PATIENT SPECIFIC MEDICAL
DEVICES AND SOLUTIONS
AT THE POINT OF CARE

3DLIFE Prints

3D SOLUTIONS FOR CARDIAC SURGERY BROCHURE

3D ANATOMICAL MODELS, MEDICAL DEVICE SIZING, SURGICAL SIMULATION SOLUTIONS

3D LIFEPRINTS
CARDIAC SOLUTIONS

SUMMARY / INDEX

WITHIN THE FOLLOWING AREAS

- Congenital cardiology
- Paediatric cardiac surgery
- Paediatric cardiology education and training

SUMMARY OF CARDIOLOGY PRODUCTS & SOLUTIONS

3D PRINTED PATIENT SPECIFIC ANATOMICAL MODELS

1. Pre-surgical assessment, planning and simulation
2. Intra-surgical use
3. Patient communication
4. Intra-operative refrence
5. Post-operative review
6. Colleague education and training

3D PRINTED SIMULATORS

1. Basic surgical skills
2. Advanced pathology simulators

Case Summary

A cardiologist requested a virtual and 3D printed model of patient's heart which presented with a bicuspid aortic valve with sinus of valsalva aneurysm, with the right coronary sinus bulges into RVOT.

This particular pathology had proven to be difficlt for medical and surgical students to visualise. The model was commissioned to support education at the hospital's cardiology department.

Description

3D LifePrints received the patient's CT scan via DICOM and proceeded to segment the scan in order to build a virtual model of the cardiothoracic anatomy.

In collaboration with the surgeon, the 3D LifePrints' biomedical engineer made deliberate alterations to the model in order to allow for better visualisation by students.

The model was hollowed out and the aneurysm shown through the pulmonary artery so that it's location could be more easily identified. While not strictly anatomically correct, and such an event would have been even more catatsrophic for the patient, it proved beneficial for educational purposes and highlights the flexibility 3D modelling can bring.

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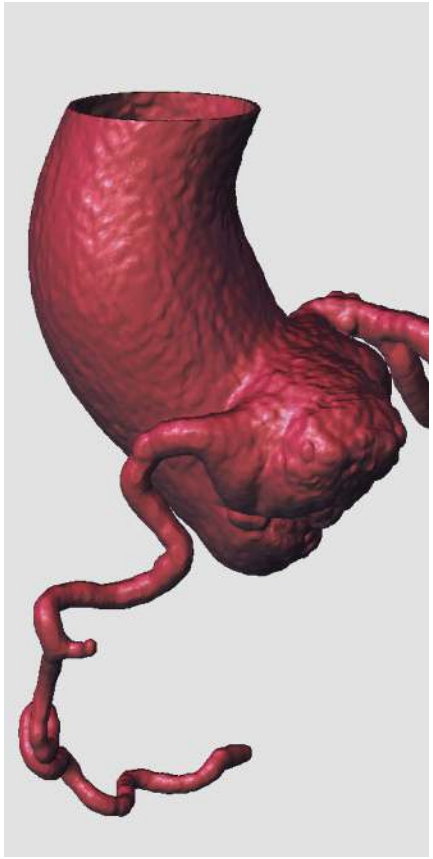
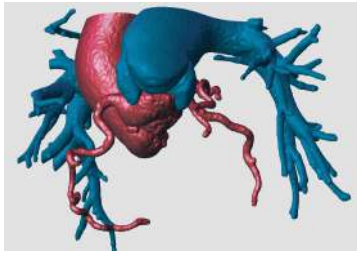
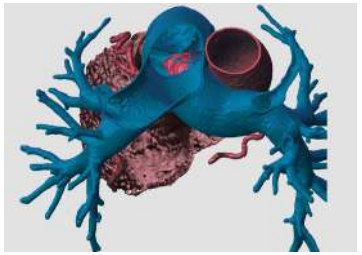
CASE STUDY

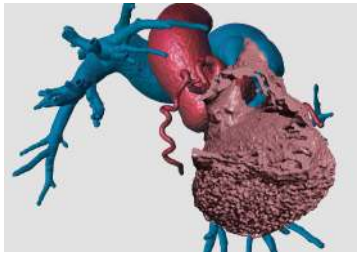
CARDIOLOGICAL EDUCATION

SPECIALITY: CARDIOLOGY
PROCEDURE: PRESENTATION OF SINUS OF VALSALVA ANEURYSM
DEVICE: 3D VIRTUAL AND PRINTED PATIENT SPECIFIC ANATOMICAL MODEL









OUTCOME / BENEFITS

In this case, the virtual model proved to be incredibly effective in presenting the pathology to medical audiences that a 3D printed model was also created.

The model was printed in multicolour, softer material, and added to the department's repetoire of teaching resources.

Case Summary

A patient who suffered a sub-aortic pseudoaneurysm, resulting in a breach of vessel walls, required surgery to repair the damage. Initially, the decision was made to insert 2 PDA plugs via catheter to close the aneurysm, however despite the insertion, further CT scans showed residual upper communication in the aneurysm.

The surgical team requested a model of the heart's current condition to further plan treatment options and determine the best strategy for the patient. To optimise the process, a model of the patient's heart pre-treatment was also commissioned for full visibility of the treatment pathway.

