## WOUND EVALUATIONS AND BANDAGING

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Introduction: Wound healing is a complex event that consists of phases that will occur simultaneously as well as continuously. Most of what is occurring is microscopic, but it is important to try and associate certain aspects of the wound healing process that we can see to these microscopic events. Cytokines, growth factors, and key cell types are going to initiate, maintain, and modulate the healing process. The goal of this lecture will be to review the microscopic events, describe the macroscopic changes, and then apply this information to open wounds and their evaluations.

There are 3 main phases in wound healing; inflammation, repair, and maturation. The inflammatory phase is characterized by vascular permeability, chemotaxis, and cell activation. The proliferative or repair phase has fibroblast proliferation, angiogenesis, and epithelialization. Last the maturation or remodeling phase is hallmarked with reorganization of the collagen and gain in strength. We will discuss each phase in depth.

Following an injury, capillaries and lymphatics are damaged which results in bleeding and lymph fluid accumulation. The vessels will undergo vasoconstriction for about 5-10 minutes after the insult in response to catecholamines, serotonin, histamine, and bradykinin. Next there is vasodilation that occurs with an increase in vascular permeability. This results in transudation of plasma and cells. The most important cell in this stage is the platelet which helps to organize the blood clot and releases cytokines and growth factors. The blood clot acts as a hemostatic plug, barrier to infection and fluid loss, and a substrate for organization of the wound (provisional extracellular matrix, ECM).

The term extracellular matrix is used to refer to the wound bed at various stages in the healing process. Initially in the inflammatory phase the provisional ECM is composed of fibronectin and fibrin that has binding sites for the white blood cells and connective tissue cells that will be migrating into the wound. Later this ECM reorganizes into the granulation tissue during the repair phase. It is composed of collagen (initially type 3, then type 1 predominates), hyaluronan, laminin, and proteoglycans. Lastly the ECM will become the scar that will undergo collagen reorganization in the maturation phase.

The inflammatory phase is characterized by neutrophils and macrophages that enter the wound and provide debridement. Fibrinogen is converted to fibrin which releases fibrinopeptides; these serve as chemoattractants for neutrophils. Neutrophils migrate into the wound within 6 hours. They phagocytize bacteria and debris and release toxic oxygen species that kill bacteria, degrade macromolecules, denatured ECM and damaged cells. Pus or exudate that we see is from the wound fluid, degrading neutrophils and denatured tissue.

Monocytes predominate in older wounds (by 5 days), because neutrophils are short lived. Monocytes are essential cells and become the wound macrophage, can become multinucleated giant cells, or evolve into epithelial cells and histiocytes. Macrophages produce mediators that modulate wound healing; fibroblast growth factor (FGF), epidermal growth factor (EGF), platelet-derived growth factor (PDGF), transforming growth factor alpha and beta (TGFα, TGFβ), tumor necrosis factor (TNF), interleukins, and matrix metalloproteinases (MMPs).

Early the macrophages provide debridement with phagocytosis and later the macrophages help modify the provisional ECM into granulation tissue. Macrophages have good survivability and become the directors of wound healing. They modulate fibroplasia, angiogenesis, and stimulate collagen production with the release of various cytokines and growth factors. The inflammatory phase usually lasts about 3-5 days and is sometimes called the lag phase. This is because there is no gain in strength during this phase.

The transition from the inflammatory phase is marked by invasion of fibroblasts and subsequent accumulation of collagen into the wound. The provisional ECM transitions into granulation tissue by 3-5 days after the injury. Epithelialization and wound contraction also occur. The repair phase is typically from days 5-21, but this is dependent on many other factors.

Granulation tissue fills the defect, protects the wound, is a barrier to infection, provides scaffolding for epithelialization, and contains myofibroblasts. The myofibroblast, a specialized fibroblast, is responsible for contraction of the wound. Granulation tissue can be dark red all the way to pale depending on the amount of angiogenesis and collagen deposition.

Early in the repair phase there will be an in-growth of new capillaries from pre-existing vessels at the wound edges, endothelial sprouting. Macrophages produce FGF, VEGF, and TGFβ which are the main mediators of angiogenesis. Low oxygen tension and increased lactic acid can also stimulate angiogenesis within the wound.

Fibroplasia will occur as mesenchymal cells migrate into the wound. The nearby fibroblasts will proliferate and via expression of integrin receptors migrate. Fibrinolysis occurs as collagenases are needed to help clear the path as the fibroblasts are migrating. Another cell type that was already discussed was the myofibroblast which contains contractile filaments that allow for contraction. The fibroblasts then begin synthesizing the ECM by producing collagen, proteoglycans, and glycoproteins. The collagen is unorganized and accumulates the most during days 7-14 after wounding. The wound gains strength during this phase as the collagen is deposited.

The epithelial cells at the margin will begin to move and migrate using the granulation tissue as a scaffold. These cells will then proliferate working to cover the wound. Epithelialization can be seen as soon as 4-5 days, but it starts 1-2 days after the injury. This process takes place under the scab, which is why scabs fall off. Re-epithelialization may not be complete depending on the wound and host factors (discussed later).

Contraction is visible after 5-9 days after the injury. This is the reduction in wound size. There is intussusceptive growth as the surrounding skin stretches, centripetal advancement. This is predominately due to the myofibroblast and TGFβ1, TGFβ2, and PDGF. The collagen in the wound is not responsible for contraction. The wound will continue to contract until there is negative feedback from contact inhibition or excessive tension. Contraction can result in contracture which is the shortening of the scar tissue which will result in a distortion of function over certain areas of the body, i.e. a joint.

An incised wound that was sutured closed may have complete epithelialization by 24-48 hours. A partial thickness wound that has a variable portion of the dermis can heal by adnexal re-epithelialization which takes ~21 days. There will be immediate migration over the surface of the wound from the wound margins and adnexal structures left in the dermis. If there is a full thickness wound it will heal by wound

contraction and epithelialization. The adnexal structures won't regenerate, and pigmentation may be variable.

The maturation phase is hallmarked by the transition from ECM to a scar. The cellularity in the wound decreases and the collagen fiber bundles become thicker, increase cross-linking (making them stronger), and change orientation along lines of tension. This process takes months to years and the increase in mechanical strength is slow. The MMPs and tissue inhibitor of MMPs (TIMP) work to degrade the ECM, remodel, inhibit angiogenesis, and induce apoptosis.

The gain in strength in an open wound is slow. The most rapid gain in strength occurs between 7-14 days as collagen deposition occurs. An open wound has approximately 20% of its final strength within 3 weeks of the injury. A wound may never have the tensile strength of the original tissue; a scar is only 70-80% as strong as normal tissue. Interestingly, different tissues gain strength at different rates. The sutured wound of the intestine and urinary bladder is 80% of normal tensile strength at 10 days.

So if we approach this in a problem solving format, what are the types of goals we would need through each phase of wound healing? During the inflammation phase we would like to reduce contamination, prevent infection, and clean and debride the wound. Whereas during the repair phase we want to protect the granulation tissue and provide topical stimulants for wound healing depending on the events taking place (epithelialization and contraction). Lastly, during the maturation phase we want to protect the fragile epidermis as it begins to stratify.

