3-7] Despite the enormous efforts to elucidate the mechanisms of the development of MODS following trauma and advances in trauma care that have resulted in important changes in the morbidity and a gradual improvement in mortality,[8-14] MODS is still a leading cause of late postinjury death

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and morbidity and the leading cause of late postinjury mortality and extended intensive care unit (ICU) length of stay. Numerous studies have demonstrated how excessive systemic inflammation following trauma participates in the development of MODS.[4-7] However, recent studies have demonstrated the importance of early prediction and early resuscitation for MODS to improve the outcome. A higher injury severity score (ISS) has been associated with a longer stay in the ICU, greater requirement for mechanical ventilation, and longer total hospital stay and overall mortality.[14-16]

We hypothesized that when controlling for injury severity, MODS development is directly related to the age of the patient. The objective of this study was to determine the correlation between ISS and MODS and between the severely injured young (aged 18–64 years) and elderly (aged 65 years) patients.

MATERIALS AND METHODS

This was a cross-sectional observational study gathering data from a hospital-based trauma registry. Trauma centers (TCs) were defined as those accredited by the Pennsylvania Trauma Systems Foundation as being Level I and Level II. Accredited pediatric TCs were included as TC facilities. Cases were considered to have been TC cases if they were admitted to an accredited TC. The Pennsylvania Trauma Systems Foundation uses a categorization system analogous to the American College of Surgeons criteria. All other hospitals were considered as non-TCs.

The ISS is based on an anatomical scoring system that provides an overall score for patients with multiple injuries. Each injury is assigned an abbreviated injury scale (AIS) score and allocated to one of the six body regions such as the head and neck, face, chest, abdomen, extremities (including pelvis), and external. Only the highest AIS-05 score in each body region is used. To calculate the ISS score, the score of the three most severely injured body regions is squared, and the results are added to produce the ISS score.

ICDMAP-90 (Tri-Analytics, Inc., Bel Air, MD, USA) software was used to compute AIS scores and ISS. The Association for the Advancement of Automotive Medicine developed code translation maps to be used by computerized mapping systems for converting injury-related International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes and Tenth Revision (ICD-10-CM) codes into AIS-derived metrics to determine the significance of injury. The mapping tool that translates ICD-9-CM and ICD-10-CM codes to the AIS standard is critical for clinical and research purposes, including epidemiologic analyses of large administrative injury databases. Previous maps are outdated (using earlier AIS or ICD standards) and incomplete, identifying the need for a contemporary tool which translates ICD-CM codes to the AIS standard. Most importantly, the mapping tool was designed by those who are familiar with the nuances of both the ICD and AIS coding systems and was validated by comparing it to the rules and best practices of conventional coding completed by trained and certified coders.

The ICD-9-CM and the ICD-9 External Cause codes or "E codes" were used to identify acute trauma cases. Poisonings, single-system burns, and late effects of injury were excluded from the study. Severe injuries were defined as those cases with an ISS >15. The presence of MODS was based on the definitions proposed and accepted.[17]

Descriptive statistics were used to present group characteristics. Descriptive statistics and confidence intervals (CIs) were used to present group characteristics. For categorical variables, Chi-square test and Fisher's exact test were used to assess associations; for these variables, the odds ratio was used as the measure of strength of association. Levene's test for equality of variances was used to assess homogeneity of variance for continuous variables, and the Student's *t*-test was used for the assessment of associations between these variables. For all tests, statistical significance was set at the 0.05 level. All analyses were performed with SPSS for Windows 9.01 standard version (SPSS, Inc., Chicago, IL, USA). Institutional Review Board approval was obtained under a minimal risk protocol.

RESULTS

Six hundred forty-two adult trauma patients were included, with 469 (73.05%) classified as young (18–54 years old) and 173 (26.95%) as elderly (>65 years old) [Figure 1 and Table 1], demonstrating a 2.71-times greater sample representing younger adults.

When analyzing the age groups, the relationship between ISS >15 and the age groups, we found that among the 469 young adults, 193 had ISS >15 (41.2%) and 35 of these developed MODS (35 of 193, or 18.1%). Among the 173 elderly patients, 88 had an ISS >15 (50.9%) and 51 met the definition for MODS (51 of 173, 29.5%).

Looking at MODS development, we found that severely injured (ISS >15) young and elderly groups were more likely to develop MODS compared with those with an ISS <15 ($P < 0.001$, odds ratio [OR]: 3.68; 95% CI: 1.71–8.00 and $P < 0.001$, OR: 5.17; 95% CI: 2.74–9.80, respectively). When the young and elderly groups were directly compared, the latter had a higher likelihood of developing MODS ($P < 0.001$; OR: 5.17; 95% CI: 2.74–9.80).

