ORIGINAL ARTICLE

Predictive ability of shock index in survival of ICU admitted emergency surgery patients: A retrospective cohort study

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ABSTRACT

BACKGROUND: Shock index (SI) is defined as the ratio of heart rate to systolic blood pressure and is a feasible and reliable tool to assess patients' circulatory status in emergency conditions. Its efficiency was shown in hemorrhagic shock, sepsis, trauma, and emergency triages. This study was planned to evaluate predictive ability of SI on 28-day survival of intensive care unit (ICU) admitted emergency surgery (eSurg) patients.

METHODS: The study was conducted in a 20-bed capacity ICU of a University Hospital. Medical records of patients who were admitted to ICU after an eSurg between January 1, 2017, and December 31, 2019, were retrospectively scanned. Patients with age <18 and >90, elective surgeries, no written consents, missing data, and lost to follow-up were excluded from the study. Patients age, gender, surgery type, associated medical comorbidity, ICU mechanic ventilatory (MV) length, length of stay (LOS), and 28-day survival status were recorded. Selected pre-operative (pre-op) and post-operative (post-op) laboratory parameters (hemoglobin [Hb], platelet count, international normalized ratio [INR], and pH) were collected, sequential organ failure assessment and SI scores were calculated. Data were statistically processed with 95% confidence interval and $p<0.05$ significance in relation to survival.

RESULTS: Patient survival rate was 95%. Abdominal and gastrointestinal surgeries constituted 47% of the cases. The most frequent comorbidities were cardiovascular and pulmonary diseases. In statistical analyses, neither surgery type nor associated medical condition was related to patient outcome. The mean LOS was 2.3 days. The mean MV length was about 23 h and significantly shorter in survived patients ($p<0.001$, $t=-7.5$). The higher post-op Hb levels were related to the higher survival ($p=0.020$, $t=2.4$). Post-op higher INR levels were found as a negative prognostic factor for survival ($p=0.025$, $t=-2.3$). Both pre-op and post-op pH levels were significantly related to patient survival ($p=0.001$, $t=1.9$ and $p<0.001$, $t=7.1$). The lower post-op SI scores were predictive to the shorter MV lengths ($p=0.010$, $t=1.9$). A significant relation was presented between lower pre-op and especially post-op SI scores and patients' survival ($p=0.001$, $t=-1.6$ and $p=0.001$, $t=-2.9$).

CONCLUSION: This study presented that SI scores successfully predicted patients' survival in ICU admitted eSurg patients. We believe that the SI forgotten in the dusty shelves of the literature does not get the importance it deserves. SI is a simplistic, reliable, and highly cost-effective assessment tool. Larger prospective RCTs should be planned to assess feasibility and reliability of SI in different patient populations.

Keywords: Emergency surgery; shock index; survival.

INTRODUCTION

The shock index (SI) concept was first introduced by Allgöwer and Burri in 1967 to assess circulatory status of patients in emergency conditions.[1] It was a simple physiologic score that was obtained from patients' heart rate (beat per min)/systolic blood pressure (mmHg). Roughly as a basic repeatable rule, cutoff value of 1< is assumed as a worsening condition.[2] It has been suggested for hemorrhagic shock, sepsis, trauma, and emergency triages too.[3–5] A modified form was

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also proposed as more predictive in case of geriatric populations, in that SI was multiplied by patients' age (age.SI).[4] SI has also been evaluated in some cardiovascular and pulmonary conditions.[6,7]

SI has gained popularity in the 90s, then lost favor probably due to trends of novo and complex parameters introduced by technological improvements.[8] It was not to blame that scientist was looking for more precise parameters for predictions. On the other hand, newer purposed parameters and score calculations have challenges such as complexity and feasibility, cost-effectivity issues, and are time consuming, especially in case of emergency situations. Thereafter, SI recently has regained attention.[5,9,10] SI is a feasible and valuable parameter to assess patient outcomes, and solely cost effective that we believe that it deserves more concern.

