Noninvasive Hemodynamic Monitoring Facilitates Organ Recovery

Editor’s Note: This article is based on an interview with Cynthia Willis, Certified Procurement Transplant Coordinator, LifeShare of the Carolinas in Charlotte, NC, and input from William Miles, MD, at Carolinas Medical Center, and Michael Bowdish, MD, cardiothoracic transplant surgeon at the University of North Carolina Hospital.

The availability of noninvasive hemodynamic monitoring has facilitated the process of recovery of donor organs, according to Cynthia Willis, Certified Procurement Transplant Coordinator with LifeShare of the Carolinas in Charlotte, NC. She has found that monitoring fluid status with the FloTrac system (Edwards Lifesciences) has helped to stabilize donors earlier and has therefore increased the number of organs available for transplant in a shorter timeframe.

Recovery of thoracic organs (heart and lungs) is difficult on a number of fronts. Donors are often accident or gunshot victims with massive chest injuries. Even more challenging, however, is the catecholamine storm that occurs with brain death. This condition can lead to neurogenic pulmonary edema secondary to fluid overload. It can also cause a heart to appear to have had a myocardial infarction. “It isn’t actually an MI,” said Ms. Willis. “The heart will typically recover, but it usually takes 24 to 48 hours for the recovery to be seen on an echocardiogram.” The organ transplant registry, UNOS, requires an echocardiogram before a heart can be considered for transplant.

In both of these situations, it is difficult to manage the patient without hemodynamic data, and it is difficult to obtain data from invasive means - i.e., from a Swan-Ganz catheter. The unavailability of a physician to place a Swan-Ganz catheter often renders that option untenable.

However, clinicians can use data from the FloTrac system for fluid management and also to track cardiac output.

Case report

Ms. Willis described a recent case to illustrate the utility of the FloTrac system:

A 23-year-old male was admitted with traumatic brain injury and was subsequently declared brain dead. Prior to placing this patient on the FloTrac system, he received an excessive amount of fluid over a 24-hour period - 24 liters of crystalloids, 3 liters of colloids and 5 liters of blood - but remained hemodynamically unstable.

The initial echocardiogram at 9:01 am taken immediately after weaning him off of all pressors showed an ejection fraction (EF) of 35%.

Fast Facts about Organ Transplants

- Between January 1, 1988 and March 31, 2009, there were 456,859 transplants in the U.S. of all organs – kidney, pancreas, liver, heart, lung, and intestine.¹

- Since 1988, there have been 45,803 heart transplants; so far this year, there have been 528.¹

- The waiting list for an organ transplant was 102,342 in the U.S. as of July 1, 2009 (some individuals may be listed on more than one registry).¹

- As of June 26, there have been 3,568 donors and 7,000 transplants in 2009.¹

- Each day, about 77 people receive organ transplants. However, 19 people die each day waiting for transplants that can’t take place because of the shortage of donated organs.²

- The number of people requiring a life-saving transplant continues to rise faster than the number of available donors. Approximately 300 new transplant candidates are added to the waiting list each month.²

- Living donations are increasing to meet the organ shortage; about 6,000 living donations take place each year.³

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Study Describes Benefits of ScvO\textsubscript{2} Monitoring in Critically Ill Children

Although mixed venous oxygen saturation (ScvO\textsubscript{2}) reflects an early imbalance between oxygen delivery and consumption, it is difficult to obtain such measures via pulmonary artery catheters in children. Central venous oxygen saturation (ScvO\textsubscript{2}) has been shown to be a valid surrogate for SvO\textsubscript{2} and is easier to achieve because many critically ill patients have central lines. A modified pediatric oximetry catheter (PediaSat, Edwards Lifesciences) is now available to enable continuous ScvO\textsubscript{2} readings in children.

To assess the new catheter’s accuracy, researchers compared its readings with intermittent co-oximetry values in critically ill children. The study included 19 children predominantly post-cardiac bypass surgery, with a mean age of 24.5 months (range 1 day to 14.3 years). All had central lines in place and were receiving mechanical ventilation in the pediatric ICU. Oxygen saturation measures were obtained from the distal port of the catheter and compared simultaneously with the reading on the Vigileo monitor. Intermittent sampling was done every 6 hours.

“A system that provides continuous monitoring of ScvO\textsubscript{2} in children of all ages and demonstrates accurate trending compared with co-oximetry values would therefore be a benefit to children.”

