Correlation Between Blood Volume and Pulmonary Artery Catheter Measurements

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Introduction

Blood volume (BV) measurement has been available for over sixty years, but not widely used in daily clinical practice due to the cumbersome technique.

The knowledge of intravascular volume status of a critically ill patient is important for fluid and cardiovascular management. Information from pulmonary artery catheter (PAC) parameters are useful for determination of cardiac output, but central venous pressure (CVP) and pulmonary artery occlusion pressure (PAOP) reflect volume in relationship to cardiac function and may not measure intravascular volume. We investigated the relationship between parameters obtained from PAC and simultaneous measurement of blood volume

Methods

Surgical patients with pulmonary artery catheters (PAC) and with some clinical parameter which needed treatment (tachycardia, hypotension, urine output, cardiac output, oxygenation or renal dysfunction) had BV measurements. Hemodynamic values, including blood pressure, heart rate, CVP, PAOP, cardiac index (CI) and stroke volume index (SVI) were obtained simultaneously with BV measurement.

Blood Volume Measurement

Blood volume was measured by using a commercially available kit, BVA-100 (Daxor, NY). After obtaining baseline sample of 5ml, I^{131}-labeled albumin was injected over 1 minute. Serial blood samples were drawn at 12, 18, 24, 30, and 36 minutes from the time of isotope injection. Radioactivity was measured in duplicate in semi automated counter. A minimum of three samples within standard deviation of less than 3.9% was used to calculate plasma volume (PV) by extrapolating to time zero. The hematocrit of the sample was measured to obtain the Red cell volume (RBCV) to plasma volume ratio, which calculation of blood volume as PV + RBCV. " Normal" BV level was determined from patient's height and ideal body weight in a proprietary algorithm by the company using data from the Metropolitan Life Table. Hypervolemia = measured BV>8% of normal predicted value. Euvolemia = measured BV within 8% of normal predicted value. Hypovolemia = measured BV < normal predicted value

Results

Twenty ICU patients contributed 29 simultaneous blood volume and pulmonary artery catheter values. Characteristics of the study group are presented in Table 1. Correlation between BV and PAC values are presented in Figures 1-4.

Results - cont

Euvolemia was present in 11 of 29 instances, hypervolemia in 17 of 29 instances, with 1 value demonstrating hypovolemia. BV in relationship to different ranges of PAOP are presented in Figure 5. In 6 of 29 instances, treatment was changed based on BV information. In 4 of 6, there was improvement in cardiac, pulmonary and or/renal function.

Table 1. Patients Demographics

Age (years)	62.5	±	20.7	(mean ± SD)	18 Š87	(range)
APACHE II	21.1	±	4.78	(mean ± SD)	12 Š26	(range)
ICU day of BV measurement	7.7	±	8.5	(mean ± SD)	1 Š30	(ra nge)
Trauma patients	n = 8					
General Surgery	n = 12					
Septic Shock/Severe Sepsis	n = 6					
Hemorr hagic s hock	n = 9					
Respiratory Failure	n = 5					
Mortality	1/20 (5%)					

Correlation Curves

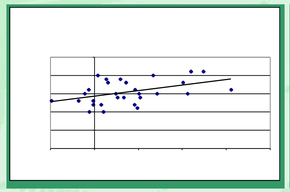


Figure 1

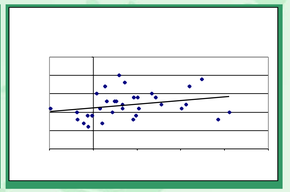


Figure 2

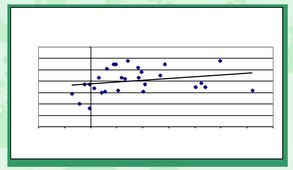


Figure 3

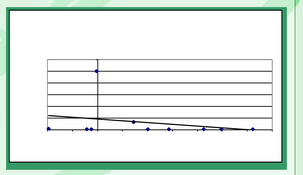
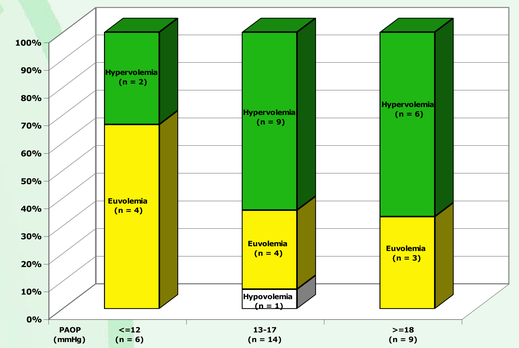


Figure 4

Figure 5.
Distribution of BV status by PAOP level



Green = hypervolemia. Yellow = euvolemia

Conclusions

Although there was a statistically significant correlation between PAOP and BV, BV information resulted in different treatment in 6 out of 29 instances (21% of the time) with 4/6 times showing clinical improvement when BV information was used. Regardless of different ranges of PAOP, whether PAOP was ≤12 mm Hg, 13-18 mm Hg, or >18 mm Hg, it was difficult to predict euvolemia vs hypervolemia. All our patients had skin edema from shock and resuscitation and assessment of intravascular volume was difficult. There may be a role for BV measurement in patients after the acute resuscitation when there is clinical dilemma regarding volume treatment.

Due to limitations of a retrospective study, we cannot infer outcome benefits until a prospective randomized study is done.