Essentially, SI has worked well in emergency situations. Therefore, in this study, we planned to test SI ability to indicate the outcome in postoperatively intensive care unit (ICU)-admitted emergency surgery (eSurg) patients. SI levels were calculated in both pre-operative (pre-op) and post-operative (post-op) period, and outcome was defined as 28-day survival.

MATERIALS AND METHODS

Design and Settings

This study was conducted in Trakya University Training and Research Hospital (TUH). TUH has been serving as a regional referral hospital for advanced and complicated cases. It has 1000 ward-based bed capacity, 15 operation theater rooms, performing 15.000–17.000 annual operations and about 5–10% of them constitutes emergency operations (750–1.700). TUH has six mixed-type (medical/surgical) tertiary degree ICU clinics that each has 10-bed capacity. Patients who require ICU admission are admitted according to bed availability in any of six ICUs. In this study, data of two ICU wards (20 beds) were processed.

The study was designed as a retrospective cohort. Medical records (MRs) of patients who were admitted to ICU after an eSurg between January 1, 2017, and December 31, 2019, were retrospectively scanned in hospital software database. The exclusion criteria were patients age <18 and >90, elective surgeries, no written consents, missing data, and lost to follow-up to 28 days.

Data Collection

The primary: Patients age, gender, surgery type, associated medical comorbidity, post-op ICU mechanic ventilatory (MV) support duration (MV length) hours, ICU length of stay (LOS) days, and 28-day survival status were collected. Surgery types were classified under subheadings of that gastrointestinal system (GIS), central nervous system, orthopedics, obstetrics-gynecologic, urologic, abdominal (liver, spleen, and pancreas), multiple trauma, and thorax surgeries. Comorbidity statuses were subclassified under subheadings of that cardiovascular, pulmonary, nephrological, other, and non. Survival was defined as that home discharge before 28 days or in hospital survival on 28 days.

The secondary: Patients pre-op and post-op selected laboratory parameters (hemoglobin [Hb], platelet count [PLT], international normalized ratio [INR], and arterial blood gas pH), sequential organ failure assessment (SOFA), SI, and age. SI scores were collected. Pre-op values were readings just before the operation, and post-ops were readings at the time of ICU admission. Totally administered blood product (erythrocyte, PLT, plasma, cryoprecipitate, etc.) and intravenous fluid volumes (balanced, hypo- or hyper-tonic, volume expanders, etc.) during intraoperative period were also calculated and noted.

Outcome Measures

The primary hypothesis of this study was that pre-op and post-op SI values predicted 28-day patient outcome and related to MV length and LOS, in eSurg patients who were postoperatively admitted to ICU.

Statistical Analyses

Data were presented as mean ± standard deviation, frequency, and percentage or min-max values when appropriate. After notable correlations were checked by correlations analyses, main comparisons were proceeded by t-tests. Repeated measures and regression analyses were conducted. All tests were two tailed with 95% confidence intervals and $p<0.05$ was deemed statistically significant. Statistical analyses were performed by SPSS statistical software program (IBM® SPSS® Statistics ver25, Ill, USA, 2017).

Ethical Aspects

The approval was received from local bioethical board. Written informed consents for "processing and publishing personal medical data for scientific purposes" had been obtained at ICU admissions (institutional policy) from patients or legally authorized surrogates when patients were intubated, ventilated, unconscious, or sedated.

RESULTS

MRs of included 182 patients were processed. Patient age, gender, surgery types, and associated medical comorbidities are presented in Table 1. Mean patient ages and male/female ratios were similar. Survival rate was about 95%. Abdominal and GIS surgeries constituted 47% of the cases, and the most frequent comorbidities were cardiovascular and pulmonary conditions, while one-third of the patients had no recorded comorbidity. In statistical analyses, neither surgery type nor associated medical condition was related to patient outcome.