Description

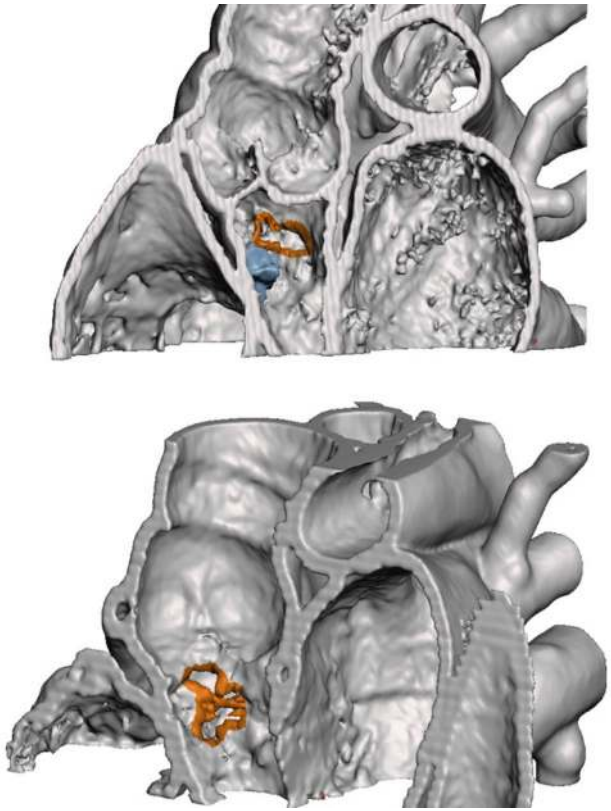
3D LifePrints used medical 3D segmentation software to develop two virtual models. The first model (top picture) was used to show the most up-to-date relationship of the false chamber with the left ventricular outflow tract (LVOT) and both atria and aorta, following the patient underwent corrective surgery.

The second model (bottom picture) was a rendition of the historical CT scan taken prior to the decision to intervene with PDA plugs. This was used to trace their decision-making process from the very beginning of the patient's treatment.

3D LIFEPRINTS
CASE STUDY

CARDIOLOGY PRE-SURGICAL PLANNING

SPECIALITY: CARDIOLOGY
PROCEDURE: SUB-AORTIC PSEUDOANEURYSM POST ROSS PROCEDURE
DEVICE: SEGMENTATION & 3D VIRTUAL MODEL



OUTCOME / BENEFITS

The latest treatment strategy, supported by insight from both models, resulted in the surgical team successfully closing the intracardiac aneurysm and the patient being discharged for full recovery.

These models are being used by the cardiology department to catalogue their patient's condition in 3D detail for fuller understanding and refinement of future treatment strategies. They will also act as an advanced teaching aid for other cardiac surgeons at the hospital.

Case Summary

A combined study between a specialist heart and chest hospital and the UK's North West Innovation Agency sought to investigate the deployment of differently sized occlusion devices in the treatment of atrial septal defects (ASD).

A series of 20 patient-specific models of hearts presenting with atrial septal defects were requested to help support the study.

Description

3D LifePrints segmented all 20 patient CT scans to develop the 3D virtual models. These models were then 3D printed in soft-tissue like material to provide investigators with realistic haptics when experimenting with the range of occlusion devices.

These models were prepared within a week of the patient receiving their cardiac CT or MRI scan.

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CASE STUDY

CARDIOLOGICAL PRE-SURGICAL PLANNING

SPECIALITY: CARDIOLOGY
PROCEDURE: OCCLUSION OF ATRIAL SEPTAL DEFECT
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODELS

OUTCOME / BENEFITS

Prior to surgery, these models were successfully used to deploy several occlusion devices, of various sizes, to seal the ASD and encourage tissue growth over time.

The model series proved to be an effective tool for clinicians seeking to improve the accuracy of the chosen device size.

Case Summary

In this rare case, cardiologists and surgeons at specialist heart and chest hospital needed to treat a patient presenting with a large build-up of calcification around their mitral valve.

This model formed part of a series looking at Hypertrophic Cardiomyopathy (HCM) in patients, and the effectiveness of 3D modelling and printing as an adjunct to traditional scan interpretation for clinicians and surgeons during their pre-surgical planning.

Description

3D LifePrints segmented the patient's scan data and developed a virtual model of their heart. This model was then 3D printed in a softer material that provides a more realistic feel than more rigid options.

