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PRINCIPLES OF RECONSTRUCTIVE SURGERY

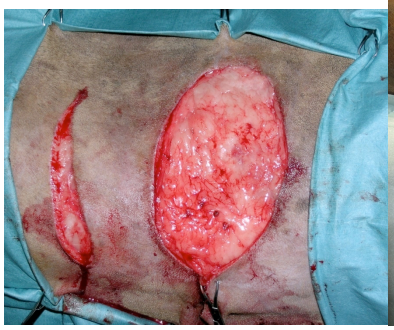
Reconstructive surgery is often necessary to close defects derived by trauma or *en bloc* excision of tumours.
Regarding oncological surgery, the first principle to address is that it is essential to remove any part being suspected as or containing tumour. This should be *performed the first time*, i.e. when surgery has the best chance to be really curative or, at least, to control the primary tumor. The second principle is that it is better to allow a second intention healing rather than leaving some neoplastic tissue because its removal complicates the primary closure of the wound. Several techniques provide the possibility of reconstruction when an aggressive removal does not allow a primary direct closure. A correct preoperative planning should be opportunely prepared (extent of trichotomy, surgical preparation of the entire area, etc). In general it is preferable to perform geometrical wound as these are easier to reconstruct.

Reconstructive procedures are referred to as 1) tension-relieving techniques, 2) local flaps, 3) distant flap techniques, axial pattern flaps, free grafts, myocutaneous and muscle flaps. In some instances omentalization may also be useful as the great omentum may provide protection, immunological defence, and support for an early granulation. Even absorbable or, more frequently, non absorbable meshes may be used as a support. Pavletic (2010) offers a complete description of these techniques.

1) **SECOND INTENTION HEALING** and tie-over.
Consider also the use of VAC (Vacuum systems) to speed granulation.

2) TENSION-RELIEVING TECHNIQUES (Pavletic 2010)

- undermining (below the panniculus layer, if present, to preserve the subdermal plexus and associated direct cutaneous vessels) and stretching. After that closure is possible in many cases. Skin suture should not be under tension
- create geometric wounds (triangular, squared, rectangular to facilitate closure; start closure from angles)
- Y-U plasty, Z-plasty
- release incision / multiple release incisions (distal limbs)
- walking sutures
- tension suture pattern / retention sutures


single release incision


multiple release incisions


tension suture pattern

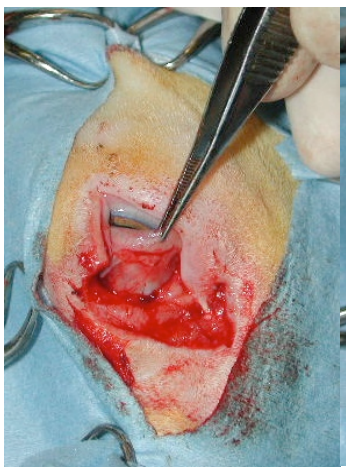
3) **LOCAL FLAPS**. They are NOT based on a precisely defined vascularisation. When present, they must be elevated including the panniculus layer. The base should be large enough to support the perfusion of the subdermal plexus of the entire flap being elevated; even its length should be proportional to the base of the flap in order to avoid necrosis of the most distal part. They may be: advancement and rotating flaps.

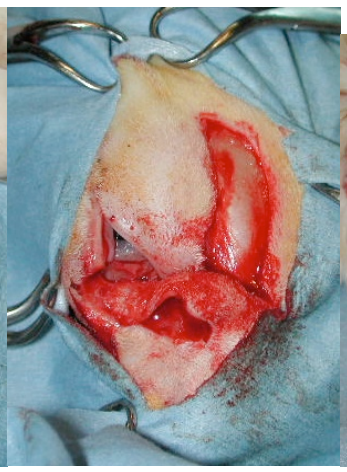
a) *Advancement flaps* are usually used to close squared or rectangular defects; the width of the flap should be equal to the defect's width. To close the defect one or two flaps (H plasty) may be used.


Single advancement flap


Double advancement flaps (H plasty)

b) *rotating (pivoting) flaps.* The most used are
- *Transposition flap:* the flap is rotated, usually between 45-90°; its width should be equal to the defect's width and its base is aligned along one defect's margin.





(Schmidt K, Bertani C, Martano M, Morello E, **Buracco P**. Reconstruction of the lower eyelid by third eyelid lateral advancement and local transposition cutaneous flap after "en bloc" resection of squamous cell carcinoma in 5 cats. Vet Surg. 2005, 34(1):78-82)

- *Interposition (interpolation) flap.* In this case there is the lack of a common border. The defect is reached through a “bridge” incision.

4) DISTANT FLAPS (Pavletic, 2010)

Their vascularization is similar to that of local flaps. In the past they were mostly used to cover defects of the limbs. At present they are very rarely used as free grafts and axial pattern flaps are easier to manage. They may be:

- *direct:* single pedicle or bipedicle coming from the inferior part of the thorax or abdomen. The pedicles are progressively divided in 15-20 days. An important disadvange is the need to immobilize the limb.

Pouch technique. Usually this technique is used for an intercalary limb defect (with the limb extremity exiting through the pouch) and not for a distal defect as shown in this case.

- *indirect:* usually they are constructed as tubed-flaps that in 2-3 weeks are progressively cut at one end, reopened, rotated and trasferred.

Indirect flap. In 2-3 weeks one extremity is resected, the tube is opened and transposed by rotation (even creating a bridge incision, if needed)

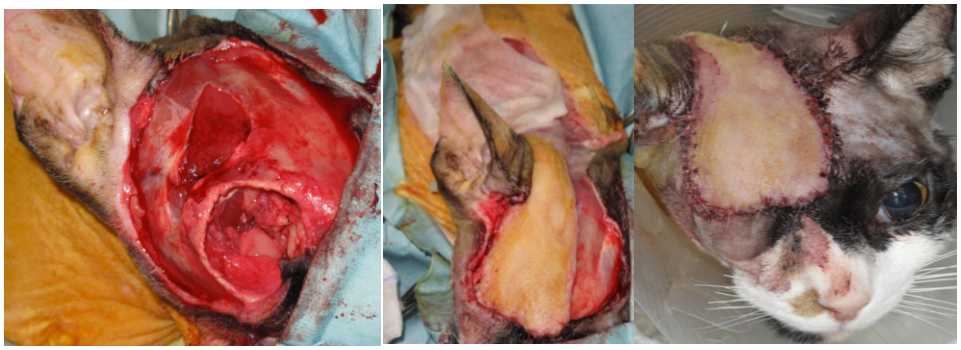
5) AXIAL PATTERN FLAPS (Pavletic, 2010)

The skin flap being elevated has a well known vascularization (specific direct cutaneous artery and vein). The flap is usually *peninsular* (skin incised on three sides); in some instances they can be extended with a supplemental “L” design. In *island* flaps all the four sides are severed but the vascular pedicle is preserved. These flaps may be tranferred

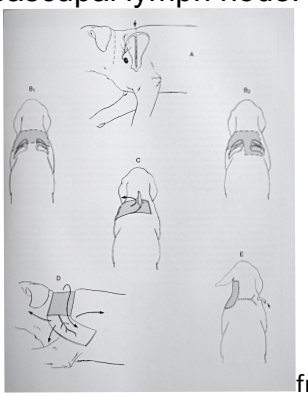
according to different angles of rotation. If the defect to cover is far away, the latter may be reached a) through a “bridge” incision or b) tubing the tract of the flap running over an intact skin (the tube will be then eliminitated in 2-3 weeks). The followings are the most important axial pattern flaps; readers should refer to Pavletic (2010) for details.

- *Facial artery:* to close defects of the upper lid/cheek and nasal region. This is a transposition flap. The flap is centered on the labial commissure, the dorsal border is parallel to the zygomatic arch while the ventral one is parallel to the lower border of the mandible; the caudal border depends on the defect to cover taking in account that the flap has to be rotated cranially (Yates et al., 2007).

- *Caudal auricular artery:* it is centered over the dorsolateral neck up to the caudal lower part of the pinna. The base is at the level of the atlas wing and its undermining should include platisma. It is used to close frontonasal defects.



- *Cervical cutaneous branch of the omocervical artery*: to close defects of regions such as face, ear, shoulder, neck, axillary. Borders: caudal, scapular spine; cranial, at the level of the preascupal lymph node.



from Pavletic, 2010

- *Thoracodorsal artery:* it is more robust than the previous one. It is used to close defects of regions such as shoulder, forelimb, elbow, axilla, and thorax. In cats it can reach the carpal region. Borders: cranial, scapular spine; caudal, at a distance equal to the one between the cranial border and the upper caudal scapular angle. It may be created with a "L" extension.


- *Superficial brachial artery:* to close defects of elbow region, antebrachium up to carpal region. The flap is centered over the cranial aspect of the brachium, parallel to humerus.

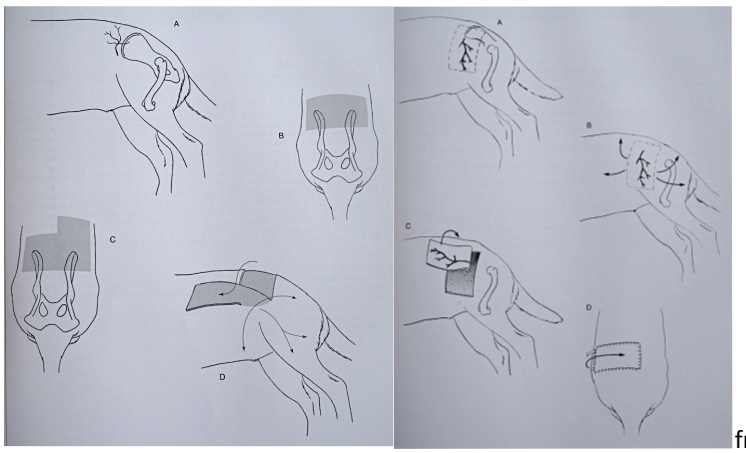
in this case the flap has been tubed for the tract running on the intact skin. The tube has been progressively divided in 20 days (starting after 10 days).

- *Lateral thoracic artery (forelimb fold flap):* for defects of the elbow region


- *Caudal superficial epigastric artery:* the flap includes mammary glands # (2), 3, 4 and 5 in dogs and (2), 3 and 4 in cats. In male dogs the midline incision should include the base of the prepuce. It is useful to cover defects of regions such as caudal abdomen, flank, inguinal area, perineum, thigh, rear limbs.

- *Cranial superficial epigastric artery:* it includes mammary glands # 3, 4 and (5) (in males the flap ends cranial to the prepuce). It is mainly used for defects of the sternal region.

