

Role of Cyclical Negative Pressure Wound Therapy in Adult Burn Patients

Amrutha J S¹, Ravi Kumar Chittoria²

How to cite this article:

Amrutha J S, Ravi Kumar Chittoria/Role of Cyclical Negative Pressure Wound Therapy in Adult Burn Patients/J Cardiovasc Med Surg.2023;9(1-2): 9-13.

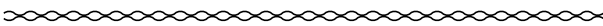
Abstract

The application of “negative pressure” has evolved to a cornerstone in the treatment of acute and chronic wounds in almost all specialties. Continuous Intermittent, and cyclic are the three types of Negative pressure Wound Therapy (NPWT). The cyclic NPWT system is similar to the intermittent mode in terms of using the same maximal sub-atmospheric pressure, but the pressure never reaches zero in the cyclic mode. The study assesses the role of cyclical Negative pressure wound therapy in adult burn wound healing.

Keywords: Cyclical negative pressure wound therapy; Burn; Adult.

INTRODUCTION

Since the introduction of the negative pressure wound therapy (NPWT) system by Morykwas and Argenta, it has been applied to a number of wounds and has become an influential and effective technique for healing simple and complex wounds. The conventional NPWT system adopts either ‘intermittent’ or ‘continuous’ mode.



Author's Affiliation: ¹Senior Resident, Department of Plastic Surgery, ²Professor, Head of IT Wing and Telemedicine, Department of Plastic Surgery & Telemedicine, Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry 605006, India.

Corresponding Author: Sartaj Ravi Kumar Chittoria, Professor, Head of IT Wing and Telemedicine, Department of Plastic Surgery & Telemedicine, Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry 605006, India.

E-mail: drchittoria@yahoo.com

Received on: 09.05.2023

Accepted on: 05.06.2023

While the continuous mode constantly applies a sub-atmospheric pressure of -125 mmHg, the intermittent mode creates a sub-atmospheric pressure of -125 mmHg for 5 minutes and a 2 minutes resting phase of 0 mmHg (Fig. 1, left).

In experiments performed on animal models, the intermittent mode showed increased perfusion level and formation of granulation tissue in the wound area compared with the continuous mode.^{1,2} Despite the effectiveness of intermittent mode in wound healing, it has been avoided in clinical application because of the pain occurring every few minutes during the initiation phase of the system to reach -125 mmHg. Thus, ‘cyclic’ mode would minimize the pain while maintaining the superior efficacy of the intermittent mode (Fig. 1, right).

The cyclic NPWT system is similar to the intermittent mode in terms of using the same maximal sub atmospheric pressure, but the pressure never reaches zero in the cyclic mode. So, it continuously creates certain pressure gradient that oscillates between -125 mmHg and the preset

sub atmospheric pressure. The cycle runs based on the changes in sub atmospheric pressure, not time,

and thus its frequency reflects the wound volume.



Fig. 1: At the time of admission

MATERIALS AND METHODS

The study is done in a tertiary care hospital in South India. The subject is a 55 year old male patient, known hypertensive for 3 years, Alleged history of accidental thermal burn with fire flame

while saving his wife from burn Patient sustained 2nd degree Flame Burn-15%TBSA involving Left Hand, Left Thigh and Leg back and Right Leg (Fig. 1). Admitted in Burns ICU, managed with antibiotics, IV Fluids, analgesics. Cyclical NPWT eight applications done. (Fig. 2)



Fig. 2: Cyclical NPWT applied

RESULTS

Cyclical NPWT is useful in improving the wound

healing of burns in adult patients. (Fig. 3). It helps in preventing wound infection and faster healing.



Fig. 3: Healed wound at the time of discharge

DISCUSSION

Over the past decades, the application of “negative pressure” has evolved to a cornerstone in the treatment of acute and chronic wounds in almost all specialties. Various available synonyms reflect the past developments and current applications of the technique involving, amongst others, “Vacuum assisted closure” (VAC), “Negative Pressure Wound Therapy” (NPWT), “closed incision Negative Pressure Therapy” (ciNPT), or “Negative Pressure Wound Therapy with instillation” (NPWTi).³ All but ciNPT are used for treatment of open wounds and exert the known beneficial effects of “negative pressure” therapy on wound healing, i.e., sufficient temporary wound closure, promotion of wound bed granulation, mechanical contraction and stabilization of wound margins, and efficient reduction of bacterial load. Wound bed perfusion represents another key factor in wound healing. Effects of “negative pressure” on wound bed perfusion have lately been widely discussed.

