



# Stroke Volume Variation as a Marker of Intravascular Volume Compared to Blood Volume Measurement



K.Pe, M.Yu, S.Moran, K.Edwards, A.Tan, S.Steinemann, M.Ghows, H.Ho, W.Koss, F.Lurie, D. Takanishi  
University of Hawaii, Department of Surgery and Critical Care and Queen's Medical Center

## Introduction

Assessment of intravascular blood volume (BV) in critically ill patients poses a challenge. Surrogate markers including stroke volume variation (SVV) are used to guide fluid therapy. SVV is a quantification of pulsus paradoxus, where the blood pressure decreases with inspiration. The reverse is true for patients on positive pressure ventilation and is termed reverse pulsus paradoxus. The SVV value used to indicate responsiveness to fluid challenge varies from SVV >9.5% to >15% depending on the literature. SVV reportedly correlates well with transesophageal echo estimations of preload status and is a sensitive indicator of fluid responsiveness. BV can also be measured directly utilizing a radio-labeled technique. Blood volume has been demonstrated to accurately assess actual intravascular volume and component volumes (plasma volume + red cell volume). Blood volume has guided hemodynamic manipulation of congestive heart failure and septic patients. This study assessed the correlation between BV and SVV.

## Objective:

- To establish relationship between SVV (a marker of fluid responsiveness) and BV (a direct measure of volume).
- To evaluate the subset of patients who may be deemed nonresponders by SVV and yet are hypovolemic by blood volume.

## Hypothesis:

There is no relationship between SVV and BV.

## Methods

Critically ill surgical patients had simultaneous measurement of SVV (FloTrac, Edwards Lifesciences, Irvine, CA), and BV (Daxor, NY, NY). Using proprietary algorithms, Edwards Lifescience's FloTrac automatically calculates interval SVV over 20 second-periods and outputs SVV as a percentage. The software takes into account blood vessel compliance changes by constantly analyzing the waveform and its relationship to their proprietary coefficient "KI". Due to FloTrac limitations, all data during irregular heart rate and spontaneous respirations were excluded.

Iodine-131 labeled-albumin technique with 5 sequential blood sampling, extrapolated to time zero, measured plasma volume (PV). From the hematocrit [red cell volume/ (red cell volume + plasma volume)], the BV (red cell volume + PV) was calculated. The values were presented as % deviation from ideal BV and hypovolemia was defined as any value less than the ideal BV.

Multiple samples are obtained to reduce error to approximately +/- 2.5% per manufacturer.

## Inclusion Criteria:

Sepsis/Severe sepsis/  
Septic shock  
ARDS/oxygenation failure  
Age>18

## Exclusion Criteria:

Comfort care  
Pregnancy  
Severe head injury



## Results

Eighteen ventilated patients contributed 74 data points with the following demographics (mean ± standard deviation): age = 57 ± 20 years, APACHE II = 24.2 ± 3.2, respiratory rate=15 ± 4, heart rate= 90 ± 20. Diagnosis included: severe sepsis/septic shock (n=12), ARDS (n=4), and cardiovascular collapse (n=2). Regression analysis showed no linear relationship between SVV and BV (r = 0.110, with R<sup>2</sup>=0.012, p=0.17). BV demonstrated hypovolemic state in 9 of 74 instances (12%) when SVV was <9.5%, and in 13 of 74 instances (18%) when SVV was <15%.