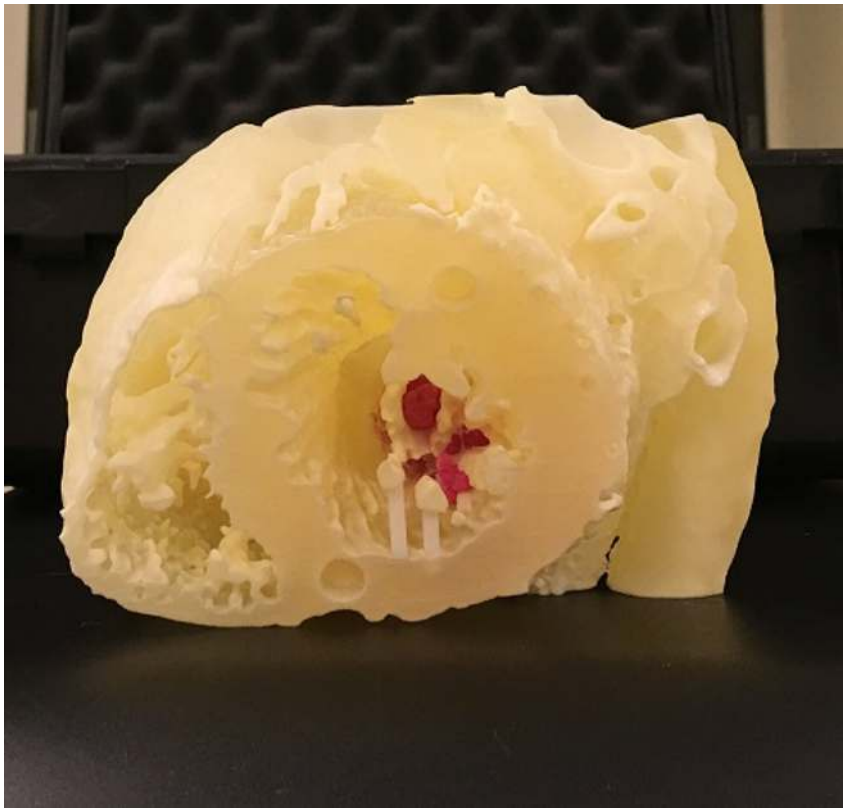
The multi-material model showed the mitral valve and its relation to the calcification in three separate parts.

3D LIFEPRINTS

CASE STUDY

CARDIOLOGICAL PRE-SURGICAL PLANNING

SPECIALITY: CARDIOLOGY
PROCEDURE: TREATMENT FOR HYPERTROPHIC CARDIOMYOPATHY
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODEL



OUTCOME / BENEFITS

The benefits of using 3D models, such as the one in this case, in pre-surgical assessment and planning led to the specialist implementing their use as the standard of care for all their complex HCM patients.

Case Summary

In this case, a surgeon at a childrens hospital requested a patient-specific anatomical model in retrospect, as a way to capture and demonstrate an extremely rare pathology of the heart.

The patient presented with Truncus Arteriosus, a congenital condition which occurs when the blood vessel coming out of the heart fails to separate completely and leaves a connection between the aorta and pulmonary artery. Their condition was also complicated by the failure of the aorta to form completely, resulting in an Interrupted Aortic Arch (IAA).

Description

3D LifePrints segmented the patient's data and developed a virtual model of their heart. This was then 3D printed in dual colour, to clearly define the flow of oxygenated (red) and deoxygenated (blue) blood.

Following surgery, the surgeon used the model to help educate surgeons who may encounter a similar condition in the future. It was also used to aid discussions with the patient's parents regarding future treatment.

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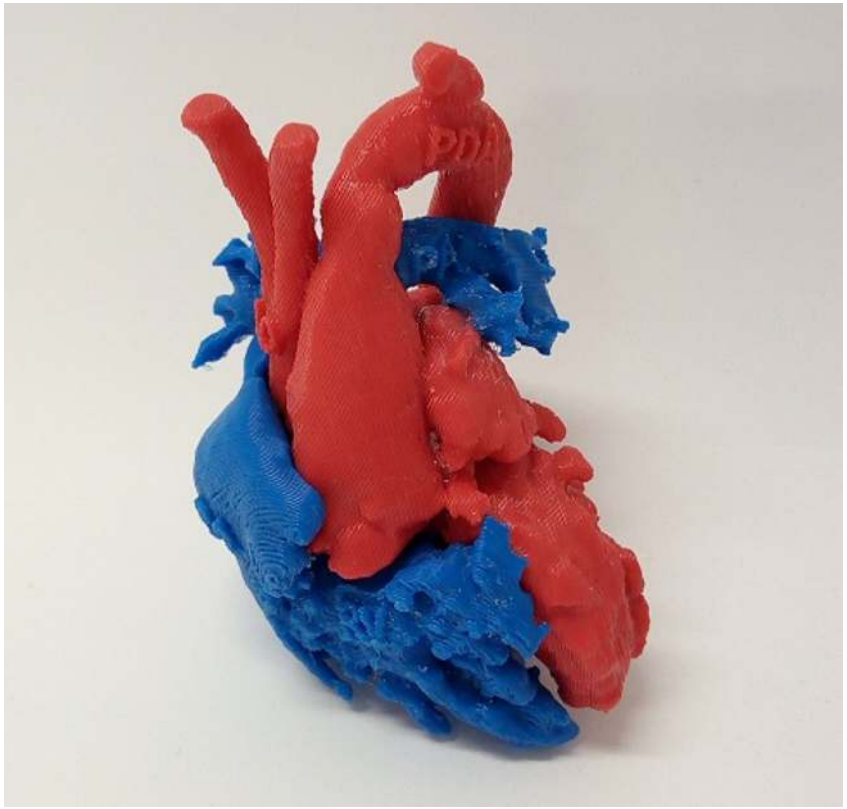
CASE STUDY

CARDIOLOGICAL POST-SURGICAL REVIEW

SPECIALITY: CARDIOLOGY
PROCEDURE: TRUNCUS ARTERIOSUS AND INTERRUPTED AORTIC ARCH REPAIR
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODEL



OUTCOME / BENEFITS

3D modelling and printing of complex pathologies such as this provide an effective adjunct to traditional surgical education and skill development methods. Rare cases can be captured for repeatable future training, ensuring high level knowledge is transferred through a medium that combines 3D visualisation with haptics.

