A Comparison Of Two Surgical Methods For Chronic Measurement Of Blood Pressure In Juvenile Rats Through Adulthood

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Introduction

Collecting chronic blood pressure (BP) from juvenile animals through adulthood can provide a number of research benefits. The number of animals used, coinciding surgical support, and animal variability can all be reduced by using one BP transmitter model throughout the animal's lifetime. The PA-C40 transmitter (DSI), typically used in rats and similar species is too large in size and catheter diameter for smaller rodent arteries. However, the PA-C10 transmitter (DSI), which is typically implanted in mice or similar-sized species, was chosen as a possible alternative to the larger PA-C40 (See Figure 1).

The PA-C10 was implanted in 12 male, juvenile rats (SD, ~90 grams) to determine the most suitable placement for the catheter and transmitter body to retain catheter patency during the growth period. Two separate surgical procedures were evaluated including direct aortic cannulation with intraperitoneal (IP) transmitter placement in six rats and direct femoral artery cannulation with subcutaneous (SQ) transmitter placement in an additional six rats. Blood pressure was monitored and collected three days per week for a total of 16 weeks. Catheter patency was determined by analyzing the collected data and visualizing in vivo catheter placement at necropsy.

Materials and Methods

Twelve male Sprague Dawley rats (Charles River Laboratories) ranging from 53.5 to 116 grams were implanted with a PA-C10 telemetry transmitter (DSI) to measure systemic blood pressure. The catheter was placed directly into the aorta and the transmitter was left in the peritoneal cavity in six of the animals while the catheter was inserted into the femoral artery and advanced approximately 2.5 cm with the transmitter placed subcutaneously in the remaining six of the animals.

Figure 1: DSI PA-C10 mouse transmitter

All animals were anesthetized and maintained with a mixture of 2% Isoflurane and 0.5 liters per minute of oxygen and all surgeries were performed aseptically. For the aortic procedure, a ventral midline laparotomy was performed. The aorta was located and occluded to restrict blood flow. A 25-gauge needle was used to puncture the aorta near the caudal occlusion suture. The blood pressure catheter was inserted into the aorta and advanced so that the tip of the catheter was positioned below the cranial occlusion suture (See Figure 2). The catheter was glued in place using Vetbond tissue adhesive (3M, St. Paul, MN). Blood flow was restored. A fiber patch was cut to size and positioned over the catheter/aorta junction. The transmitter was anchored to the dorsal musculature next to the aorta using 5-0 non-absorbable suture (See Figure 3). The abdominal wall was closed with suture and the skin was closed using 9 mm skin staples.

For the femoral artery cannulation, an incision was made through the skin over the left femoral vessels. The femoral artery was located and isolated. Three non-absorbable sutures (5-0, Silk) were placed under the vessel. The distal-most suture was used to ligate the vessel while the other two were used for occlusion during the cannulation process. The artery was punctured using a 25-gauge needle and the catheter was advanced approximately 2.5 cm into the descending aorta (See Figure 5). The ligation and occlusion sutures were secured around the catheter and cut. A subcutaneous pocket was formed on the abdomen near the incision using blunt dissection. The transmitter was placed in the pocket and the pocket was closed with a purse-string pattern to help keep the transmitter from moving (See Figure 6). The skin incision was closed using 9 mm skin staples.

All animals were allowed to recover in their home cages which were placed on heating pads. Each animal received 2mg bacon flavored Rimadyl (Carprofen) tablets (Bio-Serv, Frenchtown, NJ) for pain relief for three days after surgery.

Each animal was individually housed and its cage was placed on a RPC-1 receiver (DSI). Data were collected every ten minutes for three days a week using Dataquest ART 4.1 (DSI). The transmitters were turned off when not being sampled to conserve battery life. After approximately 125 days of implantation, the devices were turned on and left on for the duration of the study. See Figures 4 and 7 for a one hour moving average plot of the data (Systolic, Diastolic, Mean, Pulse Pressure) for each placement.

