

Vessel Transection and Sealing using Ultrasonic Wave Technology in the Porcine Animal Model

Purpose of Procedure

The purpose of this study was to evaluate vessel sealing achieved using Ultrasonic Wave Technology both intraoperatively and during the postoperative healing phase.

Anesthetic Induction and Maintenance

Each pig was pre-anesthetized with IM injections of acetylpromazine maleate (targeted dose 1.1 mg/kg) and atropine sulfate (targeted dose 0.05 mg/kg). Anesthesia was induced with an IM injection of ketamine hydrochloride (targeted dose 20 mg/kg) and xylazine (targeted dose 2 mg/kg). As needed to facilitate intubations, the pigs were masked with Isoflurane (1-5% in O₂) administered to effect via a cone placed over the nose. Once the animal reached a sufficient level of anesthesia, an endotracheal tube was placed. After intubation, the endotracheal tube was attached to a veterinary anesthesia machine. Anesthesia for the remainder of the preparation and surgical procedure was maintained by semi-closed circuit system inhalation of isoflurane (1.5-3% in O₂). Assisted ventilation was accomplished with a ventilator. Lactated Ringers solution was administered intravenously at a rate of 5ml/lb/hr throughout the procedure.

Animal Preparation

The pigs underwent a nine-day quarantine and acclimation period prior to placement on study. Physical exams were performed three to five days prior to surgery. Pre-anesthetic blood work was performed prior to anesthetic induction and included a complete blood count and serum chemistry profile. Body weights were obtained prior to anesthetic induction to facilitate drug dosage calculations. The pigs were fasted for a minimum of 12 hours prior to anesthetic induction. The pigs were transported from their vivarium housing to a designated surgical preparation area on the day of surgery. Body temperature, pulse, and respiration were recorded prior to administering the pre-anesthetic drugs. Intramuscularly pre-anesthetic drugs were administered, followed by anesthetic induction agents (see Anesthesia section above). An area on the ear of each pig was clipped and scrubbed with Chlorhexidine scrub and alcohol. An I.V. catheter was placed in an auricular vein and secured for drug and fluid administration. The pigs received an I.V. injection of the antibiotic Cefazolin targeted at a dose of 22mg/kg. An endotracheal tube was placed and attached to a veterinary anesthesia machine. Anesthesia was maintained using Isoflurane (1.5-3% in O₂). The pigs received a preoperative intramuscular injection of buprenorphine (also referred to as Buprenex) targeted at a dose of 0.005 - 0.01mg/kg. The eyes were lubricated with an ocular moisturizer. The lower chest, abdomen, ventral cervical area, femoral artery cut-down site, ECG lead sites and cautery pad site were shaved and vacuumed. An initial surgical scrub of the surgical sites was performed using Chlorhexidine and alcohol prior to transporting the pigs to the aseptic surgical suite.

Detailed Description of Surgical Technique

The pig was placed in dorsal recumbency. The skin was infused with 2-5 ml of 0.25% Bupivacaine HCl prior to making an incision. A cut-down was performed on the right femoral artery to place an arterial catheter. Arterial blood pressure was monitored throughout the procedure. A ventral midline laparotomy was performed. The spleen was identified and mobilized to expose the splenic reflection of the gastroepiploic artery and vein bundle. A ventral midline cervical incision was performed. One carotid artery was identified and skeletonized. The carotid artery and gastroepiploic artery and vein bundle were measured using a sterile ruler. Both the carotid artery and splenic reflection of the gastroepiploic artery and vein bundle were transected in this study. Test instruments were applied using generator level 3. The transection sites were examined for hemorrhage or other complications. If bleeding was observed, the vessels were occluded using haemostatic clips.

If required for evaluation of the instrument, a blood pressure challenge was performed. Following transection and sealing of the vessels using ultrasonic wave technology, Phenylephrine was administered at a targeted rate of 2-10 mcg/kg/min IV, via an infusion. An attempt was made to increase the systolic blood pressure to twice the baseline systolic pressure, as recorded at the completion of the test article applications, or to between 200-250 mmHg for a period of at least 20 minutes. The firing sites were observed during this period. The total amount of Phenylephrine administered, peak systolic blood pressure, and period of time were documented.