The model's use in conversations with the patient's parents allowed for more detailed explanation and understanding, meaning the parents were more informed about their child's condition and what future treatments would involve.

Case Summary

A paediatric patient at a childrens hospital was in need of urgent surgery to close a ventricular septal defect (VSD). The cardiac surgeon required a more thorough visualisation of the patient's heart structure prior to surgery, to help ensure a more successful outcome.

A patient-specific anatomical model was requested by the surgical team to aid in determining the location, shape and size of the ventricular septal defect.

Description

3D LifePrints segmented the patient's CT scan to develop the 3D rendering of the heart. It was then 3D printed in transparent, soft material. The model was sectioned into three parts to provide the team with internal insight into the defect.

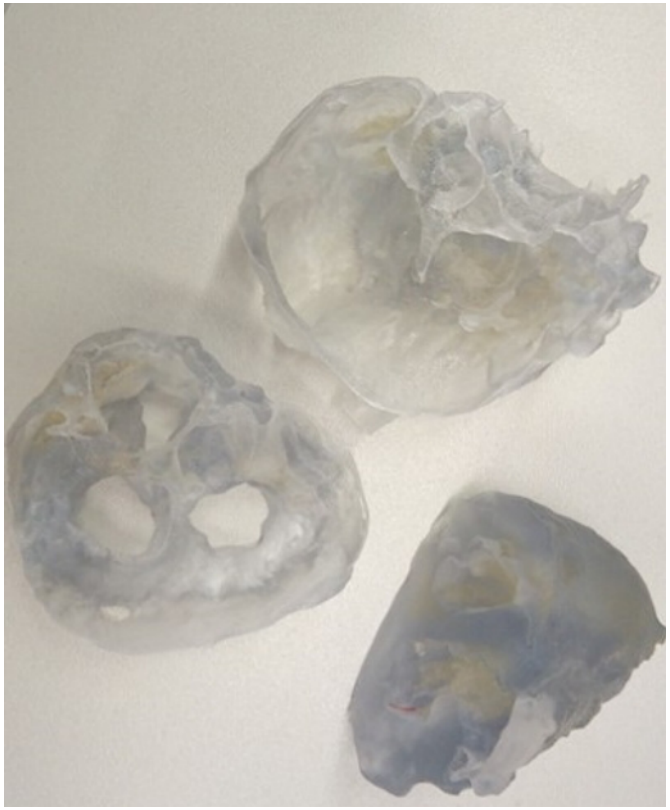
In this case the model was delivered within 24 hours of the request due to the urgency of this procedure.

3D LIFEPRINTS

CASE STUDY

PAEDIATRIC CARDIOLOGICAL PRE-SURGICAL PLANNING

SPECIALITY: CARDIOLOGY
PROCEDURE: VENTRICULAR SEPTAL DEFECT REPAIR
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODEL



OUTCOME / BENEFITS

Pre-determining the exact nature of the VSD in the planning phase resulted in a more confident surgical approach to this complex case.

The model will also be used as part of the department's future training of cardiologists and cardiac surgeons who may need to treat patient's with similar congenital heart conditions such as VSDs.

Case Summary

A paediatric patient presenting with multiple ventricular septal defects (VSD) meant a surgeon and the cardiology department at a childrens hospital would need to perform multiple surgeries to correct this congenital heart defect.

A unique model of the patient's anatomy was requested to support the team's surgical planning ahead of live theatre.

Description

3D LifePrints segmented the patient's data and produced a model based upon the volume of blood within the heart's chambers rather than the heart itself. It was 3D printed in rigid white material for clear visualisation and handling by the whole team.

The model marked a significant innovative step as 3D LifePrints moved beyond providing a copy of the heart to create something highly specific to this type of operation, proving to be of even greater use to the surgeon.

3D LIFEPRINTS
CASE STUDY

PAEDIATRIC CARDIOLOGICAL PRE-SURGICAL PLANNING

SPECIALITY: CARDIOLOGY
PROCEDURE: MULTIPLE VENTRICULAR SEPTAL DEFECT PATCHING
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODEL

OUTCOME / BENEFITS

The volume modelling application of 3D printing is an extremely useful technique to indirectly image malformations of the heart by printing the blood volume within structural cavities. The surgeon said *"this is a very impressive and imaginative way to use 3D printing for organ imaging. In this case, we were able to complement the visualisation of the cardiac defects and make the decision that it might be possible to perform a less invasive procedure"*.

The team decided no further patching of the perforations was necessary and these decisions resulted in a second surgery that was shorter, less complex and held lower risk.

