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Use of the shock index to diagnose acute hypovolemia

Aim: To determine the accuracy of the shock index in the early detection of hemodynamic changes after acute blood loss.

Materials and methods: This prospective, observational study was performed on blood donors who were giving 450 mL of blood over 20 min. Vital signs of the volunteers were recorded just before blood donation, and at 1 and 5 min after donation. Shock index was calculated by dividing the heart rate by systolic blood pressure.

Results: Fifty healthy donors (mean age 34 ± 9 years) volunteered to participate in the study. Five minute post-donation heart rate (81 ± 12 /min) and diastolic blood pressure (70 ± 10 mmHg) were significantly different from pre-donation values (77 ± 11 , 76 ± 15 , respectively). Furthermore, 1 and 5 min post-donation systolic blood pressure values (106 ± 14 , 108 ± 12 mmHg, respectively) were significantly different from pre-donation values (120 ± 20 mmHg) ($P = 0.0001$). The shock index, at both 1 and 5 min after blood donation (0.75 ± 0.14 , 0.76 ± 0.15), was significantly higher than pre-donation values (0.66 ± 0.15) ($P = 0.001$).

Conclusion: After a small amount of acute blood loss, the shock index and systolic blood pressure are better indicators of acute blood loss than heart rate.

Key words: Blood donors, diagnosis, hypovolemia, shock

Akut hipovolemi tanısında şok indeksinin kullanımı

Amaç: Akut kan kaybından sonra hemodinamik değişikliklerin erken tespiti için şok indeksinin kullanılabilirliğini tespit etmektir.

Yöntem ve gereç: Bu prospektif gözlemsel çalışma 20 dakikalık sürede 450 mL kan veren kan donörleri üzerinde yapılmıştır. Gönüllülerin vital bulguları kan vermeden hemen önce, kan verdikten sonra 1. ve 5. dakikalarda kayıt edilmiştir. Şok indeksi, kalp hızının sistolik kan basıncına bölünmesi ile hesaplanmıştır.

Bulgular: Ortalama yaşı 34 ± 9 olan 50 sağlıklı donör çalışmaya katılmak için gönüllü olmuştur. Kan verdikten sonra 5. dakikadaki kalp hızı (81 ± 12 /min) ve diyastolik kan basıncı (70 ± 10 mmHg) değerleri kan vermeden önceki değerlerden (77 ± 11 /min, 76 ± 15 mmHg) anlamlı olarak farklıydı. Kan verdikten sonraki 1. ve 5. dakikadaki sistolik kan basıncı değerleri (106 ± 14 , 108 ± 12 mmHg) kan vermeden önceki değerlerden (120 ± 20 mmHg) anlamlı olarak farklıydı ($P = 0.0001$). Kan verdikten sonraki hem 1. hem de 5. dakikadaki şok indeksi (0.75 ± 0.14 , 0.76 ± 0.15) kan vermeden önceki değerlerden (0.66 ± 0.15) anlamlı derecede yüksekti ($p=0.001$).

Sonuç: Az miktarda akut kan kaybından sonra şok indeksi ve sistolik kan basıncı, kalp hızına göre akut kan kaybının daha iyi göstergeleridir.

Anahtar sözcükler: Kan donörleri, tanı, hipovolemi, şok

Introduction

Shock is a pathological condition in which circulatory system fails to supply adequate tissue perfusion and oxygen demand (1). Signs of hypovolemic shock are related to the age of the patient, previous medical history, amount of volume deficit, and the length of time over which that deficit developed. Heart rate and blood

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pressure are not always accurate reflections of the degree of hypovolemia (2). The interaction of the physician's judgment and clinical signs is important in the initial assessment of emergency department patients with possible hypovolemia. Because internal and external stimuli may cause abnormal vital signs, management of such patients requires careful clinical skills (3).

Acute blood loss of 450 mL is not enough to produce significant changes in orthostatic heart rate (HR) or systolic blood pressure (SBP) (4). The shock index (SI) is calculated by dividing the HR by SBP, and normally ranges from 0.5 to 0.7. The SI is elevated in the setting of acute hypovolemia and left ventricular dysfunction (3,5,6). In this study, blood donations (450 mL of blood) from healthy persons were used as a model of simulated early acute hypovolemia in order to see which hemodynamic parameter (HR, SBP, or SI) was most accurate in detecting blood loss.

