Admission Shock Index Predicts Short-Term, All-Cause In-Hospital Mortality in Patients with Acute Aortic Dissection and Intramural Hematoma

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Research Article

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Abstract

Background

Acute aortic syndrome, mainly involving aortic dissection (AD) and intramural hematoma (IMH), is a life-threatening emergency with high mortality. Shock index (SI) well predicts poor outcomes of severely ill patients, but the ability of SI to prognose acute AD and IMH patients is not well known. This study aimed to investigate the association of admission SI with the 30-day, all-cause in-hospital mortality in acute AD and IMH patients.

Methods

This is a retrospective and single-center cohort study. According to Stanford classification, firstly, we showed the baseline characteristics in acute AD and IMH patients. Univariate and multivariate methods were used to evaluate the association between SI and the in-hospital mortality of acute AD and IMH. Then, patients were divided into two groups by their SIs (SI<0.7 vs SI≥0.7) based on previous studies and survival analysis was made by Kaplan-Meier method and log-rank test.

Results

This study involved 1250 consecutively recruited Chinese patients diagnosed with acute AD or IMH (Stanford A: 553 (44.2%); Stanford B: 697 (55.8%)). The 30-day, all-cause in-hospital mortality of Stanford A AD and IMH patients was 23.1% (128/553) but was 4.7% (33/697) for Stanford B AD and IMH patients. The SI significantly increased the risk of 30-day, all-cause in-hospital mortality in AD and IMH patients (Stanford A: HR 3.941, 95%CI 2.350-6.612, p<0.001; Stanford B: HR 42.213, 95%CI 8.172-218.052, p<0.001). After multivariate adjustments, the significances remained (Stanford A: HR 1.902, 95%CI 1.050-3.444, p=0.034; Stanford B: HR 21.581, 95%CI 3.818-121.969, p=0.001). The cumulative survival was significantly lower in the SI≥0.7 group than that in the SI<0.7 group (Stanford A: 61.3% vs 73.6%, p=0.0007; Stanford B: 80.5% vs 95.0%, p<0.0001). In the subgroup analysis, for those patients without surgery or TEVAR, the in-hospital mortality in the SI≥0.7 group was significantly higher than that in the SI<0.7 group (Stanford A: 52.5% vs 32.1%, p=0.003; Stanford B: 19.6% vs 4.0%, p<0.001).

Conclusion

Increased admission SI can serve as a good predictor of the 30-day, all-cause in-hospital mortality in patients with acute AD and IMH, especially for the patients without surgery or TEVAR.

Background

Acute aortic syndrome (AAS) poses a life-threatening emergency with high mortality, including aortic dissection (AD), intramural hematoma (IMH), penetrating atherosclerotic ulcers and aortic rupture [1, 2]. Notably, the vast majority of AAS patients are those with AD and IMH, accounting for 80% and 15%, respectively [1]. According to the recommendations of the 2014 ESC guidelines on the diagnosis and treatment of aortic diseases [2], strictly controlling heart rate and blood pressure is the fundamental principle for treating AD and IMH. Also, heart rate and blood pressure are well established as important predictive factors for the prognosis of AD [3, 4], and they are physiologically linked to each other [5]. Probably, a combination of heart rate and blood pressure can better predict the outcomes of AD and IMH.

Shock index (SI), defined as heart rate divided by systolic blood pressure (SBP) [6], is a good indicator for evaluating the seriousness of patients with hemorrhage, and the increase of SI proportionally responds to progressive loss of circulating blood volume [7, 8], but now, plenty of studies demonstrate that SI plays an important role in evaluating the poor outcomes of severely ill patients, such as those with ruptured abdominal aortic aneurysm [9], stroke [5, 10], acute myocardial infarction [11-14], pulmonary embolism [15, 16], and severe sepsis [17, 18]. However, it is not well known whether SI is associated with the poor prognosis of acute AD and IMH patients. This study aimed to explore the utility of admission SI for evaluating short-term in-hospital mortality in patients with acute AD and IMH.

Materials And Methods

Study population

This is a retrospective cohort study involving 1255 consecutively recruited Chinese patients diagnosed with acute AD or IMH from January 2015 to December 2020 in the First Affiliated Hospital of Shantou University Medical College in Shantou, China. The diagnosises of AD and IMH were confirmed with computed tomographic angiography of the aorta. Then we applied the Stanford classification standard to determine the types of AD and IMH. According to the computed tomographic angiography of the aorta, the Stanford A AD or IMH was defined as an intimal tear or hematoma involving the ascending aorta, whereas Stanford B AD or IMH lacked the tear or hematoma. Demographic and clinical data included gender, age, first admission SBP, first admission diastolic blood pressure (DBP), first admission heart rate, histories of hypertension and diabetes mellitus, presence of ascending aorta or aortic arch replacement surgery (surgery) or thoracic endovascular aortic repair (TEVAR), smoker status, serum creatinine (Cr), hemoglobin (HGB), uric acid (UA), low-density lipoprotein (LDL), all-cause death and length of hospitalization. Five patients were excluded for missing the data for blood pressure (4) or type of Stanford classification (1). Finally, 1250 patients were used for statistical analysis (Figure 1). After admission to hospital, the best medication therapies were administered to all patients based on their individual requirements. This study was approved by the Research Ethics Committee of the First Affiliated Hospital of Shantou University Medical College (No. B-2020-195) and data collection and analysis were conducted anonymously. Informed consent was waived due to the nature of the retrospective study.