Case Summary

A surgeon and his team at a childrens hospital were required to treat a patient in need of an Aorto-Left Ventricular Tunnel (ALVT) repair. ALVT, an extremely rare congenital defect involving an extracardiac channel connecting the ascending aorta, above the sino-tubular junction, to the left or right ventricular cavity. Without surgical intervention, heart failure is very likely.

A patient-specific anatomical model was requested to assist the team's pre-surgical planning and communication.

Description

3D LifePrints segmented the MRI scan of the patient's heart structure before using it to calculate the blood volume flowing through it.

The model was then 3D printed in a white and rigid material for the surgical team, enabling them to fully visualise the condition of the patient's heart, and formulate the best plan of approach for the upcoming repair.

3D LIFEPRINTS

CASE STUDY

PAEDIATRIC CARDIOLOGICAL PRE-SURGICAL PLANNING

SPECIALITY: CARDIOLOGY
PROCEDURE: AORTO-LEFT VENTRICULAR TUNNEL REPAIR
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODEL

OUTCOME / BENEFITS

This patient-specific model allowed the surgical team to plan the procedure for a condition which has an incidence rate as low as 0.001% of all congenital heart diseases. The planning time itself was also reduced.

The model was described as being of great use in explaining this rare congenital condition to nurses, cardiologists and to the patient's family. 3D printing in this case provided a superior method of communication than 2D scans alone.

Case Summary

Alongside using patient-specific anatomical models for pre-surgical planning, cardiology departments also use 3D LifePrints' on-site service to capture rare and complex congenital cases for educational and training purposes on a regular basis.

The surgeon requested this patient-specific model to better educate current colleagues and future cardiologists at the hospital.

Description

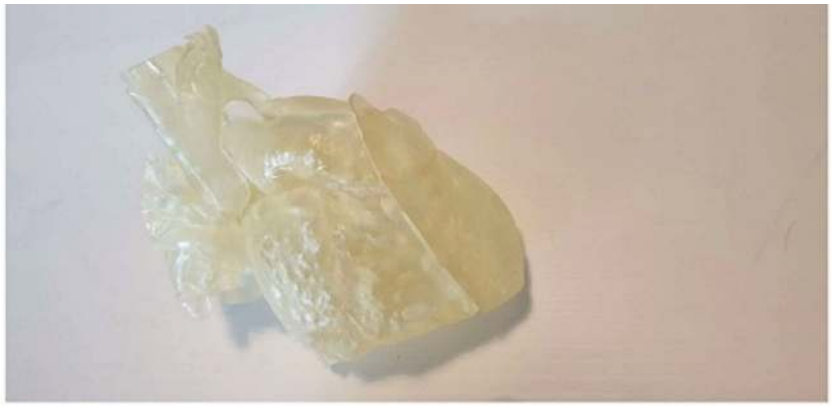
In this case, the patient presented with a previous interrupted arch and small left ventricular outflow tract (LVOT). The patient had previously undergone a Norwood procedure and Cavopulmonary anastomosis.

3D LifePrints segmented the patient's scan data and worked closely with the cardiologist, in 3D LifePrints' hub within the hospital, to produce a virtual model optimised for clear demonstrations. The virtual model was then 3D printed in a soft material for a more realistic feel.

3D LIFEPRINTS
CASE STUDY

PAEDIATRIC CARDIOLOGY EDUCATION & TRAINING

SPECIALITY: CARDIOLOGY
PROCEDURE: PREVIOUS INTERRUPTED ARCH & SMALL LVOT, NORWOOD PROCEDURE
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODEL



OUTCOME / BENEFITS

The use of 3D printed models serve as an adjunct to the department's traditional education and training methods, such as 2D CT Angiogram, CT or MRI scan interpretation. Accurate physical models allow 360-degree haptic manipulation for a more complete visualisation of the congenital heart defect by the handler.

With the model, the cardiologist is able to better explain the nature of the pathology, its effect on the patient, the treatment paths available, and the specific approach chosen in a particular case.

Case Summary

A Consultant Paediatric Cardiologist requested 20 3D printed heart models to be used as part of a professional education course exploring Fetal Cardiology, MRI and Echocardiography.

In particular, the identification of congenital heart defects and treatment options were to be discussed.

Description

All models were printed in soft material for a more life-like handling experience. In some cases, inserts for small magnets were designed into the prints.

The use of small magnets embedded within the printed sections allowed for the models to be taken apart and reassembled. This enabled interior perspectives of the congenital defects the models were portraying for the attendees.

3D LIFEPRINTS
CASE STUDY

PAEDIATRIC CARDIOLOGICAL EDUCATION & TRAINING

SPECIALITY: CARDIOLOGY
PROCEDURE: CONGENITAL HEART DEFECT IDENTIFICATION AND TREATMENT
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODELS

OUTCOME / BENEFITS

The 20 heart models, some of which could be taken apart and pieced together again, provided attendees with realistic, tactile teaching aids that could be passed around and explored as an adjunct to lectures and screen-based learning which formed the majority of the course. Combining haptics with visual learning is increasingly being seen as a more effective approach to teaching clinicians about complex pathologies and treatments than visual instruction alone.

