Shock Index as an indicator for blood transfusion or surgical intervention among multiple trauma patients in Jordan

Liqaa **Raffee**[1*], Khaled **Alawneh**[2], Wasfi **Al-Salaita**[3], Nour **Negresh**[4], Ahmad **Al-Omari**[1], Hassan **Alawneh**[5], Abeer **Khafajah**[6], Majd **Elzghairin**[6], Zaid **Tashtoush**[6], Yamen **Alawneh**[6], Rana **Haddad**[6]

1. Department of Accident and Emergency Medicine, Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan

2. Department of Diagnostic Radiology and Nuclear Medicine, Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan

3. Department of General Surgery, Jordanian Royal Medical Services, Amman, Jordan

4. Department of General Surgery, Faculty of Medicine, Al-Balqa Applied University, Al-Salt, Jordan

5. Department of Medical Engineering, Cardiff University School of Engineering, United Kingdom

6. Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan

*Corresponding author
Liqaa Raffee,
Department of Accident and Emergency Medicine,
Faculty of Medicine, Jordan University of Science and Technology,
Irbid, Jordan;
E-mail: laraffee5@just.edu.jo

ABSTRACT

Trauma remains a leading cause of mortality worldwide, with uncontrollable bleeding contributing significantly to preventable deaths. This study assessed the utility of the shock index (SI) in predicting clinical outcomes in trauma patients. A retrospective analysis was conducted on 122 trauma patients admitted to King Abdullah University Hospital, Jordan. Patients were categorized into two groups based on their SI: normal (SI < 0.9) and elevated (SI> 0.9). Clinical outcomes, including the need for interventions, blood transfusions, and neurological status, were compared between the groups. Patients with elevated SI had worse neurological outcomes (17% vs. 1.1%, $P < 0.001$), higher rates of airway interventions (23% vs. 4.3%, $P = 0.005$), increased incidence of pneumothorax/hemothorax ($P = 0.005$), and a greater need for blood transfusions (10% vs. 1.1%, $P = 0.046$). Elevated SI was associated with overall hemodynamic instability and worse clinical outcomes, supporting its use as a rapid assessment tool in trauma care. Elevated SI was strongly associated with worse clinical outcomes in trauma patients, including increased need for interventions and higher complication rates. SI proves to be a simple yet effective tool for the rapid assessment of trauma severity, while holding the potential to improve early triage and decision-making within emergency care settings.

KEYWORDS: trauma, Shock Index (SI), hemodynamic instability, pneumothorax, blood transfusion

ABBREVIATIONS: SI, Shock Index; MT, Massive Transfusion; ESPs, Emergency Surgical Procedures; SBP, Systolic Blood Pressure; ER, Emergency Room; INR, International Normalized Ratio; PT, Prothrombin Time; PTT, Partial Thromboplastin Time; rSI, Reverse Shock Index; rSIG, Reverse Shock Index with Glasgow Coma Scale; GCS, Glasgow Coma Scale

INTRODUCTION

Trauma or physical injury is a significant cause of mortality and disability worldwide [1]. It is a serious global health problem, accounting for approximately one in ten deaths worldwide [2]. Uncontrollable bleeding accounts for 39% of trauma-related deaths and is the leading cause of potentially preventable deaths in patients with major trauma [3]. The Shock Index (SI), commonly referred to as hemodynamic stability, has an accepted range value

of 0.5 to 0.7. This index is commonly used to assess the amount of blood loss [3]. A previous study suggested a classification system that stratifies patients into four categories based on SI on hospital arrival: *no shock* (< 0.6), *mild shock* (0.6–1.0), *moderate shock* (1.0–1.40), and *severe shock* (≥ 1.4). Patients with 'moderate shock' and 'severe shock' received massive transfusion (MT)(≥10/24 h) at proportions of 31% and 57%, respectively [4].

In both civilian and military populations, SI has demonstrated strong predictive value for outcomes such as massive transfusion and emergency surgical procedures, particularly in resource-lim-

ited or austere environments [5]. While systolic blood pressure (SBP) and SI are commonly used to predict outcomes in trauma patients, evidence suggests that the optimal threshold values for these indicators can vary depending on the underlying cause of trauma and the patient's clinical condition [6–10]. Factors such as advanced age, pre-existing hypertension, and the use of β-blockers or calcium channel blockers have been shown to diminish the predictive strength of SI for 30-day mortality [6]. Consequently, the effectiveness of SBP and SI as evaluation tools in older trauma patients or those receiving antihypertensive therapy remains inadequately established [11].

