Introduction

Approximately 1 in 4 humans on this earth is born with a congenital heart defect that involves the failure of the complete formation of the fossa ovalis membrane between the left and right atria. This defect, better known as a PFO or Patent Fossa Ovalis, is an opening in the fossa ovalis membrane that results from the failure of the fetal structures (septum primum and septum secundum) from closing together at the moment of birth[2]. The opening can be classified in a variety of ways, but the most common are “shunts” which cause blood to flow from one area to the other. A shunt that exists in the blood flow from the left to right atria will cause the blood pressure to increase in the right side of the heart, resulting in right-sided hypertrophy. This will cause increased pulmonary pressure and will result in less blood being pumped through the lungs and becoming oxygenated. Symptoms generally include shortness of breath due to pulmonary hypertension, but are usually diagnosed due to being asymptomatic. On the other hand a right to left shunt is much more deadly due to the venous blood becoming mixed with the oxygenated blood of the left atria and then being pumped to the rest of the body. This results in cyanosis, chronic migraines, and can even cause a transient ischemic attack (stroke). Currently, there is very little data available about the biomechanics of the Fossa ovalis membrane, so this study was performed to gather the properties needed to design devices to help fix congenital heart defects like a PFO.

The Apparatus

Figure 2: The Anatomy of the Fossa Ovalis and surrounding structures from the right side of the heart. (From the Atlas of Human Cardiovascular Anatomy by the Visible Heart Lab)

Methods

• Swine hearts were taken from the Visible Heart Laboratory after and kept in a Keb’s solution and stored at 5°C for 14 hours.
• The swine heart was then taken and warmed up to 37°C and was cannulated to the venous blood becoming mixed with the oxygenated blood of the left atria and then being pumped to the rest of the body. This results in cyanosis, chronic migraines, and can even cause a transient ischemic attack (stroke). Since the dimensions of the fossa grew larger, the forces required to puncture the defect of the heart.

Design of apparatus: A transducer (Medtronic Chatillon DFIS 2 Digital Force Gauge) was placed until a diameter of 6 mm was accomplished. The swine heart was then taken and warmed up to 37°C and was cannulated toksen to the pressurizing apparatus as shown in Figure 3. The water pump was turned on and water was adjusted so that the heart was maintained at 10 mmHg and an endoscope was inserted into the right atrium and the fossa ovalis membrane was visualized.

• As a small incision was made on the posterior lateral side of the right atrium between the superior and inferior vena cava and a series of dilations entered were placed until a diameter of 6 mm was accomplished.
• The tine transducer (Medtronic Chart® 120 Digital Force Gaug) and puncture needle system was then advanced into the right atrium and was visible on the endoscope screen. It was then lined up perpendicularly with the fossa ovalis and each of the 5 different puncture sites (Figure 2, right) were tested and the peak forces were recorded.
• The heart was then removed from the apparatus and the right atrium was cut open for the measurement of dimensions of the fossa ovalis.

Conclusion

• The testing done will be used to help Biomedical Engineers design more advanced septal occluder devices for PFO and related indications. The data collected will also help improve the transseptal delivery techniques that a large amount of medical device implantation relies on such as atrial or mitral valve replacement implantation.

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References