The models are durable enough to be used for repeat courses in years to come, allowing the hospital to continue to deliver leading cardiac training to professionals from around the world.

Case Summary

A cardiac surgeon requested two patient specific 3D printed cardiac models so that they could demonstrate the complex Senning procedure as part of a double switch operation for congenitally corrected transposition of the great arteries (TGA), to surgical trainees and other clinicians with great levels of realism.

Description

The first model (left) represented a hollow heart and therefore captured both the external and internal patient specific morphology of the heart, as a result of the 3D LifePrints engineer subtracting the blood volume from it. It was then printed in soft, translucent material proving effective for surgeons looking to simulate surgery.

The second model (right) represented the blood volume and therefore offered unparalleled visualisation of how the internal chambers and main vessels are affected by TGA. The model was printed in rigid material as it was used for visual reference only.

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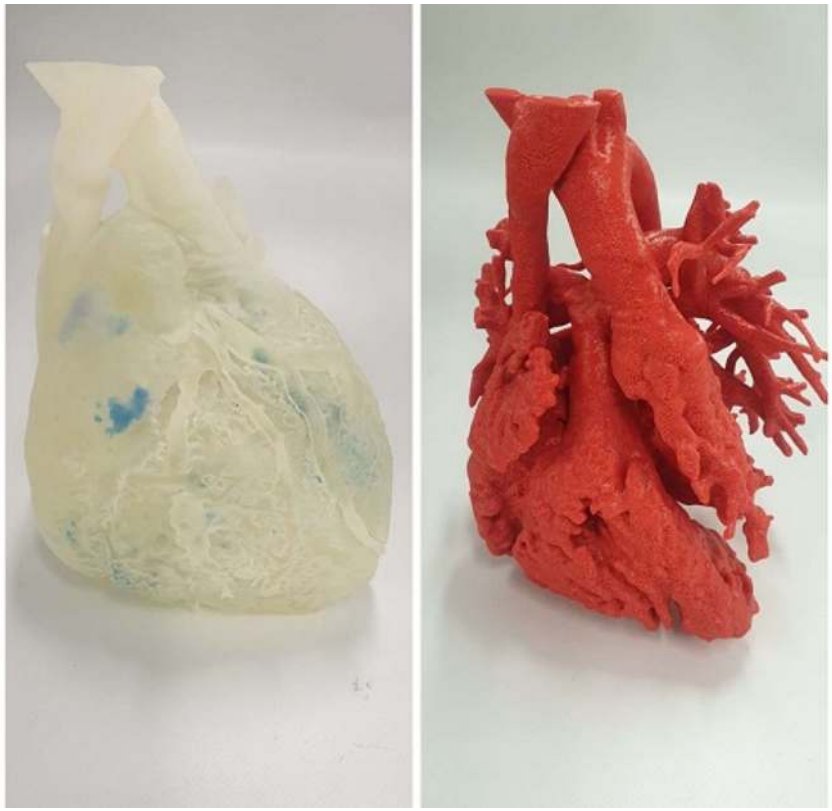
CASE STUDY

CARDIOTHORACIC EDUCATION AND TRAINING

SPECIALITY: CARDIOLOGY
PROCEDURE: SIMULATION AND TEACHING OF THE SENNING PROCEDURE
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODELS



OUTCOME / BENEFITS

The cardiac surgeon was able to use both models to effectively showcase the effects of TGA to both students and professionals about the condition.

The surgeon also performed a simulation of the Senning procedure on the translucent model, after which both models will remain as a permanent reference tool for future professional education.

Case Summary

Alongside using patient-specific anatomical models for pre-surgical planning, cardiology departments often use 3D LifePrints' on-site service to capture rare and complex congenital cases for educational and training purposes on a regular basis.

The surgeon requested this patient-specific model to better educate current colleagues and future cardiologists at the hospital.

Description

In this case, the patient was diagnosed with hypoplastic left heart syndrome (HLHS), had undergone an atrial septectomy, bilateral pulmonary artery (PA) banding and insertion of a patent ductus arteriosus (PDA) stent.

3D LifePrints segmented the patient's scan data and worked closely with the cardiologist, in 3D LifePrints' hub within the hospital, to produce a virtual model optimised for clear demonstrations. The virtual model was then 3D printed in soft material for a more realistic feel.

