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Preventive Strategies in Anesthetizing a High-Risk Patient for Robotic Surgery: A Case Report

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ABSTRACT

The physiologic consequences of intraabdominal insufflation and extreme positioning in robotic surgery predispose a patient with heart failure to complications. Reports on anesthetic strategies to prevent adverse events in patients with heart failure undergoing these types of surgeries are sparse.

A 65-year-old male, who was a known case of heart failure with reduced ejection fraction (EF), was scheduled for robot-assisted low anterior resection for rectal adenocarcinoma.

Preoperative diagnostic tools such as echocardiography, 12-lead electrocardiography, and blood tests guided preoperative risk assessment, and anesthesia-related planning and interventions. A balanced anesthetic technique using sevoflurane, atracurium, and fentanyl, with postoperative bilateral rectus sheath and subcostal block was used. In addition to standard monitors, arterial pulse pressure variation (PPV) was utilized for goal-directed fluid therapy to prevent complications.

Patient tolerated surgery and anesthesia well with no report of any complication during the perioperative course. Patient was eventually discharged and scheduled for follow-up.

The physiologic consequences of robotic surgery compound the already elevated risk for complications of a patient with heart failure. Anesthetic strategies to actively prevent adverse events are of paramount importance.

KEY WORDS: General anesthesia, heart failure, robot-assisted surgery, pulse pressure variation, goal-directed fluid therapy

INTRODUCTION

Laparoscopic devices are known to limit the field of view and wrist of motion of the surgeons. This led to the development of robotic surgeries which have overcome such challenges by providing a 3-dimensional field and natural wrist movements in a small field of view.[1] However, the cardiovascular and pulmonary consequences of abdominal insufflation are still the same. Impacts of carbon dioxide insufflation, such as increased intraabdominal pressure (IAP) and hypercarbia, may lead to serious hemodynamic or respiratory effects. [2]

Patients with heart failure who undergo abdominal surgeries have a higher risk for 90-day postoperative mortality with odds ratio of 10.34.[3] Crude mortality is 8.34-10.11% in symptomatic patients with reduced left ventricular ejection fraction of 30-39%.[3] Laparoscopic procedures have been used less frequently in HF patients due to the known physiologic effects of intraabdominal insufflation and extreme positioning. Although open operative approach is more utilized compared to laparoscopic technique in these patients, the latter may still be a safe alternative in carefully selected patient. In fact, the laparoscopic approach was associated with a 2-fold decrease in odds of 30-day mortality but had failed to identify differences in reoperation rates, and major complications.[4] As there are limited reports on these types of patients undergoing robotic surgeries, anesthetic management of these patients can be challenging. This case report focuses on the perioperative anesthetic strategies that aim to prevent complications in a patient with heart failure undergoing a robotic surgery.

CASE DESCRIPTION

A 65-year-old male was a known case of chronic coronary syndrome and heart failure with reduced ejection fraction from a 3-vessel coronary artery disease. He underwent coronary artery bypass graft and percutaneous coronary intervention in 1997 and 2019, respectively. He was maintained on bisoprolol, trimetzidine, eplerenone, ivabradine, atorvastatin, clopidogrel, empaglifozin, and sacubitril-valsartan. He was diagnosed in 2019 with rectal adenocarcinoma and underwent radiation therapy, chemotherapy, and immunotherapy in the following years. He was eventually advised surgical management, hence, surgery.
On admission, he had dyspnea on exertion with the latest echocardiogram revealing an increased concentric wall thickness of the left ventricle with moderately reduced systolic function (EF 43%), mild to moderate global hypokinesia, and reduced global longitudinal strain (-11.5%). Preoperative blood tests showed hypomagnesemia, elevated creatinine with a mildly decreased renal function. Hemoglobin, hematocrit, coagulation parameters, electrolytes were within normal limits. Baseline 12-lead electrocardiogram showed sinus rhythm, with evidence of old wall infarct and poor R wave progression. He was class 3 in the American Society of Anesthesiologist Physical Status classification, estimated to have 1.8-4.5% mortality risk. He was class IV in the Revised Cardiac Risk Index with a 15% 30-day risk of death, myocardial infarction (MI), or cardiac arrest. He had an intermediate risk (13.3%) of in-hospital post-operative pulmonary complications (including respiratory failure, respiratory infection, pleural effusion, atelectasis, pneumothorax, bronchospasm, and aspiration pneumonitis) based on the Assess Respiratory Risk in Surgical Patients in Catalonia score. He had a >10% risk for acute kidney injury (AKI) and >2% risk for critical AKI based on the Simple Postoperative AKI Risk. Using American College of Surgeons National Service Quality Improvement Program, the patient was at 21.3% risk for developing a serious perioperative complication.
Preoperatively, bisoprolol, trimetazidine, eplerenone, ivabradine, and atorvastatin were continued while sacubitril-valsartan, clopidogrel, and empagliflozin were put on hold. He was also included under the Enhanced Recovery after Surgery (ERAS) protocol and was given a high carbohydrate drink to avoid prolonged fasting. For AKI, capillary blood glucose (CBG) monitoring was done. Likewise, adequate hydration and urine output were ensured. Adequate prophylaxis for postoperative nausea and vomiting was given. Before induction, invasive arterial blood pressure monitoring was initiated. Baseline blood pressure was elevated at 140/70 mmHg with a mean arterial pressure (MAP) of (93). Midazolam, fentanyl, propofol, esmolol and atracurium were used during induction. Anesthesia was maintained with sevoflurane, atracurium (guided by neuromuscular monitoring) and fentanyl. Volume control ventilation was utilized and titrated against intraabdominal and intrathoracic pressure changes to maintain tidal volume of 6-8 ml/kg. Positive end-expiratory pressure of 5 mmHg was applied throughout. End-tidal carbon dioxide was at 26-35. Mean arterial pressure was maintained greater than 65 mmHg. Fluid management was guided by pulse pressure variation. Normothermia and adequate urine output were achieved during surgery.