Statistical analysis

The baseline characteristics are represented by mean ± standard deviation or median (interquartile range) for continuous variables and percentage for categorical variables. For quantitative data, the distributions were assessed by the histograms. Patients were categorized into surviving or non-surviving groups according to the outcomes within 30 days after hospitalization. The Mann-Whitney U test was used for the comparisons of two groups of continuous variables without normality and the chi-square was used for the comparisons of categorical variables.

SI was defined as the ratio of admission heart rate and SBP. Proportions of missing data about LDL, UA, serum creatinine and smoker status in the non-surviving group were much higher. So, we did not delete this data to avoid bias, and multiple imputation with 5-fold imputations was used to impute the missing data for covariates to account for possible confounders. Univariate and multivariate Cox proportional hazards models were performed to identify which variables were the independent risk factors or the protective factors associated with the 30-day all-cause mortality in the hospital. Then, patients were divided into two groups according to their SIs (SI<0.7 vs

SI≥0.7) based on previous studies [5, 11, 12, 19], and the cumulative survival was calculated by Kaplan-Meier method, and the difference of groups (SI<0.7 vs SI≥0.7) was compared by log-rank test. Subgroup analysis was conducted to define the difference of in-hospital mortality between the SI<0.7 group and SI≥0.7 group for Stanford A AD and IMH with surgery or not and for Stanford B AD and IMH with TEVAR or not.

All statistical tests were 2-tailed, and p-values <0.05 indicated statistical significance. All statistical analysis were carried out using SPSS statistical software (Version 26.0, SPSS Inc., Chicago, Illinois). And the survival curve, bar chart and forest plot were constructed using GraphPad Prism version 9.2.0 for MacOS (GraphPad Software, San Diego, California USA, www.graphpad.com).

Results

1. Baseline characteristics of the study population

This retrospective cohort study recruited 1255 consecutive Chinese patients diagnosed with acute AD or IMH, from January 2015 to January 2020 in the First Affiliated Hospital of Shantou University Medical College. Five patients were excluded for missing data regarding blood pressure (4) and type of Stanford classification (1). Finally, 1250 patients were used for statistical analysis, and were comprised of 553 (44.2%) Stanford A AD and IMH patients and 697 (55.8%) Stanford B AD and IMH patients. In the Stanford A AD and IMH group, there were 159 females (28.8%), the average age was 59.4 years old, and 23.1% (128/553) patients died in the hospital within the 30-day follow-up time. In the Stanford B AD and IMH group, the female proportion, average age, and mortality were respectively 18.2% (127/697), 61.8 years old, and 4.7% (33/697). Admission SI in the non-surviving group was significantly higher than that in the surviving group, regardless of the Stanford classification (Stanford A: 0.66 vs 0.55, p=0.001; Stanford B: 0.61 vs 0.50, p=0.009). Furthermore, the average age, proportion of AD, SBP, DBP, Cr, LDL, UA and receipt of surgery were different in Stanford A AD and IMH. But in Stanford B AD and IMH, the differences were in proportion of AD, DBP, heart rate, Cr, HGB, and UA. In all acute AD and IMH patients, the time in hospital was much shorter for the non-surviving group (Table 1).

2. Association of SI at admission with the risk of 30-day, all-cause mortality in acute AD and IMH patients.

Admission SI had a 3.9-fold increased risk of 30-day, all-cause in-hospital mortality for Stanford A AD and IMH patients (HR 3.941, 95%CI 2.350-6.612, P<0.001), but a 42.2-fold increased risk for Stanford B AD and IMH patients (HR 42.213, 95%CI 8.172-218.052, P<0.001), as determined by univariate Cox proportional hazards models (Supplemental Table 1). After multivariate adjustments, these significant associations remained (Stanford A: HR 1.902, 95%CI 1.050-3.444, p=0.034; Stanford B: HR 21.581, 95%CI 3.818-121.969, p=0.001) (Table 2).

Based on the previous studies, a relatively normal SI ranges from 0.5 to 0.7, and an SI≥0.7 is a good predictor for the poor prognosis of seriously ill patients [12, 19]. So, we stratified SI into SI<0.7 and SI≥0.7 and found that the cumulative survival was significantly lower in the SI≥0.7 group than that in the SI<0.7 group (Stanford A: 61.3% vs 73.6%, p=0.0007; Stanford B: 80.5% vs 95.0%, p<0.0001) (Figure 2).

3. Subgroup analysis: associations of admission SI with 30-day, all-cause in-hospital mortality in acute AD and IMH patients with surgery/TEVAR or not.

In the subgroup analysis, the 30-day, all-cause in-hospital mortality in the SI≥0.7 group was higher than that in the SI<0.7 group (Stanford A: 34.3% vs 20.5%, p=0.003; Stanford B: 15.2% vs 3.6%, p=0.001). And for the patients with

surgery (Stanford A AD and IMH) or TEVAR (Stanford B AD and IMH), there was no significant difference in the in-hospital mortality, regardless of the SI strata (Stanford A AD and IMH with surgery: 10.9% vs 7.2%, P=0.595; Stanford B AD and IMH with TEVAR: 5.0% vs 2.9%, P=0.484) (Figure 3 or Supplement Table 2). However, for the patients without surgery or TEVAR, the in-hospital mortality in the SI≥0.7 group was significantly higher than that in the SI<0.7 group (Stanford A AD and IMH with non-surgery: 52.5% vs 32.1%, p=0.003; Stanford B AD and IMH with non-TEVAR: 19.6% vs 4.0%, p<0.001).

