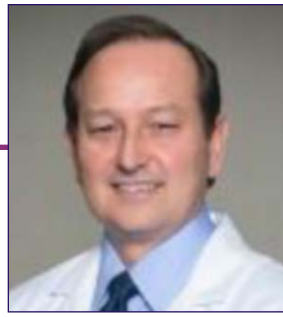
The Utility of Negative Pressure Wound Therapy for Wound Bed Preparation: The Why, the How and the Who

Luis Fernandez, MD, KHS, KCOEG, FACS, FASAS, FCCP, FCCM, FICS



Dr. Fernandez is a Clinical Assistant Professor of Surgery and Family Practice at the University of Texas Health Center at Tyler. He is also an Attending Teaching Staff in the Division of Surgery for Mother Frances Health System and East Texas Medical Center in Tyler. Dr. Fernandez obtained his residency training at Loyola University, the University of Illinois, the University of Chicago and Northwestern University, Chicago, Illinois, with special training in Trauma and Burns at Kings County Hospital, SUNY Down State System, Brooklyn, New York, NY. He is well published in multiple areas of research both in peer-reviewed articles and book chapters, and has made numerous oral and poster presentations at national and international conferences.

NOTE: As with any case study, the results and outcomes should not be interpreted as a guarantee or warranty of similar results. Individual results may vary depending on the patient's circumstances and condition.

THE WHY

Complex and chronic wounds in the United States affect over 6 million patients, with nearly $50 billion (U.S.) spent on their treatment annually[1, 2]. The treatment of chronic wounds and the concomitant economic burden is growing rapidly due to increasing health care costs, an aging population and a sharp rise in the incidence of diabetes and obesity worldwide [3-5].

Complex wounds have a significant impact on patient outcomes, morbidity, mortality cost and lead to longer hospital stays[6, 7]. As a result of the cumulative advances in medical care in the last century, an aging population, a sharp rise in the incidence of diabetes and obesity worldwide, and the subsequent improvement in survival, the incidence of complex and chronic wounds appears to be increasing[8]. It is, therefore, incumbent for surgeons to be well versed in all aspects of the care and management of patients with complex wounds, their co-morbidities, and to be skilled in the use of new technologies that can accelerate the wound's repair process.

THE HOW

The proliferation of new strategies in prevention, treatment and management has improved the care of complex and chronic wounds patients significantly in the last few decades. The development of negative pressure wound therapy (NPWT), introduced commercially after the studies of Argenta and Morykwas in 1997, was a seminal turning point in the way we approached the care of the complex/chronic wound[9]. NPWT creates an environment that promotes wound healing by preparing the wound bed for closure, reducing edema, promoting granulation tissue formation and perfusion, and by removing exudate and infectious material. These mechanisms and other effects of NPWT have been validated by various experimental and clinical studies[9-17].

MECHANISMS OF ACTION

In their excellent review, Huang et al, noted that clinical observations into the effect of NPWT have identified 4 primary mechanisms of action: *(1) the immediate decrease in size of the wound when negative pressure is applied termed macro deformation; (2) micro deformation: the effects at the foam-wound interface; (3) fluid and debris removal; and (4) stabilization of the wound environment* (Figure 1)[18, 19].

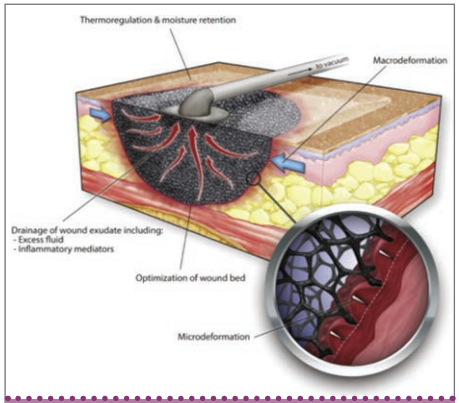


Figure 1: Huang C, Leavitt T, Bayer LR, Orgill DP. Effect of negative pressure wound therapy on wound healing. *Curr Probl Surg.* 2014;51(7):301-331.

There are also secondary effects involved in direct mechanical sheer stretching of the cellular cytoskeleton. The microstrain or cell stretch created by the black reticulated open cell foam (ROCF-G; V.A.C.® GRANUFOAM™ Dressing) is hypothesized to be translated to the cells by cell surface receptors linked to the extracellular matrix (eg, integrins) (Figure 2)[11] and may affect biological tissue responses, which can potentially impact wound healing. The microstrain can create tissue deformations, which may stimulate cellular activity and lead to granulation tissue formation.[11, 18-20]

In vivo evidence has shown that porcine non-infected full-thickness wounds treated with NPWT with instillation and dwell time (NPWTi-d; V.A.C. VERAFLO™ Therapy) using saline and a specialized reticulated open cell foam dressing (ROCF-V; V.A.C. VERAFLO™ Dressing) demonstrated increased granulation tissue formation compared to standard NPWT with ROCF-G dressing after 7 days of therapy.[21, 22] They concluded that: *"Negative pressure wound therapy with controlled instillation of fluids (NPWTi) is the next generation of*

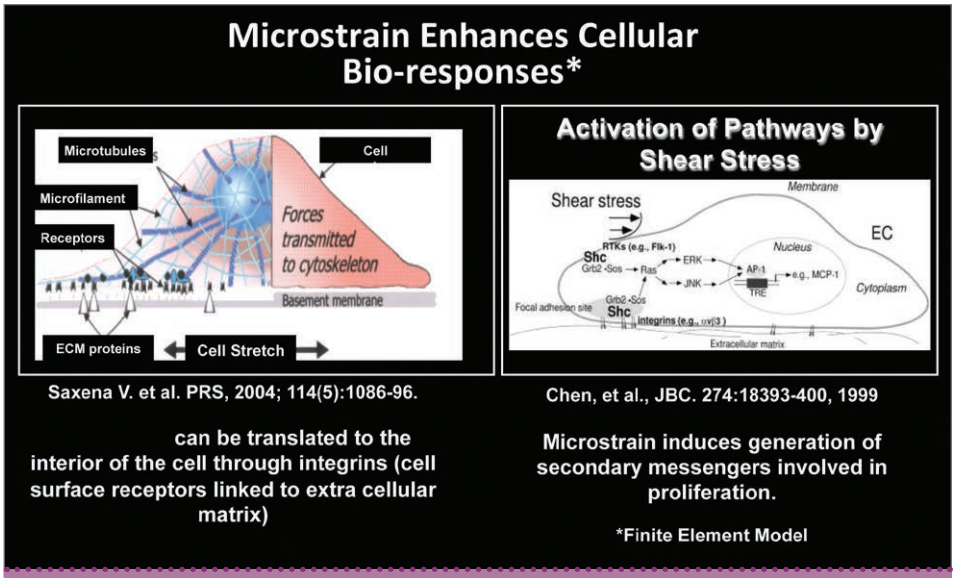


Figure 2: Modes of delivery of Negative Pressure Wound Therapy and their effects

negative pressure therapy", and that the new V.A.C.ULTA™ Therapy System and the specialized ROCF-V wound dressing provides discrete wound irrigation and fluid removal phases between negative pressure cycles and simplifies wound cleansing by allowing for automated and contained volumetric wound lavage. The new ROCF-V dressing has modified hydrophobic and mechanical properties compared to the existing ROCF-G dressing, enhancing fluid delivery while potentially reducing the likelihood of tearing or particle retention at dressing changes. This study also shows NPWTi-d with ROCF-V to be effective in a non-infected porcine wound model, resulting in more granulation tissue than standard NPWT with ROCF-G; the authors noted that these results should be confirmed in human studies[21, 22].

NPWT can be delivered as continuous pressure or intermittent mode of pressure[21]. In their *ex vivo* study of porcine skin, Lessing et al, described the two types of intermittent modes of NPWT: *"intermittent NPWT, where negative pressure alternates between a set pressure and no pressure for programmed periods of time; and dynamic (variable) NPWT, in which negative pressure transitions between a high pressure and a low pressure following programmed rise and fall times"* (Figure 3[21, 22]).

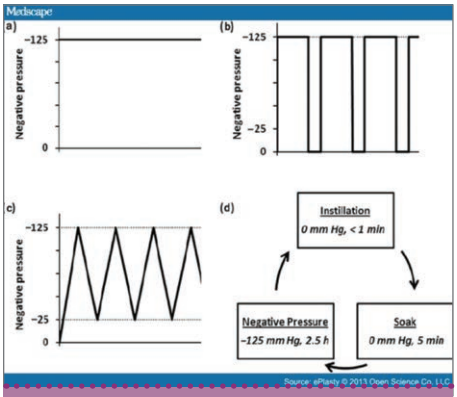


Figure 3: Lessing MC, James RB, Ingram SC. Comparison of the effects of different negative pressure wound therapy modes - continuous, noncontinuous, and with instillation - on porcine excisional wounds. *Eplasty* 2013; 13:e51.

They also compared the different modes of therapy with negative pressure utilizing saline instillation. They noted that the average observed granulation thickness was not statistically different among the different modes of NPWT wounds at day 7. They did note, however, that the average granulation thickness of NPWTi-d treated wounds was statistically greater ($P < .05$) by 44%, 57%, and 40%, respectively, than that of wounds treated with continuous, intermittent, and dynamic NPWT. (Figure 4[21])

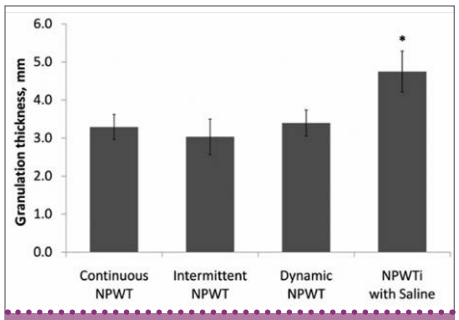


Figure 4: Measured granulation tissue thickness of treated wounds.