CBG during surgery were 88 mg/dL and 148 mg/dL at the 1st and 4th hour, respectively. Intraoperatively, a circumferential rectal mass was visualized which was excised adequately. Intraabdominal pressure was kept at 12-15 mmHg. Peak inspiratory pressure during insufflation was at 15-19 cmH_2O. Estimated blood loss was 500 mL. Adequate replacement was done with a fluid balance of 150 ml. Before emergence, bilateral rectus sheath block and bilateral subcostal block were done. Muscle relaxation was fully reversed with neostigmine as verified by neuromuscular monitoring. The patient was extubated fully awake and was transferred afterward to the post-anesthesia care unit. Acute postoperative pain was adequately controlled with ketorolac, paracetamol and tramadol. No complication occurred during the postoperative period. The patient was eventually discharged 4 days after surgery.

DISCUSSION

Intraabdominal insufflation is the main factor that causes physiologic changes in robotic surgeries. The increase in IAP leads to increase in afterload and preload, and decrease in cardiac output. Moreover, this also displaces the diaphragm which increases the airway pressure and decreases the pulmonary compliance. Carbon dioxide is also highly soluble which promotes hypercarbia, especially in prolonged insufflation period, resulting in tachycardia, hypertension, and increased cardiac output. If not addressed, patients may become acidotic which may cause cardiac depression. In patients with cardiovascular disease, the impact of these changes is more deleterious compared to healthy patients; hence, a well-planned perioperative care should be given.[2]

Robotic colon surgeries such as low anterior resection, sigmoidectomy, or abdominoperineal resection require patients to be in a lithotomy position with arms tucked at the sides and then placed on a steep Trendelenburg position for an optimized view of the surgical field. This extreme positioning gravitates the intraabdominal organs against the thoracic cavity which decreases the lung compliance and functional residual capacity which may lead to hypercapnia and acidosis due to ventilation-perfusion mismatch. Moreover, the central venous pressure, pulmonary artery pressure, and pulmonary capillary wedge pressure also increase. The decreased venous return and increased systemic vascular resistance lead to decreased cardiac output which may result in increased myocardial oxygen demand. Additionally, it may also increase the intraocular and intracranial pressure. [5]

Patients with heart failure are at increased risk for perioperative morbidity and mortality. An article by Sweitzer says that the determination of ejection fraction with echocardiography is essential in estimating the risk for complication in patients with heart failure. Systolic heart failure with EF <30% is predicted to have the highest risk of developing perioperative major cardiovascular events (PMCE) such as MI, pulmonary edema, or cardiovascular death, followed by systolic heart failure with EF >30%, then patients with diastolic heart failure. Patients with elevated preoperative levels of C-reactive protein and B-type natriuretic peptide are strongly predicted to have serious postoperative cardiovascular events after noncardiac surgery.[6] In this case, the patient had an EF of 43%, signifying an increased risk for PMCE than normal. Revised cardiac risk index estimates a 15% risk for major cardiac events in this patient.