Discussion

This study investigated the prognostic value of admission SI in patients with acute AD and IMH and obtained several important findings. First, admission SI is associated with short-term, all-cause in-hospital mortality of acute AD and IMH patients. Second, after multivariate adjustments, admission SI was still an independent risk factor for predicting the 30-day, all-cause in-hospital mortality. Third, for patients with a high risk of mortality (SI≥0.7), timely surgery or TEVAR will improve the unfavorable 30-day, in-hospital outcomes.

AD and IMH are life-threatening aortic diseases with high mortality due to potentially fatal complications. A previous study indicates that the early mortality of acute AD is about 1-2% per hour once symptoms occur [20]. Some studies found that the hospitalization mortality is between 20% and 30% in patients with acute AD [20, 21]. Separately, the inpatient mortality for Stanford B AD, about 10% in a recent Japanese nationwide survey [22], is much lower than that for Stanford A AD (up to 32.5%) [23]. According to the analysis from the International Registry of Acute Aortic Dissection, the in-hospital mortalities of Stanford A AD and IMH patients are 26.5% and 26.6% separately, and that are 11.1% and 4.4% for Stanford B AD and IMH patients [24]. However, the difference of mortality from AD and IMH did not reach statistical significance [24]. And in the present study, the in-hospital mortalities for Stanford A and Stanford B AD and IMH are 23.1% and 4.7% respectively, which are a little bit lower than that publicized by previous studies [22-24]. These improved mortalities might be associated with the increased ability of quick diagnose with AAS and obtaining more effective treatments both medication and surgery or TEVAR. However, the long-term outcomes of Stanford B AD are not necessarily better than that of Stanford A AD [25, 26]. Stanford B AD is also associated with a high mortality rate (~20% at 3 years [26]) and a high morbidity rate (~30% morbidity at 2 years) in the long term [27, 28]. Thus, quick patients screening is so important for acute AD and IMH that we could provide the optimal interventions as early as possible, including not only medical therapy but also surgery or TEVAR.

In 1967, the concept of SI was first proposed as a simple and effective index to evaluate the degree of hypovolemia in hemorrhage and infectious shock states [6]. A previous study has shown that SI is inversely related to blood loss, cardiac index, stroke volume, left ventricular stroke work and mean blood pressure [8], and it provides a non-invasive means to monitor deterioration or recovery of left ventricular stroke work during acute hypovolemic and normovolemic circulatory failure [8]. Elevated SI predicts hemodynamic instability and has been demonstrated to be associated with many critical diseases, such as ruptured abdominal aortic aneurysm [9], stroke [5, 10], acute myocardial infarction [11-14], pulmonary embolism [15, 16], severe sepsis [17, 18], trauma [29], and pneumonia [30, 31]. As a meaningful indicator of predicting pre-hospital or in-hospital risk [5, 9, 11, 13], SI plays an important role in making decisions for treatment of these emergency conditions.

When acute AD or IMH occurs, effective circulating blood volume may decrease, which proportionally lead to hemodynamic instability reflected by a blood pressure decrease and heart rate increase. In the events of accompanying stabbing pain, malperfusion or renal dysfunction, the situation of hemodynamic instability would

further deteriorate, especially with cardiac tamponade and rupture of the aorta. So, as a simple index of representing hemodynamic instability, SI should be associated with the risk of death in acute AD and IMH. And our study confirms this relationship, showing that admission SI predicts the 30-day, all-cause in-hospital mortality in acute AD and IMH. Also, in the subgroup analysis, we found that, for the patients without surgery (Stanford A AD and IMH) or TEVAR (Stanford B AD and IMH), the SI≥0.7 indicated the higher in-hospital mortality. This is a very meaningful finding for guiding clinical practice. According to the strata of SI (<0.7 vs ≥0.7), we can further identify the high-risk patients. Then, to decrease the dying risk, it is necessary to monitor patients much closely and to develop better treatment for them.

Although the sample size of our study is large, some limitations need to be acknowledged. First, this is a retrospective study, which poses a risk of patient selection bias. Second, as a single-center study, our participants cannot represent all patients with acute AD and IMH. In addition, we only investigated the relationship between admission SI and the short-time, in-hospital mortality in acute AD and IMH patients, but we do not know how it arises. Strictly designed multi-center prospective studies are needed to further clarify the pathophysiologic mechanisms.

Conclusion

In conclusion, increased admission SI can serve as a good predictor of the 30-day, all-cause in-hospital mortality in patients with acute AD and IMH, especially for the patients without surgery or TEVAR.

Abbreviations

AAS, acute aortic syndrome; AD, aortic dissection; bpm, beat per minute; CI, confidence interval; Cr, serum creatinine; DBP, diastolic blood pressure; HGB, hemoglobin; HR, hazard ratio; IMH, intramural hematoma; LDL, lower-density lipoprotein; M(IQR), median (interquartile range); SBP, systolic blood pressure; SD, standard deviation; SI, shock index; TEVAR, thoracic endovascular aortic repair; UA, uric acid.

Declarations

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Authors' contributions

XT, XZ designed the study. LH, YC, JT analyzed the data. LH, YC were major contributors in drafting the manuscript. XT, XZ revised the article. SW, QX, JS collected the information of the participants. All authors read the manuscript and approved the final version.

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played no role in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.

Availability of data and materials

The datasets used for the analysis in the current study are available from the corresponding authors on reasonable request.

