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Demonstration of bovine heart by corrosion cast technique

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Abstract
The specimens made of corrosion cast technique are an important teaching aid for the better understanding of luminal organs. Casts made with silicone resin will be a good museum specimen and a valuable teaching aid. To prepare the cast for this study, the bovine heart with its blood vessels collected from the slaughter house were utilised. Air curable silicone resin for injecting into the cardiac chambers through great blood vessels were used in two forms *viz.,* white silicone without stainer and colored silicone with stainer. The casts thus obtained after curing and maceration were finally air dried and utilised for this study. Highly durable casts of bovine heart obtained were used to demonstrate the anatomical relationship of cardiac chambers and its supply by the coronary artery. The morphological details of the bovine heart were well preserved in the cast made of silicone resin. Hence casts of bovine heart will be highly useful for academic purpose, research and for display in the museum.

Keywords: Silicone cast, coronary cast, heart corrosion cast

Introduction
Casting of biological specimens means the process of filling natural or pathological hollow spaces of a specimen with an extraneous material followed by corrosion which refers to removal of the tissue surrounding the casted hollow space, so that the solidified cast formed depicts the 3D architecture of the hollow organ (Haenssgen *et al.,* 2014) [3].
A specimen made of corrosion cast technique is an important teaching aid for the better understanding of luminal organs. Corrosion cast specimens are durable, odourless and pleasant for handling. It provides better visualisation of the morphology of organs (Menaka *et al*., 2015) [7]. Leonardo Da vinci was the first to prepare a cast by injecting dissolved wax into bovine ventricles and heart chambers (Mishra and Sethi, 2015) [8].
Since the corrosion casting technique has evolved, various materials such as metal alloys, celloidin, latex gum, epoxy resin, polyester resin and silicone have been tried to improve the casting technique in order to produce a replica of the biological structure. Corrosion cast specimens are generally used to study the three-dimensional structure of blood vessel, ductal system and cavities of an organ. A well-prepared cast can be an excellent teaching tool to have an in-depth knowledge of the organ, as they will replicate the vasculature and ductal system anatomy (Mishra and Sethi, 2015) [8].
Understanding of the overlapping cardiac chambers can be difficult for a first-year undergraduate veterinary student. Hence, for the better understanding and visualisation of the relationship between atrium and ventricles, the cast of bovine heart with its great blood vessels were made using silicone resin (Henry *et al*., 1998) [5].

Materials and methods
The steps in preparation of corrosion casts of bovine heart were described below

1. Procurement of Sample
For the preparation of corrosion cast specimens, fresh organs have to be utilised. Hence for the present study, the heart with aorta, venacava and pulmonary artery were collected from the slaughtered bovine species and the study was carried out. As the casting material have to be injected through aorta and pulmonary artery, these vessels were ligated leaving a short distance and then the heart were dissected out. To remove the blood clots in the cardiac chambers, the collected organs were initially flushed and washed with warm normal saline.

2. Injection of Casting material
Air curable Silicone resin was used as a casting material in this study to prepare the cast of

bovine heart as described by Sivagnanam *et al.* (2014) [11] and Menaka *et al.* (2015) [7] for making the corrosion cast of lung and bronchial tree pattern. Haenssgen *et al*. (2014) [3] reported that the silicone rubber was an elastomer composed of silicone, carbon, hydrogen and oxygen and also stated that the silicone resin was generally non-reactive, stable and resistant to extreme environment and temperature.

Silicone resin for injecting through great blood vessels were used in two forms *viz.*, white silicone without stainer and colored silicone with stainer.

a. Injecting white silicone resin

As stated by Hartman and Groenewald (2014) [4], the catridge of white silicone resin without any stainer was fixed in the dispensing handgun and the nozzle was fixed onto the tip of the catridge. Then the tip of the nozzle was first inserted into aorta and the resin was injected by hand pressure till it appeared on the surface of left ventricle. Similarly, silicone resin was injected into right ventricle, left atrium and right atrium via pulmonary artery, pulmonary vein and venacava respectively.

b. Injecting colored silicone resin

Red stainer was added to the silicone resin and a little quantity of chloroform was used to dilute the resin which reduces the viscosity and facilitates the flow of resin into the chambers. Then red stained silicone resin was injected into the Aorta using the dispensing handgun to fill the left ventricle. In the similar way, blue stained silicone resin was injected into the pulmonary artery for the right ventricle. Atrium of left and right side was filled with white silicone resin.

