

Understanding the Surgical Wound

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### Abstract

Several factors need to be carefully considered by the surgical first assistant when creating and managing wounds for the performance of surgical interventions. Practitioners need to have a clear understanding of the basic surgical incision considerations, wound classification system, factors that affect wound healing, types and mechanisms of wound healing, and common complications that can arise during the postoperative recovery of the surgical patient. Each of these topics is outlined and reviewed for the surgical first assistant practitioner.

*Keywords:* wound healing, surgical incision, tissue approximation, wound closure, wound classification, tissue handling, Halsted Principles, surgical site infection, wound complications, suturing

### Understanding the Surgical Wound

Although access to the operative site is accomplished via a myriad of different methods and approaches, each shares an often overlooked and misunderstood commonality: the surgical wound. According to Taber's Cyclopedic Medical Dictionary (21<sup>st</sup> Ed.), a wound is defined as a “break in the continuity of body structures caused by violence, trauma, or surgery to tissues” (Venes, et al., 2009, p. 2503). While there is certainly a break in body structure continuity associated with surgical wounds, they differ from other wound types in that they are made intentionally and under controlled circumstances for the purpose of operative intervention. Great care must be taken to ensure that an appropriate wound – either incisional or excisional – is created and cared for in order to carry out a safe and effective operation for the surgical patient and help ensure their successful postoperative recovery. In accomplishing this task, several important factors must be considered by the surgical first assistant (Price & Smith, 2008).

#### **Basic Surgical Incision Considerations**

Described as the intentional cutting of intact body tissue, the incisional surgical wound, or incision, is an integral part of any operative intervention and is often the first step in the exposure, repair, and/or removal of anatomic structures (Price & Smith, 2008). Surgical incisions are sometimes performed without much thought, given the overall complexity of the anticipated procedure. However, Ellis, Bucknall, and Cox (1985) note that a well-planned and expertly-executed incision allows for the best possible access to the operative field, the ability to extend the incision in the event of an unforeseen complication, and the most effective closure of the wound.

Niederhuber (1998) states that, “An incision becomes a balance between a wound that will heal rapidly with minimal scarring and disfigurement and a wound that offers ample access

to the task at hand” (p. 80). For the surgeon and first assistant, access in the form of exposure and visualization are critical to the carrying out of a safe and successful operation and is directly impacted by the location, size or length, and direction of the incision (Sutton, Rogers, & Hurd, 1999). Generally speaking, the location and length of the surgical incision are most often dictated by the type of anticipated surgical intervention. These incisions should be long enough to provide for effective access to the operative field, but small enough to allow for the rapid and complication-free recovery of the patient postoperatively. The direction of the incision should be made in the direction of the tissue fibers to ensure the best cosmetic result after the wound has healed. Incisions should also be made in areas that are easily concealable, such as along normal skin wrinkle lines, whenever possible. While making the incision, the surgeon should also be mindful of the fact that the wound will heal from side-to-side, rather than from end-to-end (Ethicon, 2007). The use of well-planned surgical incisions made in a conscientious and conservative manner will greatly enhance the likelihood of proper, complication-free wound healing in the surgical patient. However, effective wound healing and management are largely dependent upon the classification of the surgical wound.

### **Wound Classifications**

Depending upon several factors, such as the area of the body accessed and the care in which that access takes place, the degree of microbial contamination of the wound will vary. Therefore, wounds are classified into four categories or classes to describe the level of contamination present (Price & Smith, 2008).

#### **Class I Surgical Wounds**

Approximately 75% of surgical wounds can be classified as class I or clean wounds (Niederhuber, 1998). These consist of an incision or excision made under ideal sterile

circumstances with no break in aseptic technique during the course of the operation. In addition, entry into the aerodigestive, biliary, or urinary tracts is avoided as these areas contain high numbers of microbial contaminants. Class I wounds can be approximated or closed using primary wound closure techniques and carry a low infection rate of approximately 1-5% (Price & Smith, 2008).

### **Class II Surgical Wounds**

Class II wounds, described as clean-contaminated, include those surgical wounds in which a minor break in sterile technique occurs, a wound drain is placed, and/or controlled access into the aerodigestive, biliary, or genitourinary tract occurs. These wounds carry an inherently higher risk of infection – approximately 10% due to the higher microbial count – yet can still be approximated using primary wound closure techniques (Price & Smith, 2008).

### **Class III Surgical Wounds**

Contaminated wounds are categorized as class III. These are the result of a major break in sterile/aseptic technique, traumatic injuries or other microbial contamination before the start of the procedure, acute inflammation, and/or surgical incisions resulting in gross spillage of contents from the aerodigestive, biliary, or genitourinary tract. Contaminated wounds contain high levels of microbial contamination and can become actively infected within six hours (Niederhuber, 1998; Price & Smith, 2008). The infection rate of a class III wound is approximately 15-20% (Price & Smith, 2008).