Ethics approval and consent to participate

The Research Ethics Committee of the First Affiliated Hospital of Shantou University Medical College approved the study (No. B-2020-195) and granted a waiver of consent because of the retrospective nature of the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Morello F, Santoro M, Fargion AT, Grifoni S, Nazerian P: **Diagnosis and management of acute aortic syndromes in the emergency department**. *Intern Emerg Med* 2021, **16**(1):171-181.
2. Erbel R, Aboyans V, Boileau C, Bossone E, Bartolomeo RD, Eggebrecht H, Evangelista A, Falk V, Frank H, Gaemperli O *et al*: **2014 ESC Guidelines on the diagnosis and treatment of aortic diseases: Document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC)**. *Eur Heart J* 2014, **35**(41):2873-2926.
3. Bossone E, Gorla R, LaBounty TM, Suzuki T, Gilon D, Strauss C, Ballotta A, Patel HJ, Evangelista A, Ehrlich MP *et al*: **Presenting Systolic Blood Pressure and Outcomes in Patients With Acute Aortic Dissection**. *J Am Coll Cardiol* 2018, **71**(13):1432-1440.
4. Evangelista A, Isselbacher EM, Bossone E, Gleason TG, Eusanio MD, Sechtem U, Ehrlich MP, Trimarchi S, Braverman AC, Myrmel T *et al*: **Insights From the International Registry of Acute Aortic Dissection: A 20-Year Experience of Collaborative Clinical Research**. *Circulation* 2018, **137**(17):1846-1860.
5. Myint PK, Sheng S, Xian Y, Matsouaka RA, Reeves MJ, Saver JL, Bhatt DL, Fonarow GC, Schwamm LH, Smith EE: **Shock Index Predicts Patient-Related Clinical Outcomes in Stroke**. *J Am Heart Assoc* 2018, **7**(18):e007581.
6. Allgower M, Burri C: **["Shock index"]**. *Dtsch Med Wochenschr* 1967, **92**(43):1947-1950.
7. Olaussen A, Blackburn T, Mitra B, Fitzgerald M: **Review article: shock index for prediction of critical bleeding post-trauma: a systematic review**. *Emerg Med Australas* 2014, **26**(3):223-228.
8. Rady MY, Nightingale P, Little RA, Edwards JD: **Shock index: a re-evaluation in acute circulatory failure**. *Resuscitation* 1992, **23**(3):227-234.
9. Dirks NM, Mestrom MM, van der Lugt MM, van Osch FP, Peters NM, Elshof JM, Barten DM: **Utility of Shock Index for Suspected Rupture of Abdominal Aortic Aneurysms**. *Prehosp Emerg Care* 2020:1-8.

10. McCall SJ, Musgrave SD, Potter JF, Hale R, Clark AB, Mamas MA, Metcalf AK, Day DJ, Warburton EA, Bachmann MO *et al*: **The shock index predicts acute mortality outcomes in stroke**. *Int J Cardiol* 2015, **182**:523-527.
11. Hwang JK, Jang WJ, Song YB, Lima JA, Guallar E, Choe YH, Choi S, Kim EK, Hahn JY, Choi SH *et al*: **Shock Index as a Predictor of Myocardial Injury in ST-segment Elevation Myocardial Infarction**. *Am J Med Sci* 2016, **352**(6):574-581.
12. Huang B, Yang Y, Zhu J, Liang Y, Tan H, Yu L, Gao X, Li J: **Usefulness of the admission shock index for predicting short-term outcomes in patients with ST-segment elevation myocardial infarction**. *Am J Cardiol* 2014, **114**(9):1315-1321.
13. Kobayashi A, Misumida N, Luger D, Kanei Y: **Shock Index as a predictor for In-hospital mortality in patients with non-ST-segment elevation myocardial infarction**. *Cardiovasc Revasc Med* 2016, **17**(4):225-228.
14. Ndrepepa G, Cassese S, Xhepa E, Fusaro M, Laugwitz KL, Schunkert H, Kastrati A: **Association of shock index with short-term and long-term prognosis after ST-segment elevation myocardial infarction**. *Coron Artery Dis* 2019, **30**(8):575-583.
15. Toosi MS, Merlino JD, Leeper KV: **Prognostic value of the shock index along with transthoracic echocardiography in risk stratification of patients with acute pulmonary embolism**. *Am J Cardiol* 2008, **101**(5):700-705.
16. Otero R, Trujillo-Santos J, Cayuela A, Rodriguez C, Barron M, Martin JJ, Monreal M, Registro Informatizado de la Enfermedad Tromboembolica I: **Haemodynamically unstable pulmonary embolism in the RIETE Registry: systolic blood pressure or shock index?***Eur Respir J* 2007, **30**(6):1111-1116.
17. Gupta S, Alam A: **Shock index is better than conventional vital signs for assessing higher level of care and mortality in severe sepsis or shock**. *Am J Emerg Med* 2020.
18. Jayaprakash N, Gajic O, Frank RD, Smischney N: **Elevated modified shock index in early sepsis is associated with myocardial dysfunction and mortality**. *J Crit Care* 2018, **43**:30-35.
19. Berger T, Green J, Horeczko T, Hagar Y, Garg N, Suarez A, Panacek E, Shapiro N: **Shock index and early recognition of sepsis in the emergency department: pilot study**. *West J Emerg Med* 2013, **14**(2):168-174.
20. Zhang J, Jiang Y, Gao C, Feng J, Wang A: **Risk factors for hospital death in patients with acute aortic dissection**. *Heart Lung Circ* 2015, **24**(4):348-353.
21. Golledge J, Eagle KA: **Acute aortic dissection**. *Lancet* 2008, **372**(9632):55-66.
22. Mitsuoka M, Inoue N, Mori S, Matsumoto T, Meguro T: **Renal dysfunction on admission as a predictor for in-hospital mortality of patients with stanford type B acute aortic dissection**. *Ann Vasc Dis* 2013, **6**(3):624-630.
23. Mehta RH, Suzuki T, Hagan PG, Bossone E, Gilon D, Llovet A, Maroto LC, Cooper JV, Smith DE, Armstrong WF *et al*: **Predicting death in patients with acute type a aortic dissection**. *Circulation* 2002, **105**(2):200-206.
24. Harris KM, Braverman AC, Eagle KA, Woznicki EM, Pyeritz RE, Myrmel T, Peterson MD, Voehringer M, Fattori R, Januzzi JL *et al*: **Acute aortic intramural hematoma: an analysis from the International Registry of Acute Aortic Dissection**. *Circulation* 2012, **126**(11 Suppl 1):S91-96.
25. Tsai TT, Evangelista A, Nienaber CA, Trimarchi S, Sechtem U, Fattori R, Myrmel T, Pape L, Cooper JV, Smith DE *et al*: **Long-term survival in patients presenting with type A acute aortic dissection: insights from the International Registry of Acute Aortic Dissection (IRAD)**. *Circulation* 2006, **114**(1 Suppl):I350-356.
26. Tsai TT, Fattori R, Trimarchi S, Isselbacher E, Myrmel T, Evangelista A, Hutchison S, Sechtem U, Cooper JV, Smith DE *et al*: **Long-term survival in patients presenting with type B acute aortic dissection: insights from the**