## Demographics:

Age=57 +/- 20 years  
APACHE II = 24.2+/- 3.2  
RR = 15+4

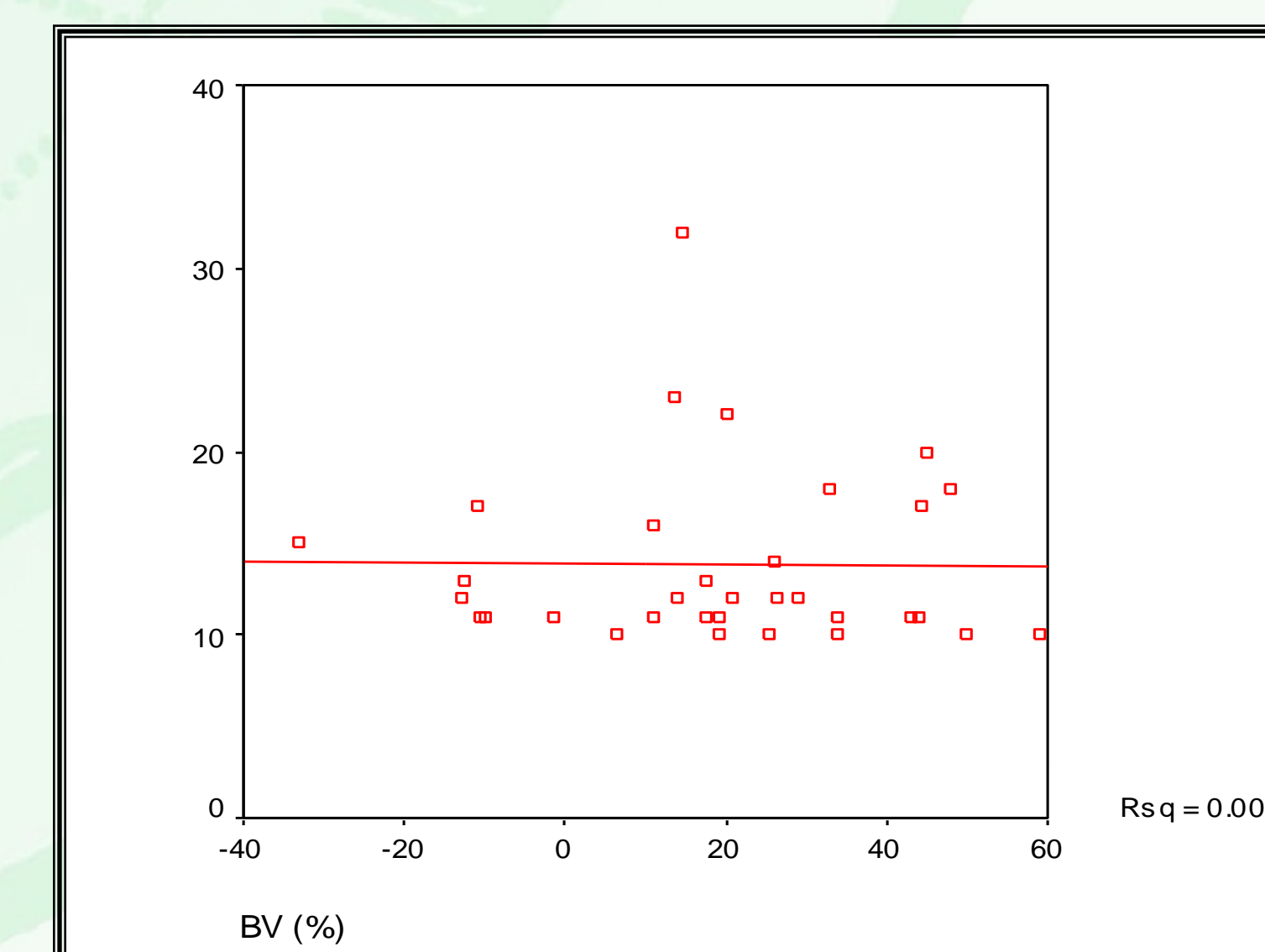
