Surgical Recommendations to Optimize Femoral/Iliac Artery Cannulation

Due to its size, location, and ease of access, the femoral artery is frequently used for blood pressure catheter placement. Less frequently, the catheter is inserted directly into an iliac artery. Both of these approaches provide accessible anatomic locations to allow for high quality blood pressure signals with good longevity.

This placement can cause some limitations to the blood flow to the catheterized limb due to the physical presence of the catheter in the upstream blood vessel, and/or the ligation of the femoral artery more distally. This compromise in blood flow to the limb may potentially induce a hindlimb paresis/paralysis in the catheterized limb, and can occur with femoral artery cannulation or direct cannulation of the iliac artery. There are a variety of factors that increase the risk of this complication. These factors will be discussed below, along with possible means to mitigate the risk.

Surgical Technique

- Damage to the femoral nerve, and/or extensive dissection could also cause post-operative complications.
- Careful surgical techniques can help decrease the risk of complications:
    - Ensure that no nerves are damaged during dissection (avoid grasping the nerve with any instruments) and ensure that it is not included in ligation.
    - Use minimal dissection, but ensure that enough artery is exposed to allow for easy catheter insertion.
    - Take care with instruments such as retractors to avoid further damage to tissue or nerves.

Animal Size

- A smaller [body weight] animal is more likely to experience hindlimb complications associated with an upstream catheter. Some facilities have established a minimum size required to support the placement of a hindlimb catheter based upon their historical perspective.
- DSI suggests a 4 kg minimum in NHP and an 8 kg minimum in canine and swine as a starting point with modifications based on experience in your animal population.

Intra-operative Blood Pressure

- Hypotension (mean arterial blood pressure lower than 60 mm Hg) during surgery predisposes to hindlimb complications. The animal may be dependent on blood flow through collateral blood vessels due to the ligated/partially obstructed upstream artery, and hypotension decreases blood flow to [smaller] peripheral blood vessels.
- In order to mitigate hypotension, it is critical to obtain an accurate assessment of the patient's blood pressure.

    - Indirect methods include doppler flow and oscillometric, which is more accurate. Both methods require accurate cuff placement and sizing (cuff width 40% of the limb diameter).
    - Direct blood pressure monitoring via an arterial line is the most accurate method.
    - Live telemetry data collection during surgery will allow for an extremely accurate assessment of blood pressure (and heart rate and arrhythmias) once the arterial catheter is placed. However, depending on the length of surgery, telemetric blood pressure measurements may not be available until late in the procedure. Therefore, some other method to measure blood pressure should be used until this time.
    - Even the most accurate equipment won't help if there is not a dedicated anesthetist who frequently monitors vital signs (including blood pressure) and closely tracks and responds to trends.
- There are a variety of means to maintain adequate blood pressure under general anesthesia. The veterinary and surgical team should consult prior to the surgery to develop a plan, and ensure all supplies, such as fluid therapy and potential rescue medications are readily available during surgery. Having doses and infusion rates for important medications pre-calculated can be invaluable in case of an emergency. Potential interventions include, but are not limited to:
    - Maintain inhalational anesthesia at an appropriate level (i.e. MAC to 1.3 MAC)
        - Adequate pre-medication and/or intra-operative continuous rate infusions (CRI) (e.g. opioid, lidocaine, etc.) can help decrease the required MAC.
    - Provide fluid therapy
        - Isotonic crystalloids for maintenance (e.g. 0.45% NaCl or Lactated Ringers), and may be bolused as needed.
        - Additives may be used as needed (e.g. dextrose, etc.).
        - Colloids maybe used to expand the intravascular space if crystalloids are ineffective at maintaining blood pressure.
    - Support with positive ionotrophs may be added if needed to maintain BP, and are typically administered as a CRI (e.g. dopamine, dobutamine, phenylephrine, norepinephrine).

<u>Surgical Duration</u>

- Increased surgical time can cause prolonged hypotension and decreased blood flow to the affected limb.
- All steps should be taken to maximize surgical efficiency to decrease surgical time, without compromising the quality.
    - During complex surgeries more than one surgeon may be able to work on different anatomical locations at the same time (e.g. one surgeon works on the jugular vein while the other surgeon accesses the femoral artery).
    - Having skilled assistants is also helpful to expedite the surgery.
    - Planning ahead to ensure all necessary supplies are easily accessible is also critical to avoid unnecessary delays.

