Integrative Trauma and Emergency Medicine

Case report

University of Chicago Physical Therapist Role in Critical Wound Care: A Case Study of Negative Pressure Wound Therapy

This article was published in the following Scient Open Access Journal:
Integrative Trauma and Emergency Medicine
Received March 26, 2018; **Accepted** April 04, 2018; **Published** April 13, 2018

Mieczyslawa Franczyk* PT, PhD, MPH
The University of Chicago Medicine, Therapy Services, USA

Abstract

Wound management has been a part of physical therapy practice since the existence of physical therapy in the United States and has been the focus of one of the systems in the Guide to Physical Therapist Practice [1-4]. Wound management is a mandatory component of physical therapist education programs [5,6]. Physical therapists specializing in area of wound management have an opportunity to achieve certification through the American Board of Wound Management.

The University of Chicago Medicine (UOCM) is a facility with 800 beds and a reputation for managing difficult wound cases. The physical therapists in UOCM have been involved in wound care for over 40 years. Therapists manage wounds; burns, surgical wounds, chronic wounds, vascular conditions, diabetic wounds. Procedures therapists include are: selective debridement, pulsed lavage, hydrotherapy, negative pressure wound therapy (NPWT), dressing recommendation, electrical stimulation and serial casting. Prior to 1996 less than 5 patients a year were treated with NPWT. This changed after July of 1996. A 7-year old boy was run over by a fire truck. He sustained multiple injuries including an open pelvic fraction and eventually required hemipelvectomy. Surgeons managed him with NWPT, vacuum assisted closure (VAC; Kinetics Concepts, Inc., San Antonio, TX) therapy and delayed soft tissue reconstruction. The patient's course was remarkably free of problems, and he was rapidly discharged to a rehab facility and then home. Soon the hospital was one of KCI's larger accounts, and clinicians began to publish case series and expert opinions in support these techniques [7-9].

This paper is a practical guide for physical therapists and other clinicians involved in the care of patients with complex abdominal wounds with fistulae in acute and critical care settings focusing on NPWT for wound care and functional training of critical ill adult population.

Role of therapy in wound care

Illness or trauma to a body system may lead to temporary or permanent impairments or disability. An acute care physical therapist needs to have a broad knowledge of pathophysiology and how disease processes can further limit the functional mobility of person. Physical therapists working with a patient in the acute care setting initiate rehabilitative techniques that influence early restoration of maximum functional mobility and reduce the risk of the secondary complications [10]. Physical therapists work closely with the patient's medical team (nursing, physicians, social worker, case manager. etc) to ensure that patient's discharge destination will provide the patient with the best opportunity for recovery. For the physical therapists and others who are involved in treatment of patients with wounds, understanding the structure and function of the skin, muscles and fascia as well as wound extent are important. Location of the wound and the implications for movement and positioning are also necessary to understand. Potential secondary functional dysfunction and psychological trauma may affect management of the patient in acute and post-acute care. Complex wounds that extend past the dermal layer or into the body cavity result in moderate to severe dysfunction depending on the extent and depth of injury. Large fluid lost may cause changes in electrolyte balance or changes in blood pressure. These fluid losses can lead to dehydration and periwound denudation. Patients may experience orthostatic hypotension which can cause complications for mobility training.

It is important understand the patient's physical and functional conditions prior to the injury/surgery. Examining the patient to determine the current state will serve as

***Corresponding Author:** Mieczyslawa Franczyk, PT, PhD, MPH, The University of Chicago Medicine, USA, Email: Mieczyslawa.Franczyk@uchospitals.edu

a reference to judge the patient's improvements throughout the entire treatment process.

When examining the patient, it is important to address impairments, which includes flexibility, muscle strength, ability to change body position and functional abilities including ambulation. Following the examination, evaluation of wound and wound location the physical therapist will establish the patient's prognosis and plan of care that won't hinder wound healing but allows the patient's achieving his functional goals. Wound care requires a strategic approach individualized for each patient's medical history and conditions. Results of wound culture, how much non-viable tissue covers wound bed, type and amount of drainage, risk factors for delayed healing such as diabetes, impaired circulations, type of medication patient is on, and nutritional status all play a roll. Pain tolerance, patient's knowledge and understanding of wound care, patient's compliance, and presence of contraindications for use any dressing/modality for wound treatment including applications of NPWT are also important considerations.

The clinician will decide what protective barrier between wound bed and filler needs to be used, are interference materials (dressings) relevant to NPWT mechanism of action and how it affect cell stimulation and tissue stress. Goals will vary depending on the patient's physical status and phase of recovery, as well as the patient's wishes. The physical therapists and others who are involved in treatment of patients with wounds should be aware of the body position in bed, during sitting, transfer or ambulation that add stress on area(s) of wound location during physical activity.

Specific considerations for abdominal wounds

Open abdomen is an abdominal wall defect created by intentionally leaving an abdominal incision open at the end of completion surgery or by opening (or re-opening) the abdomen because of concern for abdominal compartment syndrome. open abdomen is managed with temporary abdominal closure using one of several techniques one of it is application of NPWT dressing [11-14]. The application of NPWT opposes the lateral retraction of the abdominal muscle and improves the likelihood of primary fascia closure and aloud to control and quantify fluid loss. Also allows early patient mobilization to prevent complications of prolonged bed rest.