In clinical practice, the solutions used can vary from topical wound cleansers to antiseptics to normal saline. Gabriel et al demonstrated in a small study of 15 patients with complex infected wounds that instilling silver nitrate helped to reduce bioburden, decreased days of treatment, time to clearance of wound infection, time to wound closure and allowed early hospital discharge compared with the standard moist wound-care therapy control group patients[23-26].

CURRENT USE AND RECOMMENDATIONS OF NPWTi-d

The use of NPWTi-d appears to be increasing, manifesting in a growing body of reported practical and comparative clinical literature[27-30]. Several best practice expert panel recommendations have been developed to better guide the clinician in the most appropriate use of NPWTi-d[31, 32].

When utilizing NPWTi-d, a topical wound solution is introduced into the wound bed and dwells for a planned period of time and then is removed during a cycle of NPWT. The therapy provides cleansing of the wound bed and removal of infectious materials. The existing literature shows NPWTi-d may be used to prepare the wound to enhance granulation tissue formation between operative debridements and may be utilized in various wound types. (Figure 5[18, 30-32]).

THE WHO: *Case Presentations*

Case 1: COMPLEX OPEN ABDOMEN

This is a female, in her late sixties who has a history of prior rue en y bariatric gastric by-pass 10 yrs. prior to her admission. The patient had undergone emergency abdominal exploration and is found to have ischemic bowel and undergoes resection of 54 cm of efferent jejunum, abdominal washout, and initial damage control surgery.

Postoperatively, the patient has multiple organ system failure abdominal compartment syndrome and was managed with the ABTHERA™ Open Abdomen Negative Pressure Therapy System for her open abdomen. After multiple abdominal washouts, the patient improves, undergoes successful intestinal re-anastomosis and is closed with STRATTICE™ Reconstructive Tissue Matrix (RTM; LifeCell Corporation, an Allergan Affiliate, Parsippany, NJ).

Approximately 2 weeks later, the patient presents with bloody-purulent discharge from the abdominal incision and partial

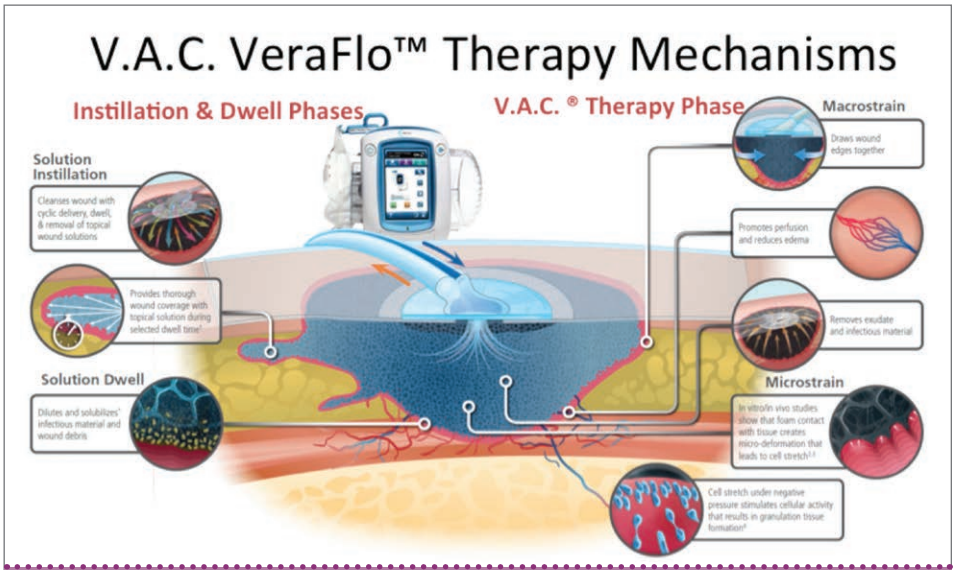


Figure 5: 1. Rycerz AM, et al. *Int Wound J* 2013;10:214-220. 2. Saxena SM, et al. *Plast Recon Surg* 2004;114(5):1086-1095. 3. McNulty AK, et al. *Wound Repair Regen* 2009 Mar;17(3):192-199. 4. McNulty AK, et al. *Wound Repair Regen* 2007;15:838-846.

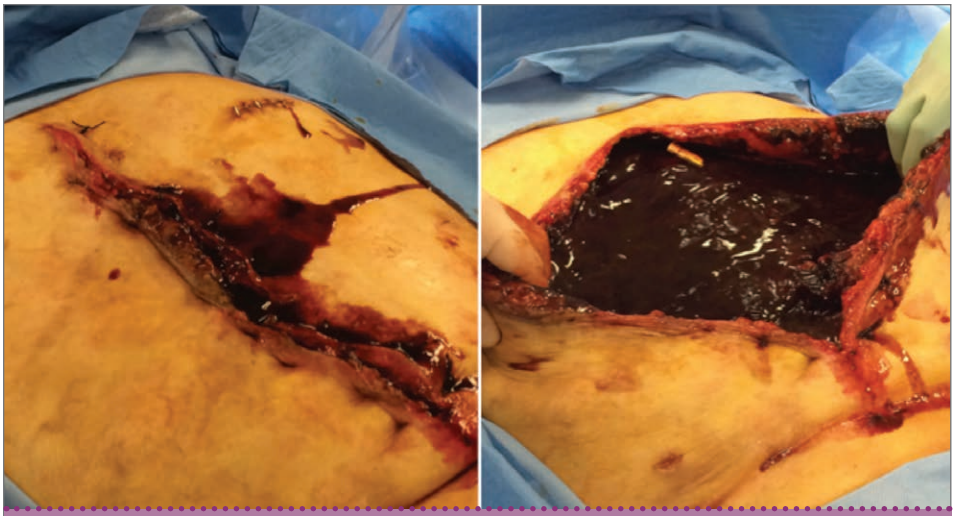


Figure 6: Patient with enteroatmospheric fistula, during initial debridement.

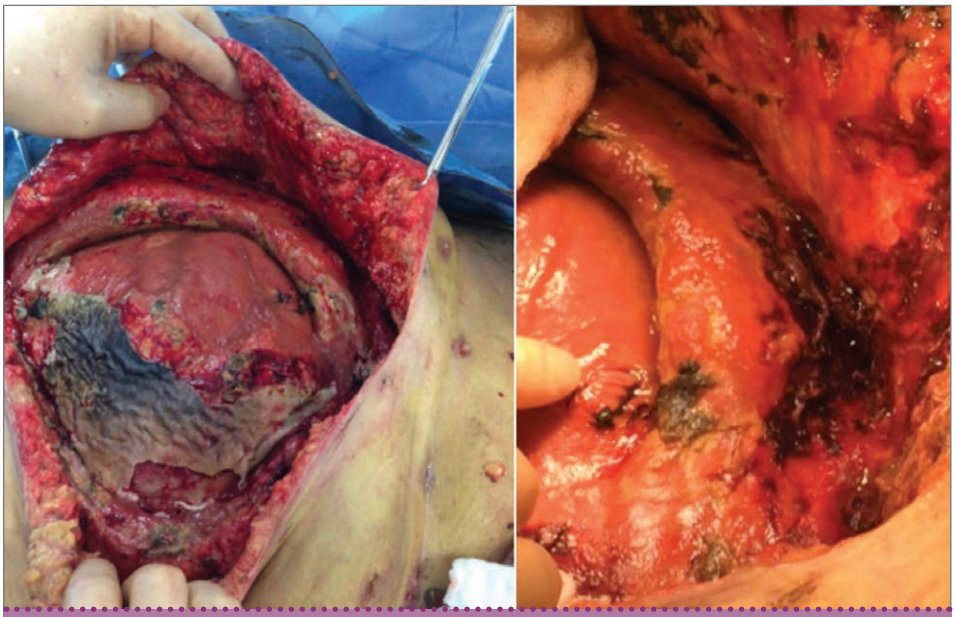


Figure 7: Patient with enteroatmospheric fistula, during initial debridement. The remnants of the STRATTICE™ RTM can be seen on the right image. The surgeons' finger points to the enteroatmospheric fistula.

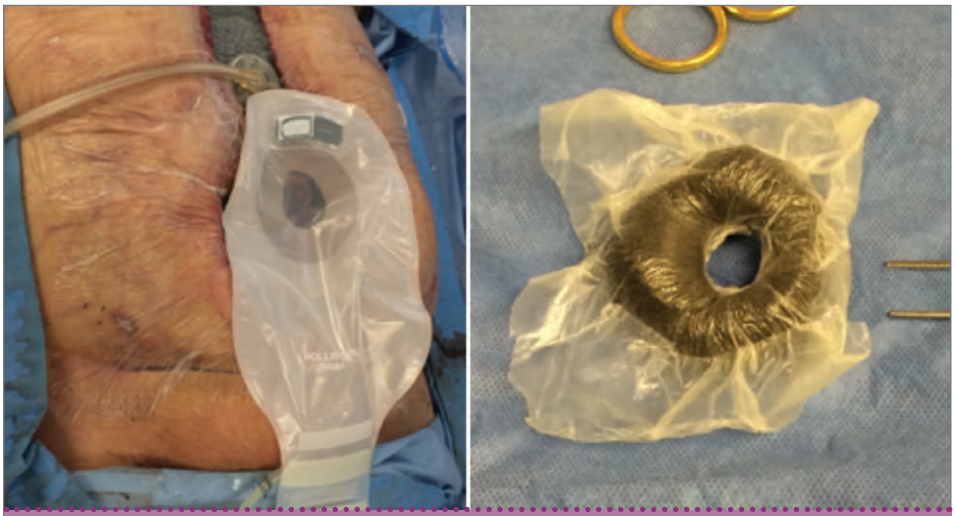


Figure 8: Patient with enteroatmospheric fistula, during initial debridement. The wound was debrided, the underlying tissue was protected with a layer of ADAPTIC TOUCH™ Dressing and V.A.C. WHITEFOAM™ Dressing. An ostomy negative pressure ring was constructed to control the fistula.

dissolution of the STRATTICE™ RTM due to an enteroatmospheric fistula (Figure 6, 7).