### **Class IV Surgical Wounds**

Finally, class IV wounds, also known as dirty or infected wounds, are those wounds in which an open, traumatic injury older than four hours is present, there is gross microbial contamination before the start of the procedure, or in which unintentional visceral perforation has

resulted in the presence of infected foreign material in the wound (Niederhuber, 1998; Price & Smith, 2008). Class IV wounds carry an infection rate as high as 40% (Price & Smith, 2008).

### **Considerations**

A solid understanding of the wound classification system coupled with the proper application of sterile and aseptic technique, minimal and appropriate tissue handling following Halsted's principles, and the use of antibiotic prophylaxis can serve to significantly lower the risk of infection associated with each class of surgical wound (Nandi, Rajan, Mak, Chan, & So, 1999). It is important to note that the wound class can change at any moment during the operation depending on a myriad of factors including the actions of surgical team members and the presence of infectious material. Therefore, the final classification of the surgical wound is not established and documented until the end of the operative procedure (Price & Smith, 2008). The outcome of this final classification, in conjunction with several other patient-related and surgical-team-related factors, plays a major role in the healing of the surgical wound.

### **Factors That Affect Wound Healing**

The healing of the surgical wound is dependent upon a myriad of factors, some patient-related, and others under the direct control of the operative team members. Each of these factors can have a direct impact on the rate of wound healing, the tensile tissue strength of the wound, and the risk of associated postoperative infection.

#### **Patient Related Factors**

The patient related factors that affect wound healing are the patient's age, weight, nutritional status, level of dehydration, blood supply to the surgical wound, and general health including the presence of comorbid diseases or conditions. It is also necessary to consider

whether or not the patient is a smoker, undergoing radiation treatment or therapy, or is otherwise in an immunocompromised state (Ethicon, 2007; Price & Smith, 2008).

### **Surgical Team Factors**

Factors under the control of the surgical team members are the type of incision utilized, the type of tissue dissection employed, the use of proper tissue handling techniques, the length of the procedure, the achievement of adequate hemostasis, and the proper closure of the surgical wound. Precise tissue approximation and the secure closure of the incision are also vital elements. Tissue approximation and closure should eliminate dead space without causing ischemia to the wound edges (Price & Smith, 2008).

### **Halsted's Principles**

One of the most influential surgeons and healthcare educators in the history of medicine, William S. Halsted (1852-1922), is credited as setting “the tone for modern American surgical training” (Niederhuber, 1998). Several of his innovations, including the Halsted stitch and the wearing of gloves to reduce infection, are still central to operative technique today (Johns Hopkins, n.d.). Halsted's Principles of Tissue Handling are perhaps his greatest legacy. Some of the key components of his theories with regard to wound management and closure are outlined as follows:

- the use of interrupted sutures leads to greater wound strength during healing and if one knot slips or breaks, the others serve to maintain integrity and prevent dehiscence,
- interrupted sutures are a barrier to infection as microbial contamination wicks along continuous suture lines,
- the selection of suture material and diameter should be consistent with wound security,

- long suture tails left after tying and cutting can cause inflammation and irritation of the adjacent tissues,
- dead space within the wound must be eliminated by thorough approximation of the tissues under the skin,
- the use of silk suture in the presence of infection must be avoided,
- and approximation of the wound edges must be secure without applying pressure to the tissues, as doing so leads to ischemic strangulation (Phillips, 2007).

### **Types of Wound Healing**

Under normal circumstances, surgical and traumatic wounds follow a relatively predictable pattern of healing. Based upon the condition of the patient's tissues, the manner in which those tissues were handled, and the presence of contamination, the surgeon will decide which of three methods would be the best approach to wound healing. The three types of wound healing that occur are healing by first intention, second intention, or third intention (Ethicon, 2007).

#### **First Intention Wound Healing**

Healing by first intention, also known as primary union, occurs when disrupted tissue is closed using primary wound approximation methods such as sutures, staples, or tape. The wound edges must be properly approximated to ensure the removal of dead space, leaving the wound to heal normally from side to side. Over time, the tensile strength of the wound increases and reaches 70-80% by the third postoperative month. Primary union is the most common type of surgical wound healing and is indicated for class I and II wounds. There are four phases of first intention wound healing (Cohen, et al., 1999; Ethicon, 2007; Price & Smith, 2008).

**Phase I, the Inflammatory Response Phase.** Immediately following the disruption of normal tissue, the body initiates phase I – the substrate or the inflammatory response phase – of the wound healing process (Fuller, 2005). This phase lasts between one and five days and is characterized by the achievement of hemostasis and the activation of the body's immune response system. Localized inflammation leads to increased blood supply to the healing area and results in the accumulation of tissue fluids, cells, and fibroblasts in the wound. Damaged tissue and foreign objects are debrided through the actions of phagocytic leukocytes and proteolytic enzymes (Ethicon, 2007; Fuller, 2005). Cumulatively, these processes prepare the damaged tissue for the second phase in wound healing.