Materials and methods

This prospective, observational study was performed in the Blood Donation Center of our university medical center. Healthy donors were approached regarding participation and informed consent forms for inclusion in the study were obtained. Exclusion criteria were: body temperature greater than 38 °C, hemoglobin <11 mg/dL, age <17 years, weight <50 kg (110 lb), and pregnancy. Patients using any prescription medicine were also excluded to reduce variables that might affect HR and blood pressure. During the study, no fluids were given orally or parenterally. Vital signs of the patients were obtained in the semi-supine position just before donation, and 1 min and 5 min after donation. Blood pressures were measured manually by auscultation. To prevent intraobserver variability, all vital signs were measured by the same person. Our subjects donated 450 mL of blood via 16-gauge catheter in 20 min. Shock index was calculated by dividing the HR by SBP. Data were analyzed using SPSS for Windows version 11.0 (SPSS Inc., Chicago, USA) by repeated variance analysis, comparing pre-donation with each post-donation value by the Bonferroni procedure. Results were considered statistically significant if $P < 0.05$.

Results

Fifty individuals who passed routine screening examination for blood donation gave informed consent to participate in the study. Most (96%, $n = 48$) of the subjects were male, and the mean age was 34 ± 9 (range 18-55) years. Statistically significant findings included the change in HR and diastolic BP from pre- to 5 min post-donation, and the change in systolic BP from pre- to both 1 and 5 min post-donation. Five minute post-donation heart rate ($81 \pm 12 \text{ min}^{-1}$) was significantly higher than pre-donation heart rate ($77 \pm 11 \text{ min}^{-1}$) ($P = 0.04$). Five minute post donation diastolic blood pressure ($70 \pm 10 \text{ mmHg}$) was significantly lower than the pre-donation value ($76 \pm 15 \text{ mmHg}$) ($P = 0.02$). Furthermore, 1 and 5 min post-donation systolic blood pressure values (106 ± 14 , $108 \pm 12 \text{ mmHg}$, respectively) were significantly different from the pre-donation values ($120 \pm 20 \text{ mmHg}$) ($P = 0.0001$). The shock index at both 1 and 5 min after blood donation (0.75 ± 0.14 , 0.76 ± 0.15) was significantly higher than the pre-donation values (0.66 ± 0.15) ($P = 0.001$) (Table).

Discussion

Vital signs are essential components of the evaluation and resuscitation of patients with hypovolemia (7). Tachycardia is usually known to occur in early phases of hypovolemia (3,8). Birkhahn et al. observed a significant rise in heart rate after acute blood loss, but the rate remained within normal range (<100 beats per minute) (3). We also observed a significantly higher heart rate at 5 min after acute blood loss in our model. Because it is still in normal limits, its usefulness as a marker of acute hypovolemia is limited.

Shock is usually accompanied by systolic hypotension (SBP < 90 mmHg). However, the blood pressure may not fall if the peripheral vascular resistance has increased in response to decreased cardiac output. The sensitivity of blood pressure to detect global tissue hypoperfusion is low (8). Although the fall in SBP in our subjects was statistically significant after a 450 mL blood loss, it was still within "normal" range (>100 mmHg). Thus its usefulness as a marker of acute hypovolemia is limited.

Table 1. Heart rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), and shock index in 50 volunteers donating 450 mL of blood: mean \pm standard deviation.

	Pre-donation Mean \pm standard deviation	1 min post-donation Mean \pm standard deviation	5 min post-donation Mean \pm standard deviation	F	p
Heart rate	77 \pm 11 ^c	79 \pm 13	81 \pm 12 ^a	3.28	0.04
DBP (mm Hg)	76 \pm 15 ^c	71 \pm 11	70 \pm 10 ^a	4.11	0.02
SBP (mm Hg)	120 \pm 20 ^{bc}	106 \pm 14 ^a	108 \pm 12 ^a	14.64	0.0001
Shock index (Beats/min•mmHg)	0.66 \pm 0.15 ^{bc}	0.75 \pm 0.14 ^a	0.76 \pm 0.15 ^a	7.94	0.001

a: Shows the difference with pre-donation

b: Shows the difference with 1 min post-donation

c: Shows the difference with 5 min post-donation

The shock index can be easily calculated from the vital signs in every patient and has been shown to correlate well with left ventricular and diastolic pressures (3,5-7). It is an important sign of ruptured ectopic pregnancy, traumatic injury, sepsis, and gastrointestinal hemorrhage (3,7,9). As reported in a similar study (3), we found the SI to increase significantly after an acute loss of blood, and its values came to lie within the "abnormal" range (3,5,6). Birkhahn et al. (3) showed that the SI was a better marker than heart rate or systolic blood pressure in identifying blood loss. Although our patients were in a different body position (semi-supine) than those of Birkhahn et al. (supine), we obtained similar results regarding the sensitivity of SI for detecting acute

blood loss. This was a valid model for our clinicians because vital signs in our patients are measured with them in the semi-supine position.

In this model of acute blood loss in a non-emergent setting, the shock index is a better marker of acute hypovolemia than heart rate or systolic/diastolic blood pressure.

Limitations of the study: Because we performed the study with healthy volunteer subjects, we only took 450 mL of blood per subject. This may be the limitation of our study. If the study is performed experimentally and with a larger volume of blood, statistical and clinical differences in the results may be shown more obviously.

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