Shock Index Correlates with Extravasation on Angiographs of Patients with Hemorrhage in the Head and Neck Region

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The shock index (SI) is simply calculated as heart rate (HR; beats per minute) divided by systolic blood pressure (SBP; mmHg), and it is a sensitive indicator of left ventricular dysfunction. Persistent elevation of the SI value has been associated with poor outcome in critically ill patients, and it has been reported to be a predictor of gastrointestinal hemorrhage, ruptured ectopic pregnancy, blunt hepatic injury, splenic injury, sepsis, and pulmonary embolism. We applied univariate and multivariate logistic regression analyses to determine the relationship of the clinical findings in patients with hemorrhage in the head and neck region with angiographic evidence of extravasation. Our study population comprised 42 patients (age range, 18–79 years; average, 55.3 years), of whom 32 had cancer-related etiologies (76.2%). Of the 52 angiograms obtained, 22 showed contrast extravasation (42.3%), while 30 did not (57.7%). Clinical findings including the shock index (SI), hemoglobin (Hb) level, platelet (PLT) count and age were analyzed. The reciprocal root-transformed SI (transformed SI) correlated with the angiographic evidence of extravasation in multivariate logistic regression analysis (p < 0.05). No significant difference in angiographic extravasation was observed between cancerous and non-cancerous patients. There is significant difference of SI in contrast extravasation between (ICA or CCA) and ECA groups (p = 0.02). The optimal cut-off point of SI for predicting angiographic extravasation was 0.87 (sensitivity: 63.6%; specificity: 73.3%). We conclude that in patients with head and neck hemorrhage, angiographic evidence of extravasation has a modest correlation with preangiographic SI. Patients with an elevated SI would have a higher probability of angiographic extravasation. Furthermore, if bleeding focus cannot be identified at angiography, the existence of hemorrhage in other region or temporarily restricted bleeding due to vasospasm, should be considered.

Massive bleeding in the head and neck region is not uncommon in clinical practice. The etiology of bleeding includes advanced malignancy, trauma, infection, and vascular lesions. The management of major bleeding in this region is variable. If conservative therapy is not successful, angiography can play an important role in localizing the sites of extravasation and transcatheter embolization can be performed if technically feasible.

The shock index (SI) is simply calculated as heart rate (HR; beats per minute) divided by systolic blood pressure (SBP; mmHg). The SI is a sensitive indicator of left ventricular dysfunction, and its value can elevate with left ventricular dysfunction. The SI normally ranges between 0.5 and 0.7. Persistent elevation of the SI has been associated with poor outcome in critically ill patients. The SI has been reported to be a predictor of gastrointestinal hemorrhage, ruptured ectopic pregnancy, blunt hepatic injury, splenic injury, sepsis, and pulmonary embolism [1-7].

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In clinical practice, it is sometimes difficult to monitor the severity of hemorrhage, which might bring the patient to an unnecessary interventional procedure. In order to apply the SI in predicting angiographic extravasation, we used univariate and multivariate logistic regression analyses to correlate the SI value and clinical data with angiographic results.

**MATERIALS AND METHODS**

**Patients**

We retrospectively reviewed 52 angiograms obtained for 42 patients (38 men, 4 women; age range, 18–79 years; average, 55.3 years) between January 2003 and August 2007 in our hospital. All patients were referred by otolaryngologist (ENT specialist) after failed conventional treatment, generally including gauze packing, balloon packing or endoscope-guided electrocoagulation. The primary causes consisted of the followings: hypopharyngeal cancer (n = 11; 26.2%), tongue cancer (n = 7; 16.7%), tonsillar cancer (n = 3; 7.1%), facial bone fracture (n = 7; 16.7%), nasopharyngeal cancer (n = 5; 11.9%), buccal cancer (n = 4; 9.5%), hepatocellular carcinoma with skull base metastasis (n = 1; 2.4%), thyroid cancer (n = 1; 2.4%), traumatic oral bleeding (n = 2; 4.8%) and tracheostomy bleeding (n = 1; 2.4%). Their preangiographic SBP, HR, Hb level, and PLT count were recorded and the SI was calculated using the HR and SBP. All patients received fluid resuscitation or blood transfusion and no patient required the use of vasopressors during angiography.

