CRITICAL CARE

LETTER

Misleading indexed hemodynamic parameters: the clinical importance of discordant BMI and BSA at extremes of weight

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The widespread availability of minimally invasive hemodynamic monitors encourages evaluation of cardiac output (CO) and stroke volume (SV) in real time, and they are integral to goal-directed therapy, algorithm-based treatment plans. Patients with extremes of body surface area (BSA) are at risk of having their indices erroneously evaluated despite adequate non-indexed values. We evaluated the use of body mass index (BMI) in this population and identified a discordance of BSA and BMI values at extreme weights. We recommend unindexed values in these patients when deciding treatment options.

Physiologic parameters are indexed or normalized by dividing the absolute values by the BSA. The cardiac and stroke indices are CO/BSA and SV/BSA, respectively. Large BSAs due to morbid obesity can distort indexed values. A normal CO or SV when divided by an extreme BSA will yield a low cardiac index or stroke index despite even supraphysiologic actual hemodynamic performance [1]. Consequently, this may lead to therapeutic interventions opposite to patients' needs.

BMI itself, even when extreme, does not cause clinically significant increases in CO or SV [2]. However, BSA and BMI are not interchangeable. As evidenced by Table 1, BSA and BMI do not always correlate. The surface area of a short person with extreme weight can be significantly less than a taller, thinner person. Similarly, the BSA of a tall person compared with a shorter person with proportional weights would be much greater but their BMIs would be similar.

The BSA and BMI of a simulated patient with height and weight varying (DuBois and DuBois formula) are presented in Table 1. The bold values illustrate the BSA at which patients are in danger of being misclassified as having a falsely low cardiac index despite adequate CO, given standard algorithms [1]. The table reveals BMI–BSA discordance, most prominently observed in very tall or short persons. For example, patients weighing 181 kg may be misclassified using BSA if they are taller than 178 cm despite a decrease in their BMI with increasing height. However, a person weighing 181 kg who is shorter

Table 1. Body surface area/body mass index demonstrating discordance as height increases

Weight		Height (inches/cm)					
Pounds	kg	60/152	65/165	68/173	70/178	76/193	84/213
100	45	1.39/19.5	1.47/16.5	1.52/15.0	1.55/14.2	1.65/12.1	1.77/9.90
120	54	1.50/23.4	1.59/19.8	1.65/18.0	1.68/17.0	1.78/14.5	1.92/11.9
380	172	2.80/74.4	2.60/64.7	2.68/57.5	2.74/54.3	**2.91**/46.2	**3.13**/37.9
400	181	2.51/78.3	2.66/66.5	2.74/60.5	**2.80**/57.1	**2.97**/48.6	**3.20**/39.9
420	191	2.56/82.7	2.71/70.2	**2.80**/63.8	**2.86**/60.3	**3.04**/51.3	**3.27**/42.1
440	200	2.61/86.6	2.77/73.5	**2.86**/66.8	**2.92**/63.1	**3.10**/53.7	**3.33**/44.1
480	218	2.71/94.4	**2.90**/80.1	**2.97**/72.8	**3.03**/68.8	**3.21**/58.5	**3.46**/48.1
540	245	**2.85**/106	**2.85**/90.0	**3.12**/81.9	**3.18**/77.3	**3.38**/65.8	**3.63**/54.0
600	272	**2.98**/118	**2.98**/99.9	**3.26**/90.9	**3.33**/85.8	**3.53**/73.0	**3.80**/60.0

Bold body surface area values identify values at which patients with normal cardiac output are in danger of being misclassified as having a low cardiac index.

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than 178 cm will have a decreasing BSA with decreasing height yet their BMI will be increasing.

Owing to this discordance of BSA and BMI in extremely morbidly obese patients, and the negligible impact of BMI on cardiac performance measured by CO or SV, evaluation of hemodynamic performance using the cardiac and stroke indices may be misleading. Clinicians may focus on the absolute hemodynamic data as opposed to indexed values in these patients when deciding treatment options [3].

Abbreviations
BMI, body mass index; BSA, body surface area; CO, cardiac output; SV, stroke volume.

Competing interests
The authors declare that they have no competing interests.

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References

1. Adler AC, Nathanson BH, Raghunathan K, McGee WT: **Extremes of weight may lead to inaccurate reporting of body surface area (BSA) indexed hemodynamic parameters [abstract A#574].** Poster presented at the American Society of Anesthesiology meeting, October 13 2012. Washington DC; 2012.
2. Stelfox HT, Ahmed SB, Ribeiro RA, Gettings EM, Pomerantsev E, Schmidt U: **Hemodynamic monitoring in obese patients: the impact of body mass index on cardiac output and stroke volume.** *Crit Care Med* 2006, **34:**1243-1246.
3. Adler AC, Nathanson BH, Raghunathan K, McGee WT: **Indexed hemodynamic measurements may be inappropriate at body surface area extremes.** *Crit Care* 2012, **16:**149.

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