

Conjoined Holstein Calves

A Short History

2014-Present

The GVSU plastination lab acquired the conjoined female newborn (cesarean section) Holstein calves from a local dairy farm in November 2014. They did not survive their entry into the world due in large part to the developmental anomalies present at birth.

Externally each calf had a head, neck, 2 forelimbs (4 in all), only one hindlimb (2 total) and 1 tail. Each also had its own vertebral column and ribs, but instead of the ribs projecting ventrally from the vertebral column, they stuck out laterally and the forelimbs did too, so each calf looked as if it was a person who was told it to "put your hands up." Most of our ribs connect to our sternum in the middle of our chest, but this was not the arrangement in The Girls. For them it was as if someone had sawed through the middle of their sternums and opened up their chests, then stuck them together so that the two sternums, one on either side, were half from one calf and half from the other.

Not having any idea about what things looked like inside, we decided to inject as much of the arterial system as possible with red latex to increase the visibility of these blood vessels. The injection was done through the right femoral artery, which proved to be a fortuitous decision, as the arterial system is much better developed in this calf, who we decided to call **Tessie**. The Girls were then skinned (except for **Bessie's** (the other calf) head and the tails, and preserved in a solution of 10% formalin.

Once the formalin preservation was complete a long period (2 years) of dissection began, with nearly all of the dissection carried out by GVSU students under our close supervision. Our intention was to show as much of the internal anatomy of The Girls as possible, while retaining relationships which could be understood by anyone looking at them. Since most animals with similar developmental anomalies are displayed as intact taxidermy specimens, we saw the opportunity to allow people to see what is normally hidden from view and therefore increase their understanding of embryonic development and how it can run amok when a single fertilized egg divides abnormally.

Once the dissection was complete in early 2017 we began the plastination process, which entailed dehydrating The Girls in acetone and then impregnating them under vacuum with a silicone polymer, followed by a final posing and treatment with a silicone catalyst to set the impregnation polymer, resulting in a permanently preserved dry specimen. By the end of 2018 The Girls were finally ready for their debut in public.

The major anatomical features of Bessie and Tessie are as follows:

- The vertebral columns of the two calves are separate superiorly, then nearly join in the lumbar region, only to separate again to pass into the 2 tails
- Ribs project on both sides from the vertebral columns, but Tessie's right ribs and Bessie's left ones are much better developed than the those on the other sides.
- As noted, each sternum is formed half by one calf and half by the other. The sternum formed from the right side of Tessie and the left side of Bessie is better developed than the other sternum.
- All normal internal structures above the diaphragm are present in each calf - two lungs in their own pleural cavities and one heart in its own pericardial cavity, plus an esophagus and all the usual blood vessels and glands.
- Tessie's heart is much larger than Bessie's, as are both her thoracic aorta and thoracic inferior vena cava.
- Below the diaphragm there is one liver. Below the liver is a single inferior vena cava (IVC), but it branches into two vena cavae as it passes toward the hearts from the liver, one passing to each heart. Tessie's IVC is intact and much larger than Bessie's, which can be seen protruding from the liver, but had to be cut from its connection to the heart when we opened the abdomen and separated the two thoraxes. There is red latex in Tessie's IVC because of a normal prenatal heart vessel called the ductus arteriosus. See if Alexa knows anything about it, and why it is connected to the presence of the red latex inside.
- There are 2 separate stomachs, each with the 4 chambers seen in cattle: the esophagus opens into the very large **rumen** (cows are ruminants☺) which connects to the much smaller **reticulum** (it's reticulated!), then an odd little chamber with "shelves" in it called the **omasum** and finally the **abomasum**, which drains into the small intestine. Tessie's stomach was removed to reveal the structures behind it. The separate intestines were also removed for this reason, but they eventually joined so that there is a single rectum.
- Two spleens were located behind the liver. They have been moved from this normal position in order to show other structures back there. Tessie's spleen is the one with red latex in its artery, which arose from her abdominal aorta. Blood supply to Bessie's spleen was from her abdominal aorta, but interestingly, both splenic veins combine before entering the liver. The small

pancreases were removed to show the abdominal vessels more clearly.

- Three kidneys are present. One might expect there to be 4 of them, two for each calf. Instead, the kidney in each calf on the better developed side (larger ribs and sternum) looks "normal" and its ureter leads to a "normal" single urinary bladder in front of the uterus. On the other, less well-developed side, there is a third kidney, likely a fusion of one from each calf, and it has two ureters which appear to connect to a second urinary bladder behind the rectum. It is unclear how this bladder is connected to the other one, if it is at all.
 - The abdominal aortas of the two calves are quite different. Tessie's aorta supplies nearly all of the abdominal organs, including the liver, her stomach, both spleens and all of the kidneys. It's branches also supply both sides of the pelvic cavity. Bessie's abdominal aorta supplies her stomach, and ends in two small branches, one to her hindlimb and the other to the lower portion of the intestine (which has been removed). It has no branches to the kidneys, but because it contains some red latex it must have had small connections to Tessie's aorta which were lost during dissection.
 - There is a single umbilical cord which presumably connected to a single placenta. An individual's umbilical cord normally contains two umbilical arteries, one from each of the two pelvic (internal iliac) arteries, one umbilical vein which passes through the liver, and a connection from the urinary bladder called the urachus. The Girl's umbilical cord has one umbilical artery, from Tessie's pelvic artery, one umbilical vein going to the liver, and the large urachus from the "normal" urinary bladder.
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A number of individuals were involved in the **dissection** of The Girls, but most of the intricate and detailed work was done by two GVSU students, **Betsy Witte**, a BMS undergraduate, and **Megan Glazier**, an MHS graduate student. Anatomy Lab Supervisor **Kim Wieber** lent her expertise during several phases of the dissection process, and **Tim Strickler** shepherded The Girls through the steps involved in the plastination process.

Legacy Metal Fabricating, LLC of Grand Rapids built the tanks which were used in the dehydration and silicone impregnation parts of the plastination sequence, and **Frank Sylvester** provided transportation for these items. The stand on which The Girls are displayed was also built by **Legacy Metal**, and modified by **Jeff Woolett** and **Tim Strickler**.

Questions about Tessie & Bessie, or the GVSU Plastination Lab? Email Tim Strickler- strickl@gvsu.edu.

