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Facilitation of Wound Healing Following Laparoscopic and Conventional Abdominal Surgery with Dressings, Patches, Antibiotics, etc.

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Abstract

Wounds due to surgical incisions and due to injuries often do not heal and can result in complications like slow healing and infections. Several approaches to facilitate wound healing are constantly being developed. Here we discuss various wounds and multiple ways to treat wounds especially those resulting from abdominal surgery either due to conventional surgery or due to laparoscopic surgery. In future, there are various possibilities in the pipeline that could result in accelerated wound healing as well as tissue regeneration.

Keywords: wound, healing, surgery, laparoscopic, infection

1. Introduction

An estimated 313 million surgical procedures are performed worldwide annually [1]. The quality of incision selection and postoperative wound healing play significant critical roles in patient recovery and rehabilitation. Mortality and morbidity rates are affected by surgical wound complications. The importance of surgical incisions and wound care has been documented throughout history to primarily prevent wound infection has been from the time Alexander the Great was treated with saffron for injuries from a piercing spear. Over the years, several new ways of performing surgery and treating wound have advanced wound care. In the last century, endoscopic surgery has significantly reduced incision damage, and antibiotics were introduced to control infections and facilitate healing. Neosporin with its triple antibiotics has been commonly used, can be purchased over the counter, and can be used for minor

Diabetic wounds	Types of dressings	Process of cleaning and caring for wound
	<ul style="list-style-type: none"> • Daily saline • Dressings that provide a moist environment [5] 	<ul style="list-style-type: none"> • Offload wound • Debridement if necessary of nonviable tissue to promote accelerated wound healing • Antibiotic therapy if indicated • Control blood glucose levels • Correction of peripheral arterial insufficiency • Diabetic footwear • Hyperbaric oxygen chamber • Skin grafting [6]
General surgical incisions Stitches, skin glue, staples, steri-strips	<ul style="list-style-type: none"> • Sterile dressing • Wet to dry dressing 	<ul style="list-style-type: none"> • Keep incision clean and dry • Prophylactic antibiotics • Gauze pad or soft cloth to clean wound with normal saline or soapy water [7]
Laparoscopic incisions Subcuticular stitch, staples, skin glue	<ul style="list-style-type: none"> • Nonadherent dressing gauze to absorb light drainage • Transparent film 	<ul style="list-style-type: none"> • Prophylactic antibiotics • Betadine prep • Post-op dressing can be removed in 48 h
Gunshot wounds	<ul style="list-style-type: none"> • Keep wound clean and dry • Stop bleeding with pressure/tourniquet 	<ul style="list-style-type: none"> • Possible surgery to remove bullet or bone [8] • Crushing tissue or stretching of tissue • Antibiotics
Wounds from sharp objects (knives, blades)	<ul style="list-style-type: none"> • Keep wound clean and dry • Clean dressing 	<ul style="list-style-type: none"> • If through the sole of a shoe <i>Pseudomonas</i> can be the cause of infection • Possibly need tetanus shot

Table 1. Wound care table for different types of wounds.

cuts and wounds that do not require stitches. With antibiotic resistance manifesting itself in recent decades, other new ways have become essential. Current and future wound healing measures are in a constant state of flux, and when an agent proves useful, it can help many patients who have been affected. Carbohydrate-derived fulvic acid (CHD-FA) is a topical agent, which has been used to prevent drug-resistant bacterial and fungal infections, and contains anti-inflammatory properties for those who have suffered a traumatic wound [2]. Wounds can occur due to several different causes as summarized in **Table 1**. Several wound care options are currently available (**Table 2**) and could become available in the future (**Table 3**). A surgical incision is an aperture into the body to permit the work of the planned operation to proceed. The choice of incision for laparotomy depends on the area that needs to be exposed, the elective or emergency nature of the operation, and personal preference. There are two approaches used nowadays: traditional incision and minimally invasive. This book chapter provides a brief review of recent progress in surgical procedure and wound care of incisions during abdominal surgeries.