The researchers “found a good correlation between these two methods in critically ill children.” Analysis of the 104 paired samples determined a mean bias of 1.09% with a standard deviation of 8.48. There was good correlation between values, with a regression analysis result of 0.81. The system also demonstrated accurate trending. The authors noted that continuous ScvO\textsubscript{2} has also been shown to demonstrate better correlation with cardiac index than other routine hemodynamic variables such as heart rate, mean arterial pressure or central venous pressure.

There were no complications or technical failures associated with the catheter. Nor were there any documented episodes of catheter-related bloodstream infections or clot formation. The researchers noted, “The catheters have both antimicrobial and thrombo-resistant properties, but it was not possible to attribute the lack of complications to these features.”

Another potential benefit of continuous ScvO\textsubscript{2} monitoring is the reduced need for frequent blood draws. Intermittent sampling is “less than ideal”, particularly when a patient’s clinical condition is fluctuating rapidly. Repeated line sampling may increase the incidence of catheter-related bloodstream infections and the need for blood transfusions.

How Does It Work?
The PediaSat oximetry catheter is a double lumen 4.5F catheter in 5 cm or 8 cm lengths. It has one 23-gauge proximal lumen and a 20-gauge distal lumen. Two fiberoptic wires emit and receive infrared light from an oximetry module. They terminate next to the port of the distal lumen. The return signal is then routed through the oximetry module to a Vigileo monitor, which displays real-time ScvO\textsubscript{2} values and a graphic trend.

New Consensus Statement Examines Glycemic Control in Hospitalized Patients

Substantial observational evidence links hyperglycemia in hospitalized patients to poor outcomes - regardless of whether or not the patient has diabetes. Some studies have suggested that intensive treatment of hyperglycemia improved outcomes, while others have not found any reduction in mortality. Further, there have been reports of high rates of severe hypoglycemia following intensive treatment of hyperglycemia, leading to safety concerns.

While there is a growing national movement advocating the management of inpatient hyperglycemia as a quality-of-care measure, inconsistent results regarding the effectiveness of glycemic control interventions have created confusion.

Hyperglycemia in hospitalized patients is “unequivocally associated” with adverse outcomes. When it occurs in acutely ill patients with previously normal glucose tolerance, it is called “stress hyperglycemia.”

The American Association of Clinical Endocrinologists and American Diabetes Association (ADA) sought to address some of the confusion by updating their Consensus Statement on Inpatient Glycemic Control. The organizations’ goals in revising the statement included identification of reasonable, achievable and safe glycemic targets and descriptions of the protocols, procedures and system improvements needed to facilitate their implementation. Both the ADA and the American College of Endocrinology recommend tight glycemic control in critical care units.

Consensus Panel members conducted extensive literature reviews on all aspects of glycemic control, including potential outcomes, appropriate targets for different patient populations, treatment options, safety concerns, cost-effectiveness, and areas for future research. Their recommendations include specific targets and doses for critically ill and non-critically ill patients.

Glycemic Control Is Cost-Effective

The Consensus Statement cites a number of pharmacoeconomic analyses that have found inpatient glycemic control to be cost-effective, with results such as these:

- In open-heart patients whose hyperglycemia was controlled, the incidence of deep sternal wound infections was reduced by 66%, resulting in a total net savings to the hospital of $4,638 per patient.
- Intensive glycemic control in 1,600 patients in a medical ICU was associated with a total cost savings of $1,580 per patient.
- Strict normalization of blood glucose levels in mechanically ventilated surgical ICU patients achieved cost savings of $3,476 per patient.
- Using an insulin protocol in hyperglycemic patients in an Emergency Department reduced hospital stay by 1.5 days.

The panel concluded that “intensive glycemic control programs have reported substantial cost savings, primarily attributable to decreases in laboratory, pharmacy, and radiology costs, fewer inpatient complications, decreased ventilator days, and reductions in ICU and hospital length of stay.”

“Optimization of inpatient glycemic management not only is effective in reducing morbidity and mortality but also is cost-effective.”

Frequent Glucose Monitoring Is Required

With IV insulin therapy in critically ill patients, frequent glucose monitoring is “essential to minimize the occurrence of hypoglycemia and to achieve optimal glucose control.” The Statement also recommends caution in interpreting results of point of care glucose meters in patients with anemia, polycythemia, hypoperfusion, and use of some medications. The Consensus Panel recommended additional research on the role of continuous glucose monitoring systems in inpatient settings.