**Angiography**

All angiographies were performed on a digital angiographic system (KXO-100G; Toshiba, Japan). Initial diagnostic arteriograms of the common carotid artery (CCA), internal carotid artery (ICA) and external carotid artery (ECA) were obtained on each side. For CCA, ICA, ECA angiographies, iohexamate meglumine (Conray; Mallinckrodt Inc., St. Louis, USA) or iohexol (Omnipaque; GE Healthcare, Ireland Cork, Ireland) was injected as a bolus dose at 6 ml/s, 4 ml/s, and 1.5 ml/s, respectively (the total volume was 12 ml, 8 ml, and 9 ml, respectively). First, a 5-Fr catheter (Cordis; Cordis Co., Miami, USA) was inserted from the femoral artery using the Seldinger technique. Placement of the 5-Fr catheter was aided by a 0.035 inch torque Radifocus guidewire (Terumo Co., Tokyo, Japan). For a highly selective angiography, a coaxial 2.5-Fr microcatheter (Renegade; Boston Scientific, USA) was used. This microcatheter was inserted in conjunction with a 0.014 inch guide wire (Transcend; Boston Scientific, USA) with a flexible tip.

**Embolization Technique**

Due to a technical issue, palliative treatment was administered when the site of extravasation was located in the CCA or ICA. If extravasation was identified in the ECA or its branches, we proceeded to superselective catheterization with the 2.5-Fr microcatheter. Embolization was performed using embolization microcoils, glue (n-butylcyanoacrylate [NBCA]; Ingenor, Minvasys, France) and gelatin sponge (Gelfoam; Upjohn, USA). Postembolization angiography was performed via using a microcatheter or a guide catheter until no evident contrast extravasation appreciated.

**Image Interpretation and Preoperative Clinical Examination**

All the angiograms were inspected by 2 interventional radiologists (LS Hsu and HH Weng) for detecting extravasation. They also evaluated the postembolization angiograms to determine whether embolization was successful. In this article, angiographic extravasation was defined as contrast extravasation into airway, pharynx, mouth, nose, the surrounding compartment, or other open space, and it also included presence of pseudoaneurysms.

All the preangiographic clinical data of the patients including the HR, SBP, Hb level, and PLT count, and age were collected. According to the underlying etiology, the patients were divided into 2 groups—cancerous and non-cancerous.

**Statistical Analysis**

All statistical analyses were carried out using Stata V 9.2 statistical package (Stata Corp LP, College Station, TX). The clinical data were expressed as mean ± standard deviation. Normality was tested using the Shapiro-Wilk W test. The SI value was not normally distributed, and we transformed the SI value with reciprocal root transformation. We then used univariate and multivariate logistic regression analyses to analyze the correlation between the angiographic finding of extravasation and clinical information including transformed SI, Hb level, PLT count, and age. In addition, extravasation (binary logistic regression test), SI, Hb level and PLT count (Mann-Whitney U test) were...
SHOCK INDEX CORRELATES WITH ANGIOGRAPHIC EXTRAVASATION IN THE HEAD AND NECK REGION

RESULTS

Table 1 shows preangiographic clinical data, including SI, Hb level, PLT count, and age. Table 2 shows the results of univariate and multivariate logistic regression analyses between angiographic extravasation and preangiographic clinical data including age, transformed SI, Hb level, and PLT count.

In univariate analysis, transformed SI and Hb level were significantly correlated with angiographic extravasation. However, in multivariate analysis, only the transformed SI exhibited a significant correlation with the presence of angiographic extravasation (odds ratio: 0.025; p < 0.05).

Based on the etiology of bleeding, all cases were categorized into 2 groups: non-cancerous group (n = 12) and cancerous group (n = 40) (Table 3). The SIs of the former and the latter were 0.94 ± 0.51 and 0.69 ± 0.20, respectively, and the difference between the groups was significant (p = 0.04). The patients with a cancerous etiology exhibited a higher SI. However, no significant difference in angiographic extravasation, Hb level and PLT count was observed between the cancerous and non-cancerous groups.