Clinician assessing abdominal wound for application of NPWT dressing should ask the following questions:

- Is fascia intact or disrupted? If disrupted; does fascia tissue is healthy or not?
- Is mesh graft was used for fascia closure? If yes what type of mesh was used?
- Can the wound bed be visualized? If tunneling, how long there are? Should it be open for better wound visualization?
- If there is a fistula visible in wound bed or not, but fluid color/consistence could suggest of fistula presence.
- What is a volume of fluid lost from wound? Is there risk of disturbance in electrolyte balance or dehydration?
- Is the patient under sedation or awake and requires pain medication for dressing change
- Are there risk factors for delaying healing?
- What magnitude of pressure could be apply to wound?
- What functional activity and when patient could be exposed to?
- What strengthening exercises could patient initiate as early as possible?
- Should patient wear abdominal compression garment (binder) or could we use Montgomery Straps to secure surgical site in the situation when compression garment could not or should not be used?

Specific considerations for open abdominal wound with a fistula

An enterocutaneous fistulae (ECF) is an abnormal passage between the lumen of the gastrointestinal tract and the skin. The fistulae may be caused by deterioration of the primary anastomosis or an unidentified injury to the bowel during the operative process. Fistulae may be result of abdominal sepsis or to secondary bowel injury during the process of dressing of abdominal wound. Regardless of the cause, the formation of the fistulae into open abdominal wound profoundly impairs the patient's physical and psychological well-being. Patient with fistulae experiences delayed and impaired wound healing, periwound chemical denudation, increased pain leading to decreased mobility, depression, social isolation, odor, chronic appliance leaks, dehydration, extended hospital stay [16-21]. The main goals for fistulae care are, containment of effluent, protect of the peri-wound skin, control odor, maximization of mobility and easy of care. Different techniques can be utilized for management of non-surgical fistulae. Techniques such as; suction wound drainage system, pouching, wound managers, NPWT. Treating difficult-to-heal wound requires individualized approach for each patient. Adapting the NPWT and pouching system allows containing drainage, protecting the perwound skin and facilitating closure of the wound. The potential risk of bleeding, new fistulae formation and infection need to be taking in consideration and protective barrier must be utilized. With progression of wound healing and decreasing of fistulae output wound drainage system or NPWT dressing can be changed to pouching. The clinician working with acute abdominal wound should be aware of possibility of developing fistula when waking patient up from deep sedation. Patient should have abdominal binder or stabilization of abdomen in place when weaning occurs to decrease the internal pressure; to stabilize the abdominal wall against forces such as a strong cough with extubation.

Fistulae/wound assessment prior to NPWT dressing application:

- Determine fistulae(s) location within GI system
- Determine fistula location within wound bed
- Determine size of fistulae and amount of granulation tissue is at the base of wound
- Determine if it low or high output fistulae
- Determine if you could use the bolster (several layers of impregnated gauze over fistulae) with NPWT dressing
- Determine if you need to use pouching system with NPWT dressing

- Determine if you should add suction system to the pouch in case of high output fistulae

Physiology of healing

According to the American Physical Therapy Association (APTA) *Guide to Physical Therapy practice,* the physical therapist provides "application of therapeutic procedures and modalities that are intended to enhance wound perfusion, manage scar, promote an optimal wound environment, remove excess exudates from a wound complex, and eliminate non-viable tissue from a wound bed. procedures and modalities may include sharp debridement; dressings; orthotic, protective and supportive devices; physical agents and mechanical and electrotherapeutic modalities: and topical agents (3,4) In order to effectively use different techniques/dressings including NPWT to promote wound healing the clinician must have a detailed knowledge of the physiology of wound healing and the wound's influence on anatomical structure and patient's mobility.

The normal wound healing process can be divided into 4 overlapping phases: coagulation, inflammation, formation of granulation tissue (proliferative phase), and remodeling or scar formation. During the coagulation phase, blood-clotting events prevent excessive bleeding and provide interim protection of the wounded area. Progression of the inflammatory phase leads to the recruitment of leukocytes, neutrophils, and macrophages; the production of growth factors; and the activation of dermal and epidermal cells. Completion of the proliferative phase of wound healing leads to formation of ECM-rich, vascularized granulation tissue. Finally, ECM remodeling and cell apoptosis lead to the formation of scar tissue with physical properties that are comparable with unwounded skin.

Many factors can interact with one or more phases of wound healing process which can facilitate or decrease its rate, such as local and systematic factors. Local factors are those which directly influence characteristics of wound itself, while systematic factors consist of those which related to state of individuals and their abilities regarding wound healing. Some systematic factors include infection, age and sex hormones, stress, diabetic, obesity, medication, alcoholism, smoking and nutrition.

Clinicians should understand differences between wound contraction and wound contracture [22]. Contraction is independent of epithelial migration and relies on the presence of wound granulation tissue. During contraction the edges migrate toward the center to "shrink" the wound, areas of loose skin will contract nicely, but less mobile areas as the ankle, cannot contract as much. Contraction is a process that is completed in a few weeks. Contracture is the shrinkage of a scar through the process of collagen remodeling. Contractures develop over the entire maturation phase of scar formation and therefore can intensify over months.

Role of NPWT in critical care

NPWT is affective modality to promote wound healing in a variety of wounds if used appropriately. NPWT was initially described in the 1980s and was approved by FDA in 1997 [23-25]. It is well documented in literature that NPWT promotes a moist wound healing environment and has several modes of action on wound beds including angiogenesis, stimulation of growth of granulation tissue, evacuation of wound exudates, wound contraction, promote increased lymphatic and venous drainage, decrease bacterial bioburden, reduce edema, promote wound closure by application of mechanical stress on the wound bed, provide splinting effect, and reduce the number of dressing changes.

Indication for it use: wounds after sternotomy, infected by-pass, abdominal wounds, infected mesh after abdominal surgery, skin grafts, muscle/omental flaps, burns, wounds caused by trauma, high risk surgical incisions and many other wounds in adults and children in different settings as hospitals, rehab facilities, home.