Upon completion of the instrument evaluation, the catheter was removed from the femoral artery and a ligature of 2-0 silk was used proximal to the puncture site to control bleeding. That artery was permanently occluded following its use.

The incision sites were closed using standard surgical technique. 0-Prolene was used to close the fascia, 2-0 Vicryl was used subcutaneous, and staples were used to close the margins of the skin.

Intra-Operative Monitoring Procedures

With each firing of the test instruments, the generator level setting, transection time, and systolic blood pressure were recorded. In addition, tissue sticking, tissue effect, transection profile, and homeostasis were noted and recorded.

An anesthesia monitoring record was maintained for the duration of the procedure. Intraoperative measurements were recorded a minimum of every 15 minutes. Measurements included heart rate, respiration, and invasive blood pressure when the arterial line was in place. Body temperature, ETCO₂, SPO₂, inhalation anesthetic level, tidal volume, and ventilator pressure were recorded a minimum of every 30 minutes. A Dynamap MPS Select or Datex Ohmeda monitor was used to obtain the intra-operative

readings. Physical methods were also used to monitor the pigs during surgery. These methods included assessing eye reflexes, muscle tone, peripheral pulses, capillary refill time and mucous membrane color.

Post-Operative Monitoring Procedures

The pigs were recovered in individual recovery cages in a dedicated recovery room. Body temperature was maintained using warm water heating blankets or heat lamps. The pigs were extubated once they regained the ability to swallow. Temperature, pulse, and respiration were monitored a minimum of every 30 minutes throughout the recovery period until the animals were able to maintain sternal recumbency. Once the animal was deemed fully recovered as determined by a trained member of the veterinary staff, it was returned to its vivarium housing and given access to food and water.

Body temperature, pulse, and respiration were recorded in the animal's chart for seven days following surgery. A member of the vivarium or veterinary staff observed each animal for normal eating, drinking, defecation, urination, general appearance, behavior, response to stimuli and incision sites a minimum of once daily. If abnormalities were noted during the daily observations, the Attending Veterinarian and Study Director were notified and the appropriate course of action was determined.

Methods of Pain Assessment

The pigs were observed daily during the post-operative survival period for any sign of discomfort such as reluctance to move, guarding the abdomen, heart rate and respirations above normal limits, dilated pupils and a decrease in appetite. Additional pain medication was prescribed and administered as determined necessary by the Attending Veterinarian in consultation with the Study Director.

Analgesics Used

Prior to making the skin incisions, local skin blocks were administered by injecting 2-5 mls of 0.25% Bupivacaine (SQ) at the proposed incision sites. The surgical procedure was performed under general anesthesia.

The pigs received intramuscular injections of buprenorphine (also referred to as Buprenex) targeted at a dose of 0.008mg/kg. The first dose was delivered prior to the surgical procedure. The pigs continued to receive IM injections every 8 to 14 hours for a total of 4 post-operative doses. Additional analgesics were available for prescription by the Attending Veterinarian if it was determined that Buprenex was not adequate for pain control.

Follow-up Treatment

The pigs were weighed once weekly during the post-surgical survival period. Additional follow-up treatment was initiated if signs of abnormality were noted during daily post-

surgical observations. Due to an observation of elevated body temperature at 3-5 days post-op, a seven-day course of the antibiotic Ceftiofur (Naxcel, 2.2 mg/kg IM once a day) was initiated for three of the pigs. If any abnormalities were noted that could not be treated and appeared to cause the animal unnecessary pain or distress, the animal was euthanized and a necropsy was performed at that time.

Euthanasia

Four animals were euthanized four days post-surgery and four animals were euthanized fourteen days post-surgery. Body weights were obtained prior to necropsy to facilitate drug dosage calculations. The pigs were anesthetized with an intramuscular injection of a mixture of Telazol reconstituted with 100mg/ml xylazine (also referred to as TranquiVed or Rompun), targeted at a dose of 5mg/kg. An intramuscular (IM) injection of glycopyrrolate (also referred to as glyco or Robinul) was administered concurrently, targeted at a dose of 0.01mg/kg. Once the pigs were anesthetized, an IV catheter was placed. The pigs were euthanized with an IV injection of pentobarbital sodium euthanasia solution (Beuthanasia) at a minimum dose of 1ml/10 pounds. Following administration of the drug, the animals were observed via auscultation to ensure that respiratory and cardiac function had ceased.