According to extravasation sites, twenty-two angiographies showing contrast extravasation were categorized into two groups: (ICA or CCA) (n=8) and ECA (n=14). The results were shown in Table 4. There is significant difference of SI between the two groups (p=0.02).

Figure 1 shows the ROC curve for the application of SI in predicting angiographic extravasation. The area under the curve is 0.717. The asymptomatic 95% CI ranges between 0.573 and 0.862.

Our results showed that at the cut-off point of 0.87, the model had a 63.6% sensitivity and a 73.3% specificity for discriminating between the angiographic presence and absence of extravasation.

Table 1. Preangiographic clinical data of all cases (mean ± SD)

<table>
<thead>
<tr>
<th>Extravasation</th>
<th>present (n = 22)</th>
<th>absent (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI</td>
<td>1.08 ± 0.62</td>
<td>0.74 ± 0.24</td>
</tr>
<tr>
<td>Hb level (g/dl)</td>
<td>8.34 ± 2.35</td>
<td>9.82 ± 2.04</td>
</tr>
<tr>
<td>PLT count (&gt;1000/mm³)</td>
<td>258.82 ± 110.85</td>
<td>233.27 ± 128.87</td>
</tr>
<tr>
<td>Age (year)</td>
<td>54.73 ± 10.36</td>
<td>56.0 ± 14.08</td>
</tr>
</tbody>
</table>

Table 2. Univariate and multivariate logistic regression analyses of preangiographic data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate odds ratio</th>
<th>95% CI</th>
<th>p value</th>
<th>Multivariate odds ratio</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformed SI</td>
<td>0.016</td>
<td>0.001–0.354</td>
<td>0.009*</td>
<td>0.025</td>
<td>0.01–0.584</td>
<td>0.022*</td>
</tr>
<tr>
<td>Hb level (g/dl)</td>
<td>0.716</td>
<td>0.532–0.965</td>
<td>0.028*</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>PLT count (&gt;1000/mm³)</td>
<td>1.000</td>
<td>0.999–1.000</td>
<td>0.451</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Age (year)</td>
<td>0.992</td>
<td>0.949–1.037</td>
<td>0.715</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

*p < 0.05

Table 3. Preangiographic clinical data of cancerous and non-cancerous patients (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Cancerous (n=40)</th>
<th>Non-cancerous (n=12)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI</td>
<td>0.94 ± 0.51</td>
<td>0.69 ± 0.20</td>
<td>0.04*</td>
</tr>
<tr>
<td>Hb level (g/dl)</td>
<td>8.91 ± 2.07</td>
<td>10.15 ± 2.76</td>
<td>0.409</td>
</tr>
<tr>
<td>PLT count (&gt;1000/mm³)</td>
<td>254.05 ± 128.03</td>
<td>210.83 ± 91.14</td>
<td>0.161</td>
</tr>
<tr>
<td>Extravasation</td>
<td>20</td>
<td>2</td>
<td>0.054</td>
</tr>
</tbody>
</table>

*p < 0.05

Correlated with the etiology. According to extravasation sites, twenty-two angiographies showing contrast extravasation were categorized into two groups: (ICA or CCA) and ECA. The SI was correlated with extravasation sites with Mann-Whitney U test.

According to Zweig and Campell [8], a receiver operator characteristic (ROC) curve was used to determine the cut-off value for optimal sensitivity and specificity of SI. The area under the curve was used as a measurement of diagnostic performance of the test. The results are presented as values with 95% confidence interval.
ROC curve for the application of SI in predicting angiographic extravasation

**DISCUSSION**

The principal findings of this study were as follows: (1) SI correlates significantly with the presence of angiographic extravasation in cases of head and neck hemorrhage. (2) No significant difference in angiographic extravasation exists between cancerous and non-cancerous patients. (3) There is significant difference of SI in contrast extravasation between (ICA or CCA) and ECA groups. (4) A cut-off SI value of 0.87 can discriminate between the angiographic presence and absence of extravasation.

