Continuing Medical Education

The Effective Use of Negative Pressure Wound Therapy

When to start, when to stop, and what comes next?

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Goals and Objectives

After completing this CME:

1) The reader will become more familiar with early appropriate use of negative pressure wound therapy (NPWT)

2) The reader will become more familiar with expected results during NPWT therapy

3) The reader will become more familiar with when to stop the NPWT treatment

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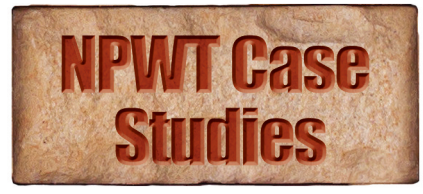
*Following this article, an answer sheet and full set of instructions are provided (pg. 172).—**Editor***

Introduction

With over 20 million Americans currently suffering from diabetes, an additional six million undiagnosed diabetics and another 54 million pre-diabetics, the future medical, economic, and social burden imposed by this epidemic are difficult to imagine.[1] It has been predicted that by the year 2025, the prevalence of diabetes will reach 250 million cases worldwide.[2]

Diabetics account for over 60% of all non-traumatic lower extremity amputations. Diabetics suffer a severe constellation of disease-related complications and 40-70% suffer from complications of the lower extremity.[2] Nearly 85% of lower extremity amputations occur in the setting of a chronic open wound. Glycemic control is obviously an important treatment goal, but it does not always substantially alter the healing of chronic lower extremity ulcers. The obstruction of larger blood vessels is responsible for less than 20% of diabetic wounds.



Today, we recognize the primary cause of non-healing wounds is the progressive degeneration of nerves in the foot, induced by micro-angiopathy of the small vessels feeding nerve fascicles.[2] These wounds may involve excessive nonviable necrotic tissue and ultimately require amputation of

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parts of the limb, or even the whole limb. Such wounds are considered to be complex and are best treated surgically with debridement of necrotic tissue. This creates an environment for viable wound bed preparation. The concept of wound bed preparation was introduced by Schultz and colleagues in 2002.[2] The goal is to create a favorable environment for rapid endogenous healing of wounds. The use of negative pressure wound therapy (NPWT) was proposed by Argenta, et al. and Morykwas and co-workers in 1997.[2]

At Boston Medical Center (BMC), we have found NPWT to be one of the modalities foot and ankle surgeons can utilize in healing the most difficult wounds. NPWT is used in the treatment of chronic, acute, sub-acute, and traumatic wounds[8-10] and is effective in both the macro- and micro-environment.[11] This includes providing a moist, closed wound healing environment, drawing wound edges together, removing infectious materials and fluids, reducing edema, and promoting tissue perfusion and granulation tissue formation, which together help in the preparation of the wound bed for closure by delayed primary or secondary intention. Because of these reasons, we believe that early intervention at the most appropriate time in addition to close follow up, taking heed to plan for the appropriate next steps, will maximize the outcome, and perhaps avoid unnecessary amputations.

Before application of the NPWT device, aggressive debridement is performed for the purpose of removing fibrotic, infected or necrotic tissue.

It is well known that selection of proper wound healing therapies depends on many variables: underlying co-morbidities, nutritional status, and a history of tobacco use, etc. In addition, it has historically been accepted that dressing changes should be performed every two to three days, with the duration of therapy lasting as long as several months. However, we have found that the duration of NPWT and frequency of associated dressing changes require correct individualization.

The purpose of this article is to present cases that outline and detail when to choose NPWT, when to stop, and tips to prevent maceration and frequent dressing changes. The time frame of treatment largely depends on the type of ulcers and the level of exudate. Also, acute infected cases with immediate surgical debridement often requires less treatment time compared to chronic infected cases without debridement. This article will present cases demonstrating that with aggressive wound debridement, as well as appropriate antibiotic coverage in the face of infection, NPWT can have a more efficient and positive outcome.