International Registry of Acute Aortic Dissection. *Circulation* 2006, **114**(21):2226-2231.

27. Akutsu K, Nejima J, Kiuchi K, Sasaki K, Ochi M, Tanaka K, Takano T: **Effects of the patent false lumen on the long-term outcome of type B acute aortic dissection**. *Eur J Cardiothorac Surg* 2004, **26**(2):359-366.
28. Kodama K, Nishigami K, Sakamoto T, Sawamura T, Hirayama T, Misumi H, Nakao K: **Tight heart rate control reduces secondary adverse events in patients with type B acute aortic dissection**. *Circulation* 2008, **118**(14 Suppl):S167-170.
29. McNab A, Burns B, Bhullar I, Chesire D, Kerwin A: **An analysis of shock index as a correlate for outcomes in trauma by age group**. *Surgery* 2013, **154**(2):384-387.
30. Myint PK, Bhaniani A, Bradshaw SM, Alobeidi F, Tariq SM: **Usefulness of shock index and adjusted shock index in the severity assessment of community-acquired pneumonia**. *Respiration* 2009, **77**(4):468-469.

1. Sankaran P, Kamath AV, Tariq SM, Ruffell H, Smith AC, Prentice P, Subramanian DN, Musonda P, Myint PK: **Are shock index and adjusted shock index useful in predicting mortality and length of stay in community-acquired pneumonia?***Eur J Intern Med* 2011, **22**(3):282-285.

Tables

Table 1. **Baseline characteristics of the study participants.**

Variables	All patients (N=1250)	Surviving (n=1089)	Non-surviving (n=161)	P-value
Stanford A AD and IMH, N (%)	553 (44.2)	425 (76.9)	128 (23.1)	
Female, n (%)	159 (28.8)	116 (27.3)	43 (33.6)	0.167 [a]
Age (years), mean ± SD	59.4 ± 12.1	58.7 ± 12.2	61.7 ± 11.5	0.014 [b]
AD, n (%)	440 (79.6)	323 (76.0)	117 (91.4)	<0.001 [a]
Hypertension, n (%)	415 (75.0)	316 (74.4)	99 (77.3)	0.470 [a]
Diabetes, n (%)	35 (6.3)	30 (7.1)	5 (3.9)	0.199 [a]
Smoker, n (%)	318 (58.5)	244 (57.8)	74 (60.7)	0.576 [a]
Missing, n (%)	9 (1.6)			
SBP (mmHg), mean ± SD	147.1 ± 33.6	150.8 ± 31.9	135.0 ± 36.3	<0.001 [b]
DBP (mmHg), mean ± SD	83.4 ± 20.9	85.3 ± 19.9	77.4 ± 23.0	<0.001 [b]
Herat rate (bpm), mean ± SD	79.0 ± 18.4	78.8 ± 17.6	79.8 ± 20.8	0.577 [b]
Cr (μmol/L), mean ± SD	148.7 ± 107.6	138.7 ± 102.0	181.2 ± 118.7	0.001 [b]
Missing, n (%)	44 (8.0)	36 (8.5)	8 (6.3)	
LDL (mmol/L), mean ± SD	2.91 ± 0.76	2.96 ± 0.75	2.70 ± 0.77	0.004 [b]
Missing, n (%)	105 (19.0)	66 (15.5)	39 (30.5)	
UA (mmol/L), mean ± SD	433.5 ± 138.2	419.2 ± 132.2	492.7 ± 147.5	<0.001 [b]
Missing, n (%)	111 (20.1)	69 (16.2)	42 (32.8)	
HGB, mean ± SD	122.1 ± 16.9)	122.0 ± 16.7)	122.6 ± 17.5	0.735 [b]
Missing, n (%)	49 (8.9)	41 (9.6)	8 (6.3)	
Surgery, n (%)	254 (45.9)	234 (55.1)	20 (15.6)	<0.001 [a]
SI, mean ± SD	0.57 ± 0.23	0.55 ± 0.18	0.66 ± 0.34	0.001 [b]
Follow-up time (days), M (IQR)	12 (18)	15 (16)	1 (3)	<0.001 [c]
Stanford B AD and IMH, N (%)	697 (55.8)	664 (95.3)	33 (4.7)	
Female, n (%)	127 (18.2)	122 (18.4)	5 (15.2)	0.640 [a]
Age (years), mean ± SD	61.8 ± 12.5	61.7 ± 12.4	63.9 ± 14.5	0.312
AD, n (%)	422 (60.5)	396 (59.6)	26 (78.8)	0.028 [a]

