

Hip Arthroplasty in a Patient with Severe Pulmonary Hypertension- Case Report

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Abstract

A 58-year-old man suffered cardiac arrest during anaesthetic preparation for a total hip replacement (THR). Post-resuscitation investigation revealed severe pulmonary hypertension. 12 months later, he was re-presented to another hospital with now unbearable pain from his hip arthritis for a THR. A multidisciplinary approach to management, perioperative care in an appropriately equipped facility and an understanding of the events at the first presentation which may have contributed to cardiac arrest were central to successful management.

Keywords: Nitric oxide, Non-cardiac surgery, Pulmonary hypertension, Pulmonary vasodilator, Right ventricular failure.

Introduction

Pulmonary hypertension (PH) presents significant increases in morbidity and mortality in association with anaesthesia and surgery related to pulmonary hypertensive crisis, right ventricular (RV) ischemia, RV failure, cardiac arrest, and death [1]. Patients are often counseled against having elective procedures because of the risk of sudden perioperative death [1]. The family of a patient who suffered cardiac arrest during anaesthesia for hip arthroplasty with intercurrent severe PH were advised that he was unsuitable for a further attempt at hip arthroplasty. While considerable information enhancing our understanding of perioperative management of anesthesia in patients with PH has emerged over the past decade, there is more to learn in optimizing the perioperative assessment and intraoperative care of these patients. It is eminently feasible to offer major surgery to these patients and attain a good outcome. A multidisciplinary approach involving orthopedic surgery, anaesthesia, cardiology, and intensive care enabled thorough evaluation and management with aggressive intraoperative monitoring and preparedness to manage the hazards associated with this condition. Thorough briefing of the nursing staff ensured preparedness. Frank's discussion with the patient and their family ensured the risks involved were understood.

Case Report

A 58-year-old man presented for elective total hip replacement (THR) for osteoarthritis of his hip joint.

Past medical history included renal calculi and epilepsy. He was not taking antiepileptic medication and had not had a seizure for 18 years. He smoked 10 cigarettes per day and consumed a moderate amount of

alcohol.

The pre-operative blood test revealed no abnormality

He proceeded to surgery without further investigation for hip arthroplasty under spinal anaesthesia. He received intravenous (IV) midazolam 2 mg, followed by 16.5 mg 0.5% heavy bupivacaine with Fentanyl 15 mcg intrathecally. He quickly became confused and uncooperative. It was decided to proceed to a general anaesthetic with a target-controlled infusion of propofol and a laryngeal mask. Soon after, the patient suffered asystolic cardiac arrest. Cardiopulmonary resuscitation was commenced, he was intubated, IV adrenaline boluses were administered followed by adrenaline infusion. Following resuscitation, he was transferred to intensive care.

A transthoracic echocardiogram revealed severe RV dilatation and dysfunction, and RV hypertrophy. There was PH with peak pulmonary artery (PA) pressure of 85 mmHg plus moderate to severe Tricuspid valve regurgitation. Left ventricular (LV) function was normal. Computed tomography (CT) pulmonary angiography revealed multiple pulmonary emboli (PE).

Approximately 12 months later, he presented for hip arthroplasty to another hospital.

He was admitted to the hospital for several days before surgery for investigation assessment and optimization. Consultation between anaesthesia, surgery, intensive care, and cardiology occurred for perioperative planning. There was a discussion with the patient and family about risk as part of the consent process. The operating facility was a large surgical center with a well-established cardiothoracic surgical unit.

Preoperative echocardiography revealed severe RV dilatation/dysfunction, moderate LV dysfunction, an LV ejection

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Submitted: 09/10/2023; Reviewed: 05/11/2023; Accepted: 19/04/2024; Published: 10/08/2024

DOI: <https://doi.org/10.13107/jaccr.2024.v10.i02.238>

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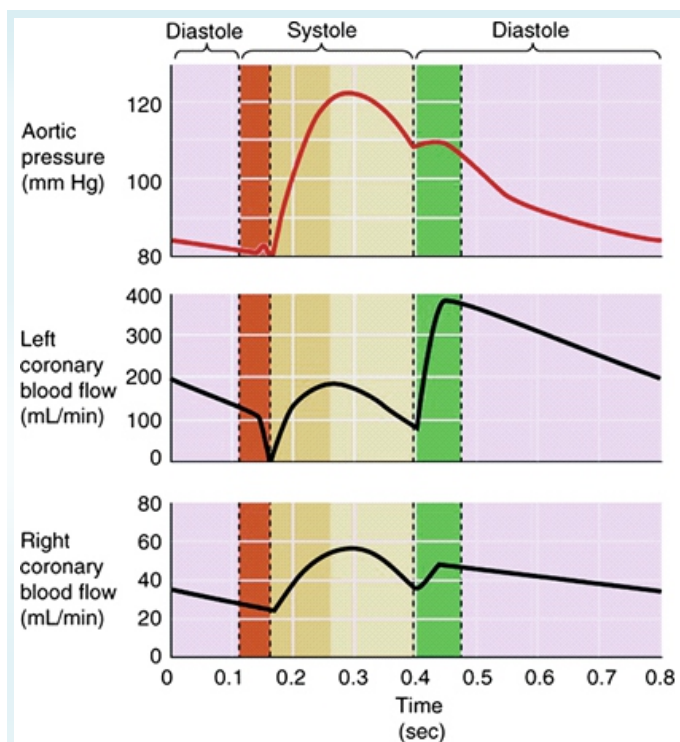


