PEER REVIEWED

Fundamentals of **Surgical Oncology** in Small Animals

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Cancer is one of the major causes of morbidity in veterinary patients, and surgical removal of tumors is one of the most common surgical procedures performed by veterinarians.

In human surgical oncology, 60% of human patients battling cancer are cured by surgery alone.[1] Likewise, in veterinary medicine, surgery is considered the most important component of treatment in dogs and cats suffering from solid tumors because, in many cases, surgery offers the best chance for improving patients' quality of life.[2,3]

To help assure a positive outcome, the veterinarian needs a thorough understanding of the basic principles of surgical oncology, including:

- Characteristics of specific tumor being treated
- Surgical options available
- Potential need for adjunctive treatments, such as chemotherapy or radiation therapy.

Regardless of the treatment options sought, the overall goal of the therapeutic plan is to improve the patient's quality of life.

PATIENT EVALUATION

The patient's treatment plan should be based on:

- Complete history
- Thorough physical examination
- Diagnostic imaging
- Clinical pathology with cytology
- Histopathology, when appropriate.

Tumor Identification

The annual physical examination plays a key role in detecting neoplasia, either directly via palpation or through paraneoplastic syndromes, which may be found on routine blood and urine analysis. The physical examination allows detection of possible tumor presence and identification of concurrent conditions that may influence the treatment plan.

When a tumor is identified, record its size, location, and gross appearance, and palpate regional lymph nodes. If the lymph nodes are enlarged, firm, or immovable, the suspicion of a metastatic neoplasm rises; however, normal lymph node palpation does not guarantee lack of metastasis. Therefore, some form of lymph node biopsy is recommended in most cases.

Tumor Evaluation

Histopathologic analysis of tissues obtained by biopsy allows definitive diagnosis of:

- Tumor type (hyperplasia, metaplasia, or neoplasia)
- Biological behavior (malignant or benign)
- Aggressiveness
- Tumor grade.

There are 4 main types of tumor biopsy techniques:

1. **Fine-needle aspiration** (FNA) is a cost-effective, minimally-invasive procedure that is useful for differentiating non-neoplastic from neoplastic diseases and, in many situations, obtaining a definitive diagnosis.
   - FNA is usually reserved for cutaneous and subcutaneous masses; some tumors, such as mast cell tumors and lymphoma, are readily identifiable on most needle aspirates.
   - Intracavitary structures (especially splenic and hepatic masses) may be sampled with ultrasonography or computed tomography guidance.[4-6]
   - However, FNA is generally the least diagnostic biopsy technique due to the minimal amount of tissue sampled and lack of organized tissue architecture, which prevents tumor grading.
   - Certain tumor types, such as sarcomas, may not exfoliate cells well, leading to false-negative results. Interpret negative aspirates or aspirates with questionable results with caution, and utilize more aggressive biopsy techniques when clinically appropriate.
2. **Needle-Core biopsy** is more invasive than FNA but has proven to be highly diagnostic, with an accuracy of 100% for epithelial cell tumors and 94% for mesenchymal cell tumors.[5]
   - Needle-core biopsy includes 2 main techniques:
     - » Tru-cut needle-core biopsy (soft tissue)
     - » Jamshidi needle-core biopsy (ossified tissue).
   - Typically, sedation and local anesthesia provide sufficient analgesia for biopsy collection. Caution should be used to avoid infiltrating anesthetic agents into the tumor to prevent distortion of the collected tissues.[6]
   - Collecting multiple tissue samples increases the accuracy of biopsies.
3. **Incisional biopsy** is utilized when less invasive techniques fail to yield a diagnosis.
   - Wedge and punch biopsies are examples of incisional biopsy techniques; they are:
     - » Especially useful for diagnosis of soft, friable, inflamed, and/or necrotic tumors.
     - » Commonly used to sample peripheral lymph nodes and masses located on the extremities.[7]
   - For most cases, include the border between normal healthy tissue and abnormal tissue, which allows the pathologist to determine extent of tumor invasion into normal tissue.
4. **Excisional biopsy** allows the identified tumor to be removed in its entirety, with or without additional surgical margins.
   - While this is a common approach for mass removal in veterinary medicine, it remains controversial:
     - » It may provide a diagnosis and, therefore, a therapeutic plan, but the mass is removed without knowing the tumor type.
     - » It is also often impossible to excise the mass without contaminating clean tissue planes or complicating future surgical procedures.
   - A less invasive biopsy procedure is generally recommended to guide the surgeon in choosing the appropriate method of surgical resection.
   - Excisional biopsy is best reserved for cases in which adequate surgical margins are easily achievable with biopsy alone (eg, small cutaneous mass on trunk of a dog).