The underlying viscera were protected with the use of ADAPTIC TOUCH™ Non-Adhering Silicone Dressing and V.A.C. WHITEFOAM™ Dressing (polyvinyl alcohol) was used with V.A.C.® Therapy. An ostomy negative pressure ring was constructed to control the fistula. After the enteroatmospheric fistula was controlled, V.A.C.® Therapy was discontinued, and the patient underwent therapy with V.A.C. VERAFLO™ Therapy with saline instillation (dwell time of 10 minutes and NPWT for 2 hours) until an adequate granulation tissue bed was obtained (Figure 8, 9).

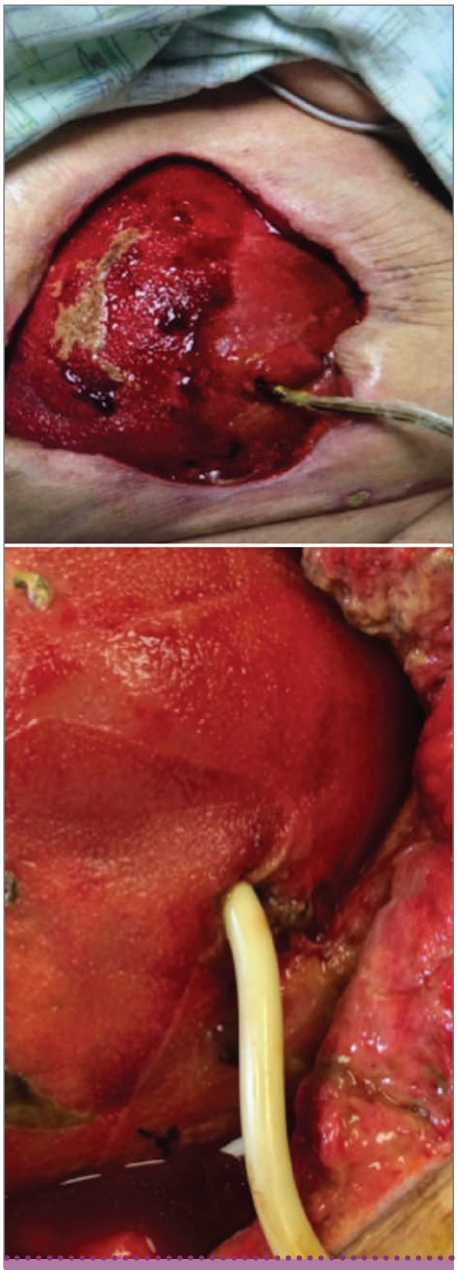


Figure 9: Excellent granulation tissue noted on a clean wound base after V.A.C. VERAFLO™ Therapy with saline. A Foley catheter was used to control fistula output.

The patient was then transitioned to standard V.A.C.® Therapy. The patient achieved significant re-epithelialization and the enteroatmospheric small bowel intestinal fistula was well controlled. The patient was able to tolerate small frequent meals and meet her nutritional requirements. The patient underwent inpatient rehabilitation and was discharged home after a prolonged hospital/rehab stay (Figure 10).

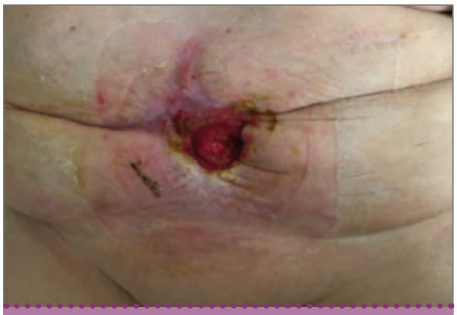


Figure 10: Excellent re- epithelialization of tissue without surgical flap advancement required.

Case 2: NECROTIZING FASCIITIS

The patient is a 40-year-old female with a history of insulin dependent diabetes mellitus, hypertension, morbid obesity, adult respiratory distress syndrome, multiple organ system failure on pressors due to septic shock from massive perineal, and pelvic necrotizing fasciitis. The patient's right thigh and perineal area is shown after initial debridement, subsequent second debridement and V.A.C. VERAFLO™ Therapy with saline (dwell time of 10 minutes and NPWT for 2 hours) on postoperative day 2-10 (Figure 11-13).

The patient underwent multiple debridements and subsequent transition to standard V.A.C.® Therapy. On hospital day 70, the patient underwent split-thickness skin grafting to the right thigh, inguinal area, perineum, supra-pubic area, right buttocks and back with application of ACell's MatriStem®, MicroMatrix® 2-1000 mg EM and four 10 x 15 cm ACell's MatriStem® wound sheets. The patient was transferred to an inpatient rehabilitation center and subsequently discharged home, tolerating a diet and ambulatory *without the need for fecal diversion* (Figure 14).

The use of V.A.C. VERAFLO™ Therapy with normal saline contributed to positive outcomes for both patients. These included reduction in anticipated morbidity, mortality, successful wound healing, and returning to the previous level of functioning. Despite consideration of amputation of the right limb and fecal diversion in the case of the second patient, both of these patients have returned to their preadmission level of activity.

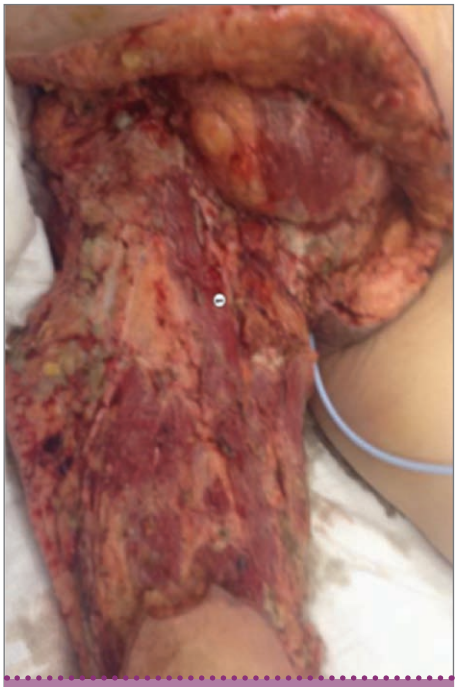


Figure 11: Necrotizing fasciitis patient s/p initial debridement and V.A.C. VERAFLO™ Therapy with saline, postoperative day 2.

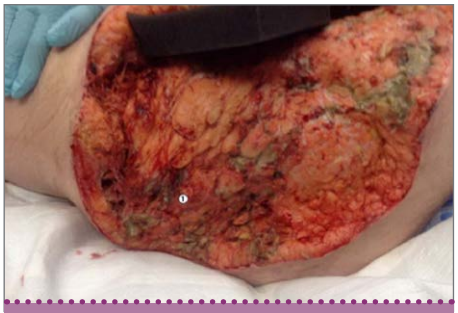


Figure 12: Necrotizing fasciitis patient s/p initial debridement and V.A.C. VERAFLO™ Therapy with saline, postoperative day 2.

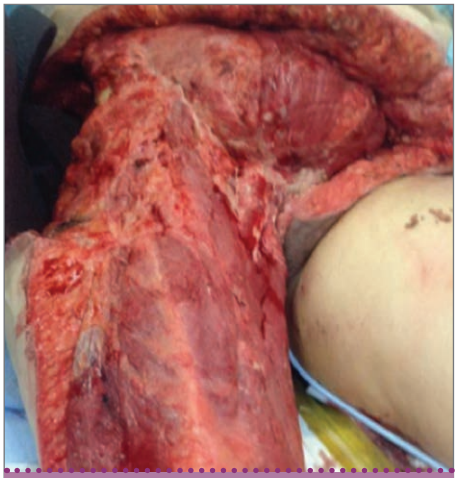
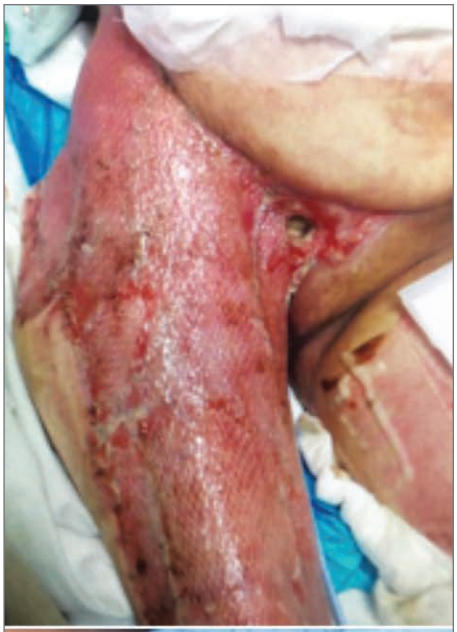


Figure 13: Necrotizing fasciitis patient s/p 2nd debridement and V.A.C. VERAFLO™ Therapy with saline.