2. Traditional incision

Traditional abdominal surgery refers to operating through an open abdominal incision known as laparotomy. The goal is to provide adequate exposure for the anticipated procedure while taking into account the possibility that the planned procedure may change depending upon

Types of dressing	Primary or secondary dressing	Functions/indications	Pros	Cons	Frequency of dressing change
Hydrogels (e.g., IntraSite Gel, generic hydrogel)	Primary	<ul style="list-style-type: none"> Give the wound a moist environment Used for shallow dry ulcers Autolytic debridement 	<ul style="list-style-type: none"> Hydrates wound, liquefies necrotic tissue on wound surface Nonstick Soothing effect 	<ul style="list-style-type: none"> Must have a secondary dressing Not meant for significant exudate 	<ul style="list-style-type: none"> Change when other dressings are changed
Alginates <ul style="list-style-type: none"> Calcium alginate (AlgiSite, Aquacel, Sorbsan) Calcium alginate with silver (Aquacel Ag) Calcium-sodium alginate (Kaltostat) Carboxymethyl cellulose (CMC) silver oxysalt dressing Biosorb gelling fiber 	Primary	<ul style="list-style-type: none"> Ulcers with copious exudate Silver can be added to give antibacterial effect-infected ulcers/presence of a biofilm-oxidized silver reduces viable biofilm High absorptive capacity can be used in packing Form a gel like covering over the wound keeping it moist 	<ul style="list-style-type: none"> Significantly absorbent Don't inhibit wound contraction Can be used in infected pressure ulcers 	<ul style="list-style-type: none"> Must have a secondary dressing May be too drying if wound isn't exudative Fiber residue 	<ul style="list-style-type: none"> 1-2x a week Silver-Weekly
Antimicrobial dressings <ul style="list-style-type: none"> Gauze Alginate Foam 	Primary	<ul style="list-style-type: none"> 72 h of antibacterial properties Use with negative pressure wound therapy Used for packing wounds with dead space 	<ul style="list-style-type: none"> Doesn't require a secondary dressing Inexpensive 	<ul style="list-style-type: none"> Doesn't eradicate bacteria in wound 	Every 72 h
Transparent film <ul style="list-style-type: none"> Generic transparent gauze Tegaderm Opsite 	Primary or secondary	<ul style="list-style-type: none"> Semipermeable membrane waterproof but permeable to water vapor and oxygen Keep wound moisturized while preventing bacterial contamination Provides autolytic debridement Superficial/light exudative wounds Often the preferred secondary dressing Used to prevent friction injuries 	<ul style="list-style-type: none"> Transparent evaluation of wound without removal of dressing Waterproof and gas permeable Keep moist environment 	<ul style="list-style-type: none"> Skin damage if removed improperly Limited absorptive properties Shouldn't be used for infected ulcers Roll up in coccyx region 	Every 7-10 days

Types of dressing	Primary or secondary dressing	Functions/indications	Pros	Cons	Frequency of dressing change
Hydrocolloids <ul style="list-style-type: none"> • Generic hydrocolloids • Duoderm 	Primary or secondary	<ul style="list-style-type: none"> • Used in epithelizing and granulation wounds Ulcers with light to moderate exudate [9] • Gel-forming covering keeps in moisture and protects wound • Hydrocolloid sheets help autolytic debridement by keeping wound exudate in contact with necrotic tissue (slough and eschar) • Paste and powders increase absorptive capacity 	<ul style="list-style-type: none"> • Easy application, forms to wound well • decreasing pain • Used to protect body areas at risk for friction injury or tape injury 	<ul style="list-style-type: none"> • Never used for infected wounds • Not used for moderate to heavy exudative wounds • Reside and foul odor may arise from breakdown of product 	Every 7 days
Foams <ul style="list-style-type: none"> • Generic foam • PolyMem • Foam with AMD 	Primary	<ul style="list-style-type: none"> • Ulcers highly exudate • Highly absorbent of exudate which keeps it off the wound and decreases damage to surrounding tissue • Deep cavity wounds to prevent premature closure, absorbing exudate and maintaining a moist environment • Weeping ulcers • Diabetic foot ulcers [10] 	<ul style="list-style-type: none"> • Absorbent characteristics • Comfortable and form well to wound • Used for painful /risk for shear injury pressure ulcers 	<ul style="list-style-type: none"> • Require secondary dressing usually • Drying effect 	<ul style="list-style-type: none"> • Varies • Silver- Up to 7 days
Debriding agents <ul style="list-style-type: none"> • Santyl (Health point) • Accuzyme (Health point) 					
Other options -Prp, PDGF, low-frequency ultrasound therapy (MIST, celleration) with composite dressings, and synthetic skin substitutes					

