

The Principles of Surgical Oncology: Diagnosis and Staging*

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Abstract: The surgical treatment of neoplasms is one of the most common procedures performed in small animal practice. The proper approach to surgical oncology requires a knowledge of tumor types and their biologic behavior, different treatment modalities, and prognosis. A thorough physical examination is required to determine the presence and extent of a tumor, evaluate regional lymph nodes, and identify comorbid or paraneoplastic conditions that may influence anesthetic and surgical management. Various imaging modalities can be used for clinical staging to determine the location, size, and extent of a local tumor, as well as the presence of regional and distant metastasis. Biopsy of the tumor is often necessary to identify tumor type. Fine-needle aspiration, needle-core biopsy, incisional biopsy, or excisional biopsy may be used. The results of clinical staging tests and tumor biopsy are then used to ascertain treatment options and prognosis.

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Cancer is one of the major causes of death in cats and dogs, but it is also a treatable chronic disease. Even if treatment is ultimately not curative, the period between treatment and death is frequently associated with a better quality of life than would otherwise be afforded. The successful treatment of animals with neoplasia requires a positive, dedicated, but realistic approach by both the owner and veterinarian. Choosing the appropriate treatment requires a knowledge of the biologic behavior of tumors as well as treatment options. Treatment may need to integrate multiple disciplines, including surgery, medical oncology, and radiation oncology. This multimodality effort is aimed at maximizing the benefits of treatment and the potential for cure while minimizing adverse effects.^{1,2}

Surgery plays a pivotal role in oncology, particularly for the diagnosis and definitive treatment of solid tumors. Surgery is the most effective way to treat solid tumors, is noncarcinogenic, and is less immunosuppressive than radiation therapy and chemotherapy. Surgery also has a role in cancer prevention and palliation. Disadvantages to surgery include associated morbidity, such as func-

tional impairment (e.g., limb amputation), and cosmetic issues (e.g., radical bilateral maxillectomy).^{1,2}

A knowledge of the principles and proper practice of surgical oncology is essential to the appropriate management of cats and dogs with neoplasia. The principles involve diagnostic workup and clinical staging; knowledge of the indications for, limitations of, and techniques for surgical biopsy and resection; and an understanding of how surgery can be used in combination with other treatments such as radiation therapy. Appropriate planning and adherence to the principles of surgical oncology should address the following questions³:

- ▶ What are the type and stage of the tumor?
- ▶ Do the biopsy results correlate with the clinical presentation?
- ▶ What is the biologic behavior of the tumor?
- ▶ What is the proper surgical approach (e.g., intralesional, marginal, wide, radical resection)?
- ▶ What are the alternatives or adjuncts to surgical resection?
- ▶ What are the owner's expectations, and are these expectations reasonable?

*A companion article, "The Principles of Surgical Oncology: Surgery and Multimodality Therapy," is also available on CompendiumVet.com.

Signalment

Neoplasms tend to be diagnosed more commonly in older animals, but they can affect animals of any age. Tumors known to occur in younger animals include certain oral tumors (e.g., benign inductive fibroameloblastoma in cats, undifferentiated malignant oral tumors in dogs),⁴ renal nephroblastoma,⁵ and canine appendicular osteosarcoma (OSA).⁶ Age can provide some prognostic information. Malignant tumors in younger animals tend to have a more aggressive biologic behavior than the same disease in older animals, as in dogs with appendicular OSA.⁶ It is important to remember that age is not a disease; advancing age does not influence tumor biology or response to treatment and, hence, does not preclude the use of curative-intent treatment options such as aggressive surgery, full-course radiation therapy, or chemotherapy.^{7,8} Physiologic function and comorbid conditions should be the major factors in determining treatment options.⁸ In fact, most clinical reports detailing encouraging outcomes for neoplasms involve older animals. For example, the median survival time (MST) for 75 dogs (median age: 10.6 years) with surgically resected soft tissue sarcomas (STSs) was 1416 days,⁹ and the MST for 42 dogs (median age: 11.0 years) after liver lobectomy for massive hepatocellular carcinoma exceeded 1460 days.¹⁰ Breed and sex predispositions have been reported for various tumors but rarely provide useful diagnostic or prognostic information.

Physical Examination

The physical examination is important for the assessment of general health status as well as neoplastic and comorbid conditions. Findings may influence the selection of management options because certain conditions, such as paraneoplastic syndromes (e.g., cancer cachexia) and nonneoplastic concomitant diseases (e.g., renal failure, congestive heart failure), affect anesthetic and surgical management.

The physical examination should also be used to evaluate the primary tumor, regional lymph nodes, and any other tumors found. The characteristics of the primary tumor are important for clinical staging and may assist in determining treatment options (e.g., local resection versus limb amputation for extremity STS, depending on size and degree of fixation)

and prognosis. If regional lymph nodes are enlarged, firm, or fixed, then the diagnostic workup, treatment options, and prognosis may change because of the need for lymph node biopsy to determine whether the lymph node is reactive or metastatic. If it is metastatic, more aggressive surgery may be required for appropriate management, or another modality may be preferable to surgery (e.g., chemotherapy for dogs with a metastatic mast cell tumor [MCT]). However, although palpation of the regional lymph nodes is important during physical examination, it is not as accurate as either fine-needle aspiration (FNA) or biopsy, and, for tumors such as oral melanoma, assessment of regional lymph node status should not depend on palpation alone.¹¹ It is also essential to look beyond the presenting mass for other tumors. For example, multiple MCTs are reported in up to 14% of dogs and 20% of cats,¹² and 50% of dogs with adrenal pheochromocytomas have additional, unrelated tumors.¹³