Organ Recovery  

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The patient was placed on the FloTrac system and closely monitored while being managed according to the stroke volume variation (SVV) algorithm which the staff had amended to indicate specific medications and dosages to administer based on the SVV and the stroke volume index (SVI) readings. The patient was started on dobutamine at 1.5 mcg/kg/min; his SVV was 12-15%, SVI 25-35, and cardiac output (CO) 3.5-4.0 L/min. Within 1-1/2 hours, the SVV was 13%, SVI 45, and CO 8.0. Dobutamine was stopped and these hemodynamic parameters were maintained. Based on the improving cardiac numbers, a repeat echocardiogram was ordered. Performed only six hours after the first one, the second echo report read, “directly compared to the study from earlier today, the left ventricular (LV) systolic function is improved” - EF is 45%.

“Monitoring fluid status with the FloTrac system has helped to stabilize donors earlier and has therefore increased the number of organs available for transplant in a shorter timeframe.”

This evaluation enabled the staff to begin the search for a heart transplant recipient. “Before we had the FloTrac system, we had to guess when to do the next echocardiogram,” said Ms. Willis. “We usually did it after the patient was weaned off pressors. But this was not scientific, not based on data. Now we can do the echo when the patient is hemodynamically optimized – when we know the actual status of the heart.”

The trauma patient required only minimal additional fluid management throughout the afternoon. The fluids were determined by following the SVV algorithm with values provided by the FloTrac system. The patient did not require any additional inotropes after the initial “dobutamine stress” infusion.

The final echocardiogram was completed 12 hours after the initial one and was “completely normal” with an EF of 55-60%. This echo was done at the request of the accepting transplant center.

The heart was refused by many centers unwilling to wait for improvements that they felt would take 24+ hours. The accepting center was pleased to have continuous cardiac monitoring and function that improved in < 6 hours.

The heart was transplanted at the University of North Carolina Hospital. The recipient was a father of four. As of this writing, seven months later, he is doing “extremely well,” regaining function and hoping to return to work.

In this particular circumstance, waiting 24 to 48 hours in hopes the cardiac function would improve was not an option. Ms. Willis said, “Had we not had the noninvasive monitoring capability to guide our interventions, this heart would not have been transplanted.” The cardiothoracic transplant surgeon, Dr. Michael Bowdish, commented, “My impression was that the noninvasive monitoring was pretty accurate. I would think in situations where it’s hard to get a Swan-Ganz catheter measurement (i.e., smaller places), it would definitely have a place in donor management. I would have no problem accepting numbers obtained noninvasively from a reasonable donor.”

Ms. Willis was especially impressed by the reduced time required to “manage” the heart back to transplantable condition. Using the FloTrac system for fluid management also reduces the chance of losing other organs due to extended management times and diminishes the likelihood of neurogenic pulmonary edema caused by fluid overload. “Overall, this enhanced management approach reduces the financial cost of maintaining a donor patient in the ICU,” she added.

While it is possible to maintain a donor for 24 to 48 hours while the heart recovers, a wait of that duration poses a problem for the donor’s family. “Once a family has consented to donation, they want it completed in a timely manner so they can move forward with funeral plans and finding the emotional closure they need. When a family has so graciously set their own grief aside to save another life, we owe it to them to use every tool available to maximize their gift while meeting their needs.”

LifeShare of the Carolinas is the federally designated Organ Procurement Organization for the Charlotte, NC, region. LifeShare partners with Carolinas Medical Center to provide donor organs to patients awaiting transplantation.

LifeShare follows the best practice model, which calls for the transplant surgeon, surgical critical care physician, and LifeShare’s recovery coordinator to aggressively manage the deceased donors in order to decrease cold ischemic time, increase organ quality, and increase the number of organs recovered per donor. Last year, LifeShare recovered 310 organs for transplant (of the 34,088 recovered nationally); the figures for 2007 were LifeShare 353, nationally 34,630.
Fast Facts

- Most living donors are family members or close friends.\(^3\)
- A living donor can donate one of two lobes of their liver, one of two kidneys, one lung or part of a lung, part of the pancreas, or part of the intestines.\(^3\)
- Living donors should be physically fit, in good health, between the ages of 18 and 60, and should not have had diabetes, cancer, high blood pressure, kidney disease, or heart disease.\(^3\)
- Most religions support organ and tissue donation as a charitable act of love and giving.\(^4\)

Transplant Statistics\(^5\)

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<th>No. transplants/ year</th>
<th>Heart*</th>
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<td>75%</td>
<td>60%</td>
<td>85%**</td>
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</table>

* 2003 data  
** This is the number of people living “fairly normal” lives one year after the transplant.


Low ScvO\(_2\) Found To Predict Poor Outcomes in Brain Injuries

Researchers in Florence, Italy, assessed the role of continuous central venous oxygen saturation (ScvO\(_2\)) monitoring in patients with brain injury due to trauma. Their goal was to determine whether reports on the prognostic value of ScvO\(_2\) in cardiac disease, sepsis and trauma would be reproduced in patients with brain injury.