Figure 1: Characteristics of flow-dynamics of the left & right coronary circulation. Koepfen BM, Stenton BA. Regulation of heart and vasculature. Berne and Levy Physiology 6th Edition, 2010; 370-392.

fraction of 40%, and paradoxical septal motion. PA pressure was 50 mmHg (mean). Recent coronary angiography was normal and was not repeated. Hb was 192. A hematologist was consulted who diagnosed polycythemia rubra vera which likely contributed to his PE at his first presentation. CT pulmonary angiography and venous Doppler revealed no evidence of current deep vein thrombosis or PE. Apixaban 5 mg BD for his previous PE was discontinued 4 days before surgery and he was commenced on enoxaparin 40 mg daily by subcutaneous injection for 4 days preoperatively. He has commenced on nebivolol 5 mg daily to reduce PA pressure.

There was no premedication administered. An IV cannula, radial artery catheter, right internal jugular central venous catheter, and PA catheter were placed under local anaesthesia and invasive pressure monitoring was established. A delivery system for nitric oxide (NO) was ready, using the air liquide healthcare no delivery and monitoring device (SoKINOX™).

He was pre-oxygenated and administered midazolam 5 mg, fentanyl 1000 mcg, pancuronium 12 mg, and an 8 mm tracheal tube placed with minimal hemodynamic disturbance. Sevoflurane 0.5–1% was used throughout with added doses of fentanyl totaling 2 mg. His PA pressure was 70/45 mmHg. NO was introduced at 10 ppm increasing to 15 ppm then 20 ppm over 10 min. This reduced his PA pressure to 55/35 mmHg. Intraoperative transesophageal echocardiography (TOE) confirmed his preoperative echo findings and remained in place for the procedure.

As planned, an uncemented THR was performed robotically. He remained stable throughout the procedure with small intermittent doses of metaraminol to support systemic blood pressure (BP). Inotropic infusions were ready if required. Lower limb arthroplasty poses a risk of embolization of bone marrow, cement, and bone debris

which can cause increases in pulmonary vascular resistance (PVR) and acute right heart failure. This was monitored echocardiographically and was most evident while the acetabular component was being inserted but was not associated with any measurable effect on PA pressure.

Post-operatively, he was transferred to the intensive care unit, ventilated, and on NO at 16 ppm. He was extubated overnight. The NO was weaned slowly overnight using the NO supplier's recommended guidelines. Post-extubation analgesia consisted of tapentadol SR 100 mg BD ceased after 2 days, Tapentadol IR 50 mg 6th hourly prn, diclofenac 50 mg, paracetamol 100 mg 6th hourly. He received cefazolin 1 g 6th hourly for 24 h and regular ondansetron 4 mg intravenously 8th hourly to treat nausea. He was sat out of bed on day 1, transferred to the ward on day 2, and resumed the normal clinical pathway for post-operative management of patients following THR at our facility. He was discharged on day 5 post-operative.

Discussion

PH is a well-known risk factor for perioperative complications, morbidity, and mortality. Many outcome studies confirm this [1, 2, 3, 4].

A consensus statement published in 2021 [5] by Price et al., made several recommendations surrounding the perioperative management of non-cardiac, non-obstetric surgery in patients with PH. The importance of a multidisciplinary approach throughout the perioperative period was highlighted, including preoperative evaluation and optimization of RV function. The avoidance of right coronary ischemia is essential and includes assessment of right coronary occlusion, perioperative pulmonary vasodilator therapy as required, and circulatory support with invasive pressure monitoring of systemic central venous, and pulmonary arterial pressure perioperatively. These measures require management in an appropriately equipped surgical facility with cardiac and intensive care services and the availability of pulmonary vasodilator therapy. There should also be the facility to institute extracorporeal membrane oxygenation (ECMO) if necessary. An open and frank discussion with the patient and family about perioperative risk is essential to provide ample opportunity to assess risk against therapeutic objectives.

Severe PH is defined as mPAP > 50 mmHg or PVR > 600 dynes·sec·cm⁻⁵ and is characterized by the World Health Organization into 5 groups [6].

Pulmonary arterial hypertension (PAH)

- I. PAH with left heart disease
- II. PAH with lung disease and/or chronic hypoxemia
- III. PAH caused by chronic thromboembolic disease
- IV. Miscellaneous

Irrespective of the etiology, the result of PH on the right heart is similar, resulting in right heart failure. It often involves small and medium pulmonary arterial vessels causing histological changes including intimal injury resulting in a hypercoagulable state. This can result in further pulmonary vascular injury from venous thrombosis and PE [6].