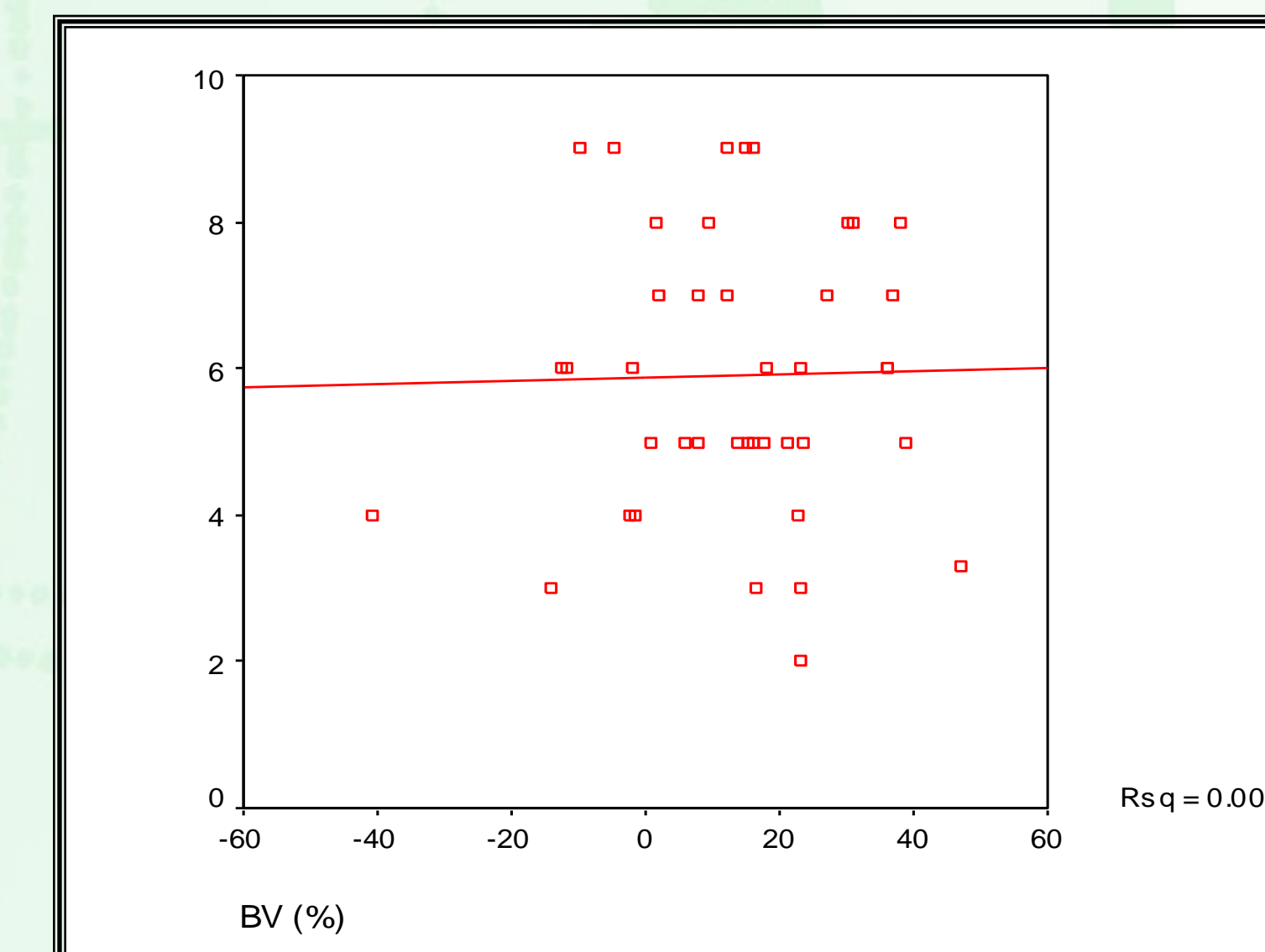
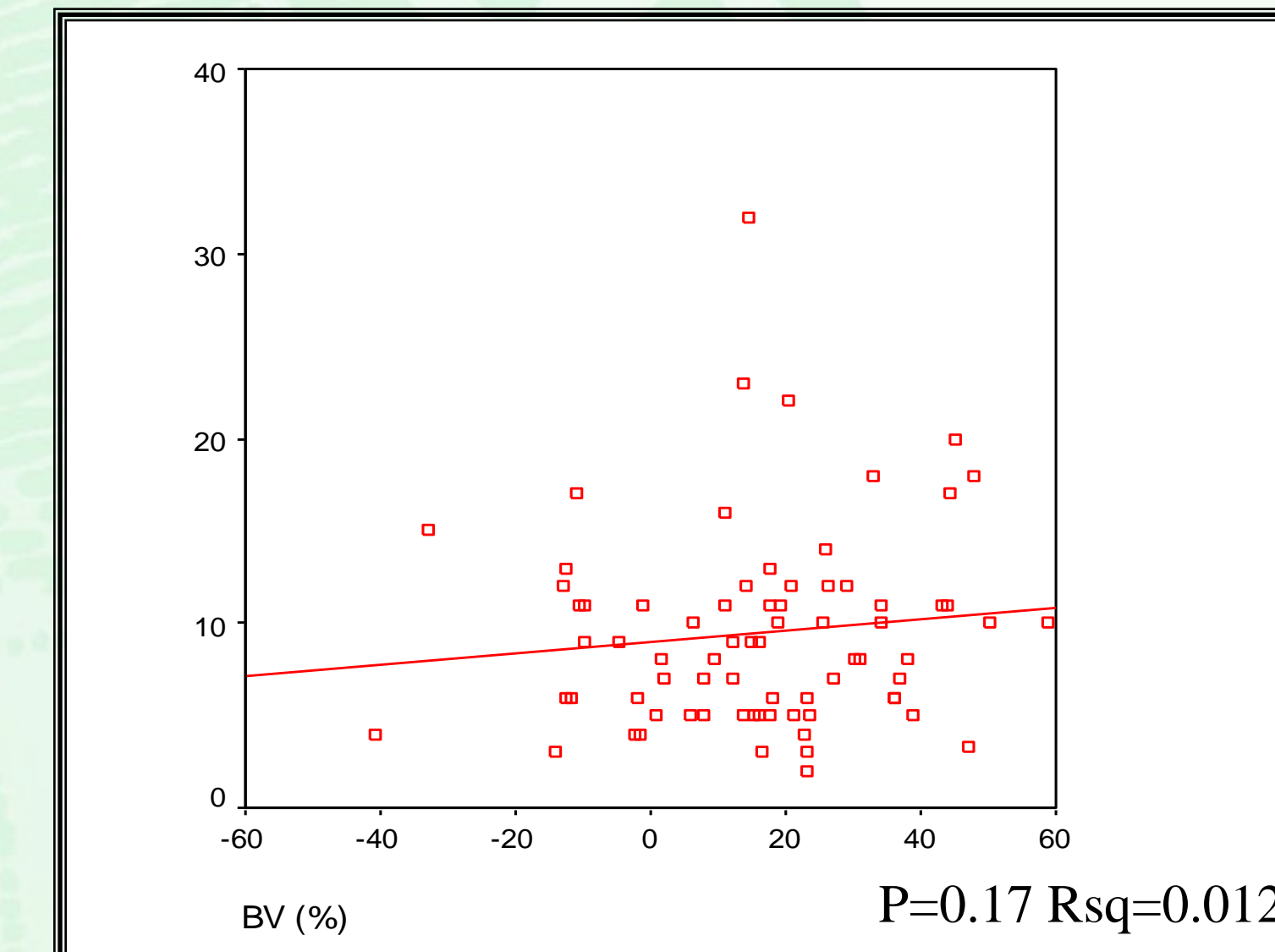
(ALL mechanically ventilated with no spontaneous respirations)