Blood Tests

General blood tests, such as hematology and serum biochemistry panels, are important to identify conditions that may influence anesthetic and surgical management (e.g., anemia, hypoproteinemia, renal failure, liver failure) and paraneoplastic syndromes (e.g., hypercalcemia, hypoglycemia; **BOX 1**). More specific blood tests may be required for certain tumors, such as parathyroid hormone and parathyroid hormone-related protein assays for assessment of animals with hypercalcemia. Clotting times should be evaluated for certain breeds (e.g., Doberman pinscher), tumors (e.g., splenic hemangiosarcoma, mammary carcinoma), and procedures with a high risk of intraoperative hemorrhage (e.g., maxillectomy, chest wall resection, thyroidectomy). Unlike human oncology, tumor markers are not well established for the diagnosis and monitoring of animals with cancer.¹⁴

Tumor Biopsy

Biopsy provides essential information for diagnosis (neoplastic versus nonneoplastic, benign versus malignant), treatment options, and prognosis. There are four main types of biopsy technique: FNA, needle-core biopsy, incisional biopsy, and excisional biopsy. Regardless of the technique performed, the same instruments should not be used to sample multiple

QuickNotes

Surgical oncology requires a knowledge of tumor biology, biologic behavior, treatment modalities, and prognosis.

BOX 1

Common Paraneoplastic Syndromes and Their Associated Tumor Types⁷

- ▶ Hypercalcemia
 - ▶ Apocrine gland adenocarcinoma of the anal sacs
 - ▶ Lymphoma (especially cranial mediastinal)
 - ▶ Multiple myeloma
 - ▶ Thymoma
- ▶ Hypoglycemia
 - ▶ Insulinoma
 - ▶ Leiomyosarcoma
 - ▶ Hepatic tumors
- ▶ Hypertension
 - ▶ Adrenal pheochromocytoma
 - ▶ Adrenocortical adenoma/adenocarcinoma
- ▶ Hypotension
 - ▶ Mast cell tumor
- ▶ Hyperviscosity
 - ▶ Multiple myeloma
 - ▶ Lymphoma
- ▶ Coagulopathy
 - ▶ Hemangiosarcoma
 - ▶ Thyroid carcinoma
 - ▶ Mast cell tumor

masses because of the risk of contamination. Samples of cells or tissue are submitted for cytologic or histopathologic analysis, respectively. The ideal biopsy technique should simply and safely procure an adequate sample of tissue and consistently result in an accurate diagnosis.² Faulty techniques and instruments can damage the sample, resulting in an incorrect diagnosis or failure to make a diagnosis.¹⁵ Biopsy results enable the oncologist to determine the (1) type of tumor, (2) biologic behavior of the tumor, (3) appropriate level of aggression for surgical resection (surgical dose), (4) need for adjunctive therapy, and (5) likely prognosis. **BOX 2** provides a clinical example of this information.

However, a biopsy is not required for every tumor before definitive treatment (**BOX 3**). The three principal reasons for performing a biopsy are if the results may affect one or more of the following^{15,16}:

BOX 2

Clinical Example: Application of Biopsy Results for a Vaccine-Associated Sarcoma

Presentation: Rapidly growing, fixed, ulcerated, subcutaneous mass in the interscapular region of a cat.

Biopsy technique: FNA or incisional biopsy.

Diagnosis: Vaccine-associated sarcoma (VAS).

Clinical application of biopsy result:

- ▶ Rules out other possible neoplastic and nonneoplastic diseases.
- ▶ Is consistent with the clinical presentation of the mass. A diagnosis of benign inclusion cyst, for example, would not be consistent with the clinical behavior of a mass in an area typical of VASs, indicating the need for a second opinion.
- ▶ Allows prediction of the biologic behavior of the tumor to dictate treatment options, including surgical dose and combination with other therapies. Local tumor recurrence is common in cats with VAS, but distant metastasis is uncommon and occurs in fewer than 25% of cases. For this reason, aggressive local treatment is required to control local disease and decrease the risk of local recurrence (i.e., wide surgical resection with a minimum of 3 to 5 cm for lateral margins and two fascial planes for deep margins, in combination with either preoperative or postoperative radiation therapy but not chemotherapy).^a
- ▶ Allows determination of prognosis from tumor type and biologic behavior. For a cat with a VAS, the median survival time is 2 months if the tumor is incompletely resected, 9 to 16 months if it is completely excised with wide surgical resection, and up to 23 months if surgical resection is combined with radiation therapy.^{27,28,b}
- ▶ Permits the owner to make an informed decision with a realistic expectation of the outcome.

^aLiptak JM, Withrow SJ. Cancer of the gastrointestinal tract: oral tumors. In: Withrow SJ, Vail DM, eds. *Small Animal Clinical Oncology*. 4th ed. Philadelphia: Saunders Elsevier; 2007:455-475.

^bCohen M, Wright JC, Brawner WR, et al. Use of surgery and electron beam irradiation, with or without chemotherapy, for treatment of vaccine-associated sarcomas in cats: 78 cases (1996-2000). *JAVMA* 2001;219:1582.

