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Anaesthetic management of cardiac phaeochromocytoma: A case series

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ABSTRACT

INTRODUCTION: Primary cardiac phaeochromocytoma is uncommon, with few anaesthetists encountering this rare pathology in clinical practice. Further, there is little information available on the detailed intraoperative and postoperative haemodynamics and principles of the anaesthetic management of this condition.

PRESENTATION OF CASE: We present a retrospective, single-centre case series of four patients with cardiac phaeochromocytoma who presented for surgical excision. We describe the perioperative evaluation and management of these patients, consideration of the requirements for cardiopulmonary bypass, and the analgesic and pharmacologic interventions needed to maintain stable perioperative and intraoperative haemodynamics.

DISCUSSION: Octreotide scintigraphy, in addition to echocardiography, cardiac MRI and coronary angiography proved vital in the preoperative evaluation of these patients. Preoperative anaesthetic management of cardiac phaeochromocytoma involved alpha-adrenergic blockade, judicious beta-adrenergic blockade and hydration. Intraoperatively, the administration of vasodilatory agents prior to, and vasoconstricting agents with volume therapy after tumour excision, were the key elements of anaesthetic management. Furthermore, we believe that cardiopulmonary bypass plays a pertinent role in cardiac phaeochromocytoma excision and that the risks and benefits of pulmonary artery catheters should be considered before use in these patients.

CONCLUSION: Management of cardiac phaeochromocytoma is complex and demands careful perioperative planning and management. Perioperative morbidity is common and anaethetists play an important role in achieving a successful outcome for patients who present for excision of cardiac phaeochromocytoma.

1. Introduction

Phaeochromocytoma is a catecholamine-producing tumour arising from chromaffin-positive cells of the sympathetic nervous system. This tumour can produce considerable amounts of catecholamines - primarily noradrenaline, resulting in an extreme hyper-sympathetic state, with deleterious haemodynamic consequences. Whilst the majority of phaeochromocytomas are found in the adrenal glands, aberrant collections of chromaffin tissue may be the site for the development of phaeochromocytoma [1]. Less than 2% occur within the chest, mostly in the posterior mediastinum, whereas cardiac phaeochromocytoma of the middle mediastinum are rare [2–4].

Primary cardiac phaeochromocytoma is uncommon and many anaesthetists will never encounter this pathology. Besterman et al. reported the first case of primary cardiac phaeochromocytoma in 1974, with subsequent cases reported over the following years [5–8]. However, there is little information available on the specific anaesthetic considerations when managing these complex cases. Therefore, we present a case series of cardiac phaeochromocytoma describing the perioperative management, requirements for cardiopulmonary bypass and the pharmacological interventions used to maintain stable intraoperative haemodynamics. This work has been reported in line with the PROCESS criteria [9].

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Table 1
Anatomical and coronary angiography findings in four patients diagnosed with primary phaeochromocytoma.

	Case 1	Case 2	Case 3	Case 4
Age(years), gender	17, Male	35, Female	19, Male	44, Male
Location and size of tumour(s)	Anterior wall of the aorta and outflow tract of the right ventricle (4.5 x 3.0 cm)	Left atrium (4.6 x 4.9 cm)	Lateral aspect of the aortic root (6.0 x 3.0 cm)	Exterior surface of right atrioventricular groove (8.0 x 5.5 cm), and the inferior border of right pulmonary artery (6.0 x 4.0 cm)
Tumour vascular supply on coronary angiography	Right coronary artery, which was completely obstructed by the tumour at its root	Circumflex branch of left coronary artery	Left internal mammary artery and sinoatrial nodal artery (branch of the right coronary artery)	Right coronary artery and circumflex branch of left coronary artery. Incidental finding of 80% stenosis to the mid left anterior descending coronary artery

