ISSN: 2573 - 9611

Short Communication

Journal of Pediatrics & Neonatal Biology

# Multimodality Imaging and 3D Modeling in Cardiac Surgical Planning: A Case of Infant with Isolated Left Atrial Appendage Aneurysm

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**Submitted**: 03 Apr 2020; **Accepted**: 09 Apr 2020; **Published**: 22 Apr 2020

## Abstract

*We present here a case of an infant who was prenatally diagnosed with an isolated left atrial appendage aneurysm. Although asymptomatic, we proceeded with surgical resection due to rapid progression of aneurysm size. Multimodality imaging – transthoracic echocardiography, transesophageal echocardiography, and cardiac computed tomography – was used for procedural planning, from which a detailed 3D computational model and 3D print of this patient's heart were created. The aneurysmectomy was performed at 6 months of age, with an uneventful postoperative course.*

**Keywords:** left atrial appendage aneurysm (LAAA), transthoracic echocardiography (TTE), transesophageal echocardiography (TEE), computed tomography (CT), Digital Imaging and Communications in Medicine (DICOM), 3D Modeling, 3D Printing, Surgery

## Introduction

An aneurysm within the left atrial appendage (LAAA) is a rare congenital anomaly that has been described in the literature, particularly in infants. Although their causes are unknown, in one case it has been reported to be associated with a focal aplasia of the pericardium*[1]. Thromboembolism, atrial arrhythmias and congestive heart failure have been reported as complications; however, the natural history is not well known. It has been demonstrated that 3D modeling can greatly assist in surgical planning for congenital heart surgery*[2]. Because of the rarity of LAAA as well as their unique presentations, for our patient, 3D models were pursued as a beneficial aid for surgical planning.

## Methods

### 1) Clinical Presentation

A 3.5 kg male term neonate was diagnosed with a LAAA during routine prenatal screening. The pregnancy was uneventful, and he was born via spontaneous vaginal delivery. A post-natal echocardiogram at 3 weeks of age showed LAAA with a biplane volume of 20 mL/m$^2$; thus, aspirin was started for thromboprophylaxis. A repeat echocardiogram at 7 weeks of age showed increasing size of LAAA to 36 mL/m$^2$. Holter monitoring provided no evidence of arrhythmias. Using cardiac computed tomography (CT), the LAAA was measured at 2.8 x 3.4 x 2.4 cm, with no identified extrapericardial extension; yet, there was mild mass effect detected on the left superior pulmonary vein, without upstream dilation. At 4 months of age, the LAAA volume reached 42 mL/m$^2$. A repeat CT at 5 months of age indicated the LAAA volume to be 68 mL/m$^2$. After a multidisciplinary team discussion, the decision was made to proceed with aneurysmectomy.

### 2) 3D Modeling and Surgical Planning

DICOM files were obtained from CT imaging and imported into Materialise Mimics® software. Through manual segmentation of the images, a blood volume model of the heart, major vessels, and local vasculature was created. This segmented body was then imported into Materialise 3matic® software. At this stage, the model was further refined for visual assessments. A 1 mm shell was created around the blood volume to then provide a hollowed interior view of the heart, so to better visualize the internal anatomy. Additionally, a window was computationally cut through the aneurysm in the model, so to allow for studies of the left atrium as well as the anatomy of the LAAA itself. Once these 3D models were complete, several versions were printed to show the blood volume at 100% scale as well as the shelled, hollowed, and windowed models at 130% scale. Various models were sliced using Ultimaker© Cura software and then printed on an Ultimaker© 3 Extended printer.

### 3) Surgery

The surgical procedure was performed at 6 months of age (8.8 kg): a minimally invasive approach was selected. Through a lower mini-sternotomy, both lobes of the thymus gland were separated, and the pericardial cavity was accessed. The LAAA was quite large, with evidence of space-occupying lesion, even causing some extrinsic compression on the left ventricular chamber. The base of the appendage itself was narrow but was communicating with the remaining left atrial cavity: there was no evidence of intracavitary thrombus. A 5/0 purse string PROLENE® suture was placed at the base of the aneurysm, and this was snared. We attempted placing a side-biting clamp at its base; however, at this point during the procedure there was hemodynamic instability. Next, we made a small incision in the aneurysm to decompress it and decrease its size. It was then resected just above the purse string suture line. Multiple pledgeted 5/0 PROLENE® sutures, in a horizontal mattress fashion, were then placed at the base of the resected appendage to achieve hemostasis, and the purse string suture was removed. Subsequently, a transesophageal echocardiogram (TEE) indicated: 1) a widely patent left upper pulmonary vein, 2) normal flows in the left main coronary artery, and 3) no changes in ventricular functions or the mitral valve competency. The postoperative course was uneventful, and he was discharged on the fourth postoperative day.

## Results

The subsequent pathology report indicated a thick layer of fibrous connective tissue, consistent with pericardium, in parallel with the myocardium. Various clinical images as well as 3D models of the patient cardiac anatomy can be seen in Figure 1. Also shown, the resected surgical specimen was approximately 4cm in length. It should also be noted that there was no congenital aplasia of pericardium as the cause of the aneurysm.

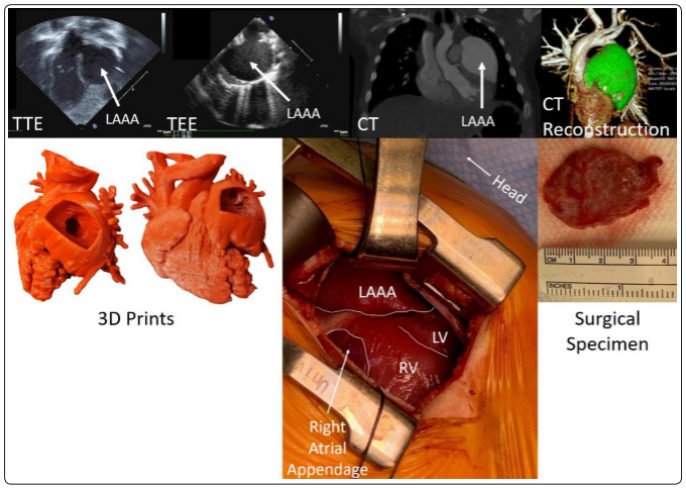


**Figure 1:** Multimodal imaging obtained/generated for our LAAA patient. Top row, from left to right: transthoracic echocardiogram (TTE), transesophageal echocardiogram (TEE), cardiac CT, and CT reconstruction. Bottom row, from left to right: generated 3D prints, an intraoperative photograph of heart in chest, and the excised surgical specimen (post-aneurysmectomy).

## Conclusion

A LAAA usually presents as a progressive defect and such patients may be asymptomatic for decades*[3-4]. Although complications like thrombotic events or arrhythmias might occur, most LAAA are treated by aneurysmectomy to prevent these events*[4]. This unique case demonstrated the uses of multimodality imaging in complementing diagnostic abilities, which were also aided by computational modeling. Resultant 3D prints proved to be valuable assets for surgical planning and for parental counseling.


## Acknowledgments

We would like to acknowledge other co-investigators within the Visible Heart® Laboratories for their expertise.


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