MATERIAL AND METHODS

Study design and setting

This was a retrospective cross-sectional study conducted at King Abdullah University Hospital (KAUH) in Irbid, Jordan. Data were collected for all patients admitted to the Emergency Room (ER) between March 2016 and March 2023. Patients under the age of 18 and pregnant women were excluded from the study.

Questionnaire and data collection

Data were extracted using a structured spreadsheet based on the World Health Organization (WHO) Trauma Care Checklist (Figure 1) [12]. Variables in the data collection spreadsheet included socio-demographic characteristics, comorbidities, clinical manifestations, and imaging findings. Information was gathered by reviewing each patient's history, physical examination notes, and radiological reports available in the EMRs.

Statistical analysis

For continuous variables, the median and interquartile range (IQR) were used to describe central tendency and deviation. Categorical variables were summarized using frequencies and percentages (%). The association between demographic, clinical, and laboratory variables with study groups was assessed using the Wilcoxon (Mann–Whitney U test) test for continuous variables, while the chi-squared (χ^2) and Fisher's exact tests were employed for categorical variables, particularly when the count within a category was less than 5. Statistical significance was set at a P value of < 0.05. All statistical analyses were performed using SPSS version 26.

RESULTS

A total of 122 patients were included in the study. Among them, 30 patients (24.6%) had an elevated SI (SI> 0.9), and 92 patients (75.4%) had a normal SI (SI ≤ 0.9). Most patients were men (74%), with a median age of 33 years. Most patients (93%) presented with a Glasgow Coma Scale (GCS) score of 8 or higher, and 11 patients (9%) required airway intervention. The median heart rate was 84 beats per minute, the median respiratory rate was 18, and the median temperature was 36.9 degrees Celsius. Additionally, 11 patients (9%) experienced tension pneumothorax or hemothorax (Table 1).

Patients in the elevated SI group were less likely to have a GCS ≥ 8 compared to those with a normal SI (80% vs. 97%, $P =$

0.007). Also, patients with an elevated SI had a higher need for airway intervention (23% vs. 4.3%, $P = 0.005$). Patients in the elevated SI group experienced a higher heart rate ($P < 0.001$), higher respiratory rate ($P < 0.001$), and higher rates of tension pneumothorax/hemothorax ($P = 0.005$) when compared to the normal SI group. No significant differences were observed in gender, age, or temperature between the two groups.

Eight patients presented with external bleeding, while 76% had intact neurovascular examinations. Only four patients (3.3%) required a blood transfusion. The median ICU stay was 3.5 days, whereas the median hospital stay length was 4 days. The median Injury Severity Score (ISS) was 8. All patients passed away in the hospital (Table 2).

In terms of neurologic findings, loss of consciousness was significantly more common in the elevated SI group (17% vs. 1.1%, *P < 0.001*). Additionally, blood transfusion was more frequently required in this group (10% vs. 1.1%, *P = 0.046*). Patients with elevated SI also had higher platelet counts, with this difference reaching statistical significance (*P = 0.013*). No significant differences were observed between groups in terms of external bleeding, international normalized ratio (INR), prothrombin time (PT), partial thromboplastin time (PTT), ICU length of stay, total duration of hospitalization, or ISS. Based on SI classification by shock severity, 24 patients (19%) were categorized as having no shock, 72 patients (59%) had mild shock, and 26 patients (21%) experienced moderate to severe shock. The results were consistent with the prior classification (Tables 3 and 4).

DISCUSSION

Trauma and physical injury are major contributors to mortality and disability globally, posing a significant public health challenge and accounting for about 10% of deaths worldwide. Uncontrolled bleeding is responsible for 39% of trauma-related deaths and is the leading cause of potentially preventable fatalities in patients with severe trauma [1,2]. Advanced age, hypertension, and the use of β-blockers or calcium channel blockers can impact the association between SI and 30-day mortality. The effectiveness of SBP and SI as assessment tools in geriatric trauma patients or those on antihypertensive medications remains unclear. Therefore, this study aimed to investigate the utility of SI as a potential indicator to guide clinical management decisions. Specifically, the need for blood transfusions and other critical interventions was evaluated in a cohort of patients with multiple traumas admitted to a tertiary care center in Jordan.