Aggressive surgical intervention and early use of NPWT appears to allow for expedient growth of granulation tissue and can therefore decrease the wound volume rapidly. This aggressive and early use of NPWT allows a quicker transition to a more superficial wound. Once this occurs, we find that we are able to rapidly move towards complete closure and then proceed to other wound closure modalities such as non-contact ultra sound, split thickness skin graft, bioengineered alternative tissue, platelet rich plasma, growth factors, collagen products or healing via secondary intention with standard care.

NPWT should be changed every two to four days, and can be stopped within four weeks.

Methods

Before NPWT is begun, it is critical to define desired treatment goals, objectives and clinical endpoints.[3] For example, clinical end points of a 50% volume reduction, 80% granulation tissue formation or complete closure might be selected. In general, key goals are to: reduce and manage exudate, reduce peri-wound edema, increase blood flow to the wound site, promote granulation tissue formation, reduce wound bed size, and optimize the wound bed. In addition, it is important to ensure that patient co-morbidities, nutritional status, and patient adherence are being optimized so that maximum benefit from NPWT can be achieved. Once the above issues have been addressed and goals defined, then an initial one to four weeks of therapy is recommended, again depending on the patient's ulcer condition.

A study performed by Eginton (2003)[4] compared VAC therapy for two weeks vs. conventional moist gauze dressing for two weeks on 10 patients with diabetic foot wounds and with adequate perfusion. This study showed that 59% of cases had a reduced wound volume, and NPWT treatment showed the improvement of wound healing. A study by Armstrong and Lavery (2005)[5] compared VAC therapy with modern moist wound therapy for 16 weeks on 162 patients after diabetic amputations up to the trans-metatarsal amputation (TMA) level with evidence of adequate perfusion. They found that 56% of those treated with NPWT healed versus 39% in the control group. In addition, the median wound bed preparation time was 42 days with NPWT compared to 84 days in the controlled group.

In *The Role of Negative Pressure Wound Therapy in the Spectrum of Wound Healing: A Guideline Document* written by Bollero, Driver, et al.,[6] it was recommended that if NPWT does not achieve a 30% reduction in wound volume within six weeks, then treatment needs to transition from NPWT to another treatment modality. Similar recommenda-

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Figure 1a: Wound at initial screening

Figure 1b: Wound at one week

tions are also suggested by the agency for healthcare research and quality.

At BMC, our most common indications for the application of NPWT are for patients who have evidence of adequate blood flow and open foot wounds with significant tissue defects. Before application of the NPWT device, aggressive debridement is performed for the purpose of removing fibrotic, infected or necrotic tissue. We change the dressing in accordance with the standard recommendations[5] of at least three times per week.

Our process for most infected ulcers is to first debride the wound site aggressively, initiate intravenous antibiotics based on culture and sensitivities and concurrent NPWT for up to four weeks. We prepare the wound edges with a liberal application of hydrocolloid to protect the skin from maceration and tearing, and lastly apply the transparent NPWT drape along with the knee compression wrap. For interdigital spaces, we use stoma adhesive paste or paste strip to control seal.

Once we obtain ulcer volume reduction and healthy granulation tissue, resolved infection and less drainage, we transition away from NPWT and to the second level of care suited for a more superficial and less complex wound. This care could be delayed primary wound closure, skin graft, application of bio-engineered alternative tissue, non-contact ultrasound, platelet rich growth factors therapy, transcutaneous continuous oxygen, or any collagen products.

Results

Case 1

A 58 year old Caucasian female with past medical history of sarcoidosis, diabetes mellitus type-2 with neuropathy, multiple foot wounds, osteomyelitis of the foot was self-referred for evaluation of a chronic non-healing left foot ulcer. An MRI performed at the former facility confirmed a bone infection. Previous treatments consisted of left partial calcanectomy where approximately 10% was removed and left first ray partial resection performed. The patient received hyperbaric oxygen therapy, and a long-term course of intravenous antibiotics and two skin grafts prior to referral.

