

HD-X Device Surgical Manual for Mouse



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HD-X11 Device Surgical Manual
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Introduction

The HD-X devices are surgically implanted in laboratory animals to acquire research data as part of the PhysioTel HD telemetry system. They can detect internal animal characteristics (e.g. blood pressure, ECG, and heart rate), process the information into data and transmit the data from within the animals via radio-frequency signals. In addition to transmission of physiological data, the HD-X devices also provide digital data that contains the device's serial number, factory calibrations, device ON time and battery voltage. This manual contains detailed procedures for implantation of the HD-X11 telemetry device to acquire a blood pressure signal and ECG and the HD-X10 device to acquire a blood pressure signal. The techniques described are designed for mice but may be applicable to other, similarly sized animals.

The HD-X devices are available in two different configurations: the HD-X11, equipped with one pressure-sensing catheter and one set of biopotential leads, and the HD-X10, equipped with one pressure-sensing catheter. More information about operating the HD-X system may be found in the DSI Implantable Telemetry System Manual (007678-003).

The HD-X Device Surgical Manual is intended for use by lab personnel who will perform, or assist in, the surgical procedures to implant devices into animals for use with PhysioTel HD Telemetry Systems. HD-X users must ensure they have the appropriate software to accommodate their devices; contact your sales representative if your version of software does not contain the option for your device model.

The surgical procedures written in this manual are at a level of detail appropriate for persons who have previous experience with animal surgical procedures in similarly sized species.

WARNING: The HD-X implantable devices are not intended for use in humans. It is a misuse of these devices, and a possible violation of law, to use these devices in humans.

Required Supplies for the HD-X Surgery

Some equipment needs may vary depending on the type of surgical procedure chosen to perform. Please refer to the Small Animal Surgical Supplies technical note at www.datasci.com for a complete listing of required lab supplies.

Rodent Anesthesia Guidelines

Surgical anesthesia in laboratory mice is often challenging. Individual anesthetic protocols should be tested for each animal strain and variation before attempting survival surgery. Typically, the surgical procedure will require 40-60 minutes of surgical anesthesia. Please consult your staff veterinarian for proper anesthetic protocols and training. The surgical procedures described in this manual were developed using inhalation anesthesia consisting of Isoflurane and Oxygen.

The following anesthetic regimen should only be used as a guide and should be modified to the individual animal and institution's protocol.

Inhalation anesthesia for mice using Isoflurane and Oxygen:

- Induction: 2.5% Isoflurane and 1 liter per minute oxygen
- Maintenance: 1.5% Isoflurane and ½ liter per minute oxygen

Anesthetized mice are predisposed to hypothermia and hyperthermia because of their small size. The use of supplemental heat sources such as warm water bottles, heating pads, or thermal lamps are important to maintain baseline body temperature. Both hypothermia and hyperthermia will prolong the recovery period and may result in death of the animal.

Proper anesthesia and aseptic technique are important for proper wound recovery and humane treatment of laboratory animals. For additional help in determining which anesthetic protocol is suitable for you, contact your staff veterinarian or refer to the Anesthesia Reference Manual (391-0055-001) prepared by DSI as a guide to assist you in choosing an appropriate anesthetic agent for a wide variety of common laboratory species.

Peri-operative Antibiotics and Analgesics

The use of peri-operative antibiotics may be applied at the discretion of the investigator. The combination of sterile device packaging and proper aseptic technique are typically the only requirements necessary for successful surgical outcomes. Investigators should follow the guidelines of their own institution. Questions regarding the use of antibiotics should be directed to your staff veterinarian.

The use of pre- and post-surgical analgesics is strongly encouraged for all surgical manipulations performed on laboratory animals. "An integral component of veterinary medical care is prevention or alleviation of pain associated with procedural and surgical protocols. . . The selection of appropriate analgesics and anesthetics should reflect professional veterinary judgment as to which best meets clinical and humane requirements as well as the needs of the research protocol."¹ Questions regarding the use of analgesics should be directed to your staff veterinarian.

HD-X11 Device Description

The HD-X11 measures a pressure signal, a biopotential signal, temperature, and physical activity in mice and other similarly sized animals. It is a cylindrical device, with one catheter and a pair of biopotential leads. Suture ribs are an optional feature and are made of a soft, flexible material. For suture rib handling recommendations and best practices, please refer to the Proper Techniques for Maximizing the Use of the Suture Rib technical note at www.datasci.com.

It is important that you are familiar with the HD-X11 device and its function before you attempt implantation. Please refer to the DSI Implantable Telemetry System Manual (007678-003) for complete details.

The device consists of the following major components:

- Device Body
 - Suture rib (optional, not showing)
- Pressure Catheter
- Biopotential Leads

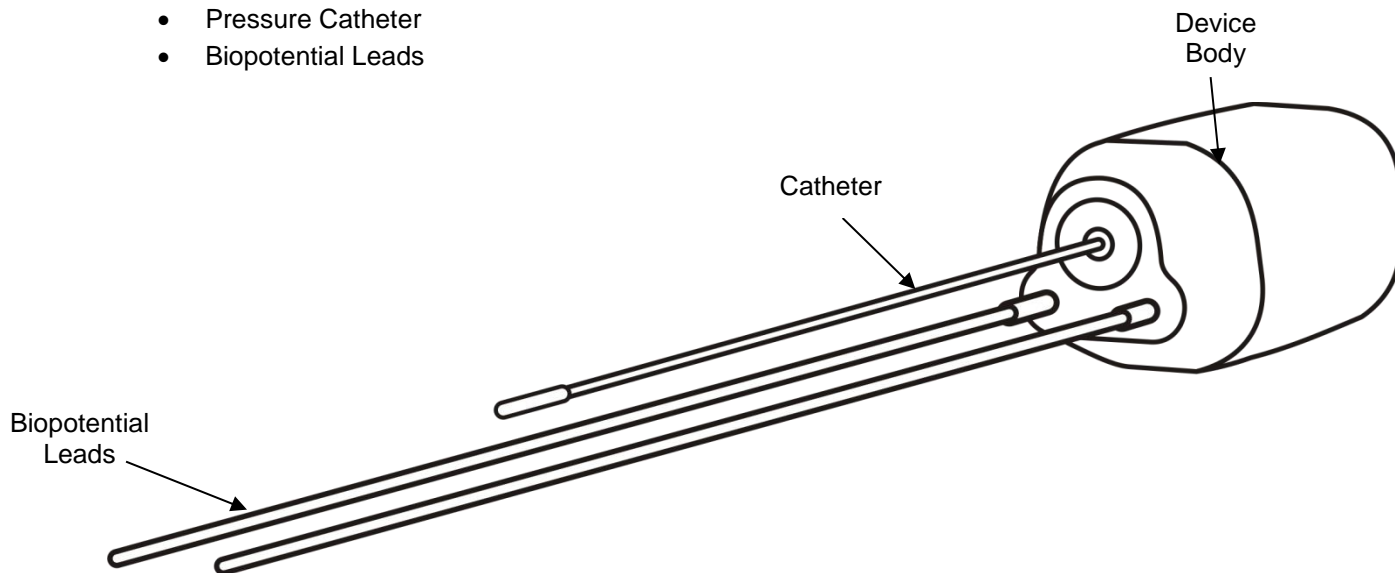


Figure 1: HD-X11

¹ Guide for the Care and Use of Laboratory Animals, Eight Edition, NRC, *National Academy Press*, 2011

HD-X10 Device Description

The HD-X10 measures a pressure signal, temperature, and physical activity in mice and other similarly sized animals. It is a cylindrical device with one catheter. Suture ribs are an optional feature and are made of a soft, flexible material. For suture rib handling recommendations and best practices, please refer to the Proper Techniques for Maximizing the Use of the Suture Rib technical note at www.datasci.com.

It is important that you are familiar with the HD-X10 device and its function before you attempt implantation. Please refer to the DSI Implantable Telemetry System Manual (007678-003) for complete details.

The device consists of the following major components:

- Device Body
 - Suture rib (optional, not showing)
- Pressure Catheter

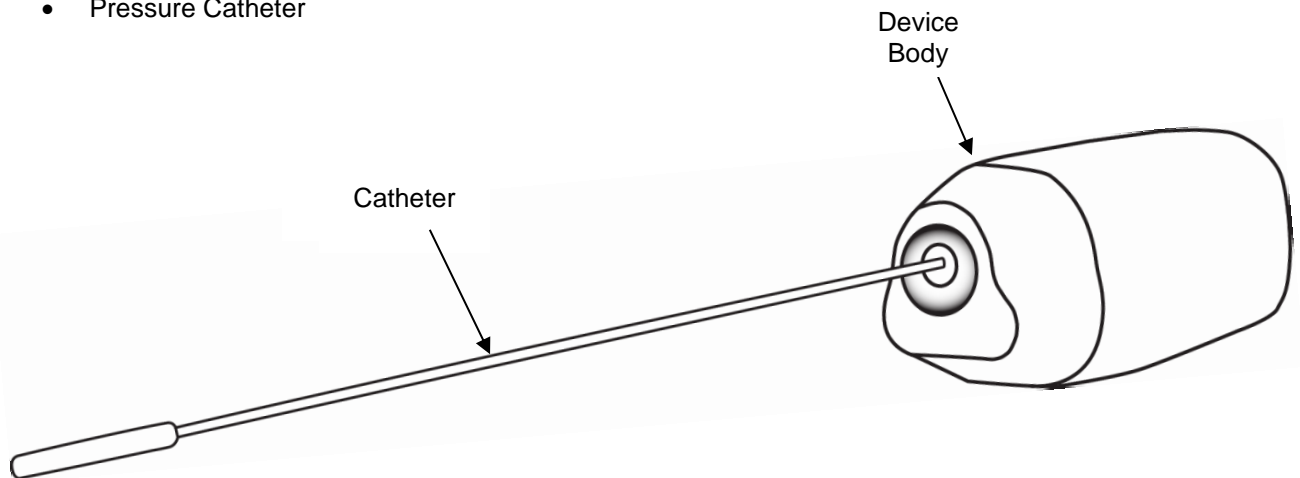


Figure 2: HD-X10

It is also important to be familiar with the catheter and its features. The catheter is filled with a non-compressible fill fluid and a gel plug at the tip and thus must be handled with great care. **Mishandling the catheter will result in damage to the pressure sensor.** Please refer to the Preventing Damaged Sensors in Blood Pressure Implants technical note at www.datasci.com for further information. See Figure 3 for a detailed diagram of the catheter.

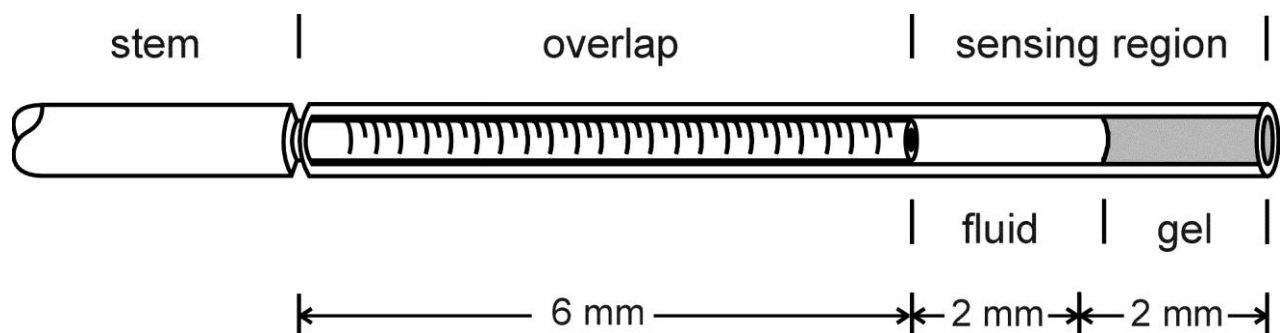


Figure 3: Blood pressure catheter

Device Implantation Site Selection

HD-X devices can be placed either subcutaneously or in the abdominal cavity of the mouse. For subcutaneous placement with carotid artery cannulation, the minimum recommended animal weight is 19.0 grams. For placement in the abdominal cavity with abdominal aorta cannulation, the minimum recommended animal weight is 30.0 grams. For placement in the abdominal cavity with carotid artery cannulation, the minimum recommended animal weight is 23.0 grams.

