HEMIPELVECTOMY IN THE DOG AND CAT: SURGICAL DESCRIPTION AND RESULTS OF A VSSO RETROSPECTIVE STUDY
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Hemipelvectomy has been described as an extensive, aggressive surgery for the management of tumors or functional abnormalities (e.g. fracture malunion) involving the pelvis or associated soft tissues. Variable amounts of the hemi-pelvis may be removed, with preservation of a proportion of ilium or ischium possible depending on the location of the tumor. In most cases, hemipelvectomy necessitates amputation of the ipsilateral hind-limb, although this is not an essential part of the procedure and is dictated by the actual tissue compartment that needs to be removed as part of the oncologic procedure.

Apart from isolated case reports, there is currently only one case series in the veterinary literature that describes the outcome of hemipelvectomy in the dog and cat. In this report, a variety of tumor types were described, with a variable outcome. A surgical description for this procedure has been recently described although no additional clinical information was provided. The procedure demands a thorough understanding of the regional anatomy and oncological principles.

This lecture will present the results of a multi-institutional retrospective study performed by members of VSSO. This study provides the clinical details and outcome on a cohort of 100 dogs and cats that underwent hemipelvectomy surgery for a variety of neoplastic disorders.

Neoplastic disease affecting the pelvis (and proximal femur), or the muscles and nerves of the upper thigh are the most common reason for surgery to be considered. In this study, the majority of tumors were of mesenchymal origin. Soft tissue sarcoma (n=43) [which included fibrosarcoma, spindle cell sarcoma, liposarcoma, histiocytic sarcoma and peripheral nerve sheath tumors] were the most common tumor type reported, with osteosarcoma (n=31) being the next most common tumor type. Other tumors reported included chondrosarcoma (n=11), hemangiosarcoma (n=6) and infiltrative lipoma (n=5). Singular tumor types included a mast cell tumor and multilobular osteochondrosarcoma. In two cases, no tumor was identified despite initial investigations being suggestive of a neoplastic disorder.

In the study population, there were 89 dogs and 11 cats. There were 44 males and 56 females; 80% of the females and 68% of males were neutered. The mean age at time of diagnosis was 8.4 yrs (SD ± 3), with a range from 2 to 16 years. The most common dog breed was the Labrador retriever (n=14), but a wide variety of individual breed types were recorded. All of the cats were described as domestic short haired.

In 43 cases, patients presented with a palpable mass (either on external palpation or on rectal assessment). Palpation of the mass was not usually resented by the patient. In some cases, ulceration of the overlying skin may have occurred due to pressure necrosis. In one patient, a discharging sinus was present. Three patients presented due to faecal tenesmus and constipation, with intrapelvic obstruction due to a mass discovered during the course of the investigation. In the remaining 38 cases, the only presenting sign was a hind-limb lameness. The lameness may have been acute (and the result of an apparent injury), or was of a more chronic nature.

The mean duration of clinical signs prior to surgery was 108 days, with 75% of patients presenting within 4.5 months. However, in a few cases, clinical signs had been present for more than a year prior to surgical management. Dogs with osteosarcoma and chondrosarcoma tended to present with a more acute clinical history, with 88% and 71%
of cases presenting for surgery within 3 months of the onset of clinical signs. This contrasted with just 41% of soft tissue sarcoma cases being operated within the same time period.

When a pelvic mass is not evident on physical examination alone, radiological evaluation using plain radiographs of the pelvis may be considered an important part of the lameness evaluation. Occasionally, survey radiographs may reveal evidence of destructive bone disease or pathological fracture. However, they are rarely diagnostic for tumors affecting the soft tissues. Many palpably occult tumors were only diagnosed with co-axial imaging such as CT or MRI. These modalities should therefore be considered whenever dealing with a hindlimb lameness that is eluding diagnosis.

Thorough orthopedic and neurologic examination and clinical staging with thoracic imaging and abdominal ultrasound should be performed as most tumors affecting the pelvis will have metastatic potential. If metastasis has occurred, an aggressive local surgery may be inappropriate for the patient.

Essential surgical planning for patients undergoing hemipelvectomy initial focuses on the muscle units that must be removed in order to achieve a compartmental resection about the tumor. A secondary but equally important decision is the preservation of adequately robust tissue to enable closure of the abdominal wall, as the surgery results in exposure of the abdomen and pelvic canal. Failure to plan for this requirement may leave the surgeon scrabbling to appose any available tissue, which may be insufficient for definitive closure.