Regardless of the **treatment options** sought, the **overall goal** of the therapeutic plan is to **improve the patient's quality of life**.

Biopsy Procedure

Carefully plan the biopsy procedure to prevent spread of neoplastic cells to unaffected tissues and allow removal of biopsy tracks or scars during surgical excision of the tumor. When obtaining a biopsy from a vascular organ, such as the liver or spleen, coagulation testing should be considered.

Although a presurgical biopsy is not always required, it is essential when the:

- Surgical plan will be affected by tumor characteristics
- Tumor location will make closure of the surgical site difficult without reconstructive surgery (ie, skin flaps, grafts)
- Owner's willingness to treat may be altered based on diagnosis.

Once the biopsy is collected and properly preserved, have it processed and evaluated by a histopathologist.

GRADING & STAGING

Tumor Grading

Tumor grade is the histopathologic assessment of the tumor's aggressiveness, and includes information, such as the mitotic index, invasiveness into surrounding tissues, and degree of differentiation. This information is valuable when the surgeon is developing a treatment plan for the patient.

For some tumor types, the grading scheme may also include features, such as percent necrosis; for these neoplasms, a grade may not be accurately assessed by incisional biopsy.

Tumor Staging

If the tumor is suspected to be malignant, tumor staging establishes to what extent the tumor has invaded local, regional, or distant (systemic) tissues.

Method of tumor metastasis is highly dependent upon the tumor type: Carcinomas and round cell tumors tend to spread via lymphatic routes, while sarcomas tend to spread via hematogenous routes. Common areas where metastatic disease is identified include the lungs and lymph nodes.

In most cases, the following diagnostics are recommended:[2]

- Three-view thoracic radiographs
- Regional lymph node palpation
- Biopsy (as mentioned earlier, lymph node palpation does not guarantee lack of metastasis).

Additional diagnostics, such as abdominal ultrasound, may be needed depending on the biologic behavior of the tumor. Other modalities, such as computed tomography or magnetic resonance, may help increase the sensitivity of detecting metastatic disease and more accurately determine the local extent of the tumor in an effort to determine prognosis and help guide resection.

SURGICAL INTERVENTION

There are 4 levels of surgical aggressiveness, or surgical "dose," to classify the extent of surgical resection (**Figure 1**).[8,9] The most common surgical mistake is use of a surgical dose that is too low, which results from concerns about the ability to close the resultant defect.[8] However, if the diagnosis of malignancy has been confirmed, it may be better to manage an open wound than leave tumor cells behind.[10]

Figure 1. *A representation of a primary soft tissue tumor (**blue**), tumor pseudocapsule, and surrounding reactive zone (**yellow**), along with two satellite tumors (**light blue**); the lateral margins of the 4 levels of surgical resection are depicted (**dotted lines**): intralesional (**inner most black dotted line**), marginal (**black dotted line at the level of the pseudocapsule**), wide (**white**), and radical excision (**chartreuse**). Illustration by Michael Orencole.*

Surgical Planning

Careful surgical planning should be performed, as the first surgery is often the surgeon's best chance for achieving a positive outcome.

Multiple factors should be considered when determining aggressiveness of surgery:

- Type of tumor
- Short- and long-term prognosis
- Ability to achieve desired surgical margins, with an acceptable level of morbidity
- Concurrent disease
- Owner wishes
- Availability of adjunctive therapy, if needed following surgery.

Careful surgical planning should be performed, as the **first surgery** is often the surgeon's **best chance** for achieving a **positive outcome**.