Additional surgical history included two previous kidney transplants. Also, the patient admitted to feelings of depression reportedly because she was told that she required an amputation. She felt as if she had no other options and sought our facility as a last resort for preserving her limb.

Initial physical exam confirmed a 3.5 x 2.7 x 0.5 cm mildly infected open wound located on the posterior plantar aspect of the left heel just distal to the insertion of the Achilles tendon (Figure 1a). Her pedal pulses were palpable and she had a complete loss of protective sensation via Semmes-Weinstein monofilament. Local wound debridement was performed, and the patient was placed on a course of oral clindamycin for seven days. The ulcer was recalcitrant due to an osseous pressure point. The patient was scheduled for surgical resection of the infected portions of the remaining calcaneus.

The patient was taken to the operating room for removal of infected bone and soft tissue, and placement of antibiotic beads. The antibiotic beads were removed three days later and NPWT was instituted to cover the bone with granulation tissue and decrease depth in preparation of delayed primary closure. The follow-up care included: NPWT changed three times per week, a four-layer compression wrap with a posterior splint, wheelchair and intravenous antibiotic treatment for four weeks (Figures 1b, 1c.) NPWT was discontinued two weeks after a volume reduction greater than 50%, and 100% granulation tissue formation were observed at the wound site. She was then taken back to the operating room for

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Figure 1d: Wound at week sixteen

Figure 1c: Wound at week four

delayed primary wound closure. Offloading with a wheel chair, splint, and compression wrap and posterior splint continued until complete surgical site healing (Figure 1d).

Case 2

This is a 62 year old African-American male who self-referred for right forefoot pain and fever of two weeks duration without history of trauma. His medical history includes hypertension, hypercholesterolemia, neuropathy and type-2 diabetes. The patient lives by himself and has a history of smoking one pack per day for 20 years. The patient presented with hyperkeratotic lesions under the plantar aspect of the 1st to 4th metatarsal heads of right foot with an ulcer probe to the plantar aspect of the right 3rd metatarsal head with purulent drainage and cellulitis extended to the ankle. Also a 1 cm. superficial ulceration was noted on the plantar aspect of the proximal interphalangeal joint (PIPJ) aspect of the 3rd digit of the right foot. Wide excision debridement was performed, cultures were taken, and the patient was admitted for IV antibiotics.

Figure 2a: Wound at one week

Figure 2b: Wound at week two

Pertinent admission labs were: white blood cell (WBC) count of 13.9, cardio reactive protein (CRP) 112.4mg/L, blood glucose 227 mg/dl, albumin 4.0 g/ dl, pre-albumin 29mg/dl, and temperature 102.8F. Cultures grew 3(+) Staph aureus that was sensitive to intravenous (IV) Vancomycin. An x-ray confirmed no osteomyelitis. The ABI was 1.18 with normal arterial flow. During admission, the patient had excisional debridement performed at the bedside twice to remove non-viable soft tissue. The patient was treated with IV antibiotics for six days before being discharged with oral antibiotics (Figures 2a, 2b).

After being discharged from the hospital, the patient cancelled two consecutive follow-up appointments at the podiatry clinic. One month post-discharge there was no observed progression of wound healing despite good moist wound therapy and strict non-weight-bearing status (Figure 2c). An NPWT device was placed on the wound site to stimulate angiogenesis, control bio-burden, and to promote granulation tissue. The ulcer size prior to NPWT application was 4cm x 2.4cm x 1cm with pale granulation tissue and moderate exudate. Prior to placement of the NPWT device, aggressive debridement was performed. A 50% area reduction and good granulation tissue was seen after the first week of NPWT. NPWT was employed for a total of four weeks followed with an alginate dressing for an additional three weeks, along with offloading foam until complete closure (Figure 2d).

Case 3

This is a 72 year old Hispanic male with a history of hypertension, peripheral neuropathy of unknown etiology, presenting to the emergency department with a chief complaint of ulceration on his left second toe for five days after dropping a heavy object onto his toe. Symptoms included severe pain, swelling, purulent drainage, cellulitis, and discoloration of his skin to most of the forefoot. The patient did have palpable dorsalis pedis and posterior tibialis pulses. ABI was 1.19 with normal arterial flow. Despite the x-ray being unremarkable and showing no signs of gas formation, the podiatry surgeon was concerned that a necrotizing infection was present.