Hypertension, n (%)	577 (82.8)	548 (82.5)	29 (87.9)	0.427 [a]
Diabetes, n (%)	70 (10.0)	67 (10.1)	3 (9.1)	0.850 [a]
Smoker, n (%)	461 (66.6)	440 (66.8)	21 (63.6)	0.710 [a]
Missing, n (%)	5 (0.7)			
SBP (mmHg), mean ± SD	163.5 ± 33.2	164.0 ± 32.8	152.9 ± 40.1	0.061 [b]
DBP (mmHg), mean ± SD	94.9 ± 19.7	95.3 ± 19.6	88.2 ± 21.2	0.045 [b]
Herat rate (bpm), mean ± SD	79.3 ± 14.7	79.0 ± 14.5	86.2 ± 17.5	0.006 [b]
Cr (μmol/L), mean ± SD	141.5 ± 147.3	138.1 ± 146.8	209.5 ± 142.6	0.007 [b]
Missing, n (%)	22 (3.2)	21 (3.2)	1 (3.0)	
LDL (mmol/L), mean ± SD	3.03 ± 0.77	3.04 ± 0.76	2.98 ± 0.88	0.704 [b]
Missing, n (%)	36 (5.2)	32 (4.8)	4 (12.1)	
UA (mmol/L), mean ± SD	408.6 ± 123.6	405.7 ± 122.4	473.1 ± 134.2	0.004 [b]
Missing, n (%)	34 (4.9)	30 (4.5)	4 (12.1)	
HGB, mean ± SD	123.1 ± 20.2	123.7 ± 19.9	111.4 ± 22.3	0.001 [b]
Missing, n (%)	56 (8.0)	54 (8.1)	2 (6.1)	
TEVAR, n (%)	225 (32.3)	218 (32.8)	7 (21.2)	0.164 [a]
SI, mean ± SD	0.51 ± 0.14	0.50 ± 0.14	0.61 ± 0.23	0.009 [b]
Follow-up time (days), M (IQR	12 (9)	12 (10)	2 (4)	<0.001 [c]

Data are presented as mean ± SD, M (IQR) or number (percentage).

[a] Pearson chi-square test, [b] independent samples t-test, [c] Mann-Whitney U test.

Abbreviations: AD, aortic dissection; bpm, beat per minute; Cr, serum creatinine; DBP, diastolic blood pressure; HGB, hemoglobin; IMH, intramural hematoma; LDL, lower-density lipoprotein; M(IQR), median (interquartile range); SBP, systolic blood pressure; SD, standard deviation; SI, shock index; TEVAR, thoracic endovascular aortic repair; UA, uric acid.

Table 2. **Associations of SI with the 30-day, all-cause in-hospital mortality in acute AD and IMH patients.**

Independent variable	Stanford A		Stanford B	
	HR (95%CI)	HR (95%CI)	HR (95%CI)	HR (95%CI)
SI	3.941 (2.350-6.612) ***	1.902 (1.050-3.444) *	42.213 (8.172-218.052) ***	21.581 (3.818-121.969) **
Age		1.013 (0.997-1.028)		
IMH (vs AD)		0.188 (0.099-0.356) ***		0.377 (0.159-0.892) *
Surgery		0.091 (0.054-0.153) ***		
TEVAR				0.397 (0.166-0.950) *
Cr		1.001 (0.999-1.003)		1.001 (0.999-1.002)
HGB				0.989 (0.975-1.004)
UA		1.002 (1.001-1.004) **		1.002 (1.000-1.004) *
LDL		0.815 (0.617-1.078)		

Values are based on univariate or multivariate Cox proportional hazards models (ENTER method). Results are shown as the HR (95% CI). Statistical significance is indicated when the 95% CI does not contain 1. *P<0.05, **p<0.01, ***p<0.001.

Abbreviations: AD, aortic dissection; CI, confidence interval; Cr, serum creatinine; HGB, hemoglobin; HR, hazard ratio; IMH, intramural hematoma; LDL, lower-density lipoprotein; SI, shock index; TEVAR, thoracic endovascular aortic repair; UA, uric acid.

