Surgery tips for the soon-to-be and new practitioner

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Abstract

Surgical procedures conducted on livestock in field settings carry their own set of unique challenges related to environmental factors, variable quality of facilities available to the veterinarian, untrained surgical assistants in the form of owners or farm workers (or no available help at all), and access to surgical instruments, anesthetics and emergency drugs limited to what is carried on the veterinarian's practice vehicle or clinic. Adhering to the basic principles of surgery specifically applied to the veterinarian performing surgery in the field can help decrease the incidence of surgical site infections, improve patient outcomes, and avoid failure of the surgical intervention.

Key words: bovine, surgery, suture material, tension, antisepsis

Introduction

In the late 1800s, Dr. William Halsted, credited as one of the founding fathers of Johns Hopkins Hospital in Baltimore, Md. and a forefather of the practice of modern surgery, developed a set of surgical principles that are, to this day, the standard of practice in surgical theaters across the globe. By following Halsted's Surgical Principles (Table 1), our patients have a better surgical outcome, decreased post-operative complications, and therefore, less cost to the producer in the post-operative period. Each of these principles are described specifically as they apply to the large animal field veterinary surgeon.

1. Gentle tissue handling using the appropriate instrument

Gentle is not usually a word that is used synonymously with bovine surgery. And often, the "appropriate" instrument may be the surgeon's hand or the arms of an assistant when trying to replace a segment of bowel into the abdomen (or keeping it from coming out further!) or replacing a prolapsed uterus. However, this principle definitely has application to the large animal veterinary surgeon, and by paying attention to the small details, one may change the course of the post-operative recovery period. The purpose of this principle is to decrease tissue trauma. Traumatized tissue becomes edematous, often contributes to blood within the surgical field, or the tissue can lose its blood supply completely resulting in necrotic tissue. These factors contribute to post-operative inflammation, patient discomfort, and surgical site complications. The surgeries that this principle is best applied to are surgeries specifically involving the gastrointestinal tract, urinary bladder, uterus and surgery of synovial structures.

When handling abdominal viscera, it is important to avoid using fingertips so as to not perforate a segment of distended bowel or create a rent in the mesentery that can lead to incarceration of bowel in the post-operative period. In addition, dry gauze should never be used on serosal surfaces. Dry gauze causes serosal irritation leading to post-operative adhesion formation. If it is necessary to remove blood from serosal surfaces (see principle #4), moistened gauze should be used, or alternatively, if the bowel is able to be exteriorized, lavage of the bowel segment with warm sterile saline would be warranted. Lavage also serves the purpose of removal of inflammatory mediators, excess protein and blood components, and bacteria from the surface of the affected bowel. Non-traumatizing instruments should be used on skin, serosa and mucosal surfaces. Demonstrating judicious use of Brown-Adson or Debakey thumb forceps to evert skin, grasp intestinal wall during a resection and anastomosis, or when handling a urinary bladder during cystotomy, results in decreased inflammation at the site of instrument application. Avoid using hemostatic forceps, such as Halsted mosquito forceps, Kelly forceps, and Carmalt forceps on incisional edges as this causes crushing of the incision line and a delay in wound healing.

2. Use aseptic technique

Aseptic technique is the basic tenet of the surgical principles. This goes far beyond just surgical preparation of the patient and sterilized instruments and is the biggest player in the development of post-operative surgical site infections. While the use of the word sterility would indicate that there were no microorganisms within our surgical field, it is a premature notion to actually be able to achieve a completely sterile field. This is because there are so many different factors associated with achieving sterility. When discussing bacteria specifically these factors include bacterial virulence, host immunity and bacterial load. A general rule can be applied that when bacterial load reaches or exceeds 105 microorganisms per gram of tissue, the risk of surgical site infection rises drastically.[1] Keep in mind that bacteria are derived from 4 main sources during a surgical procedure. These are the environment, the surgeon (or surgeons), the patient and the instruments. Instruments are the only factor that is able to be completely sterilized. The other 3 must be managed.

