Perioperative Patient Monitoring: Case Studies in Major Abdominal Surgery

Case Study 1: A 58-Year-Old Man Scheduled for Partial Right Nephrectomy and Resection Of a Tumor Infiltrating the Inferior Vena Cava

The patient’s medical history included a previous left nephrectomy, myocardial infarction, and hypertension (treated with β-blockers and calcium antagonists). His American Society of Anesthesiologists classification was 3 (patient with severe systemic disease). Resection of right kidney tumor infiltrating the inferior vena cava (IVC) with IVC clamp and IVC replacement with pros thesis was planned. Anesthetic management included general anesthesia induction and maintenance with a target-controlled infusion of propofol and remifentanil. Cerebral regional oxygen saturation (rSO₂), nominal cardiac output (CO), and other hemodynamic vials were monitored using the INVOS and LiDCO systems.

During surgery, the IVC was clamped and anesthesia placed following the removal of liver metastases and two-thirds of the right kidney. After IVC clamp, the LiDCOrapid monitor displayed the fall in blood pressure (BP) and stroke volume (SV), as well as a sudden rise in stroke volume variation (SVV). Although the exact amount for a fluid challenge is controversial, our practice uses the ratio of 5 mL per kg of weight over a few minutes (ie, 5 times patient weight 95 kg, or 500 mL). The patient was administered 500 mL of 6% hydroxyethyl starch 130/0.4 and BP and SV recovered. The LiDCOrapid monitor displayed the effect of this fluid challenge in the event-response screen with an increase in SV of 92%, SV returned to the normal range of 11%. Loss of venous return for any reason, such as sudden or continuing major blood loss (MBL), can similarly result in an increase in SV, which may be the first sign that MBL is occurring.

The period of IVC clamping, nominal CO, SV, and BP each decreased (Figure); rSO₂ also fell after clamping. Maintaining preinduction values of these parameters during surgery minimizes the build up of oxygen debt. In abdominal surgery, maintenance of rSO₂ is important to prevent occult cerebral hypoxia as well as hypoxia in other organs. Following fluid administration, SV decreased together with rSO₂ and BP as well as a gradual rise of nominal CO and SV. Using the INVOS system, LiDCOrapid monitor, and other assessment tools, monitoring aided in the maintenance of rSO₂ and nominal CO after the initial period of clamping and fluid challenge. When the IVC clamp was removed, nominal CO increased. The LiDCOrapid monitor tracked results of the fluid challenge in terms of fall in SV and increase in nominal SV and BP. Appropriate fluid challenge resulted in a gradual rise in rSO₂ suggesting restoration of oxygen delivery.

After removal of two-thirds of the remaining right kidney, creatinine levels peaked at approximately 900 mg/dL at postoperative day 7, and then decreased to 250 mg/dL, reflecting the patient’s limited kidney function. Despite the fact that the patient had roughly one-sixth of total renal mass postoperatively, his renal function recovered and he did not require dialysis.

Perioperative Hemodynamic Monitoring

To potentially improve outcomes and reduce complications, monitoring modalities that reflect the patient’s dynamic intra-vascular physiology in real time should be employed. Increasingly, clinicians have turned to hemodynamic assessment to measure cardiac output to guide vasoressor support for oxygen delivery, organ perfusion, and blood pressure (BP), as well as the use of appropriate anesthetics. Data has shown that using hemodynamic assessments to guide fluid management leads to reduced hypovolemia and hyperperfusion. Using the measurement of stroke volume (SV), stroke volume variation, and pulse pressure variation, over other volume indicators like central venous pressure (CVP), have been effective in reducing complications and improving outcomes via goal-directed protocols. Evidence suggests that goal-directed hemodynamic optimization of high-risk patients initiated in the operating room and continued in the ICU improves short-term outcomes as well as long-term survival. Pearson and colleagues studied the difference between goal-directed therapy—evaluating fluid response by change in SV and oxygen delivery using the LiDCO™ plus advanced hemodynamic monitoring system—versus fluid administration guided by CVP in 122 patients undergoing major vascular, upper and lower gastrointestinal, hepatobiliary, and urologic surgeries. The authors found that patients receiving goal-directed therapy developed fewer complications and had reduced hospital LOS.

Cerebral Oximetry

Maintenance of adequate cerebral oxygenation and blood flow—potentially preventing neurocognitive morbidities—is critical in the management of surgical patients. The INVOS™ cerebral/somatic oximeter uses near-infrared spectroscopy to non-invasively monitor regional cerebral blood oxygen saturation, and recent studies have shown its benefit in major abdominal surgery. Casati and colleagues randomized 122 elderly patients to intraoperative cerebral
Monitoring Level of Consciousness

Developing a goal-directed approach regarding anesthetic use also has been shown to reduce overall anesthetic consumption and lead to improved recovery times. The BIS™ (Bispectral Index) Level of Consciousness (LOC) system monitors brain function by analyzing electroencephalographic data using a proprietary algorithm that calculates a value between 0 (the absence of brain activity) and 100 (fully awake). Validation studies have demonstrated that a BIS value between 40 and 60 is considered suitable for surgical anesthesia and reflects a decreased cerebral metabolic rate and a low probability of awareness. In a retrospective analysis of 24,120 cases, Sessler and colleagues found that patients who simultaneously experience low-normal BIS values, mean arterial pressure (MAP), and minimum alveolar concentration have nearly triple the risk for 30-day mortality compared with those whose numbers are higher.

