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Measurement of Blood Volume Benefits Critically Ill Patients

In a Small Pilot Study, Hawaiian Investigators Found That Measurement Would Have Significantly Altered Treatment

Elizabeth Douglas

Phoenix–Blood volume analysis can be a valuable tool in the treatment of critically ill patients, Hawaiian investigators contend. "Blood volume measurement can help you out in patients [in whom it is] difficult to estimate volume status by traditional means," Elisabeth N. Biuk-Aghai, MD, said at the 2005 annual meeting of the Society of Critical Care Medicine.

In a pilot study that included eight critically ill patients, blood volume data would have significantly altered management in the large proportion in whom fluid status could not be reliably determined with current clinical tools, Dr. Biuk-Aghai reported. She is Surgical Critical Care Fellow, University of Hawaii John A. Burns School of Medicine, Honolulu.

The Hawaiian intensivists used the commercially available BVA-100 (Daxor Corporation; New York City) to measure patients' blood volume. Two to three days later, they unblinded the results to see if the information would have altered treatment. Importantly, the patients chosen for the study were those whose volume status was questioned by the treating physicians. They performed 29 blood volume measurements in the eight patients.

In half of the 20 assessments of patients with a pulmonary artery catheter, treatment would have been different had the blood volume data been available. "Most of the time, it would have been less fluid," said Dr. Biuk-Aghai. In 33% of the assessments of patients with no pulmonary artery catheter, treatment would have been altered with blood volume data.

Furthermore, no correlation was found between blood volume data and traditional markers of fluid status–pulmonary artery occlusion pressure, central venous pressure, B-type natriuretic peptide levels and stroke volume index.

"We are currently using blood volume measurement in our clinical practice in our ICU and are treating according to the blood volume information," Dr. Biuk-Aghai told *Anesthesiology News*. A second prospective study in which blood volume measurement will be used to evaluate length of stay and patient outcome is being planned.

Other Perspectives

That blood volume data would have changed clinical management is intriguing, said Stuart D. Katz, MD. However, the finding needs to be validated in a larger patient population, he told *Anesthesiology News* . Dr. Katz is Associate Professor of Internal Medicine and Cardiology, Yale University School of Medicine, New Haven, Conn.

These study results are comparable with those found by Dr. Katz and colleagues (*Am J Cardiol* 2004;93:1254-1259) in a population of patients with stable heart failure. In 43 ambulatory

patients with congestive heart failure, "currently available clinical tools to evaluate volume status were not very good at predicting status as measured by the blood volume analyzer," he said. "Physical assessment was wrong most of the time," as determined by blood volume analysis and pulmonary capillary wedge pressure (available in 16 patients).

Furthermore, in the population with stable heart failure, volume overload as determined by the blood volume analyzer "was a perfect predictor of bad outcomes."

In his study, wedge pressure and blood volume analysis "correlated nicely," Dr. Katz said. That they did not in this critically ill population may indicate that blood volume is dissociated from wedge pressure in critical illness. Additional studies are warranted to characterize the determinants of blood volume and cardiac filling pressures in critically ill patients, he suggested.

Although there are inherent problems with the use of traditional clinical indicators of volume status, such markers have been used for many years in guiding initial resuscitation efforts and subsequent care, noted session moderator Heidi J. Dalton, MD. Transitioning away from traditional indicators on the basis of a new modality that is still relatively unproven will take more data and study. She asked Dr. Biuk-Aghai about the accuracy of the new blood volume measurements. In addition, she pointed out that clinicians would give fluids during the initial resuscitation of patients in shock or with trauma irrespective of blood volume measurements. Dr. Dalton is Medical Director, Critical Care Medicine, and Professor of Pediatrics at The George Washington University School of Medicine and Health Sciences, Washington, D.C.

The BVA-100 has been compared with radioisotope measurement of blood volume, which is the gold standard, said Dr. Biuk-Aghai. The co-inventor of the BVA-100, Joseph Feldschuh, MD, has found the accuracy of the machine to be ±2.5%. Dr. Feldschuh currently is President, CEO and Chief Scientist of Daxor.

Blood volume measurements are valuable not during initial resuscitation but rather a few days later in those patients in whom it is difficult to determine the cause of depressed vital signs, wedge pressure or urine output, said Dr. Biuk-Aghai. Does the patient need a diuretic or fluid?