Environment

The necessity for field surgery in a production animal practice is implicit. In a perfect world, our veterinary clinics would all have haul-in facilities with a dedicated surgical suite equipped with positive pressure ventilation, filters that remove 90% of particulate matter from the circulating air, air movement that started at the ceiling and flowed to the floor, and 15 air exchanges every hour as recommended by the Centers for Disease Control. However, the expense incurred to construct a surgery suite that meets these parameters, the resulting increased cost of using this surgical facility, and the sometimes inconvenience and cost to the producer incurred by hauling an animal into a clinic make it impractical. Additionally, there are certain instances (i.e. uterine prolapse, abdominal trauma resulting in evisceration) in which transporting the animal could result in a poorer outcome when initial treatment on the farm is indicated. However, on the other side of the equation is that all environments

Table 1: Halsted's surgical principles.

1.	Gentle tissue handling using the appropriate instrument
2.	Use aseptic techniques
3.	Use sharp dissection of tissue
4.	Employ meticulous hemostasis, using fine, non-irritating suture material in minimal amounts
5.	Obliterate dead space
6.	Avoid tension

encountered in the field are not created equal. If the practitioner is given the option of performing surgery in a tie stall in front of a fan during the noonday heat or walking the cow into an enclosed room or headgate separate from bedding and other sources of organic debris, the choice should be to perform the surgery in the area that decreases the chance of contamination from particulate matter in the air. By avoiding surgery in alleyways and under fans, and using a dedicated surgical area at farms free of flies, environmental contamination may be somewhat controlled. In addition, tying down the tail of the cow can prevent the tail from coming into contact with the surgical site or the during the procedure. This can easily be accomplished with baling twine tied to the switch of the tail with the other end of the twine tied to the contralateral hock. Alternatively, a soft, small diameter cotton rope can be tied with a bowline knot to make a collar around the cow's neck with the long tail of the rope then tied to the switch of the tail. Caution should be taken not to tie the cow's tail to an inanimate object such as a chute post or other object next to the cow in the event that the cow should go down or escape causing trauma to the tail.

Surgical personnel

Attention to detail in the preparation of the surgeon and surgeon's assistants can greatly minimize the potential for inadvertent contamination of the surgical site. Human hair carries a significant bacterial load and a head cover should be worn to prevent hair from falling onto the surgical site and contamination of the site from bacteria shed from the surgeon's head. Additionally, arms should be covered by a surgical gown or sterile plastic sleeve following cleansing of the skin with surgical scrub. The use of sterile surgical gloves, especially when entering an abdomen or synovial structure, cannot be overstated. Gloves that are worn should fit properly, be within their expiration dates, and put on using sterile (preferably via closed) techniques. Fingernails should be clipped so not as to protrude above the fingertip and devoid of debris under the nail to ward off further contamination in the unfortunate incident of a broken surgical glove. The cuff of the surgical gown should not be exposed as this will absorb fluids and allow bacteria from the surgeon to permeate into the surgical field. By the end of a surgical procedure, one study found that up to 31% of gloves have holes in them.[2] In large animal surgery, because of the nature of the size of the patient and resulting interventions, I would expect that this incidence may be higher. If contamination is anticipated, the surgeon should double glove and discard the outer gloves after the contamination has occurred. The use of surgical masks is also advocated as they do effectively redirect the wearer's breath away from the surgical field. Admittedly, most veterinary surgeons in the field do not follow barrier nursing. At the very minimum, for routine, fast procedures (i.e. the uncomplicated left displaced abomasum) a sterile OB sleeve and sterile surgical gloves should be worn, the surgeon's hair should be either pulled back with a rubber band or put under a clean ball cap, and a clean scrub shirt or coveralls should be worn.