Surgical Doses

1. **Intralesional**, or debulking, surgery is incomplete resection of a tumor (inside the pseudocapsule) with residual gross disease[10]; it is rarely an acceptable treatment for neoplastic diseases, whether benign or malignant. This technique leaves a tumor cell burden that is often too large to result in a positive outcome even with adjunctive treatments, such as radiation therapy and chemotherapy.[11]
2. **Marginal resection** is defined as removing the majority of the tumor just outside the tumor's pseudocapsule. This approach works well with lipomas and other benign tumors; however, it tends to fail with malignant neoplasms because satellite tumors are often left behind.[2] In some cases, marginal resection can be combined with adjuvant therapies, such as radiation or chemotherapy, to provide an optimum outcome.

   Excisional biopsy of a malignant tumor, without prior knowledge of tumor type, is essentially an unplanned marginal resection and should be avoided in most cases. Marginal resection of malignant tumors can complicate subsequent surgical interventions, which may require a more aggressive approach, as the remaining neoplastic cells are usually poorly defined.[2]
3. **Wide resection** is a form of curative-intent surgery: the intent is to resect macroscopic (primary tumor) and microscopic (satellite cells) tumor burdens, including biopsy tracks. This surgical dose is recommended over intralesional and marginal resections for treatment and management of solid tumors (see **Determining Surgical Margins**).[2]
4. **Radical resection** is removal of an entire tissue compartment. Examples include removal of

a complete organ, such as splenectomy to remove a splenic hemangiosarcoma or limb amputation to treat appendicular osteosarcoma. Depending on tumor location, type, and size, radical resection is occasionally needed to completely excise the primary tumor and its surrounding pseudocapsule and satellite tumor cells.

In some cases, adequate surgical margins may be too disfiguring, painful, or expensive; minimally advantageous; or simply incompatible with life.[2] Therefore, when planning radical resections, strongly consider patient quality of life.

Tissue Handling

Careful tumor handling is required to prevent exfoliation of cells and local recurrence.[2,6,8,9] To minimize seeding of neoplastic cells, avoid direct handling of the tumor and change surgical gloves and instrument packs between tumor excision and closure.

Surgical Closure

For some large defects in areas that can be easily bandaged (eg, extremity, trunk), consider leaving the wound open while awaiting the biopsy report. If the margins are not clean, resect additional tissue until a clean margin is obtained; then close the wound. This is particularly useful when the wound requires major reconstructive surgery, such as an axial pattern flap or skin graft.[14]

Make the decision to use a surgical drain during closure carefully, and avoid if possible. Placement of a drain may increase the chance of seeding neoplastic cells and complicate future resections, if the primary resection was incomplete.[2]

Tissue Analysis

Resected tissue should be properly prepared for analysis:

- If the resection is marginal, it is helpful to "pin" the tissue on cardboard, which prevents shrinkage during fixation.

DETERMINING SURGICAL MARGINS

In order to achieve a wide resection, excise a normal tissue margin en bloc with the gross tumor. Determine the width of the surgical margins by:

- Tumor type and grade, if appropriate (eg, mast cell tumors)[12]
- Biologic behavior
- Anatomic location
- Barrier provided by surrounding tissues (tumor resistant fascial layers).[2,9,10]

It is imperative to remember that margins are 3-dimensional:

- **Lateral margin** width is determined by tumor type and biologic behavior.
  - → **Benign tumors** and **most malignant carcinomas** can be completely resected with *1-cm lateral margins*.
  - → **Soft tissue sarcomas** can be resected with *3-cm lateral margins*.[2]
  - → **Mast cell tumors** are typically resected with *at least 2-cm lateral margins*, although grade 1 tumors may be adequately excised with *1-cm margins*.[12]

  In order to accurately achieve the desired lateral margin, use of a surgical marking pen and ruler is advisable **(Figure 2)**.