They measured ScvO\(_2\) in 121 patients with severe brain injury after major trauma in the first 24 hours after admission to the Trauma Center’s ICU. They commented that ScvO\(_2\) can be easily monitored with a central venous line, whereas mixed venous oxygen saturation (SvO\(_2\)) requires pulmonary artery catheterization. The ScvO\(_2\) continuous monitoring was performed with the Vigileo system (Edwards Lifesciences).

The overall 28-day mortality was 18.2%. Patients who survived had ScvO\(_2\) values of 70.1% ± 8.9; the ScvO\(_2\) values for those who died were 66.7% ± 11.9 (\(P=0.046\)). The researchers determined that an ScvO\(_2\) value of 65% or less carried a significant relative risk for death. Injury scores and lactate levels were also lower in patients with lower ScvO\(_2\), leading to the caution that ScvO\(_2\) monitoring should not be considered a substitute for lactate monitoring or injury scores in predicting outcome. Patients with ScvO\(_2\) values over 65% showed significant reductions in both ICU and total hospital length of stay.

The researchers concluded that early monitoring of ScvO\(_2\) could aid in predicting outcome in patients with major trauma and head injury and thus should be done in these patients.


What’s New on the Web

www.OACC.org  
Organization for Advancing Critical Care Monitoring

New continuing education programs are available on the web site of the Organization for Advancing Critical Care Monitoring. Check it out - it’s free!

New CME courses and faculty are:
- The Economics of Sepsis (Betsy Gross, RN)  
- Intra-abdominal Hypertension - The ARDS of the Gut (Timothy R. Wolfe, MD)  
- Expanded Applications for Hemodynamic Monitoring 2009: APCO and Dynamic Variables of Volume Status - Clinical Application (William T. McGee, MD)

A Midsummer’s Read

Recent articles on various aspects of critical care are reviewed and highlighted on these websites:

Critical Care Forum offers a listing of the top 20 articles accessed in the past month, the past year, and “all time”.
http://ccforum.com/mostviewedalltime

Faculty of 1000 is an English site featuring articles recommended and rated by leaders in medicine. A subscription is required (£150/year); there is a three-week free trial.
http://www.f1000medicine.com/browse/CRITCARE?max=50
With attendance of more than 5500, the 2009 National Training Institute and Critical Care Expo in New Orleans was a big success. Following are reports on some of the “Creative Solutions” poster presentations on quality initiatives, sepsis management, and glucose monitoring.

**Quality Initiatives**

**Don’t Forget the Night Owls**

Awareness that ICU night shift nurses are typically excluded from the benefits of interdisciplinary patient rounds (such as education, communication, camaraderie, and reinforcement of core measures and therapeutic care bundles) led to the development of a Quality Rounds program at a non-teaching community hospital. The program includes a Quality Checklist of essential elements of recommended treatment protocols to enhance handoff communication.

Use of the Quality Checklist has brought indicators, initiatives and measures previously discussed only on the day shift into the daily practice and discussion of the night shift. The previously left-out staff has become increasingly motivated and engaged in improving the quality of care delivered to patients. Further, quality indicator data has continued to improve since the inception of the Quality Rounds in October 2007, with no incidents of ventilator-associated pneumonia since November 2007 or central line-associated bacteremia since October 2007.

Zucconi M. Extending the Benefits of Interdisciplinary ICU Rounds to Nightshift. Abstract CS78.

**ICU CATs Improve Quality**

To improve quality of care in an adult medical surgical ICU, the manager, educator and critical care clinical nurse specialist formulated and implemented a Clinical Action Team, also known as a CAT. The first CAT focused on the need to reduce ventilator associated pneumonia (VAP) in the ICU population. The team, which met monthly for four hours, included staff nurses and physicians plus a critical care clinical nurse specialist, respiratory therapist and infection control nurse. The CAT coordinated VAP prevention strategies, monitored compliance with the ventilator bundle and educated the nursing staff, with a subsequent reduction of VAP in the ICU. There has also been a reduction in nosocomial infections, and patient outcomes in the ICU have improved.

Following the success of the first CAT, three other ICU CATs have been developed: Infection Prevention, Neuro Trauma and Critical Care. Responding to the success of the ICU CATs, other units within the hospital have implemented their own CATs. Staff nurses are engaged in the work of their CAT and are proud of their accomplishments.

Jacobs L. Herding CATs: A Nurse Managers Dream to Increase Quality of Care. Abstract CS81.