- *Deep circumflex iliac artery (dorsal and ventral branch).*



from Pavletic, 2010

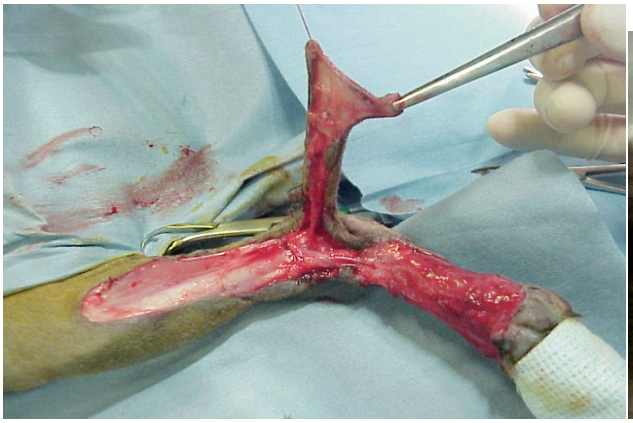
dorsal branch ventral branch

- *Genicular:* as the supporting vessels are not very large, larger flaps should be avoided.



courtesy of dr Bussadori R.

- *Reverse saphenous counduit flap:* the flap is constructed on the medial aspect of the tibial region. Its survival is provided by an alternative and complex vascularization.




- *Lateral caudal (tail) arteries:* for defects of perineum and caudodorsal trunk. The bony part of the tail is amputated and the flap relies on its skin.

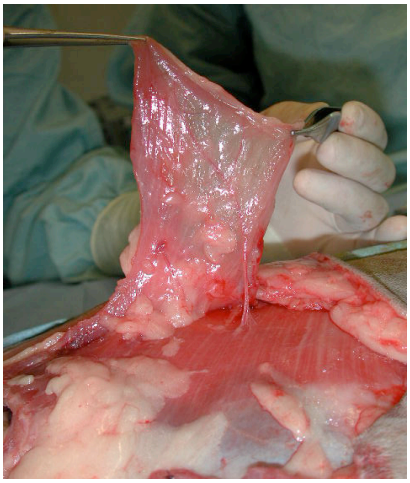

6) MYOCUTANEOUS FLAPS (Pavletic, 2010)

- *Latissimus dorsi myocutaneous f.*: it is used to cover defects of the elbow region where a thick coverage (skin/muscle) is usually necessary. Borders: dorsal, from ventral to acromion toward the 13th rib head; ventral, from the forelimb fold parallel to the previous one.

7) MUSCULAR FLAPS

Even muscles, as the skin, may be moved from their original position to close a defect, to reinforce a closure, to bring vascularization, etc.

The *latissimus dorsi muscle* and *external abdominal oblique muscle* flaps, for example, are used to cover defects of the thoracic and abdominal wall, respectively.



external abdominal oblique muscle flap

8) FREE GRAFTS

Free grafts are pieces of skin of different shape, size and thickness that are excised from a donor site (usually the lateral thorax or abdomen) and transferred in a recipient one (more often distal limbs). They can be prepared as *partial* (epidermis and a limited part of dermis) or *full* (epidermis and dermis) *thickness* grafts. They may be harvested manually or with a dermatotome. In veterinary medicine full thickness free grafts are more often used. Their

survival depends on neovascularization; partial thickness grafts heal easier than full thickness ones. All the adipose tissue must be carefully eliminated. Ideally, they are harvested from the donor site and positioned over a healthy granulation tissue; however, they may also be placed on a fresh wound. Full thickness grafts, if healed correctly, are haired. More frequent causes of failure are movement, infection and collection of fluid (blood, serum) under the graft; to avoid collection of fluid, alternate full thickness incisions are performed in the graft. Bandage is performed in 3 layers: 1) non-adherent dressing with an oil-based antibiotic ointment, 2) absorptive/padding layer (cotton roll), and 3) elastic wrap (e.g. self-fix). If the gratf has been applied over a joint region, the latter should be immobilized. Tie-over bandages may be used in problematic areas. First change (be very careful ! irrigate with warm sterile saline) after 72 hours, then every 3-4 days.

fresh wound 15 days 65 days

- *Punch* or *pinch* grafts may also be harvested and used but only if there is a healthy granulation tissue. They are excised from the skin (with punch or blade), the fat is eliminated and are then inserted into small pockets created with the blade into the granulation tissue. Then, they are protected (bandage) as already commented previously.

9) **USE OF DRAINS**

The most important indications for drains are to prevent collection of fluid (seroma) in the wound or to evacuate exudates. In general drains are kept in place not longer than 3-5 days in order to avoid complications such as ascending infection, foreign body reaction and inflammation and pain. Drains are protected with a bandage.

Drains may be passive or active.

Passive drains (drainage by gravity): the most used is the Penrose drain, a soft tubular strip of latex that drains fluids by capillary action. Fenestration is not indicated to increase drainage; its size is based on the space to drain; however, larger areas are not effectivlely drained in such a way. The drain should exit from a gravitational opening that must not correspond to the wound itself. At the level of the opening may be applied 1-2 sutures to fix it. The drainage is finally covered with a light bandage. Removal of the drain (after 3-5 days) is performed cutting the sutures and pulling it out of the wound.

Active drains are based on closed suction devices in which a vacuum system allows an active drainage of fluids. They are indicated to drain (and to measure) great amount of fluids, usually as a result of accumulation in large dead spaces. The most common is the Jackson-Pratt Active Drain System. A rigid fenestrated device (silicone) is positioned under the skin while the non fenestrated portion exits the skin from a small hole that is closed with a purse-string suture around the tube. A "Roman sandal" suture is then applied to fix the exiting tube that finally terminates in the vacuum canister. The latter is fixed as it is more appropriate over the animal's body. The most important advantage is that drainage is independent of gravity, with a minimal risk of ascending infection. In case of obstruction, the drain is removed from the canister and flushed with warm sterile saline. In case of entry of air into the wound (even through sutures) or rupture of the tube, the draining ability is lost. In case of air entry through the sutures, Pavletic suggests the application of oinment, cyanoacrylate glue or reinforcing sutures.

A home-made close suction system (for small cavities) may be created with a 50-60 ml syringe, Kirschner wires, a three way valve (facultative) and a silicone tube (fenestrated in the part that lies in the cavity to drain).

USE OF ANTIBIOTICS

Chapter 10 of Fossum 2007 (pag. 79-89) provides an excellent review of the item.

Classification of antibiotics based on their mechanisms of action

1. effect on the bacterial cell wall (for example β-lactam ring antibiotics such as *penicillins*, *cephalosporins*, *carbapenems*, *monobactams*; vancomycin; bacitracin; polymixin, nystatin and amphotericin B; imidazoles)
2. effect on synthesis of protein (chloramphenicol, tetracycline, erythromycin, *clindamycin*, *aminoglycosides*) or DNA (*fluoroquinolones*, trimethoprin-sulfonamide)

Some details on spectrum of action of the most common antibiotics used in veterinary medicine

Penicillins: generally effective against Gram+ aerobes and Gram+ and - anaerobes. To avoid resistance, penicillinase inhibitors may be combined (e.g. amoxicillin + clavulanic acid)

First generation cephalosporins (cephalexin, cephalotin, cefazolin, cefadroxil): wide spectrum against Gram+, variable against Gram-, poor activity against anaerobes

Second and Third generation cephalosporins. Second generation cephs. more active than first generation cephs. against Gram - and anaerobes. Third generation cephs. effective against > 90% Gram- but often less active than first generation on Gram +

- Cefotetan and Cefoxitin: anaerobes and Gram- bacilli (*E. coli*). Indicated in peritonitis

- Cefotaxime: wide spectrum, Gram positive and negative, most active against *Staphylococcus*; good concentration in spinal fluid

- Ceftazidime: *Pseudomonas aeruginosa*

- Cefixime: limited activity against Gram+

- Cefaperazone: effective agains Enterobacteriaceae

- Ceftriaxone (Rocephin): for CNS infection and borreliosis

- Ceftiofur: third generation cephs. active against Gram+

- Cefepime: fourth generation, broad spectrum (Gram positive cocci, Gram negative enterobacteriaceae, *Pseudomonas aeruginosa*

Other β-lactam antibiotics (carbapenems, monobactams)

- Imipenem: resistant to β-lactamase, effective against Gram-, not nephrotoxic

- *Imipenem*: broadest spectrum (Gram- and Gram+ anaerobes and aerobes. NOT active against methicillin-resistant Staphylococci or resistant strain of *Enterococcus faecium.* It should be used in selected cases (severely sick animals after failure with other antibiotics) in order not to cause resistance.

- *Aztreonam*: resistant to β-lactamase, effective against Gram- aerobes, little acitivity against anaerobes, no activity on Gram+. It should be used in combination with others.

Other antibiotics

- *Chloramphenicol*: broad spectrum (strepto, staphylo, *Brucella* spp., *Pasteurella* spp., anaerobes); poor activity against Pseudomonas

- *Tetracyclines*: Gram+ and Gram- including Chlamydia, rickettsiae, spirochetes, Mycoplasma, some protozoa, etc; not effective for staphylo, enterococci, Pseudomonas and Enterobacteriaceae

- *Erythromycin* and derivates: narrow spectrum - prokinetic. Derivates: *azithromycin* (staphylo, strepto and anaerobic, Mycoplasma, Bartonella, Toxoplasma)

- *Clindamycin*: Gram+ (staphylo, strepto, clostridia, many *Actinomyces* and some *Nocardia,* etc). Often used to treat infections resistant to penicillins and erythromycin.

- *Aminoglycosides* (amikacin, gentamicin, kanamycin, neomycin, etc). Effective against Gram- and Gram+ (Enterobacteriaceae, Pseudomonas); synergistic effect with β-lactam antibiotics. NOT active against anaerobes. Nephrotoxicity may be decreased prolonging interval of administration and increasing dose.

- *Fluoroquinolones* (*enrofloxacin*, difloxacin, ciprofloxacin, ofloxacin, *marbofloxacin*): Gram- and staphylo, *Rickettsia rickettsii*. Some Pseudomas, *E. coli*, Enterococcus and Staphylo (including methicillin-resistant *Staphylococcus aureus - MRSA*) are now resistant.

- *Trimethoprin-sulfonamide*: the combination is bactericidal; broad spectrum (most strepto, many staphylo, *Nocardia)*, uneffective against Pseudomanas.

General principles

In general the use of antibiotics depends on the type of surgical procedure being performed. Antibiotics MUST NOT substitute a correct asepsis during surgery or an uncorrect management of an open wound. Their use should be limited to selected cases based on a specific rationale. Antibiotics are absolutely needed when the patient's defenses are compromised.

The efficacy of antibiotics is influenced by several factors such as: a) culture and susceptibility of bacteria to that drug (see also spectrum of action), b) dose of the antibiotic (bacteriostatic or bactericidal), c) frequency, route and length of administration, d) overuse and antibiotic resistance establishment. Antibiotic resistance, that may arise through different mechanisms, is a very critical point as it can heavily influence the efficacy of an antibiotic treatment only theoretically efficacious.