Figures

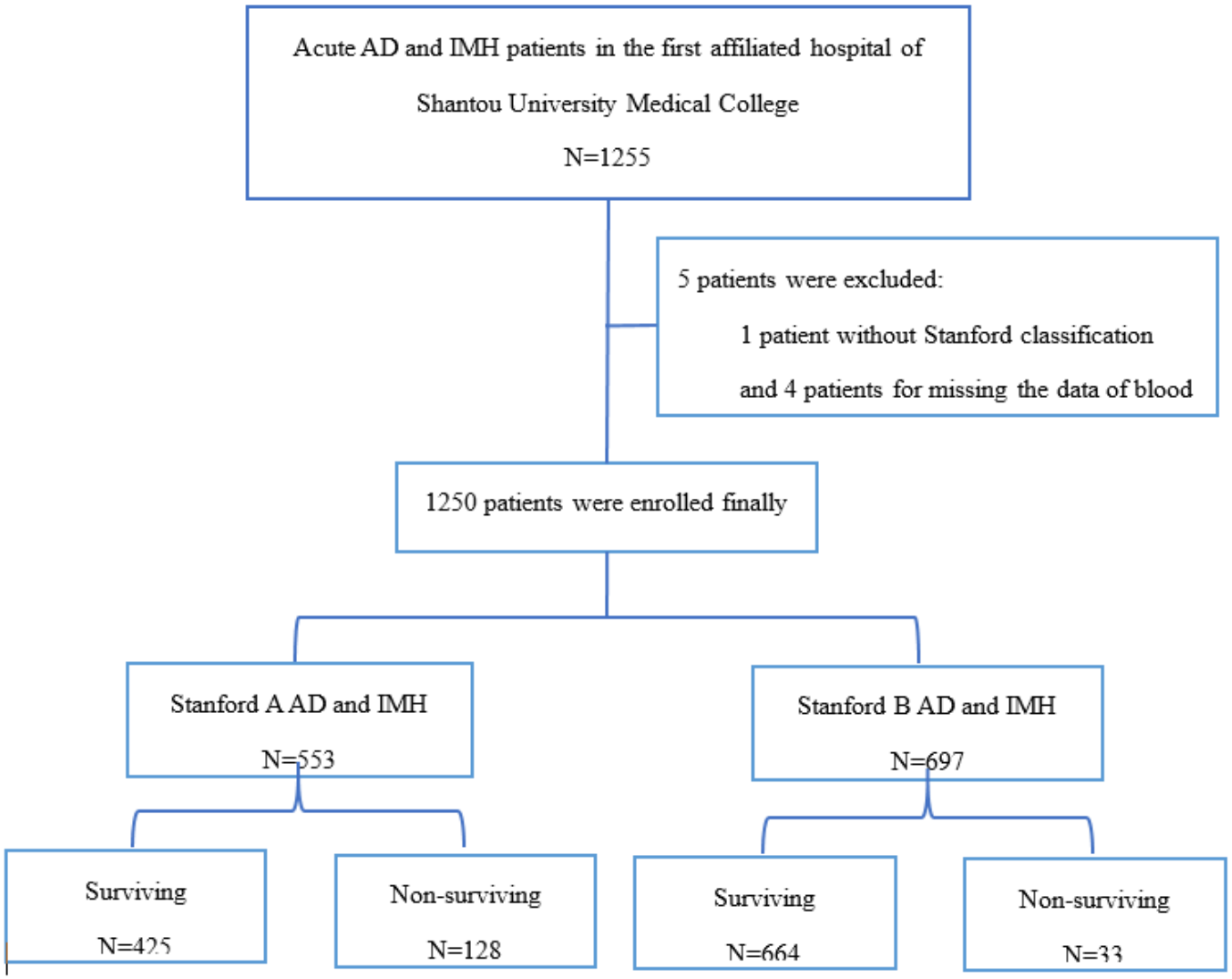

Figure 1

Diagram of screening acute AD and IMH patients. Abbreviations: AD, aortic dissection; IMH, intramural hematoma.

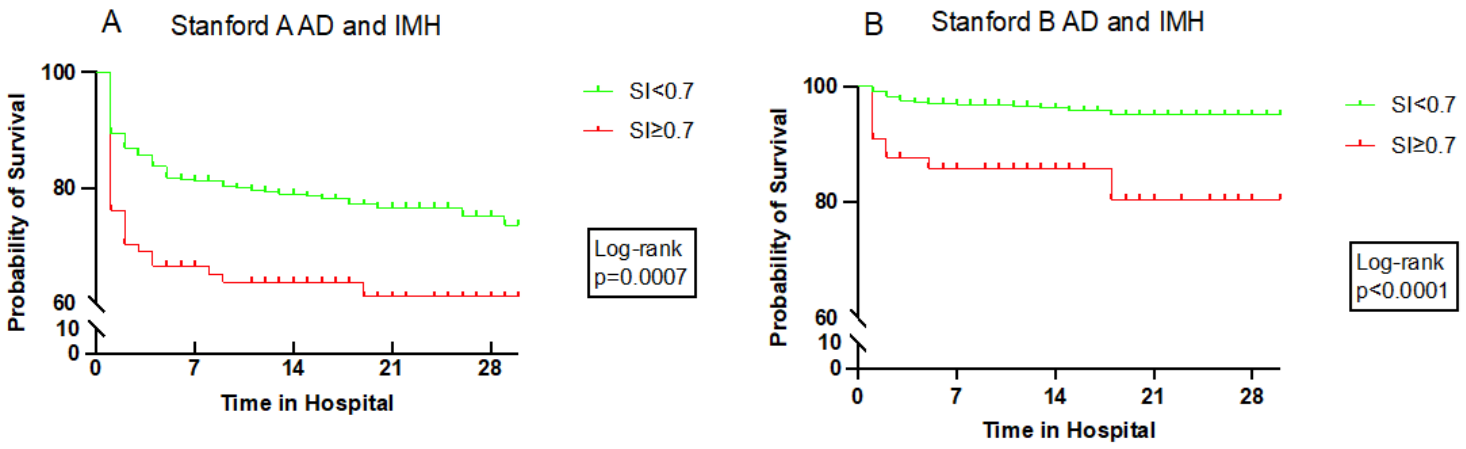

Figure 2

Survival curve of SI vs 30-day, all-cause in-hospital mortality in acute AD and IMH patients. A. Difference of cumulative survival probability between SI<0.7 and SI≥0.7 for Stanford A AD and IMH. B. Difference of cumulative survival probability between SI<0.7 and SI≥0.7 for Stanford B AD and IMH. Abbreviations: AD, aortic dissection; IMH, intramural hematoma; SI, shock index.