- ▶ Treatment options (e.g., mandibulectomy or maxillectomy for most oral tumors versus coarse-fraction radiation therapy for an oral melanoma)
- ▶ Extent of treatment (e.g., less than 1 cm lateral surgical margins for a benign histiocytoma versus 3 cm lateral surgical margins for a cutaneous STS)
- ▶ Owner's willingness to treat (e.g., if an owner is averse to chemotherapy, biopsy of a suspected primary bone tumor can differentiate rib and appendicular OSA, for which chemotherapy is recommended, from other primary bone tumors that do not require adjuvant chemotherapy, such as chondrosarcoma)

BOX 3

Masses That May Not Require Preoperative Biopsy**▶ Suspected primary splenic tumor**

- ▶ Results will not change treatment options (splenectomy).
- ▶ Biopsy-related complications include increased risk of hemorrhage from the tumor and seeding the peritoneal space with tumor cells.
- ▶ Most splenic biopsy results are not diagnostic because of the high risk of blood contamination.⁴⁷

▶ Suspected isolated lung mass

- ▶ Results will not change treatment options (lobectomy).
- ▶ Biopsy-related complications include increased risk of seeding the pleural space with neoplastic cells or infected material and complications of a blind or guided percutaneous intrathoracic biopsy (hemothorax, pneumothorax, iatrogenic cardiac puncture).²²

▶ Suspected primary bone tumor with typical signalment and presentation

- ▶ Results will not change treatment options (limb amputation or limb-sparing surgery).
- ▶ Biopsy-related complications include pathologic fracture through the biopsy tract and treatment delays because of processing time and incorrect results (e.g., reactive bone).^a
- ▶ An exception to no preoperative biopsy in dogs with a suspected primary bone tumor is if the willingness of the owners to treat is changed by the biopsy results. For example, a preoperative biopsy should be performed if an owner does not want to treat his or her dog with chemotherapy because chemotherapy is required for curative-intent treatment in dogs with appendicular osteosarcoma but not chondrosarcoma.

▶ Tumors for which the biopsy procedure carries the same risks as definitive surgery (e.g., tumors of the brain and spinal cord).¹⁶

^aWykes PM, Withrow SJ, Powers BE. Closed biopsy for diagnosis of long bone tumors: accuracy and results. *JAAHA* 1985;21:489-494.

Fine-Needle Aspiration

In general, the likelihood of an accurate diagnosis improves with biopsy techniques that procure a larger volume of tissue.¹⁵ However, FNA is economical, does not require sedation or general anesthesia, can be diagnostic for certain tumor types (e.g., MCT), and guides therapy by differentiating nonneoplastic from neoplastic diseases and classifying tumors as round cell, epithelial cell, or mesenchymal (spindle) cell.¹⁷

FNA is readily performed on cutaneous and subcutaneous lesions, but accurate aspiration of samples from within intracavitary structures (e.g., retrobulbar space, thoracic cavity, abdominal cavity) may require guidance via

ultrasonography or computed tomography (CT).¹⁸ Cytologic assessment of FNA samples provides better information about cytoplasmic and nuclear detail than histopathologic evaluation of surgical biopsy samples, but surgical samples provide better information about structural and architectural detail.¹⁹ The techniques of FNA and proper slide preparation are discussed in detail elsewhere.²⁰

The diagnostic accuracy of FNA depends on technique, tumor type, and tumor location. For most tumors, it is lower than that of needle-core, incisional, or excisional biopsy, but the cost, complexity, and potential complications of FNA are decreased compared with the other techniques. The accuracy of FNA is improved by using 21-gauge or larger hypodermic needles, with a minimum of 10 insertions into the mass.²¹ In general, FNA is more accurate for cutaneous and subcutaneous lesions than for intracavitary lesions, particularly splenic and hepatic masses.^{17,22} It is also more sensitive for round cell and epithelial tumors (70% to 100% and 67% to 98%, respectively) than for mesenchymal tumors (50% to 61%)^{17,18} because epithelial and round cell tumors exfoliate large numbers of cells in sheets, whereas spindle cell tumors exfoliate cells individually and in low numbers. Between 13% and 35% of FNA samples are nondiagnostic, usually because of hemodilution and blood contamination.^{18,22} Overall accuracy rates range from 64% to more than 90%, with sensitivities and specificities from 64% to 96% and 65% to 100%, respectively.^{17,18}

Needle-Core Biopsy

Needle-core biopsy provides a small volume of tissue for impression smears or histopathology. Examples of techniques include TruCut needle-core biopsy for samples from organs and other soft tissue structures and Jamshidi needle-core biopsy for bone samples. Ultrasound-guided biopsies of intraabdominal organs can be performed with specialized needle-core biopsy instruments.

Sedation and local anesthesia are usually sufficient for obtaining needle-core biopsy samples.^{15,16} Local anesthesia is not required for needle-core biopsy of oral tumors, which are poorly innervated, but should be used in the overlying skin for cutaneous and subcutaneous lesions so a small incision can be made for

insertion of the biopsy needle.^{15,16} The infiltration of local anesthetic agents into or adjacent to the tumor should be avoided because of an increased risk of metastasis and distortion of histologic architecture.² Once the biopsy has been performed, the core of tissue should be carefully removed with a scalpel blade, hypodermic needle, or fine tissue forceps to avoid iatrogenic damage to the sample.¹⁵ In general, the diagnostic accuracy of needle-core biopsy is superior to that of FNA but inferior to that of incisional or excisional biopsy.¹⁶ As a result, obtaining multiple needle-core biopsy samples is often recommended to improve diagnostic accuracy.^{16,23}