The value of SI can be easily calculated based on physiological variables that are measured in every patient and has been shown to correlate well with left ventricular end-diastolic pressure. Rady et al. (1994) found that an elevated SI (>0.9) is beneficial in identifying patients requiring admission and/or intensive care despite apparently stable vital signs in the Emergency Department [9]. Furthermore, the SI provides a noninvasive means to monitor the deterioration or recovery of left ventricular stroke volume during acute hypovolemic and normovolemic circulatory failure [10]. The SI has also been reported to be a predictor of gastrointestinal hemorrhage, ruptured ectopic pregnancy, blunt hepatic injury, splenic injury, sepsis, and pulmonary embolism. To the best of our knowledge, there exists no report regarding the relationship between SI and hemorrhage in the head and neck region.

Nakasone et al. reported that in patients with gastrointestinal bleeding, angiographic visualization of extravasation is associated with the pre-embolization SI. The cut-off SI value was determined to be 0.52, with a 92% sensitivity and a 86% specificity for discriminating between the angiographic presence and absence of extravasation [5].

Birkhahn et al. used different ranges of SI values for evaluating patients with abdominal pain and vaginal bleeding within the first trimester of pregnancy. Patients without ruptured ectopic pregnancy had SI values within 0.5–0.7, whereas subjects with SI > 0.85 were 15.0 times more likely the cases of ruptured ectopic pregnancy (1). Onah et al. concluded that the SI has a high predictive value for ruptured ectopic pregnancy in the Nigerian population (SI ≥ 0.935, odds ratio = 4.5) [6].

Hagiwara et al. evaluated the efficacy of transcatheter arterial embolization (TAE) for patients with blunt hepatic injury. Twenty-eight patients with high-grade hepatic injury (Mirvis classification, 3 or 4) underwent arteriography, and TAE was performed for 15 patients. Embolization was successful in all 15 patients, and the SI value was significantly reduced for 15 patients. Embolization was successful in all 15 patients, and the SI value was significantly reduced 1 hr after TAE (SI immediately before TAE, 1.25 ± 0.23; 1 hr after TAE, 0.76 ± 0.12) (p < 0.01) [3].

Kucher et al. reported a novel management strategy for patients with suspected pulmonary embolism (PE) that facilitated a rapid diagnosis and treatment with a low 30-day mortality. In patients with suspected PE, the SI is a simple parameter that allows the estimation of the time available for diagnostic approaches. Based on this strategy, in patients with an SI of <1, there is sufficient time for performing imaging tests in order to accurately diagnose PE, whereas in those with an SI of ≥1, reperfusion treatment should be commenced without any delay [4].

In hemodynamically unstable patients with blunt splenic injury, Hagiwara et al. reported that the SI at the start of TAE was 1.46 ± 0.30 and that at the completion of TAE was 0.77 ± 0.21 (p < 0.001) [2]. Sekikawa et al. evaluated 65 patients with blunt splenic injury who underwent TAE for the management of bleeding. The results showed that the absence of concomitant pelvic injury, a higher Hb

Table 4. Location of contrast extravasation and SI value (mean ± SD)

<table>
<thead>
<tr>
<th>Location of contrast extravasation</th>
<th>numbers of angiographies (total number = 22)</th>
<th>SI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCA or ICA</td>
<td>8</td>
<td>1.46 ± 0.84</td>
<td>0.02*</td>
</tr>
<tr>
<td>ECA</td>
<td>14</td>
<td>0.87 ± 0.31</td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.05
level, higher hematocrit, higher BP, greater increases in BP during TAE, and a decreased requirement for blood transfusions before TAE were associated with good clinical outcome. The SI had no significant correlation with the outcome [7].

Evaluation of the severity of bleeding is not always easy for clinicians. Similarly, estimating the total blood loss is also difficult. Even laboratory data cannot reflect the exact status of blood loss. According to previous researches and the findings of the present study, the SI is a good parameter for a clinician to evaluate the condition of patients and adopt appropriate management strategies. In addition, the SI can hint the possibility of contrast extravasation before angiography. If extravasation focuses cannot be identified in patients with a high SI value during angiography, it is possible that hemorrhage in other region exists or bleeding stops temporarily due to vasospasm.