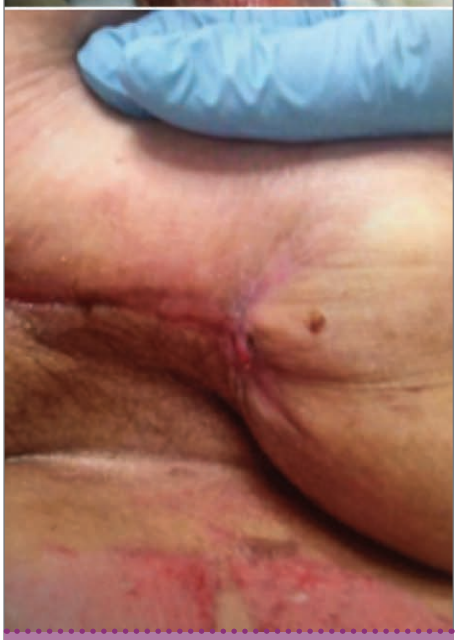


Figure 14: Definitive wound coverage with split thickness skin graft on HD 70.

CONCLUSION

Chronic and complex wounds continue to be a significant challenge in wound healing. Several factors, such as the patient's comorbidities, topographic location of the wound, presence of fistulae, presence of fomites (e.g. synthetic vascular grafts, orthopedic-neurosurgical hardware), active infection and the chronicity of the tissue injury can cause the wound to deteriorate and stall.

Randomized, controlled clinical studies should be developed to compare the effectiveness of NPWTi-d to other, non-NPWT methods of care and to determine the effect of NPWTi-d versus standard irrigation practices on wound healing and over all patient

outcomes. The optimal treatment paradigm in preparation of the wound bed should be that which is the most efficient in removing elevated inflammatory cytokines, enzymatic elements, cellular debris, necrotic tissue, and infection.

Automated wound cleansing combined with negative pressure therapy is a revolutionary new tool in wound management. NPWTi-d has been shown to have a marked and positive effect in the cleansing of devitalized tissue, removal of exudates, debris, militating against bioburden, a more rapid creation of granulation tissue and effectively creating a healthier wound bed. As experience with this new approach expands, we will have better data that will help inform the clinician as to what therapeutic regimen is most appropriate for the treatment of the complex, chronic wound.

References:

1. Fife CE, Carter MJ. Wound care outcomes and associated cost among patients treated in US outpatient wound centers: data from the US Wound Registry. *Wounds* 2012; 24:10–17 [PubMed] [Ref list]
2. Driver VR, et al. The costs of diabetic foot: the economic case for the limb salvage team. *J Am Podiatr Med Assoc* 2010; 100:335–341 [PubMed] [Ref list]
3. Hossain P, Kawar BEI, Nahas M. Obesity and diabetes in the developing world--a growing challenge. *N Engl J Med.* 2007; 356:213–5. [PubMed] [Ref list]
4. Administration on Aging A; Services, DoHaH. A profile of older Americancs. 2007. Pp. 1–19. http://www.wvseniorservices.gov/Portals/0/pdf/ProfileOfOlderAmericans.pdf. [Ref list]
5. Singer AJ, Clark RA. Cutaneous wound healing. *N Engl J Med.* 1999; 341:738–46. [PubMed] [Ref list]
6. Ferreira MC, Tuma P Jr, Carvalho VF, Kamamoto F. Complex wounds. I (Sao Paulo). 2006;61(6):571-8.
7. Kirkland KB, Briggs JP, Trivette SL, et al. The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. *Infect Control Hosp Epidemiol.* 1999 Nov. 20(11): 725-30. [Medline].
8. Sen CK, et al. Human skin wounds: a major and snowballing threat to public health and the economy. *Wound Repair Regen.* 2009; 17:763–771 [PMC free article] [PubMed]
9. Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. *Ann Plast Surg.* 1997;38(6):563-76; discussion 577. [Links]
10. KCI Licensing. *V.A.C. Therapy Clinical Guidelines.* San Antonio, TX: Kinetic Concepts, Inc; 2010.
11. Saxena V, Hwang CW, Huang S, Eichbaum Q, Ingber D, Orgill DP. Vacuum-assisted closure: microdeformations of wounds and cell proliferation. *Plast Reconstr Surg.* 2004; 114(5):1086–96; discussion 1097–8.
12. McNulty AK, Schmidt M, Feeley T, Kieswetter K. Effects of negative pressure wound therapy on fibroblast viability, chemotactic signaling, and proliferation in a provisional wound (fibrin) matrix. *Wound Repair Regen.* 2007; 15(6):838–46.
13. McNulty AK, Schmidt M, Feeley T, Villanueva P, Kieswetter K. Effects of negative pressure wound therapy on cellular energetics in fibroblasts grown in a provisional wound (fibrin) matrix. *Wound Repair Regen.* 2009; 17(2):192–9.
14. Scherer SS, Pietramaggiori G, Mathews JC, Prsa MJ, Huang S, Orgill DP. The mechanism of action of the vacuum-assisted closure device. *Plast Reconstr Surg.* 2008; 122(3): 786–97.
15. Dastouri P, Helm DL, Scherer SS, Pietramaggiori G, Younan G, Orgill DP. Waveform modulation of negative-pressure wound therapy in the murine model. *Plast Reconstr Surg.*2011; 127(4): 1460–6.
16. Armstrong DG, Lavery LA. Negative pressure wound therapy after partial diabetic foot amputation: a multicentre, randomised controlled trial. *Lancet.* 2005; 366(9498): 1704–10.
17. Blume PA, Walters J, Payne W, Ayala J, Lantis J. Comparison of negative pressure wound therapy using vacuum-assisted closure with advanced moist wound therapy in the treatment of diabetic foot ulcers. *Diabetes Care.* 2008;31(4):631–6.
18. Huang C, Leavitt T, Bayer LR, Orgill DP. Effect of negative pressure wound therapy on wound healing. *Curr Probl Surg* (2014) 51(7): 301–31. Doi: 10.1067/j.cpsurg.2014.04.001PubMed Abstract | CrossRef Full Text | Google Scholar
19. D.P. Orgill, E.K. Manders, B.E. Sumpio, et al.The mechanisms of action of vacuum assisted closure: more to learn. *Surgery*, 146 (1) (2009), pp. 40–51
20. Chen KD, Li YS, Kim M, Li S, Yuan S, Chien S, Shyy JY. (1999) *J Biol Chem* 274:18393-400.
21. Lessing C, Slack P, Hong KZ, Kilpadi D, McNulty A. Negative pressure wound therapy with controlled saline instillation (NPWTi): dressing properties and granulation response *in vivo*. *Wounds.* 2011; 23:309–19. [PubMed]
22. Lessing MC, James RB, Ingram SC. Comparison of the effects of different negative pressure wound therapy modes - continuous, noncontinuous, and with instillation - on porcine excisional wounds. *Eplasty* 2013; 13:e51.
23. Gabriel A, Shores J, Heinrich C, Bagai W, Kalina S, Sogioka N, et al. Negative pressure wound therapy with instillation: a pilot study describing a new method for treating infected wounds. *Int Wound J.* 2008; 5:399–413. [PubMed]
24. Schintler MV, Prandl EC, Kreuzwirt G, Grohmann MR, Spendel S, Scharnagl E. The impact of the VAC Instill in severe soft tissue infections and necrotizing fasciitis. *Infection.* 2009;37:S31–2.
25. Timmers MS, Graafland N, Bernards AT, Nelissen RG, van Dissel JT, Jukema GN. Negative pressure wound treatment with polyvinyl alcohol foam and polyhexanide antiseptic solution instillation in posttraumatic osteomyelitis. *Wound Repair Regen.* 2009; 17:278–86. [PubMed]
26. Bernstein BH, Tam H. Combination of subatmospheric pressure dressing and gravity feed antibiotic instillation in the treatment of postsurgical diabetic foot wounds: a case series. *Wounds.* 2005; 17:37–48.
27. Kim PJ, Attinger CE, Steinberg JS, Evans KK. Negative pressure wound thera- py with instillation: past, present, and future. *Surg Technol Int.* 2015; 26:51–56.
28. Kim PJ, Attinger CE, Crist BD, et al. Negative pressure wound therapy with instilla- tion: review of evidence and recommendations. Podiatr Today. 2015;suppl:1-20.
29. Gabriel A, Kahn K, Karmy-Jones R. Use of negative pressure wound therapy with automated, volumetric instillation for the treatment of ex- tremity and trunk wounds: clinical outcomes and potential cost-effectiveness. *Eplasty.* 2014; 14:e41.
30. Kim PJ, Attinger CE, Steinberg JS, et al. The impact of negative-pressure wound therapy with instillation compared with standard negative-pressure wound therapy: a retrospective, historical, cohort, controlled study. *Plast Reconstr Surg.* 2014; 133(3): 709–716.
31. Gupta S, Gabriel A, Lantis J, Téot L. Clinical recommendations and practical guide for negative pressure wound therapy with instillation. *Int Wound J*, 2015. [PubMed]
32. Clinician panel recommendations for use of negative pressure wound therapy with instillation. McKanna M, Geraci J, Hall K, Hauan B, Howell M, Huey T, Lucius A, Mendez-Eastman S, Purcell K, Raizman R, Shepherd D, Gabriel A. http://www.o-wm.com/files/owm/Acelty_Supp_0416.pdf *Ostomy Wound Manage*. 2016;April: 1–14.

Removing Sloughy Tissue from Wounds Using a New NPWT Foam Dressing with Instillation

Luc Téot

Wound Healing Unit, Montpellier University Hospital

Sergiu Fluieraru

Wound Healing Unit, Montpellier University Hospital

Christine Faure

Wound Healing Unit, Montpellier University Hospital

NOTE: As with any case study, the results and outcomes should not be interpreted as a guarantee or warranty of similar results. Individual results may vary depending on the patient's circumstances and condition.