Precautions for NPWT dressing: exposed internal organs**,** exposed vascular system**,** patients on anticoagulants**,** fistula of unknown source. Some studies have successfully implemented NPWT in case of exposed organs.

Contraindications for NPWT dressing according to FDA guidelines conditions: untreated osteomyelitis**,** necrotic tissue in wound bed**,** malignancy in wound**,** non-enteric and unexplored fistulas**,** exposed anastomotic site***,** exposed vasculature***,** exposed organs***,** exposed nerves*

*some medical centers implement NPWT **with precautions** [15,26-28].

The following problems have been mentioned in the literature regarding NPWT : bleeding, overgrowth of granulation tissue into foam, gossypiboma - retained foreign body, pain, enteric fistulae if filler (foam or gauze) placed over compromised intestine, less frequent dressing change could mask rapidly spreading infection, tissue adherence, achieving and maintaining a vacuum seal can be difficult at times, peri-wound skin damage, clinicians must be well trained and educated [24,25,29,30-34]. There are multiple physical effects of sub-atmospheric pressure to the wound: suction forces, topical pressure and shearing forces. These mechanisms must be understood before its usage in various clinical indications. The suction forces have been reported to reveres lymphatic flow, reduce bacteria count, evacuate wound fluids, decompress tissue edema and induce granulation tissue formation. Topical pressure should reflect the types of tissue being treated, pressure in the underlying tissue increases with elevation suction. Sharing forces: it was demonstrated that the application of cyclical tensile force generated transient, alternating hypoxia and reperfusion that lead to accelerated tissue growth and enhances wound healing [33,35]. As proposed by Miller and Bybordi [33] any system that meets these criteria must be a sub-atmospheric pressure generating wound therapy system. Since wounds do not have the ability to recognize differences between NPWT technologies, their response is based on the presence of this force.

What pressure should be used?

The level of sub-atmospheric pressure for optimal pressure is not known. Several studies documented that optimal level of sub-atmospheric pressure for treating a wound is -75 to -80 mmHg [33-40]. The same study shown effect of wound healing under application of - 45 mmHg pressure or lower [26]. Clinical experience suggests that choosing level of pressure for wound therapy depends on wound type, location, tissue composition, patient's age and pain tolerance.

If cyclic pressure is an important factor - what is most effective cycle?

- **Constant:** the unit operates for a 24-hour period (standard)
- **Periodic:** the unit operates for some period less than 24 hours (6-8 hours) or more than one treatment period per 24 hours
- **Intermittent:** alternates between on and off or lower/higher pressure
- **Continuous:** pressure is maintained during a given treatment period

Different pressure should be used to obtain ideal healing for soft versus dense tissue injury

- soft tissue -60 mmHg to -80 mmHg
- denser tissue -80 mmHg to -100 mmHg
- pressure sensitive areas (e.g. open heart) -10 mmHg to -40 mmHg via pleur-evac [27]
- NPWT dressing can be engaged at pressure of -50 mmHg to -125 mmHg depends from fistulae output, patient's medical conditions, and pain tolerance [18,19,21].

NPWT over STSG/Allograft/Integra – pressure setting

- hands, feet, penis -50 mmHg to -75 mmHg or lower if the graft is circumferential
- other area up to -125 mmHg or to patient's tolerance

Why lower pressure?

- Minimize adverse effects
- Avoid hemorrhage of previously coagulated vessels
- Minimize possible ischemic effect
- Decrease pain

NPWT at University of Chicago Medicine

There has been expansion in the number of NPWT devices on the market in past decade. In contrast, rental cost and dressing supply cost did not decreased. Daily cost for rental of the pump and purchase of the dressing kit (dressing and canister) varies from $54 to $150 per day depending from marketed system [41]. With expansion of NPWT devices (commercial and "home-made/home grow method") we see increased types of wound filler materials; foam, gauze, wound interface dressing [42]. Several studies were done to compare wound tissue response to foam or gauze. Though, these materials have different properties effects are similar in reduction of wound surface area, similar degree of micro-deformation but there are differences in the properties of granulation tissue and presence of pain with dressing change. Growth of granulation tissue into foam causes tissue disruption on removal and patients experiencing more pain (9), gauze is reported not to be susceptible to tissue in growth and is less painful with dressing change [38-46]. Gauze is easier to apply in wound including tunneling and undermining and allows safety removing from deep wound tunneling or undermining.

Physical therapists at the UOCM are responsible for most of the labor associated with wound management. As the use of VAC therapy increased, its expense became a significant burden to the Therapy Services Department. Other problems also began to develop. The dressing changes were very painful and some patients refused to have the dressing re-applied after it was removed [9]. In some cases, it was also difficult to maintain a seal with the VAC dressing because of persistent fluid or air leaks. However, the most important obstacle to the use of VAC therapy was a shortage of suction machine. It was usually impossible to start VAC therapy on the short notice, at night, or on weekend. In an effort to deal with the supply chain problem the Chicago clinicians began to improvise methods of negative pressure therapy using off-the-shelf supply and wall suction in 2005. They called this method G-SUC: a shortened from of "Gauze-Suction Dressing". Initial results with this technique were promising. In 2007 the group received IRB approval to conduct a randomized trial comparing VAC and G-SUC for patients with acute wounds over age of 18.