If the collection of core body temperature is required, the device must be placed in the abdominal cavity. If the device is placed subcutaneously, ensure that it lies flat under the skin and that the subcutaneous pocket is large enough to accommodate the device comfortably.

Considerations

With this surgery, it is important that the animal strain has a complete Circle of Willis (See Figure 4). This surgery involves ligating the left common carotid artery and a complete Circle of Willis is critical to enable the right carotid to provide the blood supply to the entire brain. Certain mouse strains or models may have a higher proportion of individuals without a complete Circle of Willis. Indications of an incomplete Circle of Willis include neurologic abnormalities such as a head tilt, circling in one direction, or seizures after surgery. To ensure that each new animal model to be used has a complete Circle of Willis, ligate the left carotid artery in a pilot animal, allow the animal to recover and verify that the animal does not show any abnormalities, such as those listed above.

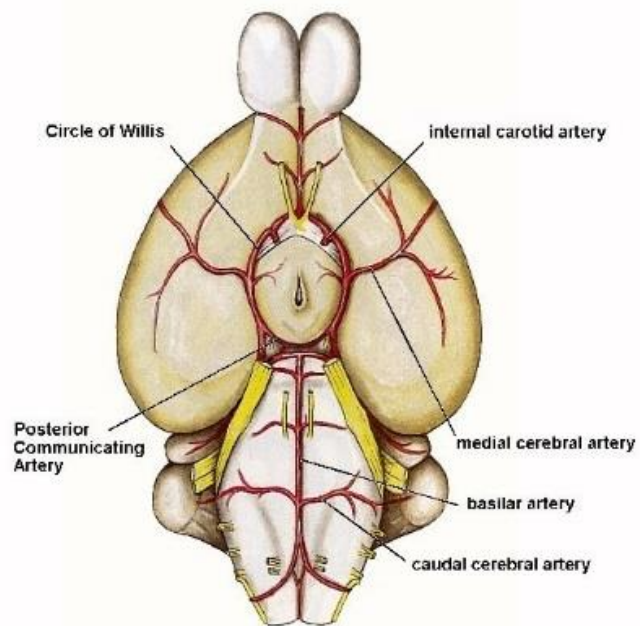


Figure 4: Circle of Willis

Recommended Procedure to Determine the Correct Insertion Depth for Mouse Carotid

To maintain catheter patency throughout the length of a study, the catheter tip should be located in the freely-flowing blood of the aortic arch. Depending on the mouse strain, gender, age and size (weight), the catheter may have to be advanced to different depths. It is recommended, before any survival surgery is performed, to determine the catheter insertion depth for each type of mouse to be implanted. This is done by performing a sternotomy on at least two representative euthanized mice and locating the aortic arch in relation to the carotid bifurcation. More animals may be necessary if there is a high degree of variability in the animal population. Measurements are taken to determine the appropriate length to insert the catheter. Follow the example below for exact steps.

Note: This process must be performed for every cohort, strain, gender and weight including genetically modified models. See end of document for more details on genetically modified or inbred strains of mice.

Example: Implanting a cohort of 30 C57 male mice.

- 1) Weigh all of the mice and put the weights in order of the smallest to the largest (see Table at right).
- 2) Determine the mouse whose weight is the middle (#15 highlighted in yellow). That mouse will be the median mouse.
- 3) Now identify the animal whose weight is midway between the smallest mouse and the median mouse (#8 highlighted in green). This will be the first animal to be used for a depth measurement.
- 4) Now identify the animal whose weight is midway between the median mouse and the largest mouse (#22 highlighted in pink). This will be the second animal to be used for a depth measurement.
- 5) Anesthetize one of the animals to be measured. Clip the hair from the ventral neck and chest area.
- 6) Isolate the carotid bifurcation (internal and external carotid). Isolating prior to euthanizing the animal makes the carotid bifurcation easier to identify.

Animal #	Weight (g)
1	28.7
2	28.8
3	28.9
4	28.9
5	29.4
6	29.5
7	29.8
8	30.3
9	30.6
10	31.1
11	31.3
12	31.3
13	31.4
14	31.4
15	31.4
16	31.6
17	31.8
18	32.1
19	32.1
20	32.2
21	32.4
22	32.4
23	32.5
24	32.6
25	32.7
26	32.9
27	33
28	33.5
29	34.6
30	34.7

- 7) Tie a piece of suture at the bifurcation. (See Figure 5)

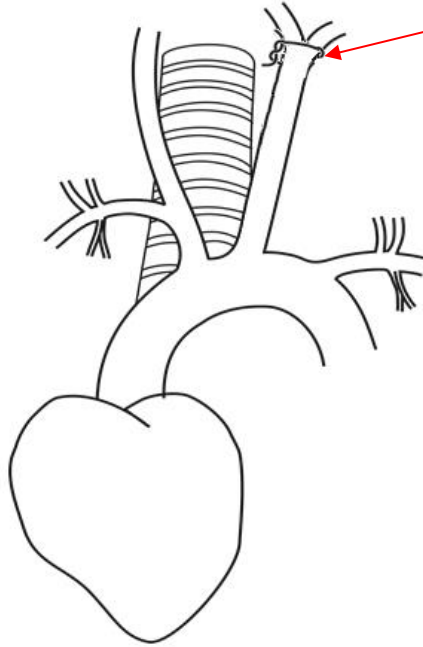


Figure 5: Suture tie placed at carotid bifurcation

- 8) Euthanize the animal by a standard technique. **Do not use cervical dislocation because this can change your measurements.** Place the animal in dorsal recumbency with the hindlimbs near you and the head away from you.
- 9) Using a small surgical scissors, cut across the diaphragm and through the rib cage on both the right and left lateral sides and remove the chest plate to fully expose the thoracic cavity. (See Figure 6)

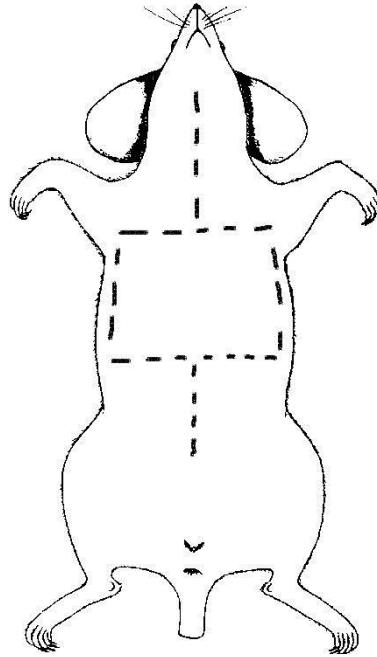


Figure 6: Incisions for locating the carotid and aortic arch

- 10) Along the midline cut through the manubrium and incise cranially to the ventral neck region. (See Figure 6)
- 11) Locate the heart. The thymus will first need to be dissected before the aortic arch can be visualized. The thymus is white in color and can be gently removed. **Be careful to only grasp the thymus during the dissection. Avoid grasping any vessels as the aortic arch is located underneath the thymus.**
- 12) Once the thymus is removed, locate the aortic arch. Gently isolate the arch from the surrounding tissue.
- 13) Locate where left carotid artery branches from the aortic arch.

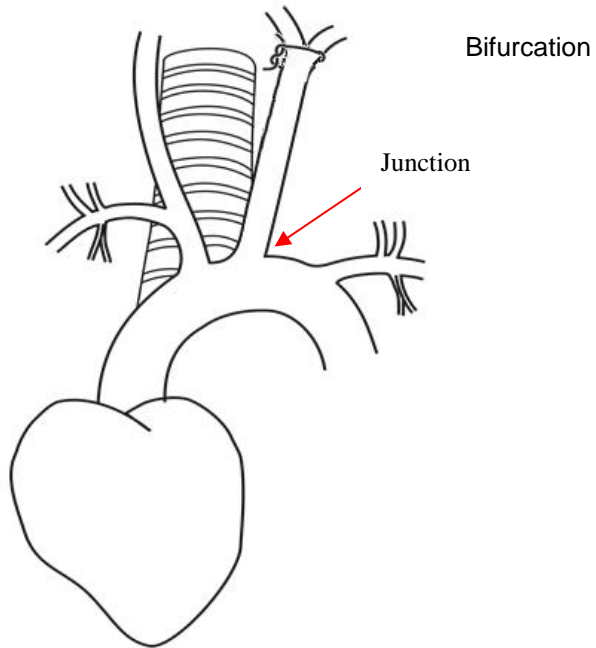


Figure 7: Suture tie at carotid bifurcation and junction of left carotid artery to aortic arch

- 14) Locate the left carotid artery and the suture at the bifurcation. (Figure 7)
- 15) Measure in millimeters from the carotid bifurcation suture to the junction of the carotid artery and aortic arch. Record this measurement. (Figure 8)

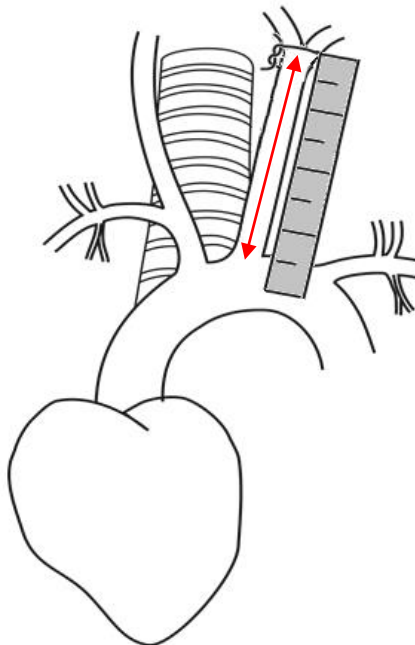


Figure 8: Measure from suture to top of arch

- 16) Repeat steps 5 through 16 for the second representative mouse.
- 17) Optimal placement should be with 2 mm of the catheter positioned in the aortic arch. (See Figure 9)

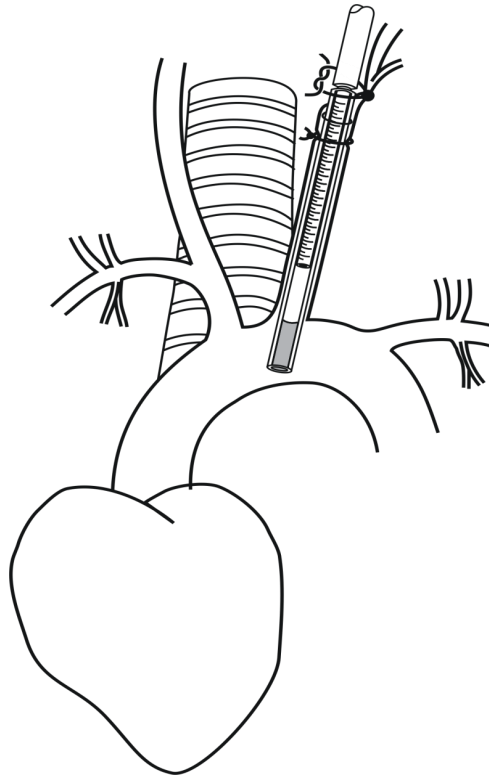


Figure 9: Catheter placement of 2 mm in the aortic arch

- 18) Since placement within the aortic arch is desired, add an additional 2 mm to the measurement of the distance between the carotid artery bifurcation suture and the top of the aortic arch to determine the total insertion depth.
- a. Desired placement is 2 mm into the aortic arch:
 - i. If your total insertion depth was 14 mm and the notch was located at 10 mm then the catheter would be advanced until the notch is 4 mm caudal to the bifurcation suture.
 - 1. Total depth 14 mm = 12 mm carotid artery bifurcation to the top of the aortic arch + 2 mm
 - ii. If your total insertion depth was 12 mm and the notch was located at 10 mm, then the catheter would be advanced until the notch is even with the bifurcation suture. (See Figure 11)
 - 1. Total depth 12 mm = 10 mm carotid artery bifurcation to the top of the aortic arch + 2 mm

Note: Each catheter must be measured as there may be slight variation in the distance from catheter tip to notch.