2. Presentation of case

Between 2006 and 2012, four patients with cardiac phaeochromocytoma presented to our university teaching hospital. All patients presented with symptoms of excessive sweating, palpitations and dizziness. The patient in Case 1 additionally reported intermittent chest discomfort. Clinical examination of all patients revealed resting tachycardia, hypertension and postural hypotension. Markedly elevated levels of 24-hour urinary total catecholamines, vanillylmandelic acid, and metanephrines were found. Octreotide scintigraphy (Tc-99m-Oct) diagnosed cardiac phaeochromocytoma in three of four cases, which was subsequently confirmed by echocardiography and cardiac magnetic resonance imaging (MRI). Cardiac MRI diagnosed cardiac phaeochromocytoma in Case 4. Preoperative coronary angiography was then performed to evaluate the vascular supply of the tumours. Anatomical and coronary angiography findings for all four patients are presented in Table 1. In Case 2, it was noted that vascularisation to the tumour was supplied from the circumflex branch of the left coronary artery. The need to ligate a portion of the circumflex branch of the left coronary artery distal to the tumour and the subsequent risk of postoperative myocardial ischaemia was anticipated, allowing for careful intraoperative planning. Coronary angiography in Case 3 verified that the internal mammary artery and sinoatrial nodal artery were supplying the tumour. Tumours supplied by the internal mammary artery may adhere to the pericardium and thus, during pericardial manipulation, haemodynamic fluctuation was also anticipated.

Preoperative management over 4-weeks involved alpha and beta-adrenergic blockade with phenoxybenzamine and metoprolol. Upon normalisation of blood pressure and heart rate, elective median sternotomy followed, performed under general anaesthesia with moderate hypothermic cardiopulmonary bypass (CPB) (Table 2). Monitoring included 5-lead electrocardiography, invasive central venous and blood pressure monitoring, pulse oximetry, bispectral index and bladder and nasopharyngeal temperatures. Anaesthesia was induced with midazolam (3–5 mg), fentanyl (5–10 u g/kg), propofol (1–2 mg/kg) and pancuronium (0.1 mg/kg). Anaesthesia was maintained with 1 MAC of isoflurane with a FiO_2 of 0.5. Intraoperative analgesia included boluses of fentanyl (200ug). Muscle relaxation was maintained with boluses of pancuronium.

A summary of the surgical approach, cardiopulmonary bypass (CPB) requirements and aortic cross-clamp times for each patient are summarised in Table 2. Endotracheal intubation, skin incision and sternotomy did not provoke significant haemodynamic fluctuation. However, in Case 1, during dissection of the tumour prior to aortic cannulation, blood pressure rose abruptly to 170/100 mmHg (Fig. 1). This was stabilised with esmolol (0.5 mg/kg) and fentanyl (300ug). In Case 3, blood pressure rose to 200/100 mmHg with a sudden sinus tachycardia of 110 bpm during manipulation of the pericardium. This was stabilised with phentolamine (4 mg) (Fig. 2). An image of the cardiac tumour visualised in Case 3 is shown in Fig. 3.

Modest hypothermia between 33–34 degrees Celsius was maintained for all patients during CPB. Each patient was uneventfully separated from CPB with continuous noradrenaline (1–10 ug/min) and dopamine infusions (1–3 u g/kg/min). Fluid intervention in Cases 1–3 included lactated Ringer's solution (1500–2500 ml), colloid (500–1500 ml), residual CPB blood (500–1000 ml), and additional packed red blood cells (560–1100 ml). Fresh frozen plasma (15 ml/kg) was required in all cases to correct a medical coagulopathy. In Case 4, significant and major active bleeding from the right pulmonary artery was identified, which was surgically managed with 4.0 prolene sutures, primary closure and packing. Haemostasis was achieved after almost four hours, necessitating 12 units of packed red blood cells and 1600 ml of cell saved blood. This large volume resuscitation with blood resulted in a subsequent dilutional coagulopathy, compounded by hypothermia, necessitating

Table 2
Summary of the surgical approach, cardiopulmonary bypass (CPB) requirements and aortic cross-clamp times.

