Resection of a large primary left ventricle tumour by cardiac autotransplantation in a 2-month-old infant: a case report

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Background
Surgery is the fundamental method for the treatment of primary cardiac tumours. However, due to the inaccessibility of anatomy and the proximity of important structures, it is very difficult to completely resect tumours of the left atrium or left ventricle without damaging the normal tissues. Cardiac autotransplantation for the resection of cardiac tumours is carried out by taking out the heart from the body, resecting cardiac tumours, and then transplanting the heart back into the body.

Case summary
This article presents a successful case of cardiac autotransplantation for the complete resection of primary cardiac tumour in a 2-month-old infant and shares the noteworthy experience.

Discussion
Tumours located in the left atrium and left ventricle are difficult to be exposed because of their deep posterior location and proximity to important anatomical structures such as mitral valve and chordae tendineae. How to resect the tumours completely without damaging the normal tissues is a great challenge. This case proves that cardiac autotransplantation is a good solution for tumours that are difficult to be resected completely by orthotopic cardiac transplantation.

Keywords
Cardiac tumours • Cardiac autotransplantation • Infants • 3D printing • Case report

Learning points
• Cardiac autotransplantation is a good solution for tumours that are difficult to be resected completely by orthotopic cardiac transplantation.
• The application of 3D printing is of great help to the plan design and implementation of surgeries.
• Technical details of cardiac autotransplantation are the key to successful surgery.

Introduction
Primary cardiac tumours are rare with an incidence of around 0.0017–0.03%.1 They can occur in each cardiac chamber. In those patients with a large tumour volume, haemodynamic obstruction, presence of cardiac arrhythmia or drug resistance, the tumours should be resected as soon as possible.2 Since Cooley firstly used cardiac autotransplantation to resect left atrial tumours in 1985, reports on cardiac autotransplantation in the resection of cardiac tumours are rare, and no cases of cardiac autotransplantation have been
reported where the cardiac tumours in infants under 2-month-old were resected.³ We successfully performed cardiac autotransplantation in a 2-month-old infant with primary giant left ventricular tumour.

**Timeline**

| Date               | Event                                                                 |
|--------------------|----------------------------------------------------------------------|
| 14 January 2019    | A 2-month-old male infant was admitted to our hospital due to paroxysmal supraventricular tachycardia |
| 15 January 2019    | This infant was diagnosed with left ventricle tumour by colour Doppler echocardiography and computed tomographic angiography |
| 21 January 2019    | The 3D heart model showed a 27 × 17 × 25 mm mass that originated from the anterior and lateral wall of the left ventricle, occupying 80% of cavity volume of the left ventricular obstructing mitral valve inflow |
| 26 January 2019    | Cardiac autotransplantation was performed                             |
| 29 January 2019    | Weaning from mechanical ventilation                                   |
| 3 February 2019    | Discharge from intensive care                                         |
| 8 February 2019    | Hospital discharge                                                    |

**Case presentation**

A 2-month-old 4.8 kg male infant was admitted to our hospital due to paroxysmal supraventricular tachycardia. Later this infant was diagnosed with left ventricle tumour by colour Doppler echocardiography and computed tomographic angiography (Figure 1). Based on imaging measurements, the tumour was large relative to left ventricle. In order to better reveal the adjacent relationship between tumour and surrounding tissues, we used 3D printing to restore the heart of this infant. The heart model showed a 27 × 17 × 25 mm mass that originated from the anterior and lateral wall of the left ventricle, occupying 80% of cavity volume of the left ventricular obstructing mitral valve inflow (Figure 2).

In view of the extensive adhesions of the base of the tumour to the anterior wall and side wall of left ventricle, as well as its proximity to the mitral valve, chordae tendineae, and other important anatomical structures, the orthotopic cardiac tumour resection would be difficult and risky; therefore, we adopted the technology of heart autotransplantation. The surgical procedure was briefly described as follows: open a median sternotomy incision, institute cardiopulmonary bypass, isolate the heart, remove the tumour, and return the heart to its original position (Figure 3). Histology revealed rhabdomyoma (Figure 4). The afflicted child left hospital 13 days thereafter and no tumour recurrence or arrhythmia in 5 months of follow-up.