The preliminary outcomes evaluated were wound surface area and wound volume area. Secondary outcomes were cost of supply and equipment, cost of dressing application as measured by the time required for each dressing change, and pain associated with each dressing change as measured by the patient self-reported pain levels as well as amount of narcotic analgesia used. The cost of direct labor was also documented. The reductions in wound surface area and volume were similar in both groups (P = 0.60 and 0.19, respectively, for the group-by-time interaction). The estimated difference (VAC vs GSUC) was 0.4% (95% confidence interval 1.0, 1.7) for wound surface area and 1.4% (95% confidence interval: 0.7, 3.5) for volume. The mean cost per day for GSUC therapy was $4.22 versus $96.51 for VAC therapy (P G 0.01) and the average time required for a GSUC dressing change was 19 minutes versus 31 minutes for a VAC dressing change (P G 0.01). A retrospective cost analysis was performed at the University of Chicago Medical Center between 1999 and 2014. Total of 35,871 days of NPWT was provided during the 15-year span. Theoretical average cost of VAC was $94.01/d versus $3.61/d for GSUC, whereas actual average was $111.18/d versus $4.26/d. Average labor cost was $20.11/dressing change versus $12.32. Combined, total cost of VAC therapy was estimated at $119,224 per every 1,000 days of therapy versus $9,188 for the GSUC [47].

The sum of pain intensity differences was 0.50 in the GSUC group compared with 1.73 for the VAC group (P = 0.02) [9].

After the trial was completed and the data analyzed clinicians rapidly embraced G-SUC and the number of patient treated with VAC therapy began to fall. By 2009 the UOCM had abandoned VAC therapy. In 2010 and 2011, 12 and 17 patients respectively were treated with VAC therapy. These patients were enrolled in a randomized trial to compare the effectiveness of VAC and G-SUC dressing as bolster over split skin grafts [48]. Other than for clinical research VAC was no longer used. The main limitations of GSUC dressing is portability. In an outpatient/home setting where supplies and equipment need to be packaged and delivered in a portable way, all commercial devices that provide NPWT in such a way still make sense. However in a facility/hospital setting our clinical experiences allows us to believe that significantly greater cost of commercialized devices as demonstrated our study-without increased therapeutic efficacy is not well justified.

A total of 5323 patients (4927 adults and 396 children) -46,670days of NPWT was treated with NPWT dressing between

July 1,1999 and June 30, 2017 total of 2149 patients were treated with VAC dressing between July 1, 1999 and June 30, 2011 and 3174 patients were treated with G-SUC dressing between July 1, 2006 and June 30, 2017.

Acute Abdomen Cases

With a "clean" wound immediately post-surgery a *sterile technique* must be used; with other wounds a *clean technique may be used (Figure 1)*.

You will also need "plastic wrap" or Mepitel dressing to use as protective barrier over Vicryl mesh.

Wound care management:

- Cut a plastic to the size of the exposed intestine (to avoid causing fistulas)
- Make a lot of holes in the plastic (cut/punch plastic by blade or scissors)
- Apply the gauze (or foam) over the plastic
- Insert one or 2 red rubber catheters when using not commercial system
- Seal the dressing than cut hole to apply track to be connected to unit
- **Setting**: Continuous pressure -50 mmHg to -80 mmHg
- Closely observe wound drainage, green/yellow fluid in drain/canister suggest fistulae formation, **stop the NPWT and contact service.**
- Pt should have abdominal binder or Montgomery straps to stabilize abdominal wall 24/7
- If new stoma present binder should have cut hole over stoma

Functional mobility training interventions:

- Log-roll position for supine to sit on edge of bed, decreased stress on abdominal wall during supine to sitting position
- Isometric exercises to abdominal muscle in junction with exhalation, ankle pumps, strengthening exercises to the lower extremity muscles
- Exercises in lying or sitting
- Maximize exercises tolerance
- Optimize functional mobility as soon as patient off sedation; rolling, supine to sit, scoot sideway or up/down in bed, moving from lying to sitting, functional transfer. Functional training could be initiated with patient intubated awaken and medically stable

Case study 1: Pt with history of bladder cancer, s/p cystecomyneo-bladder in July 2011. S/P ureteal transplant on July 23,2012 discharged home on July 26, 2012. On August 2, 2012 patient was transfered from OCH for small bowel obstruction. On August 5, 2012 pt underwent abdominal wash out for purulent fluid collection, wound was closed with Bogota Bag and NPWT dressing. Photos are labeled with dates of interevention in 2012 (Figures 2 and 3).

Open abdominal wound with fistula

When granulation tissue is present over the intestine you may or may not need to use protective barriers (Adaptic dressing, Vaseline gauze, or Xeroform gauze). The thickness of the granulation tissue will determine if you need a protective

Figure 1: OPEN ABDOMINAL WOUND WITH EXPOSED INTESTINE (Vicryl mesh covering the wound, Photos A, B & C).

Figure 2: Patient was seen for physical therapy treatment during ICU stay, wound was prepared for surgical closure with skin graft. Patient underwent wound closure with skin graft.

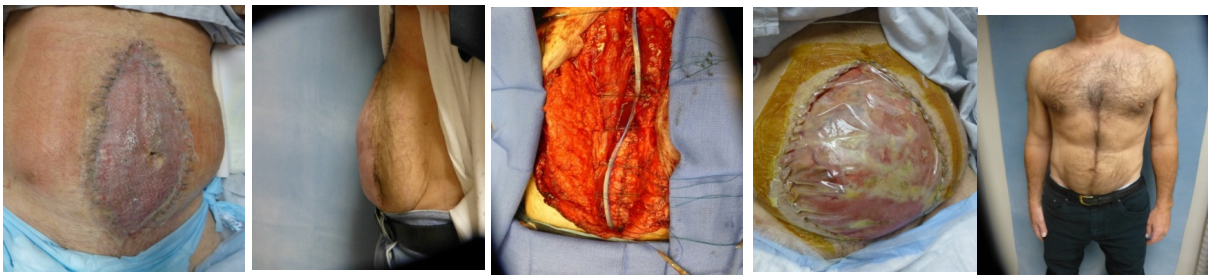


Figure 3: Abdominal wall correction.
Prior to abdominal wall correction patient exercises daily with goal to decrease weight.

barrier (information of age of wound and time of surgery is very important). Fresh fistula = need protective barrier if you do not use pouching system; old fistula (older than 5-6 weeks) isolated from wound nay not need a protective barrier, use pouching system with NPWT dressing. Remember wound filler (foam or gauze) should not touch fistulae, good practice to use protective barrier to prevent fistulae from wound filler.