Catheter and Device Placement

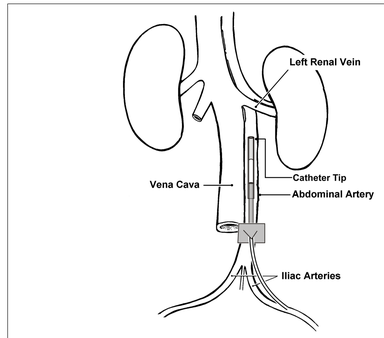

Figure 2: Catheter tip placement for the aortic cannulation

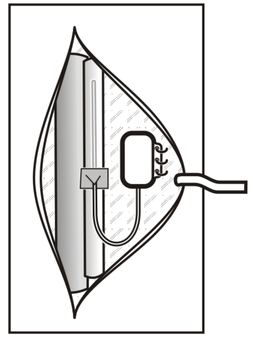

Figure 3: Transmitter placement for the aortic cannulation

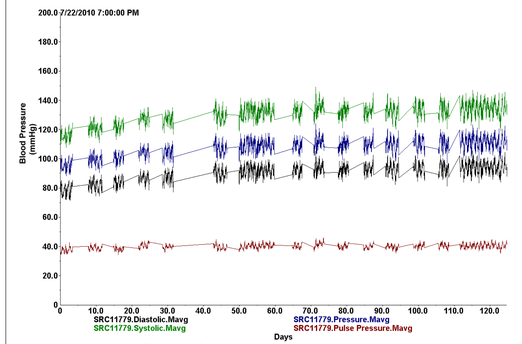

Figure 4: One hour moving average parameter plot for the aortic cannulation

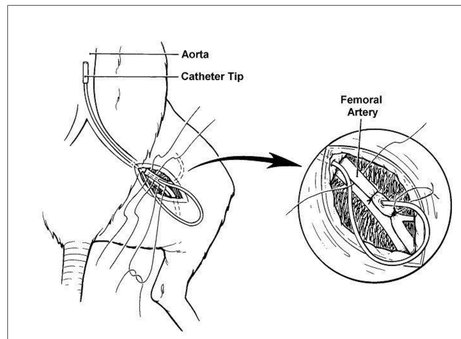

Figure 5: Catheter tip placement for the femoral cannulation

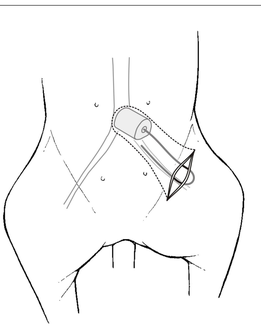

Figure 6: Transmitter placement for the femoral cannulation

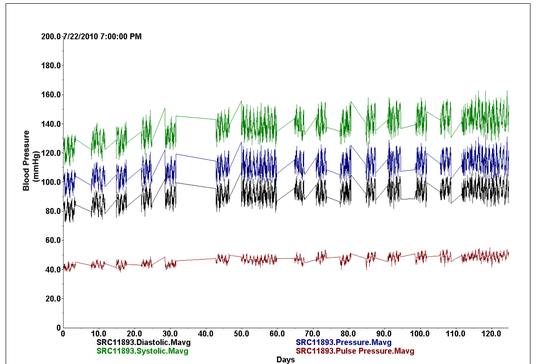

Figure 7: One hour moving average parameter plot for the femoral cannulation

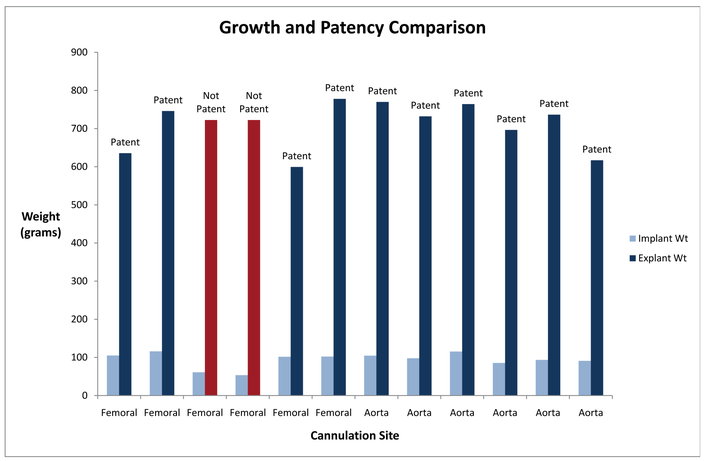

Figure 8: The catheter condition in correlation to the placement of the catheter and animal weight

Conclusions/Perspectives

All six of the animals that had direct aorta cannulation had patent catheters after 158 days of implantation. At the time of explant, the distance between the insertion site and the catheter tip was 9 mm for all of the catheters except for one which was 7 mm.

Four out of the six animals that were femorally cannulated were still patent at the end of 158 days. In two animals (53.5 and 61 grams), the catheter either became completely withdrawn from the artery or withdrew so much that it was near the insertion site where blood flow was not present. With the other four animals at the time of explant, the catheter tip was either placed between 1.0-1.5 cm cranial to the iliac bifurcation or between 3.5-5.0 mm caudal to the iliac bifurcation. See Figure 8 for a comparison chart highlighting the two placements and their outcomes.

Animals that were 100 grams or more in weight did not experience the extreme catheter withdrawal issue when the catheter was placed in the femoral artery. It is conceivable that the smaller animals had too great of a growth curve to sustain catheter tip placement in either the descending aorta or iliac artery. Further testing is recommended to confirm this hypothesis.

Transmitter placement was another factor to take into consideration with the use of small animals. Four out of six transmitters placed IP were still attached to the muscle or surrounding connective tissue. The other two had become detached. This is most likely due to fat and connective tissue interference. All six transmitters placed SQ were still in place at the time of explant.

Summary

The direct aorta approach was more successful and reliable in these small rodents. However, this approach is more invasive and is considered a major surgery.

The femoral arterial cannulation procedure may be considered as a less invasive alternative. However, our results indicate that animals should be 100 grams or greater in weight. Further investigation in smaller animals is recommended to confirm this. This procedure does have advantages over the aortic placement since a major body cavity need not be entered.

Another factor to consider is that the battery life of the PA-C10 transmitter is six weeks compared to four months while using a PA-C40 transmitter. Organized sampling protocols and diligence of turning the transmitters on and off when not in use will be necessary.

The study was designed to develop a viable solution to monitor cardiovascular parameters in juvenile rats through adulthood while ensuring catheter patency. We have confirmed that it is possible and most reliable by using the PA-C10 transmitter with the catheter directly inserted into the aorta with the transmitter secured to the surrounding muscle rather than the abdominal wall, which is the common placement with larger telemetry transmitters.

References

PA Device Surgical Manual, DSI