In our cohort, a marked elevation in the shock index (SI > 0.9) was observed, and the GCS was significantly higher in those with elevated SI compared to those with lower SI, in addition to a significantly higher need for airway intervention. Several studies utilized the reverse shock index (rSI), a ratio of systolic blood pressure and heart rate multiplied by the GCS (rSIG), with the intent of forming a prediction for in-hospital trauma patients' mortality. The rSI was introduced by a research group in Taiwan in response to the observation that, in many trauma cases, systolic blood pressure tends to decrease more substantially than heart rate. This dynamic often results in an rSI value less than 1, which has been associated with worse outcomes and increased mortality risk [7,13].

Furthermore, our results revealed that higher SI was also associated with higher pulse rates, respiratory rates, and increased incidence of tension pneumothorax or hemothorax, which are crit-

Figure 1. WHO Trauma Care Checklist

Table 1. Comparison of demographic and clinical indicators by shock index in trauma patients

Characteristic	Elevated n = 30[1]	Normal n = 92[1]	P value [2]	Overall n = 122[1]
Gender			0.6	
Female	9 (30%)	23 (25%)		32 (26%)
Male	21 (70%)	69 (75%)		90 (74%)
Age	36 (13, 40)	32 (25, 43)	0.3	33 (22, 43)
Glasgow coma scale			0.007	
8 or more	24 (80%)	89 (97%)		113 (93%)
Less than 8	6 (20%)	3 (3.3%)		9 (7.4%)
Was further airway intervention needed?	7 (23%)	4 (4.3%)	0.005	11 (9.0%)
Heart rate	94 (81, 119)	80 (75, 90)	<0.001	84 (78, 95)
Respiratory rate	19 (18, 22)	17 (16, 18)	<0.001	18 (16, 19)
Temperature	36.9 (36.8, 37.0)	36.8 (36.7, 37.0)	0.2	36.9 (36.7, 37.0)
Tension pneumothorax/hemothorax	7 (23%)	4 (4.3%)	0.005	11 (9.0%)

[1] n (%); Median (IQR)
[2] Pearson's Chi-squared test; Wilcoxon rank sum test; Fisher's exact test

Table 2. Patient outcomes compared by shock index score categories

Characteristic	Elevated, n = 30[1]	Normal, n = 92[1]	P value[2]	Overall, n = 122[1]
External bleeding	0 (0%)	8 (8.7%)	0.2	8 (6.6%)
Neurovascular exam			<0.001	
Drowsy	0 (0%)	7 (7.9%)		7 (5.9%)
Intact	21 (70%)	70 (79%)		91 (76%)
Intubated	4 (13%)	0 (0%)		4 (3.4%)
Loss of consciousness	5 (17%)	1 (1.1%)		6 (5.0%)
Normal	0 (0%)	11 (12%)		11 (9.2%)
Need for blood transfusion	3 (10%)	1 (1.1%)	0.046	4 (3.3%)
INR	1.00 (1.00, 1.10)	1.10 (1.02, 1.20)	0.10	1.09 (1.00, 1.20)
PT	14.00 (13.20, 14.60)	14.30 (13.55, 15.75)	0.4	14.15 (13.30, 15.63)
PTT	27.00 (26.00, 29.00)	26.40 (24.60, 28.45)	0.2	26.55 (25.00, 28.73)
PLT	281 (249, 299)	241 (198, 287)	0.013	255 (204, 293)
ICU length stay	4.0 (1.0, 8.0)	3.0 (1.0, 5.0)	0.5	3.5 (1.0, 5.0)
Hospital length stay	8 (2, 21)	4 (2, 7)	0.2	4 (2, 7)
Injury severity score	6 (3, 23)	8 (4, 16)	0.8	8 (4, 16)
Mortality after ER	30 (100%)	92 (100%)		122 (100%)

[1] n (%); Median (IQR)
[2] Fisher's exact test; Wilcoxon rank sum test

Table 3. Baseline characteristics and clinical findings stratified by shock index (SI) category