**Phase II, the Proliferative Phase.** Once the debridement system of phase I is well underway, the tissues can begin the process of repair or proliferation. The proliferative phase is the second phase in normal wound healing. Phase II typically begins around the third day following tissue damage and can take between five and twenty days to complete (Fuller, 2005; Price & Smith, 2008). Fibroblasts begin the formation of a network of collagen fibers (granulation) between the edges of the wound. The collagen works to form connective tissue and bridge the wound together. Epithelialization of the wound occurs and the collagen matrix is filled with new blood vessels which supply rich nutrients to the proliferating tissue (Ethicon, 2007; Fuller, 2005). As this process continues, the pliability of the wound is increased and the tensile strength is restored to approximately 25-30% (Price & Smith, 2008). Wound contraction may develop depending on the area of the body and is typically found on the buttocks, back, and posterior neck. With the tissues pulled tightly together, the sutures can be removed during this phase of wound healing (Fuller, 2005).

**Phase III, the Remodeling or Maturation Phase.** The third phase of wound healing, known as the remodeling or maturation phase, typically begins around the fourteenth to twenty-first day following tissue disruption and can last as long as one year. During this phase, the wound fully regains tensile strength and wound contraction from myofibroblasts is completed. The maturation of the wound causes a decrease in local vascularity resulting in a paler, more mature scar or cicatrix. It is important to note that excess collagen can adversely affect scar tissue formation leading to the presentation of keloids or raised, thickened scars (Ethicon, 2007; Fuller, 2005; Price & Smith, 2008).

### **Second Intention Wound Healing**

Secondary wound closure, or spontaneous wound closure, results from the spontaneous closure of the wound margins through the normal biologic processes of tissue granulation and contraction which take place from the bottom up. In this type of healing, the wound edges are not approximated as in first intention healing because suturing or stapling would trap contaminated material within the wound causing infection and other complications. Also, the inflammation present in the various phases of wound healing through first intention would cause sutures placed in the wound to break down as a result of phagocytic and enzymatic activity. Therefore, the wound is left open during healing (Cohen, et al., 1999; Fuller, 2005; Price & Smith, 2008). Utilization of this technique is often preferred after debridement of an infected wound or the removal of necrotic tissue (Price & Smith, 2008). As the wound heals, it may need to be packed with a moist dressing to keep it from drying out. As these dressings dry, they adhere to adjacent infected and necrotic tissue, which is then removed during dressing changes. Healing through second intention typically lasts an extended period while the presence of infection subsides and the body fills the wound with granulation tissue (Cohen, et al., 1999).

### **Third Intention Wound Healing**

Third intention wound healing, or delayed-primary wound closure, is a combination of primary and secondary wound closure methods and is utilized when suturing of the wound must be delayed. In this form of wound healing, the wound is left to heal by second intention or granulation for three to five days, after which it is approximated using sutures as in primary closure. This method is particularly useful in the management of wounds requiring frequent irrigation, those with significant microbial contamination, or in the presence of foreign bodies, extensive tissue damage, or dehisced wound edges (Cohen, et al., 1999; Fuller, 2005). Dehisced wounds typically present with weakened margins that need time to heal before being reapproximated (Cohen, et al., 1999). Other examples of wounds typically managed through third intention wound healing techniques are those related to motor vehicle trauma and tissue damage from gunshots and penetrating knife wounds (Ethicon, 2007).

### **Possible Complications**

As with the surgical intervention itself, any number of complications can arise during the course of wound healing. As previously noted, several factors that influence healing are inherent to the patient. However, those factors related to surgical site infection and postoperative wound dehiscence are under the direct control of the surgical team members (Price & Smith, 2008). A clear understanding of the common complications, their risks, and the methods of preventing them are necessary to help ensure proper wound healing and patient recovery.

### **Surgical Site Infection**

As infection ensues, the tissues are overcome by the presence of bacterial contamination, which may result in increased morbidity and mortality. The risk of surgical site infection (SSI) can be greatly increased depending upon factors such as the manner in which the wound is

approximated, the level of adherence to aseptic technique, how the tissues are handled intraoperatively, the removal and evacuation of blood and devitalized tissues, and the final classification of the wound (Howard, 1999). The administration of preoperative antibiotic prophylaxis may be indicated to reduce this risk (Caruthers, May, & Ward-English, 1995).