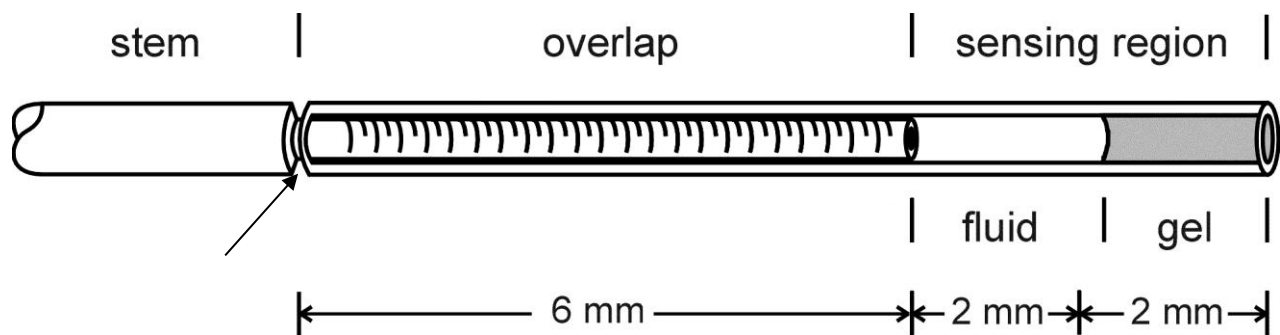


Figure 10: Notch on catheter indicated by arrow

- 19) Repeat this process when changing to a new cohort of animals, strain, gender or weight range of animals.
- 20) After determining the correct depth for your representative mice from above, use these animal weights and measurements to determine the depth for the rest of the cohort.
 - a. Record all your measurements and the depth used for each animal. As a general guide add or subtract approximately 0.5 mm for every 1 gram of body weight difference.
 - b. Even though you may use the 0.5 mm as a guide as stated above it is important to make sure that the depth that you select it is still in line with the two representative mice that you measured. At a certain age animals grow more in girth than in length so there will be a maximum depth that you should never exceed. Experience will allow you to determine this depth.
 - c. Example:

Animal #	Weight (g)	Measured depth (mm)	add 2 mm
1	28.7		11
8	30.3	10	12
9	30.6		12
15	31.4		12.5
21	32.4		13
22	32.4	11	13
29	34.6		14

Note: These measurements are for the example only. The cohort of animals that you will use will be different than these above. Do not use these measurements for your own animals.

- 21) When first working with the catheter, verify tip placement following the Verification of Catheter Placement section in the Appendix on all implanted animals. This will allow a better determination of depth and feedback on surgical technique.
 - a. If the catheter was inserted 12 mm by the surgeon and upon necropsy the catheter was found to only be inserted 10 mm, the surgeon ought to take extra care to ensure

measurements are correct in future surgeries and that the catheter is not slipping back while the surgeon is tying the knots. The surgeon may also wish to ensure knot-tying technique is correct and square knots are tied securely.

- 22) If the depth placement is consistently very successful after working with the catheter for a while, only perform the verification in the case of data that is not as expected.
- 23) If all the animals except for a few worked well, do not make adjustments to your technique for depth measurements. **The depth determination process needs to be completed with every cohort as over time the genetics can change and the measurements will change.**
- 24) If most of the animals had issues with the data, adjust your depths based on the animals that were explanted and had tip placement verified. Necropsy data is very important to determine the potential causes of failures and if any changes are needed to improve placement of the catheter. Refer to the Verification of Catheter Tip Location section in the Appendix.
- 25) By verifying catheter tip placement, adjustments can be made, if needed, for subsequent surgeries involving the same strain, gender and weight of animal.
- 26) Contact Technical Support with any questions at support@datasci.com.

Genetically Engineered and Inbred Mice

Due to the high value of these animals, it is understandable that it is not practical to sacrifice the animals to obtain a depth measurement. However, measurements must be taken to determine the correct depth to ensure accurate data. Use an animal from a terminal study that is in the same weight, sex and strain as the ones you will be implanting. If this is not feasible, implant only one animal at a time verifying the tip location and adjust the measurements as you have more experience.

Surgical Implantation of the HD-X Devices

This section of the manual describes surgical procedures to obtain systemic pressure measurements and ECG. Systemic blood pressure is obtained either via cannulation of the carotid artery with advancement into the aorta or direct cannulation of the abdominal aorta. Please refer to Appendix C for catheter configuration options.

Before starting surgery, record the pressure offset from the device and hydrate the catheter by following the proceeding directions.

Before removing the device from its sterile package:

1. Turn the device to the ON mode with a magnet and audibly verify proper device operation with a radio tuned to the low end of the AM band. DSI recommends turning the device on 1-4 hours before implantation to allow the electronic components to stabilize.
2. Record the serial number of the device and ensure that the device has been identified with the animal in which it will be implanted.
3. Measure and record the pressure offset from each pressure channel. For help with this process, refer to the DSI Implantable Telemetry System Manual (007678-003).
4. If implanting for the first time, verify that the Battery ON TIME for the device reads "0 days" in the software. Sampling must be started to obtain this information, which will be derived from saving the data trace.

To hydrate the catheter:

1. Open the sterile package by peeling back the white package cover from the clear plastic tray. Do not discard the white package cover as it contains important device calibration information. Also do not discard the sterile package as it can be used for eventual return of the device to DSI.
2. Lift the clear tray cover and flood the channel where the catheter lies with sterile saline. At this time, do not touch the device or sterile inner tray. This may compromise sterility.
3. Replace the clear tray cover and set the package aside until you are ready to transfer the device to your sterile surgical field. The catheter should be hydrated for approximately 30 minutes before implantation.

Note: The catheter is very hydrophilic and, if not hydrated, will absorb water from the blood. This can cause the gel to recede due to catheter expansion and leave a void at the tip of the catheter, which could increase the risk of blood clot formation.

Surgical Preparation

1. Administer the appropriate surgical anesthesia.
2. Apply Artificial Tears eye ointment to each eye.
3. Remove the body hair liberally from all intended incision sites.
4. Surgically scrub the incision sites with disinfectant soap (i.e. Chlorhexidine scrub) and sterile saline. A series of three scrubs with both the disinfectant soap and sterile saline is recommended
5. Once the animal is prepped for surgery and a sterile field has been established, the surgery is ready to begin.

Carotid Artery Cannulation with Subcutaneous Device Placement

The catheter will be placed in the left carotid artery and positioned so that the sensing region of the catheter is in the aortic arch. The device portion of the device is ideally positioned along the lateral flank between the forelimb and hind limb. A subcutaneous pocket is formed by blunt dissection from the neck incision down along the animal's flank. If the animal is less than 25.0 grams, the device should be placed on the right flank of the animal. If the animal is more than 25.0 grams, the device should be placed on the left flank of the animal.

Carotid Cannulation (*Tissue hydration should be maintained throughout the procedure.*)

1. Position the animal in dorsal recumbency on the surgery table with the head closest to the surgeon. Provide supplemental warmth during the surgery.
2. Loosely tape the animal's forelimbs to the table.
3. Establish a sterile surgical field and apply sterile draping material.
4. Using small surgical scissors make a 1.5 cm midline incision through the skin on the neck.
5. Carefully separate the mandibular glands using sterile cotton tip applicators or fine-tipped forceps.
6. Carefully retract the left mandibular gland using an elastic stay hook and tape the hook to the surgery table.
7. Locate the carotid artery along the left side of the trachea using sterile cotton tip applicators. Using fine tipped, curved forceps, carefully isolate the vessel from the surrounding tissue, making sure not to disturb the vagus nerve.
8. Pass three pieces of 5-0 or 6-0 non-absorbable suture underneath the isolated artery section. The furthest cranial suture will be used to permanently ligate the carotid artery while the suture closer to the heart will be used to temporarily occlude blood flow to allow for placement of the catheter. The middle suture will be used to hold the catheter in place after cannulation of the artery. (See Figure 11)

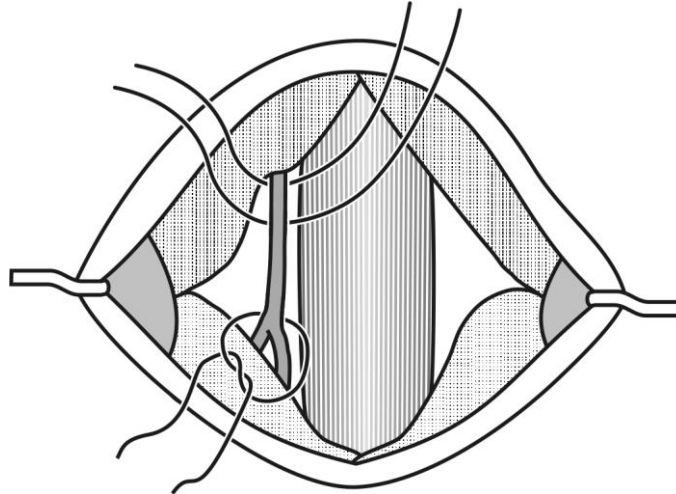


Figure 11: Left carotid artery isolated with occlusion sutures in place.

This illustration is orientated with the head at the bottom of the page.

9. Position the ligation suture just proximal to the bifurcation of the interior and exterior carotid arteries. Tie a secure knot around the artery to ligate the vessel and tape the suture tails cranially to the surgery table.
10. Make a loose knot in both the occlusion suture and the middle suture and position them as close to the clavicle as possible thus isolating at least 6 mm of the artery.
11. After making a loose knot in both pieces of suture, clamp a hemostat on or tape down one of the tails of the middle suture.
12. Remove the device from the sterile package and transfer it to the sterile field. Do not handle the device by grasping the catheter. This may cause damage to the catheter or the pressure sensor.
13. Turn the AM radio on and carefully remove the tip cover. Removal of the tip cover should be done by alternating gentle traction and release. Take care to prevent gel loss due to compression of the catheter or sudden release of the tip cover. Always examine the catheter under high magnification before implantation for gel loss or bubbles. If there is gel loss or bubbles, the catheter will need to be re-gelled. For help with this process, refer to the Guidelines for the Re-gel of Mouse-Sized Catheters on our website: www.datasci.com . A video clip of this procedure is also available on our website.
14. Prepare a catheter introducer by bending the beveled tip of a 25-gauge syringe needle. Hold the syringe needle with the beveled side facing up. Grasp just the beveled area of the needle with a needle holder and bend the tip downward to an angle of approximately 90°. (See Figure 12) The syringe needle may be placed onto a 1 cc syringe to be used as a handle to hold onto the needle and allow for a clear view of the surgical area.

