Modeling of Chronic Ventral Hernia in Rabbit

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Statement of Purpose: Hernia repair is one of the most frequently performed surgical operations in the US with approximately 800,000 procedures performed annually.[1] The vast majority of these repairs employ a "tension-free" technique which involves the use of synthetic surgical meshes. Although these procedures appear to have reduced the frequency of recurrence, they have led to the introduction of several long-term complications. One of the main tools bioengineers employ in studying medical devices, such as surgical meshes, is by animal testing. Therefore the applicability of the animal model used is of utmost importance as it must, as closely as possible, mimic the human situation. This allows researchers to discover potential adverse reactions prior to testing in a clinical setting. Current animal models used to study hernia repair are not perfect and often do not replicate the chronic wound pathology associated with hernias in humans.[2] These generally involve en-bloc abdominal wall defect creation in the animal followed by repair of that defect all in the same surgery.[3] The main issue encountered here is that the wound is not allowed to mature prior to mesh repair, as one would see in the clinical setting where hernias exist months and even years prior to repair. The present study examines various approaches at creating a chronic ventral hernia model in New Zealand White (NZW) rabbits for studying current and new surgical mesh constructions.

Methods: A total of 4 NZW female rabbits were used for this study. The surgical procedure and times were slightly adjusted for each animal based on subsequent outcomes as it related to creation of a chronic ventral hernia model. Following defect creation the areolar tissue was re-approximated with skin closure using 3-O PDS-II (Ethicon, Inc.) suture for each animal. Tissumend II (VPL) tissue adhesive was used to seal the incision site after skin closure. *Animal No. 1* – A 3x1 cm section of the abdominal wall musculature was excised while leaving the peritoneum intact approximately 3 cm below the xiphoid process and centered along the linea alba (upper left side of abdomen). Skin closure was accomplished as previously described. The abdominal wall defect was allowed to mature for 36 days, at which point the animal was euthanized and examined for hernia creation. *Animal No. 2* – Approximately 13 cm below the xiphoid process and 2 cm away from the linea alba (lower left side of abdomen) a 3x1 cm section of the abdominal wall musculature was excised and a 2 cm incision through the peritoneum was created. Two knots of Vicryl 2-O suture were placed 0.5 cm in on each side of the incision that was made into the peritoneum. Skin closure was accomplished as previously described. The abdominal wall defect was allowed to mature for 35 days, at which point the animal was euthanized and examined for hernia creation. *Animal No. 3* – Approximately 13 cm below the xiphoid process and 2 cm away from the linea alba a 3x1 cm section of the abdominal wall musculature was excised and a 3 cm incision through the peritoneum was created. Skin closure was accomplished as previously described. Animal was euthanized 10 days following creation surgery as humane endpoints were reached prior to the planned end date. *Animal No. 4* – Approximately 3 cm below the xiphoid process and 2 cm away from the linea alba (upper left side of abdomen) a 1.5 cm incision/full thickness defect was created through the peritoneum. Skin closure was accomplished as previously described. The abdominal wall defect was allowed to mature for 23 days, at which point an exploration surgery was conducted to determine the outcome.

Results: Palpation and visual examination of Animal No. 1 and 2 showed no signs of a hernia. Exploration surgeries performed following euthanasia of these animals confirmed these findings. The defect creation procedure employed on Animal No. 3 resulted in a large hernia which included portions of the bladder, large intestine, and uterine horn. This was mainly due to the location of the hernia which required early euthanasia of that animal. In Animal No. 4, the defect size was reduced and moved back to the upper left side of the abdomen to avoid strangulation of critical organs. Exploration surgery performed 23 days post-op revealed a small hernia in the abdominal wall as shown in Figure 1 below.

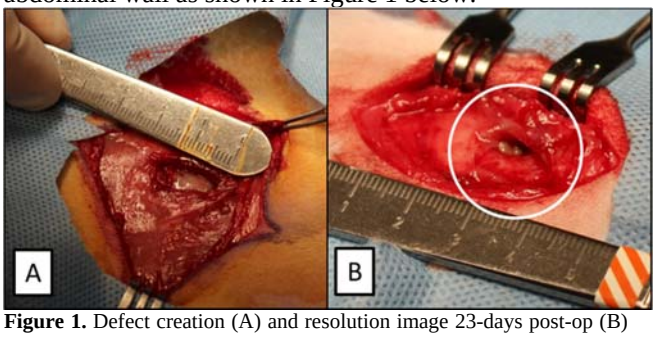

Figure 1. Defect creation (A) and resolution image 23-days post-op (B) indicating presence of a ventral hernia (~0.6 cm) for Animal No. 4.

Conclusions: The preliminary results presented here indicate that an open laparotomy of at least 1.5 cm through the peritoneum is required to result in a mature ventral hernia in NZW rabbits. Preferably, the defect is positioned in the upper half section of the abdominal wall beginning approximately 3 cm below the xiphoid to prevent strangulation of critical organs. Further studies are currently under way to confirm reproducibility of this model and it's applicability to hernia mesh research. By separating hernia creation from mesh repair during animal testing, we believe that future work will more closely relate back to the clinical situation in humans.

References:

1. Rutkow, I.M. *Surg Clin North Am.* 83(5), 1045 (2003).
2. Bringman, S., et al. *Hernia*. 14, 81-87 (2010).
3. Penttinen, R., et al. *Hernia*. 12, 337-344 (2008).

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