**Sepsis Protocols**

**“Surviving Sepsis” Moves Out of the ICU**

An interprofessional Sepsis Task Force was created to extend the Surviving Sepsis Campaign principles to the acute care setting. The group designed a program to educate staff nurses to recognize signs and symptoms of sepsis and to implement a six-hour bundle. Early recognition enables them to initiate early treatment, essentially moving implementation of proven Surviving Sepsis interventions beyond the ICU/ED.

Initial implementation of the ICU Sepsis Protocol yielded a reduction of sepsis-associated mortality rates from 40% to less than 20%. Identical metrics will be utilized to evaluate the program’s effects house-wide. The effectiveness of RN education will be measured through satisfaction surveys and MD education by use of the six-hour bundle outside the ICU. According to the presenter, “Early recognition and treatment of sepsis must become ingrained into the hospital culture and evolve as the standard of care. This alone will insure that we will continue to see positive outcomes associated with early sepsis intervention.”

Norman T. Joining Forces, ICU and Acute Care Nurses Avert Disaster through Early Sepsis Recognition and Treatment. Abstract CS91.
No Nurse Left Behind

At a community trauma hospital, a dedicated sepsis coordinator position was created to drive compliance with Surviving Sepsis interventions hospital-wide. After evaluating existing systems and outcomes, and applying the lessons learned nationally over the past four years on execution of sepsis interventions, a “tool-kit” approach with broad, house-wide implementation was undertaken. Ten multidisciplinary groups collaborated to produce a root-cause analysis on each barrier to attainment. Every nurse on every unit was engaged, as emergency, critical care and medical/surgical units focused on patient flow, communication across units and problem solving.

Data on 76 patients with severe sepsis or septic shock who had at least one critical care bed day since implementation of the program demonstrates its success (see Table below.) Compliance with Early Goal-Directed Therapy improved from 0% to 71%, and the rate of lactate screening increased from 63% to 96% (both p<0.05).

<table>
<thead>
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<th>Measure</th>
<th>Before (N=57)</th>
<th>After (N=76)</th>
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<td>In-hospital mortality</td>
<td>29.8%</td>
<td>15.8%</td>
<td>P&lt;0.05</td>
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<tr>
<td>Respiratory failure requiring intubation</td>
<td>58%</td>
<td>35%</td>
<td>P&lt;0.05</td>
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<td>Sepsis patients requiring hemodialysis</td>
<td>18%</td>
<td>11%</td>
<td>P=0.32</td>
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</table>


Sepsis Screening Tool Reduces Code Blues

A proactive rapid response screening tool using a combination of computerized lab/test results was created to identify potential severe sepsis patients by adding the white blood cell count and creatinine. The goal was to identify potential severe sepsis patients earlier, before a rapid response is called or the patient requires emergent intervention on the floor. Once the screen identifies a potential patient, a member of the rapid response or sepsis committee goes to the patient’s bedside to assess the patient for severe sepsis. Treatment is begun with initiation of the Severe Sepsis Order Set, thus preventing treatment delays and reducing the need to transfer the patient to a higher level of care.

In its first year of use, 75% of the patients who were identified by the proactive screening were positive for severe sepsis. The sepsis mortality index has decreased from 2.2 to 1.6. Identifying and treating non-ICU patients earlier has decreased the number of Code Blues by 20.6% compared to the same time a year ago, and transfers to the ICU/IMC from the floors are down by 56%.

Pyle K. No Nurse Left Behind: Sharing The Lessons Learned after 4 Years of the Surviving Sepsis Campaign. Abstract C598.

Blood Glucose Monitoring

Blood Glucose Variability Signals Trouble

The feasibility of using blood glucose (BG) variability in stress-induced hyperglycemia as a warning sign for worsening patient condition requiring intervention was investigated. Point-of-care BG values and other clinical measures were collected from the medical records of the three non-diabetic but hyperglycemic patients in a surgical trauma ICU whose BG values had stabilized with the use of continuous IV insulin therapy. All exhibited BG variability as their condition worsened, and medical intervention was required; there was no apparent cause for the increased hyperglycemia. Hence the researchers suggest that acute episodes of glucose fluctuation may be interpreted as sentinel events which signal impending clinical worsening. They commented, “These events warrant investigation of the underlying cause and potentially offer opportunity for earlier treatment to offset the patient’s further decline.” They also suggested that further research is needed to determine clinical conditions that place patients at most risk for these dangerous fluctuations.

Reed C. The Importance and Implications of Understanding Blood Glucose Variability. Abstract CS115.
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What Do YOU Think?
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E-mail option available
Would you prefer to receive via e-mail? It is available in a user-friendly “reader version.”
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How can you improve donor organ recovery?
See page 1.