International Journal on Orthopaedics and Trauma

Negative Pressure Wound Therapy and the Perfusion Paradox Part Two: Clinical Cases of Pressure Injuries and Wound Healing Unsing Low Pressure Wound Therapy and a Novel Thermoplastic Dressing

Research Article

Volume 2 Issue 1- 2026

Author Details

Colton C Mowers1, Michael S. Shuler2, Christina Blalock3, Marie Saylor3, Brett A Freedman4

[1]*Department of Orthopaedic Surgery, Rush Medical College, USA*

[2]*Department of Orthopedic Surgery, Athens Orthopedic Clinic, USA*

[3]*Landmark Hospital, Athens, USA*

[4]*Department of Orthopaedic Surgery, Mayo Clinic, USA*

*Corresponding author

Brett A Freedman, Department of Orthopaedic Surgery, Mayo Clinic, Rochester, MN,USA

Article History

Received: April 20, 2026 Accepted: May 05, 2026 Published: May 06, 2026

Introduction

In the initial article in this 2-part series, we described the paradox of negative pressure wound therapy (NPWT). According to Newton's 3rd law, when we apply -125mmHg of negative pressure to a black foam NPWT dressing, a reciprocal positive pressure is forced against the underlying wound bed. Because of the compressive properties of foam, this actually is amplified, such that the average contact pressure below a foam NPWT dressing set at -125mmHg is about +187mmHg, or >6x greater than the capillary filling pressure of the wound bed tissue [1]. While this paradox has been known and documented since 2009, in the absence of a reliable alternative, it has been accepted as a necessary by-product of foam NPWT [2]. However, larger prospective studies have demonstrated non-superior outcomes for NPWT as compared to standard dressings, like wet-to-dry gauze dressings, especially for the treatment of pressure injuries, in which the primary cause of the injury is excessive, continuous pressure against the tissue [3]. The focus of this part of the series is to highlight illustrative cases and discuss the concept of low pressure wound therapy (LPWT) in the treatment of pressure injury wounds.

Case Presentation

42-year-old male history of end-stage renal disease status post renal transplant 13 years prior with history of poorly controlled insulin dependent diabetes mellitus, hemodialysis, hyperlipidemia, hypertension, neuropathy, amputation left foot, chronic kidney disease (stage 5), seizures, stroke, CVA and ventilator dependent. The patient had a recent admission for acute hypoxic respiratory failure secondary to aspiration pneumonia requiring intubation and eventual trach and PEG as well as cardiac arrest. He was admitted to the LTAC hospital for ventilator weaning, intravenous antibiotics and antifungal treatment (meropenem/vancomycin and micafungin), nutritional support and rehabilitation. Over the course of their complicated care, the patient developed a Stage IV sacral pressure injury with sacral osteomyelitis prior to admission to the LTAC (Figure 1A).

The patient was treated for approximately 3 months with pressure injury prevention protocols, bedside debridements and traditional foam (GranuFoam®, Solventum, Inc) NPWT at -125mmHg continuous suction with twice weekly dressing changes (Figure 1B). Due to stagnation with some propagation of the wound dimensions, despite months of traditional NPWT, the patient was converted to a novel TPE NPWT (PREVENT®, Clear Choice Therapeutics, Inc) dressing run at low pressure (-75 mmHg; continuous) with twice weekly dressing changes. After approximately 3 weeks of TPE NPWT therapy (which was the only change in the prior treatment plan), the patient showed significant and progressive healing with wound volume reduction and healthy granulation formation over the sacrum, as well as reduction in the size of the satellite superficial portions of the wound (Figure 1C). Note the honey-comb undulations in the granulation is a temporary effect that smooths after discontinuation of TPE NPWT.

©2026 Mowers. This work is published and licensed by Example Press Limited. The full terms of this license are available at https://skeenapublishers.com/terms-conditions and incorporate the Creative Commons Attribution – Non Commercial (unported, v3.0) License (http://creativecommons.org/licenses/by-nc/3.0/). By accessing the work you hereby accept the Terms. Non-commercial uses of the work are permitted without any further permission from Emample Press, provided the work is properly attributed.

