

- [15] Nwawka OK, Kabutey NK, Locke CM, Castro-Aragon I, Kim D. Ultrasound-guided needle localization to aid foreign body removal in pediatric patients. *J Foot Ankle Surg* 2014;53(1):67–70. <http://dx.doi.org/10.1053/j.jfas.2013.09.006> [Epub 2013 Nov 13].
- [16] Borgohain B, Borgohain N, Handique A, Gogoi PJ. Case report and brief review of literature on sonographic detection of accidentally implanted wooden foreign body causing persistent sinus. *Crit Ultrasound J* 2012;4(1):10. <http://dx.doi.org/10.1186/2036-7902-4-10>.
- [17] Jecković M, Anupindi SA, Barbir SB, Lovrenski J. Is ultrasound useful in detection and follow-up of gastric foreign bodies in children? *Clin Imaging* 2013;37(6):1043–7.
- [18] Tahmasebi M, Zareizadeh H, Motamedfar A. Accuracy of ultrasonography in detecting radiolucent soft-tissue foreign bodies. *Indian J Radiol Imaging* 2014;24(2):196–200.

## Utility of shock index calculation in hemorrhagic trauma



CrossMark

We read with great interest the article by Edla et al [1] comparing heart rate variability (HRV) metrics vs routine vital signs as diagnostic tests to improve trauma patient management focusing on the identification of trauma patients with major hemorrhage. They conducted a multivariate analysis using routine vital signs (heart rate, respiratory rate, systolic blood pressure, and pulse pressure) as the comparator to test the hypothesis that HRV metrics can improve the identification of patients with major hemorrhage. However, when combined with routine vital signs, HRV added negligible additional discriminatory value. The authors addressed a very important question as far as the most substantial clinical problem facing physicians being the identification of hemorrhagic trauma. In prehospital setting, current trauma triage relies on abnormal physiological criteria to determine the patient's mode of transport, priority of treatment, destination for treatment, and need for possible life-saving interventions.

We would like to go further into the debate and speculate that calculation of the shock index (SI) may be more useful for caregivers than isolated measurements of systolic blood pressure (SBP) and heart rate (HR) in the compensatory phase of shock. The SI is defined as the ratio of HR to SBP. This easily calculable score in the field has been demonstrated to be a pragmatic and useful guide for diagnosing acute hypovolemia in the presence of normal HR and blood pressure. Shock index has been shown to correlate with other indices of end-organ perfusion such as central venous oxygen saturation and arterial lactic acid concentration [2]. Compared with HR or SBP alone, SI has been suggested to be a better measure of hemodynamic stability [3]. Rady et al [4] evaluated a SI cutoff point of 0.9 in a cohort of 275 adult patients presenting to an emergency department with stable vital signs. The authors found that a SI greater than 0.9 was associated with an illness that was treated immediately, admission to the hospital, and intensive therapy on admission. A given set of vital signs may on initial interpretation appear unalarming, but calculation of SI added additional perspective that could influence clinical decisions [5].

To conclude, we would like to know if the authors, maybe based on a retrospective analysis of the data set of 402 subjects, could test the usefulness of SI (with a cutoff value of 0.9) in initial assessment of patients with ongoing exsanguinations?

Marilyn Franchin, MD\*  
 Daniel Jost, MD  
 Hugues Lefort, MD  
 Stephane Travers, MD  
 Jean-Pierre Tourtier, MD

*Emergency Medical Department, Fire Brigade of Paris, Paris, France*

\*Corresponding author at: Emergency Medical Department  
 Fire Brigade of Paris. 1, place Jules Renard F-75017 Paris, France

E-mail address [marilyn.franchin@pompiersparis.fr](mailto:marilyn.franchin@pompiersparis.fr)

## References

- [1] Edla S, Reisner AT, Liu J, et al. Is heart rate variability better than routine vital signs for pre-hospital identification of major hemorrhage? *Am J Emerg Med* 2015;33(2):254–61.
- [2] Rady MY. The role of central venous oximetry, lactic acid concentration and shock index in the evaluation of clinical shock: a review. *Resuscitation* 1992;24:55–60.
- [3] Birkhahn RH, Gaeta TJ, Terry D, Bove JJ, Tloczkowski J. Shock index in diagnosing early acute hypovolemia. *Am J Emerg Med* 1994;23:323–6.
- [4] Rady MY, Smithline HA, Blake H, Nowak R, Rivers E. A comparison of the shock index and conventional vital signs to identify acute, critical illness in the emergency department. *Ann Emerg Med* 1994;24:685–90.
- [5] Vandromme MJ, Griffin RL, Kerby JD, et al. Identifying risk for massive transfusion in the relatively normotensive patient: utility of the prehospital shock index. *J Trauma* 2011;70:384–8.