Patient preparation

Patient preparation is very important in maintaining aseptic technique. Dirty patients should be brushed or the surgical site bathed prior to surgery in an area remote from where the surgery is to take place. This will reduce the amount of bacteria and dust in the air at the surgical location. A surgical drape is always advocated that covers the abdomen (in the case of a laparotomy) and decreases the amount of environmental contamination from dirt, hair and bacteria derived from the animal's hide. The surgical site should be shaved with a #40 blade to remove hair as close to the skin as possible. The use of a razor blade to remove hair has been shown to increase the number of bacteria on the skin as the result of microabrasions (and even macroabrasions at times!) and resulting emergence of bacteria from hair follicles. Additionally, the added skin trauma increases healing times in humans. Hair that is clipped with a #10 blade is too long and contributes to the number of bacteria and hair that invade a surgical incision. The perimeter of the shaved area should exceed the anticipated incision by a minimum of 4 inches. If a drape is not used, the perimeter should be increased to 10-12 inches on all sides of the incision to minimize hair, dust and hair particles from entering the incision and to also prevent the surgeon from accidentally touching the animal outside of the area of surgical preparation.

The surgical site should then be washed with a brush, soap and water to remove gross contamination, dirt and oils. Next, the site should be prepped with a surgical scrub, not a surgical solution. There is a big difference between the two. Current choices are either povidone iodine- or chlorhexidine-based products. Studies comparing surgical scrub performance in cattle would suggest that chlorhexidine-based scrubs should be used in field settings because of the increased residual antibacterial activity. The person preparing the surgical site should wear, at a minimum, latex exam gloves to prep the site.

Antibiotics are not an alternative to poor surgical technique, which is inclusive of all of Halsted's principles. An Iowa State University study that looked at the evidence supporting the use of antibiotics administered intra-abdominally in cattle at the conclusion of abdominal surgeries failed to find a valid reason for their use.[3] The study concluded that post-operative use of antibiotics according to the labeled route is preferable to intraperitoneal use based on "the availability of registered sodium ampicillin and procaine penicillin G preparations with defined withholding periods for the IM route, a lack of evidence that the IP [Intraperitoneal] route is a preferable administration route, and limited, but consistent, evidence that IP administration in healthy cattle is associated with high variability." By following the surgical principles outlined in these proceedings as best as reasonably possible in field situations, the use of antibiotics as labeled is prudent and valuable in the post-operative period.

3. Use sharp dissection of tissue

This principle aims to provide better wound healing when the incision is primarily closed. One simple method of demonstrating this principle is to make your complete skin incision in one

pass of the scalpel instead of several small strokes overlapping each other. Multiple small incisions create multiple planes of dissection within the skin and muscle layers causing incomplete apposition of tissue during closure and a resultant delay in healing time. This also increases the presence of small pockets for serum, blood and white blood cells to accumulate and increases the risk of incisional infection. As an extension of this surgical principle, "gridding" the internal abdominal oblique and transverse abdominus muscles parallel to the direction of the muscle fibers during paralumbar laparotomy procedures results in less bleeding (see Halsted's principle #4) and provides better apposition of these layers during closure. This results in a more effective, anatomically correct body wall reconstruction at the time of closure decreasing the chance of a deep infection of the incision. Another commonly encountered bovine procedure that this principle applies to is intestinal resection and anastomosis. When resecting a segment of compromised bowel, use a stack of wet gauze sponges (5 or more) and place them directly under the proposed site of resection between your palm and the segment of bowel. Then make one bold transecting incision to remove the dead bowel. By using your palm as a firm surface to cut against, while protecting your hand with the stack of moistened gauze sponges, this will allow you to make a clean incision which will make the consequent apposition of your bowel edges much easier and less likely to leak. Finally, while sharp dissection of tissue is an important principle, there are certainly times when working in delicate areas such as the upper airway or around vessels, where blunt dissection may be more appropriate (see principle #1).