Table 1. Patients' general characteristics, surgery types, and medical comorbidities, presented as frequencies (n)

Characteristics	All	Survived	Ex
Total	182	172	10
Age (mean±SD)	61±17	61±17	59±20
Male/female	94/88	88/84	6/4
Surgery type			
GIS	78	72	6
CNS	34	34	–
Orthopedics	26	26	–
Obs.-Gyn.	16	16	–
Urologic	10	10	–
Abdominal	8	8	–
Multiple trauma	6	2	4
Thorax	4	4	–
Medical comorbidity			
Cardiovascular	60	58	2
Pulmonary	26	22	4
Nephrological	12	12	0
Other	26	24	2
Non	58	56	2

GIS: Gastrointestinal system; CNS: Central nervous system; Obs.-Gyn.: Obstetrics gynecology; Abdominal: Liver, spleen, pancreas; SD: Standard deviation.

Pre-op and post-op laboratory values and clinical scores of patients are presented in Table 2. In statistical comparisons, pre-op Hb levels were similar, while post-op Hb levels were significantly related to patient survival. Changes in PLT levels did not show any statistical correlation with patient survival. Increased post-op INR levels were related to mortality. The reason for this effect could be progression of organ (e.g., liver) dysfunction, intraoperative massive replacements, or insult itself that required surgery. Both pre-op and post-op pH readings were significantly related to patient survival. The low pH levels were assessed as a reflection of worse metabolic/respiratory compensation that led mortality. Calculated pre-op SOFA scores were similar. On the other hand, post-op SOFA scores of survived patients were significantly lower.

As the primary hypothesis of this study, the lower pre- and especially post-op SI scores were significantly correlated with the higher patients' survival. That relation was not shown by age.SI.

Intraoperative fluid replacement volumes were not different between groups nor related to survival (Table 3). On the other hand, mortality was significantly related to higher intraoperative blood product replacements. The mean MV length was about 23 h and significantly shorter in survived patients. The mean LOS was 2.3 days, and this was significantly shorter in survived patients, although min-max ranges were similar. The shorter MV hours and LOS were both related to better outcomes, possibly indicated to benefits of early extubation and discharge when possible. The lower post-op SI levels were significantly related to the shorter MV lengths (p=0.010, t=1.9).

DISCUSSION

In this study, we objected to test a hypothesis that peri-operative SI values could predict 28-day survival in eSurg patients who were postoperatively admitted to ICU. Evaluation of 182 patients' data was supported this hypothesis. In subgroup analysis, neither eSurg type nor associated medical comorbidity influenced the outcome.

Although, it is justifiable to suspect on reliability of SI that physiologic alterations, fitness status, used cardiac medications, etc., may alter it, studies on trained athletes, healthy blood donors, or chronic cardiac conditions have showed the credibility of SI.[11–13] The SI should be concerned especially in emergency conditions that require urgent interventions, when losing time by waiting for laboratory results is critical for patient survival. It is also valid for triage decisions. One should also note that most of SI studies have been on surgical situations, and dependability of SI in medical conditions is limited yet, and need to be evaluated.[10] On the other hand, it was purposed as a useful tool for emergency triage of medical patients, too.[5,10,14]

The value of SI in geriatric population was also debated, against proposed age.SI modifications.[15] Age modified SI levels were not correlated to patient survival in our study. This can be due to the mean age of our sample was about 60s and that cannot be accounted as a geriatric population. The age.SI score could gain a better performance in advanced ages, as in Pandit et al.[15] study, the reported mean age was 77.

Delta SI was recently proposed by Kim et al.[9] but that was not found predictive. Herein, we could propose that pre-op SI values could be beneficial in triage and decision for an urgent intervention, and then, post-op SI values could be useful to predict outcome, thus to intensify therapeutic approaches, such as alerting massive transfusion protocols as Vandromme et al.[16] mentioned.[17]

SI has been evaluated in cardiac situations that showed promising predictive ability on patient survival.[18–20] In respect of cardiac studies and our findings; (1) lower intraoperative blood product requirements, (2) higher post-op Hb levels, and (3) higher pH levels were related to better outcomes, those were indicators of a better metabolic, cardiovascular, and perfusion status. We believe that all those parameters are successfully reflected and predicted by SI levels.[21,22]