Much of the information necessary for surgical planning can be obtained by CT or MRI and this forms an essential element of the pre-surgical management. Contrast agents should be used to allow the full extent of the tumor reaction to be assessed. Whilst MRI will provide superior information to CT on soft tissue structures, adequate information on tissue compartments and barriers can still be obtained to enable planning with CT. Each individual patient will have a unique presentation in terms of tumor type, location and extent so the precise surgical considerations will differ between each. There are six major categories for hemipelvectomy.

1. **Total hemipelvectomy**: removal of the ipsilateral hindlimb and hemi-pelvis to the level of the pubic symphysis. The ilial wing is elevated at the sacroiliac junction - if possible, a sliver of ventral ilial wing can be preserved along with the origin of the sartorius muscle to facilitate closure. Partial sacrectomy (up to one third of the sacral body) may also be performed if necessary. This may be considered for tumors affecting the ilium, ischium or pubis where resection of the entire skeletal compartment is necessary.

2. **Mid-to-cranial hemipelvectomy**: removal of the ipsilateral hindlimb, acetabulum and ilial wing, extending to the level of the pubic symphysis. This approach is ideal for soft tissue tumors located cranial to the femur (i.e. within the extensor muscles). This approach preserves the site of origin of the semimembranosus/tendinosus muscles which may be used for closure of the abdominal defect.

3. **Mid-to-caudal hemipelvectomy**: removal of the ipsilateral hindlimb, acetabulum and ischium wing, extending from just caudal to the sacroiliac joint and medially to the level of the pubic symphysis. This approach preserves a small section of ilial wing and the site of origin for the sartorius muscle which is ideal for the closure of the abdominal wall. This approach may be considered for soft tissue tumors located caudal to the femur (e.g. within the flexor muscles) or for peripheral nerve sheath tumors. Good access to the entire lumbosacral nerve plexus and intervertebral foramen is possible with this approach.

4. **Ischiectomy**: reserved for tumors confined to the ischium or semimembranosus/semitendinosus muscles. Can be performed without requiring amputation of the hindlimb. Uncommon.
5. **Cranial iliectomy**: reserved for tumors confined to the ilial wing or sartorius muscle. Can be performed without requiring amputation of the hindlimb. Uncommon.

6. **Acetabulectomy**: removal of the femoral head and acetabulum. Reserved for tumors confined to the coxofemoral joint without extension into the surrounding tissues. In the cat, has also been described for management of fracture malunion causing faecal obstipation. Can be performed without requiring amputation of the hindlimb, though some gait effect may be observed similar to femoral head ostectomy.

Hemipelvectomy is a major surgery with the potential for significant hemorrhage due to transection through large muscle groups and proximity to major vessels. Moderate intraoperative hemorrhage (10-20% of blood volume) was reported in 8 patients, but severe hemorrhage requiring transfusion was very uncommon (required in only 2 patients). Complications will be reduced when anatomical knowledge and sound surgical technique is followed.

Anaesthesia management should be performed as for a hindlimb amputation, with consideration for multi-modal preemptive analgesia. Systemic opioids, in combination with a morphine and/or lignocaine epidural is effective in most instances. Non-steroidal anti-inflammatory drugs should be withheld until after the patient has recovered from surgery, in case of hypotension during a prolonged surgery. Performing local nerve blocks with bupivacaine should be considered prior to transection of major nerves during the surgery. In addition, splash blocks or wound diffusion catheters may enable good post-operative pain relief.

The following description outlines the dissection necessary for a total hemipelvectomy or mid-to-caudal hemipelvectomy (options 1 and 3, above). Some extrapolation of the fundamental principles may be required if other variations of hemipelvectomy are required - close consultation of an anatomical text is usually necessary. A wide area of the limb and pelvic limb is prepared, extending medially to the level of the contralateral stifle, cranially to mid abdomen and dorsally across to the opposite coxofemoral joint. The anal canal should be evacuated and a purse string suture placed to protect against bowel evacuation during the surgery. For a similar reason it may be useful to also empty the bladder via catheterization. An indwelling urinary catheter may be placed to facilitate management in the post-operative period until full mobility has been achieved.