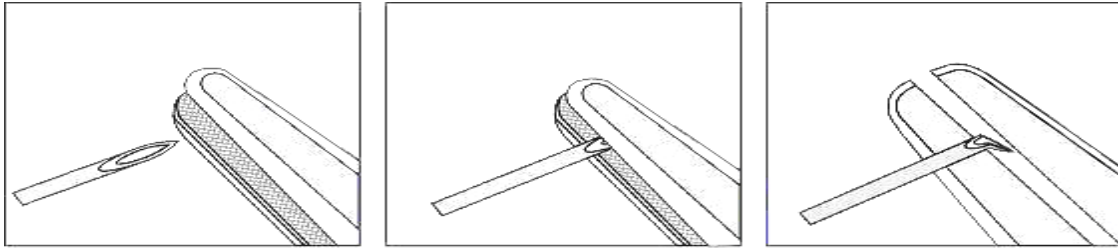


Figure 12: Needle bending technique

15. Gently apply tension to the occlusion suture closest to the clavicle using a hemostat. This will elevate the artery and occlude blood flow. Caution: Excessive tension can damage the artery.
16. Grasp the tip of the catheter just distal to the thin-walled section using a Vessel Cannulation Forceps.
17. Using the 25-gauge needle as an introducer, pierce the artery just proximal to the ligation suture and insert the catheter upstream toward the aorta. (See Figure 13) Once the catheter is inserted into the vessel, withdraw the catheter introducer.

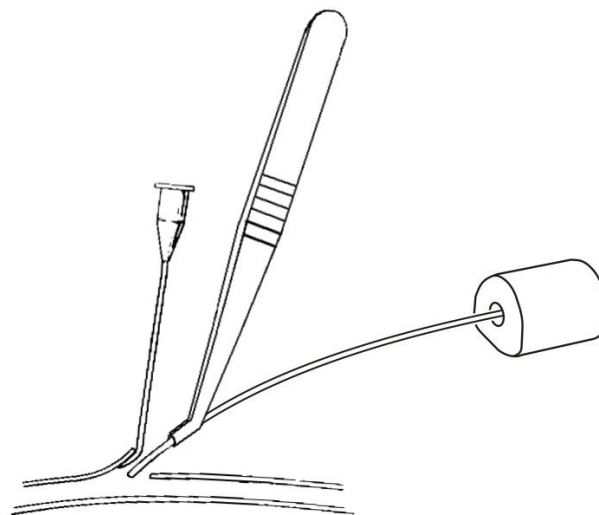


Figure 13: Vessel cannulation technique

18. Advance the catheter into the artery until it reaches the occlusion suture.
19. Position the middle suture around the artery and catheter. Secure the catheter by pulling the loose suture tail to tighten the knot. Releasing the catheter before it is secured may cause it to come out of the vessel.
20. Once the catheter is secured, release the tension on the occlusion suture and advance the catheter beyond the suture into the thoracic cavity.

21. Continue to advance the catheter so that at least 2 mm of the sensing region of the catheter is positioned in the aortic arch. (See Figure 14) Depending on the mouse strain, gender and weight, the catheter may have to be advanced to different lengths to reach the aortic arch. It is recommended, before any survival surgery is performed, to verify the catheter tip placement for each type of mouse to be implanted. This can be done by performing a sternotomy on a cannulated, euthanized mouse and locating the aortic arch. Measurements can be taken to determine the appropriate length to insert the catheter. For specific instructions on how to verify tip placement on euthanized animals, please refer to Appendix B.

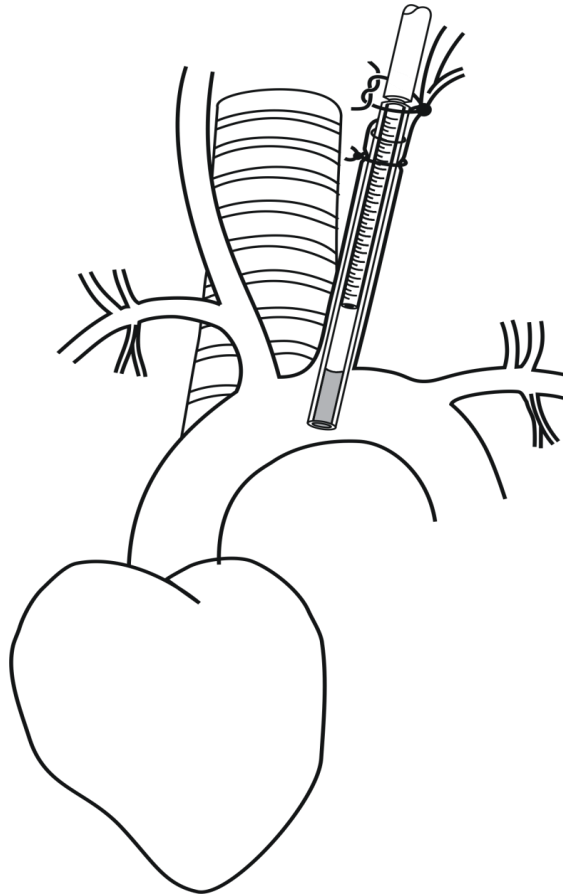


Figure 14: Optimal catheter placement in the aortic arch

22. Tighten the occlusion suture and the middle suture around the artery and catheter to seal the artery wall around the catheter stem.
23. Release the tension on the ligation suture and tie the loose ends around the catheter stem to help anchor it in place.
24. Trim all suture tails as short as possible.

Subcutaneous Device Placement

1. Insert small surgical scissors into the incision and form a subcutaneous pocket by using blunt dissection. (See Figure 15) If the pocket is not made large enough, the skin will be stretched too tightly across the contours of the device and pressure necrosis may result.



Figure 15: Subcutaneous pocket formation by blunt dissection

2. Once the pocket is formed, irrigate the pocket with a 3 cc syringe filled with warm, sterile saline. The syringe should easily slide down the full length of the pocket. Insert the device against the body. (See Figure 16)

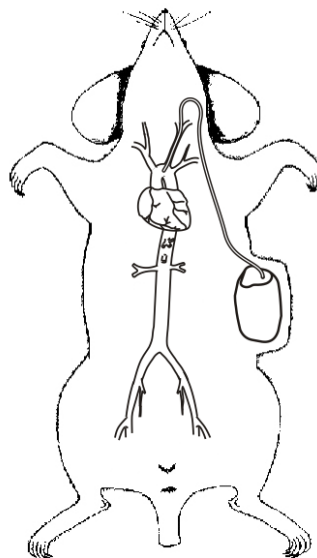


Figure 16: Subcutaneous placement of HD-X11

3. If using the HD-X11, proceed to the section entitled **Placement of ECG Leads with Subcutaneous Device Placement**.

Placement of ECG Leads with Subcutaneous Device Placement

Once the device is in place, the leads will be tunneled subcutaneously to the desired ECG electrode locations. (See Figure 18)

1. Shorten the lead material to the appropriate length with a pair of scissors. A small amount of lead may be coiled under the skin to account for growth of the animal and re-use of the device. However too much lead material could result in skin necrosis.
2. Cut around the silicone tubing at the tip of the lead using a sharp sterile scalpel blade and remove approximately 1 cm of the silicone tubing to expose the stainless steel wire.
3. Make tip covers by using the excess silicone tubing. After the silicone tubing is cut (Step 2), pull it to the end of the lead but do not remove it from the lead. Tie a piece of 5-0 or 6-0 non-absorbable suture around the silicone tubing and lead to secure the tubing in place. Cut off the excess silicone tubing that extends past the lead as this is not needed. (See Figure 17)
4. Place another suture around the silicone tubing just proximal to the exposed portion of the wire. This will inhibit fluids from migrating along the interior of the lead. (See Figure 17)



Figure 17: ECG lead

5. Ensure Steps 2 through 4 are completed for each lead.
6. Grasp the terminal end of the positive lead (red tubing) with a small hemostat and tunnel it subcutaneously from the neck incision to the left caudal rib region. This lead is positioned approximately 1 cm to the left of the xyphoid process. (See Figure 18)
7. Release the lead and withdraw the hemostat leaving the lead in place under the skin.
8. Grasp the terminal end of the negative lead (clear tubing) with a small hemostat and tunnel it subcutaneously from the neck incision to the right pectoral muscle. (See Figure 18)
9. Release the lead and withdraw the hemostat leaving the lead in place under the skin.

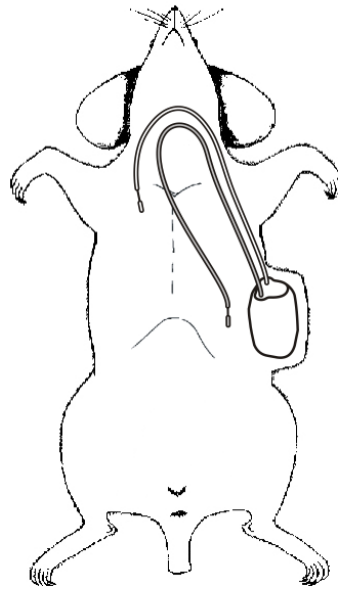
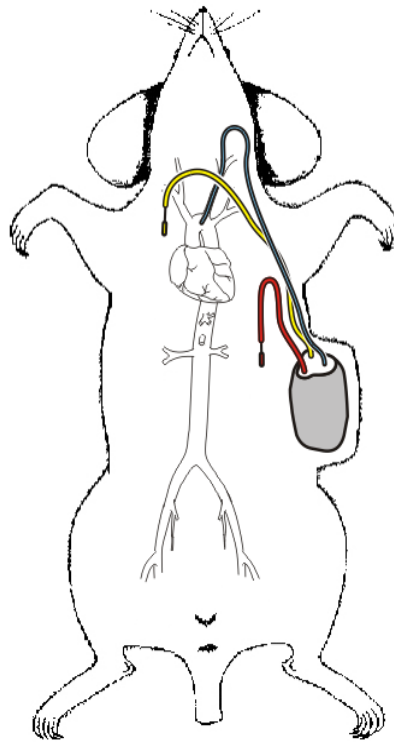


Figure 2: Modified lead II configuration

10. Ensure both leads are lying flat against the muscle for the whole length of the lead. This will avoid irritation of the tissue.
11. Secure both leads near the neck incision by placing a stay suture through the chest muscle and around the leads using 5-0 or 6-0 non-absorbable suture.
12. Close the skin incision using 5-0 or 6-0 absorbable or non-absorbable suture. Once closed, seal the incision with a tissue adhesive, such as Vetbond or Gluture.



**Figure 19: HD-X11 in place
(Yellow=negative ECG lead, Red=positive
ECG lead, Blue=catheter)**

Surgical Recovery

1. Discontinue surgical anesthesia.
2. Maintain supplemental warmth throughout the anesthetic recovery.
3. Administer post-surgical analgesia.
4. Monitor animal closely for the return of normal postures and behaviors.

This completes the carotid artery cannulation procedure with subcutaneous device and ECG lead placement.

Carotid Artery Cannulation with Intraperitoneal Device Placement

The catheter will be placed in the left carotid artery and positioned so that the sensing region of the catheter is in the aortic arch. If using the HD-X11, the biopotential leads will be routed subcutaneously to collect an ECG signal. The device portion of the device is positioned inside the intraperitoneal cavity. The suture rib on the device should be incorporated into the abdominal wall closure.