Types of dressing	Primary or secondary dressing	Functions/indications	Pros	Cons	Frequency of dressing change
Negative pressure wound therapy (NPWT) • Pico	Computerized vacuum device applies negative pressure which decreases wound healing time				Changed every 72 h
Velcro adjustable wraps • Ready wrap	Limitations—training the patient and families to apply correctly with				
Larval debridement therapy	Limitations are asphyxiation of the larva mortality, escape	Offloading of the coccyx/sacral region provided the best chance for larval survival			
Near-infrared spectroscopy (NIRS)					
Dehydrated human amnion/chorion membrane (dHACM) • PURION		Chronic wounds regenerate damaged tissue			
Dehydrated human umbilical cord allograft (dHUC) • PURION PLUS process		<ul style="list-style-type: none"> Chronic wounds in difficult-to-heal areas Provides connective tissue matrix to supplement damaged tissue 			
Honey impregnated absorbent dressing (e.g., MANUKAhd)	Contains <i>Leptospermum scoparium</i> honey	<ul style="list-style-type: none"> Maintains a moist environment Moderate to heavy exudative wounds 			
Trauma wounds • Polymeric membrane dressings (PMD) • PMD + silver	Standard protocol of care in the ED	<ul style="list-style-type: none"> Resorbs blister exudate, reduces edema Silver–Antibacterial 			

Table 2. Types of dressings and patches that are currently available.



Table 3. Future options for wound care.

intraoperative findings or complications. Historically, the earliest surgeries were crude and were performed out of desperation. It wasn't until the 1900s that the risk of dying after surgery mainly due to infection was less than 50%. After the turn of the century, the likelihood of surviving surgery was greater than the chance of dying during or immediately after surgery. Early techniques were rudimentary, or even barbaric by today's standards, as anesthesia was not commonly used until the mid-to-late 1800s.

Today, surgery takes a wide variety of forms and is often performed using minimally invasive techniques. This has shortened recovery times, improved outcomes, and minimized complications for most patients. However, laparotomy is still used in some types of surgery, especially in organ transplantation (such as the liver, pancreas, and kidney), because it allows extensive dissection and anastomoses.

For traditional abdominal surgery, the incision should interfere minimally with abdominal wall function by preserving important abdominal structures and heal with adequate strength to reduce the risk of wound disruption and herniation. During surgery, wisely chosen incisions and correct methods of making and closing such wounds are factors of great importance. Any mistake, such as a badly placed incision, inept methods of suturing, or random selection of suture material, may result in serious complications such as unnecessary functional disruption, hematoma formation, ugly scar formation, wound dehiscence and herniation, or complete disruption of the wound [3].

The specific surgical incision will depend on the underlying pathology, site, patient factors, and the surgeon's preference and experience. The key principles of making surgical incisions are (1) for maximal wound strength with minimal scarring, incisions should try to follow Langer's lines where possible, and (2) where possible, muscles should be split and not cut. There are several types of laparotomy, such as longitudinal (vertical), transverse, and oblique, and each has various sizes and positions to fit different surgical goals.

3. Minimally invasive surgery

The recent development of endoscopic and laparoscopic technology has revolutionized traditional surgery concepts facilitating patient friendly access to even the most remote of abdominal organs [4]. Laparoscopic surgery requires small incisions to be made in the skin, which allows instruments to be passed into the abdominal cavity. Common instruments include the camera, cutting and dissecting scissors, and grippers. The port sites will vary depending on the

surgery being performed, yet the umbilicus is nearly always used as a port site to allow the camera to pass through at this time; the technique is still under development, and further improvement such as artificial intelligence (AI) or real-time, dynamic AI system will speed up the procedure, enhance safety, and improve outcomes. Once the operation is over, surgical excisions can be closed by sutures, staples, steri-strips, tissue glue, or a combination of these agents. The wound should be covered in a protective dressing like gauze and attached with a paper adhesive tape and kept dry for a few days, before normal washing can resume. Pre- and postoperative prophylactic antibiotics can be administered for laparoscopic surgery but are debatable and not recommended by the WHO if the wound is not contaminated.

4. Routine care postsurgery

Wound care for an incision starts before making the initial cut and lasts until the end of the patients' healing process; it's important to maintain proper surgical field cleanliness and to prepare a patient with the right technique before performing any type of laparoscopic surgery [5]. Medical patients that are undergoing laparoscopic surgery should be given antibiotics usually a first-generation cephalosporin 30 minutes prior to the incision as well as prepped with betadine, a povidone iodine, or hexachlorophene before surgery. Giving antibiotics post-operatively depends on the type of the laparoscopic procedure done; the patient is normally given 1–3 postoperative doses, and if it's a colorectal surgery, then three doses is usually given due to the higher risk for infection.