Noticed that our study had some limitations. First, retrospective design was a weakness, vulnerable to recall, and al-

Table 2. Presentation of patients' pre-/post-operative laboratory and clinic parameters

	All (n=182)	Survived (n=172)	Ex (n=10)	Statistics
Laboratory				
Hemoglobin				
Pre-op	11.8±1.6	11.8±1.6	12.14±2.3	–
Post-op	11.1±1.6	11.2±1.5	9.5±2.0	p=0.020, t=2.4
Platelet count, read as x1000 (K)				
Pre-op	256±128	257±130	245±95	–
Post-op	224±105	228±105	152±75	–
International normalized ratio				
Pre-op	1.23±0.30	1.22±0.29	1.38±0.53	–
Post-op	1.24±0.29	1.22±0.27	1.51±0.40	p=0.025, t=-2.3
pH				
Pre-op	7.375±0.095	7.380±0.082	7.296±0.226	p=0.001, t=1.9
Post-op	7.379±0.071	7.389±0.048	7.202±0.151	p<0.001, t=7.1
Clinical				
Sequential organ failure assessment				
Pre-op	3.40±2.50	3.36±3.78	4.00±3.39	–
Post-op	2.24±1.99	2.16±1.85	3.60±3.78	p=0.025, t=-1.6
Shock index				
Pre-op	0.62±0.21	0.61±0.18	0.76±0.53	p=0.001, t=-1.6
Post-op	0.76±0.42	0.72±0.18	1.6±1.57	p=0.001, t=-2.9
Shock index multiplied by age				
Pre-op	36.4±13.6	36.3±13.9	37.5±8.9	–
Post-op	44.1±16.2	43.6±15.9	52.8±22.1	–

Values were presented as mean±standard deviation and statistically compared by t-tests.

Table 3. presentation of intra-operative volume replacements and intensive care unit follow-up measures (mean±standard deviation) of patients and statistical comparisons (t-tests)

	All samples	Survived	Ex	Statistics
Volume replacements				
Fluid	4658±2526	4661±2526	4600±2819	–
Blood products	1398±2882	1191±1488	4960±11091	p<0.001, t=-3.0
Follow-up				
Mechanical ventilation support length (hours)	23 (1–636)	11 (1–197)	230 (24–636)	p<0.001, t=-7.5
Length of stay (days)	2.3 (1–28)	1.8 (1–23)	10.8 (1–28)	p<0.001, t=-5.2

location bias, and credibility of recordings could be criticized. Therefore, we tried to exclude inconvincible or missing data as possible. A wider range of laboratory and clinical parameters was not taken into analyses. Because only vital and mandatory parameters were noted in MRs that were required in course of eSurg. After all, it was not possible to exclude possible confounders by multivariate analyses. SOFA scores, rather than specific trauma or surgical scores, could be debatable for our surgical patient sample, although a statistical significance was shown. In addition, we did not define cutoff values for SI to test for predictivity. Because, it could have been misleading to set it, due to small sample size, and mortality number was quite low to proceed 2×2 contingency or ROC curve calculations. Consecutive and repetitive SI calculations would have been better and more precise. Finally, only eSurg patients admitted to ICU were included into this

study. The other patients who were not admitted to ICU and elective surgeries were not considered. We believe that these criticized limitations would give some clues and provide guidance for planning more precise future studies on SI as a promising and feasible predictor.

Conclusion

This study presented that SI scores successfully predicted patients' survival in ICU admitted eSurg patients. We believe that the SI forgotten in the dusty shelves of the literature does not get the importance it deserves. SI is a simplistic, reliable, and highly cost-effective assessment tool. Larger prospective RCTs should be planned to assess feasibility and reliability of SI in different patient populations.