Unfortunately, the treating nurse who made the transition to TPE NPWT went on vacation, and the covering nurse switched the patient back to traditional foam NPWT at -125mmHg continuous suction for 3 days (Figure 1D). After only 3 days of treatment with foam NPWT at -125mmHg, the wound showed marked regression of healing. The primary and satellite wounds expanded. The prior healthy granulation over the sacrum regressed once again exposing the sacrum. The wound edges were necrotic and enlarging. Ultimately, the patient was placed on comfort cares and transitioned to hospice where he succumbed to his multiple medical comorbidities.

Figure: 1(a)

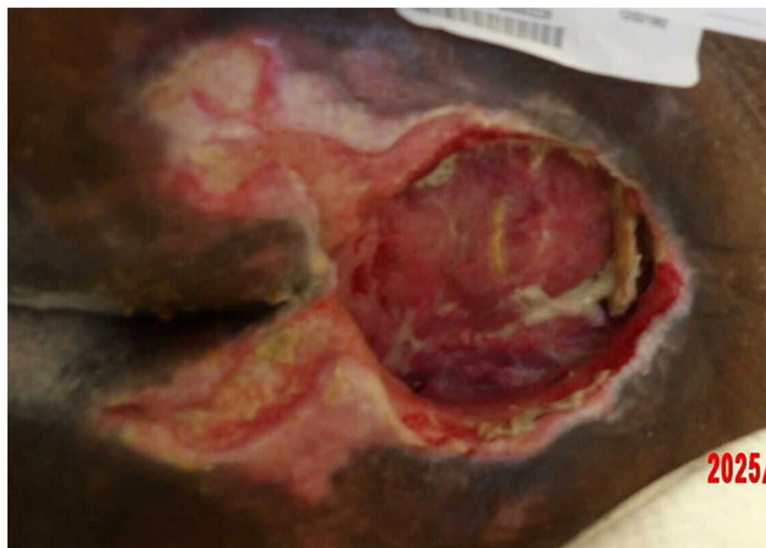

Figure: 1(b)

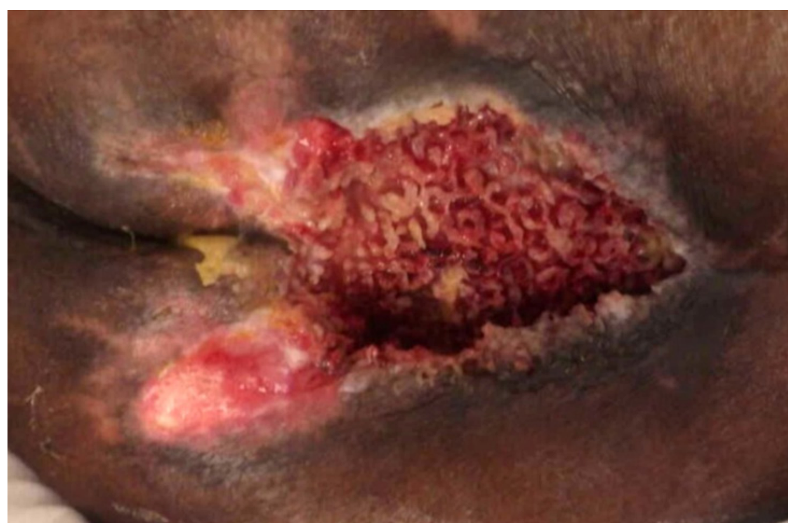

Figure: 1(c)

Citation: Mowers CC, Shuler MS, Blalock C, et al. Negative Pressure Wound Therapy and the Perfusion Paradox Part Two: Clinical Cases of Pressure Injuries and Wound Healing Unsing Low Pressure Wound Therapy and a Novel Thermoplastic Dressing. *Int J. Orth & Trauma.* 2026; 2(1): 1-6. DOI : 10.51626/ijot.2026.02.00004

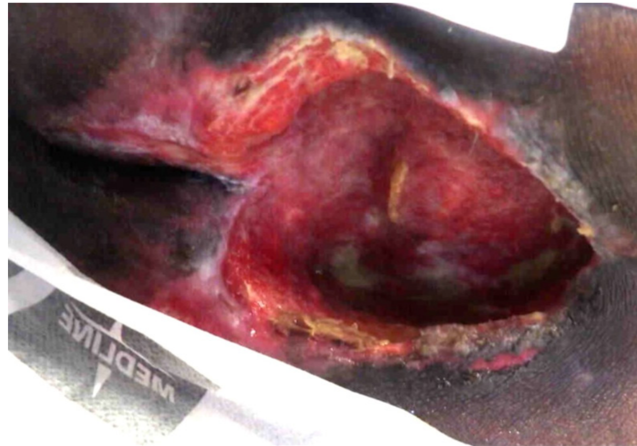

Figure: 1(d)