INTRODUCTION

Removing sloughy tissue in wounds can be challenging for many clinicians. Clinical assessment of wound depth and undermining is a skill that is poorly acquired, owing to a lack of understanding of the pathophysiological determination of wound infection. Surgical wound debridement can be tedious and sometimes considered a "second class" surgery that clinicians delay or avoid. Additionally, in certain patients, complete surgical debridement may not be appropriate and may even be contraindicated based on various patient and wound factors.[1] For a variety of reasons, some patients present with critical complications due to the persistence of high bacterial burden.

Negative pressure wound therapy with instillation of fluids and a dwell time (NPWTi-d) is an advanced wound management modality that has been found to help manage bioburden in complex wounds[2,3] or when there is failure of conventional NPWT.[4-7] The therapy facilitates automatic instillation of topical solutions that are cyclically fed into the foam dressing via an

additional set of tubing and held for a user-selected period before removal by negative pressure. The combination of topical wound solutions and NPWT assists with wound cleansing and removal of wound exudate and infectious material.[4]

A reticulated open-cell foam dressing that includes an array of through holes in its wound contact layer (ROCF-CC; V.A.C. VERAFLO CLEANSE CHOICE™ Dressing, KCI, an ACELITY Company, San Antonio, TX) is the latest iteration of NPWTi-d.[8] The foam dressing is used adjunctively with NPWTi-d and consists of two foam layers: a wound contact layer with 1.0 cm diameter holes spaced 0.5 cm apart and a cover layer without holes. Adjunctive use of NPWTi-d with ROCF-CC provides for immediate cleansing of wounds that may contain slough and/or and non-viable tissue when surgical debridement is not immediately available or may not be clinically appropriate.[8] The dressing is meant to help facilitate the removal of thick wound exudates such as fibrinous materials and slough when used with NPWTi-d. We have been using this new technology at Montpellier University Hospital (Montpellier, France) since 2015 to assist in removal of nonviable tissue when we are not able to take patients into the operating room.

BACKGROUND

The first commercially available device combining NPWT and intermittent instillation of solutions was introduced in 2002.[9] Wolvos (2004) first reported on the outcomes using this device with a variety of solutions, using a dwell time of 5 minutes and the resumption of negative pressure for 3 hours at –125 mmHg.[9] Automated instillation with NPWT was developed to create a controlled, protected environment for flushing and cleansing wounds by the proposed mechanism of loosening soluble contaminants in the wound bed followed by subsequent removal during NPWT.[10,11] A next-generation NPWTi-d device was introduced in 2011 that allows the clinician to visually determine the correct instillation volume, perform a test cycle to confirm appropriate settings and soak the dressing with a topical solution prior to dressing removal.[5] In 2013, a panel of experts published international consensus guidelines designed to address the appropriate use of NPWT with intermittent instillation.[12] More recently, an updated review of the evidence and recommendations for use of NPWTi-d were published by an expert working group.[13] In these recommendations, normal saline was recommended as the preferred solution to instill with NPWTi-d, based on evidence demonstrating that normal saline can achieve outcomes similar to other types of solutions.[2,4,5,7,13] The device settings we have used in our institution for NPWTi-d with ROCF-CC are within the parameters set forth in the 2015 review, which suggested a cycle frequency of 2 – 4 hours at –125 mmHg and a dwell time of 10 – 20 minutes.[13]

PRACTICAL SUGGESTIONS FOR USE

Based on our hospital's experience with the new ROCF-CC dressing, we have developed some practical advice for clinicians to maximise use of NPWTi-d with ROCF-CC to help achieve optimal patient outcomes:

1) *Users should maintain good understanding of the foam characteristics:* Three pieces of foam are included in each dressing kit: one contact layer with through holes (18 x 12.5 x 0.8cm) and two cover layer foams of two different thicknesses: 0.8 and 1.6 cm.

   The through holes in the ROCF-CC contact layer measure 1.0 cm in diameter and are spaced 0.5 cm apart. When wet, ROCF-CC foam has a tensile/tear strength that is three times greater than a wet standard reticulated open-cell foam dressing (ROCF-V; V.A.C. VERAFLO™ Dressing, KCI, an Acelity company, San Antonio, TX). ROCF-CC is more absorptive (less hydrophobic) than ROCF-V, and exudate viscosity removal is up to 30 centipoise.
2) Large pieces of hard necrotic tissue should be debrided prior to use of ROCF-CC.
3) *NPWTi-d with ROCF-CC should not be used* prior to initiation of antibiotics *when bone infection is confirmed* with a positive probe. A bone biopsy should be performed after debridement to confirm the presence of bacteria and their sensitivities to antibiotics as well as the presence of bone tissue necrosis. In cases of a positive bone biopsy, an MRI may be prescribed to confirm the presence of osteitic bone. When an infection is confirmed, culture-specific antibiotics should be initiated.
4) The ROCF-CC dressing can be applied to all wounds in a similar manner.

A. *Placing the dressing:* The wound contact layer with through holes is cut to size and placed completely into the open wound, over the surface of the wound bed (Figure 1A). The cover layer (without holes) is placed over the wound contact layer to cover the wound contact layer as well as to fill the undermined areas around the wound. A second cover layer provided in the dressing kit can be used for filling deep wounds (Figure 1B,C).

B. *Placing the drape and starting instillation:* An adhesive drape is placed over the two (or three) foam layers, and instillation tubing is applied to the dressing as appropriate and connected to the NPWTi-d device.

C. *Initiating NPWTi-d:* Our facility has experienced good outcomes with saline instillation every 3.5 hours with a dwell time of 10 minutes. If the desired results are not obtained with saline, other topical solutions can be considered and applied in accordance with manufacturer's recommendations.[9] The recommended level of negative pressure is –125 mmHg, and dressings should be changed every 2-3 days.

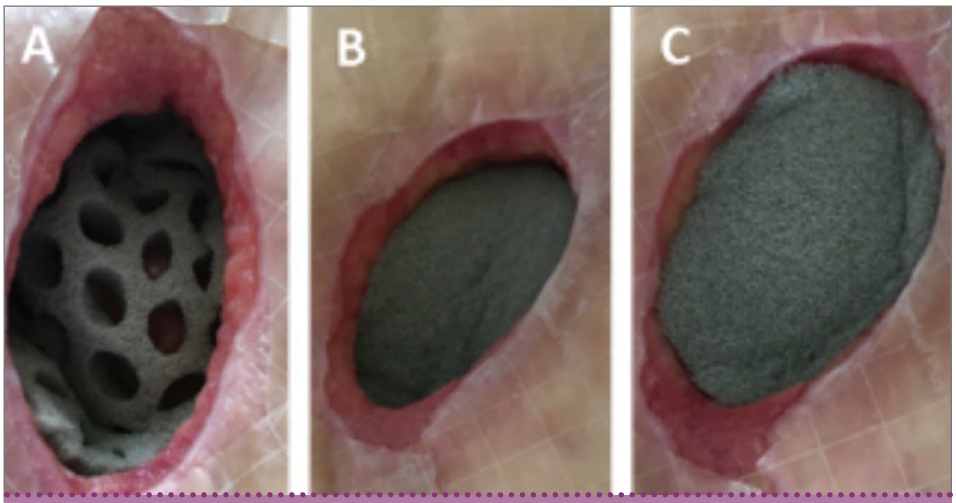


Figure 1: Wound contact layer with through holes was placed first in the wound bed (A). A layer of cover foam is placed over the contact layer (B). A second layer of cover foam is placed in this deep abdominal wound (C).

D. ***Dressing changes:*** At each dressing change, the contact layer and the cover layer foams are removed along with sloughy tissue, the wound is manually washed with saline, and a new dressing is applied.

E. Pain relief management (10 mg oral morphine) may be administered prior to dressing removal if needed. The pain associated with the dressing change pain usually increases following the rapid progression of granulation. Usually when necrotic tissue and fibrin are still present, some pain is observed.

F. Extreme care should be taken not to leave any piece of ROCF-CC dressing in the wound after dressing removal, particularly because of the way in which granulation tissue develops through the holes in the wound contact layer. Figure 2A shows penetration of granulation columns through the holes of the wound contact layer after three days of being in place, prior to dressing change, and Figure 2B shows the typical depth of the columns immediately after foam removal.

CLINICAL EXPERIENCE AND CASES

In our experience at our institution, approximately 95% of wounds have displayed rapid granulation tissue formation underneath the wound contact layer foam. This 'sprouting' has been observed at the first dressing change at 3 days, and through to 9 days (3 dressing changes). We have noted that most of the non-viable tissue is removed at the first dressing change after 3 days of therapy. In most of the cases, the wound bed contains ≤10% devitalised tissue at the third dressing change after 9 days of therapy, with a rapid decrease of the necrotic/fibrinous tissue. Figures 3-5 display typical progression of wounds underneath the ROCF-CC dressing.

Figure 6 shows removal of the ROCF-CC wound contact layer along with layers of nonviable tissue from a sacral pressure ulcer with various tissue depths. During use of NPWTi-d with ROCF-CC, holes in the contact layer foam were rapidly filled with red 'islands' of granulation tissue covered with white/yellow fibrin and non viable tissue (Figure 4A). The base of the wound bed apart from the islands, or columns, was more rapidly cleansed of the undesired tissue (Figure 4B). A soak feature of the NPWTi-d device allowed easier removal of the contact layer (Figure 4C). Slough and other nonviable tissue were removed with the contact layer (Figure 4D).

CLINICAL INDICATIONS

In our experience, the clinical indications for NPWTi-d with ROCF-CC appear to favor large wounds in which fibrin and/or a layer of devitalized tissue are still present. These characteristics may be observed in pressure ulcers, venous leg ulcers, surgical wounds, or diabetic foot wounds. The unique combination of NPWTi-d with ROCF-CC to promote granulation tissue formation and help remove devitalised tissue opens up a wide spectrum of clinical indications for the system, including situations where removing the devitalized tissue layers of undermined areas or large cavities is indicated. Table 1 displays an abbreviated list of wound types and characteristics that may benefit from use of NPWTi-d with ROCF-CC versus NPWT, based on our experiences with the foam at our institution.