Types of NPWT

1. **Continuous NPWT:** The continuous mode constantly applies a sub-atmospheric pressure of -125 mmHg.
2. **Intermittent NPWT:** The intermittent mode creates a sub-atmospheric pressure of -125 mmHg for 5 minutes and a 2 minutes resting phase of 0 mmHg.
3. **Cyclic NPWT:** The cyclic NPWT system is similar to the intermittent mode in terms of using the same maximal sub atmospheric pressure, but the pressure never reaches zero in the cyclic mode. So, it continuously creates certain pressure gradient that oscillates between -125 mmHg and the preset sub atmospheric pressure.

Results from different research groups have partly shown diverging results which could seriously question the hypothesis of an enhancement of local and adjacent wound bed perfusion due to application of a negative pressure dressing.^{4,5} Actual doubt was risen based on the physically driven understanding of a compression of underlying tissues through application of a negative pressure dressing, particularly, on the capillary network that is subjected to surface pressure. Consecutively, occlusion of microvessels would result in a diminished rather than enhanced capillary blood flow, causing local hypoxia and,

probably, ischemia. Moreover, the utilization of an otherwise broadly used technique for perfusion analysis, laser doppler velocimetry, was questioned to be flawed due to the impact of “pressure artifacts”⁶, therefore resulting in a false positive sign of an enhancement in perfusion underneath an applied NPWT dressing.

On the contrary, current research regarding perfusion alterations due to ciNPT and the application of negative pressure wound therapy over closed incisions found that blood flow and consecutive tissue oxygenation acutely improved upon treatment.⁷⁻⁹ Additionally, NPWT was also successfully applied in free tissue transfer, with a reduction of postoperative tissue damage instead of an increment.¹⁰ No adverse effects of negative pressure were found. In a previous analysis, we used continuous laser doppler flowmetry combined with white light spectroscopy for a comprehensive real time analysis of microcirculatory changes under an NPWT dressing.⁸ Application of an intermittent negative pressure resulted in a stepwise increase in local tissue perfusion with a consecutive enhancement of tissue oxygen saturation.

Within this preclinical study on acute changes of cutaneous microcirculation under an applied NPWT dressing, we observed a significant increase of local perfusion dynamics with consecutive improvement of tissue oxygen saturation.

Interestingly, all three compared modes of application, continuous, intermittent, and cyclic, resulted in locally enhanced microcirculation of a greater or lesser extent.

In the comparison of different application modes, we observed superior effects on local and remote cutaneous perfusion in the cyclic group.

The continuous mode represented the most common setting in clinical wound care according to a published meta-analysis of Suissa et al. in 2011, in which discontinuous applications were rarely reported.¹²

Notably, continuous treatment represents the generally accepted standard of care despite already available early evidence of superior capabilities of an intermittent NPWT treatment with respect to formation of granulation tissue or angiogenesis. Most likely, this is attributable to the fact that intermittent activation of “negative pressure,” which causes repeated spikes in surface pressure to the wound, is believed to be unpleasing.

Lately, the introduction of the “cyclic mode” appears as a promising compromise combining

both the satisfaction of patients and superior wound treatment.¹³ Pain levels were generally low in cyclic NPWT.

In human cutaneous microcirculation, resting capillary pressure was reported in a range from 10.5 to 22.5 mmHg or even 41.0 mmHg.^{14,15} Thus, applied surface pressure of ~30.0 mmHg via a NPWT dressing could potentially result in an occlusion of cutaneous capillaries. Given the finding that capillary pressure also increases in response to a higher venous pressure, at least a sub-total occlusion of the dermal microvasculature due to the intervention can be assumed.¹⁶ Overall, the mechanisms of cutaneous vascular response to certain stimuli are complex, especially concerning vasodilation and improvement of local flow.¹⁷ Repeated capillary (sub-total) occlusion represents a strong stimulus for the affected tissue. Both post-occlusive reactive hyperemia (PORHA) and increased mechano-humoral transduction to the vascular bed result in alterations of intravascular shear stress and could be accountable for superior effects in the intermittent and, particularly, in the cyclic group.^{18,19} We also assessed changes of cutaneous microcirculation on the contralateral thigh and found stronger effects in the cyclic group. Previous studies on Remote Ischemic Conditioning (RIC), showed alterations in the applied stimulus can influence the triggered improvement of cutaneous perfusion.^{20,21}

Duration of applied pressure, number of repeated cycles, and body site are important variables to optimize the conditioning effect on the improvement of remote microcirculation.

Advantage of cyclic NPWT

1. Less painful when compared to intermittent NPWT.
2. Superior effects on local and remote cutaneous perfusion in the cyclic type compared to others.

Disadvantage of cyclic NPWT

1. Requires expansive devices to fluctuate between sub atmospheric pressure.
2. To perform cyclic NPWT in classic suction device is cumbersome.