The diagnostic accuracy of needle-core biopsy for neoplastic diseases is excellent, with reported sensitivities, specificities, and positive predictive values as high as 96%, 97%, and 96%, respectively, and 100% of epithelial cell tumors and 94% of mesenchymal tumors correlating with surgical biopsy results.¹⁹ Complications are rare but include fistula formation, hemorrhage, infection, and tumor seeding.²²

Incisional Biopsy

Incisional biopsy techniques, which include wedge and punch biopsy, are recommended in most cases, especially for soft, friable, inflamed, and necrotic tumors; peripheral lymph nodes; and masses located on the extremities.^{15,16} Incisional biopsy can be performed using sedation and local or regional anesthesia, but general anesthesia is occasionally required. As with needle-core biopsy, incisional biopsy can be performed using sedation without local anesthesia in dogs with oral tumors.¹⁵

An incisional biopsy sample should include a junction between normal and abnormal tissue so that tumor invasion into normal tissue can be assessed.^{15,23} However, some surgeons believe that this may disrupt and extend the tumor margins because cellular activity is greatest in the peripheral aspects of the tumor.^{1,15} Normal tissue should not be included in the biopsy sample if it will be required for reconstructive procedures after definitive resection. Incisional biopsy should not be performed in areas of inflammation, necrosis, or ulceration because this increases the possibility that the sample will not be representative of the disease process.^{15,16} Aseptic technique

with meticulous hemostasis and reduction of dead space is required to minimize the risk of complications such as hematoma and tumor spread.¹⁵ Drains should not be used because tumor cells will seed along the drainage tract and potentially complicate definitive surgical resection¹⁵ (**FIGURE 1**).

When performing an incisional biopsy, it is important to plan the location and direction so that the biopsy scar and tract, which are contaminated with tumor cells, can be resected en bloc with the tumor, using appropriate surgical margins. Poorly planned surgical biopsies can have a dramatic impact on case management by increasing the surgical dose required for complete resection, limiting treatment options, or making further treatment impossible.^{24–36} For example, incisional biopsy of an oral mass through the overlying lip¹⁶ would spread tumor cells into the lip, which is rarely involved in oral tumors, subsequently requiring either a more aggressive surgical resection to remove the biopsy tract through the lip or the use of radiation therapy in combination with surgical resection because of the increased risk of incomplete resection. Such a biopsy approach may also make it impossible to resect the tumor and adequately reconstruct the defect because the labial mucosa is no longer available for reconstruction. To avoid inappropriate approaches, the incisional biopsy should be performed by the same surgeon who will undertake definitive surgery so that both the primary tumor and biopsy tract can be resected en bloc without compromising the ability to completely excise the tumor or the functional and cosmetic outcome.^{1,26}

Excisional Biopsy

The role of excisional biopsy is controversial. Excisional biopsy is one of the more commonly performed techniques in veterinary medicine because of its potential to combine both diagnosis and therapy in a single procedure.¹⁶ Ideally, it is considered the procedure of choice only if it can be performed without contaminating new tissue planes or further compromising the ultimate surgical procedure. However, this is often not possible in cats and dogs with neoplasia, and without prior knowledge of tumor type, the chance that an excisional biopsy will be therapeutic as well as diagnostic is random. Hence,

QuickNotes

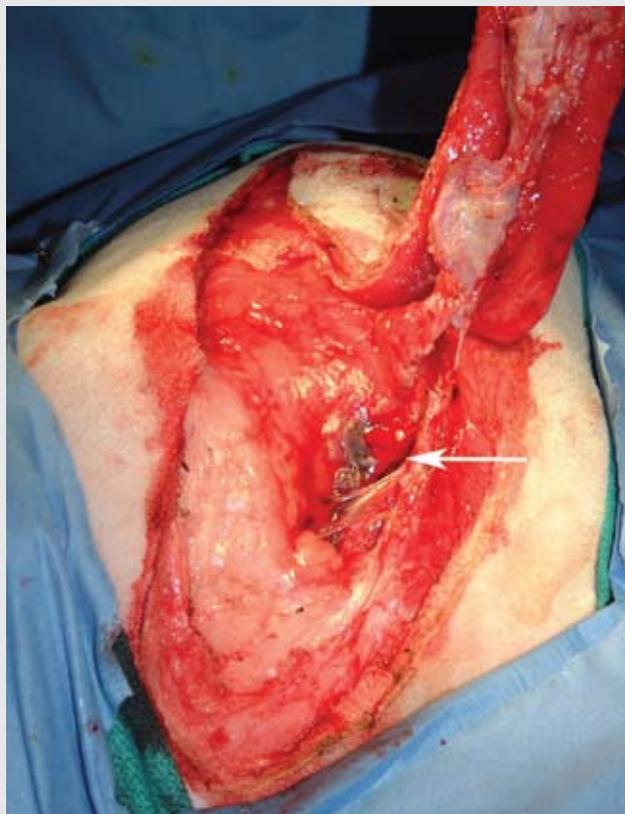
Clinical staging tests are used to determine local tumor characteristics and identify metastatic disease in regional lymph nodes and distant sites.

FIGURE 1

Consequences of drain use after tumor resection.



A Penrose drain was used after resection of a soft tissue sarcoma on the lateral thigh of a dog. However, the tumor was incompletely resected, and the drain stoma (arrow) was consequently considered contaminated with tumor cells. The drain site extended the margins for definitive surgery by approximately 5 cm.