DISCUSSION

Injury-related MODS was noted to become a prevalent condition as the improvements in critical care during the 1970s.[8] Over the past decades, significant efforts have been invested in research which designed to better understand MODS. With changes in population demographics and injury mechanisms and improvements in trauma care, changes in the epidemiology of MODS are also becoming evident.[9-14] In spite of significant improvements in trauma patient management, MODS still remains the most significant contributor of late postinjury mortality and ICU resource utilization.[15-18]

The etiology of MODS is complex and is depended on patient factors, injury factors, and treatment factors. MODS develops in trauma patients following hemorrhagic shock and resuscitation into early systemic inflammatory response syndrome (SIRS). An overwhelming initial insult may precipitate severe SIRS and subsequent MODS. MODS is a systemic, dysfunctional inflammatory response following hemorrhagic shock with reperfusion injury. The complete pathophysiology of MODS is still being elucidated; however, the significant progression of knowledge has been made in the past 10 years.

In postinjury situations, much of the early organ dysfunction will return to normal within 48 h of injury after completing the resuscitation. MODS is organ dysfunction within the first 48 h of the initial insult. Organ dysfunction is common during resuscitation and is a different entity to MODS. Hemorrhagic shock following injury causes whole-body hypoperfusion, followed by subsequent reperfusion during resuscitation, resulting in the release of cytokines, pro-inflammatory lipids, and proteins from the reperfused tissues.

Blood transfusion administered within the first 24 h following trauma has also been associated with an increased rate of SIRS, increased mortality, and longer ICU stay.[19] Reductions in blood transfusion in the resuscitation period correlate with improved outcome and less MODS.

Several risk factors have been identified as predictors of outcome in severe trauma patients, including age, obesity, large blood transfusions, development of abdominal compartment syndrome, and ISS [Table 2], have been correlated to bad outcomes.[19-22] Our study not only corroborated the direct relationship of a severe ISS (>15) with the development of MODS but also demonstrated an age-related effect where elderly patients were more likely to develop MODS than those classified as young. This could be explained by physiologic reserve and comorbidities, highlighting the importance of early aggressive interventions in this subgroup.

Postinjury MODS remains a relevant issue for the trauma clinician. MODS continues to be responsible for most of the late trauma mortality, postinjury morbidity, and utilization of significant ICU resources. There have been significant improvements in our understanding of the pathophysiology of MODS, but despite improvements in trauma care, there are no specific therapies for MODS. MODS continues to provide both basic science and clinical questions, and by providing answers, the care of the trauma patient will continue to improve. Based on our study results, further research needs to focus on controlling individual items related to this increased mortality in older patients as well as perhaps targeted interventions for older patients in an effort to improve outcomes. Limitations of this study include the retrospective nature and sample size.

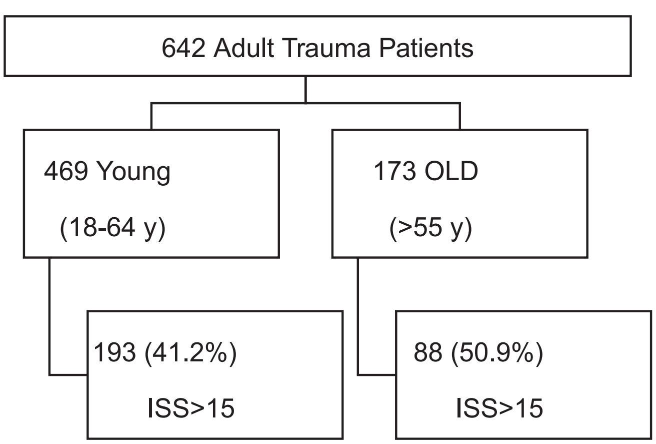

Figure 1: Patient distribution. *ISS=Injury severity score

CONCLUSION

This study demonstrated a direct relationship between

Table 1: Patient Classification

Patient Category	ISS <15 *n* %)	ISS >15 *n* (%)	
Young (*n*=469)	276 (58.8%)	193 (41.2%)	NO MODS *n*=158 (81.9%) YES MODS *n*=35 (18.1%)
Old (*n*=173)	85 (49.1%)	88 (50.9%)	NO MODS *n*=37 (42.1%) YES MODS *n*=51 (57.9%)

*ISS=Injury Severity Score, MODS=Multiple Organ Disfunction Syndrome

Table 2: Example of injury severity score calculation

Region	Description of injury	AIS	Square top three
Head and neck	Cerebral contusion	3	9
Face	No injury	0	
Thorax	Flail chest	4	16
Abdomen	Minor hepatic contusion	2	25
	Complex splenic rupture	5	
Extremities	Femoral fracture	3	
External	No injury	0	
ISS			50