Case Presentation

A 62-year-old wheelchair bound female was admitted to a long-term acute care (LTAC) hospital after two surgical debridements for wound management. Her past medical history included obesity, Fechtner Syndrome, hypertension, hyperlipidemia, asthma, lymphedema and current treatment for breast cancer.

The patient had been surgically irrigated and debrided twice during her initial acute hospitalization. The initial surgery included excisional debridement (sharp, electrocautery and VersaJet) of an infected necrotic wound over the left buttock and leg which measured 840 cm^2. Three days later she underwent an additional surgery for further excisional debridement of necrotic tissue, resulting in a wound that measured 33 x 24 x 5.5cm. Additionally, there was tunneling towards the superior margin of the wound measuring 6 cm in depth. The wound was packed with Kerlix soaked in saline and then covered with ABD pads changed on a daily basis.

Cultures from the debridement were positive for methicillin-resistant Staphylococcus aureus (MRSA), Proteus mirabilis, and Clostridium perfringens. The patient received IV Unasyn therapy. Once there was no plan for additional surgical debridement, the patient was started on traditional black foam (GranuFoam®, Solventum, Inc) NPWT at -125mmHg continuous suction with twice weekly changes. The wound size at the initiation of black foam NPWT was 3.5x11x0.3cm at the left upper leg and 23x15x7 at the left buttocks with 15cm tunneling (Figure 2A). After 8 days of black foam NPWT with minimal progression towards healing, the patient was switched to a TPE NPWT dressing (PREVENT®, Clear Choice Therapeutics, Inc) at -75mmHg continuous suction with twice weekly changes. The wounds at that point measured 3.2x10x0.3cm at the left upper leg and 22.8x14.5x7 at left buttocks with 15cm tunneling. The wound progression over the course of care at the LTAC is documented in (Table 1).

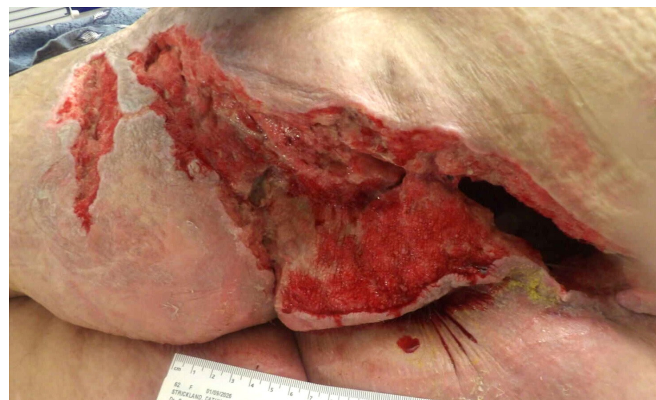

Figure 2: A & B. Wound appearance at time of initiation of black foam NPWT at LTAC.

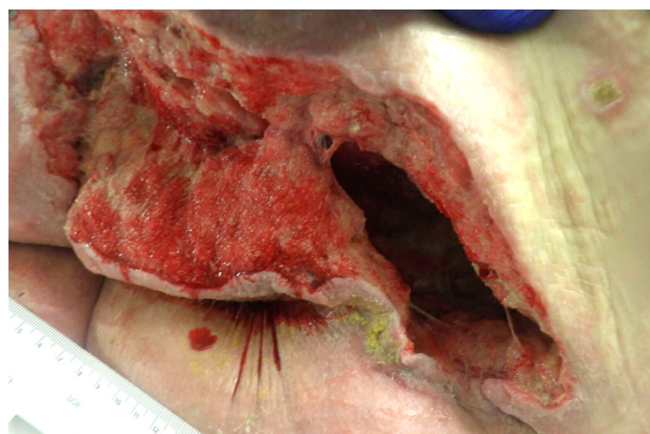

Figure 2: Note the deep tunneling at the superior margin of the left buttock wound (15cm).

