INTRODUCTION
Patients with left ventricular dysfunction due to ischemic heart disease are at higher risk of perioperative complications when undergoing non-cardiac surgery. These patients are frequently on many long-term cardiogenic and vasoactive medications. As a result, they may require extensive monitoring to facilitate optimal outcome. Knowledge of hemodynamic parameters such as cardiac index (CI) and systemic vascular resistance index (SVRI) can help in managing the high risk surgical patient and provide insight to their postoperative care.

CASE NOTES
The patient presenting with severe left ventricular dysfunction required repeat bilateral knee replacements. Because of observed religious practices, the patient refused transfusion of blood or blood products. Simultaneous bilateral knee replacement was scheduled per institutional protocol.

Pre-Operative
Upon admission, the patient’s blood pressure was 110/80 mmHg and hemoglobin was 10 G/dL. Routine laboratory examination was normal. Echocardiogram showed severe left ventricular dysfunction (ejection fraction 25%), moderate mitral regurgitation, severe tricuspid regurgitation and pulmonary hypertension (65 mmHg). Coronary angiogram showed diffuse disease and the patient was not a candidate for percutaneous coronary interventions or CABG surgery. The patient’s daily medications at admission were as follows: 50 mg tablet atenolol, insulin as per blood sugar, nimusulide tablet 3x, 10 mg tablet prednisolone 2x, 2.5 mg lisonopril tablet, and allopurinol tablet. She had also been taking clopidogrel and aspirin, both discontinued one week prior to surgery. All medications except atenolol were stopped one day prior to surgery. The patient preferred general anesthesia.

Clinical Events
Patient details: 72-year-old female, height: 175 cm, weight: 92 kg, BSA: 2.08
Medical history: Hypertension for 32 years, diabetes mellitus, rheumatoid arthritis, gout, multiple orthopedic surgeries

Causes of potential anesthetic complications:
- Long standing hypertension
- Severe left ventricular dysfunction
- Severe coronary artery disease
- Chronic insulin dependent diabetes mellitus
- Chronic steroid consumption
- Use of anticoagulant, angiotensin converting enzyme (ACE) inhibitor medications
- Anticipated challenges due to tourniquet application and release
- Long duration of surgery (over four hours)
- Inability to use blood or blood products

General anesthesia was administered while monitoring heart rate (HR), mean arterial pressure (MAP), central venous pressure (CVP), CI, core temperature, oxygen saturation, end tidal carbon dioxide, blood loss, urine output and arterial blood gas estimation. The FloTrac system was selected for continuous cardiac output monitoring because tricuspid regurgitation and pulmonary hypertension can cause the pulmonary artery catheter to report erroneous values as well as make it difficult to place.
Table 1: Intraoperative hemodynamic changes

<table>
<thead>
<tr>
<th></th>
<th>Baseline values</th>
<th>After release of tourniquet #1</th>
<th>10 min after dopamine</th>
<th>10 min after vasopressin</th>
<th>End of Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR/min</td>
<td>55</td>
<td>60</td>
<td>98</td>
<td>82</td>
<td>74</td>
</tr>
<tr>
<td>MAP mmHg</td>
<td>80</td>
<td>40</td>
<td>49</td>
<td>90</td>
<td>88</td>
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<tr>
<td>CVP mmHg</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>CI L/min/m²</td>
<td>3.8</td>
<td>4.2</td>
<td>4.5</td>
<td>3.6</td>
<td>3.1</td>
</tr>
<tr>
<td>SVRI dynes_s/cm²</td>
<td>1737</td>
<td>711</td>
<td>945</td>
<td>2160</td>
<td>2065</td>
</tr>
</tbody>
</table>

200 mg of hydrocortisone hemisuccinate was administered intravenously one hour prior to surgery and 200 µgms of fentanyl was administered thirty minutes prior to surgery. Right internal jugular vein was cannulated with 7 French triple lumen catheter and left radial artery with 20 G cannula. CI was monitored by connecting the FloTrac sensor to the arterial line. The baseline hemodynamic data are shown in Table 1. General endotracheal anesthesia was commenced using 150 mg of propofol, 100 mg of rocuronium bromide.

Intra-Operative
Left knee replacement was completed in a tourniquet time of 90 minutes. Upon tourniquet release, the patient became hypotensive (MAP of 40 mmHg). Dopamine was infused at 5 µgms/kg/min and CI increased immediately, while MAP and SVRI continued to be low. There was concern about the ongoing low perfusion pressure in view of the coronary artery disease. Decreased organ perfusion was evident from low urine output. Vasopressin infusion was started and increases in MAP and SVRI were noted immediately. Ultimately, improvement in tissue perfusion was noticed by an increase in urine output. The hemodynamic changes can be seen in Table 1. Following the commencement of vasopressin administration, hemodynamic parameters returned to normal and no further problems were experienced when the second tourniquet was released. The total blood loss in the intraoperative period was 350 mL as estimated by the gravimetric method.

DISCUSSION
It is becoming more and more common to see patients presenting for surgery having multiple medical problems and who are taking multiple medications. As a result, advanced hemodynamic monitoring in the perioperative period for high risk patients is pivotal for better surgical outcomes. In this case, the FloTrac system provided insight used to improve tissue perfusion through pharmacological selection and titration. Although similar benefits may be obtained using a Swan-Ganz catheter, with this patient it was anticipated that pulmonary artery catheter placement would be difficult in the presence of tricuspid regurgitation and pulmonary hypertension in addition to the potential for inaccurate data. The high CI and low SVRI seen most likely came as a result of the preoperative use of ACE inhibitors and intra-operative tourniquet release. This situation can be difficult to diagnose without CI monitoring because traditional vital signs may be misleading. ACE inhibitors are commonly used due to the overwhelming evidence showing improved outcomes when they are administered. Although most ACE inhibitors currently available are short acting, their residual action may decrease SVRI. This condition may further deteriorate in the intraoperative period with the use of inhalational anesthetic agents or tourniquet release as was seen. Using vasopressors, which can potentially cause coronary vasoconstriction, may be debatable in patients with coronary artery disease, however the patient's low SVRI helped make that decision. This case study highlights the need for and benefits of advanced hemodynamic monitoring techniques in day-to-day practice. FloTrac system provides advanced hemodynamic information that can be used to manage complex, high risk patients such as this one. The insight into cardiac function and vascular tone as delivered by the FloTrac system gave specific and sensitive information from which the patient's care was optimized.

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