4. Employ meticulous hemostasis, using fine, non-irritating suture material in minimal amounts

The principle of hemostasis serves to reduce the incidence of hematoma and seroma formation in the postoperative period which directly decreases the likelihood of abscessation of the incision in the post-operative period. However, in surgical procedures involving large animals, this has to be tempered with a dose of reality. Most procedures are performed with the animal standing with the benefit of a lidocaine block, which starts to wane within 30-45 minutes. Hemostasis takes time, and time is money. However, it directly affects the risk of post-operative complications in large animals. In horses, it has been shown that the incidence of abdominal incisional complications doubles when surgery lasts longer than 2 hours.[4] So, while it imperative to ligate large vessels, leaving smaller vessels to clot on their own often saves surgical time. Alternatively, a hemostat can be placed on smaller, identifiable vessels for a period of time (usually 1-2 minutes) to crush the vessel without having to place a ligature. Larger vessels, though, will require a suture as they generally continue to bleed following removal of the hemostatic clamp. If using the latter technique, be cognizant of your instrument if the abdomen is opened while the instrument is still in the incision so as to not inadvertently leave an instrument in the abdominal cavity.

The choice of suture material is very important and while Halsted specifically refers to the choice of suture material in the process of hemostasis, we broaden this concept to include the use of suture material in general. The type and size of suture material is a key component of the post-operative healing process and patient morbidity after surgery is complete. The perfect suture material would be suitable for all applications, easy to handle, non-irritating to tissue, have high tensile strength, but a small diameter, excellent knot security, non-wicking behavior, be easy to sterilize, readily absorbable following its intended purpose, and inexpensive. Obviously, this material does not exist. So, in the meantime, we are left with a multitude of options. Tables 2 and 3 at the end of these proceedings are provided to help identify some of the more common sutures used in large animal practice, their characteristics, where they should be used, and the advantages and disadvantages of each.

When choosing a suture material, one should consider the procedure being performed. The suture material should be as strong as the normal tissue through which it is placed. For example, when tension is expected (see principle #6) a suture material with high tensile strength should be used. Another guideline is that the reduction in suture strength should be inversely proportional to expected strength of the healing wound. A good example of this is the use of Poliglecaprone (Monocryl) in the urinary bladder or small intestine. Poliglecaprone loses significant tensile strength within two weeks and these organs have excellent blood supply and thus are expected to heal very quickly. Another comparative example in the process of suture selection is skin which should be closed with material with more elastic properties to accommodate tissue swelling versus the abdominal wall which should be closed with material that is more stiff to prevent gaps in the incisional repair. Finally, when incisions are sufficiently healed, superficial sutures should be removed. This is especially important in the ventral abomasopexy procedure as failure to remove the non-absorbable suture can lead to an abomasal fistula in the ventral body wall. Second, the strength of a wound (or incision) is more dependent on the ability of the tissue to hold a suture than it is on the strength of the suture material. Take, for example, closing muscle layers.

The strongest suture commercially available can be used, but the ability of muscle to hold suture is poor because of the fiber orientation and friability of muscle. While it has been included in the table, catgut deserves special consideration. Catgut has been in use for centuries and was one of the first suture materials developed for use during the Roman Empire. In 2001, as a result of the BSE outbreak, it was banned for use in the United Kingdom as it is made from bovine submucosa. The newer synthetic suture materials are preferable to the use of catgut for a number of reasons. Some of the properties of catgut that make it a less-than-ideal choice for suture selection include its immunogenicity and resultant marked inflammatory response by the tissues, very poor knot security and tensile strength, and rapid absorption profile especially in the face of contamination or infection. In addition, when catgut becomes wet, the tensile strength and knot security further decline. Reports in the veterinary literature document the increased incidence of adhesion formation, marked inflammatory response, and incisional herniation as a result of its use.[5,6] While it is an inexpensive suture material, the increased rate of surgical complications associated with its use, the availability of more synthetic materials on the veterinary market (meaning more competition and less expense), and the unfriendly nature of catgut to tissue make it a poor choice. Applications that may benefit from the use of catgut are omentopexy or pyloropexy due to the benefit of inflammation and adhesion formation in these procedures. There also may be some application for catgut in limited reproductive-based procedures in bulls where temporary attachment of a Penrose drain to the penis is warranted.