The drain also extended the deep margins (arrow), resulting in the inability to achieve complete surgical resection of this contaminated surgical scar. Because of the inappropriate use of a drain in this dog, more extensive surgery and adjunctive radiation therapy were required than would have otherwise been needed. Drains should not be used in oncologic surgery and cannot compensate for poor hemostatic technique.

an excisional biopsy should only be performed when treatment will not be affected by knowledge of the tumor type (e.g., splenic tumor).¹⁵ A less invasive biopsy procedure, such as FNA or needle-core biopsy, may provide sufficient information to plan the definitive surgical procedure and is preferable to excisional biopsy.

The initial surgical procedure provides the best chance for a cure and should not be compromised by inadequate planning.^{2,3} For example, the MST for cats after unplanned excisional biopsy of a VAS is 2 months, which is significantly worse than the MST of up to 16 months after an appropriately planned, curative-intent resection.^{27,28} Likewise, an excisional biopsy of a cutaneous MCT, which

can be easily diagnosed with FNA cytology, will result in incomplete excision because of insufficient margins if the tumor type is not known before surgical resection. This confers unnecessary risk because of the need for further anesthesia and more extensive surgery or radiation therapy. Also, local tumor recurrence significantly decreases survival time in dogs with MCTs.²⁹

If an excisional biopsy must be performed, it should be carefully planned with the knowledge that surgical resection of the biopsy tract will be required if the mass is not completely excised. This may be appropriate for tumors located in areas with sufficient soft tissue coverage to allow subsequent resection and primary closure, such as the lateral thoracic and

abdominal walls, but is not recommended for areas with limited tissue availability, such as the head and limbs.

Histopathology

Tissue samples from needle-core, incisional, and excisional biopsies should be fixed in 10% buffered formalin at one part tissue to 10 parts formalin.^{1,15,26} Brain, peripheral nerve, eye, and muscle tissue require special handling techniques and fixatives.¹⁶ All samples should be submitted to a veterinary pathologist because the histologic type and grade of tumor are often important in treatment planning. If the biopsy results do not correlate with the clinical presentation, then the clinician should discuss the case with the pathologist and request resectioning, special stains (e.g., toluidine blue for MCTs or immunohistochemistry), or a second opinion from another pathologist.^{2,15,23} Histopathologic confirmation is still required after definitive surgical resection, as biopsies only sample a small region of the tumor and may not be representative of the true tumor type because of tumor heterogeneity. For example, appendicular OSA is often misdiagnosed as fibrosarcoma or chondrosarcoma based on needle-core biopsy results because of the fibroblastic or chondroblastic proliferation in some OSAs.¹⁶

Clinical Staging

If a tumor is considered to be malignant on the basis of either clinical suspicion or biopsy confirmation, clinical staging should be done to describe the extent of the local tumor and the presence of regional and distant metastatic disease. Palpation and imaging are used to determine the size of the primary tumor and degree of local invasion (**FIGURE 2**). A biopsy is recommended in most cases for preoperative diagnosis of the primary lesion.

Local Tumor Imaging

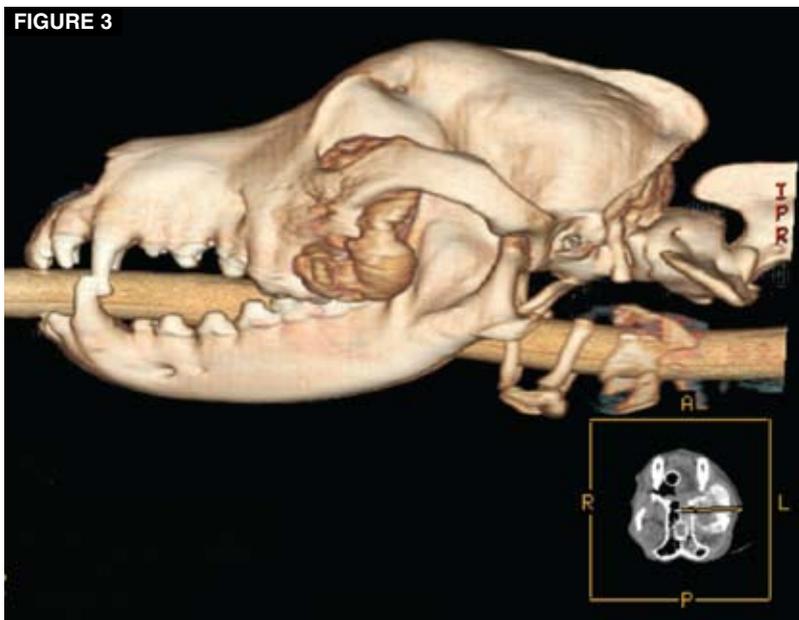
Imaging of the primary tumor is important for evaluating tumor location and degree of involvement with adjacent structures and for surgical planning. A number of imaging modalities are available for these purposes. Radiography is recommended for assessing the presence and extent of tumors of the appendicular and axial skeleton, lungs, and cranial mediastinum.



Magnetic resonance imaging (MRI) scan of a cat with an interscapular vaccine-associated sarcoma (VAS). On palpation, the mass was mobile, well circumscribed, and approximately 2 cm in diameter. However, the contrast-enhanced MRI scan shows tumor extension well beyond these margins (arrows), involving more than 25% of the circumference of the cat at this level. As a result of this MRI scan, surgery was not recommended, and the cat received palliative radiation therapy. Gadolinium-enhanced MRI scanning is recommended for imaging local tumors in cats with a suspected VAS to determine whether the mass can be excised with adequate surgical margins.