3. Curing

Curing will polymerise and harden the silicone resin. The hearts of bovine species injected with white and colored silicone resins were allowed for air curing by hanging the specimens till it gets hardened at room temperature (Barsczz *et al*., 2019 and Autifi *et al*., 2015) [2, 1].

4. Maceration

The bovine heart injected with white silicone resin was allowed for natural maceration. After 3-5 days, white colored cast of bovine heart was obtained which was then washed in running tap water to remove the remnants of the tissue attached in the cast of bovine heart and then air dried. (Sivagnanam *et al*., 2014) [11].

The bovine heart injected with colored silicone resin was kept immersed in potassium hydroxide solution till the surrounding tissues get macerated. Then the cast specimen obtained was washed in running tap water and air dried (Jessica and Mukilan, 2019) [6]. To differentiate and demonstrate the coronary arteries of both sides and the cardiac chambers with its blood vessels, the different chambers were also painted in different colors for easy understanding of the students.

Results and discussion

Highly durable casts of bovine heart obtained were utilized to demonstrate the anatomical relationship of cardiac chambers and its supply by the coronary artery. As the great blood vessels of heart were filled with casting material, it enhanced the visualisation of their branching and distribution pattern as mentioned by Haenssg *et al.* (2014) [3].

The casts of bovine heart were irregular cone shaped and the surfaces had grooves which indicated the division of heart into two atria and two ventricles. The coronary grooves indicated the division between the atria and ventricles. The left longitudinal groove was noticed behind the origin of pulmonary artery and the right longitudinal groove below the posterior venacava (Sisson and Grossman, 1953) [10].

Cardiac chambers with its valves

In the cast obtained, the left ventricle was larger than the right and formed the apex of the heart. The left atrio-ventricular orifice was guarded by bicuspid valve. The orifice of aorta from the left ventricle was found guarded by aortic valve and was composed of three semilunar cusps (Fig.1). One cusp was anterior and the others were right and left posterior.

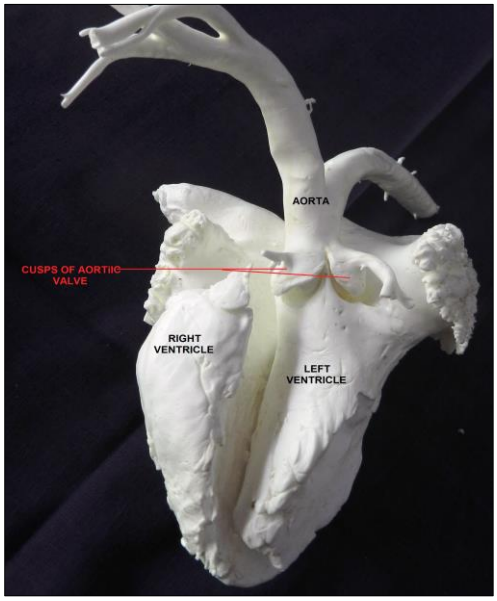

Fig 1: Cast of Bovine Heart showing the ventricles and aorta with its valve

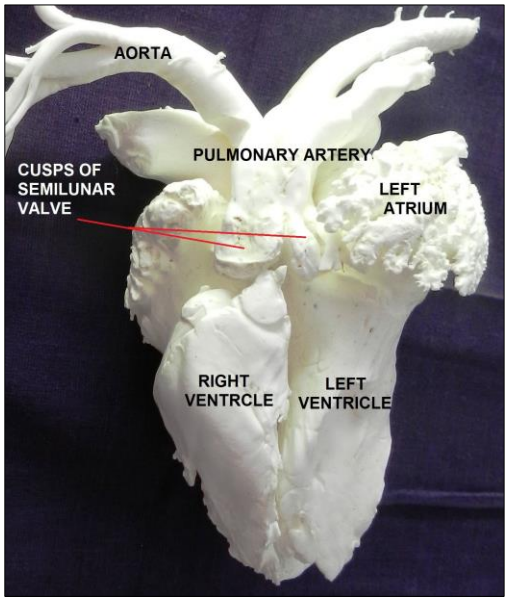

Fig 2: Cast of Bovine Heart showing the different chambers and pulmonary artery with its valve

The right ventricle was found communicating with the right atrium through tricuspid valve which consisted of three cusps. The pulmonary artery originated from the right ventricle and its orifice was found guarded by semilunar valve with three

semilunar cusps (Fig.2). One cusp was medial in position, one was lateral and the third was posterior in position.
The right atrium formed the right anterior part and left atrium formed the posterior part of the base of heart and both atria consisted of auricle and sinus venarum.
The above structures could be easily visualised in the cast of bovine heart but the structures like chordae tendinae, musculi papillaris and moderator bands could not be differentiated in the casts as they were in the lumen of the chambers.