Table 2: Common non-absorbable suture materials.

Non-absorbable suture materials in ruminant surgery									
Polyamide	Nylon	Multifilament or monofilament	Good; lost after 2 years	Poor	Poor	Non-absorbable	Skin; Do not use within body cavities	Can use in contaminated wounds	Poor handling characteristics
Polyester	Mersilene, Ethibond, Synthofil, Dagrofil, Ticron	Multifilament or monofilament	Very High	Moderate	Poor	Non-absorbable	Skin; Do not use in contaminated tissue	Sustained tensile strength	High degree of drag through tissues, causes marked tissue reaction
Polybutester	Novafil	Monofilament	Low- displays elasticity	Good	Good	Non-absorbable	Skin	Minimal tissue reaction; Able to expand with edematous tissue	High degree of elasticity results in low tensile strength
Polypropylene	Prolene, Premilene, Surgipro	Monofilament	Moderate	Poor	Good	Non-absorbable	Skin	Minimal tissue reaction; Greatest knot security of all non-absorbable sutures	High degree of memory making handling difficult
Polycaprolactam	Supramid, Braunamid, Vetafil	Multifilament	Moderate	Excellent	Very Good	Non-absorbable	Skin; Do not use in subcutaneous tissues due to tendency to form suture sinuses; Abomasopexy	Stronger than nylon	Incites a moderate tissue reaction

Table 3: Common absorbable suture materials.

Absorbable suture materials used in ruminant surgery

Material	Trade name	Strand structure	Tensile strength	Handling characteristics	Knot security	Absorption parameters	Indications	Advantages	Disadvantages
Surgical gut	Catgut, Surgical Gut, Chromic Catgut, Chromic Catgut	Multifilament	Low	Good	Poor	Variable; Absorbs faster in the presence of infection	Omentopexy, Pyloropexy	Inexpensive	Incites tissue reaction; poor knot security; capillarity
Polyglactin 910	Vicryl	Multifilament	High, Loses 25% of tensile strength at 14 days, 50% at 21 days, and 100% by 35 days	Excellent	Good	56-70 days	Abdominal wall Skin Subcutaneous Layers Omentopexy Pyloropexy Uterus	Stronger than polydioxanone initially, minimal tissue reaction	Greater drag through tissues than a monofilament
Polyglycolic Acid	Dexon, PGA, Safil	Multifilament	Loses 35% of tensile strength by day 14 and 65% by day 21	Good	Poor	60-90 days	Abdominal wall Skin Subcutaneous Layers		Greater drag through tissues than a monofilament; knots are not as secure as with Polyglactin 910
Braided Lactomer	Polys orb	Multifilament	High: Loses 20% of tensile strength by day 14 and 70% by day 21	Excellent	Excellent	56-70 days	Abdominal wall Omentopexy Pyloropexy Subcutaneous Tissue Skin	Stronger than Polyglactin 910	
Polydioxanone	PDS, PDS II, PDO II	Monofilament	High; Loses 25% of tensile strength at 14 days and 50% by day 42	Moderate	Good	180 days	Abdominal wall Skin Subcutaneous Layers	Prolonged tensile strength	Knot security is inferior to Polyglactin 910
Polyglyconate	Maxon	Monofilament	High; Loses 25% of tensile strength at 14 days and 75% by day 42	Poor due to high degree of memory	Excellent	180 days	Abdominal Wall Skin Subcutaneous Layers	Prolonged tensile strength	Poor handling characteristic compared to other sutures
Poliglecaprone	Monocryl	Monofilament	High; Loses 50% of tensile strength by day 7, 80% by day 14, and completely by day 21	Very good	Good	90-120 days	Gastrointestinal Tract Urinary bladder Subcutaneous Tissues Skin	Rapid absorption with high initial tensile strength; ideal for use in rapidly healing tissues; very low tissue drag	