Ultrasonography

Ultrasonography is a useful and cost-effective tool for the evaluation of intraabdominal neoplasms, particularly hepatic, adrenal, and urogenital tumors, and sublumbar node metastasis. Ultrasonography can also be used to guide FNA and needle-core biopsy for relatively noninvasive tissue sampling. Newer developments in ultrasound technology that have proved useful in the evaluation of primary tumors include Doppler ultrasonography to assess tumor vascularity (e.g., thyroid carcinomas in dogs) and contrast-enhanced harmonic ultrasonography for differentiation of benign from malignant hepatic and splenic tumors.³⁰ As an example of the benefits of ultrasonography in surgical planning, it can be used to differentiate noninvasive from invasive adrenal tumors.²⁷ The anesthetic and surgical planning of adrenalectomy



Computed tomography (CT) of a dog with suspected multilobular osteochondrosarcoma of the inferior orbit is used to provide three-dimensional reconstructed images that enable the surgeon to determine tumor size and accurately plan surgical margins and approach. CT is preferred for imaging of bone and intrathoracic masses.

tomy for an isolated adrenal tumor is less complicated than an adrenalectomy with en bloc thrombectomy via partial cavotomy.³¹

Nuclear Scintigraphy

Nuclear scintigraphy has some distinct advantages in the diagnostic workup of certain tumor types. For instance, whole-body bone scanning using radiolabeled technetium-99m hydroxymethylene diphosphate is particularly useful for the detection of asymptomatic synchronous or metastatic OSA lesions. In one study,³² 7.8% of 399 dogs with appendicular OSA were found to have a second, asymptomatic bone lesion using nuclear scintigraphy. This has important implications for case management, as these dogs are no longer candidates for limb amputation because of the risk of pathologic fracture and catastrophic failure through the second lesion. Whole-body bone scanning can also be used to plan surgical margins for dogs undergoing limb-sparing surgery.³³ Other indications for nuclear scintigraphy include glomerular filtration rate scanning (with technetium-99m diethylenetriaminepentaacetic acid) for evaluation of renal function before planned nephrectomy for primary renal tumors or tumors with

secondary renal involvement,³⁴ technetium-99m scanning for cats and dogs with functional thyroid tumors to identify ectopic or metastatic disease,³⁴ and somatostatin receptor scanning (with indium-111 pentetate) to identify primary and metastatic lesions in dogs with functional pancreatic insulinomas.³⁵

Computed Tomography and Magnetic Resonance Imaging

Advanced imaging techniques such as CT and magnetic resonance imaging (MRI) have revolutionized the management of animals with neoplasia. For example, before the advent of these imaging modalities, the localization of brain tumors was often based on clinical signs alone, but now CT and MRI scans are used to provide accurate three-dimensional information about tumor location for stereotactic CT-guided biopsy, radioablation, and surgical resection.³⁶ In general, CT is preferred for the evaluation of bones and MRI for soft tissue structures, but there is considerable overlap. CT is recommended for evaluation of primary tumors of the axial skeleton, particularly the skull (**FIGURE 3**), vertebral and pelvic tumors, and primary and metastatic intrathoracic tumors (because the quality of MRI is decreased by respiratory motion).³⁷ CT is faster than MRI but has lower contrast resolution and requires iodinated contrast agents and ionizing radiation.³⁷

MRI is preferred for tumors of the central (**FIGURE 4**) and peripheral nervous system and, perhaps, intraabdominal organs.³⁷ In addition, MRI has higher soft tissue resolution than CT and does not use iodine-based contrast agents. However, MRI takes longer to perform, metallic implants are a contraindication, and artifacts are common, particularly with motion.³⁷ Ultrasonography can provide similar information to MRI for localization and surgical planning of intraabdominal neoplasms, but tumor characteristics on T1- and T2-weighted MRI may provide further information on tumor type.³⁸

Positron-emission tomography, which provides in vivo information on biochemical and physiologic processes such as glucose metabolism, is not widely available in veterinary medicine.³⁹

Advanced imaging should be performed before biopsy because tissue may be distorted

QuickNotes

Four biopsy techniques exist: fine-needle aspiration, needle-core biopsy, and incisional and excisional biopsy.

by the biopsy procedure or resultant complications, such as seroma or hematoma formation.

Lymph Node Staging

Lymph node status is important in the clinical staging of cancer in cats and dogs. Regional lymph nodes should be carefully palpated for enlargement, asymmetry, and degree of fixation. However, caution should be exercised when making clinical judgments of metastasis to the regional lymph nodes based on palpation alone because lymph node size is not an accurate predictor of metastasis. In one study of 100 dogs with oral malignant melanoma, 40% of dogs with normal-sized lymph nodes had metastases and 49% of dogs with enlarged lymph nodes did not.¹¹ Therefore, biopsy is recommended to determine regional lymph node status in animals with malignant disease. FNA is usually sufficient, but incisional or excisional biopsy is sometimes required.

The sentinel lymph node (SLN) is a significant concept in human surgical oncology, based on the theory that the metastatic process occurs in an orderly progression within the lymphatic system, with tumor cells draining into a specific lymph node (i.e., the SLN) in a regional lymphatic field before draining into other regional lymph nodes.⁴⁰ The SLN has a major role as a filter and barrier for disseminating tumor cells.⁴⁰ Conceptually, distant metastasis should not be present if there is no evidence of tumor burden in the SLN, but distant metastasis is possible if the SLN is positive for tumor cells. Hence, the status of the SLN may reflect the status of the entire regional lymphatic bed.⁴⁰⁻⁴³ In human medicine, determining the SLN is crucial to the diagnosis of lymph node metastasis, early identification of patients requiring additional therapy to manage metastatic disease, and establishment of prognosis.⁴⁴ However, the concept of the SLN has not yet been widely tested or accepted in veterinary medicine.