## In reply to “Utility of shock index calculation in hemorrhagic trauma”\*



CrossMark

To the Editor,

We wish to thank the correspondents for their interest and comments regarding our report [1]. We agree that multivariate vital-sign analysis is a powerful tool. The Shock Index (SI), which scales the heart rate (HR) to the systolic blood pressure (SBP), is attractive because it can be computed mentally at the bedside. At least in theory, by examining multiple vital signs, one may better distinguish abnormal vital signs due to psychological distress (typically tachycardia with hypertension) vs blood loss and shock (relative tachycardia with normal or reduced blood pressure). In addition to the reports cited by the correspondents, SI has been studied in trauma registries of more than 16 000 [2] and 21 000 [3] patients, demonstrating that blood transfusion requirement and mortality are associated with increasing SI.

To address the question posed by the correspondents, we computed the areas under receiver operating characteristic curves (ROC AUCs) for SI using the same data set of 402 subjects from Edla et al [1]. We used that report's methodology for excluding unreliable vital signs and analyzed the average vital-sign values from each subject's initial 15 minutes of physiological data. The ROC AUCs for SI were 0.76, 0.80, and 0.81 for predicting 24-hour red blood cell transfusion greater than or equal to 1, 5, and 9 units, respectively. These ROC AUCs for SI trend higher than the ROC AUCs for HR and SBP (available in Table 2 from Edla et al [1]), although the differences were not statistically significant. The sensitivity and specificity of SI greater than 0.9 as a predictor of massive transfusion (defined as 24-hour red blood cell transfusion  $\geq 9$  units) were 63% and 83%, respectively, using the 15-minute average of SBP and HR.

One challenge of SI is that its value changed minute by minute because the patient's HR fluctuated. Many patients developed SI greater than 0.9 at least at some time point during early trauma care. In a separate analysis of 855<sup>1</sup> subjects during prehospital transport [4], we found that 57% of the patients with no significant bleeding nonetheless demonstrated SI greater than 0.9, at least transiently. We found that SI greater than 1.4 was a more practical cutoff, with a false-positive rate of only 12% in patients without bleeding; and it was sensitive to 59% of massive transfusion patients. (For comparison, note that SBP < 90 mmHg had a false-positive rate of 10% in patients without bleeding; and it was sensitive to 50% of massive transfusion patients.)

At the bedside, clinicians should consider computing SI using a time-averaged value of HR and SBP from a multiminute observation interval to reduce false alarms [5]. There are also statistical techniques that can

\* Conflicts of interest: None of the authors have any conflicts of interest to disclose.

<sup>1</sup> The 402 subjects from Edla et al [1] comprise the subset of this larger data set of 855 subjects [4] with a full set of reliable vital signs and at least 5 minutes of reliable electrocardiogram waveform data for heart rate variability analysis.

objectively distinguish transient vs clinically meaningful vital-sign abnormalities in trauma patients and that have been shown to be significantly superior to SI alone, but these techniques require specialized bedside computing capabilities [4].

## Acknowledgments

This work was supported by the US Department of Defense Medical Research and Development Program (grant D10\_I\_AR\_J6\_773) and by the Combat Casualty Care Research Area Directorate of the US Army Medical Research and Materiel Command, Fort Detrick, MD, USA. The study sponsors did not have any role in the study design, data collection, analysis and interpretation of data, report writing, or decision to submit the article for publication.

The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the US Army or of the US Department of Defense. This correspondence has been approved for public release with unlimited distribution.

Shwetha Edla, PhD

*Department of Defense Biotechnology High Performance Computing Software Applications Institute, Telemedicine and Advanced Technology Research Center, US Army Medical Research and Materiel Command, Fort Detrick, MD 21702, USA*

Andrew T. Reisner, MD

*Department of Emergency Medicine, Massachusetts General Hospital Boston, MA 02114, USA*

Jianbo Liu, PhD

*Department of Defense Biotechnology High Performance Computing Software Applications Institute, Telemedicine and Advanced Technology Research Center, US Army Medical Research and Materiel Command, Fort Detrick, MD 21702, USA*

Victor A. Convertino, PhD

Robert Carter III, PhD

*US Army Institute of Surgical Research, Fort Sam Houston, TX 78234, USA*

Jaques Reifman, PhD

*Department of Defense Biotechnology High Performance Computing Software Applications Institute, Telemedicine and Advanced Technology Research Center, US Army Medical Research and Materiel Command, Fort Detrick, MD 21702, USA*