Ethics Committee Approval: This study was approved by the Trakya University Faculty of Medicine Ethics Committee (Date: 23.11.2020, Decision No: 19/01).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Şok indeksinin yoğun bakıma yatan acil cerrahi hastalarında hayatta kalımı öngörebilme becerisi: Geriye dönük bir kohort çalışması

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AMAÇ: Kalp hızının sistolik kan basıncına oranı olarak tanımlanan "şok indeksi", acil durumlardaki hastaların dolaşım yetersizliğine işaret eden basit ve güvenilir bir göstergedir. Hemorajik şok, sepsis, travma ve acil triajda etkinliği gösterilmiştir. Bu çalışma, şok indeksinin acil cerrahi sonrası yoğun bakıma yatan hastalarda 28 günlük sağ kalımı öngörebilme kabiliyetini incelemek amacıyla planlanmıştır.

GEREÇ VE YÖNTEM: Çalışma bir üniversite hastanesinin 20 yataklı yoğun bakım kliniğinde yürütüldü. 1 Ocak 2017–31 Aralık 2019 tarihleri arasında, acil cerrahi sonrası yoğun bakıma yatan hastaların kayıtları geriye dönük olarak tarandı. Yaşı <18 ve >90 olanlar, elektif cerrahiler, verilerinin kullanımı için yazılı onamı bulunmayanlar, verileri veya takibi eksik olan hastalar çalışma dışı tutuldu. Hastaların yaşı, cinsiyeti, cerrahi türü, eşlik eden medikal durumları, yoğun bakım mekanik ventilatör süreleri, yatış süreleri ve 28 günlük sağ kalımları kaydedildi. Seçilmiş ameliyat öncesi ve sonrası laboratuvar parametreleri (Hb, PLT, INR, pH) toplandı, SOFA skor ve şok indeksleri hesaplandı. Veriler sağ kalım ile ilişkileri açısından, %95 güven aralığı ve p<0.05 anlamlılık düzeyleri kullanılarak, istatistiksel olarak karşılaştırıldı.

BULGULAR: Hastaların sağ kalım oranı %95 idi. Abdominal and gastrointestinal cerrahiler olguların %47'sini oluşturmaktaydı. En sık eşlik eden tıbbi durumlar kardiyovasküler ve pulmoner hastalıklardı. İstatistiksel analizlerde, cerrahi türü veya eşlik eden tıbbi hastalıkların sonlanım üzerine bir etkisi gösterilmedi. Hastaların ortalama yatış süresi 2.3 gündü. Ortalama mekanik ventilatör süresi 23 saat olup, sağ kalan hastalarda bu süre belirgin olarak daha kısaydı (p<0.001, t=-7.5). Ameliyat sonrası yüksek Hb düzeyleri sağ kalım ile ilişkiliydi (p=0.020, t=2.4). Ameliyat sonrası INR yüksekliği sağ kalım için negatif bir belirteçti (p=0.025, t=-2.3). Hem ameliyat öncesi hem de sonrası pH düzeyleri önemli ölçüde sağ kalım belirleyicisiydi (p=0.001, t=1.9 ve p<0.001, t=7.1). Ameliyat sonrası şok indeksi değerlerinin düşük olması mekanik ventilatör süresinin kısa olacağına işaret etmekteydi (p=0.010, t=1.9). Şok indeksinin Ameliyat öncesi ve özellikle de ameliyat sonrası dönemde düşük olması ile sağ kalım arasında belirgin bir ilişki gösterildi (p=0.001, t=-1.6 ve p=0.001, t=-2.9).

TARTIŞMA: Bu çalışma, yoğun bakıma yatan acil cerrahi hastaların "şok indeksi" değerlerinin hasta sağ kalımını öngörmede oldukça başarılı olduğunu ortaya koymaktadır. Biz, literatürün tozlu raflarında unutulmuş olan "şok indeksinin" hak ettiği önemi göremediğine inanmaktayız. Şok indeksi basit, kullanışlı, güvenilir ve maliyet etkinliği oldukça yüksek bir değerlendirme yöntemidir. Farklı hasta gruplarında şok indeksinin uygulanabilirliğini ve güvenilirliğini değerlendirecek, daha geniş, ileriye yönelik randomize kontrollü çalışmaların planlanmasına ihtiyaç vardır.

Anahtar sözcükler: Acil cerrahi; sağ kalım; şok indeksi.

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