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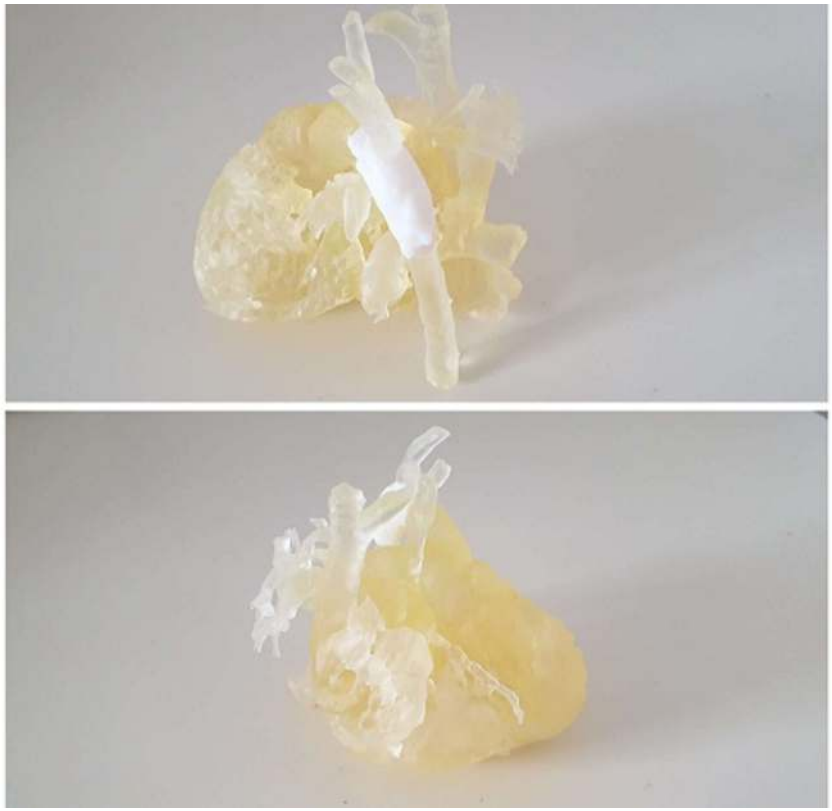
CASE STUDY

PAEDIATRIC CARDIOLOGICAL EDUCATION & TRAINING

SPECIALITY: CARDIOLOGY
PROCEDURE: ATRIAL SEPTECTOMY, BILATERAL PA BANDING & PDA
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODEL



OUTCOME / BENEFITS

The use of 3D printed models serve as an adjunct to the department's traditional education and training methods, such as 2D CT Angiogram, CT or MRI scan interpretation. Accurate physical models allow 360-degree haptic manipulation for a more complete visualisation of the congenital heart defect by the handler.

With the model, the cardiologist is able to better explain the nature of the pathology, its effect on the patient, the treatment paths available, and the specific approach chosen in a particular case.

Case Summary

Alongside using patient-specific anatomical models for pre-surgical planning, the cardiology department at a childrens hospital also uses 3D LifePrints' on-site service to capture rare and complex congenital cases for educational and training purposes on a regular basis.

A cardiologist requested this patient-specific model to better educate current colleagues and future cardiologists at the hospital.

Description

In this case, the patient presented with multiple congenital defects, including; double outlet right ventricle (DORV), transposition of the great arteries (TGA), ventricular septal defect (VSD) and a Taussig-Bing anomaly.

3D LifePrints segmented the patient's scan data and worked closely with the cardiologist, in 3D LifePrints' hub within the hospital, to produce a virtual model optimised for clear demonstrations. The virtual model was then 3D printed in soft material for a more realistic feel.

3D LIFEPRINTS

CASE STUDY

PAEDIATRIC CARDIOLOGICAL EDUCATION AND TRAINING

SPECIALITY: CARDIOLOGY
PROCEDURE: TREATMENT FOR DORV, TGA, VSD, TAUSSIG BING
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODEL

OUTCOME / BENEFITS

The use of 3D printed models serve as an adjunct to the department's traditional education and training methods, such as 2D CT Angiogram, CT or MRI scan interpretation. Accurate physical models allow 360-degree haptic manipulation for a more complete visualisation of the congenital heart defect by the handler.

With the model, the cardiologist is able to better explain the nature of the pathology, its effect on the patient, the treatment paths available, and the specific approach chosen in a particular case.

Case Summary

A cardiac surgeon at a childrens hospital requested a 3D printed anatomical model for an educational demonstration of surgical simulation at the Arab Health Exhibition in Dubai, 2017, held to showcase products from the medical and pharmaceutical industries.

Description

The heart model for this simulation was 3D printed in silicone and intentionally softened to replicate the consistency of an infant's cardiac tissue.

The model was nested in a set of 3D printed ribs to further increase the sense of realism for the surgeon and attendees. This simulation included the closure of an atrial septal defect (ASD) and widening of the pulmonary stenosis on the 3D printed heart.

The surgeon encouraged participation from the attendees, and several of them were able to practice the suturing techniques necessary for this procedure.

3D LIFEPRINTS

CASE STUDY

PAEDIATRIC CARDIOLOGICAL SURGICAL SIMULATION AND TRAINING

SPECIALITY: CARDIOLOGY
PROCEDURE: REPAIR OF CONGENITAL HEART DEFECTS
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL SIMULATION MODEL

OUTCOME / BENEFITS

As 3D print material options continue to improve, the levels of haptic realism for surgical departments looking to use 3D printed models for simulator-based training increases.

The use of 3D printed models for surgical training is on the rise due to barriers such as legality, cost and availability in the use of cadaveric models. 3D models avoid any such issues and come with the benefit of being completely customisable, not only in terms of model scale and material, but in terms of complex pathologies being available for on demand replication.

This is highly useful for training individuals in more advanced procedures for patients presenting with complex or rare conditions, such as congenital heart defects.

Case Summary

Alongside using patient-specific anatomical models for pre-surgical planning, the cardiology department at a childrens hospital also use 3D LifePrints' on-site service to capture rare and complex congenital cases for educational and training purposes on a regular basis.