Dissection begins medially, with a curvilinear incision extending along the medial thigh from the inguinal fold to the ischium. The sartorius muscle (both cranial and caudal bellies) is isolated to the level of the stifle and elevated en bloc from the leg. Ligate the branch of the descending genicular artery that passes ventral to the muscle distally. The superficial circumflex artery and vein may need to ligated more proximally to allow elevation of the muscle away from the femoral artery. Keep the ligation of this vessel close to the femoral artery. Elevate the sartorius muscle down to the level of the ilial wing. Wrap the muscle in saline soaked swabs to keep moist. The skin is then elevated to expose the midline of the pubis. The use of self-retaining retractors are useful to maintain exposure. The medial thigh muscles (adductor/gracilis/pectineus) are cut on the midline down to the pubic symphysis. There is a faint fascial aponeurosis that defines the midline at this site. Transect the abdominal muscles as they insert on the pubis and retract cranially, elevating the muscle from the ilial wing until the iliopsoas muscle is visible and the ventral surface of the ilial wing is palpable. The external iliac artery and vein are isolated and double ligated, before division. The iliopsoas muscles are isolated and transected with a scalpel blade. The ventral surface of the ilial wing is exposed with periosteal elevators.

A curvilinear skin incision is now made on the lateral surface of the thigh, joining up with the two previous medial incisions. The skin is elevated proximally to expose the lumbar
fascia above the coxofemoral joint. The skin is in close contact with the biceps femoris muscle, and there are many musculocutaneous vascular branches penetrating into the hypodermis so this dissection is tedious. However, because it is important to preserve as much skin as possible for the closure, do not be tempted to make this incision too proximal or closure may prove difficult. With the skin elevated, dissection now works caudally around the ischium, between the semitendinosus and ischiocavernous muscles, staying medial to the sacrotuberous ligament. The muscles of the pelvic diaphragm (levator ani and lateral coccygeus) should remain in situ on the medial aspect of the dissection. The superficial gluteal muscle is then transected along its length close to its dorsal origin. The lumbar fascia may also be cut cranially to expose the middle gluteal muscle.

The dissection focus now shifts cranially to the previously exposed ventral surface of the ilial wing, by adducting the leg. If a total hemipelvectomy is being performed, the sacrum can be exposed and the ilium elevated by inserting an osteotome at the sacroiliac joint and lightly separating with a mallet. A small ventral edge of ilium may need to be osteotomised (if tumor compartment allows) to preserve the origin of the previously elevated sartorius muscle. If a mid-to-caudal pelvectomy is being performed, the medial gluteal muscle can be partially elevated from the ilium to allow the ilium to be cut with an oscillating saw immediately caudal to the sacroiliac joint. The pubic symphysis is now cut with an oscillating saw or osteotome. As the leg is gently elevated from the body, remaining medial muscle attachments will be exposed and can be gently incised. The internal obturator muscle may be an important medial barrier for some tumors which have penetrated into the pelvic canal via the obturator foramen. In this instance, care needs to be taken to ensure the tumor capsule is not breached as the remaining internal obturator muscle is transected to be removed along with the amputated limb. With the leg free of muscular attachments, it will now be tethered by nerve branches from the lumbosacral plexus only, so the assistant needs to careful to support the weight of the limb. For most tumors, the nerves can be transected close to the leg; pudendal nerve branches (more caudally located) should be preserved where possible. Prior to transection, the nerve sheath should be injected with a long-acting local anaesthetic proximal to the site of transection. For peripheral nerve sheath tumors, more care is needed to map out all of the lumbosacral plexus and trace each nerve branch to the level of the intervertebral foramen at L6, L7 and S1. Each nerve is then cut sharply as it enters the foramen. Good exposure is achieved with the hemipelvectomy approach - the remaining section of iliopsoas muscle may need to be elevated to expose the most cranial foramen.

The wound is lavaged and any remaining bleeding vessels managed. The sartorius muscle can be unwrapped from its moist swab and draped across the defect. It is the secured to the abdominal muscle, adductor (with bone tunnels to the symphysis if necessary) and pelvic diaphragm to seal the exposed abdomen and pelvic canal. Care is then taken with remaining closure of subcutaneous tissues and skin to manage the dead space. Placement of a wound diffusion catheter and a large active suction drain is advisable for management of pain and dead space.