- Apply protection over tissue *not fistula* if you use pouching system
- Apply double layer of protective barrier (Xeroform, Adaptic gauze) over fistulae, next foam or gauze over wound including fistula when not using pouching system
- Apply the red rubber catheter or track over very small fistula to isolate fistulae output from wound. If it possible isolates fistulae mouth from pressure, remember pressure near fistulae may increase size of fistula.
- **Setting:** You may apply -50 mmHg to -125mmHg. It may be set up to -150 mmHg if there is a lot of drainage.

Case study 2: 53 years old female transferred from OSH for abdominal wound management (Figure 4). The patient's surgical history: 07.03.2012 pt underwent face lift, blephroplasty, abdominal plasty and ingrown toenail repair in Mexico. POD #8 patient diagnosed with septic shock, scaled skin syndrome, staph septicemia and candidasis. POD # 9 underwent exploratory laparatomy for gross fecal in contamination, fasciitis, cellulites and flank necrosis, resection an ilea segment, end ileostomy. For next 7 days patient was in induced coma, wound was closed with NPWT dressing. On 08.10.2012 family transfer the patient to Providence Memorial Hospital in El Paso, Tx. 08.13.12. Wound I&D, found multiple entero-cutaneous fistulae and necrotic abdominal wall. NPWT dressing was unsuccessful, using saline moistened gauze with silvadene cream for dressing change. 08.18.12 the patient transfer to UCM in stable medical conditions with above conditions and sacral decubitus, positive for drug resistant pseudomonas. Wound measurements 43.0 x 19.5 x 3.0 cm, and 6.0 cm undermining between 9-11 o'clock and 8.5 cm undermining between 1-2 o'clock. Initiated treatment: Mepitel dressing over exposed intestine, next NPWT with saline moistened gauze and stoma appliance over fistulae to control wound drainage and to heal damaged peri-wound skin. On 08.20.2012 pt went to OR for wound wash out, NPWT dressing was re-apply. POD # 1 physical therapist initiated functional training, continued wound management with NPWT dressing and stoma appliance

Figure 4: 53 years old female transferred from OSH for abdominal wound management

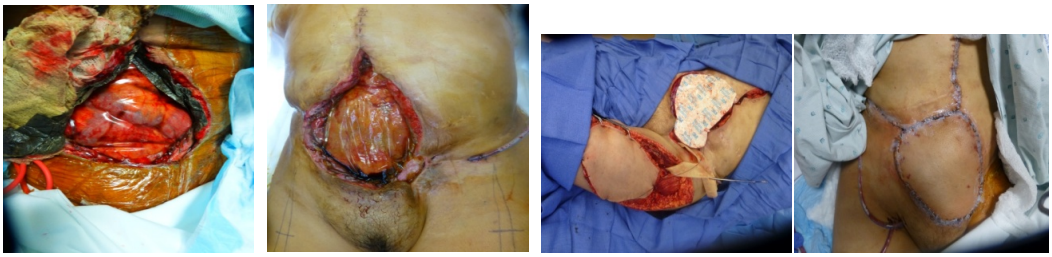
over fistulae. On 08.31.2012 patient was transferred to long time acute care (LTAC) facility for further wound management and functional training. Pt was readmitted for abdominal defect repair 8 months later. Two days after admitting pt underwent surgical procedure for take down of enterocutaneous fistula and small bowel resection (Figures 4 and 5).

Case study 2 Photos by date of intervention with description

Physical therapy intervention was initiated POD#4 with no sitting restrictions and the left knee immobilizer on all the time. Patient required maximal assist of two to be able progress from supine to standing position and initiate some steps. She tolerated 4 minutes ogf upright position. POD # 6 patient was moderate assist for transfer and could ambulate 50 feet with max A of two, tolerates > 10 minutes of activity. POD # 8 patient performed supine to stand with supervision ambulates with hand hold assist and IV pole 120 feet. POD # 11patient was off no sitting restrictions, the left knee immobilizer still on, she could able to ambulate 300 feet independently with (L) knee immobilizer, able to ascend/descend 7 steps with one hand on rail, good (L) quadriceps muscle activation. POD # 12 pt was discharged home with no post discharge physical therapy needs. pt was seen in plastic surgery clinic. She underwent abdominal wall correction on 11.17.2015 (Figure 6).

Case study 3 Abdominal Compartment Syndrome leading to fistula development.