- It is beneficial to perform a "dress rehearsal" prior to a survival surgery to ensure the entire team is fully prepared. This may involve a table-top exercise without an actual animal, or an acute surgery, if appropriate resources are available.

Supplemental Patient Warming

- Hypothermia will cause further vasoconstriction, particularly of the patient's extremities. This could possibly exacerbate the vasoconstrictive effects due to hypotension under anesthesia.
- There are a variety of patient warming systems available for veterinary surgery. They should be used throughout anesthesia (including during animal preparation and recovery), and adjusted to maintain a normal body temperature. The most effective systems maintain close contact with the animal, and effectively and evenly control temperature to prevent hot spots and patient burns. Over the counter heating pads designed for human use are contraindicated in veterinary patients, as they are likely to cause burns. Commercially available systems include:
  - Forced-air warming (e.g. Bair Hugger, SurgiVet Equator Convective Warming System, etc.)
  - Electrical conductive fabric warming (e.g. Hot Dog Warmer, ChillBuster, etc.)
  - Recirculating water pads

Patient Positioning

- Extensive pressure around the distal limb (i.e. unpadded/excessively tight restraints) can lead to hindlimb complications such as ischemic necrosis distal to the restraint. Likewise, excessive tension placed on the limb can cause damage to the nerves.
- The minimum amount and duration of hindlimb restraint should be used during surgery.
  - Alternatives to hindlimb restraints, such as vacuum-assisted patient positioning devices should be used whenever possible to position limbs.
  - When necessary, padded restraints specifically designed for patient use should be used, rather than ropes.
  - Restraints should be placed as loosely as possible around the limbs and contact between the restraint and the limb should be spread out as much as possible.
  - The minimum required amount and duration of tension should be used.
    - Tension should only be employed during the portion of the surgery when it is needed. Before, and after it is required, all tension should be released. It can be helpful for the anesthetist to keep track of when tension is applied, and help remember to discontinue as soon as possible.

Implant Selection

- Because hindlimb complications can be seen with both femoral and iliac artery catheter insertions, this issue is likely in part due to upstream partial occlusion of blood flow.
- The smallest diameter catheter that is appropriate for the species and application should be selected.
    - Catheters typically used for large animal implantation have a 1.4 mm diameter and are available in a variety of lengths, up to 40 cm.
    - Smaller diameter catheters (0.7 mm diameter) are available on some large animal implant configurations, and have a maximum length of 15 cm.

Post-operative Comfort

- In order to maximize blood flow and the development of collateral blood supply to the hindlimb and prevent disuse atrophy and/or limb contracture, animals should return to normal posture and activity levels as soon as possible after surgery. Any uncontrolled pain experienced by the animal will preclude this goal.
- A well-conceived peri-operative analgesic plan will help the animal return to normal function and activity more quickly post-operatively. The veterinary and surgical team should consult prior to surgery to develop a multimodal plan which may include:
    - Pre-operative analgesic and anti-inflammatory medications to prevent wind-up pain.
    - Local anesthetic agents
    - Post-operative patient monitoring considering the use of an ethogram to quantify behavioral changes related to pain.
    - Post-operative analgesic protocol, tailored to individual animal needs
    - Consider the use of sustained release or longer lasting medications to decrease stress associated with administration.

Evaluation of Complications

Should hindlimb complications occur, it is important to thoroughly evaluate them to learn and hopefully prevent them in the future. Whenever possible, the surgical team should be involved in this assessment. Factors to look for include:

- Evidence of thrombosis/fibrosis in situ along the catheter length or near the catheter tip.
    - If the vessel is ligated, it is normal for a thrombus to form and for the vessel to fibrose near the ligation point. This thrombosis/fibrosis typically extends to the level of a major side branch (which serves to preserve blood flow). It is abnormal for the thrombosis/fibrosis to extend proximal to a large side-branching vessel.
- Damage to/ligation of the nerve.

- Complete [or substantial] occlusion of the blood vessel by the catheter (i.e. a mismatch between the diameter of the catheter and the diameter of the artery).
- Anesthetic records can be reviewed to determine:
    - Episodes and duration of hypotension
    - Effectiveness of any interventions attempted
    - Duration of anesthesia
    - Duration of traction on the hindlimb
    - Any other complicating factors