Characteristic	No shock n = 24[1]	Mild shock n = 72[1]	Moderate / Severe shock n = 26[1]	P value[2]	Overall n = 122[1]
Gender				0.5	
Female	5 (21%)	18 (25%)	9 (35%)		32 (26%)
Male	19 (79%)	54 (75%)	17 (65%)		90 (74%)
Age	36 (27, 48)	31 (23, 41)	36 (21, 40)	0.3	33 (22, 43)
Glasgow coma scale				0.006	
8 or more	24 (100%)	69 (96%)	20 (77%)		113 (93%)
Less than 8	0 (0%)	3 (4.2%)	6 (23%)		9 (7.4%)
Was further airway intervention needed?	1 (4.2%)	3 (4.2%)	7 (27%)	0.004	11 (9.0%)
Heart rate	71 (67, 77)	87 (80, 94)	85 (81, 121)	<0.001	84 (78, 95)
Respiratory rate	16.5 (16, 17)	17.5 (16, 19)	18 (18, 22)	<0.001	18 (16, 19)
Temperature	36.80 (36.7, 36.9)	36.8 (36.7, 37.0)	36. (36.9, 37.0)	0.3	36.9 (36.7, 37.0)
Tension pneumothorax/hemothorax	1 (4.2%)	4 (5.6%)	6 (23%)	0.024	11 (9.0%)

[1] n (%); Median (IQR)
[2] Pearson's Chi-squared test; Kruskal-Wallis rank sum test; Fisher's exact test

Table 4. Patient outcomes compared by shock index score categories

Characteristic	Mild shock n = 72[1]	No shock n = 24[1]	Moderate/Se- vere shock n = 26[1]	P value[2]	Overall n = 122[1]
External bleeding	5 (6.9%)	3 (13%)	0 (0%)	0.2	8 (6.6%)
Neurovascular exam				<0.001	
Drowsy	7 (10%)	0 (0%)	0 (0%)		7 (5.9%)
Intact	51 (74%)	23 (96%)	17 (65%)		91 (76%)
Intubated	0 (0%)	0 (0%)	4 (15%)		4 (3.4%)
Loc	1 (1.4%)	0 (0%)	5 (19%)		6 (5.0%)
Normal	10 (14%)	1 (4.2%)	0 (0%)		11 (9.2%)
Need for blood transfusion	1 (1.4%)	0 (0%)	3 (12%)	0.064	4 (3.3%)
INR	1.12 (1.03, 1.20)	1.05 (0.96, 1.15)	1.00 (1.00, 1.09)	0.053	1.09 (1.00, 1.20)
PT	14.60 (13.60, 15.75)	13.90 (12.55, 14.65)	14.00 (13.05, 14.83)	0.2	14.15 (13.30, 15.63)
PTT	26.40 (24.60, 28.40)	26.70 (24.70, 28.55)	27.50 (26.00, 29.00)	0.4	26.55 (25.00, 28.73)
PLT	251 (204, 297)	223 (179, 273)	281 (255, 299)	0.026	255 (204, 293)
ICU length of stay	3.0 (1.0, 5.0)	3.0 (1.3, 4.0)	4.5 (2.5, 11.0)	0.5	3.5 (1.0, 5.0)
Hospital length of stay	4 (2, 7)	4 (3, 6)	8 (2, 21)	0.4	4 (2, 7)
Injury severity score	6 (4, 12)	9 (4, 16)	7 (2, 26)	0.6	8 (4, 16)
Mortality after ER	72 (100%)	24 (100%)	26 (100%)		122 (100%)

[1] n (%); Median (IQR)
[2] Fisher's exact test; Kruskal-Wallis rank sum test

ical factors contributing to hemodynamic instability in trauma patients. A study by Kheirbek *et al.* investigated the association between prehospital SI and the presence of significant injuries, which included pneumothorax and hemothorax, and found that patients with an elevated prehospital SI had significantly higher rates of injuries, need for transfusion, and death at the emergency department [14]. However, prehospital hypotension alone was not a significant indicator of significant injuries or the need for intervention and showed worse performance than SI [14]. Surprisingly, the association between SI and significant injury was higher in patients with normal blood pressure compared to those with prehospital hypotension, suggesting the need to increase the threshold for defining hypotension to 105 or 110 mmHg, as in several studies [14-16]. These findings highlight a potential issue where some patients with normal blood pressure might not be adequately triaged with full trauma team activation, despite having significant injuries that could have been detected through the use of SI [17,18].