When performing a laparoscopic surgery, various access approaches have been used. For the removal of the gallbladder or appendix, all the instruments may be inserted at a single incision using a Gel POINT (Applied Medical), SILSPORT (Medtronic), or Triport (Olympus) access platform. This approach is especially appropriate in a patient who is young and thin. It is more acceptable in female patients as it yields a great esthetic result, allows a wide range of motion during the surgery, and is a minimally invasive method [6, 7]. It is important to ensure if there is any suspicion of contamination or infection such as appendicitis, cholecystitis, and cystectomy that an end catch bag is used, to minimize the chance for an infection. A specimen retrieval bag, such as endocatch or endobag (Covidien), reliacatch (Medtronic), endopouch (Ethicon), and Conmed (eSutures), is used which avoids spillage and contamination of the infected specimen to minimize the chance for an infection. When closing a laparoscopic incision, there are options of using subcuticular stiches or staples. If the wound is small, a tissue adhesive skin glue such as Dermabond can be used to close the skin. The incision is then covered using Telfa, a nonadherent dressing gauze which conforms to the wound and absorbs light drainage; the gauze is then held in place with Tegaderm. Tegaderm is a semiocclusive transparent film, which self-adheres and allows insensible water loss and prevents the entry of bacteria and proteins; transparent films are known to have the fastest healing rates and lowest infection and are the most cost-effective [5]. The initial postoperative dressing can be removed in 48 h if the wound remains dry. No matter whether traditional or minimally invasive approach is used, surgical complications can occur after surgery. The most common complications include wound, infections, and dehiscence. Their management is presented here.

5. Postoperative wound infections

Surgical site infections are defined as infections that occur 30 days after surgery with no implant or within 1 year if an implant is placed and infection appears to be related to surgery. Surgical site infections (SSI) are seen in about 4% of clean wounds and 35% of contaminated wounds, so they are generally rare. However, certain risk factors predispose a patient to an SSI, which include diabetes, obesity, immunosuppression, cardiovascular disease, smoking, cancer, preventative surgery, malnutrition, and prior irradiation [8]. Obese patients are at increased risk especially if the incision is in the umbilical area due to fatty tissue not being well vascularized, the difficulty of cleaning it, and usually multiple incisions being made in obese patients. SSIs are associated with substantial morbidity and mortality. Patients with SSI are twice as likely to die, 60% more likely to be admitted to the intensive care unit, and more than five times more likely to be readmitted to the hospital after discharge.

Signs and symptoms of incisional infection vary significantly depending on the types, severity, and pathogens. The most frequent symptoms include fever, feeling of malaise, fluid drainage, increased wound pain, redness and swelling around the wound, and loss of function and movement. SSI may be caused either by endogenous or exogenous microorganisms. Most SSIs are caused by endogenous microorganisms present on the patient's skin at the site of surgical incision, and Gram-positive bacteria such as *Staphylococcus aureus* are the most common microorganisms. SSI may also be caused by organisms within the patient's body that are exposed during surgery, such as Gram-negative microorganisms in the gastrointestinal tract. Exogenous sources of microorganisms include surgical instruments, operating room surfaces, the air, and personnel. Usually all wound infections happen on day 5 after surgery, and it's safe to suspect a staph infection due to the commonality of it. Of the rarer types of infections, Group A strep is seen on day 2 and clostridium usually is seen on day 3. To diagnose surgical site infections, a clinician should look for redness, induration, warmth, pain, purulent wound drainage, separation, fever, and WBC count. If the wound is infected, the wound should be opened, explored, drained, irrigated, debridement, and dressed open then; when the infection has cleared and there is granulation tissue growth, the wound can be closed by secondary intervention [8]. Antibiotic therapy is only used for wound infections associated with cellulitis or edema. Superficial incisional infections that have been opened can usually be managed without antibiotics if there is no associated cellulitis [5].