**Discussion**

The diagnosis for cardiac tumours is not challenging, but echocardiography, computed tomography, and magnetic resonance imaging are inefficient in reflecting the size of tumours and the contiguity to normal surrounding tissues. 3D printing technology presents great advantages in grasping the size and location of tumours and their contiguity to surrounding tissues. It can help surgeons make surgical plans and locate the tumours during the surgery.⁴ In this case, 3D printing technology was used to reflect the internal structure of the heart. Speaking of in situ resection of cardiac tumours, regardless of the mitral valve orifice, aortic valve orifice, or apical incisions, the resection of tumours is still difficult to complete, not to mention that the risks of damaging the valves and chordae tendineae are high. Therefore, it
was decided that cardiac autotransplantation, \textit{in vitro} resection of cardiac tumours, and cardiac reconstruction should be adopted.

Compared with the mitral valve exposed through the atrial septum or left atrial incision under the \textit{in situ} condition, the isolated heart can be fully expanded through the left atrial incision without excessive traction-induced damage to the mitral valve, and the angle of the heart can be adjusted to facilitate the operation. Because of the deep infiltration of the tumour base, the obstruction of the tumour, and the minimal operational field of vision for the narrow cardiac chambers, the resection near the apex was performed by assistants to squeeze the tumour out of the mitral valve orifice by gently squeezing and supporting the surface of the left ventricle upwards, so that the base can be more clearly exposed for resection.

Cardiac autotransplantation is more difficult than allogeneic heart transplantation in that: (i) the right atrium must be anastomosed with the superior and inferior vena cava and (ii) due to the shortage of tissues caused by cardiac resection and heart implantation, it is difficult to suture, and no additional tissue can be retained for anastomosis.
In this case, due to the small heart and the thin blood vessels and tissues, the operation was more difficult. Therefore, we emphasize the following technical details. (i) The establishment of extracorporeal circulation: the ascending aorta was intubated near the brachiocephalic trunk, and the superior vena cava was intubated at the junction of the superior vena cava and the innominate vein to ensure that at least 1-cm superior vena cava was left at the proximal end of the catheter for separation and anastomosis. The inferior vena cava must be separated from the diaphragmatic attachment so that it can be intubated from the anterolateral wall of the lower inferior vena cava. The inferior vena cava should be retained at least 1 cm in length from the intubation site to the right atrium for separation and reimplantation. (ii) The resection of the heart: the aorta as well as the superior and inferior vena cava should be transected at the above positions, respectively. Attention should be paid so as to avoid damaging the sinoatrial node. The transection of the pulmonary artery should be near the pulmonary artery bifurcation. Incision of the left atrium is hard to execute. Firstly, the left atrium was probed through the foramen ovale with right-angle forceps and topped it at the opening of the right superior pulmonary vein. The left atrium was incised with this marker, and the top of the other three pulmonary vein openings was used as markers along this level to incise the left atrium carefully. Attention should also be paid to mark the opening of the left superior pulmonary vein using sewing marking lines so as to avoid distortion during anastomosis. (iii) The implantation of the heart: the left superior pulmonary vein was sutured with the markers retained during resection. The left atrium was closed by suturing the left superior, right inferior, right superior, left superior, and right superior pulmonary vein in succession. Subsequently, the aorta and inferior vena cava were anastomosed successively, and the aorta was opened to reduce the blocking time. Finally, the superior vena cava and main pulmonary artery were anastomosed.

**Conclusion**

The case of removal of primary cardiac tumours by cardiac autologous transplantation reported here is a rare case with low age and low weight in the world. Although this procedure requires close cooperation between a good heart transplant technique and an anaesthesia monitoring and care team, it is a good solution for in situ unresectable tumours.

**Lead author biography**

Dr Yuhang Liu graduated from the Fourth Military Medical University in Xi’an, China. He specializes in surgical treatment of congenital heart disease and specializes in surgery for complex congenital heart disease and minimally invasive surgery for congenital heart disease.

**Supplementary material**

Supplementary material is available at *European Heart Journal - Case Reports* online.

**Slide sets:** A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

**Consent:** The authors confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

**Conflict of interest:** none declared.

**References**

1. Hussain ST, Sepulveda E, Desa MY, Pettersson GB, Gillinov AM. Successful re-resection of primary left atrial sarcoma after previous tumor resection and cardiac autotransplant procedures. *Ann Thorac Surg* 2016;102:e227–e228.
2. Hoffmeier A, Sindermann JR, Scheld HH, Martens S. Cardiac tumors—diagnosis and surgical treatment. *Dtsch Arztebl Int* 2014;111:205–211.
3. Conklin LD, Reardon M. Autotransplantation of the heart for primary cardiac malignancy: development and surgical technique. *Tex Heart Inst J* 2002;29:105–108.
4. Schmauss D, Gerber N, Sodian R. Three-dimensional printing of models for surgical planning in patients with primary cardiac tumors. *J Thorac Cardiovasc Surg* 2013;145:1407–1408.