MRSA (*methicillin-resistant Staphylococcus aureus*), for example, is a serious problem even in veterinary medicine. This bacterium, present in hospitals, is now resistant to many β-lactam antibiotics and is transmissible by contact. Patients affected may have an evident infection or be asymptomatic. Another example is provided by *Stahylococcus intermedius*: in fact, recent studies have revealed that 20% of *S. i.* strains have now become resistant to oxaciclin. Resistance may also affect other bacteria and antibiotics and this should encourage a rationale use of these drugs in order to avoid it (Wayne et al, 2011).

Infections and surgical procedures

It should first emphasized that *Halsted principles* should be respected during surgery to avoid infection or not to worsen a pre-existing situation: therefore the never old principles of delicate manipulation of tissues, accurate hemostasis, preservation of circulation, aseptic technique, sutures without tension with avoidance of dead space and approximation of tissues are still very important.

The risk of infection potentially may start as soon as the first incision is performed; infection may develop early after surgery or even after 1 month or later (even after 1 year if a prosthetic implant has been applied. It should be noted that bacteria from patient are presumed to be responsible of most wound infection; however, in many instances infection derives from environmentally resistant bacteria (nosocomial infections). Some important rules must be respected. They are: a) strict asepsis of both surgical site and surgeons, b) stric asepsis, accurate technique and lavage during surgery, c) limited and controlled number of persons in the surgical room (1.3 higher risk for each additional person - Eugster et al, 2004), d) reduction of both the anesthetic (Beal et al, 2000) and surgical time to the minimum (the risk of infection doubles every 70 minutes of surgery - Eugster et al, 2004), and e) appropriate use of the antimicrobial prophylaxis. Other potential risk factors to be taken in account include: age (very young or old) and preopearive condition of the animal. Finally, the use of propofol (likely contamined through multiple using) has been shown to increase of 3.8 times the risk of infection in one study (Hedman et al., 1999).

Surgical procedures are classified as:

a) *clean* (risk of infection from 0 to 4.4%): procedures where respiratory, gastrointestinal, genitourinary and oropharynx are not entered

b) *clean contaminated* (risk of infection up to 10%): cholecystectomy, enterotomy, small intestinal resection, etc

c) *contaminated* (risk of infection up to 28%): when there is spillage of infected fluid, biliary diversion, etc

d) *dirty* (infection is already present): abscess, peritonitis, perforation of intestine, bulla osteotomy, etc.

Prophylactic use of antibiotics

The antibiotic must be present in the blood stream and tissues at the time of the incision; that implies that an empirical drug (but active on the most likely present bacteria - ideally the drug should be active at least against 80% of probable contaminants) is administered intravenously from 30 to 60 minutes before incision). Bacteria may also be suspected on the basis of the surgical procedure to be performed.

More common bacteria are *Staphylococci, Streptococci* and *E.coli* in dogs and *Pasteurella* in cats; anaerobes are usually a concern in case of hepatobiliary and colorectal surgery. Ideally, in case of clean procedures, prophylactic antibiotics are not necessary but the history of the hospital should be taken into account.

More commonly, cefazolin (22 mg/kg I.V.) is used. The drug is repeated every 1.5-2 hours in protracted procedures but is is discontinued after surgery (within 24 hours).

Some examples of procedures that require prophylactic antibiotics are: 1) surgeries longer than 90', prosthesis implantation (e.g. meshes), severely infected or traumatized wounds, abdominal abscess, colorectal surgery, esophageal surgery, hepatobliary procedures with pre-existing infections, urinary surgery with infected urine, etc.

Therapeutic use of antibiotics

First of all consider that postoperative antibiotics do not avoid infection. However provided that the surgical technique has been correct in terms of surgical asepsis, in some instances (foreign bodies, traumatic wounds, necrosis, hematoma, seroma, etc), the risk of postoperative infection is higher than normal.

The gold standard is using antibiotics a) when it is really necessary and b) based on culture and susceptibility test. If really necessary, empirical treatments are started based on the most likely contaminants causing infection (*Staphylococcus* spp. and Gram - negative bacilli; anaerobes and facultative anaerobes (e.g. *Streptococcus* spp.) are a concern in case of intestinal surgery, hepatobliary tract surgery, deep wounds and dentristry). Then, more specific treatments should be based on results of cytology and culture susceptibility tests.

Postoperatively, infection may also be as a complication of supportive measures (catheters, drainages, etc). This usually occurs in hospitalized animals. If a catether or a

tube is present, antibiotics do not protect from infection and the treatment should be inititiated after that the device has been removed and a susceptibility test performed. Postoperatively seroma formation may be an indication for antibiotic treatment.

PRINCIPLES OF ONCOLOGICAL SURGERY

Surgery is the most important modality of treatment for most localised tumours since it results in a higher rate of cure than all other modalities. However, for many neoplasms, a multimodal approach is often preferred in order to reach the best results in terms of both disease free period and overall survival. If a combined approach is selected, surgery may be less aggressive as other therapeutic tools (i.e., chemotherapy and/or radiotherapy) have shown to be effective for the control of that specific tumour. These treatments can be used preoperatively (neoadjuvant), postoperatively (adjuvant) or intraoperatively. Novel treatments, based on molecular targets (e.g., anti-tyrokinase inhibitors), antigens (vaccines), etc, are now available even in veterinary medicine.

Therapeutic planning depends on an effective tumor preoperative diagnosis and staging. Cytology and histology are standard techniques to give a name to the tumour (fine-needle aspirate and incisional biopsy); the marginal excision of a lesion, especially if superficial, with no preoperative diagnosis and staging is definitively an incorrect procedure; *marginal excisional biopsy should be reserved to bening lesions only*. Complete tumour staging implies that both the primary tumour has been identified and that it has been ascertained if it has already spread regionally and/or elsewhere. Based on the standard biological-clinical behaviour of that specific tumour, metastasis is carefully searched at the level of the regional/satellite lymph nodes, lungs, liver, spleen, etc. If enlarged, regional/satellite lymph nodes are aspirated but metastasis, even if present, may still be missed; therefore, enlarged regional lymph node(s) should be excised together with the primary tumour and submitted to histological evaluation. In case of endocavitary or deep lymph nodes and/masses, ultrasound- or CT-guided fine needle aspiration or surgical exploration is warranted. Lung metastasis evaluation is provided by right and left lateral and ventro-dorsal views; however, CT scan has been shown to be superior to radiography. Other sites are evaluated depending on the standard clinical biology of that specific tumour. For very aggressive tumours, a “total body” CT scan is preferable. Attention is also driven to specific paraneoplastic syndromes that may accompany the neoplastic growth keeping in mind that some of them may represent a medical emergency (e.g. hypoglcemia, hypercalcemia).

Diagnostic imaging techniques (especially CT or MRI) should be used to determine the extent and size of the primary tumour, mainly if an *en bloc* excision is planned. Some aspects must be kept in mind when a tumour surgical excision is planned: 1) knowledge of the standard biological behaviour of that tumour vs. excision margins; 2) general clinical and metabolic conditions of the animal before surgery (however, the age of the animal should not be considered as a limiting factor if clinical conditions are good - old age is not a disease!), 3) postoperative life expectancy of at least 3-6 months, 4) the first surgery is the one that has most probabilities to be successful if surgery is the principal option (e.g. many mast cell tumours, feline injection site sarcomas, soft tissue sarcomas, etc); 5) the resection of the tumour with wide margins all around it may result in the removal of the underlying bone, even if the latter appear normal both clinically and radiographically; 6) if an aggressive surgery is planned, even reconstruction needs to be planned. Regarding this, it is imperative to consider: a) the surgeon's individual skills, b) all the possible

reconstructive techniques applicable in that specific case, and c) the consequent functional deficit caused postoperatively in the animal (that means that the postoperative quality of life and function of these patients must be from acceptable to good). In general, limitations are mainly related to the probability to get a definitive cure or, at least, to significantly prolong animal's survival, preventing or delaying the metastatic spread, rather than causing a real functional limitation (consider for example how much to extend a rostral bilateral mandibulectomy vs. a conserved ability of the animal to eat).

Aggressive surgery is addressed to local tumour control; metastasis is usually controlled with adjuvant chemotherapy, vaccines, etc, while local recurrence control needs local treatments such as radiation therapy. In case of incomplete surgery ("dirty" excision margins at histology) a second surgery and/or adjuvant radiotherapy represent possible further options whilst chemotherapy is decided based on the histologic grade and/or other prognostic factors (e.g. ki-67 for grade II mast cell tumor, oral melanoma; etc). It is also the case to emphasize the importance to identify, after tumour removal and before submitting the specimen to histology, the *excision margins* applying sutures (dorsal vs. ventral, cranial vs. caudal, etc) and ink (e.g. china ink) at the level of the excised tumoral specimen bed where the surgeon may have the suspicion to have been "incomplete". *Histology result (clean vs. dirty) represents the first prognostic factor for many tumours curable surgically*.

General guidelines

- Use cryosurgery for very small epithelial tumours (e.g small and superficial squamous cell carcinoma) or when the anaesthetic risk is really too high.
- Do not use local anaesthesia to remove tumours: you will work badly and the injection may spread the tumour. Regional anaesthesia may be used when indicated (critical patient).
- In general, keep in mind the Halstead's principles when performing your surgery.
- The bioptic site must be removed "en bloc".
- Drape skin incisions to limit tumour implantation.
- Use surgical instruments as much as possible and not hands that may spread the tumour. Change surgical gloves whenever appropriate. Don't grasp the tumour with forceps: again, this may cause tumour spread.
- For the dissection use scalpel as much as you can; scissors may be used to dissect between different planes. Other modalities such as electrocoagulation and laser can be used but they may complicate identification of tumour margins (burnt tissue).
- Ligate or fulgurate early all the tributary vessels (firstly veins, if feasible).
- For suturing it is better to use monofilament than braided material in order to limit adhesion of neoplastic cells.
- Even if controversial for the possibility of spreading tumour cells, perform wound lavage removing as much fluid as possible. In such a way, blood clots and tissue debris, potentially bearing neoplastic cells, are removed.
- Do not use for the reconstruction the same surgical instruments, drapes and gloves used to remove the tumour.
- When the tumour has been removed, check that excision margins are macroscopically appropriate. At this point you can also perform an intraoperative cytological examination.
- Always submit the mass for histopathology (even if you already had a preoperative diagnosis).
- Always identify margins for the pathologist and ask to have them examined.

Types of surgery and resection margins

Oncological surgical procedures may be classified as :
1) *diagnostic*: it is applied when less invasive procedures are not diagnostic. The goal is to get a sample of tissue to submit to cytology and histology. It is referred to as "incisional biopsy" (wedge of tissue obtained in an area easily removable in the subsequent resection of the tumour) and "excisional biopsy" (e.g., exploratory thoracotomy or laparotomy, or removal of cutaneous lesions surely benign);
2) *cytoreductive* (debulking). Inoperability may depend on both the type of growth (infiltrative vs. expansive pattern) and tumour location (neck, axial skeleton, great vessels, nerves, etc, i.e. parts that cannot be radically excised without compromising some vital functions or life). Inoperable tumours may be debulked but it has been proved that further therapeutic tools may be effective in controlling their growth (radiation, chemotherapy);
3) *curative*: it provides an “en bloc” excision of the tumour with margins of 1-4 cm of normal tissue all around it; sometimes, depending on the neoplastic location and tumor type, this is realized removing also the underlying bone (mandibulectomy, maxillectomy, amputation, partial or total scapulectomy, pelvectomy, limb salvage, rib resection, etc);
4) *palliative*: it is rarely applied. It may be used if a real postoperative improvement of the quality of life of the animal is expected (e.g. pericardectomy, metastasectomy, etc). It should also have been proved that further adjuvant therapeutic tools may prolong survival.