When closing a wound, if there is a large incision, staples are usually used because they are less reactive than sutures and have a better end result; however, sutures are utilized when there might be tension on the skin to distribute it easily. Staples are also less likely to obscure wound drainage and impending separation than subcuticular sutures, and if part of the wound is infected with staples, only remove the selected staples without opening the entire skin incisions as it generally happens once a subcuticular stitch is cut [4]. The distance between the placements of staples is what determines how the wound will drain. The wound should stop draining in about 2–3 days; when it does, it should be left uncovered. If it continues to drain, it can be kept covered and the dressings changed daily until it stops draining.

Complications from surgery like bleeding beyond a certain period say 10 days from the incision site does not really happen after laparoscopic surgery. Any bleeding usually happens early; the trocar can tamponade during the surgery and can injure a vessel. The bleeding

depends on where the incision site is. The subcuticular superficial arteries can bleed or the inferior epigastric vessel if there was a lateral incision made. Usually the nurse will inform the doctor that the dressings are saturated and a pressure dressing is placed until the bleeding stops.

Some other complications from surgery include seromas, hematomas, fascial dehiscence, hernias, evisceration, and nerve injury. Seromas and hematomas are not common with laparoscopic incisions and seen more with open surgery; when a seroma or hematoma has occurred, it can be aspirated, and if a seroma recurs, it should be aspirated until it's fully gone. The wound can also have dehiscence; the main reasons for wound dehiscence are failure of the suture to remain anchored to the fascia, suture damage, knot failure, and stitches applied too close together. In 95% of abdominal wall dehiscence, the sutures and knots are intact, but the suture has pulled through the necrotic fascia due to the sutures being too close to the edge of a wound or under too much tension. If fascial disruption is suspected, wound exploration should be done in the operating room; complete dehiscence is a surgical emergency and is associated with a 10% mortality rate [4]. Management of SSI depends on the severity of the infection. Minor and superficial infections may be treated with antibiotic therapy. If the infection is deep and severe with pus or fluid drainage, the wound should be opened, explored, drained, irrigated, debrided, and dressed open, and the dressing should be changed daily or more often if the drainage is severe. When the infection has cleared and there is granulation tissue growth, the wound can be closed by secondary intention [8]. Antibiotic therapy is only used for wound infections associated with cellulitis or edema. Superficial incisional infections that have been opened can usually be managed without antibiotics if there is no associated cellulitis [5].

6. Wound dehiscence

The quality of postoperative wound healing plays a significant role and is critical in patient recovery and rehabilitation because mortality and morbidity rates are affected by surgical wound dehiscence (SWD). SWD is defined as partial or total disruption of any or all layers of operative wounds—from simple skin dehiscence and hernia formation to the most severe and potentially lethal forms characterized by evisceration, gastrointestinal anastomotic leaks, pancreatic fistulas, and vascular pseudoaneurysms. The impact of SWD can be considerable: increased mortality, delayed hospital discharge, readmission, future surgery, delayed adjuvant treatment, suboptimal esthetic outcome, and impaired psychosocial well-being. SWD occurrence rates can vary significantly, from 0.65 to 2.1% in sternotomy to as high as 16.9–41.8% in pilonidal sinus surgery, and the cost for these wounds was \$13.1 billion according to Medicare data from a 2014 report.

7. Bleeding and hematoma

Bleeding is a relatively rare complication if the wound is inspected carefully before closing. Bleeding usually happens early; the trocar can tamponade during the surgery and can injure a

vessel. When the blood comes out from the wound, it can be seen. However, if the blood is inside the wound, it causes hematoma or seroma. Management depends on the site and severity of the bleeding. The hematoma should be decompressed and blood is removed. If a relatively larger vessel is involved and still shows active bleeding, a suture should be used to stop it, but this is rare. For minor bleeding, a pressure dressing is placed until the bleeding stops.

8. Concluding remarks

Risk factors for most young and healthy patients and surgical wound complications are rare when the surgery is done carefully. However, risk factors for developing wound complications exist in various patients, and surgical procedure itself can also play a major role in developing complications. This includes older age, diabetes, renal diseases, the use of tobacco products and steroids, compromised immune system, obesity, poor nutritional status, and bacterial infection or colonization at a remote body sites [9–12]. To reduce wound complications, the surgical team plays a critical role. This includes adequate preoperative preparation to improve patient's overall health, careful surgical site selection, accurate procedure with as little collateral damage as possible, careful wound closure, and postoperative management. A high-quality multidisciplinary team should be able to perform safe surgeries with little complications even in some health-compromised patients.

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Conflict of interests to declare

None.

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