	Case 1	Case 2	Case 3	Case 4
Surgical approach	Median sternotomy, extracapsular dissection of the tumour initiated at its junction with the muscle of the right ventricular outflow tract. The right coronary sinus of the aorta and part of the pulmonary artery was excised and reconstructed with bioprosthetic patches for complete tumour removal.	Median sternotomy, tumour on the roof of the left atrium dissected, supplying circumflex branch of the left coronary artery distal to tumour ligated.	Median sternotomy, tumour identified at aortic root extending into right atrioventricular groove and excised. The right coronary artery was unintentionally divided at its first segment during tumour excision and a vein graft was used to bypass the right coronary artery.	Median sternotomy, tumours to the exterior surface of the right atrioventricular groove and the inferior border of the right pulmonary artery were identified and excised. The left anterior descending coronary artery was bypassed with the left internal mammary artery.
CPB duration	143 min	80 min	93 min	134 min
Aortic cross clamping time	90 min	35 min	50 min	91 min
Total duration of surgery	280 min	200 min	310 min	600 min

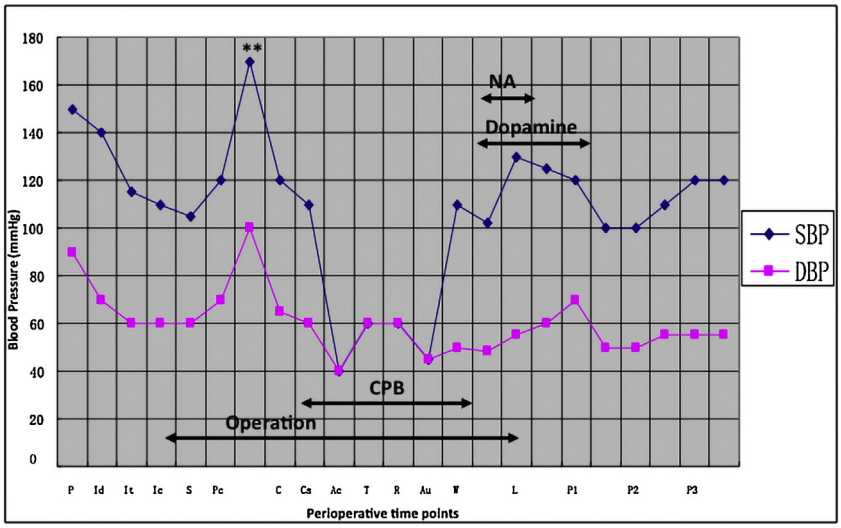

Fig. 1. Perioperative haemodynamics of Case 1.
P: pre-anaesthesia; Id: anaesthesia induction; It: endotracheal intubation; Ic: skin incision; S: sternotomy; Pc: pericardiotomy; C: cannulation; Cs: start CPB; Ac: aorta clamping; T: tumour manipulation; R: tumour excision; Au: aorta unclamping; W: weaning from CPB; L: leave for ICU; P1: postoperative day 1; P2: postoperative day 2; P3: postoperative day 3.
**BP suddenly increased to 170/100 mmHg when the surgeon separated the tumour from surrounding tissue before aortic cannulation. Total intravenous esmolol 40 mg and fentanyl 300 μg were administered.

