Case Report

Anaesthetic Management of a Patient with Fontan Circulation for Laparoscopic Cholecystectomy

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ABSTRACT

Fontan circulation is a complex surgical procedure carried out in infants in a staged fashion, where caval circulation is connected to the pulmonary circulation, bypassing the heart. The ventricular activity will drive the blood to pulmonary circulation, which, after oxygenation, will return to heart and then will distribute through-out the body. The pulmonary vascular resistance determines the preload, which further depends upon the volume status of the body. This physiology is further complicated by the presence of arrythmia, liver cirrhosis, caval-pulmonary shunt thrombosis and low ventricular activity. Anaesthetic implication of such case includes challenges to manage preload, maintenance of pulmonary vascular resistance, preservation of the single ventricular function and avoidance of circuit thrombosis. Here we present a case of 15 years female who presented to our centre for laparoscopic cholecystectomy.

Keywords: Cholecystectomy; Circulation; Laparoscopic.

INTRODUCTION

The Fontan procedure was first described by Francis Fontan in 1971 for the management of tricuspid atresia. [1] Since then the Fontan procedure has been used to treat congenital heart defects that result in a single ventricle physiology. It involves the surgical re-direction of blood from the vena cava directly to the pulmonary arteries without the interposition of a functional ventricle. It relies on the premise that systemic venous return is sufficient to drive blood through the pulmonary circulation and into the functional left ventricle.[1] Over the years the procedure has undergone multiple surgical modifications, resulting in improved physiology and survival rate. [2,3]

Although the Fontan circulation may sustain life for decades, most patients will develop a form of chronic heart failure. Exercise capacity is reduced due to the limited ability to augment pulmonary blood flow over the time. Many patients will develop atrial tachyarrythmia over the time. Few patients may land up developing liver cirrhosis, renal sclerosis, plastic bronchitis, and/or circuit thrombosis. [3] Increasing numbers of individuals with Fontan physiology are now surviving into adulthood and their life span is increasing. [2,4,5]

CASE DETAILS

Fifteen years female weighing 45 kg, with symptomatic cholelithiasis planned for laparoscopic cholecystectomy, had undergone staged Fontan procedure at 3 years and 12 years of age for double outlet right ventricle (DORV). Her first postoperative was uneventful but the second post-operative period was complicated with pleural effusion, resulting prolonged stay in an ICU. She was under warfarin for 1 year and then was switched to oral aspirin 75 mg once a day. She was in her usual state of health and was able to carry out her daily activities with METS > 4 and NYHA 1. Later she developed right upper quadrant pain and diagnosed to have symptomatic cholelithiasis. She was referred to our centre for laparoscopic cholecystectomy. Her baseline vital parameters revealed heart rate of 80 bpm, blood pressure of 100/60 mmHg and SPO_2 96% at room air without cyanosis. Her haemoglobin was 14.6 gm/dL and renal and liver function tests were within the normal limits. Twelve leads electrocardiogram

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showed normal sinus rhythm with heart rate of 75 bpm and echocardiogram demonstrated post bidirectional cavopulmonary shunt (patent) and completion fontan status with large perimembranous ventricular septal defect (VSD) 1.2 cm, bidirectional shunt, with large atrial septal defect (ASD), with normal biventricular contraction with ejection fraction 60%. The discussion among the cardiologist, anaesthesist and surgeons was carried out before the day of surgery for safer perioperative management. The perioperative period risk versus benefit was discussed with the family member and postoperative monitoring bed in coronary care unit (CCU) was arranged. She was kept nil per oral (NPO) for 8 hours to solid food and for 2 hours to clear liquid.

In the preoperative room, 20 G IV cannula was secured in right dorsum of hand and Ringer's lactate was initiated at the rate of 80 ml/hour.

In the operation room, the monitors including ECG, pulse oximetry and non-invasive blood pressure revealed vital parameters similar to the baseline. Ceftriaxone 1gm was injected as prophylaxis for infective endocarditis. Arterial line was secured in left radial artery with 22G cannula under ultrasound guidance after skin infiltration of 1% lidocaine in awake state. 250 ml of RL was infused as bolus prior to initiation of anaesthesia. Anaesthesia was induced with fentanyl 200mcg, propofol 50mg and she was paralysed with vecuronium 5mg and trachea was intubated with 6.5 mm cuffed PVC endotracheal tube. There were no haemodynamic changes after induction and intubation. Anaesthesia was maintained with sevoflurane 1.5-2.5 % monitoring the vital parameters and MAC value. Intermittent positive pressure ventilation with tidal volume of 280 ml, respiratory rate 12-18 breath per minute targeting the end tidal carbon dioxide between 30-35 mmHg, PEEP of 3 mmHg and FiO2 of 100% was initiated and continued. Intraoperatively she received Morphine 5 mg, Paracetamol 675mg, Lidocaine 60mg, ketorolac 30 mg, Ondansetron 4 mg and Dexamethasone 4 mg. During the creation of the port, 0.25% bupivacaine 2-3 ml was injected at the skin by the surgeon. Intraperitoneal instillation of carbon dioxide was done in controlled fashion to avoid sudden rise in intra-abdominal pressure limiting the venous return and ultimately cardiac output. The flow was initiated at 1 LPM then intraabdominal pressure was targeted to 6 mmHg. There was no major fluctuation of the vital parameters throughout the surgery. The surgeons were moderately satisfied with the low flow and intraabdominal pressure and there were no issues with the surgical exposure. After the gallbladder was resected, instillation with 0.25% ropivacaine 10ml at liver bed was performed. The total duration of the surgery was 25 minutes and she received 1.0 Litres of ringer's lactate during intraoperative period. Before 5 minutes of extubation, Fentanyl 25 mcg was injected and she was extubated awake. There were no major haemodynamic changes after extubation. She was then transferred to post anaesthesia recovery unit then to CCU under monitoring.