As we consider the normal healing process, it is important to take into consideration the factors that can have an impact on the normal healing process. As we look to different treatment options and new methods of wound healing, we examine these factors and try interventions to optimize the healing process. There are 3 categories of factors that have an affect on wound healing; physical, endogenous, and exogenous factors. The physical factors may include things like oxygen tension or temperature. Endogenous factors include hypoproteinemia, altered microcirculation, uremia, liver disease, steroids, or infection. Lastly, exogenous factors such as vitamins and minerals, NSAIDS, steroids, cytotoxic drugs, radiation therapy, and antiseptics can affect wound healing.

Wound Classification Schemes and Wounding Mechanisms: The wound factors that should be listed with each injury include mechanism of the wound, duration, and contamination. We can describe the wound by how it was caused or the mechanism of the wound; mechanical, chemical/ toxin, thermal, radiation, pressure, draining tracts. Examples of mechanical wounds include abrasions, incision or lacerations, degloving or shearing, puncture or projectile wounds and bite wounds. Draining tracts are often the result of infection, sequestrum, implants, foreign body or immune mediated disease. The mechanism allows us to consider the forces that were exerted to create the wound with shear tension and compression forces being the most common. Shear forces usually are created with a small amount of energy to a small area. They tend to be more superficial, but if the object is sharp they can be deep with contamination. Tension forces occur when there is a striking force at an angle with high energy. This usually results in a flap of skin or avulsion with subsequent trauma to tissues from ischemia and contamination. Compression forces are from a striking force with high energy resulting in significant trauma to the tissues from ischemia, shredding and contamination. Breaking the wounds into mechanisms can allow us to characterize a group of wounds based on the effects that they cause including the size, depth, degree of contamination, damage to surrounding tissues and treatment strategies.

We also classify the wound based on the amount, type and time of contamination. Wounds can be considered clean, clean contaminated, contaminated or dirty and they are considered per acute within 4-6 hours, acute or chronic. In veterinary medicine we see mostly acute wounds and there is usually some level of contamination. The difference between a contaminated wound and a dirty wound is based on the amount of time the contamination has been there, if greater than 8-12 hours the contamination has likely progressed to an infection and is now dirty. This again allows us to stratify treatment options knowing that contaminated and dirty wounds should most likely be left open initially.

It is always important to consider patient factors when evaluating the mechanism of the wound. Patients with certain comorbidities may be more at risk of different types of wounds or wound healing complications. The medications list, travel history, nutrition, and past medical history should be carefully assessed. The way to treat a wound is very dependent on host or wound factors and host factors to consider would include diabetes mellitus, hyperadrenocorticism, hypoproteinemia, uremia, anemia, FeLV, or FIV. Once the wound factors have been characterized and the patient factors described a diagnostic wound assessment can be performed.

Diagnostic Wound Evaluation: The first part in doing a diagnostic wound evaluation is to have a clear definition of the anatomy of a wound and to have a wound evaluation form that is used consistently. If the wound is not being thoroughly documented, then subtle changes that indicate complication or lack of progression can be missed delaying wound healing. The parts of the wound include the wound edge, depth, base, surface of wound bed, structures in the wound, pocketing, periwound skin, and effusion.

A diagnostic wound assessment typically requires heavy sedation or anesthesia, so should eb done in patients that are stable. The wound should be covered with sterile lubrication and the skin clipped at least 6-10cm lateral to the wound. After the skin has been scrubbed aseptic technique is used during the assessment. The location of the wound should be recorded, and size is measured in cm; length (dorsal to ventral), width (cranial to caudal), clusters can be measured as 1 wound. The depth is probed in a circular fashion using a clock face to describe the location. The periwound skin is helpful in determining if the wound is infected and if it is sustainable for closure. Features to consider are color, texture, temperature, integrity and pain. Exudate is characterized by type and quantity. If present necrotic tissue can be characterized by type and what connective tissue is involved. The wound edges should be evaluated for adherence to the wound bed and the margins evaluated for thickness, rolling, and fragile epithelium. The wound bed lists exposure of supporting structures and the presence and characterization of the granulation tissue. Lastly, cofactors for non-healing or delayed healing should be assessed; tissue ischemia, infection, osteomyelitis, pressure, necrotic tissue, foreign material, neuropathy, neoplasia, atypical etiologies.

The 6 Goals of Wound Management: When treating a patient with an open wound we aim to heal the patient as fast as possible, have minimal complications, keep cost low, and have minimal morbidity for the patient. Some wounds can be closed right away while others may have a delayed primary closure, and some heal by second intention or with third intention healing. In any wound where closure is not selected immediately proper open wound management should be initiated. The main goal of open wound management is to establish a wound bed free of necrotic tissue or infection. There are 6 steps involved in open wound management; prevent further contamination, remove foreign contamination and debride necrotic tissue, lavage, provide adequate drainage, promote a vascular wound bed, and selection of the appropriate closure type.

When a patient is presented for open wound management they may have concurrent injuries. Therefore, patients with traumatic injuries need a careful patient assessment and the problems should be triaged. The life-threatening injuries should be addressed first. If there is an open wound, the wound should be covered to prevent contamination while the patient is stabilized. We can prevent further contamination by adhering to aseptic technique when addressing the wound. Keep the patients on clean tables and always wear gloves when handling the patient. The administration of broad-spectrum antibiotics is indicated in traumatic wounds.

The wound needs to be cleaned to remove any foreign material. Start by using a sterile lubricant placed directly into the wound. Clippers should be used to remove hair from the skin edges and about 6-8cm around the wound. Chlorhexidene or betadine scrub solution can be used to clean the skin around the wound, taking care not to get the scrub into the wound as it is cytotoxic.

Lavage is used to remove foreign material and bacteria from the wound and surrounding skin. For maximum efficacy the irrigant should be delivered at 8-12 psi. This was originally described using a 35cc syringe and a 19-gauge needle, but more practically a 60 cc syringe and 18 gauge needle, a pressure bag can be used, or bulb syringe and bowl. Lavage fluid should be an isotonic crystalloid fluid such as LRS or normal saline. In grossly contaminated wounds tap water can be used as lavage. The wound can be flushed with an antiseptic such as dilute chlorhexidine at a concentration of 0.05% (1:40 dilution) or povidone-iodine at 1% (1:10 dilution).

The third step is to provide debridement and assess the wound. Strict asepsis should always be employed when tending to open wounds. Instruments that have been autoclaved, sterile gloves, and drapes should be used to prevent nosocomial infection. This is usually when the diagnostic wound evaluation is also completed. An important thing to remember is that the degree of damage to the deeper tissue may not always be apparent from the superficial wound. If the wound penetrates the abdominal cavity, an abdominal exploratory must be completed. If the wound is contaminated or dirty a deep tissue culture should be obtained for culture as superficial swabs are not effective at providing accurate culture results. The criterion that is used for removal of necrotic tissue includes the color, vascularity warmth, and contractility of the tissue. While debriding it is important to avoid disrupting the subdermal plexus as this is the blood supply to the overlying skin. The level of tissue damage may not be apparent until after 24-48 hours, therefore a staged debridement may be necessary. Some wounds may require continual debridement. The types of debridement that can be provided include surgical, enzymatic, mechanical, interactive dressings, or larval.