Figure 2. *Mark the lateral surgical margins with a surgical marking pen; for this soft-tissue sarcoma, the edge of the visible tumor is first marked, followed by marking a 3-cm lateral margin.*

- **Deep margins** tend to be the hardest to predict, and are universally determined by natural tissue barriers if deep margins (1–3 cm) are not possible.[1]
  - → **Fat, subcutaneous tissue, muscle, and parenchymal tissue** do NOT provide adequate barriers to tumor invasion or suffice as deep margins (**Figure 3**).[13]
  - → **Connective tissues, including muscle fascia, cartilage, and bone**, are resistant to neoplastic invasion, proving a natural tissue barrier.[13]

  Because of this protective barrier, deep margins should include removal of *at least 1 fascial plane*; however, vaccine-associated sarcomas require removal of *at least 2 fascial planes*.[9]

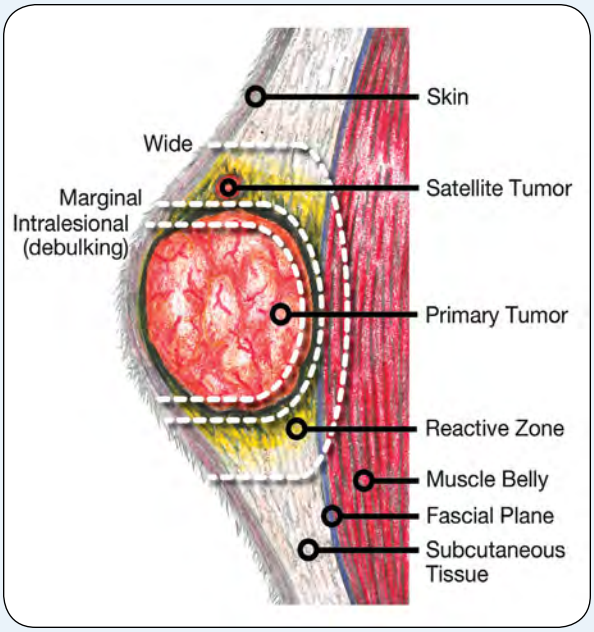

Figure 3. *Deep surgical margins are dependent upon the tissue layers and fascial planes, not actual measured depth. The intralesional margin is an incomplete resection inside the surrounding pseudocapsule (**black line**), marginal resection is dissection exterior to the surrounding pseudocapsule within the reactive zone (**yellow**), and wide margin resection removes both microscopic and macroscopic disease, including at least 1 fascial layer. Illustration by Michael Orencole.*

General Rules for Collecting Diagnostic Tissue Biopsies

1. Substantial tissue biopsies yield better diagnostic results.
2. Multiple tissue samples increase the overall understanding of the sampled site.
3. When handling tissue samples, take great care to avoid iatrogenic artifacts.
4. Always submit tissue samples to a pathologist along with pertinent, detailed information about the patient and tissues biopsied.
5. Remove any biopsy tracks or scars during tumor excision.
6. Fix tissue samples from needle-core, incisional, and excisional biopsies in 10% buffered formalin at a ratio of 10:1 (formalin:tissue).[8]

- Marking the surgical margins with ink (eg, India ink) or suture strands helps the pathologist determine the extent of tumor resection.
- With large tumors, making several partial thickness slices (ie, "loafing") with a scalpel blade ensures the entire sample is adequately fixed.
- Tissue should be promptly placed in formalin at a ratio of 10 parts formalin to 1 part tissue.[8]

Dirty Margins

Despite the surgeon's best efforts, biopsy analysis following resection occasionally reveals that the tumor was inadequately resected. Treatment of choice for most dirty margins is additional surgery to excise the surgical scar and an additional margin of normal tissue (at least 1 cm). If additional resection is not feasible due to tumor location, adjuvant therapy, such as radiation, may further eliminate the local tumor burden and decrease the chance for recurrence.[14]

IN SUMMARY

Surgery is the best tool we have to treat most neoplasms affecting our veterinary patients. Appropriate patient evaluation, surgical planning, and tissue handling are crucial to achieve a positive outcome. The veterinary surgeon should have a realistic and well-defined surgical plan that is:

- Consistent with the owner's wishes
- Capable of improving the patient's quality of life. ■

FNA = fine-needle aspiration

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