Citation: Mowers CC, Shuler MS, Blalock C, et al. Negative Pressure Wound Therapy and the Perfusion Paradox Part Two: Clinical Cases of Pressure Injuries and Wound Healing Unsing Low Pressure Wound Therapy and a Novel Thermoplastic Dressing. *Int J. Orth & Trauma.* 2026; 2(1): 1-6. DOI : 10.51626/ijot.2026.02.00004

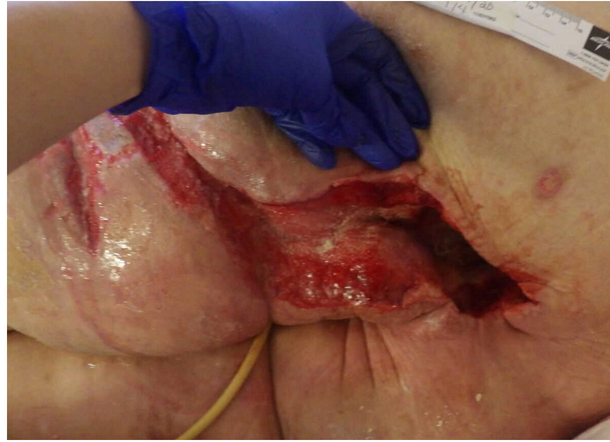

Figure 2: Same wound after 8 days of black foam NPWT treatment.

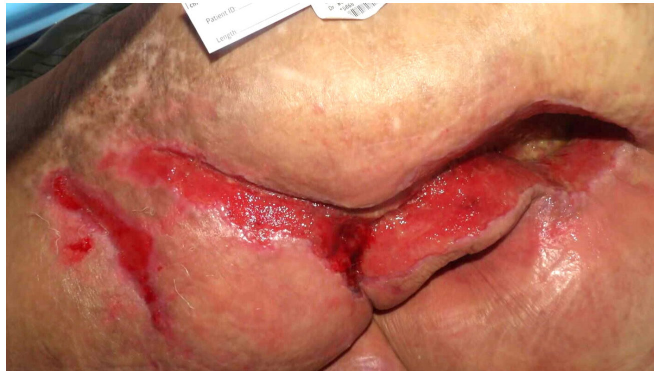

Figure 2: Same wound after 7 days on the TPE dressing with low pressure therapy (-75mmHg).

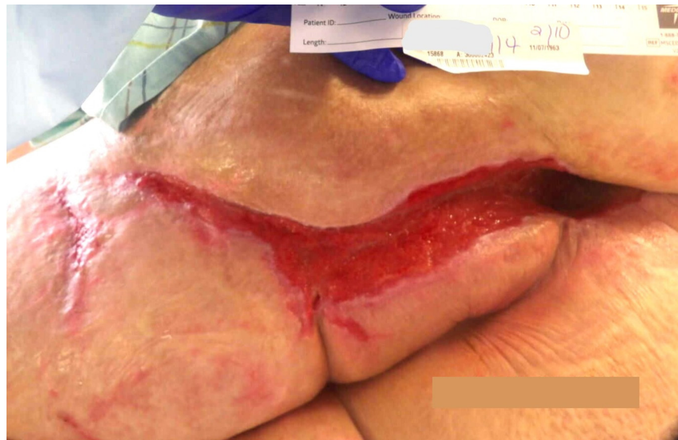

Figure 2 : Wound after 14 days on the TPE dressing.

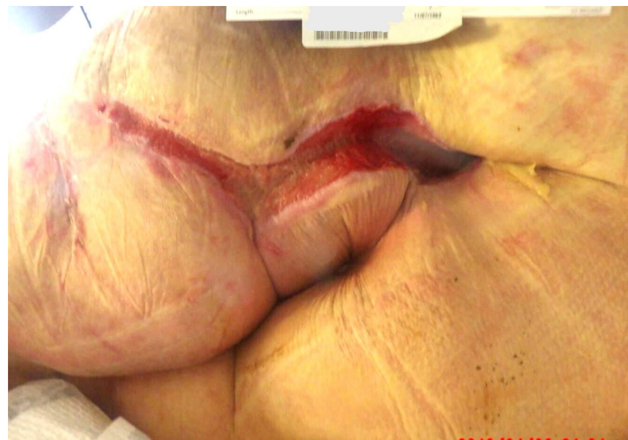

Figure 2: Wound after 24 days on the TPE dressing.