26 years old male with Hx of alcoholic pancreatitis arrived to ER 0n 02.07.11 with abdominal pain and vomiting after drinking. Patient admitted to MICU secondary to worsening medical status. PMH: Depression, Bipolar Disease, Alcoholism, Asthma,



05.28.2015 05.30.2013 05.30.2013 05.31.2013

Figure 5: preparation for wound closure with anterio, lateral thigh (ALT) muscle Photos by date of intervention with description

O8.18.12 05.26.15

Figure 6: admitting to UOCM and after abdominal wall correction

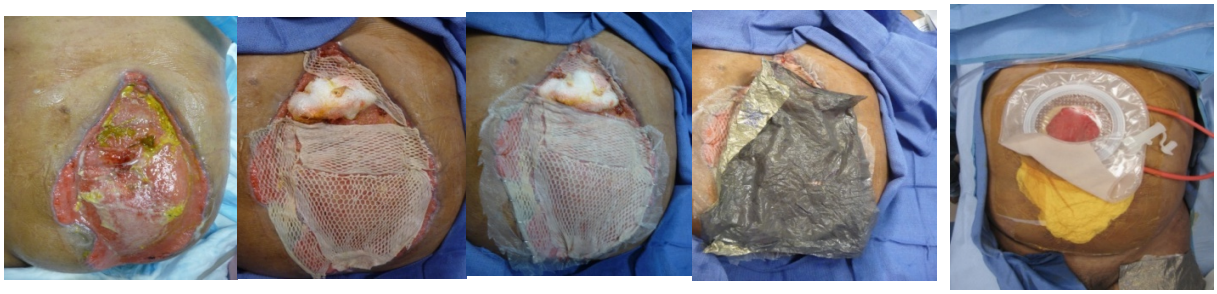


Figure 7: Wound manager to irrigate/remove fecal material

Anxiety, Pancreatitis with frequent hospitalization, smoker, poor compliance with medical advice. Patient underwent exploratory laparatomy for abdominal decompression wound closed with Bogotá bag and NPWT dressing on day of admitting. POD # 4 patient returned to OR for abdominal wash out replaced Bogotá bag and reapplications of NPWT dressing. POD #9 patient back to OR for tracheotomy for acute respiratory failure and abdominal wash and vicryl mesh wound closure, continued NPWT dressing for wound management. POD # 17 patient underwent replacement of vicryl mesh. few days later patient developed of colocutaneous fistulae. On 03.23.11 Abdominal wound closure with Allograft, application of NPWT dressing over Allograft and wound manager over fistulae. On 03/31/11 patient was transferred to acute rehabilitation center for functional training and wound management. 27 days later patient was readmitted for Allograft replacement with Autograft (Figure 7) .

Patient transferred back to rehab facility for wound care management and functional mobility training. Before discharge from UOCM dressing was managed with non-adherent dressing over skin graft and wound manager over fistula (Figures 8 and 9).

Tips and Recommendations on base of 18 years clinical experience and research with NPWT at out facility suggest the following:

•Never put foam or gauze over skin as it may macerate the skin. If you do not have DuoDerm apply bio-occlusive tape (Tegaderm) as an alternative

•For wound with exposed tendon, bone, exposed intestine, vessels protect with overlay perforated plastic, petrolatum gauze, Mepitel. You may use Hydrogel shit over tendon or exposed bone.

•Remember NPWT dressing will “dry tendon and bone structure” when apply over without protective barrier

•Younger and healthy patients wound will granulate more rapidly than adult and sick patients. New granulation tissue bleeds very easily - consider non-adherent dressing beneath foam/gauze

•Do not pack/overfill wound provide space for wound to “collapse” around dressing

•For wounds in areas off challenging anatomy use ostomy

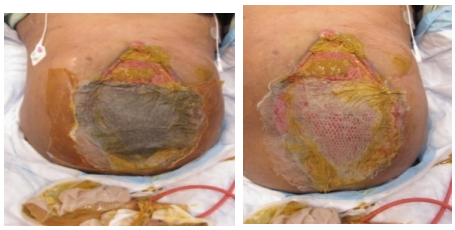


Figure 8: Allograft assessment

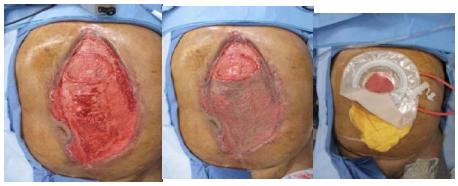


Figure 9: Allograft to autograft

paste to promote seal of transparent drape or after you seal a dressing add "cork(s)" - roll small piece of gauze and apply in area of fold or challenging anatomy and secure it with additional transparent drape.

- Use perforated plastic or Mepitiel dressing over Vicro mesh, easily bleeding and painful wounds
- Use Pleur-evac over pressure sensitive area - it will give you low pressure as -10 mmHg pressure (26).
- Place instillation drain (flat JP drain) on first layer of gauze or in the wound bed to deliver fluid into the wound (wound irrigation with antibiotic solution or Dakin's solution for infected wounds) (44)
- With very painful dressings or when working with pediatric patients you may use 1% Lidocaine without Epinephrine. You must inject the Lidocaine into the dressing close to the wound then insert saline via tubing. Wait a moment, then partially remove the dressing and put several drops on the tissue. After a moment, peel off the foam then repeat the procedure until sponge is removed. You need to have MD order for Lidocaine use [9].
- NPWT should be discontinued if no positive wound response within one week. Wound may need different treatment approach
- NPWT dressing should be assessed several times throughout each shift for appropriate seal, volume and color of fluid drain
- Patient should have abdominal binder or stabilization of abdomen in place when weaning occurs to decrease the internal pressure; to stabilize the abdominal wall against forces such as a strong cough with extubation (Figures 7-9).

Conclusion

NPWT when used for the right indications by experienced clinicians, is an excellent tool to support wound healing and save lives. For acute wounds, in an inpatient setting, the tape of filler (gauze or foam) and the source of delivered suction do not influence of clinical outcome in respect of preparation wound for surgical closure. Treating difficult to heal wounds requires a strategic approach individualized for the patient's medical history and status. NPWT is effective and safe in managing complex abdominal wound. Early beginning treatment with NPWT improves the results of treatment and decreases hospitalization time. Furthermore, cost of the NPWT treatment strictly depends on the time and duration of intervention and a system used (43, 45, 47,49, 50, 51). The use of GSUC from traditional VAC therapy is a cost saver for departments. Furthermore, being able to provide NPWT just from using easily accessible and universally available medical supplies in an inpatient setting is an added advantage of GSUC.

