SMALL INTESTINAL ANASTOMOSIS AND INTESTINAL INFUSION CATHETER IMPLANTATION IN SWINE

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Introduction
Intestinal anastomosis and implantation of catheters for segmental intestinal infusion are common procedures in a research setting. These techniques are particularly applicable to transplantation and studies involving intestinal absorption of pharmacologic agents. The unique anatomy of swine necessitates modifications of surgical techniques commonly employed in other large animal species.

Surgical Anatomy
The small intestine of swine is approximately 40 times the length of the body and accounts for approximately 4.5% of the body weight. The duodenum and ileum are each approximately 5% of the length of the small intestine with the jejunum making up the remaining 90%. In general, the length and width of the small and large intestine of a 30-40 kg pig equals that of a human. Further details on anatomy can be found at the following link:

(http://www.sinclairresearch.com/PDF%20Files/comparative%20anatomy%20of%20the%20pig%20(06-2003).pdf)

The duodenum exits the stomach on the right side in the region of the 10th-12th intercostal space and continues caudally dorsal to the colon. As it crosses the medial plane on the visceral surface of the liver at the root of the mesentery it turns cranially and becomes the jejunum. The duodenum is more tightly attached than the jejunum, of which the majority is located as close coils in the caudal ventral portion of the abdomen. The ileum progresses to the left side of the abdomen and joins the cecum in the dorsal cranial portion of the left paralumbar fossa. The duodenum and ileum have slightly thicker wall structure than the ileum and the difference may be readily palpated. Aggregated lymph nodules (Peyer’s Patches) can be readily identified as pale band-like or oval structures in the jejunum and ileum.

The bile duct enters the duodenum 1.5-6 cm from the pylorus. The pancreatic duct is separate and enters the duodenum 10-20 cm from the pylorus. The distances increase with the size of the pig with the smaller value representing weanlings and the larger value representing adults.

The unique anatomy of the mesentery and vascular arcades are of particular importance when performing surgery on the small intestine (Figure 1). The mesentery remains thin and friable into maturity. The vascular arcades form a distinctive fan-like pattern in the mesentery and they branch in the subserosa rather than in the mesentery like other large animal species. There are numerous prominent lymph nodes in the root of the mesentery.
Surgical Preparation

Fasting a pig <50 kg BW overnight is generally sufficient to empty the stomach and small intestine. Larger pigs have a slower transit time. Liquid diets have a faster transit time. In general, it requires 2-8 hours to empty the stomach, 8-20 hours to empty the small intestine and 48-72 hours to empty the large intestine. It is not necessary or advisable to restrict water in the preoperative period. Prophylactic antibiotics may be administered either in advance of the surgery or postoperatively, but it is unnecessary unless there is a contamination during the procedure.\(^1\-3\)

The laparotomy incision may be made in several locations depending upon the area of the small intestine to be approached.\(^1\) In general, the duodenum and root of the mesentery are best approached using a midline incision in the cranial abdomen. The bulk of the jejunum may be approached either by a midline, flank or paramedian incision in the mid to caudal aspects of the abdomen. The ileum may be approached using a midline or flank incision in the cranial portion of the abdomen.

Intestinal Anastomosis

The segment of the intestine of surgical interest needs to be isolated from the abdomen by packing it with warm, wetted laparotomy sponge packs. After identifying the segment to be excised, the mesenteric vessels are ligated individually close to the root of the mesentery.

The infarcted region of the intestine can be identified and a set of pediatric atraumatic intestinal forceps is applied in the viable portion of the intestine <5 mm away from the line of demarcation. The angle of the clamps approximates the angle of the mesenteric vessels. A second set of clamps is placed on
either side of the first set of clamps in the viable tissue to prevent contamination of the incision site. In swine care must be taken to ensure that the clamping procedure is atraumatic. The intestinal wall is thin and easily damaged. Consequently, the clamps should be shod with either linen or rubber and tightened only enough to prevent contamination of the surgical field.

The incision is made between the two sets of clamps, the mesenteric vessels are transected and the piece of intestine is removed. In general, the small intestine can be sutured using simple interrupted sutures of 3-0 PDS. The first suture is placed at the mesenteric border and subsequent sutures are placed on either side working towards the anti-mesenteric border. In larger swine a two layer closure may be necessary. In that case, inverting Lembert sutures are used to oversew the simple interrupted pattern.

When suturing is completed the remaining set of clamps is removed and the anastomosis is checked for patency and leakage. Any leakage is repaired by additional sutures. The mesentery is closed using horizontal mattress sutures on either side of the viable vessels. The edges of the mesentery are friable and will not hold simple interrupted or continuous suture patterns as in other species. The mattress pattern will close the mesenteric rent but will not occlude the viable vessels (Figure 2).