Distant Metastasis Staging

Three-view thoracic radiography is commonly used in the clinical staging of animals with cancer to evaluate for the presence of pulmonary metastasis. Right and left lateral thoracic projections are necessary because increased perfusion and atelectasis in the dependent lung fields result in poor contrast with meta-

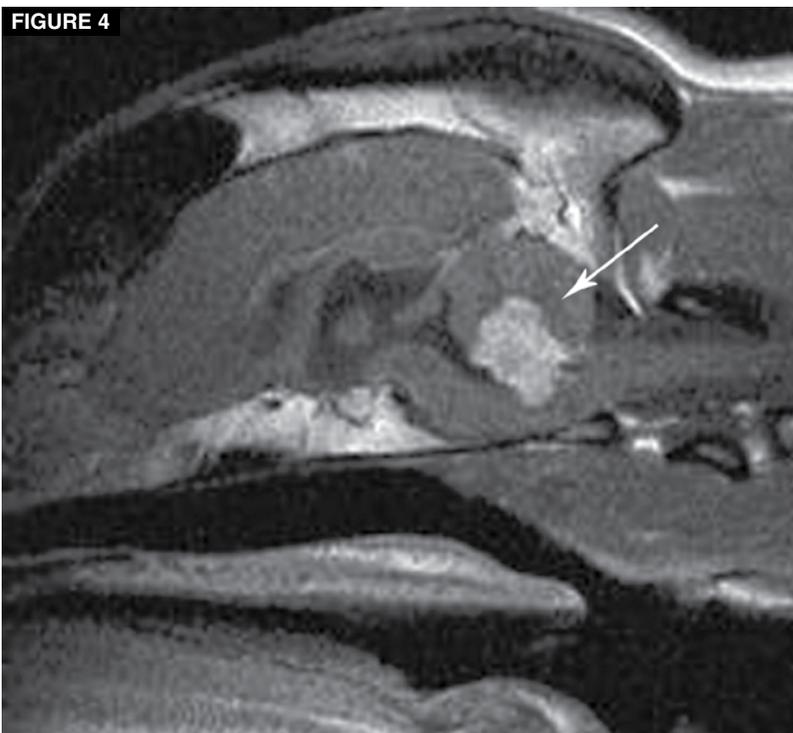


FIGURE 4
MRI of a dog presenting with hemiparesis showing a contrast-enhanced extraaxial intratentorial mass in the brainstem (arrow). The location and MRI appearance of the mass were consistent with a meningioma. Advanced imaging has revolutionized the treatment of intracranial tumors by providing accurate information on tumor location, thus enabling the surgeon to determine resectability and plan the surgical approach.

static lesions, which also have a soft tissue density (FIGURE 5). The nondependent lung fields have better ventilation, which (combined with greater lesion-to-film magnification) increases the possibility of detecting metastatic lesions (FIGURE 6). Using high-detail screens, metastatic lesions as small as 6 mm can be detected on thoracic radiographs.⁴⁵ Thoracic CT is more sensitive than radiography for the detection of metastatic lesions and can delineate lesions as small as 1 mm.⁴⁶

The imaging modalities used to assess for the presence of metastatic disease are tailored to the tumor type. For example, three-view thoracic radiography is indicated to assess for pulmonary metastasis of a wide range of tumors, particularly visceral hemangiosarcoma and appendicular OSA,^{45,47} but not for canine MCT (in which pulmonary metastases are very rare).¹² Abdominal ultrasonography and guided FNA of the spleen and liver are recommended to evaluate for systemic mastocytosis in dogs with high-grade MCT and also for metastasis in dogs with histiocytic sarcoma.¹²

FIGURE 5

Radiographs of a dog with appendicular OSA.

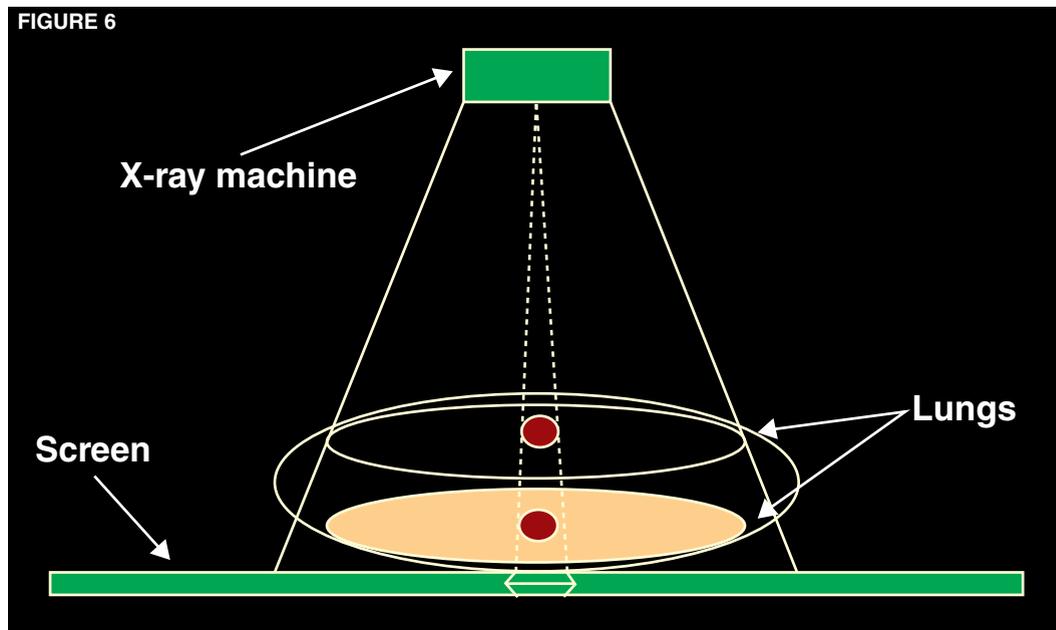


Right lateral thoracic view. Metastatic lesions are not visible.