The classification of *surgical resection margins* reflects all these different types of surgeries and the need of adjuvant treatments:
a) *intracapsular*: the mass is removed in pieces. This technique should be reserved only to benign lesions and it is obviously controindicated in case of malignant tumours but in some instances (e.g. malignancies extending in the nose, middle ear, spinal cord, etc) the surgeon is forced to remove the tumour in such a way (“debulking” or cytoreduction). An adjuvant treatment is imperative since the tumour is macroscopically still present; if not applied, surgery alone may cause poorer quality of life and shorten survival;
b) *marginal*: "shelling" a soft tissue sarcoma may be very or relatively easy but it is constantly followed by recurrence since the undermining has been performed along the "pseudocapsula" that surrounds the neoplasm. The “pseudocapsula” results from the compression operated by the growing lesion and it is formed by normal tissue and neoplastic cells; a "satellite" (small nodule, possible result of an extravascular extension of the tumour in the reactive zone around the tumor) and/or a "skip" metastasis (possible result of an intravascular metastasis in the normal tissue) may also be missed. In order to avoid local recurrence and depending on tumor type, histologic grading and appropriate immunohistochemical prognostic factors, wider margins of excision are warranted involving also the surrounding normal tissues (ideally the scar is excised as if it were a primary tumour - excision margins of 1-4 cm). A marginal excision is correct only in case of confirmed benign tumours (e.g. lipoma) or as part of a combined approach including adjuvant radiation;
c) *wide*: in this case the classic principle of oncological surgery is theoretically respected and the tumour is removed with appropriate margins. However a "skip" metastasis may still be missed. Despite the wide margin excision performed, the predominance of certain soft tissues does not ensure a clean margin excision; in fact, the nature of the soft tissue involved (muscle, fascia, ligaments, vessels, nerves, fat, etc) may reflect a different resistance to the neoplastic invasion and this should be taken into account. For example, surgeons should be taken in account that fat is not a barrier and fascia should always be

included, if present. The en bloc excision should be planned based on CT-scan or MRI;
d) *radical*: it is mainly indicated for very malignant tumours; the most classical example is amputation for osteosarcoma.

Lymph node removal
If metastasis is demonstrated, regional/satellite lymph node(s) should be removed; if further lymphatic stations appear to be involved, treatment should be decided on an individual basis since prognosis in these cases is worse. If the metastatic lymph node is fixed to the surrounding tissues (first station only), an en bloc excision combined with an adjuvant treatment is warranted. When metastasis is not cytologically demonstrated but regional/satellite lymph node(s) is/are enlarged, it/they should be removed to clinically stage the tumour (histologic evaluation).

Lung metastasis removal
Surgical removal of lung metastasis should be reserved to cases in which 1-3 lung metastatic nodules, characterized by a long doubling time, derive from a low-grade primary tumour. A prolonged disease-free interval should be expected after their removal. Adjuvant chemotherapy should be used in order to delay a further metastatic growth.

Prognosis
Prognosis involves either the evaluation of overall survival of the patient from the initial diagnosis (also when no treatment is applied) or from the beginning of treatment (disease free and/or cure rate). Prognosis can also be favourably or unfavourably influenced by other factors, not dependent only on the tumour type.

Tumour-related prognostic factors
- *Anatomical site of growth*: important mainly for localised solid tumours. It may influence prognosis in terms of :
a) surgical approachability
b) different clinical biological behaviour of some tumours depending on their different location in the body. Some classical examples are canine melanomas which are almost always malignant when oral and less malignant if grown on the flank; canine oral squamous cell carcinomas tend to be less malignant when localised rostrally in the mouth, more malignant when aboral; preputial mast cell tumours are usually more aggressive than those localised on the flank;
c) a worse prognosis may result from clinical complications such as stenosis, compression, haemorrhage, infections, functional deficits, etc caused by the neoplastic growth.
- *Clinical staging of the tumour:* a specific TNM clinical stage is given after a complete diagnostic work-up (Owen 1980). Universally applied both in human and veterinary oncology, staging provides prognostic information in most cases, facilitates the exchange of information among centres and, in a uniform population of sick animals, allows a comparison of results obtained after application of different treatment protocols. The TNM system is based on: a) T: extension and size of the primary tumour; b) N: regional lymph node(s) status; c) M: presence or absence of distant metastasis, mainly in lungs. Other factors are: d) P: it is referred to as histopathological extent (e.g. in the thickness of the wall of a cavitary organ); e) G: it expresses the malignancy grade (low, medium, high); f) L: it expresses the tendency of the tumour to invade lymphatics; g) V: it express the tendency of the tumour to invade veins.
- *Disease-related factors*: such as the paraneoplastic syndromes (hypoglycemia, hypercalcemia, hyperthyroidism, fever, anaemia, leukocytosis, DIC, gammopathies,

degranulation effects of malignant mast cells, hyperthrophic osteopathy, cachexia, neurologic manifestations, etc). They may cause more acute morbidity (and eventually mortality) than the primary tumour.
- *Chemosensitivity / Radiosensitivity*: the first is influenced by both chemoresistance and growth rate. Concerning radiation, tumours that were considered in the past as tipically radioresistant may now be approached through a combination of surgery and/or chemotherapy and radiotherapy with a dramatic improvement of both local control and overall survival (e.g. soft tissue sarcomas, nasal tumours, etc).

Patient-related prognostic factors
- *Pre-existing diseases*: cardiopathies, liver and renal diseases, etc, may make prognosis worse since they may limit the possibility of planning any treatment.
- *Immunosuppressive treatments*: in general, prolonged administrations of steroids facilitate tumour growth. This should be avoided if the intention is to try to cure the animal unless the tumour is a lymphoproliferative disorder; in the latter case, combination chemotherapy is used. In case no treatment is attempted, steroids may improve the quality of life in terminal patients, with the awareness of a likely shorter survival.

1) Surgery of skin tumors

- This item has been already discussed in the reconstructive surgery section. However, it should be noted that:

- operable malignant skin tumors need to be excised including a minimum of 2 cm of peripheral margins and one fascial plane deeply

- this may be enough in most grade II *canine mast cell tumors* to get “clean” margins at histology

- it can be excessive in most *feline cutaneous mast cell tumor* (frequently multiple in the head and neck) and *basalioma*

- *soft tissue sarcoma*, despite their low metastatic rate, usually need wider excision margins (at least 3 cm at the periphery and, if possible, from 1 to 2 fascial planes deeply) because of their infiltrative ability; skip metastasis may still be a concern

- *squamous cell carcinoma* is usually completely resected when resection with 2 cm of margin is performed but skip metastasis may still be present.

2) Surgery of oral tumors

- Oral tumors may originate from soft and hard tissues.

- Most frequent oral soft tissue malignant tumors in dogs include: *squamous cell carcinoma*, *fibrosarcoma* and *melanoma*; rarer tumors are round cell tumors such as mast cell tumor, lymphoma, plasma cell tumor, etc.

- In dogs, among epulides (that are benign), only the *acanthomatous* phenotype is capable to infiltrate the bone, thus requiring an en bloc resection.

- In dogs the most important tumor arising from bone is *osteosarcoma; ameloblastoma.* a tumor of dental origin, is also frequent.

- In cats most frequent malignant tumors deriving from soft tissues are *squamous cell carcinoma* and various types of *sarcoma.* Both ameloblastoma and osteosarcoma are rare in this species.

- Accurate *staging* (biopsy, regional/satellite lymph nodes, lungs) allows to identify patients that can benifit from surgery. Operability should be based on clinical examination only in more simple situations; CT scan (and not radiology that may understimate tissue involvement) should be used in more complicated cases. Unfortunately, in cats, most tumors are malignant and the number of cases that can be operated is very low. In fact it happens very often that tumors are already too advanced at presentation and/or localized in very critical locations (aboral with retrobulbar extension, ventral part of the tongue, lip and cheeck, etc); in very selected cases it is possible to propose a marginal excision plus radiotherapy with a curative intent while in most cases palliative radiotherapy is a reasonable option.

- *In case of malignant tumor, the first lymphatic station is removed contextually to the removal of the primary tumor even if negative for tumor involvement at cytology* (fine-needle aspiration) and sumitted to histology for staging purpose. Note that in case of melanoma, regional lymph node may be metastatic but still clinically normal.

- *In case of oral malignant tumor, the bone must be removed even if radiographically normal*, and this is performed contextually to soft tissues removal. In case of osteosarcoma a wider resection is needed (e.g. hemimandibulectomy) as the tumor originates from the bone.

- For massive maxillectomies, a temporary occlusion of one or both common carotid arteries may be performed (DOGS ONLY).

- Use absorbable monofilament material for sutures; antibiotics are given for 3-5 days postoperatively.

- Prognosis after surgery depends on the histotype and clinical stage (mainly T, size of the primary tumor and N, metastatic or not metastatic regional lymph node – often the latter is postoperative, after histology). In case of melanoma, adjuvant vaccination may control both the microscopic disease and metastatic spread and prolong survival. Adjuvant radiotherapy may be indicated for squamous cell carcinoma and fibrosarcoma.

- Palliative radiation is applicable for any inoperable malignancy.

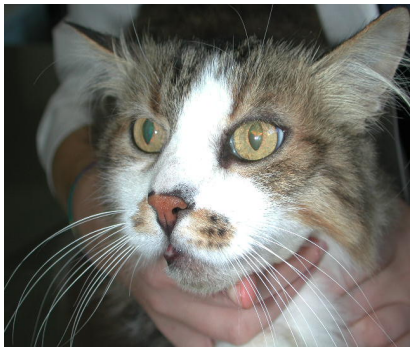
- Longer survival (> 1 year) are expected in case of rostral squamous cell carcinoma, ameloblastoma and acanthomatous epulis; besides in 25-30% of dogs operated for melanoma.

- Local recurrence is a concern in case of both melanoma and fibrosarcoma.

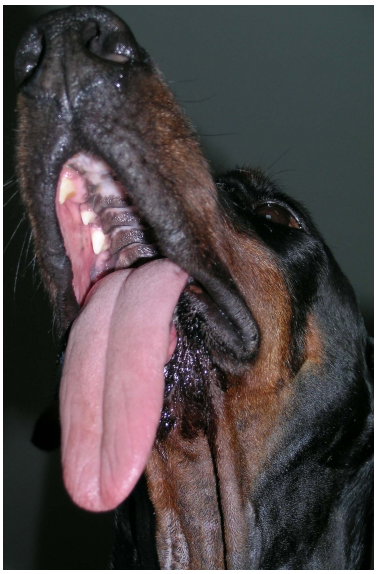
- Metastatic spread is more likely in case of melanoma.