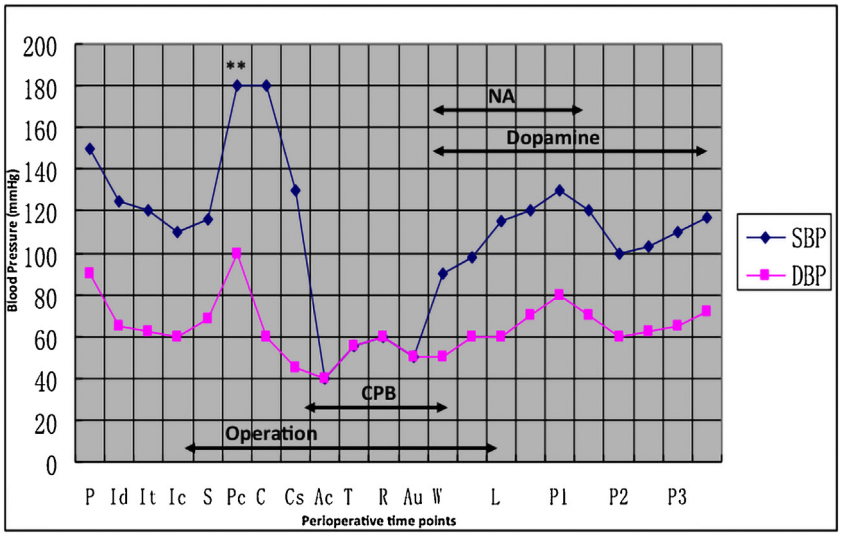

Fig. 2. Perioperative haemodynamics of Case 3.
P: pre-anaesthesia; Id: anaesthesia induction; It: endotracheal intubation; Ic: skin incision; S: sternotomy; Pc: pericardiotomy; C: cannulation; Cs: start CPB; Ac: aorta clamping; T: tumour manipulation; R: tumour excision; Au: aorta unclamping; W: weaning from CPB; L: leave for ICU; P1: postoperative day 1; P2: postoperative day 2; P3: postoperative day 3.
**BP increased abruptly during pericardiotomy, phentolamine total 4 mg was administered intravenously.

treatment with fresh frozen plasma (30 mls/kg) and platelets (10 units).

In Case 3, the right coronary artery was unintentionally divided at its first segment during tumour excision and a vein graft was considered an appropriate conduit for this case. Whilst the right internal mammary artery or a free left internal mammary artery could arguably be superior in terms of patency rates, especially in this very young age, in the setting of "non-atheromatous" non-occlusive coronary artery occlusion, we preferenced a vein graft to minimize competitive arterial flow, which may be observed when using an arterial conduit. Further, should the patient develop coronary artery disease in the future requireing surgical revascularisation, grafting with the right internal mammary artery or a free left internal mammary artery may then be advantageous.

All patients were transferred to the intensive care unit (ICU) postoperatively with dopamine and noradrenaline infusions titrated to maintain blood pressure at 100/60 mmHg. The only significant postoperative complication occurred in Case 2, where a non-Q wave myocardial infarction of the lateral wall of the left ventricle associated with a small rise in troponin I was observed. This may correlate with the involvement of the left circumflex artery in this case (Table 2). The patient was asymptomatic in the setting of postoperative analgesia and oxygen. The patient was managed conservatively with medical therapy and subsequent followed up with echocardiography and coronary angiography. No further interventions were required.

Median (interquartile range [IQR]) ICU admission duration was 3 days (IQR 3–4.7). Median (IQR) length of stay was 18 days

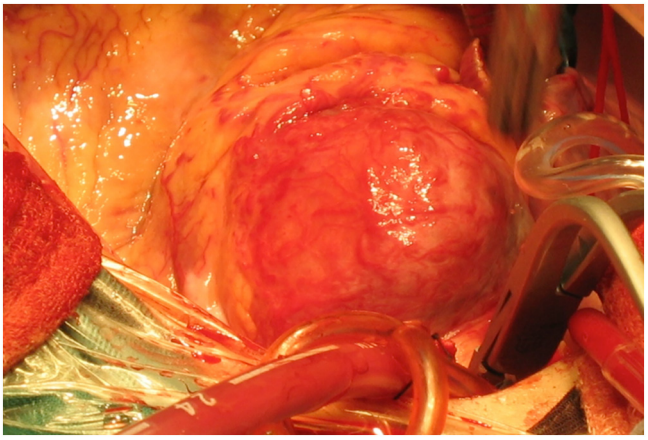

Fig. 3. Primary cardiac phaeochromocytoma originating from the root of the aorta and the outflow tract of the right ventricle observed in Case 3.

(11.5–27.5), ranging from 10 days for the shortest stay to 30 days for the longest. Histopathology in all cases demonstrated cardiac phaeochromocytoma and blood pressure and urinary concentration of catecholamines returned to normal ranges within 2 postoperative days and remained so at 3, 6 and 12 months.

3. Discussion

We present a case series of cardiac phaeochromocytoma describing our perioperative management, the advantages of instituting cardiopulmonary bypass and the pharmacological interventions used to maintain stable intraoperative haemodynamics. Preoperative anaesthetic management involved alpha-adrenergic blockade, cautious beta-adrenergic blockade and adequate hydration [10]. This helped attenuate the haemodynamic consequences of excess catecholamine secretions from the tumour, particularly during surgical manipulation. As cardiac phaeochromocytomas are usually vascularised from the aorta or coronary arteries, preoperative coronary angiography was also critical to reveal the vascular supply of the tumour, which was important to consider during surgical dissection as demonstrated in Case 2.