Preoperatively, continuation of bisoprolol, trimetazidine, ivabradine, and atorvastatin and discontinuation of sacubitril-valsartan, clopidogrel, and empagliflozin were done to decrease the risk for major cardiac events. An observational study by Lindenauer et al suggested that perioperative β-blockade provided a protective benefit only in higher-risk (e.g. RCRI ≥2 points) patients to which our patient is classified.[7]

Trimetazidine was suggested to provide myocardial protective effects, with lower occurrence of in-hospital cardiovascular events, myocardial ischemia, cardiac troponin I elevation, acute coronary events, heart failure, and arrhythmia requiring treatment.[8] Ivabradine has also shown to attenuate tachycardia to intubation and surgical stimuli, and also offers myocardial protective effects in perioperative period.[9] Several studies also suggest that patients receiving statin therapy have lower rates of perioperative cardiac events and lower mortality compared with patients not receiving statins.[10] Sacubitril-valsartan was noted to provide a good therapeutic effect on cardiac function during the perioperative period.[11] However, valsartan, a drug under angiotensin receptor blocker, causes intraoperative hypotension which may be detrimental. Given the different classes of drugs with myocardial protective effects that the patient is already on, the said drug combination was discontinued.

Intraoperative goals for patients with heart failure include preservation of cardiac output and minimizing myocardial work. As previously mentioned, intraabdominal insufflation and extreme positioning may lead to significant reduction in cardiac output. Adequate diastolic filling time is necessary given the decrease in compliance of the ventricles from increased intrathoracic pressure; hence, high central venous pressure and tachycardia should be avoided. In addition, tachycardia should also be avoided to minimize myocardial work leading to ischemia. Tachycardia during intubation and surgical stimulus was avoided with adequate depth of anesthesia and attenuation of sympathetic response. Goal-directed fluid therapy was utilized to avoid tachycardia from hypovolemia. Adequate ventilation prevented tachycardia from hypoxia and hypercarbia. Hypothermia also leads to shivering and activates sympathetic nervous system which may lead to perioperative ischemia; hence, normothermia was maintained in this case with warmed intravenous fluids.

The patient had an intermediate risk of in-hospital postoperative pulmonary complications and a >10% risk for AKI and >2% risk for critical AKI. Strategies done to reduce the risk of postoperative pulmonary complications in this case included adherence to ERAS pathways (including the use of regional nerve block which have been shown to reduce postoperative pain scores and opioid consumption compared with general anesthesia alone, with better patient satisfaction and less nausea and vomiting[12]), lung protective intraoperative ventilation (reduced tidal volumes (≤8 mL/kg) and at least 5 cmH_2O positive end expiratory pressure together with intermittent recruitment maneuvers), and goal-directed fluid therapy through the use of PPV.[13] To reduce the risk of AKI, the following were done as recommended by the Kidney Disease Improving Global Outcomes (KDIGO) guidelines: maintenance of normoglycemia, avoidance of nephrotoxic drugs including nonsteroidal anti-inflammatory drugs, use of PPV for goal-directed fluid therapy, and maintenance of MAP greater than 65 mmHg, normovolemia and adequate urine output. The intraoperative goal of optimal stroke volume can be achieved by maintaining a PPV below 13%, (highly sensitive in ensuring that fluids are given adequately). PPV monitoring to be accurate requires controlled mechanical ventilation with a tidal volume of 8 mL/kg ideal body weight, positive end expiratory pressure of 5 cmH_2O, end-tidal capnometry of 30-35 mmHg, and absence of arrhythmia on cardiac monitoring.[14]

In a study by Ghoundiwal et al, it was revealed that pneumoperitoneum did not alter the response of PPV to autotransfusion associated with the Trendelenburg maneuver.[15] The arterial line also allowed serial extraction for point-of-care-testing to monitor serum creatinine which showed insignificant changes from the patient's baseline values. Lastly, intraoperative glycemic control is also suggested to be vital in AKI risk reduction. Guidelines suggest to maintain CBG within 110-149 mg/dL.[16] In this case, the patient's CBG was at 88 mg/dL at the strat of the case. No intervention was done given the expected rise of CBG from the stress of surgery. Indeed, the next CBG revealed 148 mg/dL which was within the suggested range for glycemic control.

Proper management of a patient's risk for complications ensures the benefits of robotic surgeries. Robotic surgery offers more optimal oncological outcomes and has lower conversion rates to open surgery compared to laparoscopic technique, on top of the usual benefits of minimally-invasive surgeries such as shorter hospital stay and recovery time. In this case, there was no conversion to open surgery, patient had an unremarkable postoperative course, and he sent home after 4 days.

CONCLUSION

Robotic surgery is less invasive and more precise than the traditional open approach, allowing faster recovery and shorter hospital stay. However, physiologic consequences of increased intraabdominal pressure and extreme positioning from robotic surgery worsen the risk of complications in patients with heart failure. In this case, the patient was preoperatively assessed to have an increased risk for cardiac, pulmonary and renal complications. As such, anesthetic perioperative strategies, including goal-directed fluid therapy using pulse pressure variation, were aimed at reducing these risks. With the help of these strategies, the patient experienced no adverse event and was eventually discharged improved.

INFORMED CONSENT

A physical signed copy is available upon request.

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