The patient was taken immediately to the operating room for incision and drainage (I&D) of the left foot with resection of the 2nd toe and ray (Figure 3a). The patient was treated with four days of IV antibiotics and was discharged with four weeks of IV Vancomycin to cover MRSA. The wound measured 12. 9cm x 2.8 cm x 0.8 cm depth at the time of discharge, and NPWT was started at this time (Figure 3b). NPWT was discontinued at week four when the ulcer site showed 100% healthy granulation tissue with no deep tissue exposure (Figure 3c). Final ulcer healing was then achieved by progression to bio-engineered skin substitute along with compression wrap (Figure 3d).

Case 4

A 61 year old African-American male with a history of diabetes and

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Figure 2c: Wound at week four

Figure 2d: Wound at week eight

Figure 3a: Wound at initial screening


Figure 3b: Wound at week two

DVT was initially seen in the emergency department after sustaining a fall down a flight of stairs five days prior. Our service was consulted to evaluate his foul smelling foot ulcers, edema, cellulitis, and severe pain in his right lower extremity. On physical examination, the patient had two ulcerations on his right foot that had been there for months, according to the patient. The main ulcer was located on the top of his right foot, spanning virtually the entire dorsal aspect and measured 10cm x 8cm x 1cm. The wound bed consisted of black necrotic tissue with associated erythema, edema, and purulent drainage to tendon but not bone (Figure 4a).

The patient was admitted for infected right foot ulcerations and suspicion of DVT. Intravenous antibiotics were started for his infection and his ultrasound confirmed DVT that was treated with anticoagulation. He was hospitalized for one week, where he had multiple excisional debridements of his ulcer. Just before discharge to home, NPWT was placed to encourage healthy granulation tissue formation, remove excessive exudates, and reduce peri-wound edema.

One week later, the patient returned to the clinic and the wound was again malodorous and producing copious amounts of drainage. The wound bed appeared to be more fibrotic, with areas of necrosis and no progression of red granulation tissue formation (Figure 4b). The patient was admitted, started on IV antibiotics and taken to the operating room for additional I&D. NPWT was reinstituted and maintained along with the intravenous antibiotics until the wound bed was observed to have 100% granulation tissue and a 50% reduction in wound size. At this point, NPWT was stopped and we moved forward with a bi-layer collagen type skin substitute. His wound is still undergoing treatment and the size of his ulcer now has been reduced to 3cm x 3cm x 0.1cm depth (figure 4c). The current plan is to apply bio-engineered skin substitute or a skin graft for complete healing.

Discussion

In a retrospective study done by V.R. Driver, et al.,[6] the healing hazard ratio (HHR) showed that wounds treated with NPWT within three months of initial presentation were 3.38 times more likely to achieve healing potential, compared to NPWT instituted in wounds after a delay of 12 months or greater. This supports the theory that the earlier NPWT is applied, the more likely it is that the wound will heal. The importance of prompt aggressive wound debridement is paramount due to the fact that devitalized, necrotic tissue potentiates infection, prolongs the inflammatory phase, mechanically obstructs contraction, and impedes re-epithelialization.[6]

Non-debrided tissue may also mask underlying fluid collection or abscess, thus making it difficult to evaluate wound depth. NPWT should be changed every two to four days, and can be stopped within four weeks. In our case, we choose the early intervention with NPWT because: it provides a closed moist wound healing environment, draws the wound edges together, removes infectious materials and fluids, reduces edema, and promotes tissue perfusion and granulation tissue formation. The combined effect is to help in the preparation of the wound bed for closure by delayed primary or secondary intention. NPWT can be used as a bridge to prepare the wound for the application of a skin graft or substitute, or a bi-layer collagen matrix. It can also be used to provide granulation through secondary intent.