Conclusion

These case studies illustrate the benefits of hemodynamic assessment and fluid management throughout surgery in helping clinicians provide improved outcomes and reduce the risk for complications. As demonstrated by these cases, as well as in literature, monitoring cerebral oxygenation allows for clearer and earlier indication of oxygen deficits. Monitoring LOC provides an additional layer of understanding on appropriate anesthetic levels preserving MAP and reducing possible adverse events following surgery. These systems have the advantage of potential application in the postanesthesia care unit and the ICU, and can provide objective data to help clinicians improve patient outcomes in these acute care settings as well.

References


Disclosures: Dr. Green reported receiving honoraria from Covidiens and GlaxoSmithKline, and receiving grant/research funding from Covidien, Deltec Medical, and LiDCO Group Plc. Dr. Cannesson reported that he is a consultant for Covidien and Philips.

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Case Study 2: A 73-Year-Old Man Referred for Abdominal Aortic Aneurysm Repair

This patient’s medical history included type 2 diabetes, hypertension, and smoking (1 pack a day for 40 years, discontinued 15 years ago). His American Society of Anesthesiologists classification was 3; his weight was 72 kg. He had a surgical history of transurethral prostate resection 10 years ago. He reported being able to walk 4 flights of stairs and described no chest pain. A preoperative echocardiography (EKG) demonstrated a left ventricular ejection fraction of 55%; there was no right ventricular failure. The patient had a recent stress EKG that did not demonstrate any abnormalities; the heart was in sinus rhythm. A preoperative carotid Doppler showed a bilateral carotid stenosis (about 60% stenosis). The preoperative creatinine was normal. Aspirin was discontinued 6 days prior to surgery.

Anesthetic management included general anesthesia induction with propofol and sufentanil, maintenance with sevoflurane and sufentanil, and neuromuscular blockade with cisatracurium. Vascular access was obtained via 2 large bore IVs (16 gauge). Minimally invasive cardiac output, stroke volume (SV), and stroke volume variation (SVV) monitoring were determined using the LiDCOplus advanced hemodynamic monitor. Depth of anesthesia was assessed using the BIS™ (Bispectral Index) monitor with the goal of maintaining values between 40 and 60 and to optimize SV based on an SV optimization protocol. Fluid management consisted of a baseline crystalloid infusion (3-4 mL/kg per hour), associated to a titration of 6% hydroxyethyl starch based on the SV optimization protocol.

A significant decrease in mean arterial pressure (MAP) was observed immediately after the induction of general anesthesia. It was treated with a bolus of phenylephrine 100 mcg although SVV was high (20%). When such an acute change in MAP occurs, it is important to correct it quickly in order to avoid adverse effects on postoperative cognitive function. This hypotensive episode lasted less than 3 minutes and MAP was stable afterward.

Once hemodynamic variables are stabilized, SV optimization is key. In this case, SV was 53 mL and SVV was 18% after stabilization (Table). Following the SV optimization protocol, a bolus of 6% hydroxyethyl starch was given. This bolus decreased SV to 10% and increased SV from 53 to 61 mL (15% increase). According to the SV optimization protocol, another bolus of fluid (200 mL) was given. SVV decreased to 7% and SV increased to 66 mL (<10% increase). At this time, it was determined that SV was optimized.

The BIS monitor was used to facilitate dosing of the primary anesthetic agent in this patient. Sevoflurane was titrated in order to maintain the BIS range between 40 and 60. Sevoflurane was kept below 0.8 and 1.1 minimum alveolar concentration, and BIS values oscillated between 42 and 62. Information from the BIS monitor aided in the assessment of adequate depth of anesthesia. Titration of the anesthetic agent was useful in achieving the goal of maintaining stable MAP during the procedure. Two units of blood were given during the case. He spent 1 night in the ICU and was discharged on postoperative day 5. No complications were observed.

Table. Key Monitoring Parameters During Surgery

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>Immediately After Induction of General Anesthesia</th>
<th>15 Min After Induction of General Anesthesia</th>
<th>After 200 mL of 6% HES</th>
<th>After Additional 200 mL of 6% HES</th>
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<tr>
<td>MAP (mmHg)</td>
<td>68</td>
<td>47</td>
<td>54</td>
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<tr>
<td>SVV (%)</td>
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<td>SV (mL)</td>
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<td>61</td>
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<td>BIS Value</td>
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<td>53</td>
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<td>Left cerebral oximetry (%)</td>
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<td>62</td>
<td>73</td>
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<td>74</td>
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<tr>
<td>Right cerebral oximetry (%)</td>
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<td>Sevoflurane MAC (NA)</td>
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<td>0.9</td>
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</tr>
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Table courtesy of Maxime Cannesson, MD, PhD.