Citation: Mowers CC, Shuler MS, Blalock C, et al. Negative Pressure Wound Therapy and the Perfusion Paradox Part Two: Clinical Cases of Pressure Injuries and Wound Healing Unsing Low Pressure Wound Therapy and a Novel Thermoplastic Dressing. *Int J. Orth & Trauma.* 2026; 2(1): 1-6. DOI : 10.51626/ijot.2026.02.00004

Table 1

Dressing	Admission	Days on TPE	Left Upper Leg (cm)	Left Buttock (cm)	Buttock Tunneling (cm)
Blk Foam	4 days		3.5x11x0.3	23x15x7	15
Blk Foam	8 days		3.2x10x0.3	22.8x14.5x7	15
PREVENT	11 days	3 days	2.2x8.5x0.2	22x12x5.8	12.5
PREVENT	18 days	10 days	2.2x8.5x0.2	18x9x5.8	5.5
PREVENT	22 days	14 days	2x8x0.2	15x5.8x5	4
PREVENT	32 days	24 days	0.2x4x0.1	15x3.9x4	1
PREVENT	36 days	28 days	Healed	13x2.6x3	0

Discussion

These 2 cases highlight the concepts disclosed in Part 1, Negative Pressure Wound Therapy and the Perfusion Paradox, that described how black foam NPWT generates compressive forces that can impair perfusion despite its widely perceived clinical benefits. Although NPWT is commonly conceptualized as the application of negative pressure, the biologically relevant force at the tissue level is compressive. Suction applied across a sealed interface generates equal and opposite forces, resulting in increased contact pressure within the wound bed [4,5].

This compressive effect is dose-dependent. Increasing suction leads to progressive reductions in perfusion, with measurable decreases in blood flow and tissue oxygenation at commonly used settings such as -125 mmHg [4,5]. These findings challenge the traditional belief that higher negative pressure enhances perfusion. Foam-based wound fillers amplify this phenomenon. Due to intrinsic flow resistance and collapse under suction, foam requires higher pressures to maintain adequate fluid evacuation, especially in high exudate producing wounds [6]. Biermann et al. [1,7] demonstrated that foam interfaces set at -125mmHg negative pressure can generate contact pressures up to approximately +187mmHg, with associated reductions in blood flow and oxygenation in the wound bed tissues.

This confirms that NPWT transmits substantial positive pressure to the wound surface and can creates a hypoperfused environment. Our pilot pressure study further refines this relationship by directly quantifying contact pressure across dressing types, wound configurations, and suction levels [8,9]. In this porcine explant model, contact pressure increased proportionally with applied suction, with pump pressure accounting for the majority of variance in both peripheral and central measurements. At -125 mmHg, reticulated open cell foam and white foam generated contact pressures in the range of approximately 125 to 195 mmHg, consistent with prior experimental findings.

In contrast, the thermoplastic elastomer interface consistently produced lower contact pressures across all wound types and pressure settings. At -50 mmHg, central contact pressures with this interface were approximately 15 to 30 mmHg, a range associated with improved microvascular perfusion in prior studies of external compression stockings [6,10]. Importantly, negative pressure setting remained the dominant determinant of contact pressure, explaining approximately 77% of peripheral and 68% of central pressure variation, while dressing type and wound type contributed smaller but meaningful effects [8,9].

The 2 cases presented herein, exemplify these findings. Failure of healing pressure injuries under foam NPWT at high pressure settings (i.e. -125mmHg) may be explained by excessive compressive loading and impaired perfusion. Improvement following transition to a lower resistance interface at reduced pressure (-50mmHg) supports restoration of a more favorable microvascular environment. While low pressure wound therapy (LPWT) using the novel TPE dressing was able to salvage a highly morbid and quite possibly mortal infected pressure injury in Case 1, the tragic regression of the wound healing that occurred after just 3 days for transition back to black foam NPWT, after sustained granulation and healing was documented with LPWT using the TPE dressing, clearly illustrates the clinical consequence of high contact pressure on compromised tissue.

Both of these cases provide direct, in-human, same patient comparisons between black foam NPWT and TPE LPWT. In both cases, the more physiologically appropriate LPWT was superior. These anecdotes need to be confirmed in large prospective comparative studies, but the fact that we now have a viable alternative to black foam NPWT using high NP, allows for us to finally respond to the paradox of NPWT with a solution that is physio-"logical".