In the prevention of surgical site infections, there are several elements that must be considered. Because the degree of wound contamination is a key component of increased infection rates, strict adherence to sterile technique is paramount. Irrigation of the wound may also be indicated; however there is debate over the effectiveness of this method in reducing SSI in clean wounds (Wayne & Singer, 2008). If the wound presents with an elevated wound classification, debridement of nonviable tissue must be thorough and healing by second intention granulation may be indicated. When employing primary tissue closure techniques, the wound edges must be adequately approximated and dead space must not be left between the tissue layers. This is especially relevant to adipose tissue layers. Overuse of suture material is contraindicated and knots should be tied tightly enough to ensure approximation without strangulation and ischemia of the wound edges. The surgeon and first assistant must also give consideration to the virulence of the microorganisms that may be present within the wound and the presence of undrained serum, blood, and foreign material. The use of a wound drain may be indicated in these instances (Price & Smith, 2008; Fuller, 2005).

### **Dehiscence**

Dehiscence of the surgical wound is described as the separation of the fascial layer and usually occurs in the abdomen. According to Fischer, Fegelman, and Johannigman (1999), the incidence of postoperative wound dehiscence is approximately 2.6%. Complete dehiscence of an abdominal wound may lead to protrusion of the viscera, a complication known as evisceration

(Price & Smith, 2008). Although several patient related factors directly affect wound healing, correct wound closure technique, the proper selection of suture materials, and the maintenance of hemostasis can greatly reduce the likelihood of dehiscence (Fischer, Fegelman, & Johannigman, 1999). Surgical practitioners must also avoid the use of long, paramedian incisions whenever possible. Because dehiscence begins primarily in the fascial layer of the closed wound, the use of nonabsorbable, monofilament, interrupted sutures are indicated and may need to be accompanied by a secondary retention suture line. Other methods, such as the use of a pressure dressing, may also be utilized to reduce the presence of dead space and fluid accumulation that may separate the fascia (Price & Smith, 2008).

### **Hemorrhage**

Hemorrhage is typically evident early in the postoperative recovery of the surgical patient. Further surgery may be indicated for hematoma evacuation and to achieve hemostasis. Depending upon the amount of blood loss, shock may further complicate recovery. Meticulous attention to intraoperative hemostasis, careful tissue handling, and precise tissue approximation will serve to reduce the possibility of hemorrhage (Price & Smith, 2008).

### **Herniation**

Incomplete dehiscence of the surgical wound can lead to the herniation of body tissues or structures through defects in the fascia. The lower abdomen is the most common site of herniation. Hernias are typically diagnosed several months postoperatively and complications such as bowel incarceration and tissue ischemia may also be present (Caruthers, May, & Ward-English, 1995). In obese patients, the weight of body structures such as the panniculus adiposus can add additional stress to the surgical wound and result in incisional hernia formation (Wantz,

1999). Proper and complete closure of the abdominal wound with an appropriate suture material can reduce this risk.

### **Adhesion**

According to Price and Smith (2008), an adhesion is “an abnormal attachment of two surfaces or structures that are normally separate” (p. 283). This attachment is created within the peritoneum due to the presence of fibrous tissue and is relatively common in patients with prior abdominal surgery. In patients with multiple abdominal surgeries, the incidence of adhesion formation is approximately 90%. Gynecologic surgery patients are especially at risk (Dharmananda, 2003). Fibrous tissue growth is commonly extended beyond the specific surgical site and may include any number of nearby structures directly or indirectly impacted during surgery. Surgical team members can reduce the formation of tissue adhesions by using proper tissue handling techniques, keeping body tissues and structures moist by irrigating and minimizing blotting with dry sponges, maintaining sterile technique to reduce the risk of postoperative infection, and removing foreign material such as lint and powder granules from gloves (Price & Smith, 2008; Solomkin, Wittman, West, & Barie, 1999).

### **Suture Specific Complications**

The selection of improper suture materials can also have an adverse effect on successful wound healing. Because body tissues react to any material implanted in the tissues, it is important for the surgeon and surgical first assistant to have an in-depth, working knowledge of the various options available for the closure of the surgical wound. Proper suture selection will vary from patient to patient and from tissue to tissue. Generally speaking, most adverse reactions to suture material are the result of improper absorption or tissue irritation due to sensitivity. Tissue reactions are most frequently attributed to the use of cotton or silk materials.

Spitting of the suture from the wound, sinus tract creation, edema, and secondary scarring due to ischemic necrosis may result (Ethicon, 2007; Price & Smith, 2008).

### **Conclusion**

As surgical wounds are created to access, expose, visualize, repair, and/or remove anatomic structures, there are many factors and elements that surgical first assistant practitioners need to consider. The nature of the surgical incision, the various aspects of wound classification, the components and mechanisms of wound healing, proper tissue handling and approximation techniques, and the possible complications that may arise postoperatively are all critical elements of proper wound care and management. It is vital that practitioners understand the effects that each of these principles have on the surgical wound in order to ensure the best possible outcome for the surgical patient.

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