Corresponding author: Department of Defense Biotechnology High Performance Computing Software Applications Institute, Telemedicine and Advanced Technology Research Center, US Army Medical Research and Materiel Command, ATTN: MCMR-TT, 504 Scott St, Fort Detrick, MD 21702, USA. Tel: +1 301 619 7915; fax: +1 301 619 1983  
E-mail address: [jaques.reifman.civ@mail.mil](mailto:jaques.reifman.civ@mail.mil)

<http://dx.doi.org/10.1016/j.jem.2015.04.002>

## References

- [1] Edla S, Reisner AT, Liu J, Convertino VA, Carter III R, Reifman J. Is heart rate variability better than routine vital signs for prehospital identification of major hemorrhage? *Am J Emerg Med* 2015;33:254–61.
- [2] Zarzaur BL, Croce MA, Fischer PE, Magnotti LJ, Fabian TC. New vitals after injury: shock index for the young and age × shock index for the old. *J Surg Res* 2008;147:229–36.
- [3] Mutschler M, Nienaber U, Munzberg M, Wolf C, Schoechl H, Pafrath 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;17:R172.
- [4] Liu J, Khitrov MY, Gates JD, Odom SR, Havens JM, de Moya MA, et al. Automated analysis of vital signs to identify patients with substantial bleeding prior to hospital arrival: a feasibility study. *Shock* 2015. <http://dx.doi.org/10.1097/SHK.0000000000000328>.
- [5] Chen L, Reisner AT, Gribok A, Reifman J. Exploration of prehospital vital sign trends for the prediction of trauma outcomes. *Prehosp Emerg Care* 2009;13: 286–94.

## Peritoneal dialysis and potassium: pains and gains in the ED



To the Editor,

The article by Roseman et al [1] is indeed interesting, as the authors had brought peritoneal dialysis (PD) back to frontline and as an option for patients with severe hyperkalemia in resource-limited emergency department. However, few aspects of this article need contemplation based on our experiences with regard to potassium clearance [2]. It is well known that potassium clearance achieved by PD is markedly lower than hemodialysis.

Clearance of potassium averages approximately 17 mmol/min for intermittent PD and approximately 7 mmol/min for continuous ambulatory peritoneal dialysis (CAPD). Interestingly, higher potassium clearance (24 mmol/min) is obtained during the first hour than that of the remaining period due increased release of potassium from the cells that line the peritoneal cavity. Peritoneal dialysis patients have normal or low plasma potassium probably because of greater shift of this ion into intracellular compartment, which is facilitated by initial low pH and/or by the hyperosmolality of the instilled dialysate, which does not contain potassium [3].

Thus, patients on PD in general have high intracellular potassium content, more so those on CAPD. This process is also further enhanced due to the continuous glucose absorption from the dialysis solutions and the subsequent stimulation of intracellular uptake of potassium, mediated by insulin. However, potassium entry into peritoneal epithelium declines as patients on PD started developing peritoneal sclerosis. This intracellular overload is not only difficult to correct but also makes them susceptible for hyperkalemia easily [4]. After removal of potassium from extracellular compartment by dialysis, there will be a rebound as the intracellular potassium moves to extracellular compartment. This continues till the total body potassium is depleted. Hence, to solve these problems, there is a need for a long and sustained dialysis using a 2-L CAPD exchange 4 times per day with potassium-free dialysate [5]. We have also noticed normalization of plasma potassium levels and steady state of plasma potassium of 5 mmol/L in our cases [2]. One can estimate the potassium removal close to 33 to 35 mmol/d to avoid hyperkalemic rebound in the postdialytic period.

Peritoneal dialysis offers a unique and timely opportunity for the emergency physician to rescue; however, the limitations of potassium exchange and noninfectious complications of PD have to be kept in the mind, and the alternatives have to be discussed with patients and caregivers before preparing them for PD.

Subramanian Senthilkumaran, MD  
*Department of Emergency & Critical Care Medicine, Sri Gokulam Hospital Salem, Tamil Nadu, India*

Corresponding author: Department of Emergency & Critical Care Medicine Sri Gokulam hospital, Salem, Tamil Nadu, India  
Tel.: +91 9994634444, +91 9846349444 (Mobile)  
E-mail address: [maniansenthil@yahoo.co.in](mailto:maniansenthil@yahoo.co.in)

Florence Benita, MBBS  
*Department of Emergency Medicine Kokilaben Dhirubhai Ambani Hospital and Medical Research Institute Mumbai, India*

Gore B. Sandeep, MBBS  
*Department of Accident & Emergency Medicine, Fortis Hospital Mumbai, India*