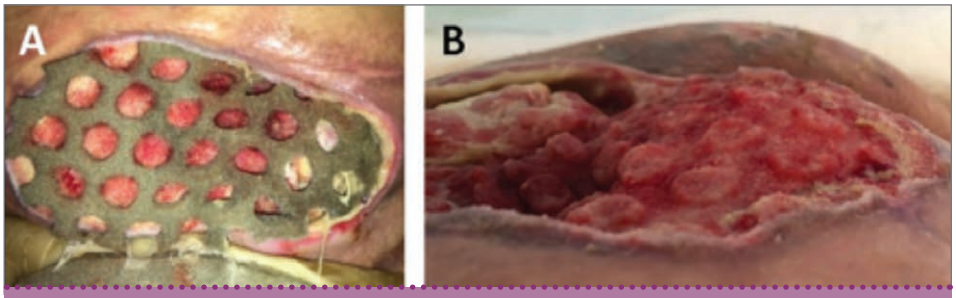


Figure 2: Columns of granulation tissue growing through the holes in the wound contact layer (A). Side angle showing depth of columns after dressing was removed on day 9 after initiation of NPWTi-d with ROCF-CC (B).

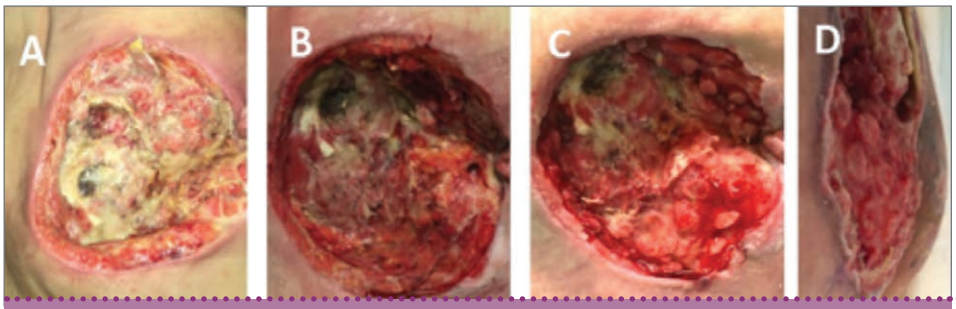


Figure 3: Buttock abscess at presentation (A). Most of slough removed on day 3 (B). Granulation tissue on day 6 (C). Granulation tissue formation on Day 9 (D).

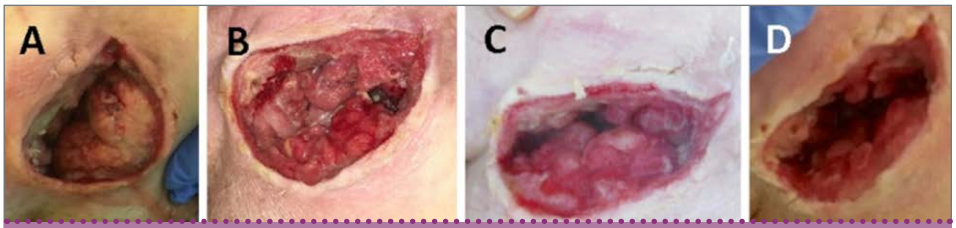


Figure 4: Evolution of a sacral pressure ulcer treated with NPWTi-d and ROCF-CC from presentation (A). First dressing change at 3 days (B). At 6 days (C). At 9 days, undermining is reduced and wound is granulated (D).

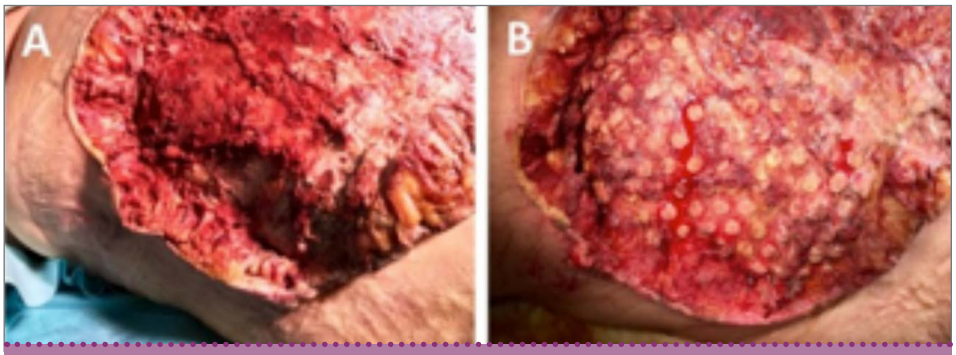


Figure 5: Large post-surgical wound (after necrectomy of infected calciphylaxis) at presentation (A). One section of the wound was covered with ROCF-CC and the rest of the wound was covered with a standard ROCF-V foam dressing; columns from the ROCF-CC were visible on the wound at first dressing change(B).

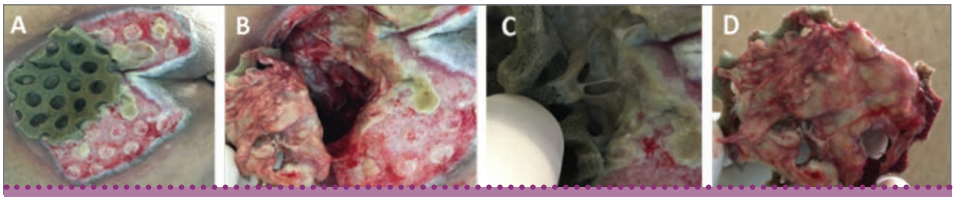


Figure 6: The wound contact layer with through holes was partially removed from the sacral pressure ulcer (A). The central portion of this ulcer was deeper than the peripheral portion (B). Careful removal of the remaining ROCF-CC dressing over the deepest part of the wound (C). Upon dressing removal, slough and nonviable tissue adhered to the portion of the wound contact layer placed in the deepest part of the wound (D).

TABLE 1: INSTITUTION RECOMMENDED INDICATIONS AND CHARACTERISTICS FOR USE OF NPWTI-D WITH ROCF-CC

Clinical indications	Open access to the wound	Limited access to the cavity
Pressure ulcer	ROCF-CC	ROCF-CC
Leg ulcer	Standard NPWT	N/A
Diabetic foot ulcer	ROCF-CC	ROCF-CC after surgical trimming if deep wound
Extensive haematoma	ROCF-CC	ROCF-CC after surgical trimming

In certain situations such as a small epidermal wound combined with a large subcutaneous abscess, cavity or haematoma, surgical trimming remains indicated as a first-line approach in order to allow complete access of the foam dressing to the edges of the wound.

CONCLUSION

Surgical debridement has been defined as a clinical necessity to remove adherent, dead or contaminated tissue from a wound to facilitate the functional process of tissue repair.[1] However, constraints persist for a variety of reasons, including limited access to operating rooms, risks of anaesthesia, lack of clinical training, contraindications and specific underlying comorbidities of the patient. Confronted with these limitations, clinicians may opt for a conservative treatment approach with surgery as the default option. NPWTi-d using ROCF-CC may address some of these limitations and clinical needs, providing an alternative wound cleansing tool to be used when surgical debridement is not appropriate or is not accessible. The new ROCF-CC dressing appears to be a clinical step forward for NPWTi-d, but its effectiveness should be confirmed by further clinical studies and randomized controlled trials.

All photos courtesy of Dr Luc Téot

References:

1. Strohal R, Dissemond J, O'Brien JJ, Piaggesi A, Rimdeika R, Young T, et al. EWMA document: debridement. An updated overview and clarification of the principle role of debridement. *J Wound Care* 2013;22(Suppl)
2. Brinkert D, Ali M, Naud M, Maire N, Trial C, Teot L. Negative pressure wound therapy with saline instillation: 131 patient case series. *Int Wound J* 2013;10(Suppl 1):56 – 60.
3. Bollero D, Degano K, Gangemi EN, Aloj D, Malvasio V, Stella M. Long-term follow-up of negative pressure wound therapy with instillation: a limb salvage procedure? *Int Wound J*. 2016 Oct;13(5):768-73.
4. Fluieraru S, Bekara F, Naud M, Herlin C, Faure C, Trial C, 1 et al. Sterile-water negative pressure instillation therapy for complex wounds and NPWT failures. *J Wound Care* 2013; 22:293 – 9.
5. Gabriel A, Kahn K, Karmy-Jones R. Use of negative pressure wound therapy with automated, volumetric instillation for the treatment of extremity and trunk wounds: clinical outcomes and potential cost-effectiveness. Eplasty. 2014 Nov 3;14:e41.
6. Goss SG, Schwartz JA, Facchin F, Avdagic E, Gendics C, Lantis JC 2nd. Negative Pressure Wound Therapy With Instillation (NPWTi) Better Reduces Post-debridement Bioburden in Chronically Infected Lower Extremity Wounds Than NPWT Alone. *J Am Coll Clin Wound Spec*. 2014 Feb 20;4(4):74-80.
7. Kim PJ, Attinger CE, Oliver N, Garwood C, Evans KK, Steinberg JS, et al. Comparison of outcomes for normal saline and an antiseptic solution for negative-pressure wound therapy with instillation. *Plast Reconstr Surg* 2015;136:657e – 64e.
8. Téot L, Boissiere F, Fluieraru S. Novel foam dressing using negative pressure 14 wound therapy with instillation to remove thick exudate. *Int Wound J* 2017; 15doi: 10.1111/iwj.12719 16
9. Wolvos T. Wound instillation--the next step in negative pressure wound therapy. Lessons learned from initial experiences. *Ostomy Wound Manage*. 2004 Nov;50(11):56-66.
10. Wolvos T. The evolution of negative pressure wound therapy: negative pressure wound therapy with instillation. *J Wound Care* 2015;24(Suppl 4b):15 – 20.
11. Gupta S, Gabriel A, Lantis J, Teot L. Clinical recommendations and practical guide for negative pressure wound therapy with instillation. *Int Wound J* 2016;13:159 –74.
12. Kim PJ, Attinger CE, Steinberg JS, Evans KK, Lehner B, Willy C, et al. Negative-pressure wound therapy with instillation: International Consensus Guidelines. *Plast Reconstr Surg* 2013;132:1569 – 79.
13. Kim PJ, AttingerCE, CristBD, GabrielA, GalianoRD, GuptaS,etal. Negative pressure wound therapy with instillation: review of evidence and recommendations. *Wounds* 2015:1 – 20.