In the *Journal of Nutrition in Clinical Practice,* Charles Wage, et al.[7] found that protein loss correlates with the volume of the exudate. Close monitoring of volume status and electrolytes is important as these significant fluid shifts created by NPWT can precipitate cardiac arrest. Another important adjunct to NPWT treatment is the use of off-loading techniques such as CAM walker boots, felted foam, or strict non-weight-bearing via bed rest. We also recommend bordering the wounds with hy-

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Figure 3c: Wound at week four

Figure 3d: Wound at week twelve

drocolloid prior to application of the NPWT device to decrease the chance of maceration.


Figure 4a: Wound at initial screening

Conclusion

In this article, we have demonstrated that NPWT is effective in increasing wound healing in a wide variety of complicated, non-healing lower extremity ulcers, or in wounds with excess tissue loss. Early thorough debridement and early use of NPWT are important so that optimal wound healing is attainable. However, our cases demonstrate the importance of utilizing an offloading device in conjunction with a multilayer compression wrap to control edema, and appropriate IV antibiotic coverage. We have found that a thin hydrocolloid placed to protect the skin from maceration is very useful and reduces skin breakdown that can be found with NPWT. We chose to discontinue NPWT once granular tissue and wound contracture was observed.


Figure 4b: Wound at week two


Figure 4c: Wound at week three

Lastly, we believe that in order to obtain a more effective and predictable wound-healing outcome, one should always consider the patient's co-morbidities, nutritional level, and social support systems. **PM**

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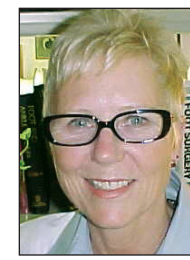

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SEE ANSWER SHEET ON PAGE 173.

1) The purpose of a gradient compression wrap is for:
- A) Off-loading
- B) Blood pressure control
- C) Controlling edema
- D) Appearance

2) What is the predicted number of diabetic diagnosed patients by year 2025?
- A) 54 million
- B) 250 million
- C) 500 million
- D) None of the above

3) What is the primary cause of a non-healing, non-ischemic diabetic ulcer today?
- A) Poor nutrition
- B) Micro-circulation
- C) Progressive degeneration of nerves
- D) B & C

4) NPWT can be used in what type of ulcers?
- A) Acute
- B) Chronic
- C) Traumatic
- D) All of the above

5) NPWT is effective in what type of environment?
- A) Micro
- B) Macro
- C) Both
- D) None of the above

6) NPWT provides for:
- A) A moist environment
- B) Reduced edema
- C) All of the above
- D) None of the above

7) Proper wound healing therapy requires:
- A) Good nutrition
- B) Good glycemic control
- C) Appropriate antibiotic treatment
- D) All of the above

8) What is the main goal of NPWT as a clinical end point?
- A) 10% volume reduction
- B) 80% granulation tissue formation
- C) All of the Above
- D) None of the Above

9) What is the function of NPWT?
- A) Remove exudate
- B) Increase blood flow
- C) Reduce peri-wound edema
- D) All of the above

10) In the Armstrong & Lavery Study, how many days was NPWT required to prepare the wound bed?
- A) 20 days
- B) 84 days
- C) 42 days
- D) 54 days

11) In the Guideline Document by Bollero and Driver, when do you stop NPWT?
- A) When volume reduction does not achieve 10% in 4 weeks
- B) When volume reduction does not achieve 10% in 6 weeks
- C) When volume reduction does not achieve 30% in 4 weeks
- D) When volume reduction does not achieve 30% in 6 weeks

12) What is the most significant requirement prior to NPWT application?
- A) Aggressive debridement to remove any necrotic tissue
- B) Remove all exudates
- C) Reduce edema of leg
- D) None of the above

13) What are the collateral therapies that BMC recommends?
- A) Off-loading ulcer properly
- B) Compression therapy
- C) Protecting the skin by using skin prep and hydrocolloid
- D) All of the above