If a wound is left open, then any effusion produced from the wound will drain onto the bandage. Contaminated and dirty wounds should be left open for this reason. In circumstances where the wound is closed and wounds with a large amount of dead space or a clean contaminated wound should also have a drain. The type of drain selected will depend on the location of the wound, amount of drainage expected, and availability. A passive drain such as a penrose can be used but it is important that the exit site is away from the wound and in a dependent location. Also, the exit site should ideally be covered by a sterile dressing at all times. Active drains such as a Jackson-Pratt drain should exit away from the wound and need to be emptied at routine intervals.

To promote a vascular bed that will be acceptable for wound healing appropriate bandaging techniques need to be employed. You should choose a bandage that will remove the exudates, provide

debridement, protect the surface, and stimulate granulation tissue formation and healing. There are various topical agents that can be used to stimulate healing at the various stages of healing.

Finally, wound closure will be determined based on the various factors previously described. The basic options for wound closure include first intention healing which is primarily suturing the wound edges together. Second intention healing takes place with the formation of granulation tissue, epithelialization and contraction. Third intention healing is delayed closure of the wound after granulation tissue has been formed.

Bandaging Open Wounds: The functions of a bandage include maintaining a moist environment, providing a local energy source, reducing edema, increasing growth factors, improving inflammatory response, improving oxygen content and improving blood flow. The two basic types of bandages used in open wound management include wet to dry bandages and moist wound healing bandages. Choosing the right type of bandage is dependent on the purpose of the bandage (soft tissue injury, orthopedic injury, surgical wound), animal factors (age, health, compliance), and wound factors (locations, depth, surrounding tissue, contamination, concurrent injuries, phase of wound healing).

When considering the different bandaging techniques of the open wound it is important to understand the components of a bandage. The primary layer is in contact with the wound and should be sterile. The secondary layer is the wicking layer and will collect the exudates produced by the wound. The tertiary layer essentially holds the bandage together. A splint or some form of immobilization can also be incorporated into the bandage.

The wet to dry bandage is a commonly used bandage for wounds in the inflammatory and early repair phases. It is useful for wounds that are contaminated or dirty with moderate to large amounts of exudate. It provides mechanical debridement of bacteria and necrotic tissue. The primary layer is a saline dampened gauze. The bandage is changed according to the amount of exudate, but it should be changed at least once a day. Once granulation tissue is present this type of bandage is usually not needed. The disadvantages of a wet to dry bandage are nonselective debridement, sedation is needed for bandage changes, it is painful, they need to be changes frequently, and bacteria can penetrate the gauze.

The moist wound healing bandages are used in wounds during the inflammatory and repair phases. The primary layer is a moisture retentive dressing (examples will be discussed). It promotes an environment where white blood cells survival and therefore provide a more selective debridement. There are decreased infection rates, lower oxygen tension, they are less painful, and there are less frequent bandage changes. Disadvantages of moist wound healing bandages include damage to peri-wound skin and the wound bed due to excessive exudate.

Primary layer options can be divided into 2 groups; nonadherent and adherent. Nonadherent layers are further categorized as occlusive or semi-occlusive and examples include calcium alginate, polyurethane foam, hydrocolloid, hydrogel, telfa pads, petrolatum-impregnated gauze - Adaptic. When to use the various primary layers is dependent on the type of wound, contamination level, phase of healing, and the amount of exudate. Non-adherent dressings are used in moist wound healing, surgical wounds, or

epithelializing wounds. Many of the primary layers can be purchased with topical agents already impregnated.

We can enhance the wound healing with the addition of various topical agents. There are many products available and many companies making new therapies for enhancing wound healing. Many of these products try to target goals such as maintaining moisture, providing an energy source, reducing edema, increasing growth factors, increasing the inflammatory response, and improving antibacterial properties.

A few that are used more commonly include silver, iodine, acemannan, honey, and sugar. Acemannan acts as a growth factor which stimulates macrophages, enhances fibroblast proliferation, increases neovascularization, enhances collagen deposition and epidermal growth. It can be used in partial or full-thickness wounds, burns, or ulcers. Honey (preferably unpasteurized) decreases edema, stimulates macrophage migration, accelerates sloughing of dead tissue, provides an energy source and promotes the development of a healthy granulation bed. Honey is also naturally broad spectrum and can be used in infected wounds. Granulated sugar can also be used in open wound management. It has very similar effects as honey. When using honey or sugar it is important to monitor for hydration or electrolyte imbalances due to the hydrophilic action of the agents.

A newer wound healing method being used is negative pressure wound therapy, also known as vacuum assisted closure (VAC). Vacuum-assisted therapy uses controlled subatmospheric pressure by applying intermittent or continuous negative pressure. This promotes wound healing and accelerates the formation of granulation tissue. The VAC was initially developed to increase wound healing by second intention in patients that were debilitated or those that were poor surgical candidates. An open cell foam sponge is cut to fit over the wound surface. An adhesive dressing is applied over the foam and skin to provide an airtight seal. The sponge is connected to a vacuum pump that transfers the fluid to a drainage canister. This type of bandage allows for moist wound healing.

The mechanism of action is thought to work by altering the physiologic and chemical environment of the wounds by removing fluid and causing mechanical stress. The vacuum removes the wound exudates, reduces tissue edema and enhances blood flow. The mechanical stress caused by the negative pressure increases cell proliferation which will increase granulation tissue formation allowing for migration of keratinocytes across the defect.

The VAC bandage can be applied in many clinical situations. This bandage can be used in the inflammatory or repair phases of wound healing. The VAC is safe to use over areas of exposed bone, tendon, or muscle. The VAC can be used in wounds that have moderate to mild exudate. This type of bandage can be useful in large wounds that are difficult to bandage. The VAC has also been applied in reconstructive surgery cases to aid in graft adherence. The disadvantages of using the VAC include expense, repeated sedation, hospitalization, and pain.

The last thing to consider when applying the bandage is the secondary and tertiary layers. These are dependent on the type of bandage that is being applied which is usually selected based on the location of the wound and the function of the bandage. For wounds on the extremities a Modified Robert Jones is a common and easy way to apply the bandage. If immobilization is needed than a splint can also be incorporated into the bandage. If the wound is on the truck or in an area that is difficult to bandage a “tie-over” bandage or an ioban bandage can be used.

The tie over bandage is very easy to apply and can be used with wet to dry or moist wound healing bandages. The patient should be sedated or anesthetized. Stay sutures are placed around the wound, the bandage is applied and then umbilical tape is used to tie-over the bandage to keep it in place. A protective layer of drape or ioban can also be used to protect the bandage from the environment.

An ioban bandage or a bandage utilizing an adhesive dressing as the tertiary layer is also useful in areas that are difficult to bandage. An adhesive spray can be used on the skin surface to help the dressing adhere. When changing an ioban bandage, leave the ioban adhered to the skin. Ioban can also be used to help relieve tension. The disadvantage of an ioban dressing is that anesthesia may be required for complete removal and the skin can become inflamed after removal.