A cardiologist requested this patient-specific model to better educate current colleagues and future cardiologists at the hospital.

Description

In this case, the patient presented with hypoplastic left heart syndrome with anomalous coronary artery originating from the main pulmonary artery, an extremely rare congenital defect which poses one of the highest levels of risk of severe ischemia or even myocardial infarction, dangerous arrhythmias, chronic circulatory failure and sudden death.

3D LifePrints segmented the patient's scan data and worked closely with the cardiologist, in 3D LifePrints' hub within the hospital, to produce a virtual model optimised for clear demonstrations. The virtual model was then 3D printed in soft material for a more realistic feel.

3D LIFEPRINTS

CASE STUDY

PAEDIATRIC CARDIOLOGICAL EDUCATION AND TRAINING

SPECIALITY: CARDIOLOGY
PROCEDURE: HLHS WITH ANOMALOUS CORONARY ARTERY FROM MPA
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODEL

OUTCOME / BENEFITS

The use of 3D printed models serve as an adjunct to the department's traditional education and training methods, such as 2D CT Angiogram, CT or MRI scan interpretation. Accurate physical models allow 360-degree haptic manipulation for a more complete visualisation of the congenital heart defect by the handler.

With the model, the cardiologist is able to better explain the nature of the pathology, its effect on the patient, the treatment paths available, and the specific approach chosen in a particular case.

Case Summary

Cardiologists at a childrens hospital were inspired to explore the use of 3D modelling and printing as a way to bring their CT angiograms of pre and post natal patients to life.

Converting the scans, made during diagnostic investigations into anti and post-natal aortic abnormalities, into 3D models proved to be a useful adjunct to traditional CT angiogram interpretation and use in communication to others involved with the patient's treatment. Explanation of the pathology and challenges inherent to each treatment pathway became much clearer in their conveyance.

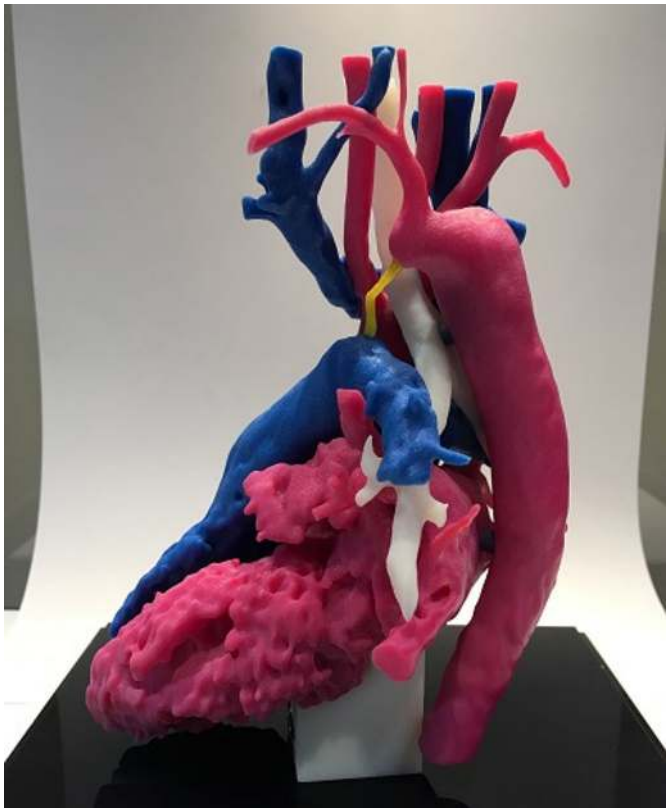
In this model, the main artery (pink) presents on the right-hand side of the patient's body, instead of the more common left-hand side. This is a right aortic arch. As the aorta descends, it joins other structures, such as the ductus ligament and the pulmonary artery, in encircling the trachea and oesophagus which can lead to breathing and feeding problems.

In terms of surgical planning, the decision to make is whether to divide the ductal ligament or consider removing the whole of the Kommerell diverticulum. The challenge in conducting surgery in an older patient such as this is that surgeons run the risk of compromising blood flow to the left arm. Earlier intervention could have created co-lateral blood supply, preventing the risk.

3D LIFEPRINTS
CASE STUDY

PAEDIATRIC CARDIOTHORACIC EDUCATION AND TRAINING

SPECIALITY: CARDIOLOGY
PROCEDURE: INVESTIGATION INTO ANTI AND POST-NATAL AORTIC ARCH ABNORMALITIES
DEVICE: 3D PRINTED PATIENT SPECIFIC ANATOMICAL MODELS



OUTCOME / BENEFITS

Over time, a collection of models has been built to aid understanding and education at the hospital and is beginning to form part of a standardised pathway into aortic arch investigation. In each case, the model acts as a focal point for surgeons as they set out procedure choices to colleagues.

Particular value has also been found in their explanatory power for junior clinicians and surgeons still in training, as well as for patient families who benefit from a clear representation of what their child faces, what the proposed treatment pathway will be, and why it was chosen in their case.

CARDIAC SOLUTIONS

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