14) A healing hazard ratio with NPWT within 3 month-old ulcer compared to 12 month-old ulcer shows:
- A) No difference between the two
- B) 3.38 times more likely to achieve healing potential in a 3 months old ulcer compared to wounds of 12 months or more
- C) 3.38 times more likely to achieve healing potential in a 12 months old ulcer compared to wounds of 3 months
- D) None of the above

15) Important factors that will help NPWT are:
- A) Aggressive debridement to remove fibrotic and necrotic tissues
- B) Proper off-loading device
- C) Proper antibiotic treatment if the patient is infected
- D) All of the above

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16) Improper debridement can cause
- A) a prolonged inflammatory phase
- B) Potentiation of the infection
- C) All of the above
- D) None of the above

17) Proper secondary treatment post-NPWT includes:
- A) Bio-engineered skin substitute: e.g., Apligraf, DermaGraft, Integra
- B) Delayed primary wound closure
- C) Skin graft
- D) All of the above

18) Why is fluid loss and electrolyte imbalance control so important?
- A) It is not important to control.
- B) Alteration will result in loss of appetite.
- C) It can cause cardiac arrest.
- D) None of the above

19) NPWT should be changed every
- A) Day
- B) Two to four days
- C) Week
- D) Two weeks

20) Under which of the following conditions would NPWT be contra-indicated?
- a) Patient is nutritionally compromised
- b) Escher or slough obscures most of the wound bed
- c) Base of wound tract or tunnel is not visible
- d) All of the above

See answer sheet on page 173.

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1. Program number (Month and Year)
2. The answers to the test
3. Your social security number
4. Credit card information

In the event you require additional CPME information, please contact PMS, Inc., at **1-631-563-1604**.

ENROLLMENT FORM & ANSWER SHEET

Please print clearly...Certificate will be issued from information below.

Name _____ Soc. Sec. #_____
Please Print: FIRST MI LAST

Address_____

City_____ State_____ Zip_____

Charge to: _____Visa _____ MasterCard _____ American Express

Card #_____Exp. Date_____

Note: Credit card is the only method of payment. Checks are no longer accepted.

Signature_____ Soc. Sec.#_____ Daytime Phone_____

State License(s)_____ Is this a new address? Yes_____ No_____

Check one: _____ I am currently enrolled. (If faxing or phoning in your answer form please note that $2.50 will be charged to your credit card.)

_____ I am not enrolled. Enclosed is my credit card information. Please charge my credit card $22.00 for each exam submitted. (plus $2.50 for each exam if submitting by fax or phone).

_____ I am not enrolled and I wish to enroll for 10 courses at $169.00 (thus saving me $51 over the cost of 10 individual exam fees). I understand there will be an additional fee of $2.50 for any exam I wish to submit via fax or phone.

ENROLLMENT FORM & ANSWER SHEET *(continued)*

EXAM #5/12
The Effective Use of Negative Pressure Wound Therapy
(Driver, Park, Ogbonna, Dinnall, and Powers)

Circle:

1.	A	B	C	D	11.	A	B	C	D
2.	A	B	C	D	12.	A	B	C	D
3.	A	B	C	D	13.	A	B	C	D
4.	A	B	C	D	14.	A	B	C	D
5.	A	B	C	D	15.	A	B	C	D
6.	A	B	C	D	16.	A	B	C	D
7.	A	B	C	D	17.	A	B	C	D
8.	A	B	C	D	18.	A	B	C	D
9.	A	B	C	D	19.	A	B	C	D
10.	A	B	C	D	20.	A	B	C	D

LESSON EVALUATION

Please indicate the date you completed this exam

_____

How much time did it take you to complete the lesson?

_____ hours _____minutes

How well did this lesson achieve its educational objectives?

_____Very well _____Well

_____Somewhat _____Not at all

What overall grade would you assign this lesson?

A B C D

Degree_____

Additional comments and suggestions for future exams:

_____

_____

_____

_____

_____

_____