Monitoring and Complications: It is important to monitor the patient for signs of complications and owners need instruction as to abnormalities to note. If the bandage is on an extremity than the toes can be monitored for spreading apart which indicates swelling. The skin can be monitored for coolness which may indicate ischemia. The bandage should be touched to see if it is wet which could be fluid from the wound, dog licking or external source, but would require a bandage change. If the patient is licking at the bandage it may indicate that there are pressure sores, irritation dermatitis, infection and it should warrant a bandage changes and careful consideration. Common complications include pressure sores especially over pressure points. The skin can develop dermatitis especially between the toes. If the bandage is too tight it will cause swelling and in worse case scenario ischemia whereas a bandage too lose may fall off. Careful consideration is needed at fractures, making sure to span the joint above and below so that the bandage doesn't act as a fulcrum at the fracture site. Skin maceration can occur in wounds that are highly effusive and aren't changed frequent enough. Careful monitoring and immediate action can usually prevent major complications from occurring.
Diagnostic Wound Evaluation: The first part in doing a diagnostic wound evaluation is to have a clear definition of the anatomy of a wound and to have a wound evaluation form that is used consistently. If the wound is not being thoroughly documented then subtle changes that indicate complication or lack of progression can be missed delaying wound healing. The parts of the wound include the wound edge, depth, base, surface of wound bed, structures in the wound, pocketing, periwound skin, and effusion. A diagnostic wound assessment typically requires heavy sedation or anesthesia, so should eb done in patients that are stable. The wound should be covered with sterile lubrication and the skin clipped at least 6-10cm lateral to the wound. After the skin has been scrubbed aseptic technique is used during the assessment. The location of the wound should be recorded and size is measured in cm; length (dorsal to ventral), width (cranial to caudal), clusters can be measured as 1 wound. The depth is probed in a circular fashion using a clock face to describe the location. The periwound skin is helpful in determining if the wound is infected and if it is sustainable for closure. Features to consider are color, texture, temperature, integrity and pain. Exudate is characterized by type and quantity. If present necrotic tissue can be characterized by type and what connective tissue is involved. The wound edges should be evaluated for adherence to the wound bed and the margins evaluated for thickness, rolling, and fragile epithelium. The wound bed lists exposure of supporting structures and the presence and characterization of the granulation tissue. Lastly, cofactors for non-healing or delayed healing should be assessed; tissue ischemia, infection, osteomyelitis, pressure, necrotic tissue, foreign material, neuropathy, neoplasia, atypical etiologies.

## ABDOMINAL SURGERY

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Introduction: It is important to have a good understanding of the anatomy of the gastrointestinal tract, understanding the blood supply, ligaments, and relation to other organs systems. This will help in deciphering the diagnostics and help in surgical decision making.

Diagnostics: When working a patient up with non-specific clinical signs such as vomiting, it can be challenging to interpret radiographs when there is not an obvious obstruction. By taking both lateral views the gas can redistribute highlighting a foreign object or you can follow loops of bowel easier. In some instances, contrast can be used to help differentiate functional obstructions from mechanical obstructions. The colon is often gas filled and can be confused with small bowel, a barium enema or a pneumocologram can be used to help delineate the colon. If the radiographs are inconclusive treat the patient medically: rehydration, antiemetics, gastroprotectants and recheck radiographs in 6-8 hours. Patients with gastroenteritis typically start to show improvement within that time, while patients with obstruction may

Localization: Sometimes the clinical signs can help in localizing the segment of bowel that is affected. Dogs that have diarrhea may have an obstruction that is located further aboral, closer to the ileum. Intussusception is also more likely to manifest with diarrhea versus other causes of obstruction. Patients with a pyloric obstruction may have projectile vomiting and a metabolic alkalosis due to the loss of gastric acids. Linear foreign bodies usually start as being partial with intermittent clinical signs and as the intestines plicate the obstruction becomes complete and the patients are sick.

Surgery: Patients should receive intraoperative broad spectrum antibiotics such as Unasyn at induction and every 90 minutes. Antibiotic are usually continued for 24 hours after surgery. A midline celiotomy is performed with an incision made from xiphoid to pubis. An exploratory laparotomy is performed, and the foreign body is located. The bowel is inspected for ischemic necrosis using subjective criteria; color, arterial pulsations, peristalsis, bleeding and texture. Sometimes a perforation will be obvious, if not then experience will help in determining if an enterotomy or resection and anastomosis is indicated. Always use more than 1 criteria to determine viability. If in doubt cut it out, is an expression used in these situations. If the bowel is healthy than a longitudinal enterotomy is made aboral to the foreign body in the non-obstructed bowel. If the bowel is ischemic or perforated a resection and anastomosis should be performed, removing the unhealthy bowel. Bowel may appear much healthier after the foreign object has been removed indicating congestion of the tissue. If the bowel stays dark in color after removal of a foreign object, then it should be removed. If the intestinal wall tears while removing the foreign object it is best to perform a resection and anastomosis.

Key principles to intestinal surgery include; prevent contamination, proper suture material, proper suture pattern, leak testing, and reinforcement. Isolate and bring the intestines out of the abdomen. If the foreign object is in the duodenal flexure, transect the duodenocolic ligament. Prior to creating an incision in the bowel, the segment to be operated should be isolated away from the abdomen; this is another reason why a larger incision may be beneficial. Laparotomy sponges are used to “pack-off” the site or keep separate the clean and contaminated areas. Set a separate set of clean instruments aside, these will be used to close the body one the GI surgery is complete. Ingesta should be milked away from the site of the incision and then the intestine atraumatically clamped using fingers or Doyen forceps.

Bobby pins can be purchased from the store, gas sterilized, and work great for atraumatic occlusion of the lumen.
When transecting bowel for a resection and anastomosis use an oblique angle to improve the blood flow to the antimesenteric edge and to adjust for luminal disparity. Suture material should be of a small gauge, absorbable, synthetic, with strength characteristics similar to the healing of the intestine. For most small animals 4-0 is a good choice, and a taper is preferable; I prefer 4-0 PDS using an RB needle. In small animal patients an appositional pattern with simple interrupted or simple continuous is recommended. A gambee pattern can also be used if there is excessive mucosal eversion.
Once the incision is closed a leak test is performed by inserting a small gauge needle (25g) on an angle into the intestine a few cm away from the incision and saline is injected into the lumen while occluding oral and aboral to the incision. A fluorescein stain can be placed into the saline to change the color to yellow making it more visible. Reinforcement using omentum or serosa can be used to patch the incision site. Some people also like to use sealants over the incision, although there is no evidence this prevents leakage. Staplers can also be used to close enterotomies and anastomoses.
Surgical gloves and instruments are changed to prevent contamination. The surgical site should be locally lavaged to remove any gross contamination prior to being placed back into the abdomen. The abdomen should also be lavaged in case of leakage or bacterial translocation. If the patient has septic peritonitis thorough lavage is recommended. Ideally suction is used to remove the fluid during and after lavage. The peritoneal cavity should have minimal fluid after lavage as the presence of fluid can prevent bacterial opsonization.
Linear foreign bodies: First release the object where is it lodged and then perform 1-4 enterotomies to remove the object without applying excessive tension which can cause perforation. Perforations occur on the mesenteric side of the bowel which is technically more challenging to evaluate due to fat. Up to 40% of dogs already have peritonitis at the time of surgery; therefore, they are more likely to require resection and anastomosis.
Intussusception: If the intestinal viability is good meaning no evidence of ischemia then a surgical reduction can be performed. When the lesion cannot be reduced, necrosis or tumor is present, then a resection and anastomosis is performed. The underlying condition should be treated as well. Enteroplication, a technique where the intestines are loosely sutured together to prevent a recurrence, can be performed if recurrence is suspected. Young patients should be dewormed and any tissue that is resected should always be submitted for histopathology.
If the obstruction is secondary to strangulation, incarceration or a tumor than a resection and anastomosis would be required. When a tumor is present, wide margins are preferred taking 6-10cm of healthy bowel on either side.