Complete Excisional Debridement of Chronic Wounds

Dennis P. Orgill, MD, PhD

Dr. Orgill is Vice Chairman for Quality Improvement in the Department of Surgery at Brigham and Women's Hospital and Professor of Surgery at Harvard Medical School. He is a reconstructive plastic surgeon and has a PhD from MIT in Medical Engineering. He is the Director of the Brigham and Women's Hospital Wound Care Center and runs a tissue engineering and wound healing Laboratory. His lab at BWH is working to develop better technologies to treat wounds including work with artificial skin, micromechanical forces, platelets and stem cells. He has consulted for several medical device and start-up companies and is the inventor on several patents. He worked on the team that developed Integra®, a skin replacement therapy that has been commercially developed and used successfully on thousands of patients.

NOTE: As with any case study, the results and outcomes should not be interpreted as a guarantee or warranty of similar results. Individual results may vary depending on the patient's circumstances and condition.

INTRODUCTION

Advances in the treatment of chronic wounds have allowed many complicated wounds to heal using non-operative measures. One challenge in dealing with complex wounds is bacterial contamination particularly in the form of a biofilm. Biofilms are defined as microrganisms that stick to themselves and often are found on a self-produced polymeric substance. Biofilms are difficult to assess and many clinicians just assume that if a wound doesn't heal it is due to biofilms. Because we don't have a direct and easy clinical way to measure biofilms, several technologies that may address biofilms have been developed and marketed. These include antimicrobial solutions, ultrasound, shock wave, enzymatic debridement, and jet irrigation. We know that bacteria in wounds can often track deep around blood vessels and other structures making topical application of antimicrobial solutions unlikely to diffuse in sufficient

quantity to kill all the bacteria. We do know that biofilms, even when disrupted, can re-form quickly possibly due to incomplete removal of bacteria. The purpose of this article is to discuss the well-known principle of excisional surgical debridement that may be the standard to which other modalities should be measured.

We see many patients in our clinic that have been on a wide variety of wound cleaning strategies and we can simply surgically close their wounds by excisional debridement followed by a flap or skin graft for closure. Certainly, if we could predict patients that will not heal with less invasive products and procedures, earlier surgical intervention would reduce the time wounds are open and avoid many complications that we see with chronic open wounds

WHAT IS COMPLETE EXCISIONAL DEBRIDEMENT?

Complete excisional debridement involves excision of the entire wound and taking a small amount of surrounding normal tissue. Typically, this would include the wound surface and about 0.3 to 0.5 cm of tissue around the wound. Very often this is done in preparation for a procedure where the wound can be closed such as a skin graft or a local flap. We often think of this in a similar fashion as an excision of a low grade malignancy, where the entire wound surface with a small margin needs to be removed.

WHAT SPECIFIC TECHNIQUES ARE USED IN COMPLETE EXCISIONAL DEBRIDEMENT?

We like to infuse a dilute solution of local anesthesia and epinephrine (tumescent solution) around the wound in advance to minimize blood loss. We do this at the beginning of the case and allow about 15 minutes to pass. In most areas, the wound can be rapidly excised with a surgical scalpel. If the wound extends into the muscle, we like using a pinpoint electrocautery to remove the deep portions of the wound. For complex wounds that track, staining them with methylene blue can facilitate visualization and help ascertain that the entire wound has been excised. In many complex wounds, they are more easily excised taking the wound out in several pieces. Many wounds have bone at their base that can be excised with an osteotome. Deep bone cultures can be obtained after excision to determine if long term antibiotics are needed. All of these wounds are colonized with bacteria. Clearly, bacteria that are removed will not cause problems for the patients. Following debridement, with a new set of sterile instruments, we obtain deep cultures (usually bone) to direct antibiotic therapy. We frequently consult with our infectious disease colleagues (Figure 1).

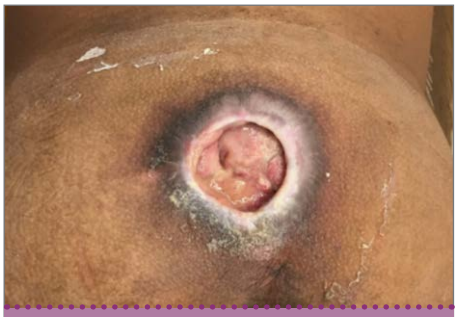


Figure 1A: Chronic Stage 4 Sacral Pressure Injury

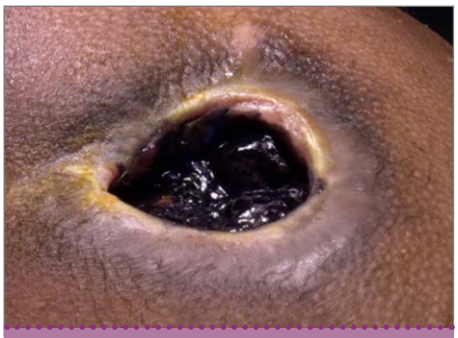


Figure 1B: The injury is painted with methylene blue.

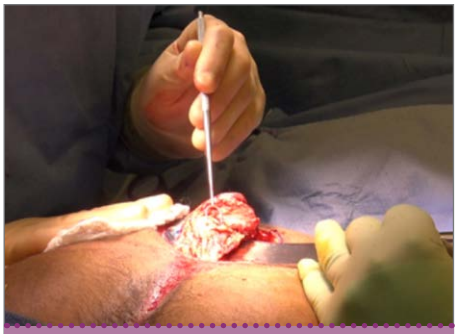


Figure 1C: After injection of lidocaine with epinephrine, the ulcer can be largely excised with the knife taking 4 to 5 mm of normal tissue around it.

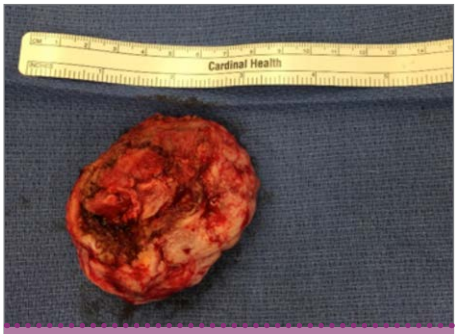


Figure 1D: A complete excision – note that no methylene blue is visible on the underside of the excision indicating that the entire ulcer surface has been excised.

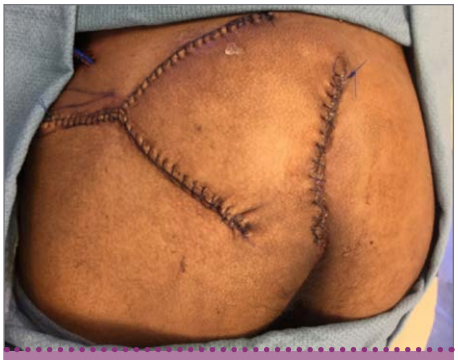


Figure 1E: After closure with a modified V to Y advancement flap.

HOW DO I CLOSE THE WOUND AFTER COMPLETE EXCISIONAL DEBRIDEMENT?

A variety of methods can be used for wound closure. For large areas, such as in a burn, split-thickness skin grafts harvested from an unburned area of the body can be grafted directly onto the excised area.[1] For smaller areas that are deep, such as a pressure sore, local flap closure is quite effective.

WHEN DO I NOT CLOSE THE WOUND?

Patients that are recovering from sepsis and have a lot of purulence in the wound are at increased risk for septic events after debridement. In these cases, we will generally do a debridement of just the necrotic and infected tissues and not try to fully excise the wound. Often, we will use a Negative Pressure Wound Therapy (NPWT) device, with or without instillation to clean the wound up and facilitate shrinkage. Once the wound is smaller, complete excisional debridement can be performed.

WHICH PATIENTS ARE NOT CANDIDATES?

Many patients with wounds have significant co-morbid disease states and are not good surgical candidates. Many wound patients have poor nutrition that should be optimized prior to closure. If there is a question about nutrition, we check albumin and pre-albumin levels and may delay excision and closure until nutritional status is optimized. Wounds need to be well drained and the patient should not be in a septic state prior to attempting closure. Patients that have mobility disorders and are unable to stay off their wounds in the post-operative period should have this procedure delayed until adequate positioning can occur.

Bleeding is always a concern. Many patients with complex wounds have had

intense angiogenesis in their wound areas and can lose a moderate amount of blood during excision. Large perforating vessels can result in substantial bleeding over a short period of time. Many of our patients are anti-coagulated and may not be completely reversed prior to surgery. NPWT devices can rapidly remove blood from the wound and should be equipped with an alarm to indicated excess fluid removal. If this occurs, the device should be shut off and efforts directed towards hemostasis should be pursued.

SUMMARY

Complete excisional debridement is an efficient surgical method to excise the wound and prepare it for direct closure by a skin graft or flap. Doing this requires substantial surgical skill and judgment. It has the advantage of being a definitive and rapid method to prepare complex wounds for closure.