AIS: Abbreviated injury scale, ISS: Injury severity score

ISS >15 and the development of MODS. We also observed a five-fold increase in the development of MODS among severely injured elderly patients. Future studies should focus on early resuscitative interventions based on prompt emergency department severity estimates calculated from anatomic and physiologic scoring systems. Limitations of this study are primarily related to the retrospective data collection process and the subsequent accuracy of the medical records. More work is needed to identify and limit specific factors related to the improving outcomes of older patients.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Evans JA, van Wessem KJ, McDougall D, Lee KA, Lyons T, Balogh ZJ, *et al.* Epidemiology of traumatic deaths: Comprehensive population-based assessment. World J Surg 2010;34:158-63.
2. Ciesla DJ, Moore EE, Johnson JL, Burch JM, Cothren CC, Sauaia A, *et al.* A 12-year prospective study of postinjury multiple organ failure: Has anything changed? Arch Surg 2005;140:432-8.
3. Adams JM, Hauser CJ, Livingston DH, Lavery RF, Fekete Z, Deitch EA, *et al.* Early trauma polymorphonuclear neutrophil responses to chemokines are associated with development of sepsis, pneumonia, and organ failure. J Trauma 2001;51:452-6.
4. Dewar DC, Mackay P, Balogh Z. Epidemiology of post-injury multiple organ failure in an Australian trauma system. ANZ J Surg 2009;79:431-6.
5. Bone RC, Balk RA, Cerra FB, Dellinger RP, Fein AM, Knaus WA, *et al.* Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. The ACCP/SCCM Consensus Conference Committee. American College of Chest Physicians/Society of Critical Care Medicine. Chest 1992;101:1644-55.
6. Nathens AB, Marshall JC. Sepsis, SIRS, and MODS: What's in a name? World J Surg 1996;20:386-91.
7. Tsukamoto T, Chanthaphavong RS, Pape HC. Current theories on the pathophysiology of multiple organ failure after trauma. Injury 2010;41:21-6.
8. Sauaia A, Moore FA, Moore EE, Haenel JB, Read RA, Lezotte DC, *et al.* Early predictors of postinjury multiple organ failure. Arch Surg 1994;129:39-45.
9. Nast-Kolb D, Aufmkolk M, Rucholtz S, Obertacke U, Waydhas C. Multiple organ failure still a major cause of morbidity but not mortality in blunt multiple trauma. J Trauma 2001;51:835-41.
10. Baue AE. Multiple, progressive, or sequential systems failure. A syndrome of the 1970s. Arch Surg 1975;110:779-81.
11. Balogh Z, McKinley BA, Cox CS Jr., Allen SJ, Cocanour CS, Kozar RA, *et al.* Abdominal compartment syndrome: The cause or effect of postinjury multiple organ failure. Shock 2003;20:483-92.
12. Ciesla DJ, Moore EE, Johnson JL, Sauaia A, Cothren CC, Moore JB, *et al.* Multiple organ dysfunction during resuscitation is not postinjury multiple organ failure. Arch Surg 2004;139:590-4.
13. Cryer HG, Leong K, McArthur DL, Demetriades D, Bongard FS, Fleming AW, *et al.* Multiple organ failure: By the time you predict it, it's already there. J Trauma 1999;46:597-604.
14. Balogh Z, Offner PJ, Moore EE, Biffl WL. NISS predicts postinjury multiple organ failure better than the ISS. J Trauma 2000;48:624-7.
15. Dewar DC, Mackay P, Balogh Z. Postinjury multiple organ dysfunction syndrome: The Australian context. ANZ J Surg 2009;79:434-9.
16. Faist E, Baue AE, Dittmer H, Heberer G. Multiple organ failure in polytrauma patients. J Trauma 1983;23:775-87.
17. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. Prognosis in acute organ-system failure. Ann Surg 1985;202:685-93.
18. Almahmoud K, Namas RA, Zaaqoq AM, Abdul-Malak O, Namas R, Zamora R, *et al*. Prehospital hypotension is associated with altered inflammation dynamics and worse outcomes following blunt trauma in humans. Crit Care Med 2015;43:1395-404.
19. Dunne JR, Malone DL, Tracy JK, Napolitano LM. Allogenic blood transfusion in the first 24 hours after trauma is associated with increased systemic inflammatory response syndrome (SIRS) and death. Surg Infect (Larchmt) 2004;5:395-404.
20. Hébert PC, Wells G, Blajchman MA, Marshall J, Martin C, Pagliarello G, *et al.* A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care. Transfusion Requirements in Critical Care Investigators, Canadian Critical Care Trials Group. N Engl J Med 1999;340:409-17.
21. Johnson JL, Moore EE, Gonzalez RJ, Fedel N, Partrick DA, Silliman CC, *et al.* Alteration of the postinjury hyperinflammatory response by means of resuscitation with a red cell substitute. J Trauma 2003;54:133-9.
22. Marshall JC, Cook DJ, Christou NV, Bernard GR, Sprung CL, Sibbald WJ, *et al.* Multiple organ dysfunction score: A reliable descriptor of a complex clinical outcome. Crit Care Med 1995;23:1638-52.