Post-operative Care: Patients recovering from intestinal surgery should continue to receive IV fluid therapy to maintain hydration and electrolyte status. Many patients have ileus following intestinal surgery due to the obstruction, surgical manipulation, pain management and electrolyte abnormalities. If the patient is having clinical signs such as regurgitation or inappetence then prokinetic drugs such as metoclopramide or cisapride should be used. In patients with evidence of ileus during surgery, a nasogastric tube can be placed prophylactically to help remove residual gas and fluid following surgery and the tube can also be used to provide enteral nutrition. When the patient is nauseous antiemetic drugs should also be administered. Patients should be managed with injectable opioids immediately following surgery for pain management. When eating they can be switched to tramadol or gabapentin, avoiding NSAIDS. Nutrition is an important aspect of recovery from intestinal surgery and patients are offered food within 24 hours.
A challenge of postoperative monitoring is differentiating major complications such as dehiscence and peritonitis versus ileus. Injury or contamination of the peritoneal cavity induces a profound

inflammatory reaction which starts with vascular permeability and movement of fluid into the peritoneal space. Mesothelial cells, mast cells, lymphocytes, neutrophils, and macrophages react-to and enhance this inflammatory reaction with the production of cytokines and recruitment of more inflammatory cells. Fluid losses into the peritoneal cavity can lead to hypovolemia and hypoproteinemia along with decreased function of the leukocytes resulting in impaired clearance. These changes can further lead to systemic alterations such as respiratory acidosis, decreased cardiac output, hypotension, tissue hypoxia and metabolic acidosis. Bacteremia, bacterial translocation and endotoxemia ensue in patients with a bacterial component to the peritonitis or in those patients with severe ileus, increased intraabdominal pressure, or impaired bile flow. The body's response to this profound inflammatory response can be as severe as pulmonary thromboembolism, disseminated intravascular coagulation, systemic inflammatory response syndrome, and multiple organ dysfunction syndrome. Most animals with peritonitis are systemically ill presenting with anorexia, vomiting, abdominal pain and distention, and fever. There may be palpable abdominal effusion, the patients may be stable or could also present moribund and laterally recumbent. Abdominocentesis can yield fluid for analysis and cytology. An abdominal ultrasound can be used to help with abdominocentesis as well as an assessment of the architecture and echogenicity of the abdominal organs. The white blood cell count of abdominal fluid that has inflammation is >5,000 but is usually much higher with a septic exudate. The presence of intracellular bacteria confirms the diagnosis of septic peritonitis. The glucose concentration of the fluid should be compared to the blood glucose concentration and a finding of the blood-to-fluid glucose concentration difference of >20mg/dL is 100% sensitive and specific for septic peritonitis.
If septic peritonitis is diagnosed after surgery, usually 3-5 days afterwards, the patient should be stabilized with fluid resuscitation as needed. Starting antimicrobials therapy is initially empirical and should include bactericidal antibiotics effective against gram + and – aerobes and anaerobes. A culture and sensitivity should be performed on the fluid to further guide antimicrobial therapies.
Surgery is the mainstay of treatment and the area that is leaking will need to be resected.
The abdomen should be thoroughly lavaged with 200-300ml/kg as a minimum and more commonly lavaging until the returning fluid is clear. Prior to closure of the abdomen a closed suction drain can be placed to help evacuate the exudate that is produced from the inflammatory reaction that will continue. The post-operative care of patients with peritonitis can be intensive with a large amount of monitoring. Patients should continue to receive parenteral antibiotics until they are receiving enteral nutrition. Nutrition is an important concept during the healing process and placement of feeding tubes at the time of surgery should be considered. Fluid therapy needs to be maintained as these patients continue to have ongoing losses of protein rich fluid into the abdominal cavity. Peritonitis, ileus, and surgery all contribute to pain and therefore multimodal therapies are beneficial with local blocks given via epidural, continuous rate infusions of a pure mu opioid and Lidocaine are helpful. Some animals may require transfusions of plasma, red blood cells, or albumin.

Prognosis: The prognosis for gastrointestinal foreign bodies is usually good with reported dehiscence rates of 3-27.7%. Risk factors for dehiscence include low albumin, peritonitis, and a higher band neutrophil count. The cause of the obstruction will influence the prognosis in each case. If the patient has septic peritonitis the prognosis carries up to a 50% mortality rate.

**Principles of Urinary Tract Surgery:**

When performing surgery on the urinary tract it is very important to have gentle tissue handling. We can achieve this goal with the use of stay sutures and avoiding using thump forceps to grasp or manipulate tissue. If you are using thumb forceps make sure to use DeBakey forceps. The normal bladder heals very quickly with mucosal defects healing within about 5 days and full thickness defects

regaining 100% of normal tissue strength within 14 - 21 days. Monofilament suture material is recommended since it causes less tissue drag in the delicate bladder and fewer bacteria will adhere (as compared to multifilament suture). Nonabsorbable suture is not required and could contribute to cystic calculi formation. The urinary tract heals quickly and therefore it is important to select suture that wont stick around for too long. Suture material that is in the lumen of the bladder can be nidus for infection or stone formation. Ideal suture types include monocryl or byosyn. The holding layer of the urinary tract (excluding kidney) is the submucosa and therefore it is imperative that you capture the submucosa when closing an incision into the urinary tract. The ideal suture pattern to close the urinary tract in small animals is appositional with full thickness bites. Tissue will always heal best when directly apposed. There is no need to place an additional suture line as the urinary tract heals quickly and fully.

Prior to surgery most patients with urinary tract disease should undergo an extensive preopertive work up including thorough physical exam, CBC, serum biochemistry, coagulation panels, urine culture, and blood pressure. Full staging should be performed in animals suspected to suffer from neoplasia. Imaging including radiographs, ultrasound, CT, or MRI can be performed (with our without contrast) to further evaluate the structure of the kidney and other abdominal organs prior to proceeding with surgery. Whenever possible, uremia, blood pressure irregularities, and electrolyte abnormalities should be corrected prior to surgery. An indwelling urinary catheter may be placed to allow quantification of urine production. Maintenance of renal perfusion is critical so pre- and intra-operative hypotension should be prevented or corrected aggressively.

If a cystotomy was created a leak test can be performed to ensure no obvious leakage. This is done by injecting saline into the bladder with a catheter or with a needle and the putting gentle pressure on the bladder while observing the incision. If the patient had radiopaque bladder stones, a post operative radiograph should be performed to ensure all stones have been removed.

Post-operatively intravenous fluids should be continued to maintain renal perfusion and to prevent obstructive blood clot formation within the urinary tract. Analgesia should be provided and animals should be monitored for anemia, oliguria/anuria, and evidence of urinary tract obstruction. Early post-operative management may include serial RBC or platelet counts, serum biochemistry panels, weight and blood pressure measurement, and quantification of urine output.