<u>Surgical procedures for oral tumors</u>

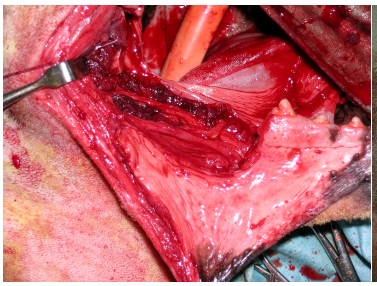
- unilateral rostral mandibulectomy or maxillectomy
- bilateral rostral mandibulectomy or maxillectomy
- segmental horizzontal mandibulectomy (advancement of the labial commissure may be needed)
- hemimandibulectomy (mainly indicated for osteosarcoma; advancement of the labial commissure needed)
- central maxillectomy
- caudal maxillectomy +/- zygomatic arch +/- lacrimal bone
- hemimaxillectomy
- tonsillectomy
- partial glossectomy

unilateral rostral mandibulectomy

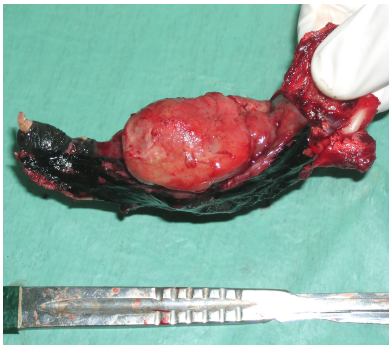


bilateral rostral mandibulectomy



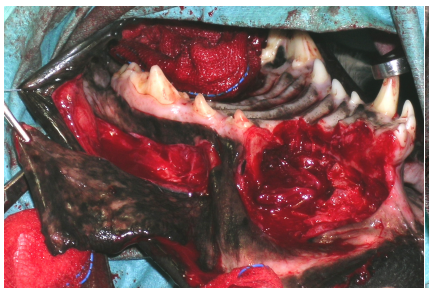
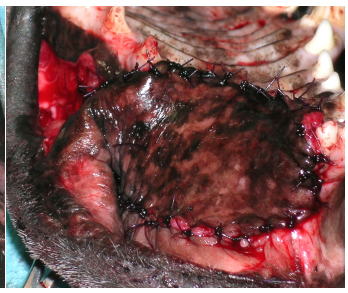
segmental horizzontal mandibelectomy - advancement of the labial commissure

horizontal mandibulectomy in a cat

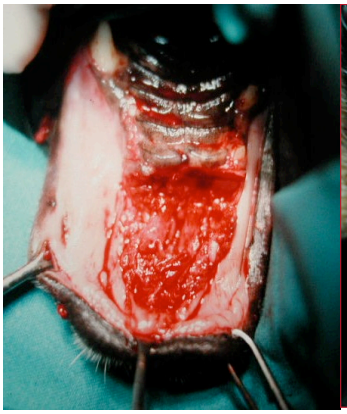
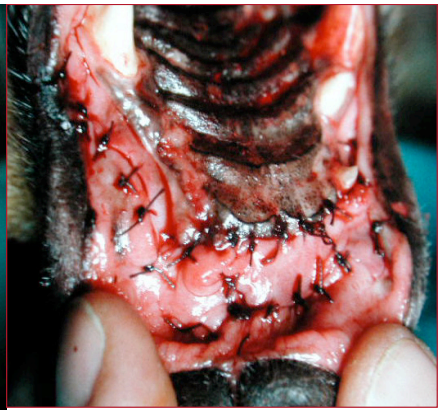
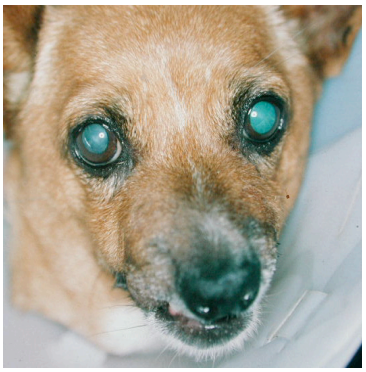


hemandibulectomy

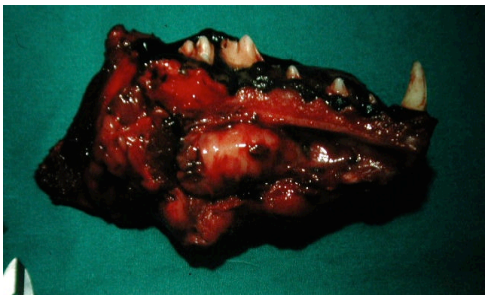
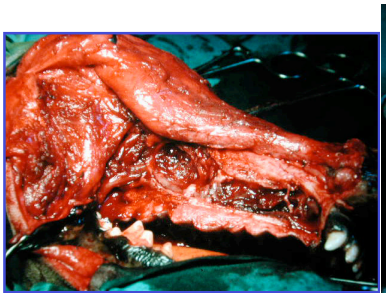
Note the esophageal tube. This should be positioned at the end of any oral surgical procedure when complications are potentially expected


Unilateral rostral maxillectomy

Bilateral rostral maxillectomy – reconstruction was performed with 2 flaps


Hemimaxillectomy



Partial glossectomy (squamous cell carcinoma)

Most common complications are:

- Hanging tongue
- Dehiscence (mainly in case of caudal maxillectomy – oronasal fistula)
- Malocclusion
- Saliva dripping
- Trauma caused by the canine tooth (extract or smooth it)
- Ranula (self-limiting)
- Transient difficulty in eating: the esophageal tube give time to the animal to learn how to manage feeding
- Cosmesis (owner)

3) Surgery of gastrointestinal tumors

Only selected topics (most frequent tumors and surgeries performed) will be briefly discussed.

Salivary glands: most tumours are *adenocarcinomas*, the remaining ones are sarcomas. Major salivary glands (especially mandibular) are usually affected. Lymphatic metastasis are frequent. Surgery is usually marginal and adjuvant radiation is necessary. Median survival is 500 days.

Esophagus: esophageal tumors are very rare and may be *carcinoma* (squamous cell, adenocarcinoma), *sarcoma* (fibros., leiomyos., extraskeletal ostes.), or *leiomyoma*. Surgery is usually not feasible and prognosis is poor. Only *leiomyoma*, more frequently localized in the distal esophagus, and *selected leiomyosarcoma* may be removed, usually in terms of marginal excision. In this case survival may be prolonged.

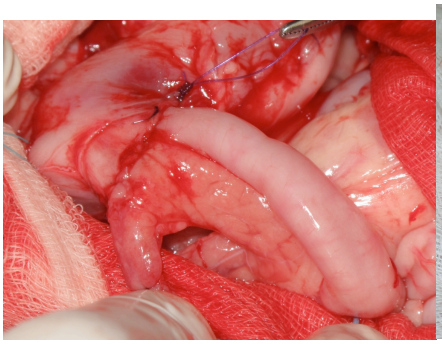
Stomach: gastric tumors are rare. In DOGS *adenocarcinoma* is the most frequent tumor (60-70%); less frequent are leiomyoma, polyp, leiomyosarcoma, lymphoma, mast cell tumor, carcinoids, etc. In CATS gastric tumors include *lymphoma* (the most frequent,

usually FeLV negative), adenocarcinoma, mast cell tumor, polyps (usually close to pylorus)

- Both the localization of most canine gastric adenocarcinoma at the level of the lesser curvature and the high metastatic potential of this tumour makes surgery not feasible in the majority of cases.

- It should be noted that if immunohistochemistry with CD117 – c-kit (tyrosinase kinase receptor) is performed, up to 50-55% of canine leiomyosarcomas is actually recognized as *gastrointestinal stromal tumors (GIST)* (Mass et al, 2007; Gillespie et al, 2011). Leiomyosarcoma and GISTS are more frequently localized in the antrum; this may allow their removal in many instances (e.g. Billrtoth 1; occasionally, if the major duodenal papilla is included in the resection, a biliary diversion such as cholecystoduodenostomy needs to be performed). GISTs, even though incompletely resected and metastatic, may be potentially treated with tyrosine kinase inhibitors (Masivet or Palladia, adjuvantly or palliatively).

- Only occasionally, in case of malignancy not involving the lesser curvature, a partial gastrectomy is feasible.



Billroth 1 for leiomyosarcoma

cholecystoduodenostomy

Intestine: tumors of intestine are the same as those of the stomach. Malignant epithelial tumors are more frequent at the level of the small intestine in cats; colorectal malignant epithelial tumors are prevalent in dogs (60-70%).

- Small intestinal *adenocarcinoma* is often already very advanced at presentation, with lymphatic, liver etc metastasis +/- abdominal effusion (the latter mainly in cats).

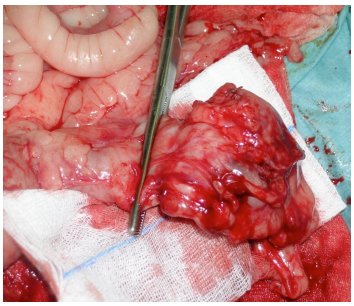
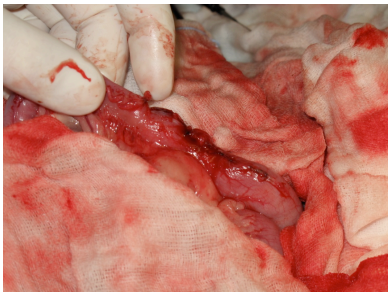
- *Leiomyosarcoma* is more likely at the level of the small intestine (occasionally it may be associated to hypoglycemia as paraneoplastic syndrome); *GIST* is more often at the level of the ileocecocolic valve or colon. Metastasis of GIST is earlier and more diffuse than leiomyosarcoma.

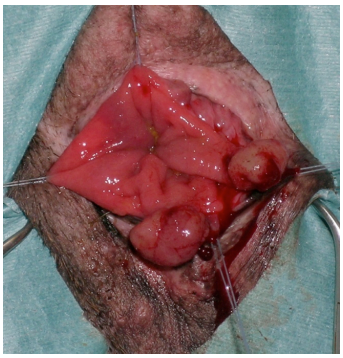
- Intestinal *mast cell tumor* is rarely detected. Among the four cases seen by the author, 2 had intussuscption. Survival ranged between 25 days to 5 months despite adjuvant chemotherapy.

- In case of solitary intestinal malignancy margins of resection (enterectomy) should include 4-8 cm of intestine macroscopically sound (these margins are not enough in case of isolated lymphomatous lesion – occasional finding). Histology is performed on both the mass and the resection extremities. Enlarged mesenteric lymph nodes are rimoved and histologically evaluated.