Photos Courtesy of Dr. Dennis Orgill

References:
1. Orgill DP. Excision and skin grafting of thermal burns. *New England Journal of Medicine*. 2009 Feb 26;360(9):893-901.

Holistic Wound Care Preparation:Treating Complex Abdominal Wounds from the Inside Out

Mary Anne Obst, RN, CWON, CCRN

Mary Anne is a certified wound nurse that works for an abdominal reconstruction service at a level I trauma center in St. Paul Minnesota. She has been a nurse for 30 yrs and worked in trauma and surgical ICU and was a flight nurse, but her real passion has been identified, caring for the patient with abdominal wounds and enteric fistula! She is a mother of four and a new grandmother, she lives in small town with her husband Andy, kids and her dog Casey Brown.

David J Dries, MD

Dr. Dries is trained in electrical and biomedical engineering before completing medical school at the University of Chicago. Dr. Dries subsequently trained in General Surgery with added qualifications in Critical Care. He has been at Regions Hospital in St. Paul and the University of Minnesota since 1999. Current research interests are inflammatory changes in the lung as mediated by mechanical ventilation, physiology of mechanical ventilation in the setting of critical illness and resuscitation of the critically ill patient. Dr. Dries has worked for the past several years in development of the CARS Program at Regions Hospital for patients with fistulas and complex abdominal problems.

Dr. Dries is the Division Medical Director for Surgical Care for HealthPartners Medical Group and Chief of Surgery at Regions Hospital, the Level I Adult and Pediatric Trauma and Burn Center in St. Paul. He is also Professor of Surgery & Anesthesiology, Clinical Adjunct Professor of Emergency Medicine and the *John F. Perry, Jr. Chair of Trauma Surgery* at the University of Minnesota.

NOTE: As with any case study, the results and outcomes should not be interpreted as a guarantee or warranty of similar results. Individual results may vary depending on the patient's circumstances and condition.

Where should wound care start? Evaluating the chart, or assessing the patient? How much should you know about a patient to best treat a wound?

Our Complex Abdominal Reconstruction Service (CARS) team treats patients with extreme abdominal wounds and underlying structural defects including the open abdomen, massive loss of domain, and enteric fistulas. Our team provides holistic care to this complex population during the months needed to prepare for definitive surgical repair. We assess the patient and evaluate the medical history to prepare for multiple aspects of wound care including dressing selection, nicotine cessation, abdominal wall support, physical strengthening, and nutrition. One role of the wound care nurse on the team is to maximize healing during this pre-surgical period. Our CARS program typically results in a successful repair of the abdomen, but team members from multiple disciplines are required for success – the most important team member is the patient!

LOCAL WOUND BED EVALUATION

Wound bed evaluation requires further study! A common standard is to monitor wound size by length, width and depth to identify trends in wound contraction and healing. Examination of the wound bed and adjacent skin are equally as important; however, this essential data is often not documented or communicated. The wound bed and adjacent skin health are key indicators for the wound healing process. In the acute care setting the wound is also evaluated by the team for tissue response to treatment and dressing selection. Holistic patient health becomes a key factor in success.

DRESSING SELECTION AND MANAGEMENT

Critical evaluation of the wound bed and the structures beneath the wound bed should drive dressing selection. Gauze dressing therapy is the historical standard of practice in the acute wound care and gauze dressings are certainly still in use. Technical advances in dressings have given wound care practitioners many alternatives, including foams, films, hydrocolloids, and alginates. A Cochrane Database review by Vermeulen et al.[1] concluded that foam dressings appear to be preferable to gauze for pain reduction, patient satisfaction and required nursing time for wound care. In many cases composite dressings or a hybrid of dressing therapies within the same patient's wound bed will yield the best results. Critical thinking at the bedside with a full understanding of the patient's holistic health

and structures beneath the wound bed are necessary for safe dressing decisions.

NICOTINE CESSATION

It is well documented that nicotine and carbon monoxide exposure affect blood flow to the wound, platelet behavior, and the overall wound healing effectiveness.[2] An aggressive nicotine cessation program with weekly urine testing for nicotine has been successful in our outpatient patient population. Our program focuses on weekly test result feedback to the patient and primary provider engagement. We have also found tools like CeDAR app (Carolina Equation for Determining Associated Risks) predict the risks and financial costs of wound related problems following complex hernia repair. The CeDAR app is easy to use and quickly identifies modifiable risk factors that the patient can address to help improve outcome such as nicotine cessation. The app encourages compliance by showing patients their risk for wound problems after surgery.

ABDOMINAL WALL SUPPORT

Support garments that are designed to relieve tension which distracts wound margins will increase patient comfort and assist the healing process. A support garment will decrease lateral stressors and protect the wound and the underlying structures from external injury. Offloading of lateral and downward strain is needed to optimize the healing process.

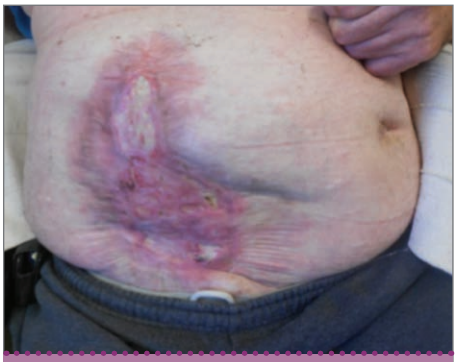


Figure 1: A support garment reduced this patient's abdominal wall tension and allowed a 10-year chronic wound to heal.

NUTRITION

Clinicians agree that patients with optimal nutrition have better wound healing. However, the means to evaluate nutritional status is not well defined.[3] The team approach is mandatory for assessing nutritional status. A wound care provider's assessment of wound size and composition complemented by dietician evaluation will provide high-risk patients with solid recommendations. Engaging the surgeon and internal medicine provider will assist in patient compliance. Each practice area can bring their knowledge to bear on the patient's fluid and caloric/protein needs and vitamin and mineral supplementation.

NUTRITION: WHERE DO YOU START?

Laboratory testing including electrolytes, pre-albumin, hemoglobin A1c, C-reactive protein, and a complete blood count can give you a good starting point. Food logs and body weight mass index with a comparison to the ideal body weight of the patient are utilized by registered dieticians to evaluate specific nutrient requirements. Changes from ideal body weight help drive nutritional supplementation including fluids, energy or caloric needs, protein, and electrolytes. Generally, patient nourishment challenges fall into three groups; the healthy patient, malnourished/ overweight and malnourished/underweight. Registered dieticians use a formulaic approach to calculate the needed grams of protein and supplements that should be taken within a 24-hour period. Understanding safe supplementation of electrolytes and vitamins with methods of delivery is the expertise of the nutritionist.[3,4]

Malnourished or under nourished patients will have healing inadequacies. Our CARS team goal is to establish and maintain oral nutrition during the healing process, however our team does utilize multiple of methods of nutrition delivery. For example, a patient may be on parental nutrition until appropriate enteral nutrition can be implemented via nasojejunal tube or via a percutaneous gastric tube. The decision on tube type depends on the patient condition and ability to take oral supplements. Several days of cross over nutrition delivery between routes of administration may occur. Meeting nutritional requirements while making a steady transition from parental nutrition to enteral nutrition and finally oral nutrition is our goal.

CASE STUDY: WOUND MANAGEMENT FROM THE INSIDE OUT

This case study shows the relationship between improved nutrition and wound healing as the patient transitions from parental nutrition to enteral nutrition to oral nutrition. Although no single metric is an ideal indicator for global nutritional health, pre-albumin measurement is useful for monitoring trends in nutritional improvement or failures in an established patient. This case study is an example of both external wound healing and internal healing that happen after surgery.

A 73-year-old female patient had elective ventral hernia repair with retrorectus mesh and bilateral transverses abdominis release. One week later a small bowel enterotomy was noted on an abdominal CT scan. An exploratory laparotomy, small bowel resection, and explantation of abdominal wall mesh initiated the wound care sequence that follows. Pre-albumin levels are color coded red, yellow, and green at each point in time to indicate nutritional concern.

NUTRITION: PATIENT PARTICIPATION

Wound progression in this patient is an excellent example of a patient with poor nutrition and a declining wound whose wound healing processes responded well to improved nutrition. In situations like this, wound healing will be minimal until nutrition can be improved. To reduce risk of wound regression post-discharge, establish a food log as part of the patient's routine as early as possible. This practice should be established before the patient returns home.

CONCLUSION

Wound care preparation should include evaluation of both the patient and the chart. This comprehensive approach will assist preparation of a successful wound care plan tailored to the patient's specific needs. Complex abdominal wounds require an individualized approach that comprehends all aspects of wound care including dressing selection, nicotine cessation, abdominal wall support, physical strengthening, and nutrition. Patience and patient participation during the months needed to prepare for final surgical repairs are necessary for the best outcomes. We always tell our patients that they are the most important player on the team, because "The only person on the team who is at every dressing change, is you!"

References:
1. Vermeulen H, Ubbink D, Goossens A, Vor R, Legemate D. Dressings and topical agents for surgical wounds healing by secondary intention. *Cochrane Database Syst Rev* 2004; (2):CD003554.
2. Sorensen, LT. Wound Healing and Infection in Surgery: The Pathophysiological Impact of Smoking, Smoking Cessation, and Nicotine Replacement Therapy: A Systematic Review. *Ann Surg* 2012; 255:1069-1079.
3. Thompson, C. Nutrients and Wound Healing: Still Searching for the Magic Bullet. *Nutr Clin Pract* 2005; 20:331-347.
4. Stechmiller, JK. Understanding the Role of Nutrition and Wound Healing. *Nutr Clin Pract* 2010; 25:61-68.