Intraperitoneal Device Placement (*Tissue hydration should be maintained throughout the procedure.*)

1. Position the animal in dorsal recumbency on the surgery table with the feet closest to the surgeon. Provide supplemental warmth during surgery.
2. Loosely tape the animal's limbs to the table.
3. Establish a sterile field and apply sterile draping material.
4. Using a small surgical scissors make a 2-3 cm midline incision through the skin on the abdomen.
5. Use blunt dissection to gently separate the skin from the abdominal wall around the incision.
6. Using small surgical scissors make a 2-3 cm midline incision through the abdominal wall. Take care not to damage internal organs. (See Figure 20)

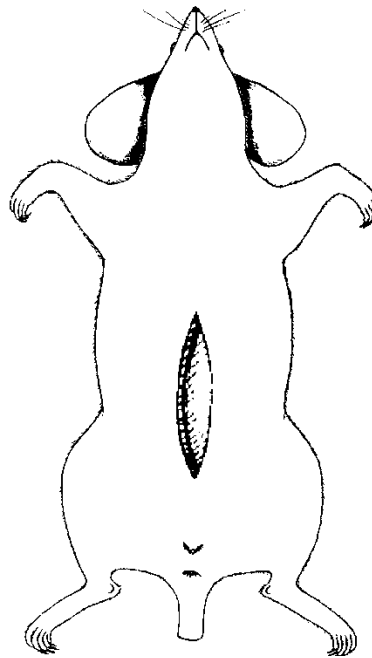


Figure 20: Ventral abdominal incision

7. Remove the device from the sterile package and transfer it to the sterile field. **Do not handle the device by grasping the catheter. This may cause damage to the catheter or the pressure sensor.**
8. Place the device on top of the intestines and carefully position the device parallel to the long axis of the body. The catheter and ECG leads (if applicable) should be directed cranially for carotid catheterization and the suture rib directed ventrally.
9. If ECG leads are present, pass an 18-gauge needle through the abdominal wall near the left (animal's left) caudolateral aspect of the incision. Pass the needle from the outside of the incision into the abdominal cavity taking care not to damage any internal organs. (See Figure 21)
10. Insert the positive lead (red tubing) through the lumen of the needle and out of the abdomen.
11. Withdraw the needle leaving the lead externalized.
12. Repeat steps 9 through 11 with the negative lead (clear tubing) exiting the abdominal cavity on the right (animal's right) lateral side. (See Figure 21)

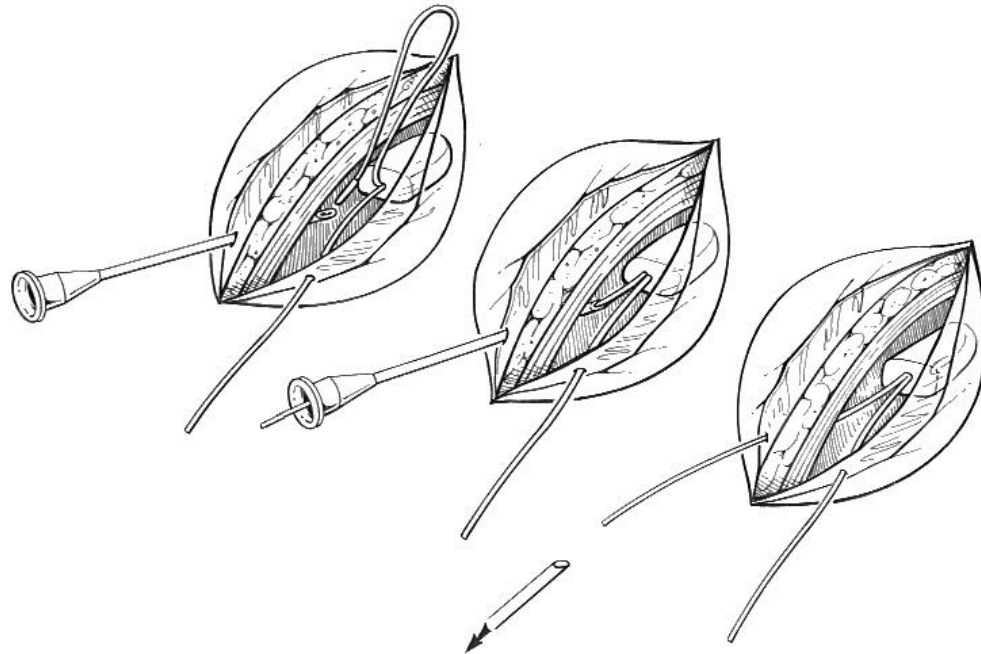


Figure 21: Externalizing the ECG leads

13. Repeat steps 9 through 11 with the catheter exiting the abdominal cavity near the cranial aspect of the incision. Be sure to remove the tip cover on the catheter before exteriorizing.
14. Irrigate the peritoneal cavity with warm, sterile saline.
15. Once the catheter and any biopotential leads are exteriorized, close the abdominal wall using 5-0 or 6-0 non-absorbable suture with a simple interrupted pattern. Incorporate the suture rib of the device into the closure.

16. If ECG leads are present, proceed to the section titled **Placement of ECG Leads with Intraperitoneal Cavity Device Placement**. If using the HD-X10, proceed to the section titled **Carotid Cannulation**.

Placement of ECG Leads with Intraperitoneal Cavity Device Placement

Once the device is in place and the leads and catheter are exteriorized from the abdominal cavity, follow the steps below for subcutaneous placement of the leads in the desired ECG electrode locations. (See Figure 23)

1. Shorten the lead material to the appropriate length with a pair of scissors. A small amount of lead may either be coiled under the skin or in the abdominal cavity to account for growth of the animal and re-use of the device. However too much lead material could result in skin necrosis or strangulation of intestines.
2. Cut around the silicone tubing at the tip of the lead using a sharp sterile scalpel blade and remove approximately 1 cm of the silicone tubing to expose the stainless steel wire.
3. Tip covers can be made by using the excess silicone tubing. After the silicone tubing is cut (Step 2), pull it to the end of the lead but do not remove it from the lead. Tie a piece of 5-0 or 6-0 non-absorbable suture around the silicone tubing and lead to secure the tubing in place. Cut off the excess silicone tubing that extends past the lead as this is not needed. (See Figure 22)
4. Place another suture around the silicone tubing just proximal to the exposed portion of the wire. This will inhibit fluids from migrating along the interior of the lead. (See Figure 22)



Figure 22: ECG lead

5. Ensure Steps 2 through 4 are completed for each lead.
6. Grasp the terminal end of the positive lead (red tubing) with a small hemostat and tunnel it subcutaneously from its site of exteriorization to the left caudal rib region. This lead is positioned approximately 1 cm to the left of the xyphoid process. (See Figure 23)
7. Release the lead and withdraw the hemostat leaving the lead in place under the skin.
8. Grasp the terminal end of the negative lead (clear tubing) with a small hemostat and tunnel it subcutaneously from its site of exteriorization to the right pectoral muscle. (See Figure 23)

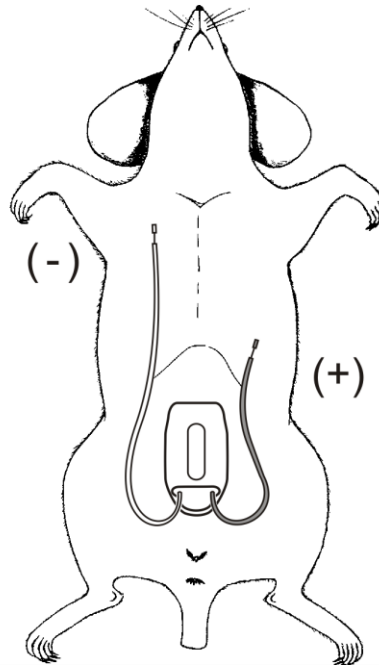


Figure 23: Modified lead II configuration with leads exiting device caudally. NOTE: leads will exit the device facing cranially if carotid will be catheterized.

9. Release the lead and withdraw the hemostat leaving the lead in place under the skin.
10. Ensure both leads are lying flat against the muscle for the whole length of the lead. This will avoid irritation of the tissue.
11. Secure both leads to the abdominal wall by placing a stay suture through the abdominal wall muscle and around the leads using 5-0 or 6-0 non-absorbable suture.
12. Place sterile, saline moistened gauze over the abdominal wall and ensure that the abdominal wall and catheter are protected so they don't become contaminated.

Carotid Cannulation (*Tissue hydration should be maintained throughout the procedure.*)

1. Position the animal in dorsal recumbency on the surgery table with the head closest to the surgeon. Provide supplemental warmth during the surgery.
2. Loosely tape the animal's forelimbs to the table.
3. Establish a sterile surgical field and apply sterile draping material.
4. Using small surgical scissors make a 1.5 cm midline incision through the skin on the neck.
5. Using a hollow trocar, tunnel the trocar subcutaneously from the neck incision to the abdominal skin incision where the catheter is.
6. Insert the catheter into the open end of the trocar and withdraw the catheter from the neck incision. The catheter should now be exiting the open the neck incision.
7. Place a sterile, saline moistened gauze over the abdominal incision to maintain tissue hydration.

8. Carefully separate the mandibular glands using sterile cotton tip applicators or fine tipped forceps.
9. Carefully retract the left mandibular gland using an elastic stay hook and tape the hook to the surgery table.
10. Locate the carotid artery along the left side of the trachea using sterile cotton tip applicators or fine tipped forceps. Using fine tipped, curved forceps, carefully isolate the vessel from the surrounding tissue, making sure not to disturb the vagus nerve.
11. Pass three pieces of 5-0 or 6-0 non-absorbable suture underneath the isolated artery section. The furthest cranial suture will be used to permanently ligate the carotid artery while the suture closer to the heart will be used to temporarily occlude blood flow to allow for placement of the catheter. The middle suture will be used to hold the catheter in place after cannulation of the artery. (See Figure 24)

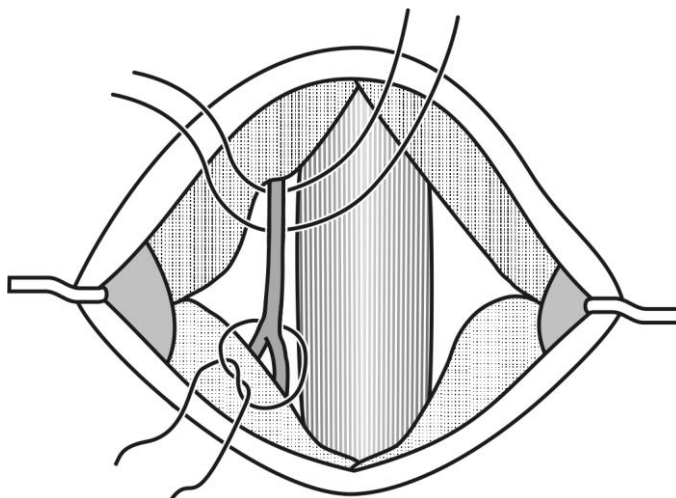


Figure 24: Left carotid artery isolated with occlusion sutures in place.

This illustration is orientated with the head at the bottom of the page.

12. Position the ligation suture just proximal to the bifurcation of the interior and exterior carotid arteries. Tie a secure knot around the artery to ligate the vessel and tape the suture tails to the surgery table.
13. Make a loose knot in both the occlusion suture and the middle suture and position them as close to the clavicle as possible thus isolating at least 6 mm of the artery.
14. After making a loose knot in both pieces of suture, clamp a hemostat on or tape down one of the tails of the middle suture.
15. Turn the AM radio on and carefully remove the tip cover (if the device hasn't been placed intraperitoneally). Removal of the tip cover should be done by alternating gentle traction and release. Take care to prevent gel loss due to compression of the catheter or sudden release of the tip cover. Always examine the catheter under high magnification before implantation for gel loss or bubbles. If there is gel loss or bubbles, the catheter will need to be re-gelled. For help with this process, refer to the Guidelines for the Re-gel of Mouse-Sized Catheters on our website: www.datasci.com. A video clip of this procedure is also available on our website.
16. Prepare a catheter introducer by bending the beveled tip of a 25-gauge syringe needle. Hold the syringe needle with the beveled side facing up. Grasp just the beveled area of the needle with a needle holder and bend the tip downward to an angle of approximately 90°. (See Figure 25) The

syringe needle may be placed onto a 1 cc syringe to be used as a handle to hold onto the needle and allow for a clear view of the surgical area.