The right ventricle, being thin-walled and more expandable than the LV tolerates changes in venous return well but is more sensitive to

changes in afterload than the left ventricle [6]. In PH right heart failure is multifactorial. As RV afterload increases there is sustained RV isovolumetric contraction, and increased RV afterload during ejection. Both contribute to increased RV oxygen demand. Elevated RV pressure results in a shift of the intraventricular septum toward the LV, impairing LV diastolic filling and stroke volume, with systemic hypotension. Pure pressure overload of the RV is uncommon in an adult heart because it is usually associated with RV dilatation and TR, limiting the increase in RV afterload [6, 8].

Right coronary blood flow and RV ischemia in PH are important. Many publications addressing right coronary blood flow are from dog experiments, and the coronary perfusion of the dog differs from the human, in that the dog's right coronary artery perfuses the right heart exclusively, and not the inferior wall and apex of the LV as it often and variably does in the human heart [7].

Considering Fig. 1, the right and left coronary flow differ. These flows as shown are as measured at the coronary ostia. The human right coronary flow can be considered in 2 parts. In a normal heart in systole, the flow goes through the right coronary artery (RCA) to all its RV distribution but the distal flow to the inferior wall of the LV and the apex mirrors left coronary blood flow. In diastole, when the extravascular compression of LV distribution of the RCA is relaxed, the flow runs off into these areas of the LV. Quantification of the degree to which the right coronary artery perfuses these areas of the LV is difficult as the degree to which it occurs, although common, is variable. Although blood flows through the RCA throughout the cardiac cycle, the RV perfusion is largely systolic. The dependence of the RV on RCA systolic flow renders it susceptible to ischemia from extravascular compression in patients with PH [5].

Perioperative anaesthetic management of this patient required an understanding of the cause of his circulatory failure at the first operation. His PH was undiagnosed at that time and likely compounded by the PE found subsequently. Further, sedation with midazolam potentially can cause hypoxia, further raising PAP. There is no evidence that this occurred at that time.

Intrathecal bupivacaine can result in systemic hypotension. The patient with PH and RV hypertrophy is more preload dependent [8] and vasoplegia from spinal anesthesia can result in a more marked reduction in cardiac output and hypotension. Once systemic BP falls below PA pressure RV ischemia and RV failure may result [8].

Pre-operative correction of reversible contributors to PH is important. Previous PE had been treated with apixaban. Nebivolol was chosen as it is a cardio-selective beta blocker particularly useful in LV dysfunction which should theoretically improve PH in addition to

the other treatments instituted.

Anesthetic management at the second presentation centered around invasive cardiovascular monitoring, intraoperative TOE, minimization of hemodynamic fluctuations with a high dose narcotic anesthetic technique, and support of systemic arterial pressure with vasopressors and/or inotropic infusion as required to ensure systemic BP remained well above PAP.

Further, reduction of PA pressures with NO was utilized. Inhaled NO is a selective pulmonary vasodilator in adult and pediatric patients. VasoKINOX™ (Air Liquide Sante International) is the preparation used, presented in cylinders at 450 ppm of NO in Nitrogen, with a dedicated delivery device compatible with an anesthetic breathing circuit. (SoKINOX™, (Air Liquide Healthcare). It utilizes servo feedback of inhaled concentration to pre-set desired concentration. Concentrations of NO and the metabolite, Nitrogen dioxide (NO₂) are displayed. NO₂ forms rapidly in the presence of oxygen causing an inflammatory reaction in the airway. NO₂ concentration must be minimized and always be kept below 0.5 ppm [10]. Delivered NO diffuses into the pulmonary vascular smooth muscle where it results in vasodilation through stimulation of guanylyl cyclase. Systemic hemodynamics are not altered because inhaled NO is rapidly inactivated by hemoglobin [9, 10].

Post-operative ventilation was required because of the high-dose narcotic technique which was chosen for hemodynamic stability, and both ventilation and NO were weaned overnight per protocols. Pulmonary hypertensive crisis is characterized by an acute increase in PVR and a decrease in cardiac output, which results in a spiral of cardiovascular collapse. Management involves aggressive treatment of systemic hypotension to avoid RV ischemia, reduction of PVR using pulmonary vasodilators, and optimizing central venous pressure (CVP) to optimize RV preload, aiming for a CVP 8–12 mmHg [5]. These steps are best instituted prophylactically and throughout the procedure. In extreme circumstances, ECMO should be considered [5].

Conclusion

The management of patients with PH undergoing lower limb arthroplasty is a serious undertaking, careful pre-operative assessment and investigation, planning, a multidisciplinary approach to management and a facility well equipped to manage these patients are central to a good outcome.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his/her consent for his/her images and other clinical information to be reported in the Journal. The patient understands that his/her name and initials will not be published, and due efforts will be made to conceal his/her identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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How to Cite this Article

Prevedoros SL, Binnekamp M, Kirsh G, Prevedoros HP | Hip Arthroplasty in a Patient with Severe Pulmonary Hypertension- Case Report | *Journal of Anaesthesia and Critical Care Case Reports* | May-August 2024; 10(2): 07-10.