On several occasions, it was "quite striking" how the blood volume data would have altered management, noted Dr. Biuk-Aghai. For three of the data points, the patient was fluid overloaded and required diuresis. However, it was not until one or two days later that clinical signs of fluid overload developed–pulmonary edema, congestive heart failure, visible fluid on chest X-ray–and treatment was started. "With blood volume analysis, we would have identified and treated these patients earlier," said Dr. Biuk-Aghai.

Another young patient had a very low corrected hematocrit, 20%, and "we couldn’t explain what was wrong with him," said Dr. Biuk-Aghai. The critical care team thought perhaps the patient had a pulmonary embolism. Blood volume analysis showed the patient was overall euvolemic to slightly hypovolemic with an expanded plasma volume and in need of blood transfusion.

Nuts and Bolts

The BVA-100 determines blood volume after ^{131}I-labeled albumin has been injected through an intravenous line. A kit that requires a single venipuncture is used for five serial blood draws (12-36 minutes after injection, plus baseline) of 1 mL each.

Samples are processed with the BVA-100 analyzer. Results are available within one hour, and preliminary results when three samples are used can be obtained in 30 minutes, Dr. Feldschuh told *Anesthesiology News*.

Results include total blood volume, plasma volume, red cell volume, and blood volume as a percentage of ideal. Percentage of ideal blood volume is calculated by using ideal height—weight curves derived from the Metropolitan Life Insurance Company tables. Percentage of ideal blood volume is the most useful of the data, said Dr. Biuk-Aghai.

The list price of the semiautomated BVA-100 system, which became commercially available in 1998, is $65,000. The disposable kits for sample collection cost $299 each.

Pilot Study

The investigators identified eight surgical ICU patients during morning rounds whose treatment might benefit from blood volume assessment. Of these, five had a pulmonary artery catheter in place. A total of 29 sets of blood volume measurements were made.

The mean patient age was 53±8 years, and the mean APACHE II (Acute Physiology and Chronic Health Evaluation II) score was 16±4. Five patients had severe sepsis/septic shock, one had acute respiratory distress syndrome (ARDS), one had severe right ventricular failure secondary to a cardiac contusion, and one was in the surgical ICU for preoperative optimization.

The prospective observational study was followed by a chart review–that is, the blood volume measurements were not available to the treating team. Two to three days after the measurements had been made, the blood volume data were unblinded and the treating team determined if they would have altered treatment.

The blood volume data would have changed the treatment in 10 of 20 instances in which pulmonary artery catheter data were available. The blood volume data would have resulted in the administration of less fluid on six occasions, two patients would not have received blood, one patient would have received more fluid, and one would have received neither blood nor fluid.

The blood volume data would have changed the treatment in three of nine instances in which pulmonary artery catheter data were not available. In two cases, the patient would have received blood, and in one instance, the patient would have received more fluid.

Lack of Correlation With Traditional Markers

The traditional parameters of volume status were determined and used to treat these patients. In the retrospective analysis, no correlation was found between percentage of ideal blood volume and pulmonary artery occlusion pressure, central venous pressure, B-type natriuretic peptide levels or stroke volume index ($P>0.05$ by Pearson's correlation coefficient or Spearman's rank correlation coefficient).

Other indications of volume status–urine output, vital signs, hematocrit and chest X-ray–were not compared with the blood volume measurements, but they were used for treatment decisions. Nonetheless, volume status was often assessed incorrectly, noted Dr. Biuk-Aghai.

Reasons included the following: hematocrit is useful as an indicator of volume status only when the patient is euvolemic; heart rate and blood pressure may be elevated as a consequence of hypovolemia, hypervolemia, or atrial stretch; and the chest X-ray may be particularly unreliable in the presence of ARDS and other primary pulmonary problems.

Co-workers with Dr. Biuk-Aghai were Andrew Tan, MD, Mihae Yu, MD, Hao Chih Ho, MD, Alyssa Chapital, MD, and Wega Koss, MD.

Based on a poster presentation (Abstract 158) at the 2005 annual meeting of the ***Society of***

Critical Care Medicine, *an article in* ***Circulation*** *(2003;107:226-229), and interviews with* ***Elisabeth N. Biuk-Aghai, MD, Stuart D. Katz, MD,*** *and* ***Joseph Feldschuh, MD.***