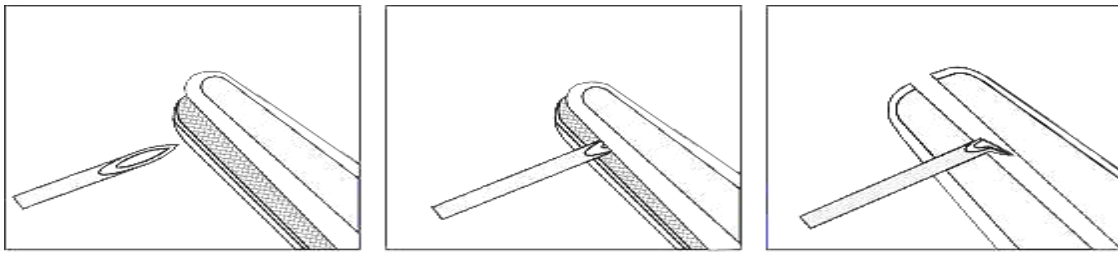


Figure 25: Needle bending technique

17. Gently apply tension to the occlusion suture closest to the clavicle using a hemostat. This will elevate the artery and occlude blood flow. Caution: Excessive tension can damage the artery.
18. Grasp the tip of the catheter just distal to the thin-walled section using a Vessel Cannulation Forceps.
19. Using the 25-gauge needle as an introducer, pierce the artery just proximal to the ligation suture and insert the catheter upstream toward the aorta. (See Figure 26) Once the catheter is inserted into the vessel, withdraw the catheter introducer.

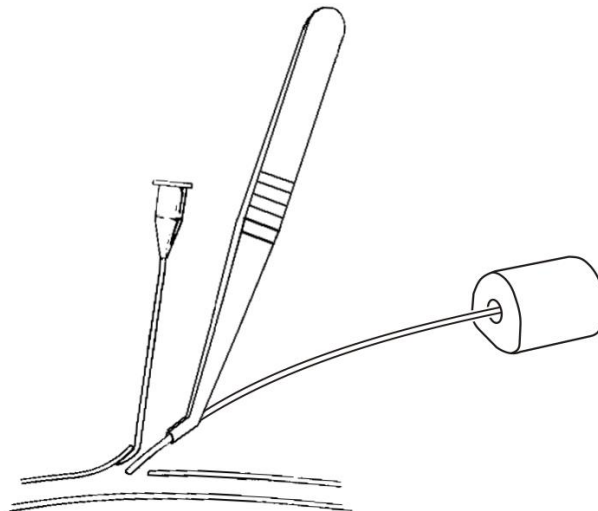


Figure 26: Vessel cannulation technique

20. Advance the catheter into the artery until it reaches the occlusion suture.
21. Position the middle suture around the artery and catheter. Secure the catheter by pulling the loose suture tail to tighten the knot. Releasing the catheter before it is secured may cause it to come out of the vessel.

22. Once the catheter is secured, release the tension on the occlusion suture and advance the catheter beyond the suture into the thoracic cavity.
23. Continue to advance the catheter so that at least 2 mm of the sensing region of the catheter is positioned in the aortic arch. (See Figure 27) Depending on the mouse strain, gender and weight, the catheter may have to be advanced to different lengths to reach the aortic arch. It is recommended, before any survival surgery is performed, to verify the catheter tip placement for each type of mouse to be implanted. This can be done by performing a sternotomy on a cannulated, euthanized mouse and locating the aortic arch. Measurements can be taken to determine the appropriate length to insert the catheter. For specific instructions on how to verify tip placement on euthanized animals, please refer to Appendix B.

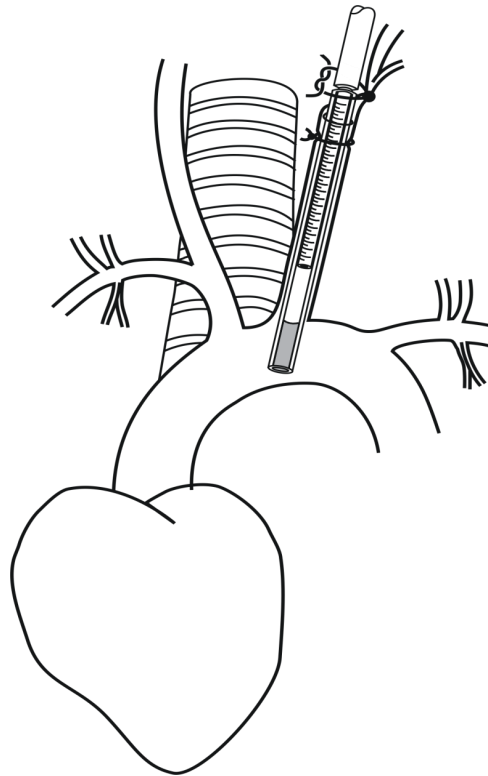
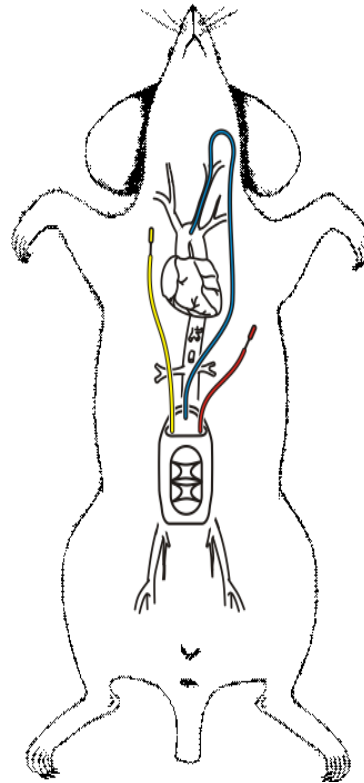


Figure 27: Optimal catheter placement in the aortic arch

24. Tighten the occlusion suture and the middle suture around the artery and catheter to seal the artery wall around the catheter stem.
25. Release the tension on the ligation suture and tie the loose ends around the catheter stem to help anchor it in place.
26. Trim all suture tails as short as possible.
27. If excess catheter length remains in the neck, feed some back into the abdominal cavity using vessel cannulation forceps. Close the neck skin incision using 5-0 or 6-0 absorbable or non-absorbable suture. Once closed, seal the incision with a tissue adhesive, such as Vetbond or Gluture.
28. Close the abdominal skin incision using wound clips or 5-0 or 6-0 absorbable or non-absorbable suture. Once closed, seal the incision with a tissue adhesive, such as Vetbond or Gluture.



**Figure 28: HD-X11 in place
(Yellow=negative ECG lead,
Red=positive ECG lead,
Blue=catheter)**

Surgical Recovery

1. Discontinue surgical anesthesia.
2. Maintain supplemental warmth throughout the anesthetic recovery.
3. Administer post-surgical analgesia.
4. Monitor animal closely for the return of normal postures and behaviors.

This completes the carotid artery cannulation procedure with intraperitoneal cavity device placement, and subcutaneous ECG lead placement.

Abdominal Aorta Cannulation with Intraperitoneal Cavity Device Placement

The catheter will be placed in the abdominal aorta and positioned so that the sensing region of the catheter is between the renal arteries and the iliac bifurcation. If applicable, the biopotential leads will be routed subcutaneously to collect an ECG signal. The device portion of the device is positioned inside the intraperitoneal cavity. The suture rib on the device should be incorporated into the abdominal wall closure.

Abdominal Aorta Cannulation (*Tissue hydration should be maintained throughout the procedure.*)

1. Position the animal in dorsal recumbency on the surgery table with the feet closest to the surgeon. Provide supplemental warmth during surgery.
2. Loosely tape the animal's limbs to the table.
3. Establish a sterile field and apply sterile draping material.
4. Using a small surgical scissors make a 2-3 cm midline incision through the skin on the abdomen.
5. Use blunt dissection to gently separate the skin from the abdominal wall around the incision.
6. Using small surgical scissors make a 2-3 cm midline incision through the abdominal wall. Take care not to damage internal organs. (See Figure 29)

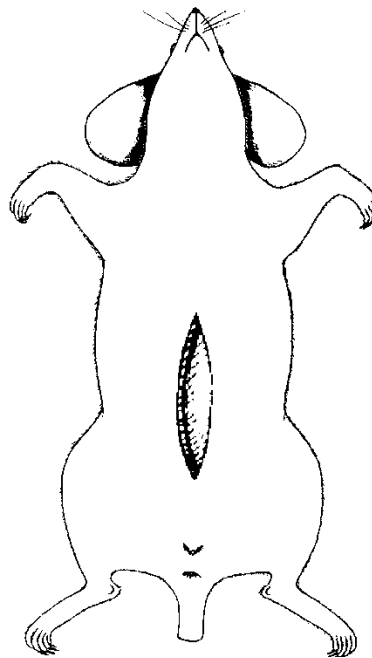


Figure 29: Ventral abdominal incision

7. With sterile cotton tip applicators, gently manipulate the intestines cranial and lateral and locate the aorta. **The surgeon should be able to visualize the entire length of the abdominal aorta from the iliac bifurcation, cranially, to the crossover of the left renal vein.**
8. Retract the intestines using a sterile 2 x 2 gauze sponge to allow access to the abdominal aorta. To form the gauze sponge retractor. (See Figure 30).