Acknowledgement

Author would like to acknowledge and thank Deana Herrman PT for her contribution to and support for this project.

References

1. Aviles F. Examining the increased role of the physical therapist within the wound care industry. *Today's Wound Clin.* 2017;8(4):23-26.
2. APTA. American Physical Therapy Association Guide to Physical Therapy Practice 3.0. 2015.
3. Bohmert J, Moffat M, Zadai C (Eds). Guide to physical therapy practice (2nd ed.rev). APTA. Alexandria, VA.
4. Today's physical therapy: A comprehensive review of a 21 century health care profession. APTA. January 2011.
5. American Physical Therapy Association. A Normative Model of Physical Therapy Assistant Education: Version 2004. Alexandria, VA: American Physical Therapy Association; 2004.
6. CAPTE. Commission on Accreditation in Physical Therapy Education. Evaluative Criteria. PT Programs. 2014.
7. Song DH, Wu LC, Lohman RF, Gottlieb LJ, Franczyk M. Vacuum Assisted Closure for the Treatment of Sternal Wounds: The Bridge between Debridement and Definitive Closure. *Past Reconstr Surg.* 2003;111(1):92-97.
8. Agrawal JP, Ogilivie M, Wu LC, et al. Vacuum-Assisted Closure for Sternal Wounds: A First line Therapeutic Management Approach. *Plast Reconstr Surg.* 2005;116(4):1035-1040.
9. Franczyk M, Lohman RF, Agarwal JP, Rupani G, Drum M, Gottlieb LJ. The Impact of Topical Lidocaine on Pain Level Assessment during and after Vacuum-Assisted Closure Dressing Changes: A Double-Blind Prospective, Randomized Study. *Plast Reconstr Surg.* 2009;124(3):854-861.

10. Schweickert WD, Pohlman MC, Pohlman AS, et al. Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomized controlled trial. *Lancet.* 2009;373(9678):1874-1882.

11. Krokowicz L, Borejsza-Wysocki M, Mackiewicz J, Iqbal A, Drews M. 10 years of Negative Pressure Wound Therapy [NPWT]: Evolution of Indication for its Use. *NPWT.* 2014;1(1):27-32.

12. Banasiewicz T, Cybulka B, Iqbal A, Francuzik W, Linder J, Drews M. Clinical and Economic Benefit of Negative Pressure Wound Therapy in treatment of the Open Abdomen. *NPWT.* 2014;1(2):39-47.

13. Brace JA. Negative Pressure Wound Therapy for Abdominal Wounds. *J Wound Ostomy Continence Nurs.* 2007;34(4):428-430.

14. Andrabi SIH, Ahmad J. Negative Pressure Therapy For Laparotomy Wounds. A World of Caution. *J WOCN.* 2007;34(4):425-427.

15. Negative Pressure Wound Therapy for the Open Abdomen. International procedure gridline [IPG 467] National Institute for Health and Care Excellence.2013.

16. Chariker ME, Jeter KF, Tintle TE, Bottsford JE. Effective management of incisional and cutaneous fistulae with closed suction wound drainage. *Contemporary Surg.* 1989;34:59-63.

17. Brindle CT, Blankenship J. Management of Complex Abdominal Wounds With Small Bowel fistulae. *J Wound Ostomy Continence Nurs.* 2009;36(4):396-403.

18. Franklin C. The Suction Pouch for Management of Simple or Complex Enterocutaneous Fistulae. *J Wound Ostomy Continence Nurs.* 2010;37(4):387-392.

19. de Leon JM. Novel Techniques Using Negative Pressure Wound Therapy for the Management of Wounds with Enterocutaneous Fistulas in a Long-term Acute Care Facility. *J Wound Ostomy Continence Nurs.* 2013;40(5):481-488.

20. Trevino CM, Vebaalen A, Bruce ML, Webb T. Conversion of an Enterocutaneous Fistula Associated With an Open Abdominal Wound Into a Drain-Controlled Enterocutaneous Fistula. *WOUNDS.* 2014;26(2) 43-46.

21. de Tullio D, Biondin V, Occhionorelli S. When a Postsurgical Dehiscence Becomes a Serious Problem. *Adv Skin Wound Care.* 2011;24(11):503-506.

22. Reginald LR, Marlys JS. Burn Care and Rehabilitation: Principles and Practice. 1994.

23. Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. *Ann Plast Surg.* 1997;38(6):563-576.

24. Morykwas MJ, Argenta LC, Shelton-Brown EI, McGuirt W. Vacuum-assisted closure: a new method for wound control and treatment. Animal studies and basic foundation. *Ann Plast Surg.* 1997;38(6):553-562.

25. Morykwas MJ, Simpson J, Punger K, Argenta A, Kremers L, Argenta J. Vacuum-Assisted Closure: State of Basic Research and Physiologic Foundation. *Plast Reconstr Surg.* 2006;117:(7)121-126.

26. Dorafshar AH, Agrawal S, Franczyk M, Agrawal J, Gottlieb LJ. Low-Pressure Negative-Pressure Wound Therapy Using the Pleur-Evac System in Hemodynamically Unstable Patients. *Plast Reconstr Surg.* 2010; 125(4):179-181.