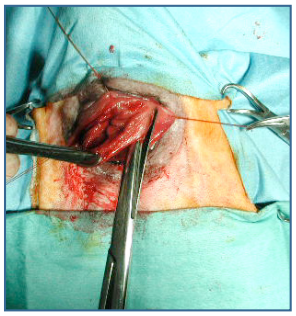
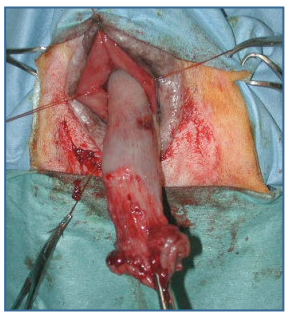
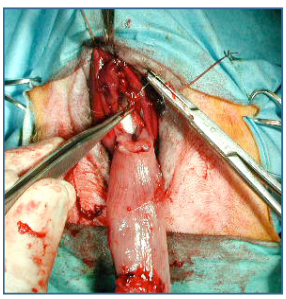
- *Colorectal tumors in dogs* include: polyps, adenocarcinomas in situ and adenocarcinoma. Metastasis (at the sublumbar lymph nodes) are rare (infiltrative adenocarcinoma) (Morello et al, 2008). Surgical procedures for these tumors include:

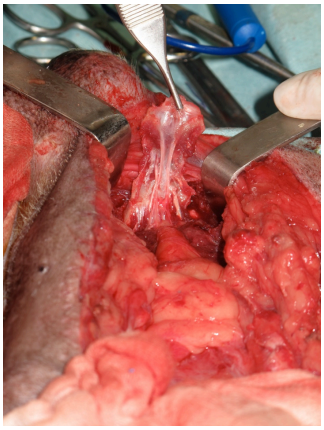
- Typhlectomy
- Subtotal/total colectomy
- Transanal pull-out and marginal excision (for polyps and adenocarcinoma in situ); an alternative is excision during endoscopy
- Rectal and transanal rectal pull through amputation
- Ischiopubic osteotomy or ostectomy and standard resection / end-to-end anastomosis (the latter procedure is at present the author's preferred one as this avoids many complications that can occur when the colorectal amputation is performed from the anus)



Thyphlectomy, GIST

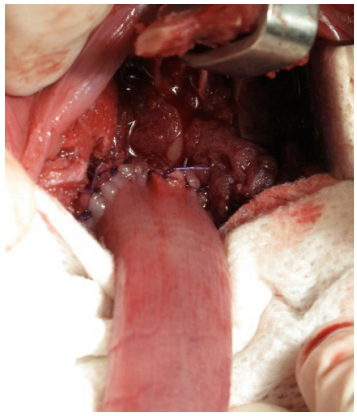


Pull out and marginal resection




Transanal pull through and end-to-end anastomosis



Puboischial ostectomy



End-to-end anastomosis after colorectal resection

- Complications of colorectal resection: hematochezia (self-limiting), dehiscence (tension, poor vascularization – more likely with the transanal approach), infection (poor technique, wrong suture material, dehiscence, etc), stenosis (tension +/- poor vascularization → ring cicatricial tissue → stenosis → tenesmus – more likely in small dogs)

- Fecal incontinence: the frequecy of evacuation may increase, faeces may be softer up to diarrhea for a certain period of time but true incontinence is observed only if a tract of distal rectum of 1.5-2 cm has NOT been preserved (Morello et al, 2008). This implies that the removal with margins of malignant tumors that are less than 3-4 cm from anus may easily cause incontinence (margins of excision should 4-8 cm on each side of the tumor !).

Liver: *hepatocellular* tumors are more frequent in DOGS, *hepatobiliary* ones in CATS. Other tumors that may involve primarily the liver are hemangiosarcoma (primary; metastasis from spleen hemangiosarcoma more frequent), lymphoma, mast cell tumor, histiocytic sarcoma, others sarcomas, carcinoids, etc

- Hypoglicemia (paraneoplastic) may occasionally be present (hepatoma).

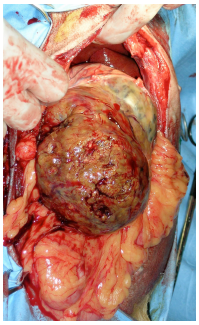
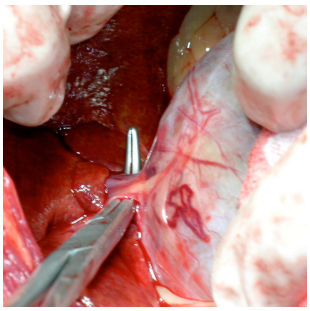
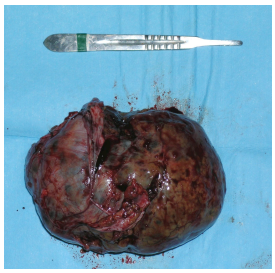
- Hepatocellular and hepatobiliary tumors include *adenoma* (cystic in cats – hepatobiliary cystadenoma) and *carcinoma* (also called cholangiocarcinoma if deriver from the biliary system). Typically carcinoma may be: *massive*, *nodular* (multifocal) or *diffuse* (worst prognosis). Cholangiocarcinoma carries a worse prognosis (metastatic up to 80-87% of cases) than hepatocellular carcinoma.

- The best prognosis may be attributed to massive hepatocellular carcinoma, especially if localized in the left lobes where a hilus is recognizable (the right and the caudate lobes need to be separated from caudal vena cava). This may allow a complete removal and a long survival (years).

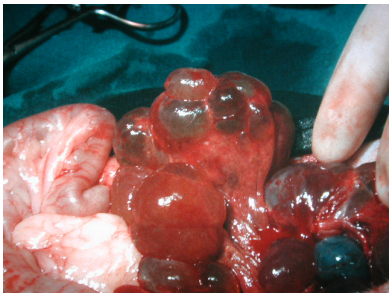
- If the central division is eliminated (quadrate and right medial lobes), even the gall bladder should be removed.

- Accurate staging (operability) is better reached with CT scan. A preoperative coagulative testing is advisable.

- As the liver physiologically contains bacteria (Clostridium, E. Coli, Streptococcus spp., Proteus, Klebsiella..), a possible tardive complication of extensive hepatic resection is abscess formation caused by these bacteria (likely activated by hypoxia). Due to this, the author‘s advice is administering wide spectrum antibiotics (against aerobes and anaerobes) postoperatively.

Massive hepatocellular carcinoma, left lobe, dog


Hepatobliary cystadenoma, cat

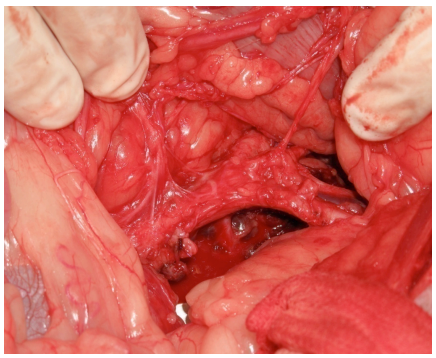
Pancreas: *esocrine adenocarcinoma* carries a poor prognosis. The reasons are a) its high metastatic rate and b) localization. If confined to the right or left limb it may occasionally be excised; in case of body involvement (often associated to jaundice), surgery becomes problematic. Total pancreatectomy is not usually performed in veterinary mredicine.

Canine perianal (hepatoid) tumors: they affect mainly elderly intact male dogs; females are usually spayed bitches (potentially with Cushing). They include *adenoma* and *epithelioma* (hormone dependent and responsive to castration) and *adenocarcinoma*. Regarding adenocarcinoma, both growth and metastasis (sublumbar lymph node, 10-15% of cases) are slow. En bloc excision, if feasible, may result in fecal incontinence if more than 50% of the external sphincter muscle is removed. If tumor involves the “tail gland”, tail amputation is usually curative. Survival is usually long.

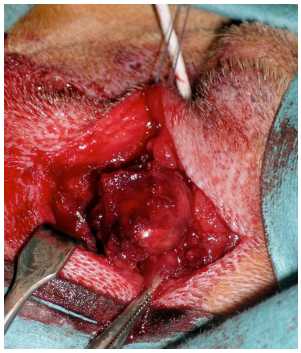
Anal sac adenocarcinoma: it affects mainly aged spayed bitches (in which it may be often associated with paraneoplastic hypercalcemia caused by a PTH-like substance) but also males and intact females; cats may be affected very rarely. Metastatic progression to sublumbar lymph nodes is early and frequent and causes fecal tenesmus. Distant metastases may develop in the spleen, liver, lungs and bone and this makes prognosis poor. Hypercalcemia represents a medical emergency and must be treated appropriately; if hypercalcemia does not resolve, surgery should be planned. After accurate staging (total body CT scan), dogs with uni- or bi-lateral (rarely) anal sac tumor and sublumbar lymphadenopathy are candidate for surgery. The latter consists in: a) marginal excision of the anal sac adenocarcinoma and b) excision, if not infiltrated in the wall of the iliac arteries (to check intraoperatively), of all enlarged sublumbar lymphonodes (usually more than 1). If hypercalcemic, effective surgery usually results in normalization of calcemia. Adjuvant chemotherapy may be a further therapeutic option (carboplatin). Survival is 12-18 months or more; if spleen metastasis is already present, survival is shorter (median 3

months).

sublumbar lymphadenopathy



after lymph node resection



anal sac excision

4) Surgery of urogenital tumors

Only selected topics will be discussed.

Kidney: renal tumors are rare (1%). In dogs > 90% are malignant and include *carcinoma* (tubular adenocarcinoma, transitional cell carcinoma), various *sarcomas*, and *embrional tumors* (Wilm's tumor, nephroblastoma, embrional nephroma). Bilateral tumors are possible in case of lymphoma and *cystadenocarcinoma* (prevalent in German shepherd dogs as genetic disease and associated with paraneoplastic nodular dermatofibrosis and, in females, uterine polyps and leiomyoma). In cats *lymphoma* is more prevalent.

- The metastatic rate of *adenocarcinoma* is up to 50% (lymph nodes, liver, lungs, bone).

- *Transitional cell carcinoma* usually derives prom the renal pelvis; its metastatic rate is lower than adenocarcinoma.

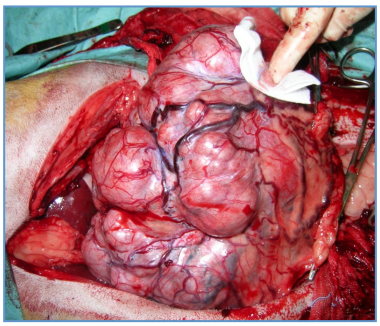
- *Nephroblastoma* usually does not spread but it may implant on the peritoneum.

- After accurate staging addressed to exclude metastasis, nephrectomy is planned. The ureter should be ligated and transected as close as possible to the bladder to avoid reflux. After nephrectomy all enlarged lymph nodes are removed or biopsied. Partial nephrectomy (polar tumor) is not advisable unless renal failure is a concern.

- At present adjuvant chemotherapy does not appear to be useful.

- Surgery is NOT an option in case of cyastadenocarcinoma (bilateral even though initially unilateral) but survival is long (months-years).