An ideal application of a NPWT dressing must respect the individual circumstances of each patient and treated wounds with respect to comorbidities, location of the wound, and tissue composition.²²

CONCLUSION

Cyclic application of “negative pressure” results in increased local cutaneous microcirculation with regards to blood flow and consecutive tissue oxygenation. Beyond that, repeated alterations between different levels of “negative pressure” due to cyclic application represent a greater stimulus for remote conditioning effects, indicating a superior local interaction with the underlying tissue.

REFERENCES

1. Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. *Ann Plast Surg* 1997;38:563-76 discussion 577.
2. Morykwas MJ, Argenta LC, Shelton-Brown EI, McGuirt W. Vacuum-assisted closure: a new method for wound control and treatment: animal studies and basic foundation. *Ann Plast Surg* 1997;38:553-62.
3. Glass GE, Nanchahal J. The methodology of negative pressure wound therapy: separating fact from fiction. *J Plast Reconstr Aesthet Surg.* (2012) 65:989-1001.
4. Kairinos N, Voogd AM, Botha PH, Kotze T, Kahn D, Hudson DA, et al. Negative-pressure wound therapy II: negative-pressure wound therapy and increased perfusion. Just an illusion? *Plast Reconstr Surg.* (2009) 123:601- 12.
5. Borgquist O, Ingemansson R, Malmjö M. Wound edge microvascular blood flow during negative-pressure wound therapy: examining the effects of pressures from -10 to -175 mmHg. *Plast Reconstr Surg.* (2010) 125:502- 9.
6. Kairinos N, McKune A, Solomons M, Hudson DA, Kahn D. The flaws of laser Doppler in negative-pressure wound therapy research. *Wound Repair Regen.* (2014) 22:424-9.
7. Muenchow S, Horch RE, Dragu A. Effects of topical negative pressure therapy on perfusion and microcirculation of human skin. *Clin Hemorheol Microcirc.* (2019) 72:365-74.
8. Sogorski A, Lehnhardt M, Goertz O, Harati K, Kapalschinski N, Hirsch T, et al. Improvement of local microcirculation through intermittent Negative Pressure Wound Therapy (NPWT). *J Tissue Viability.* (2018) 27:267- 73.
9. Muller-Seubert W, Roth S, Hauck T, Arkudas A, Horch RE, Ludolph I. Novel imaging methods reveal positive impact of topical negative pressure application on tissue perfusion in an in vivo skin model. *Int Wound J.* (2021) 18:932-9.

10. Eisenhardt SU, Schmidt Y, Thiele JR, Iblher N, Penna V, Torio-Padron N, et al. Negative pressure wound therapy reduces the ischaemia/reperfusion associated inflammatory response in free muscle flaps. *J Plast Reconstr Aesthet Surg.* (2012) 65:640-9.
11. Suissa D, Danino A, Nikolis A. Negative-pressure therapy versus standard wound care: a meta-analysis of randomized trials. *Plast Reconstr Surg.* (2011).
12. Lee KN, Ben-Nakhi M, Park EJ, Hong JP. Cyclic negative pressure wound therapy: an alternative mode to intermittent system. *Int Wound J.* (2015) 12:686-92.
13. Shore AC. Capillaroscopy and the measurement of capillary pressure. *Br J Clin Pharmacol.* (2000) 50:501-13.
14. Fagrell B. Dynamics of skin microcirculation in humans. *J Cardiovasc Pharmacol.* (1985) 7 (Suppl 3):S53- 8.
15. Mahy IR, Tooke JE, Shore AC. Capillary pressure during and after incremental venous pressure el.
16. Wong BJ, Hollowed CG. Current concepts of active vasodilation in human skin. *Temperature (Austin).* (2017) 4:41-59. Evaluation in man. *J Physiol.* (1995) 485 (Pt 1):213-9.
17. Wilkin JK. Periodic cutaneous blood flow during postocclusive reactive hyperemia. *Am J Physiol.* (1986) 250:H765- 8.
18. Glass GE, Murphy GF, Esmaceli A, Lai LM, Nanchahal J. Systematic review of molecular mechanism of action of negative-pressure wound therapy. *Br J Surg.* (2014) 101:1627-36.
19. Kolbensschlag J, Sogorski A, Timmermann C, Harati K, Daigeler A, Hirsch T, et al. Ten minutes of ischemia is superior to shorter intervals for the remote ischemic conditioning of human microcirculation. *Clin Hemorheol Microcirc.* (2017) 66:239-48.
20. Sogorski A, Spindler S, Wallner C, Dadras M, Wagner JM, Behr B, et al. Optimizing remote ischemic conditioning (RIC) of cutaneous microcirculation in humans: Number of cycles and duration of acute effects. *J Plast Reconstr Aesthet Surg.* (2021) 74:819-27.
21. Borgquist O, Ingemansson R, Malmsjö M. Individualizing the use of negative pressure wound therapy for optimal wound healing: a focused review of the literature. *Ostomy Wound Manage.* (2011) 57:44-54.