Clinical function following hemipelvectomy should be similar to that following a hindquarter amputation and will be influenced by patient size, fitness and agility. If a precedent lameness had been present prior to surgery, patients will usually accommodate to their amputee status very quickly. Most patients are mobile very soon after surgery; larger patients may benefit from some supportive walking for the first few days until they gain confidence and coordination. Disruption to urinary or fecal continence is not expected. If an epidural was used, some urinary retention may be observed.

In this study, the median duration of hospital stay following surgery was just 3 days, with 90% of patients discharged within 7 days. Drain management was the predominant reason for patients remaining in hospital. Reported perioperative complications were low,
with no complications reported in 80% of patients. Minor complications including wound issues (swelling \(n=2\), discharge \(n=1\) or skin dehiscence \(n=1\)), corneal ulceration \(n=1\) and aspiration pneumonia \(n=1\). An incisional hernia and scrotal swelling developed in one patient, which was managed by scrotal ablation and repair of the abdominal wall. Urinary retention, suspected to be due to the use of epidural analgesia, was the most commonly reported complication \(n=4\). None of the complications reported were life-threatening and all resolved with appropriate nursing care or minor surgical repair. Long term function of patients following surgery was reported by most owners to be excellent, and consistent with that expected for a hindlimb amputee. Two owners reported their dogs failed to adjust well to their amputee status.

The follow-up time for the study ranged from 5 to 2703 days, with a median follow-up time of 472 days. Forty-nine dogs were euthanased as a result of either local recurrence \(n=13\), distant metastatic disease \(n=25\) or both \(n=9\). One dog died at home, 5 days after surgery, from a suspected pulmonary thromboembolism. Five dogs were euthanased due to development of orthopedic disease in their contralateral limb that limited their mobility. Twenty-seven dogs remained alive at the end of the study period. Of these surviving dogs, local recurrence or metastasis had been diagnosed in 7 dogs.

Clean resections were not always obtained, despite the extent of resection. Chondrosarcoma were more frequently incompletely resected (64%), with osteosarcoma (26%) and soft tissue sarcoma (33%) and hemangiosarcoma (33%) being associated with similar rates. This relatively high rate of incomplete resection may reflect the large tumor size at the time of diagnosis, tumor location and some anatomical limits to resection (e.g. peripheral nerve sheath tumor affecting the lumbosacral plexus).

From Kaplan Meier analysis, the overall mean survival time was 1039 days (95% CI = 762 - 1317). The median survival time was 569 days (95% CI = 250 - 887). Cats had a significantly longer survival time compared to dogs (HR 1.7 p=0.04, 95% CI 1.02 - 2.85).

The mean estimated DFI for local recurrence for all tumor types was 364 days (95% CI = 114 - 615 days). Local recurrence decreased patient survival (HR 4.4 p=0.005, 95% CI 2.4-8.1). Local tumor recurrence developed in 15/66 (23%) of dogs despite clean margins being reported on histology; the mean DFI in these patients was about 300 days. Tumor recurrence had not developed in 8/33 patients at the time of the study, despite incomplete resection being reported, with mean survival times in this group of 356 days. On multivariate analysis, the only significant prognostic factor for an improved survival time was clean histological margins (HR 0.51 p=0.03, 95% CI 0.29 to 0.93).

Hemipelvectomy is a viable surgical procedure for the management of a wide variety of tumor types located within the pelvis or musculature of the thigh. Tumors at this location are often very large at the time of diagnosis and on first impression it would seem unlikely that effective management can be achieved. However, hemipelvectomy enables anatomical dissection of the hindlimb to be accomplished, enabling compartmental resection of most tumors. If limb sacrifice is required, case selection for surgery is similar to hindlimb amputation. Surgery requires good anatomical knowledge of the pelvic region but is not associated with a high degree of intraoperative or postoperative morbidity. The results of this retrospective study indicates that the surgery is effective for the compartmental resection of benign but locally extensive tumors like infiltrative lipoma. Of the malignant tumor types, hemangiosarcoma carries the poorest prognosis, with a median survival time of just 179 days. The high metastatic rate for soft tissue sarcoma (40%) and chondrosarcoma (45%) may reflect the large tumor size and delayed time to diagnosis as many of the lesions were not readily apparent on physical examination alone. Compared to appendicular sites, dogs with osteosarcoma of the pelvis may have a good outcome with a lower rate of metastatic disease and prolonged survival.