5. Obliterate dead space

The need to obliterate dead space directly relates to decreasing the space available for serum and blood accumulation which generally lead to seroma formation, the increased risk of abscess formation, incisional dehiscence, and prolonged time for complete incisional healing. This principle is closely related to the principles of gentle tissue handling using the appropriate instrument and the use of sharp dissection of tissue. It also requires a bit of preoperative planning and careful dissection. If a large space is encountered on closing the incision, walking sutures or intermittent deep bites of the deeper layers of the incision can reduce the amount of dead space. Another technique that can be used when closing incisions is to lavage the incision with sterile saline following each layer of closure. This will remove tissue debris, blood components, and fibrin from the incision decreasing the chance for bacteria to adhere to these particles that would increase the likelihood the seroma would turn into an abscess.

6. Avoid tension

This principle has direct application to large animal surgery because of the sheer size of some of our patients. Some of the procedures in which this is particularly important are pyloropexy, omentopexy, abdominal incision closure (i.e. hernia repair and ventral incisions), laceration repair and C-Section. Excessive tension and infection are the 2 biggest contributors of incision failure and hernia formation post-operatively. In the case of repair of a displaced abomasum, correct incision placement lower in the paralumbar fossa can prevent excessive tension on a pyloropexy or omentopexy site. When a pexy dehisces, this leaves the animal at risk of re-displacement. Additionally, when a pylorpexy site dehisces, this can lead to leakage of abomasal contents into the abdomen resulting in fulminant peritonitis and death.

It is not uncommon that what appeared to have been a simple hernia repair fails. Sometimes this has as much to do with the lack of post-operative exercise management as it does with the surgery itself. There is also a common misconception that mesh hernia repair is a straightforward, risk-free procedure. Surgical mesh can be very cumbersome to use, adds great expense to the surgery, must be placed with absolute attention to asepsis, and because it is non-absorbable and placed subcutaneously, if infection is present, a chronic draining tract will persist until the implant is removed. Additionally, the use of mesh precludes an animal from entering the food supply. When at all possible, hernias should be repaired with primary closure, however the use of the appropriate suture is very important. Calves that are less than 400 lbs should be repaired with #2 or #3 braided, absorbable suture. Polyglactin 910 (Vicryl) is a common selection. Calves greater than 400 lbs should be repaired with size #3 absorbable suture. Catgut should be avoided in areas of tension because of the properties mentioned above. The hernial ring additionally should be left in place and incorporated into the repair. The "ring" is a band of fibrous tissue encompassing the edge of the herniated wall. This fibrous ring has considerable holding power and should be left in place. The common misconception is that this ring impedes body wall healing. Rather than removing the ring, the peritoneal lining covering the ring can be debrided leaving healthy tissue that should heal if tension is managed appropriately. If a simple continuous pattern is not sufficient to manage incisional tension, tension relieving suture patterns such as the far-near-near-far, interrupted cruciates, or interrupted horizontal mattress pattern, could be considered. The ideal bite size is ~2 cm from the incisional edge and ~2 cm between sutures. When concern for incisional strength is encountered, increasing the number of sutures (or number of bites in a continuous pattern) is preferable to using a larger-sized suture material. More suture material equals more foreign body material for the body to have to absorb and increases the chances of incisional complications because of the resulting increased inflammatory reaction.

In summary, by adhering to Halsted's surgical principles as best we can, realizing that field surgery has unique risks associated with it, we strive to provide our patients with an optimal outcome.

Conflict of interest

The author declares no conflict of interest.

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