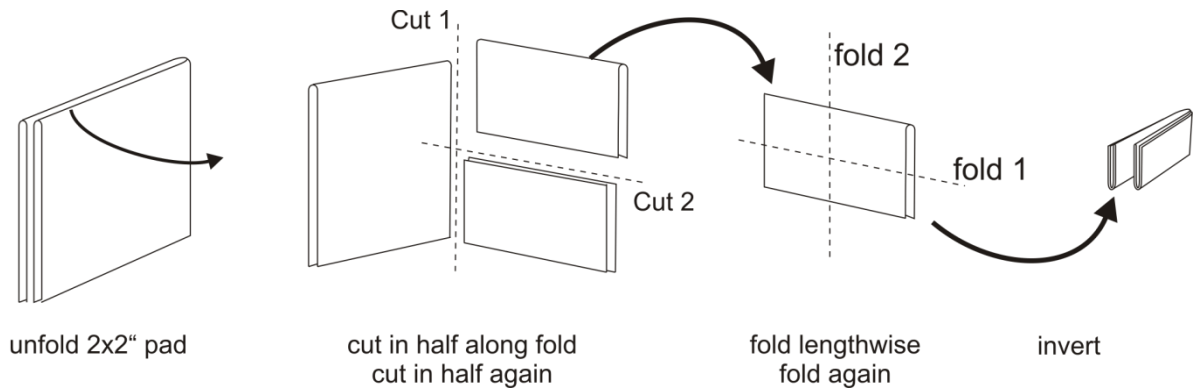


Figure 30: Directions to form the gauze sponge retractor

9. Once the gauze sponge retractor is in place, thoroughly moisten the gauze with sterile saline.
10. Using sterile cotton tip applicators carefully separate the overlying tissue from the aorta surface just caudal to the crossover of the left renal vein and just cranial to the iliac bifurcation. The catheter entry site will be just cranial to the iliac bifurcation.
11. Using vessel dilators, carefully separate the aorta from the vena cava just caudal to the left renal vein. There is often a natural separation in between the vessels in this area where they can be more easily separated.
12. Carefully pass one piece of 5-0 or 6-0 suture between the vena cava and aorta so that the suture lies underneath the aorta. This suture will be used to temporarily occlude blood flow to allow introduction of the catheter into the vessel. (See Figure 31)

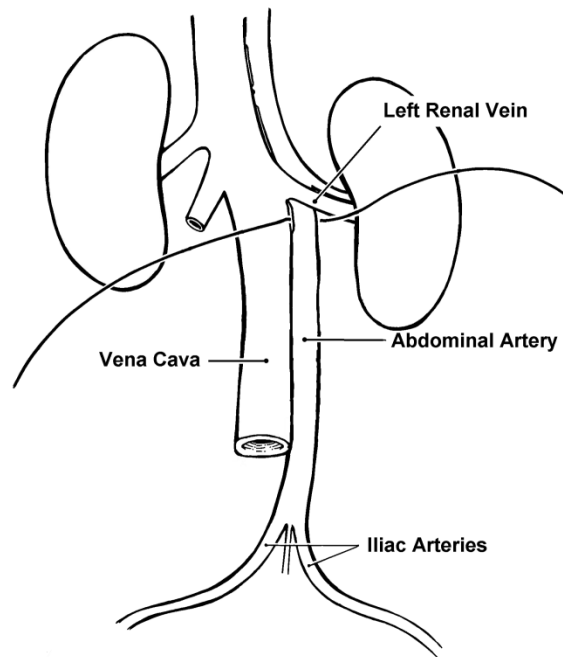


Figure 31: Proper placement of the cranial occlusion suture

13. Prepare a catheter introducer by bending the beveled tip of a 25-gauge syringe needle. Hold the syringe needle with the beveled side facing up. Grasp just the beveled area of the needle with a needle holder and bend the tip downward to an angle of approximately 90°. (See Figure 32) The syringe needle may be placed onto a 1 cc syringe to be used as a handle to hold onto the needle and allow for a clear view of the surgical area.

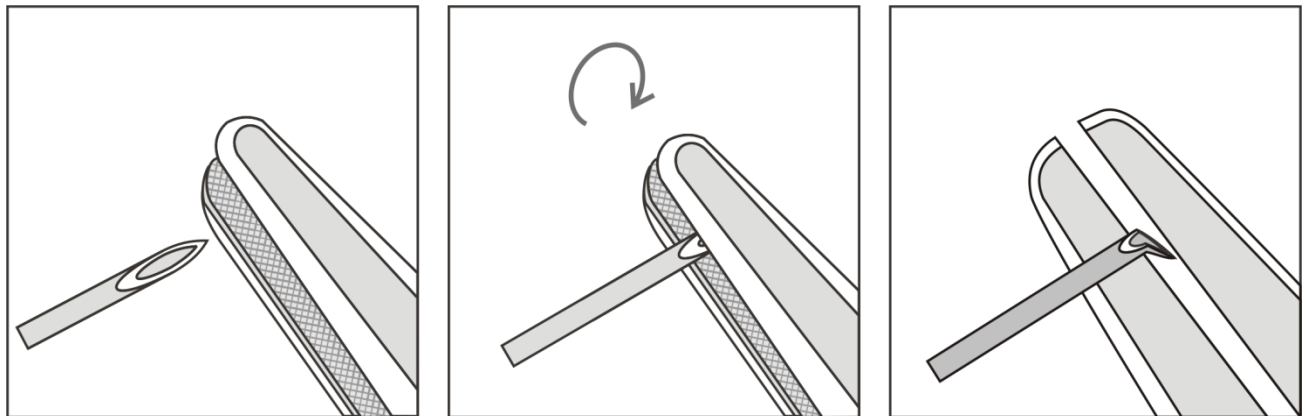


Figure 32: Needle bending technique

14. Fill two gel-loading micropipette tips with Vetbond tissue adhesive and set aside. They will be used to dispense a very small amount of adhesive to seal the vessel.

15. Remove the device from the sterile package and transfer it to the sterile field. **Do not handle the device by grasping the catheter. This may cause damage to the catheter or the pressure sensor.**
16. Turn the AM radio on and carefully remove the tip cover. Removal of the tip cover should be done by alternating gentle traction and release. **Take care to prevent gel loss due to compression of the catheter or sudden release of the tip cover. Always examine the catheter under high magnification prior to implantation for gel loss or bubbles. If there is gel loss or bubbles, the catheter will need to be re-gelled. For help with this process, refer to the Guidelines for the Re-gel of Mouse-Sized Catheters on our website: www.datasci.com . A video clip of this procedure is also available on our website.**

The process of inserting the catheter into the aorta is an intricate maneuver and needs to be performed quickly and efficiently in order to prevent hind limb ischemia.

17. Apply one drop of 2% Lidocaine to the aorta to fully dilate it, if necessary.
18. Grasp the overlap section of the catheter with a pair of Vessel Cannulation Forceps.
19. Gently apply tension to the occlusion suture using a hemostat. This will temporarily occlude blood flow in the aorta.
20. Using the 25-gauge needle as a catheter introducer, pierce the artery 1-2 mm cranial to the iliac bifurcation and insert the catheter upstream toward the heart. (See Figure 33) Once the catheter is inserted into the vessel, withdraw the catheter introducer.

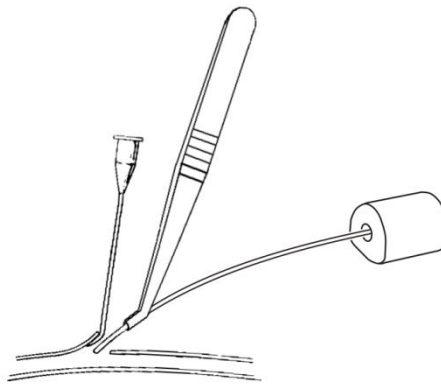


Figure 33: Vessel cannulation technique

21. Advance the catheter cranially so that the entire thin-walled section is within the vessel. Maximizing the amount of catheter that is inserted will allow for more re-uses of the device. **Do not advance the catheter past the cranial occlusion suture.**
22. Dry the aorta at the catheter entry site with cotton tip applicators and apply a very small amount of Vetbond tissue adhesive using the gel-loading micropipette tips. **If the area is not dried effectively, there will be poor bonding of the tissue adhesive, resulting in leakage.**
23. Once the Vetbond has visibly set, slowly release the tension on both of the occlusion sutures and observe the catheter entry site for leakage. If leakage is observed, re-occlude the vessel, clear the site of blood and apply only enough additional Vetbond to seal the leak.

24. Once hemostasis is achieved, apply one drop of 2% Lidocaine to the aorta to help relieve vessel spasms.
25. Verify proper catheter placement by turning the AM radio on and bringing it close to the device. A rapidly fluctuating tone corresponding with the cardiac cycle indicates a properly placed catheter. If the radio tone is not fluctuating, the catheter is not properly placed and has likely been placed either into the vena cava or within the tissue surrounding the aorta. Verification can also be done by monitoring the live signal via a telemetry system in the surgical suite.
26. Anchor the catheter in place with a small fiber patch. The patch can be prepared by cutting out a small 2 mm x 4 mm rectangle. Cut a wedge in the patch halfway across the width of the patch. (See Figure 34)

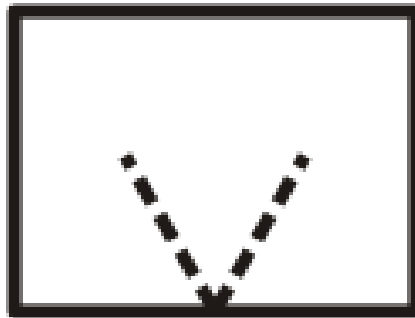


Figure 34: Cut a wedge into the fiber patch

27. Place the fiber patch across the catheter entry site with the catheter passing through the wedge. Secure the patch to the catheter, vessel, and surrounding tissues by applying a few drops of Vetbond tissue adhesive using the gel-loading micropipette tips.
28. Cut the occlusion suture close to the aorta and carefully remove the suture remnant from beneath the aorta.

Intraperitoneal Device Placement

1. Carefully remove the gauze sponge retraction taking care not to dislodge the catheter.
2. Irrigate the peritoneal cavity with warm, sterile saline. Gently massage the intestines back into place.
3. Place the device on top of the intestines and carefully position the device parallel to the long axis of the body. The catheter and ECG leads (if present) should be directed caudally and the suture rib directed ventrally.
4. To exteriorize ECG leads, pass an 18-gauge needle through the abdominal wall near the left (animal's left) caudolateral aspect of the incision. Pass the needle from the outside of the incision into the abdominal cavity taking care not to damage any internal organs. (See Figure)
5. Insert the positive lead (red tubing) through the lumen of the needle and out of the abdomen.
6. Withdraw the needle leaving the lead externalized.

7. Repeat steps 4 through 6 with the negative lead (clear tubing) exiting the abdominal cavity on the right (animal's right) lateral side. (See Figure 35)

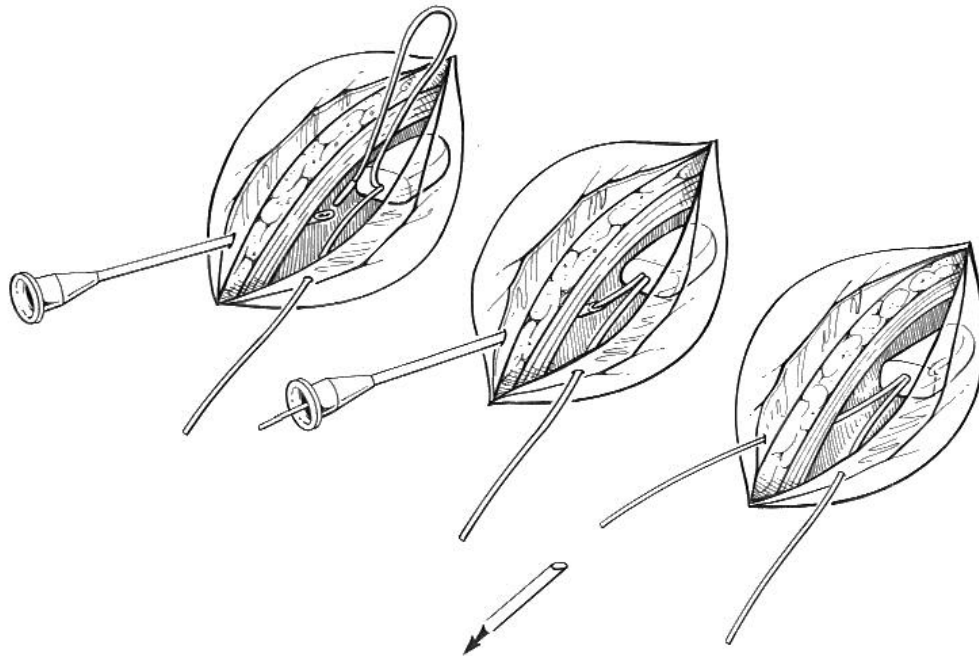


Figure 35: Externalizing the ECG leads

8. Irrigate the peritoneal cavity with warm, sterile saline.
9. Close the abdominal wall using 5-0 or 6-0 non-absorbable suture with a simple interrupted pattern. Incorporate the suture rib of the device into the closure.
10. If applicable, proceed to the section titled **Placement of ECG Leads with Intraperitoneal Cavity Device Placement**.