Blood supply to the Heart
In domestic animals, the arterial supply of the heart was from two coronary arteries (right and left), but they do not have the same importance in every species (Vazquez *et al*., 2019) [12]. At the aortic orifice, three cusps of the aortic valve were noticed from which the coronary arteries originated.
The right coronary artery (Fig.3) originated from the anterior sinus of aorta and it passed forward and downward between the conus arteriosus and right atrium to the right coronary groove in which it curved to the right and backwards to anastomose with the left coronary artery at the origin of right longitudinal groove.

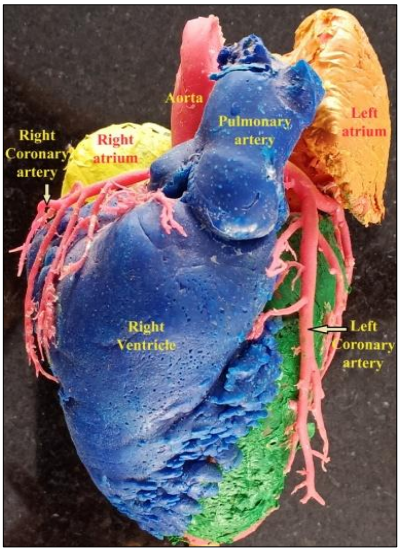

Fig 3: Cast of Bovine Heart depicting the different chambers with its right and left coronary artery

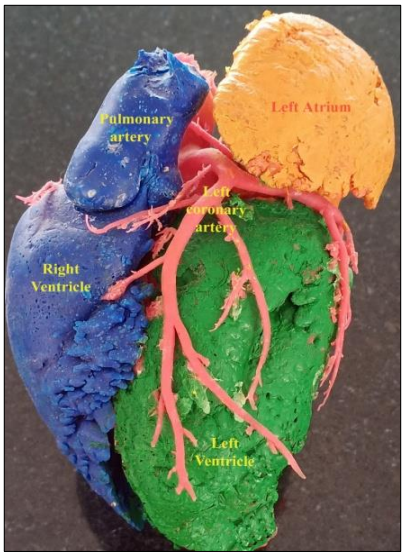

Fig 4: Cast of Bovine Heart showing the branches of left coronary artery

The left coronary artery (Fig.3,4) was larger and arose from the left posterior sinus of aorta behind the origin of pulmonary artery and the same was observed in Pampas deer (Vazquez *et al*., 2019) [12]. It then divided into two branches. The descending branch passed down the left longitudinal groove towards the apex and supplied both the ventricular walls. The circumflex branch in the coronary groove passed backward and a branch from it descended into the intermediate groove and then it curved to the right to descend into the right longitudinal groove and anastomosed with the right coronary artery.
But in horse and dog, Sisson and Grossman (1953) [10] reported that the right coronary artery was larger and gets divided into circumflex and descending branches. Thus, the branching pattern of the coronary artery differs in different animals which can be understood only with the help of these corrosion casts.

Conclusion
The morphological details of the bovine heart with its blood supply were well preserved in the cast made of silicone resin. The casts obtained were light weight, easy to handle and showed even the finest ramifications (Shanthini and Suma, 2019) [9]. Hence casts of bovine heart will be highly useful for academic purpose, research and for display in the museum.
The luminal cast of bovine heart serves as an excellent teaching aid for the students and helps in better understanding and visualization of heart chambers. It will enlighten the knowledge of comparative anatomy and such model affords the student in learning anatomy in detail through virtually realistic specimens. Thus the casts will greatly enhance the ease of studying anatomy (Jessica and Mukilan, 2019) [6].
This is a study which describes the use of a silicone resin to study the bovine heart in contrast to the use of formalin fixed specimens. The corrosion cast specimens are alternate to formalin fixed specimens.

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