This study illustrated several strengths, in which an initial focus was placed on a critical global health issue, which is trauma-related mortality and disability, by exploring the use of the shock index as a simple, reproducible, and efficient tool for assessing trauma patients. Additionally, we utilized real-world data from King Abdullah University Hospital over a seven-year period in Jordan, which provides valuable insights into patient care in a practical clinical setting, particularly in the Middle East, where data on SI usage is limited. The single-center, retrospective design inherently introduces selection bias and may limit the generalizability of our findings to other trauma care settings. Retrospective data collection relies on the accuracy and completeness of medical records, which could introduce information bias and affect data reliability. Additionally, the inability to control confounding variables, such as pre-existing comorbidities, medication use, and differences in trauma care protocols, may have influenced the outcomes observed. Additionally, the study's internal and external validity may be affected by the limited sample size, particularly the small number of patients ($n = 30$) exhibiting an elevated SI >0.9, which could impact the robustness and generalizability of the findings.

The generalizability of our findings may be limited due to the exclusion of patients under 18 years of age and pregnant women. As such, the results should be interpreted with caution and regarded as preliminary. Future multicenter prospective studies are warranted to validate these findings, address current limitations, and provide more definitive evidence on the clinical utility of the SI in trauma care. Future research should also focus on including diverse patient groups to broaden applicability and investigate the utility of SI in patients with specific health conditions. Comparative studies could assess SI against other existing tools, and implementation research should explore how SI can be integrated into trauma care protocols in various clinical settings, especially those with limited resources, to improve clinical outcomes and decision-making processes.

CONCLUSION

Our findings suggest that SI may serve as a useful tool for assessing trauma severity and predicting clinical outcomes in emergency patients. Elevated SI was associated with worse neurological outcomes, increased need for interventions and transfusions, and higher rates of significant injuries. However, given the study's single-center, retrospective design, limited sample size, and po-

tential biases, these results should be interpreted with caution. Our study serves as a preliminary investigation, and future prospective, multicenter research is needed to validate these findings, improve the robustness of conclusions, and explore the broader applicability of SI in diverse trauma populations.

Conflict of interest

The authors declare no conflict of interest.

Ethical approval

The Institutional Review Board (IRB) at King Abdullah University Hospital (KAUH) and Jordan University of Science and Technology (JUST) approved the study (Approval number: 20230467/24/07/2023). The study was performed in accordance with the principles of the Declaration of Helsinki, 1975.

Consent to participate

Data was collected from patients' electronic medical records. Data was de-identified prior to analysis.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Authorship

LR contributed to conceptualization, investigation, methodology, project administration, supervision, and writing – original draft. KA and WA-A contributed to data curation, formal analysis, validation, writing – review & editing. NN and AA-O contributed to data curation, software, visualization, and writing – original draft. HA, AK, ME, ZT, YA, and RH contributed to the investigation, data curation, and writing – original draft, as well as writing – review and editing.