Placement of ECG Leads with Intraperitoneal Cavity Device Placement

Once the device is in place and the leads are exteriorized from the abdominal cavity, follow the steps below for subcutaneous placement of the leads in the desired ECG electrode locations. (See Figure 37)

1. Shorten the lead material to the appropriate length with a pair of scissors. A small amount of lead may either be coiled under the skin or in the abdominal cavity to account for growth of the animal and re-use of the device. However too much lead material could result in skin necrosis or strangulation of intestines.
2. Cut around the silicone tubing at the tip of the lead using a sharp sterile scalpel blade and remove approximately 1 cm of the silicone tubing to expose the stainless steel wire.

3. Tip covers can be made by using the excess silicone tubing. After the silicone tubing is cut (Step 2), pull it to the end of the lead but do not remove it from the lead. Tie a piece of 5-0 or 6-0 non-absorbable suture around the silicone tubing and lead to secure the tubing in place. Cut off the excess silicone tubing that extends past the lead as this is not needed. (See Figure 36)
4. Place another suture around the silicone tubing just proximal to the exposed portion of the wire. This will inhibit fluids from migrating along the interior of the lead. (See Figure 36)

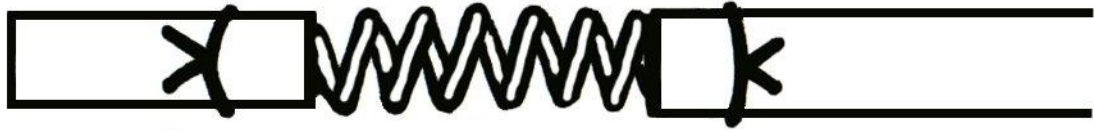


Figure 36: ECG lead

5. Ensure Steps 2 through 4 are completed for each lead.
6. Grasp the terminal end of the positive lead (red tubing) with a small hemostat and tunnel it subcutaneously from its site of exteriorization to the left caudal rib region. This lead is positioned approximately 1 cm to the left of the xyphoid process. (See Figure 37)
7. Release the lead and withdraw the hemostat leaving the lead in place under the skin.
8. Grasp the terminal end of the negative lead (clear tubing) with a small hemostat and tunnel it subcutaneously from its site of exteriorization to the right pectoral muscle. (See Figure 37)

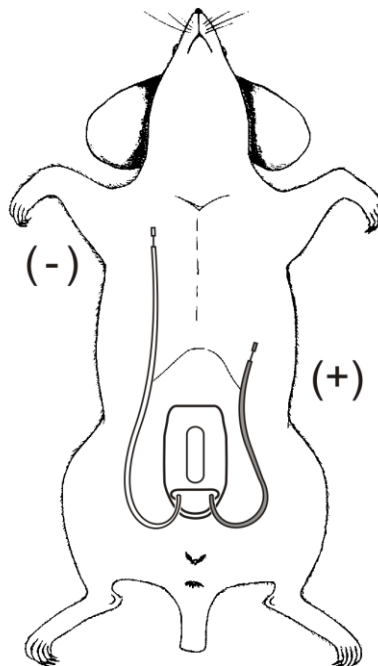
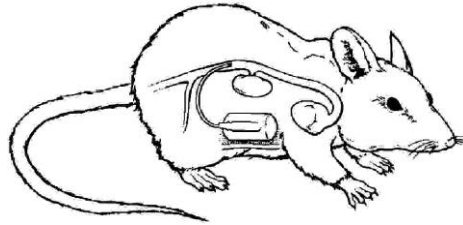


Figure 37: Modified lead II configuration

9. Release the lead and withdraw the hemostat leaving the lead in place under the skin.

10. Ensure both leads are lying flat against the muscle for the whole length of the lead. This will avoid irritation of the tissue.
11. Secure both leads to the abdominal wall by placing a stay suture through the abdominal wall muscle and around the leads using 5-0 or 6-0 non-absorbable suture.
12. Close all skin incisions using wound clips or 5-0 or 6-0 absorbable or non-absorbable suture. Once closed, seal the incision with a tissue adhesive, such as Vetbond or Gluture.



**Figure 38: Intraperitoneal placement of the device
(ECG leads not shown)**

Surgical Recovery

1. Discontinue surgical anesthesia.
2. Maintain supplemental warmth throughout the anesthetic recovery.
3. Administer post-surgical analgesia.
4. Monitor animal closely for the return of normal postures and behaviors.

This completes the abdominal aorta cannulation procedure with intraperitoneal cavity device placement, and subcutaneous ECG lead placement.

Appendix A: Device Care and Use

For information on device explantation, cleaning, storage, re-sterilization, re-gelling and more, please refer to the Technical Notes section on our website, www.datasci.com or contact Technical Services at support@datasci.com.

Please refer to the DSI Implantable Telemetry System Manual (007678-003) for detailed information on any HD-X device or the DSI website, www.datasci.com.

Operational Modes

HD-X implantable devices are equipped with two operational modes: ON, and OFF.

Implants are shipped to you in the OFF mode. The battery in the implant is not activated. When switched to ON, the implants begin to sense and transmit data. The switch to change between these two modes is in the interior of each implant and is therefore not visible. The switch is magnetically activated.

To switch operational modes:

1. Power on an AM radio and tune it to 550 kHz (the low end of the AM band).
2. Bring the radio close to the packaged implant.

It is important the implants remain in the sterile packages!

3. Momentarily bring a strong magnet within approximately one inch of the implant in the package.
4. Once the implant is implanted leave the device ON. If a protocol requires the implant to be turned off, a new two point calibration should be performed after turning the implant back ON.

Appendix B: Verification of Catheter Tip Location

To obtain catheter patency throughout the duration of the study, the catheter tip must be positioned inside the aortic arch. If the catheter tip remains in the carotid artery, it will clot and patency will be lost. Depending on the mouse strain, gender and weight, the catheter may have to be advanced to different lengths to reach the aortic arch. It is recommended, before any survival surgery is performed, to verify the catheter tip placement for each type of mouse to be implanted. This can be done by performing a sternotomy on a cannulated, euthanized mouse and locating the aortic arch. Measurements can be taken to determine the appropriate length to insert the catheter. Follow the directions below to locate the catheter tip in an implanted animal.

1. Euthanize the animal by standard technique. **Do not use cervical dislocation. This can damage the catheter.**
2. Using a small surgical scissors, cut the subcutaneous pocket open where the device is positioned. Start at the caudal aspect of the pocket and incise cranially, taking care not to cut the catheter.
3. Remove the device from the pocket and continue to incise cranially to the ventral neck region, taking care not to cut the catheter.
4. Once the catheter is free from all connective tissue, gently pick up the device and place it on the table near the animal's head. This will prevent accidental cutting of the catheter.
5. Using a small surgical scissors, make a midline incision over the abdomen and extend the incision cranially to cut through the diaphragm and sternum.
6. Using a small surgical scissors, cut through the rib cage on both the right and left lateral sides to fully expose the thoracic cavity.
7. Locate the heart. The thymus will first need to be dissected before the aortic arch can be visualized. The thymus is white in color and can be gently removed. **Be careful to only grasp the thymus during the dissection. Avoid grasping any vessels as the catheter will be located underneath the thymus in the aortic arch.**
8. Once the thymus is removed, locate the aortic arch. Gently isolate the arch from the surrounding tissue.
9. Place a fine-tipped forceps under the arch to locate the catheter tip. If the catheter tip cannot be visualized inside of the arch, move cranially with the vessel to locate the tip.
10. Determine where the tip of the catheter is positioned in relation to the aortic arch. If the catheter is in the optimal location, then the distance the catheter was inserted was correct. If the catheter is not in the optimal location, then adjustments will need to be made before any survival surgery is performed. The recommended procedure is to measure from the carotid bifurcation or the most cranial ligation suture to the junction of the carotid artery and aortic arch and add an additional 2-3 mm.
11. By verifying catheter tip placement, adjustments can be made, if needed, for subsequent surgeries involving the same strain, gender and weight of animal.
12. Repeat this process when changing to a new strain, gender or weight of animal.

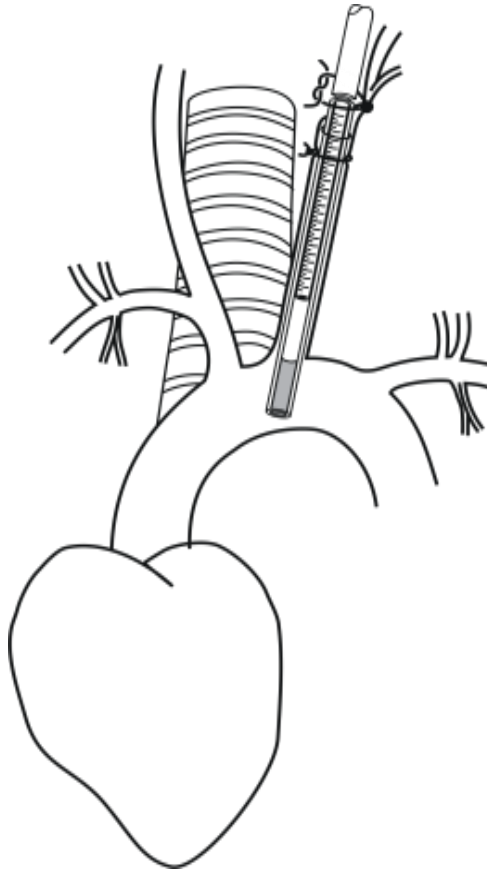


Figure 39: Optimal catheter placement in the aortic arch

Appendix C: Configuration Options

Many configurations are available to enable flexibility between studies.

All listed surgical approaches are endorsed by DSI's surgical support staff and therefore training is available for these methods on-site or at DSI headquarters. The surgical placement may vary depending on the animal model and experimentation with a non-functional training device is recommended before attempting a survival surgery. Surgical manuals are available for all procedures and videos are available for select procedures.

Papers or posters verifying these surgical methods are available via DSI's bibliography system found on the website. In unique applications, DSI may also be able to connect researchers together for further surgical or scientific development.

HD-X10

The 5cm catheter is the same as the one on the PhysioTel PA-C10 model. The 7cm catheter was developed for this product to enable carotid artery surgery while obtaining core temperature via IP placement of the device body.

270-0171XXX	PhysioCath Catheter	Suture Rib?	DSI Endorsed Surgical Approach		
			Animal Model	Device Placement	Catheter Placement
-001	5 cm		Mouse	Subcutaneous	Systemic BP from the Carotid Artery
-002	5 cm	•	Mouse	Intra-peritoneal	Systemic BP from the Descending Aorta
-007	7 cm	•	Mouse	Intra-peritoneal	Systemic BP from the Carotid Artery
-008	7 cm		Mouse/Juvenile Rat	Subcutaneous	Numerous Applications

HD-X11

The 5cm catheter is the same as the one on the PhysioTel PA-C10 model. The 7cm catheter was developed for this product to enable carotid artery surgery while obtaining core temperature via IP placement of the device body.

2700170-XXX	PhysioCath Catheter	Biopotential Lead Length	Suture Rib?	DSI Endorsed Surgical Approach		
				Animal Model	Device Placement	Catheter Placement
-001	5 cm	20 cm		Mouse	Subcutaneous	Systemic BP from the Carotid Artery
-002	5 cm	20 cm	•	Mouse	Intraperitoneal	Systemic BP from the Descending Aorta
-007	7 cm	20 cm	•	Mouse	Intraperitoneal	Systemic BP from the Carotid Artery
-008	7 cm	20 cm		Mouse/Juvenile Rat	Subcutaneous	Numerous Applications