HR = 90+ 20

## Diagnosis:

Severe sepsis /septic shock (n=12)  
ARDS (n=4)  
CV Collapse (n=2)

## Results



**BV was hypovolemic 9/74 instances (12%) when SVV <9.5%**

**BV was hypovolemic 13/74 instances (18%) when SVV <15%**



NO TREATMENT WITH FLUID



TREATMENT WITH FLUID

## Conclusions

- Clinicians may be misled by stroke volume variation
- A group of patients demonstrated hypovolemia on BV, but thought to be fluid non-responders based on SVV
- Caution: SVV measures fluid responsiveness, BV is a direct measure of volume
- No randomized trial has reported data on blood volume treatment outcomes
- Current literature on SVV are small in sample, lack outcome studies or followup

## References

- Berkenstadt H, et al. Stroke volume variation as a predictor of fluid responsiveness in patients undergoing brain surgery. *Anesth Analg* 2001;92:984-989.
- Michard F. Changes in arterial pressure during mechanical ventilation. *Anesthesiology* 2005; 103:419-428.
- Reuter DA, et al. Usefulness of left ventricular stroke volume variation to assess fluid responsiveness in patients with reduced cardiac function. *Crit. Care Med* 2003; 31:1300-404.
- Feldschuh, J Prediction of the normal blood volume: Relation of blood volume to body habitus. *Circulation* 1977; 56: 605-612