Nodular dermatofibrosis and cystadenocaercinoma (ultrasound)



Nephroblastoma

Ureters: very rare. More frequent are those that are extension of primary renal tumors; in thic case nephroureterectomy is indicated. Primary tumor include: leiomyoma, leiomyosarcoma, transitional cell carcinoma. In selected cases partial ureterectomy, end-to-end anastomosis and ureteral stenting (with double J tail catheters to avoid stenosis) may be an option.

Bladder: up to 2% of canine tumors. Females are more affected than males. Even young (<2 years) large dogs may be affected (*botryoid sarcoma* or *embrional rhabdomyosarcoma*, usually localized in the trigone and possibly associated with hyperthrophic osteopathy).

- Benign tumors: fibroma, leiomyoma, papilloma.

- Malignant tumors: *transitional cell carcinoma*, squamous cell carcinoma, adenocarcinoma, more rarely, fibrosarcoma, leiomyosarcoma, hemangiosarcoma.

- *Transitional cell carcinoma*:

a) In dogs it is more often localized in the trigonal area (*canine polypous cystitis*, an important differential, is usually at the apex and ventral part of the bladder). In cats it may be localized in less critical areas
b) It is prevalent in female dogs
c) It is invasive (and potentially implantable iatrogenically – *ultrasound-guided transcutaneous fine-needle aspiration is controindicated* – diagnosis is better reached by cystoscopy and/or ultrasound-guided catheterization and sampling)
d) cytology may overstimate – try to get sample for histology
e) regional (lymphatic) and widespread metastasis in half of cases (17% at presentation)
f) sometimes its origin is difficult to establish (urethra, prostate gland).

- Role of surgery:

a) partial cystectomy: of choiche if the trigone is not involved. A further option may be a partial cystectomy involving the trigone and uni- or bi-lateral reimplantation of ureters but there is the risk of iatrogenic spread of the tumor

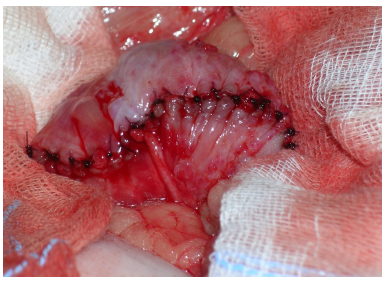
b) total cystectomy (controversial): in this case ureters may be reimplanted in the colon (quality of life ?); alternatively, in the uterine stump or urethra (with also ureteral stenting; urinary incontinence is unavoidable). Substitutive techniques are also debatable and experimental
c) surgery is often palliative. *One important point is changing gloves and surgical instruments after excision in order to avoid the iatrogenic implant of the tumor in other sites*. Even in case of histological "clean margins", recurrence is still possible. Recommended margins are 2 cm as a minimum
d) urine diversion techniques (closed catheterization with Foley or de Pezzer, cystostomy tube, etc) may be applied in case of obstruction (bladder neck). If even ureters are ostructed, prognosis is poor (even though ureters may be stented).

- Role of chemotherapy:

a) alone or as adjuvant
b) to control metastasis development and growth of the primary tumor
c) increases survival
d) piroxicam (metacam in cats)
e) drugs to combine with piroxicam: *mitoxantrone* (median survival 350 days, improvement in 75% of cases), carboplatin, gemcitabine, etc. In general, most owners are happy with palliation
f) intravescical treatment: usually uneffective because of the deep tumoral infiltration
g) multimodal treatment involving also radiotherapy and chemotherapy (and surgery, if feasible).

- Prognostic factors:

a) recurrence and/or metastasis within 1 year
b) trigone localization
c) hydroureter and hydronephrosis
d) advanced TNM at presentation
e) young age
f) involvement of urethra / prostate


partial cystectomy (up to 75% of the bladder may be resected)

Urethra: same tumors as bladder.

- *Transitional cell carcinoma* in the proximal third; *squamous cell carcinoma* more distally.

- FEMALE (old bitches), from urethra to trigone; MALE, from prostatic urethra to trigone.

- Lymphatic metastasis in 50% of cases.

- Surgery: cystourethrectomy and ureter reimplantation.

- Occasionaly, marginal excision of leiomyoma or segmental urethrectomy and end-to-end anastomosis (puboischial osteotomy or ostectomy needed).

- Urine diversion or urethral stenting (palliative).

- Chemotherapy: as before.

- Males: in case of urethral squamous cell carcinoma localized in the penis → after accurate staging → penis amputation, castration and scrotal urethrostomy.

Squamous cell carcinoma: penis amputation, castration and scrotal uethrostomy

Testicle:

- Canine tumors: interstitioma (leydigoma), seminoma, sertolioma.

- Cryptorchid dog: high risk for sertolioma (50%) and seminoma.

- *Sertolioma*: feminilazion in 50% of cases (estrogen production).

- Sertolioma and seminoma (sometimes together in the same testicle): metastasis in 2-15% of cases.

- Castration often curative. A potential negative factor may be the bone marrow depression caused by estrogens (anemia, leukopenia, thrombocytopenia).

Feminilization in a case of an intrabdominal sertolioma

Prostate gland

- Malignant tumors are not dependent on hormonal status and are more frequent in castratd males

- Medium-large dogs

- *Adenocarcinoma* (70-80%), *transitional cell carcinoma;* more rarely, leiomyosarcoma, other sarcomas

- Sublumbar lymphatic spread, vertebrae, lungs

- Possible extension to bladder / colorectum

- After accurate staging → total prostatectomy in very selected cases (after opening of pelvis). Urinary incontinence is likely.

- Palliation: urine diversion, urethral stenting.

- In general: poor prognosis.

Ovary

- Ovarian tumors are very rare. May derive from epithelial, stromal and germinal cells.

- *Epithelial* (40-50% of all ovarian tumors in dogs): adenoma, papillary adenocarcinoma (also bilateral), cystadenoma, cystadenocarcinoma, etc. *Adenocarcinoma* may cause peritoneal malignant effusion and widespread metastasis.

- *Germinal* (6.12%): dysgerminoma (also bilateral), teratoma, teratocarcinoma (metastatic in 1/3 of cases).

- *Stromal* (more common in cats, up to 50% of cases): *granulosa cell tumor* (usually unilateral, may secrete estrogens and progesterone, 20% malignant in dogs, > 50% malignant in cats; may cause peritoneal carcinomatosis with widespread metastasis), thecoma, luteoma.

Uterus

- Uterine tumors are very rare.

- Mainly mesenchimal: *leiomyoma* (85-90%), *leiomyosarcoma* (10%)

- More rarely, adenoma, adenocarcinoma (more frequent in cats).

- Prognosis after excision: good if no metastasis at surgery; relatively poor prognosis in cats with adenocarcinoma because of metastasis.

Vagina

- Relatively frequent (2-4%), second genital tumor after mammary neoplasms.

- Most are benign (*leiomyoma*, *fibroma*). Mainly in nulliparous bitches, > 2 years old (usually 10-11 ys old).

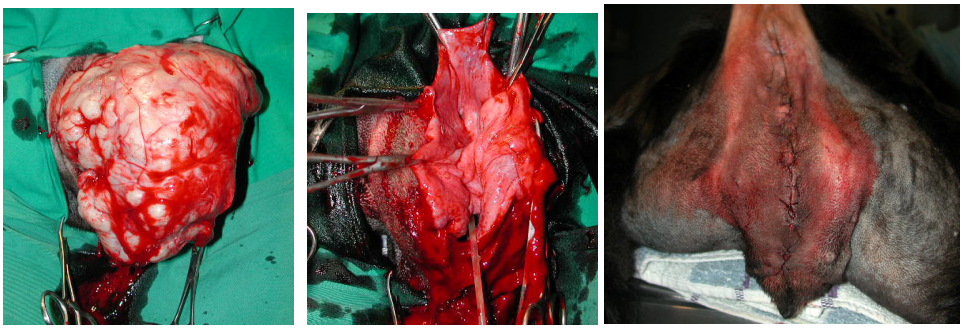
- Benign tumors are hormone-dependent → recurrence rate of 15% if bitches are not spayed at the moment of tumor excision.

- Malignant tumors are rare. Mainly *leiomyosarcoma* but also squamous cell carcinoma, adenocarcinoma, hemangiosarcoma, mast cell tumor, TVT (in endemic areas), etc

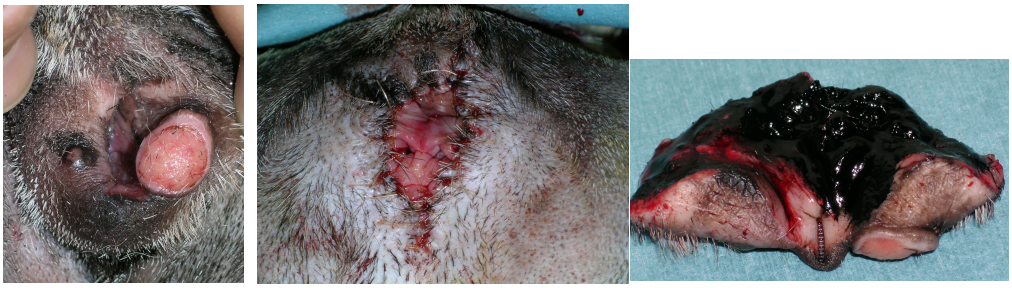
- Vaginal tumors may be intra- or extraluminal (benign tumors may protrude through vulva during estrus).

- Surgery (be always careful in identifying urethra!)

a) episiotomy, marginal excision and spaying for benign tumors
b) complete vaginectomy and urethrostomy (where possible) in case of malignant tumors (selected cases after accurate staging)



After episiotomy a large leiomyoma has been marginally resected



Grade II mast cell tumor: vulvectomy. Excision margins have been identified by china inking.

Complete vaginectomy/vulvectomy and perineal uretrostomy for vaginal leiomyosarcoma

5) Surgery of chest wall tumors

Tumors of this region may derive from

- ribs (chondrosarcoma, osteosarcoma, hemangiosarcoma)
- soft tissues (mainly soft tissue sarcomas)
- pleura (mesothelioma).

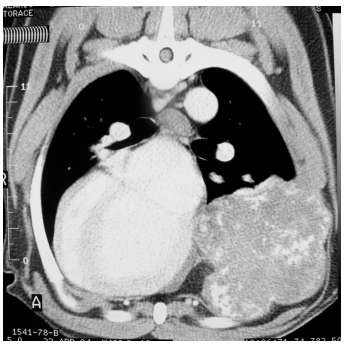
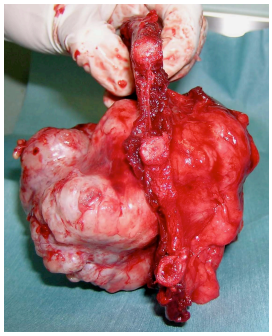
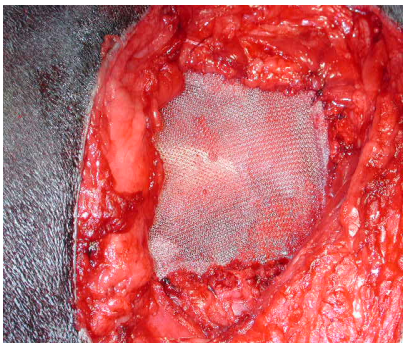
- *Bone tumors.* Rib osteosarcoma is characterized by a higher metastatic rate than appendicular osteosarcoma and only a few dogs are alive at 6 months. Adjuvant chemotherapy is essential to prolong survival (start within 6-10 days from surgery). Chondrosarcoma has a better prognosis while only rarely it is possible to plan a treatment for a rib hemangiosarcoma because of disseminated metastasis.