**Hepatic anatomy**

It is important to review the anatomy of the liver prior to taking a patient to surgery for evaluation, biopsy or possible resection. The liver sits in the cranial abdomen where it is protected under the ribs. The liver is divided into lobes based on fissures that create these separations giving rise to individual sections. The left liver lobe is divided into the left lateral and the left medial lobes. The quadrate lobe sits on midline and creates ½ of the gallbladder fossa with the other ½ coming from the right medial liver lobe. The right lateral liver lobe and caudate liver lobe are usually fused at their base. The caudate lobe has a caudate process that is dorsal and touches the right kidney and a papillary process which crosses to the left side and is covered by the lesser omentum.

The liver has several ligaments that keep it situated alongside the other organs. The coronary ligament is an extension of the peritoneal covering of the liver and connects the liver to the diaphragm. More prominent are the left and right triangular ligaments attaching the respective lobes to the diaphragm. There is a hepatorenal ligament that attaches the caudate process to the right kidney. The hepatogastric ligament is part of the lesser omentum that connects the porta hepatis to the lesser

curvature of the stomach and the hepatoduodenal ligament connects the porta hepatis to the duodenum. The hepatoduodenal ligament is the ventral border of the epiploic foramen which contains the bile duct, hepatic artery, and portal vein. Temporary occlusion of the hepatic artery and portal vein by compressing the hepatoduodenal ligament is called the Pringle maneuver.

The liver has a dual afferent blood supply with the portal vein contributing 80% of the blood and the hepatic artery 20%. Animals can survive without a hepatic artery but not a portal vein! The hepatic veins drain the liver lobes and feed into the caudal vena cava with the right and central portions being within the hepatic parenchyma. The left hepatic vein can be within the parenchyma but is usually seen between the liver and the diaphragm where the vena cava passes through the diaphragm.

**Biliary tract anatomy**

Bile is secreted from hepatocytes into the canaliculi and then enters the bile duct system. Hepatic ducts exit the liver and converge to form the common bile duct. Bile is directed up the cystic duct into the gallbladder for storage and modification. Upon eating cholecystokinin is secreted and bile flows from the gallbladder into the cystic duct and then common bile duct through the sphincter of Oddi and out of the major duodenal papilla. The common bile duct passes through the right limb of the pancreas, enters the mesenteric duodenum and travels intramurally 1-2cm before the papilla, which is usually 3-6cm aboral to the pylorus. The cystic artery, a branch of the hepatic artery, supplies the bile duct and gallbladder.

Indications for liver surgery include PSS, elevated bile acids, AV malformations, hepatopathy, focal lesions, cavitary lesions, torsion, and very rarely trauma. Surgical liver disease can be grouped as being parenchymal, biliary, neoplastic, or vascular. We will discuss portosystemic shunts, although keep in mind there are other vascular anomalies of the liver such as portal vein hypoplasia or arteriovenous malformations. Examples of parenchymal diseases include vacuolar disease, necrosis, hepatitis, cavitary lesions (abscess/ cyst), torsion, or hyperplasia. Oftentimes surgical biopsies are obtained to rule out neoplasia and histologically define the types of nodules noted on ultrasound or during explore. Older animals with Diabetes and steroid induced hepatopathies often have vacuolar changes noted in the liver. Amyloidosis may be seen secondary to chronic inflammation or in Shar peis and oriental cats. Hepatitis is classified as being acute or chronic and determining the cellular infiltrate, presence of fibrosis, and mineral content can help guide the therapy. In many instances animals are considered to have a hepatopathy and histopathology is required to classify acute versus chronic, familial, drug associated, infectious, idiopathic, regenerative, or copper accumulation.

Hemorrhage is a large risk when performing hepatobiliary surgery and can be life threatening. Prior to liver surgery a CBC should be evaluated to have a baseline PCV and evaluate platelet counts. A coagulation profile is warranted and a routine part of the preoperative assessment. Depending on the type of liver surgery anticipated, a blood type or cross match should be done beforehand as well as having blood products or substitutes available in the hospital. Patients with impaired bile flow or impaired liver function may have vitamin K deficiencies and therefore vitamin K coagulation factor deficiencies. In some cases the patients may benefit from whole blood transfusions, fresh frozen plasma, and or vitamin K supplementation.

Special anesthetic considerations include the use of drugs undergoing hepatic metabolism should be avoided or reduced in dosage. Non-steroidal anti-inflammatories should be used cautiously as patients with hepatic disease may have increased gastrin levels. During large liver lobectomies, the diaphragm may need to opened; therefore the ventilation requirements would change to accommodate an open chest. The use of alpha 2 agonists should be avoided in patients with pancreatic disease.

Broad spectrum antimicrobials are recommended in patients undergoing hepatobiliary surgery. The most common isolates from the liver seem to enteric in origin. Recommended protocols would include metronidazole and potentiated penicillin, potentiated penicillin and a fluoroquinolone or clindamycin and a fluoroquinolone.

Some patients presenting with acute diseases such as hemoabdomen or biliary tract rupture may require more intensive therapies prior to surgery such as transfusions, fluid and electrolyte replacement, colloid support, glucose supplementation, and continuous monitoring of hemodynamic status with EKG and blood pressure measurements.

**Liver biopsy techniques**

The histologic assessment of the liver is needed for many diseases that affect the parenchyma of the liver. Ideally a liver biopsy should contain 6 portal areas and therefore need to be of a sufficient size. At least 2-3 liver biopsies should be procured sampling different liver lobes. It is also important to remember that the right division of the liver receives the first branches of the blood supply and therefore may represent a healthier portion of the liver especially when getting biopsies in which vascular anomalies are a concern. Prior to biopsy the technique should be determined and this can be a function of the location, patient stability, and concurrent diseases. Lastly, the number of samples obtained is influenced by the different diagnostic testing being performed. At least 2-3 samples should be submitted for histopathology, whereas a 1cm piece of tissue should be evaluated for mineral analysis, and a 5mm sample for culture, and occasionally a sample for toxicology can be submitted.

The different approaches for sampling include percutaneous, laparoscopy and open surgical. A tru-cut biopsy needle is used with ultrasound or CT guidance to obtain a percutaneous liver biopsy. A 14 or 16 gauge needle is recommended as the 18 gauge is too small. Advantages to this technique include the less invasive nature, usually only sedation or a short anesthetic period is required, no to minimal pain. Disadvantages include hemorrhage, equipment (needle and ultrasound) and small samples.

Laparoscopic liver biopsy is a less invasive technique compared to open surgical biopsies and allows for direct visualization of the liver with more targeted biopsies. Usually 5mm cup biopsy forceps are used to sample the liver from both the periphery and the central portions of the lobes. The scope can be used to observe the biopsy sites for visualization of clotting and if needed gel foam or surgical can be placed onto the biopsy sites to help promote clot formation and hemostasis. This technique may also detect smaller lesions that were missed with diagnostic imaging techniques alone. Advantages include the magnification, visualization, larger biopsy samples, and minimally invasive attributes. Disadvantages include the cost of equipment, need for anesthesia, risk of hemorrhage, and learning curve with the technique.