Left lateral thoracic view. A suspected metastatic lesion is seen superimposed over the cardiac silhouette (arrow). Left and right lateral views of the thorax are recommended because atelectasis and increased perfusion in the dependent lung fields result in insufficient contrast for the detection of pulmonary metastasis.

FIGURE 6



Three-view thoracic radiography is recommended for evaluation of pulmonary metastasis because (A) the dependent lung fields have increased soft tissue density because of atelectasis and increased perfusion, which results in poor contrast with metastatic lesions; (B) the nondependent lung fields are well aerated, which provides better contrast with metastatic lesions that have a soft tissue density; and (C) the distance of metastatic lesions in the nondependent lung fields from the screen results in better magnification.

Nuclear scintigraphy is used to assess for bone metastasis in dogs with appendicular OSA.²⁸ Based on these findings, tumors are clinically staged according to a specific system.

The World Health Organization's TNM staging system is frequently used in veterinary medicine. In this system, *T* represents characteristics of the primary tumor, *N* represents the

TABLE 1 The World Health Organization's TNM Classification Scheme for Tumors in Domestic Animals⁴⁸

T	Primary Tumor
T0	No evidence of tumor
T1	Tumor diameter <1 cm and noninvasive
T2	Tumor diameter 1–3 cm or locally invasive
T3	Tumor diameter >3 cm or locally invasive or ulcerated
N	Regional Lymph Node
N0	No evidence of regional lymph node involvement
N1	Regional lymph node firm and enlarged
N2	Regional lymph node firm, enlarged, and fixed to surrounding tissue
N3	Lymph node involvement beyond regional lymph nodes
M	Distant Metastasis
M0	No evidence of distant metastasis
M1	Metastasis to one organ system
M2	Metastasis to more than one organ system

regional lymph nodes, and *M* represents distant metastasis (TABLE 1).⁴⁸ Other staging systems are occasionally used for specific tumor types because of their prognostic importance, such as splenic hemangiosarcomas, for which stage I tumors (localized) have a significantly better prognosis than either stage II (ruptured)

or stage III (metastatic) tumors.⁴⁷ All staging systems are used to facilitate communication between veterinary oncologists, monitor response to treatment, and provide prognostic information⁷; therefore, regardless of the system used, tumor staging should be done in a standardized, reproducible manner.

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QuickNotes

Fine-needle aspiration is recommended for sampling accessible tumors because it is minimally invasive, associated with less morbidity than other techniques, and helpful in differentiating neoplastic from benign tumors and categorizing tumor types.

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3 CE
CREDITS

CE TEST

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1. **A biopsy should be performed if the results will affect the**
 - a. treatment options.
 - b. extent of treatment.
 - c. owner's willingness to treat.
 - d. all of the above

2. **A preoperative biopsy should usually be performed for a _____ mass.**
 - a. cutaneous
 - b. lung
 - c. splenic
 - d. cerebellar

3. **Which statement regarding the diagnostic accuracy of FNA is correct?**
 - a. It is lowest for round cell tumors.
 - b. It is highest for intracavitary tumors.
 - c. It is lowest for mesenchymal tumors.
 - d. It is improved by using needles smaller than 21 gauge.

4. **Which statement about diagnosis of lymph node metastasis in dogs is true?**
 - a. Lymph nodes that are normal on palpation do not have metastasis.
 - b. Lymph nodes that are enlarged on palpation have metastasis.
 - c. Lymph node palpation has a high sensitivity for the detection of metastasis.
 - d. Lymph node aspiration is recommended for diagnosis of metastasis.

5. **The most sensitive technique for the detection of pulmonary metastasis is**
 - a. three-view thoracic radiography.
 - b. CT.
 - c. MRI.
 - d. nuclear scintigraphy.

6. **MRI is better than CT for local staging of _____ tumors.**
 - a. brain
 - b. skull
 - c. lung
 - d. vertebral

7. **Left lateral, right lateral, and ventrodorsal or dorsoventral thoracic radiographs are taken for evaluation of pulmonary metastases because metastatic lesions in the nondependent lung fields are**
 - a. better visualized because of larger metastatic lesions.
 - b. better visualized because of the contrast against aerated lung fields and magnification.
 - c. poorly visualized because of lack of contrast against perfused and poorly aerated lung fields.
 - d. poorly visualized because of smaller metastatic lesions.

8. **Nuclear scintigraphy is recommended for the clinical staging of**
 - a. appendicular OSA.
 - b. soft tissue sarcoma.
 - c. MCT.
 - d. primary lung tumor.

9. **Use of a drain in cancer surgery increases the**
 - a. extent of a tumor if surgical resection is incomplete.
 - b. risk of infection.
 - c. risk of metastasis.
 - d. risk of local tumor recurrence.

10. **What is the diagnostic accuracy of FNA biopsy for diagnosis of mesenchymal tumors?**
 - a. 30% to 45%
 - b. 50% to 61%
 - c. 67% to 98%
 - d. 70% to 100%