27. Lesniak A, Shafritz AB. Negative Pressure Wound Therapy. *Journal of Hand Surgery.* 2013;38(9): 1828-1832.

28. RentaRM, Somers KK, Cassidy L, Enters J, Arca MJ. Negative Pressure Wound Therapy in infants and children: a single-institution experience. *Journal of Surgical Research.* 2013;184(1):658-664.

29. Banwell PE. Topical negative pressure in wound care. *J Wound Care.* 1999;8(2):79-84.

30. Lu X, Chen S, Li X. The experimental study of the effects of vacuum-assisted closure on edema and vessel permeability of the wound. *Cin J Clin Rehabil.* 2003;7:1227-1245.

31. Gouttenfangeas C, Eberle M, Ruck P, et al. Functional T lymphocytes infiltrate implanted polyvinyl alcohol foams during surgical wound closure therapy. *Clin Exp Immunol.* 2001;124(3):398-405.

32. Borgquist O, Ingemansson R, Malmsjö M. The Influence of Low and High Pressure Levels during Negative-Pressure Wound Therapy on Wound Contraction and Fluid Evacuation. *Plast Reconstr Surg.* 2011;127(2):551-559.

33. Miller M, Bybordi F. Negative Pressure Darwinism: Survival of the Fittest Paradigm. *WOUNDS.* 2009;21(7):192-197.

34. Jones SM, Banwell PE, Shakespeare PG. Advances in wound healing: topical negative pressure therapy. *Postgrad med J.* 2005;81(956):353-357.

35. Huang Ch, Leavitt Tripp, Bayer LR, Orgill DP. Effect of negative pressure wound therapy on wound healing. *Curr probl Sury.* 2014;51(7),301-331.

36. Usupov YN, Yepifanov MW. Active Wound Drainage. Russian Journal: vestnik Khirurgii. 1987;42-45.

37. Borgquist O, Ingemansson R, Malmsjö M. Wound Edge Microvascular Blood Flow during Negative-Pressure Wound Therapy: Examining the Effects of Pressure from -10 to -175 mmHg. *Plast Reconstr Surg.* 2010;125(2):502-509.

38. Borgquist O, Gustafson L, Ingemansson R, Malmsjö M. Tissue Ingrowth Into Foam but Not Into Gauze During Negative Pressure Wound Therapy. Wounds. 2009;21(11):302-309.

39. Malmsjö M, Ingemansson R, Martin R, Huddleston E. wound Edge Microvascular Blood Flow: Effect of Negative Pressure Wound Therapy Using Gauze or Polyurethane Foam. *Ann Plast Surg.* 2009;63(6):676-681.

40. Borgquist O, Gustafson L, Ingemansson R, Malmsjö M. Micro- and Macromechanical effects on the Wound Bed of Negative Pressure Wound Therapy Using Gauze and Foam. *Ann Plast Surg.* 2010; 64(6):789-793.

41. National Health Expenditures 2012 Highlights.

42. Verbelen J, Hoeksema H, Heyneman A, Pirayesh A, Monstrey S. Treatment of Fournier's Gangrene With a Novel Negative Pressure Wound Therapy System. *WOUNDS.* 2011;23(11):342-349.

43. Dorafshar AH, Franczyk M, Gottlieb LJ, Wroblewski K, Lohman RF. A Prospective Randomized Trial Comparing Subatmospheric Wound Therapy with a Sealed Gauze Dressing and the Standard Vacuum-Assisted Closure Device. *Ann Plast Surg.* 2012;69(1):79-84.

44. Dorafshar AH, Franczyk M, Karian L, et al. A Prospective Randomized Trial Comparing Subatmospheric Wound Therapy with a Sealed Gauze Dressing and the Standard Vacuum-Assisted Closure Device: A Supplementary Subgroup Analysis of Infected Wounds. *WOUNDS.* 2013;25(5):121-130.

45. Tuncel U, Turan A, Bayraktar AM, Aydin U, Erkorkmaz U. Clinical experience With the Use of Gauze-based Negative Pressure Wound Therapy. *WOUNDS.* 2012;24(8):227-233.

46. Hurd T, Chadvick P, Cote J, Cockwill J, Mole TR, Smith J. Impact of gauze-based NPWT on the patient and nursing experience in the treatment of challenging wounds. *Int Wound J.* 2010;7(6):448-455.

47. Kim JJ, Franczyk M, Gottlieb LJ, Song DH. Cost-effective Alternative for negative-pressure Wound Therapy. *Plast Reconstr Surg Glob Open.* 2017;5(2).

48. Nguyen TQ, Franczyk M, Lee JC, Greives MR, O'Connor A, Gottlieb LJ. Prospective Randomized Controlled Trial Comparing Two Methods of Securing Skin Grafts Using Negative Pressure Wound Therapy: Vacuum-Assisted Closure and Gauze Suction. *J Burn Care & Research.* 2015;36(2):324-328.

49. Gill NA, Hameed A, Sajjad Y, Ahmad Z, Mirza MAJ. "Homemade" Negative Pressure Wound Therapy: Treatment of Complex Wounds Under Challenging Conditions. *WOUNDS.* 2011;23(4):84-92.

50. Sivastava RN, Dwivedi M, Bhagat AK, Raj S, Agarwal R, Chandra A. A non-randomized, controlled clinical trial of an innovative devices for negative pressure wound therapy of pressure ulcers in traumatic paraplegia patients. *Int Wound J.* 2016;13(3):343-348.

51. Kamamoto F et al. A new low-cost negative pressure wound therapy versus a commercially available therapy device widely used to treat complex traumatic injuries: a prospective, randomized, non-inferiorly trial. *Clinics.* 2017;72(12):737-742.