Open surgical biopsy techniques are maximally invasive but allow for a thorough examination of the liver and abdominal contents. This option is best for a focal disease that may require a liver lobectomy or if there are concurrent abnormalities that need to be addressed. The suture fracture technique or guillotine method is easy and commonly used. A monofilament, absorbable suture is selected and pre-tied with a surgeons throw. A peripheral portion of the liver lobe is placed through the loop and the loop is tied. This crushes through the parenchyma and compresses the vessels and ducts into the suture loop to stop bleeding. Smaller vessels may tear and ooze, but should stop with clot formation. Gel foam or surgical can be placed on the cut surface to aid in hemostasis. Alternatively a punch biopsy can be used to obtain samples from the central portion of the lobes. The punch is depressed into the parenchyma completely and then removed. The portion of liver tissue is removed, but may need to have the medial attachments cut with Metzenbaum scissors. Care should be exercised to not crush the tissue with forceps during manipulation. A piece of gel foam, the size of the punch, can be placed into the defect that was created in the liver to aid in hemostasis. If a larger piece is needed a partial or complete liver lobectomy can be performed. This can be achieved with dissection and ligation techniques, the use of vessel sealing devices, and thoracoabdominal staplers. Risks associated with bleeding are greater with larger liver resections.

**Bile sampling**

When evaluating a patient for infectious or inflammatory conditions the bile should be collected for aerobic and anaerobic culture and sensitivity. A 25 or 22 gauge needle can be used for sample

collection. This can be performed percutaneous, although much riskier, via laparoscopy or an open surgical approach. The needle is inserted into a healthy area of the gallbladder or it can be introduced through the liver and then into the gallbladder, transhepatic. Drain a large volume of bile to reduce leakage from the needle site. This should be avoided in instances where there is extrahepatic biliary obstruction of primary gallbladder disease. It has been found that bile cultures are significantly more likely to be positive than liver cultures. Potential risks may include gallbladder rupture, bile leakage, and vagal response. Smaller needle sizes help reduce the risk of vagal reactions and acute shock.

The liver has an amazing regenerative ability. About 70% of the liver can be removed, but care should when considering the function of the remaining liver. The hepatocytes undergo compensatory hypertrophy and hyperplasia following hepatectomy.

Acute inflammation is the response to injury of pancreatic tissue. The inflammation can progress to pancreatitis, but is usually reversible. Following the leukocyte infiltration fibrosis occurs and is also indicative of chronic conditions

Following biopsy patients should be monitored for potential complications. Hemorrhage is the most common complication following liver biopsy. The patients can receive crystalloid fluid therapy during recovery and potentially colloid fluids or transfusions as needed. The respiratory rate, heart rate, blood pressure and PCV/TP should be monitored. In patients with small drops in PCV/ TP and no other signs of hypovolemia, no additional surgery is generally required. Patients that are clinical for blood loss, are not responding to medical management, and continue to decompensate should be taken back to surgery to look for hemorrhage. Patients undergoing pancreatic biopsy should be monitored for signs of pancreatitis.

## SURGICAL COMPLICATIONS: CLASSIFICATIONS AND DECISION MAKING

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Introduction: Talking about complications is not a very enjoyable discussion. It usually implies some sort of technical error, patient or owner compliance issue, or poor decision making and planning. But despite the best pre-operative planning, compliance, technique, and peri-operative care, complications do happen. Complications can lead to patient morbidity, death, and increased cost, loss of trust of the client and for these reasons everything should be done to avoid surgical complications. There are many different complications and they are often dependent on the type of operation, various patient factors, surgeon factors, and post-operative care. Taking the potential complications into consideration is imperative as a surgeon and although this topic is not fun, it is very important.

Infection: An infection is the invasion of pathogens into the tissue and post-operative infections are a risk for any patient undergoing surgery. About $10^5$ bacteria per gram of tissue are needed to establish an infection. An infection can develop in the skin or subcutaneous tissues, at the body wall, within any organ, in bone, on an implant, or within a body cavity or space. The Centers for Disease Control, CDC, uses specific criteria for defining surgical site infections (SSIs). They are divided into superficial incisional, deep incisional and an organ/space SSI. A superficial incisional SSI is within 30 days of surgery is localized to the skin or subcutaneous tissue and clinically has purulent discharge, pain, swelling, redness, heat, and has a positive culture if performed. A deep incisional SSI occurs within 30 days to 1 year (if an implant is present), is in the deep soft tissue (fascia, muscle), and clinically has purulent discharge, the patient may have a fever, pain, abscess, fistula, and a positive culture if performed. An organ/ space SSI occurs within 30 days to 1 year (if an implant is present), is present in the area that was operated, has purulent discharge, abscess, and a positive culture if performed.

The risk factors for developing infections can be categorized as patient factors, procedure factors, pre-operative factors, surgical factors, or post-operative factors. The patient factors would include things like endocrinopathies, pyoderma or distant infections, or obesity. The type of procedure can be defined using the wound classification system. Pre-operative factors can play a role such as early hair removal and the use of peri-operative antibiotics. Surgical factors that may contribute to the development of SSIs include the operating room environment (number of people, ventilation), asepsis, surgical technique, and the duration of surgery. Lastly the post-operative care of the incision can contribute to infections; if the wound is not properly cared for or if the patient is in an environment that is dirty.

The best ways to avoid developing an SSI is with proper pre-operative planning. Careful review of the risk factors should result in actions that will reduce the development of a post-operative infection. Good client communications will result in good owner compliance as well.

Treatment of SSI's require antimicrobial therapy. The antibiotic can be selected empirically, but it's recommended that a culture and sensitivity be performed to guide the therapy for a more efficient and effective course. Depending on the location and condition of the infection, open wound management may need to be employed. Remember the principles of open wound management; prevent further contamination, remove foreign contamination, debride necrotic tissue, provide adequate drainage, promote a vascular wound bed, and selection of the appropriate closure type.

Implants are ideally inert and therefore do not cause any reaction in the body. Unfortunately, if bacteria contact an implant they can cause chronic infections. Bacteria secrete a biofilm while on foreign material in the body which is impenetrable by systemic administration of antimicrobial agents. Therefore, when using an implant, proper planning and review of the risk factors associated with infections must be understood prior to surgery.

Dehiscence: Dehiscence is the breakdown and subsequent opening of an incision. Risk factors for dehiscence include technical error, patient factors, infections, neoplasia, exogenous factors, and self mutilation. Although not intentional, lack of experience and knowledge can have a significant correlation to iatrogenic causes of incisional dehiscence. The type and size of suture should be selected based on the healing anticipated, the tissue, presence of infection, and the size of the animal. Remember that the rectus fascia is slow healing and therefore the suture should degrade slowly. Examples of appropriate suture include polydioxanone (PDS®), polyglyconate (Maxon®), or non-absorbable sutures. Closing the appropriate tissue layers and knowing the holding layer of the tissue being closed is especially important. Remember that the holding layer for the body wall is the external rectus fascia, and if the fascia is not correctly identified subcutaneous tissue may be closed instead resulting in a body wall hernia. Poor knot tying can result in dehiscence which can be more catastrophic if a continuous pattern was used. It is also important to take adequately sized bites of tissue and appose the tissue properly without the suture being left loose or instead being tied too tight. If the sutures are being tied tightly they can cause necrosis and tissue breakdown, in the skin they can cause irritation and potentiate self-trauma. Knowing the appropriate distance between suture placement is important and will vary on the tissue being closed. Clamping or grabbing suture material with instruments will make it weaker and could lead to suture failure.