At CCU, she received Ceftriaxone, Fentanyl, acetaminophen, Ketorolac, Heparin and vitals parameters were monitored for 12 hours. She was then discharged to ward to home subsequently on second day without any adverse event.

DISCUSSION

Fontan circulation is staged operation performed on the single ventricular pathology, in which caval circulation is diverted to pulmonary circulation bypassing the heart in staged fashion. [1] The oxygenated blood from lungs will return to atrium (one or two) then to single ventricle, which will pump blood throughout the body. This pumping force drives blood to pulmonary circulation and to the single ventricle.[1] The unique challenges possess by Fontan circulation to anaesthesiologists is the maintenance of strategies to reduce pulmonary blood flow and improve systemic ventricular function.[3] The factors that determine the pulmonary blood flow are ventricular pumping activity, volume status of the body and pulmonary vascular resistance (PVR). Many factors like pain, hypoxia, hypercarbia, hypothermia alter the PVR. Besides, anaesthetic drugs possess myocardial depressant property and avoidance of circuit thrombosis is also challenging. Pre-existing arrythmia, heart failure, protein losing enteropathy, plastic bronchitis and liver cirrhosis further add challenges to the above physiology.[2,3,4]

The status of patient with Fontan circulation can be predicted by the present NYHA status, presence of arrythmia, base line oxygen saturation and residual cardiac lesions.[3,6] Our patient has no functional limitation on ordinary activities with NYHA status 1 and no arrythmia with baseline oxygen saturation of 96% at room air and ejection fraction of 60% with no residual defect.

Based on the severity of the NYHA status, monitoring parameters can be decided. Usually, invasive monitoring is always indicated in such patients. In our case, invasive arterial blood pressure was monitored and central venous pressure monitoring was kept as reserve,

as some authors had cited the risk of central venous cannulations.[6]

Infective endocarditis prophylaxis was supplemented with Ceftriaxone 1 gm as per the AHA guideline.[4,6]

The haemodynamic goal during laryngoscopy, intubation and extubation was to avoid sympathetic stimulation which was achieved by Fentanyl pre-treatment before intubation and extubation. The haemodynamic goal during maintenance of anaesthesia was to maintain deep plane of anaesthesia, provide adequate analgesia and maintenance of PVR without affecting myocardial contractility.[3,6] The above goals were achieved by using Fentanyl, sevoflurane and morphine.

The haemodynamic changes related with laparoscopic cholecystectomy includes changes related with pneumoperitoneum, positioning and amount of carbon dioxide absorbed in the systemic circulation. Usually, the degree of intraabdominal pressure created by the pneumoperitoneum can alter the preload, affecting the afterload even in normal heart. This will further be aggravated by the head up position and positive pressure ventilation with application of PEEP.[7] Above changes are more pronounced in patients with Fontan circulation.[8] Hence, patients with fontan circulation, target IAP should be set below 10 mmHg and target IAP should be achieved as slowly as possible, minimizing the PEEP to less than 3 mmHg and controlling the degree of head up after adequately preloading.[6,9] In our patient, after preloading 250 ml of Ringers lactate, target IAP was set to 6 mmHg initially and this target was achieved slowly over minutes with the flow rate of 1 LPM allowing the heart to compensate the expected changes. There was no major haemodynamic fluctuation during the creation of pneumoperitoneum. The end tidal carbondioxide level was managed to around 30-35 mmHg maintaining respiratory rate of 12-18 breaths per minute.

Perioperative thrombosis risk is high in such cases. Thus postoperative DVT prophylaxis and early ambulation is recommended.[6] In our case, enoxaparin was supplemented for 2 days and early mobilization was started on day 1 of surgery.

The recovery profile was satisfactory in terms of pain management, nausea and vomiting prevention, early ambulation, feeding and discharge from hospital without any adverse event.

CONCLUSIONS

Fontan circulation is not only unique by the name, but also poses many unique challenges to anaesthesiologist. A sound knowledge of pathophysiology of fontan circulation is required to the anaesthesiologist to understand the changes ongoing after anaesthesia. A trained surgeon to limit the duration of surgery is also required to manage such kind of patient.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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