There is significant difference of SI in contrast extravasation between (ICA or CCA) and ECA groups in this study. The reasons may be due to large calibers and flow rate of ICA and CCA compared with those of ECA.

At our institution, conventional catheter angiography has been the technique of choice for the evaluation of patients with uncontrolled bleeding in the head and neck region. The lack of prior vascular imaging is often justified by the presumption that DSA provides greater sensitivity for the detection of treatable vascular causes of head and neck bleeding. Although CT angiography is not routinely performed before conventional angiography, we should acknowledge that CT angiography is a thorough technique that takes few seconds to provide a full angiogram in many directions. It can show arteries related to tumor, pseudoaneurysms, evaluate CCA, ICA, ECA, and branches, and AV shunting. It can include precontrast CT and postcontrast CT in addition to show blood clot, anatomic abnormalities, enhancement of tissue... etc.

Furthermore, Goodman et al. reported that CT angiography was more sensitive than digital subtraction angiography (DSA) in evaluating the pseudoaneurysm. There are three reasons for this. First, CT angiography may offer increased sensitivity to slow-filling lesions versus the short time injection at DSA. Second, CT also has greater sensitivity for faint contrast opacification because of increased overall contrast sensitivity. Thrid, the guidewire- or catheter-induced vasospasm may have temporarily restricted flow to the vessel supplying the pseudoaneurysm[11].

Nevertheless, our study had several limitations. First, the primary diseases differed among our patients, and we did not consider the total blood loss, blood transfusion requirement, and intravenous fluid administration. Second, although SI significantly correlated with the presence of angiographic extravasation, the specificity and sensitivity of the cut-off value of SI are not quite satisfactory. We acknowledged that the inhomogeneous population posed a problem because of different bleeding focuses and pathophysiologic mechanisms. Third, the palliative treatment offered at bleeding focuses located at the CCA and ICA is outdated, and more aggressive interventional treatment should be applied.

Based on the results reported here we concluded that although the cutoff value 0.87 is not quite satisfactory for discriminating between the angiographic presence and absence of extravasation in patients with head and neck bleeding, angiographic visualization of contrast extravasation is modestly correlated with the preangiographic SI. Furthermore, the SI can help predict the possibility of extravasation before angiography. And if extravasation focuses cannot be identified in patients with a high SI value during angiography, the existence of hemorrhage in other region or temporarily restricted bleeding due to vasospasm should be taken into account.

REFERENCES
Shock index correlates with angiographic extravasation in the head and neck region

Shock index correlates with angiographic extravasation in the head and neck region

在頭頸部出血的病人進行血管攝影：使用休克指數與對比劑滲漏建立關聯性

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休克指數是以每分鐘心跳數除以收縮壓（單位：毫米汞柱）而得，它是左心室功能異常的敏感指標。升高的休克指數與危急的病人較差的預後有關，同時也與腸胃道出血、子宮外孕破裂、肝臟鈍傷、脾臟外傷、敗血症和肺栓塞有關。

我們利用回溯性研究方式來分析頭頸部出血的病患與臨床資料間（休克指數、血色素、血小板、年齡）是否有關聯。42 位病人（18-79 歲，平均年齡 55.3 歲），其中 32 位的病因與癌症有關（76.2%）。總共進行了 52 次的血管攝影，22 次顯示了對比劑滲漏（42.3%），30 次則沒有發現。結果顯示休克指數與對比劑滲漏有明顯的關聯性。癌症病人與非癌症病人之間，對比劑滲漏的機率則沒有差別。休克指數用來區別對比劑滲漏的的取捨值為 0.87（敏感性：63.6%；特異性：73.3%）。我們的結論是在頭頸部出血的病人中，對比劑滲漏與血管攝影之前的休克指數高低有關。休克指數高的病人發現對比劑滲漏的機會較高。此外，如果血管攝影檢查時沒有發現對比劑滲漏，高休克指數也可以提醒我們其他部位出血或是血管腫瘤導致暫時停止出血的可能性。