- Staging: *CT scan of all the body* is essential to exclude metastasis and plan surgery.

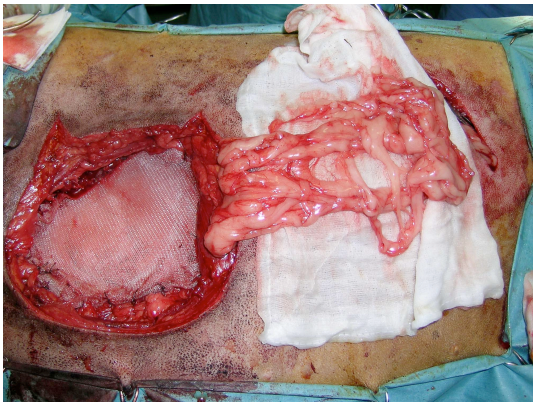
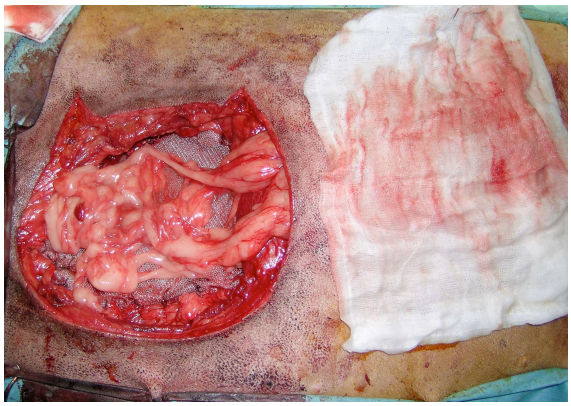
- Surgery: still recommended when the number of ribs to be removed is 6-7. After rib removal, it has also been emphasized the importance to stabilize the thoracic wall with a

rigid mesh. Techniques that can be applied (also in combination) are based on the use of:

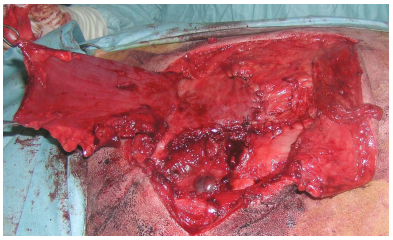
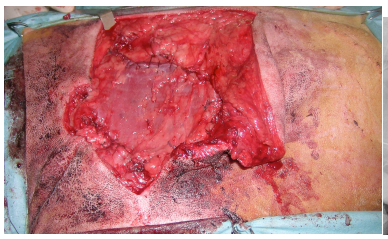
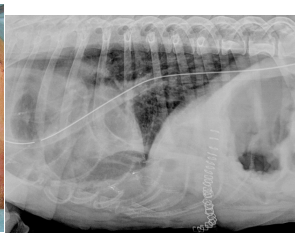
- polypropilene mesh: this is fixed with interrupted sutures using nonabsorbable monofilament material
- latissimus dorsi flap (to obtain an airtight closure)
- omentalization (the great omeunt is divided from spleen, then is taken out of the abdomen through a 2 cm dorsal paracostal incision; finally it reaches the proposed site through a subcutaneous tunnel)
- when the resection involves the caudal ribs, an alternative may be a) the advancement of the diaphragm and b) the closure of the abdominal wall defect with a muscular flap instead of the thoracic one. If the space in the thorax is evidently reduced as a result of the diaphragm advancement, a partial or complete caudal lung lobe lobectomy may be indicated
- a *thoracostomy tube* should alwayd be applied at the end of surgery to prevent fatal complications (such as pneumothorax) and removed within 24 hours.

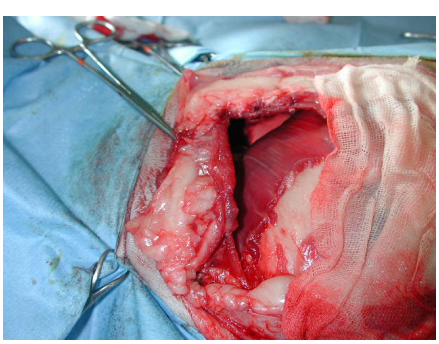
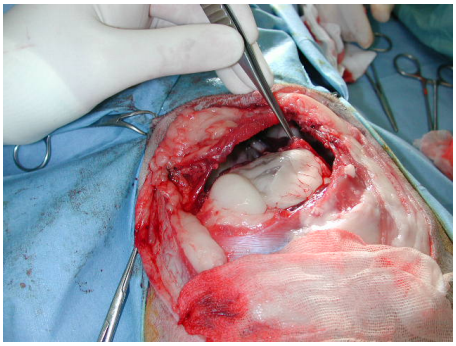
CT of a rib osteosarcoma After removal …… and mesh application

Omentalization

Latissimus dorsi flap to assure an airtight closure thoracostomy tube



Diaphragm advancement

- *Soft tissue tumors* (mesenchimal): in terms of malignancy, it is prevalent their infiltrative pattern of growth rather than their ability to spread. These tumors need to be excised with a minimum of 3 cm of peripheral margins and 1 or 2 fascial planes deeply. Sometimes this implies also the removal of the underlying ribs.

SPECIFIC FELINE TUMORS

1) Surgery of facial squamous cell carcinoma

It is a very frequent tumor, almost exclusively observed in white-haired cats or in those white-haired in critical areas such as nose, eyelids and ears. It is caused by sunlight UV. The metastatic rate is very low but its erosive ability is capable to destroys tissues if not treated at an early stage (already during the preneoplastic stage of dermatitis). Prognosis depends on the possibility to operate the cat and get “clean” margins.

Surgeries that can be perfomed are:

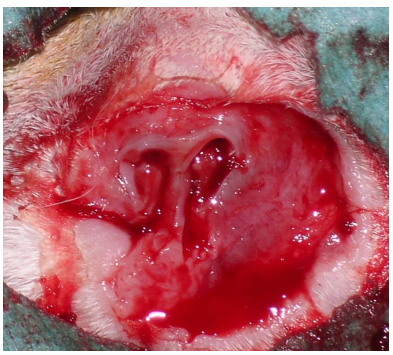
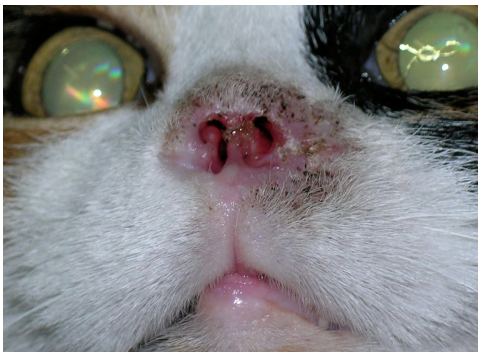
- conchectomy
- nosectomy
- eyelid resection and reconstruction (many techniques – see also rotating flaps)

Combined approaches imply to plan surgery, radiotherapy, photodynamic therapy, and local infiltration with chemotherapeutic drugs (cisplatin, carboplatin).


Conchectomy

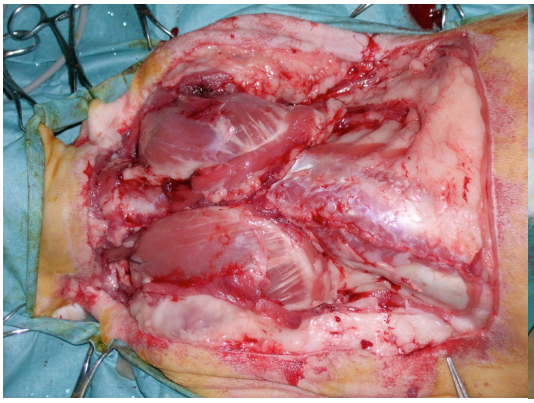


A special flap is the mucocutaneous “lip to lid” flap that is used to reconstruct the inferior eyelid (the oral mucosa is saved only at the level of the original conjunctival lining; a bridge incision is always needed (Hunt GB. Use of the lip-to-lid flap for replacement of the lower eyelid in five cats. Vet Surg. 2006, 35:284-6)



nosectomy

2) Surgery of injection site sarcoma

See review of the authors recently published on The Veterinary Journal (Martano et al. 2011).




Typical aspect of a cat submitted to an en bloc resection for an injection site sarcoma

3) Surgery of feline mammary tumors

- Between 85-90% of feline mammary tumors are malignant (*adenocarcinoma*).
- For malignant mammary disease unilateral and preferably bilateral mastectomy should be performed. The bilateral mastectomy may be performed as a two-staged procedure (two unilateral mastectomy 4-8 weeks apart) in obese cats or in those with large lesions

where there is doubt about being able to achieve a tension free closure of skin. Inguinal lymph node is removed together with the caudal mammary gland while the axillary one is excised only if enlarged through a supplemental incision.

- Prognosis for cats with adenocarcinoma is guarded and depends on:

  - *tumor size.* Reported mean survival time for T1 (tumor less 2cm) and T2 (tumor of 2-3 cm) staged cats was respectively 54 and 24 (15-24) months; for T3 (tumor >3cm) staged-cats survival ranged between 4 and 12 months. These results emphasize the need for an early diagnosis and treatment;
  - *histologic grade.* The classical distinction to well, moderately and poorly differentiated adenocarcinoma may help in predicting survival at 1 year: ranging from 100% in well differentiated tumors to 0% for poorly differentiated lesions; variable results are expected for the intermediate forms. A high ki-67 has been associated with reduced survival;
  - *extent of surgery*. Aggressive surgery alone may decrease the recurrence rate but, apparently, it does not improve the overall survival time. A study indicated that survival length was associated with surgical dose (917 days after radical bilateral mastectomy, 428 after regional mastectomy and 348 after unilateral mastectomy); however, in this retrospective study doxorubicin chemotherapy was also given. Given the lack of evidence in favour of one technique over another the author would still recommend bilateral mastectomy;
  - *clinical stage*. The influence of metastases and their location on outcome may be intuitive. One study has shown that median survival of stage I, II, III and IV mammary carcinoma was respectively 29, 12.5, 9 and 1 months. Based on another retrospective case series survival of cats developing metastases after treatment depended on the location of metastases: 331 days for animals with pulmonary metastasis and over 1500 days for those developing nodal metastasis. The latter finding was unexpected and it was attributed to the use of chemotherapy, potentially able to influence the overall metastatic pattern.

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