The appearance of dehiscence of the skin incision will vary depending on the cause and the presence of infection. Occasionally just 1 or 2 sutures may fail, and a small area may be open. Alternatively, the entire incision may be open. The treatment will be directed at closure of the wound which could be immediate or require open wound management first. Dehiscence of the body wall will result in a body wall hernia. The size of the hernia will depend on the cause of failure. Smaller hernias may allow only omentum to herniate which could lead to serosanginous fluid at the incision. Larger hernias can look rather obvious and palpation will reveal the defect in the closure. Occasionally an animal may self mutilate because of the hernia or they may cause the hernia. This leads to evisceration and some animals then consume parts of the viscera. The treatment of a body wall hernia is directed at closing the external rectus fascia. Depending on the severity, the animal may require a simple closure, lavage of the abdomen, or an intestinal resection and anastamosis. Pre-operative planning, experience and practice and good client communication about post-operative care will contribute to avoiding dehiscence.

Dehiscence of an incision of the gastrointestinal tract will lead to leakage of the intestinal contents into the abdominal cavity and septic peritonitis. Other causes of septic peritonitis include contamination from leakage at the time of surgery, contamination or rupture of infected fluid from the uterus (pyometra), urinary tract, or biliary tract, ascending infections, migrating foreign objects, or retained sponges in the abdominal cavity. Septic peritonitis is a severe and life-threatening disease and therefore careful and planned techniques when operating within the abdominal cavity are very important. Take the time to use laparotomy sponges to isolate the structure, use stay sutures and retracting devises to prevent spillage. Local lavage to the contaminated tissue is beneficial and then the entire abdomen is lavaged.

Dehiscence of an incision into the urinary tract results in an uroabdomen and chemical peritonitis. If the urine is infected, then it is also septic. The holding layers for the gastrointestinal tract and bladder are the submucosa. Remember gentle tissue handling, preservation of blood supply, and appropriate suturing techniques.

Seroma: A seroma is the formation and accumulation of sterile fluid under the skin or within a tissue. A seroma may lead to additional complications such as infection or dehiscence, therefore it is important to understand how a seroma may form. The factors contributing to seroma formation include dead space, inflammation, foreign material or irritants, high activity or high motion. Sometimes these are inherent in the location or type of surgery. Techniques that will minimize seroma formation are gentle tissue handling, closure of dead space, minimizing inflammation by keeping tissues moist during surgery and reduced surgery times, using suture material that is appropriate for the tissue type. Good post-operative care with exercise restrictions are also paramount. The treatment for a seroma is exercise restriction, e-collars, bandaging and warm compresses. Occasionally the seroma should be drained (needle versus surgical drain), but care should be used as introduction of bacteria is a risk. A seroma may be very slow to resolve and can take up to 4 weeks.

Hemorrhage: A hematoma is a collection of blood within a tissue or organ whereas hemorrhage is the ongoing loss of blood into a space or body cavity. Hemostasis is a necessary part of surgery as the effects of a hematoma or continued hemorrhage can have serious effects on the patient. The different techniques for hemostasis are covered in another lecture. All attempts should be used to stop any active bleeding at surgery. Unfortunately, bleeding may occur during recovery due to improper ligature technique, dislodgement of clots due to increases in blood pressure, an unrecognized bleeding disorder, or development of a coagulation defect. Prior to surgery review the anatomy and be aware of the blood supply in the area, review hemostasis techniques and have hemostatic agents available if needed, and properly assess the patient for any bleeding disorders or risks of developing bleeding disorders after surgery. The treatment of a hematoma may include pressure bandaging and supportive care. Hemorrhage can be treated with supportive care with fluids, blood transfusions, pressure wraps or re-operation. The decision for medical versus surgical treatment will vary in each case.

Pain: Pain management is an important part of the post-operative care that a surgeon provides. Remember that there are four different classifications of pain (somatic, visceral, sympathetic, and neurogenic) and we have many medications that can be used to target different pain pathways. Patients will have pain from the incision, manipulation of viscera, ileus, implants, sutures, inflammation, as well as many other reasons. Unfortunately, it can be difficult to assess pain in animals. Some signs to watch for include crying, excessive panting, elevated heart rate, tenderness, and reluctance to walk or lay down. Cats tend to hide or become less social. Choosing the right pain management plan will depend on the type of surgery, the patient's ability to tolerate particular medications, and the route and ability to administer the medications.

Ileus: Ileus is the lack of peristalsis of the intestinal tract that can lead to a functional intestinal obstruction. In people, ileus is a common problem after surgery. In dogs and cats, it is less of a problem but may be seen after intestinal surgery, pancreatitis, peritonitis, hypokalemia, intestinal obstruction, drugs (opioids, anticholinergics) or after intra-abdominal surgeries with extended duration. A cat or dog may not have a bowel movement immediately after surgery and this is acceptable for up to 7 days after surgery. Ileus can present a clinical problem if it is resulting in severe abdominal pain or intestinal obstruction. Signs of ileus may include vomiting, abdominal pain, lack of borborygmus on auscultation,

and inappetence. Good surgical technique and pre-operative planning can help reduce the incidence after surgery. Treatment for severe cases includes supportive care with fluid therapy, prokinetics, correction of any underlying problems (potassium), or discontinuing medications. Walking can also be helpful to stimulate normal gastrointestinal motility.

Stricture: A stricture is the narrowing of an opening, lumen, or passageway. A stricture is usually due to poor wound healing (ischemia) and improper technique. Certain anatomic locations are more prone to developing strictures such as the esophagus or ureter. Techniques to help decrease the chance of stricture formation include gentle tissue handling, proper suture selection and utilization, and good tissue apposition. There are also techniques of closing incisions to improve the diameter of the lumen versus narrow the lumen. Signs of a stricture will depend on the location of the stricture. Treatment can be either medical or surgical and this decision will be based on the clinical signs, location and previous surgery. For example, a perineal urethrostomy performed in cats with urethral obstruction can lead to stricture formation. This is usually due to inadequate dissection, too large of suture, failure to close the mucosa to the skin or self-trauma following surgery.

Disease/Procedure Specific: There are certain cancers that can cause either local or systemic effects that may alter a surgical plan. For example, a thyroid carcinoma will release cytokines that cause a local coagulopathy which can lead to substantial blood loss during surgery that may require a blood transfusion. A hemangiosarcoma can cause cardiac arrhythmias that require careful monitoring during and after surgery. Inflammatory diseases (pancreatitis, peritonitis) can cause systemic effects and lead to severe complications after surgery such as hypotension, SIRS, DIC, ARDS, and MODS. Dogs undergoing upper airway surgery are at risk of pharyngeal swelling and aspiration pneumonia post-operatively; therefore, we must monitor them closely for normal respiratory patterns.

Checklists and damage control: For decades many industries, for example the airline industry, have used checklists to lower error and complication rates and ensure safety. Checklists have recently been introduced into both human and veterinary medicine and have been found to improve patient safety and reduce medical errors. Implementing a checklist in practice can be practical and adaptable to the needs of the clinic. When errors or complications occur, it is very important to manage these directly and openly. Team meetings and morbidity mortality rounds can be very beneficial to creating an environment that favors open discussion rather than punishment. Meeting to discuss complications leads to making changes and alterations in procedures to improve outcomes.