Institution of CPB is important in the excision of cardiac phaeochromocytoma. Regardless of the location, preoperative adrenergic blockade will not guarantee prevention of intraoperative hypertension and arrhythmias that may occur during manipulation of these tumours [1]. We are of the view that once the aorta is cross-clamped, institution of CPB and cardioplegia isolate the heart from the systemic circulation, reducing the risk of intraoperative hypertension during tumour manipulation, facilitating a safer surgical dissection. In all four cases presented, manipulation of the tumour had no significant effect on blood pressure after institution of CPB and cardioplegic arrest. Haemodynamics were more stable during CPB. Wilson et al. described resection of a cardiac phaeochromocytoma through a thoracotomy without CPB and despite preoperative alpha and beta-adrenergic blockade, marked intraoperative hypertension occurred [11]. Shibata et al. measured plasma catecholamine concentrations at different time-points during an excision of a right atrium phaeochromocytoma. Interestingly, in this case the blood pressure remained almost unchanged during CPB despite marked increases in catecholamine concentration [12].

We did not observe significant haemodynamic fluctuation during induction of anaesthesia, endotracheal intubation, skin incision or sternotomy. However, such fluctuations are reported to be common with non-cardiac phaeochromocytoma [13–15]. Roizen et al. recommended several management goals prior to the excision of phaeochromocytoma: (a) blood pressure lower than 160/90 mmHg 24-hours before surgery, (b) orthostatic hypotension should not fall below 80/45 mmHg, (c) no ECG ST-T changes for at least 1 week and (d) no more than one premature ventricular contraction every 5 min [16]. In a previous article, our colleagues adopted a decrease in preoperative haematocrit by 5% together with an increase in body weight as one marker of restored blood volume [17]. In the preoperative management of all our cases, the above criteria were met. The high dosages of analgesics and sedatives characteristic of cardiac surgery administered intraoperatively may also have contributed to the haemodynamic stability observed.

As phaeochromocytoma is commonly highly a vascularized tumour, intractable bleeding during or shortly after surgery is common. In our cases, this risk was exacerbated by the administration of heparin, which was mandatory for CPB. Cardiac surgeons may spend considerable time in achieving haemostasis after tumour excision, as we observed in Case 4. In a review by Jebara et al., 4 out of 25 cardiac phaeochromocytoma patients who underwent tumour excision died due to perioperative bleeding [6]. Thus, anaesthetists are faced with the often-difficult task of maintaining appropriate blood pressure with vasoactive drugs to minimise the risk of bleeding, whilst also ensuring adequate perfusion of vital organs. Finally, we propose that insertion of a Swan-Ganz pulmonary artery catheter to monitor and treat haemodynamic change may not always be appropriate for cardiac phaeochromocytoma. Tumours can be located in the right atrium or adjacent to the aorta or pulmonary artery [7,18,19]. Thus, insertion may result in tumour stimulation, provoking undesirable haemodynamic change.

4. Conclusion

Management of cardiac phaeochromocytoma is complex and involves multi-disciplinary care. Perioperative morbidity is high and is frequently due to ventricular arrhythmias, severe hypertension, cardiogenic shock or haemorrhage. Given its rarity and complexity, future studies should aim to further characterise and compare the anaesthetic management of phaeochromocytoma.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Conflicts of interest

None.

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Ethical approval

Our institution (Peking Union Medical College Hospital) has exempted ethical approval.

Consent

Written informed consent was obtained from the patients for publication of this case series and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Author contribution

Guangjun Chen, Jingjie Wang, Wangjia Lin, Zhiyi Gong, Wei Liu, Bo Zhu and Yuguang Huang were the principle anaesthetists who managed the cases. They were involved in the study concept and design process, data collection, analysis and interpretation and also the writing of the case series.

Laurence Weinberg, Callum Robinson and Tim Ho undertook the literature review, conducted further analysis and interpretation of the data and prepared all Figures and Tables. They wrote and finalised the manuscript for publication.

All authors have viewed, and are satisfied with the manuscript submitted.

Registration of research studies

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Guarantor

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