The anastomosed intestine should be copiously flushed with saline with or without antibiotics prior to removing the laparotomy sponges. The abdominal incision is closed in a routine fashion with synthetic absorbable sutures. Alternatively the intestinal anastomosis can be performed using standard staple surgical techniques.

Intestinal Infusion Catheter Implantation

In pharmacologic studies it is frequently necessary to bypass the stomach and determine which area of the small intestine is responsible for absorption of the agent. This can be performed by implanting infusion catheters in various regions of the small intestine. Common sites would be the duodenum, jejunum and
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ileum. Generally duodenal catheters are implanted in the segment immediately caudal to the pancreatic duct. Proximal jejunum may be located at the root of the mesentery caudal to the stomach and mid jejunum in the coils of the caudal abdomen. The ileum is best located by identifying the ileocecal junction and tracing the intestinal segment cranially.

Vascular access ports have been modified to be used as intestinal infusion ports and catheters. The port itself is the same design but 7-9 Fr. silicone catheters are modified for intestinal access. The tip of the catheter cannot be left open because it will rapidly become blocked with intestinal contents. The tip of the catheter is either constructed with a burp valve or 4 slits which are cut in the intra-intestinal portion of the tip of the catheter. A suture retention bead is glued in place at the site of intra-luminal placement and a silicone cuff is preplaced approximately 1 cm above the bead. Thus, there is an intra-luminal segment with slits or a burp valve, a suture retention bead within the intestine at the site of enterotomy and a silicone cuff for placing retention sutures on the serosa (Figure 3).

All of the small intestinal sites can be accessed using a cranial to mid-abdominal midline incision. The procedures for isolating and packing the intestines are identical to that described above for anastomosis. A stab incision is made in the anti-mesenteric border of the intestine using a #11 blade, taking care to avoid direct penetration of a blood vessel. The catheter tip is inserted into the intestinal lumen in the direction of peristalsis. A purse string suture using 3-0 PDS is placed in the serosa between the suture bead, which is in the lumen of the intestine, and the silicone cuff. The silicone cuff is tacked in place with 2-4 serosal sutures using 3-0 Ethibond or other soft non absorbable suture material (Figure 4).
An elliptical pocket for the port body is made on the lateral abdominal wall. The end of the catheter is tunneled through the wall of the abdomen into the port pocket. The end of the catheter is attached to the port and the port and catheter are flushed copiously with sterile saline. The surgeon should be able to visualize the unobstructed passage of the fluid into the intestinal lumen without any leakage around the surgical site. The access port is sutured subcutaneously in place in the usual manner.1,4

This procedure is repeated for every intestinal access catheter that is placed. The catheter length should be sufficient to allow for growth of the animal during the project period without putting undue tension on the intestine. Leaving too much extra catheter length in the abdomen may lead to torsion of the intestines. This technique is only useful for infusion of substances into the intestine. It is not possible to withdraw intestinal contents through the catheter. Catheters are maintained by keeping them filled with sterile saline. Access to the port site for injections should be performed under sterile technique with skin preparation, sterile gloves and sterile supplies.

Postoperative Care
Postoperative recovery should be routine as for any other abdominal procedure. Water may be provided immediately following recovery and the animal may consume solid feed if only a catheter implantation was performed. Solid food should be withheld for the first day following surgery if an anastomosis was performed. Animals may be maintained on commercially available liquid diets such as Gatorade® (glucose/electrolyte) or Ensure® (protein/caloric). For a 20-25 kg pig the calculated amount of diet is approximately 1 qt of the glucose/electrolyte solution and 2-3 cans of the protein/caloric supplement provided bid. Postoperative analgesia should be provided and the animal monitored for postoperative complications. More complete information on postoperative care can be found at the following link: (http://www.sinclairresearch.com/PDF%20Files/perioperative%20care%20of%20swine.pdf)
The most common complications that may occur are localized infection or peritonitis from an intestinal content leakage or intussusception. Animals should be monitored for fever and abdominal pain as well as the normal postural and behavioral characteristics. Treatment should be symptomatic, however, in a research setting animals generally are euthanized if such complications occur. Intussusception is a rare occurrence but it may be associated with telescoping of the intestine over the silicone cuff in intestinal catheter implantations. If the animal is exhibiting fever, inappetance and abdominal pain, radiographs should be taken to observe for the condition. Provided that complete sterile technique is utilized during the procedure, complications should be rare.

References