Clinical Implications

These cases demonstrates that the therapeutic effectiveness of NPWT depends on the balance between fluid evacuation and preservation of perfusion. Foam-based NPWT systems, due to their intrinsic design, are a high resistance system. This obligates higher suction to function effectively, which exceeds the physiologic threshold for capillary perfusion, particularly in pressure injuries over bony prominences.

Lower resistance interfaces, like the TPE dressing, allow effective therapy at reduced suction levels, maintaining adequate fluid management while limiting excessive contact pressure. This allows the therapy to work effectively while staying within a safer, more physiologic range that preserves perfusion and supports wound healing.

Summary

These clinical cases illustrate a pressure-dependent model of NPWT efficacy. Elevated contact pressures generated by foam-based systems at conventional settings impairs wound bed perfusion which may limit healing, whereas lower pressure systems with optimized interfaces promote granulation, prevent tissue in-growth and accelerate wound healing. These findings integrate clinical observation with experimental data and provide a physiologic explanation for improved outcomes with reduced pressure therapy using the TPE dressing.

References

1. Biermann N, Geissler EK, Brix E, Lucas P, Clemans M et.al (2020) Pressure distribution and flow characteristics during negative pressure wound therapy. J Tissue Viability 29(1): 32-36.
2. Shuler MS, Mowers CC, Dhodapkar MM, Greenberg M, Ngendahimana D, et.al (2026) Contact Pressure Under Traditional Foam and Novel Thermoplastic Elastomer Negative Pressure Wound Therapy Interfaces. Wound Repair and Regeneration 34(2): e70157.

Citation: Mowers CC, Shuler MS, Blalock C, et al. Negative Pressure Wound Therapy and the Perfusion Paradox Part Two: Clinical Cases of Pressure Injuries and Wound Healing Unsing Low Pressure Wound Therapy and a Novel Thermoplastic Dressing. *Int J. Orth & Trauma.* 2026; 2(1): 1-6. DOI : 10.51626/ijot.2026.02.00004

3. Shi J, Gao Y, Tian J, Zheng Li, Fan Mei, et al. (2023) Negative pressure wound therapy for treating pressure ulcers. Cochrane Database Syst Rev 5(5):CD011334.
4. Kairinos N, Solomons M, Hudson DA (2009) Negative-pressure wound therapy I: the paradox of negative-pressure wound therapy. Plast Reconstr Surg 123(2): 589-598.
5. Kairinos N, Voogd AM, Botha PH, Tessa K, Michael S, et.al (2009) Negative-pressure wound therapy II: negative-pressure wound therapy and increased perfusion. Just an illusion? Plast Reconstr Surg 123(2): 601-612.
6. Borgquist O, Ingemansson R, Malmsjö M (2010) Wound edge microvascular blood flow during negative-pressure wound therapy: examining the effects of pressures from -10 to -175 mmHg. Plast Reconstr Surg 125(2):502-509.
7. Biermann N, Geissler EK, Brix E, Daniel S, Lukas P, et.al (2019) Oxygen levels during negative pressure wound therapy. J Tissue Viability 28(4):223-226.
8. Mowers C, Sachdev D, Knapik DM, Vani JS, Devin Q. John, et.al (2024) Male patients experience similar improvement in clinical and functional outcomes despite higher revision rates following reverse shoulder arthroplasty acompared to female patients: a systematic review and meta-analysis. Seminars in Arthroplasty: JSES. 34(4): 928-935.
9. (2026) Schedule. Accessed April 9.
10. Borgquist O, Ingemansson R, Malmsjö M (2011) The influence of low and high pressure levels during negative-pressure wound therapy on wound contraction and fluid evacuation. Plast Reconstr Surg 127(2):551-559.

Citation: Mowers CC, Shuler MS, Blalock C, et al. Negative Pressure Wound Therapy and the Perfusion Paradox Part Two: Clinical Cases of Pressure Injuries and Wound Healing Unsing Low Pressure Wound Therapy and a Novel Thermoplastic Dressing. *Int J. Orth & Trauma.* 2026; 2(1): 1-6. DOI : 10.51626/ijot.2026.02.00004