REFERENCES

1. Baradari AG, Firouzian A, Davanlou A, Aarabi M, Daneshiyan M, Kiakolaye YT. Comparison of patients' admission, mean and highest SOFA scores in prediction of ICU mortality: a prospective observational study. Mater Sociomed. 2016 Oct;28(5):343–7. doi: 10.5455/msm.2016.28.343-347
2. Rossiter ND. Trauma—the forgotten pandemic? Int Orthop. 2022 Jan;46(1):3–11. doi: 10.1007/s00264-021-05213-z
3. Rossaint R, Bouillon B, Cerny V, Coats TJ, Duranteau J, Fernández-Mondéjar E, *et al.* Management of bleeding following major trauma: an updated European guideline. Crit Care. 2010;14(2):R52. doi: 10.1186/cc8943
4. Mutschler M, Nienaber U, Münzberg M, Wölfl C, Schoechl H, Paffrath T, *et al.* The Shock Index revisited – a fast guide to transfusion requirement? A retrospective analysis on 21,853 patients derived from the TraumaRegister DGU. Crit Care. 2013 Aug 12;17(4):R172. doi: 10.1186/cc12851
5. Marenco CW, Lammers DT, Morte KR, Bingham JR, Martin MJ, Eckert MJ. Shock Index as a predictor of massive transfusion and emergency surgery on the modern battlefield. J Surg Res. 2020 Dec;256:112–8. doi: 10.1016/j.jss.2020.06.024
6. Kristensen AKB, Holler JG, Hallas J, Lassen A, Shapiro NI. Is shock index a valid predictor of mortality in emergency department patients with hypertension, diabetes, high age, or receipt of β- or calcium channel blockers? Ann Emerg Med. 2016 Jan;67(1):106–13.e6. doi: 10.1016/j.annemergmed.2015.05.020
7. Lai WH, Rau CS, Hsu SY, Wu SC, Kuo PJ, Hsieh HY, *et al.* Using the Reverse Shock Index at the Injury Scene and in the Emergency Department to Identify High-Risk Patients: A Cross-Sectional Retrospective Study. Int J Environ Res Public Health. 2016;13(4):357. doi: 10.3390/ijerph13040357
8. Martin JT, Alkhoury F, O'Connor JA, Kyriakides TC, Bonadies JA. 'Normal' vital signs belie occult hypoperfusion in geriatric trauma patients. Am Surg. 2010 Jan;76(1):65–9. doi: 10.1177/000313481007600113
9. Park SJ, Lee MJ, Kim C, Jung H, Kim SH, Nho W, *et al.* The impact of age and receipt antihypertensives to systolic blood pressure and shock index at injury scene and in the emergency department to predict massive transfusion in trauma patients. Scand J Trauma Resusc Emerg Med. 2021 Jan 30;29:26. doi: 10.1186/s13049-021-00840-2

10. Lulla A, Lumba-Brown A, Totten AM, Maher PJ, Badjatia N, Bell R, *et al.* Prehospital guidelines for the management of traumatic brain injury - 3rd edition. Prehosp Emerg Care. 2020;24(2):243–51. doi: 10.1080/10903127.2023.2187905

11. Kim SY, Hong KJ, Shin SD, Ro YS, Ahn KO, Kim YJ, *et al.* Validation of the Shock Index, Modified Shock Index, and Age Shock Index for Predicting Mortality of Geriatric Trauma Patients in Emergency Departments. J Korean Med Sci. 2016 Dec;31(12):2026–32. doi: 10.3346/jkms.2016.31.12.2026

12. World Health Organization. World report on road traffic injury prevention: summary. Geneva: World Health Organization; 2004.

13. Kuo SCH, Kuo PJ, Hsu SY, Rau CS, Chen YC, Hsieh HY, *et al.* The use of the reverse shock index to identify high-risk trauma patients in addition to the criteria for trauma team activation: a cross-sectional study based on a trauma registry system. BMJ Open. 2016 Jun 21;6(6):e011072. doi: 10.1136/bmjopen-2016-011072

14. Kheirbek T, Martin TJ, Cao J, Hall BM, Lueckel S, Adams CA. Prehospital shock index outperforms hypotension alone in predicting significant injury in trauma patients. Trauma Surg Acute Care Open. 2021;6(1):e000712. doi: 10.1136/tsaco-2021-000712

15. Eastridge BJ, Salinas J, McManus JG, Blackburn L, Bugler EM, Cooke WH, *et al.* Hypotension begins at 110 mm Hg: redefining "hypotension" with data. J Trauma. 2007;63(2):291–9. doi: 10.1097/TA.0b013e31809ed924

16. Seamon MJ, Feather C, Smith BP, Kulp H, Gaughan JP, Goldberg AJ. Just one drop: the significance of a single hypotensive blood pressure reading during trauma resuscitations. J Trauma. 2010 Jun;68(6):1289–95. doi: 10.1097/TA.0b013e3181db05dc

17. Haider AA, Azim A, Rhee P, Kulvatunyou N, Ibraheem K, Tang A, *et al.* Substituting systolic blood pressure with shock index in the National Trauma Triage Protocol. J Trauma Acute Care Surg. 2016 Dec;81(6):1136–41. doi: 10.1097/TA.0000000000001205

18. Oyetunji TA. Redefining hypotension in the elderly. Arch Surg. 2011 Jul 1;146(7):865. doi: 10.1001/archsurg.2011.154