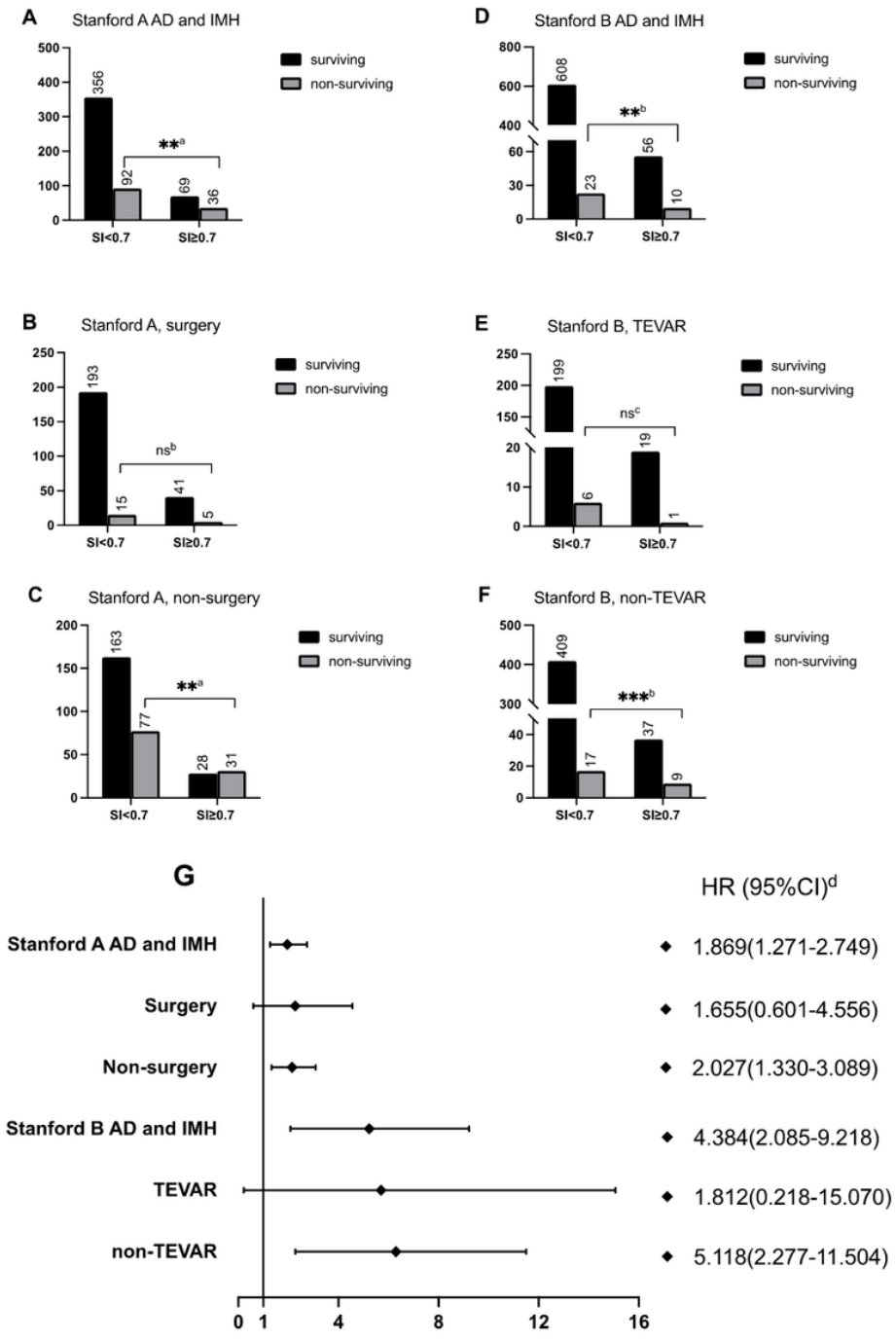

Figure 3

Subgroup analysis of SI associated with the in-hospital mortality in AD and IMH patients. Values are based on the 2-samples Chi-square test or univariate Cox proportional hazards model. a Pearson Chi-square test, b continuity correction test; c Fisher's exact test; d univariate Cox proportional hazards model. *P<0.05, **p<0.01, ***p<0.001.

Abbreviations: AD, aortic dissection; IMH, intramural hematoma; CI, confidence interval; HR, hazard ratio; SI, shock index; TEVAR, thoracic endovascular aortic repair.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaltable1.Univariateanalysisof30dayallcauseinhospitalmortalityinacuteADandIMHpatients.docx
- Supplementtable2.SubgroupanalysisofSIassociatedwiththeinhospitalmortalityinacuteADandIMHpatients.docx