Getting Positive Results with Negative Pressure Wound Therapy: The Story Behind NPWT

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CONFLICT OF INTEREST

There is no conflict of interest on the part of this speaker

OBJECTIVES

- Describe the state of the science as it relates to Negative Pressure Wound Therapy (NPWT).
- Discuss the five mechanisms of action of NPWT.
## NPWT Terminology

- Vacuum-Assisted Closure: V.A.C.®  
  - Registered trademark  
- Topical Negative Pressure: TNP  
- Vacuum Sealing Technique: VST  
- Sealed Surface Suction: SSS  
- Negative Pressure Therapy: NPT  
- Negative Pressure Wound Therapy: NPWT  
  - Most widely accepted term

## NPWT History

- 1500 BC: Cupping
- 1947: Russia post-op wound exudate mgmt
- 1952: Used prophylactically to reduce complications

### 1986: Kremlin Papers
  - Decrease wound healing times and reduce hospitalizations

### 1989: M. Chariker & K. Jeter
- Effects of NPWT in healing wounds  
  - Chariker & Jeter technique

### 1989-2000's: NPWT systems released in US
NPWT Devices

- Wound VAC®
- EZ Care™
- Engenex®
- Genadyne A4
- Kalypto
- Medela® - Invia

NPWT Devices

- MoblVac®
- Prodigy™
- Renasys
- Svedman™
- Venturi™
- Prospera PRO-IT™

Foam-Based NPWT

- Reticulated (black) foam
  - For promoting granulation tissue formation
- Polyvinylalcohol (white) foam
  - More dense
  - Better for undermined/tunneled areas
- Silver reticulated foam (KCI only)
- Negative pressure rates: -40 - -200 mmHg
**Gauze/Drain-Based NPWT**

- Based on Chariker-Jeter method
- Different drains & gauze
- Excellent for wounds with dead space
- Less pain
- Negative pressure rates: -60-80mmHg

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**What’s New!!!**

- **SNaP™**
  - Spring operated
  - 3 different cartridges
    - 75, 100, 125mmHg
  - Canister 60cc
  - Disposable

- **PICO™**
  - Battery operated
  - 80mmHg
  - No canister
  - Disposable

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**Is there a BEST device?**

- ECRI Institute Evidence-Based Practice Center performed a review of NPWT devices.

- Commissioned by Agency for Healthcare Research and Quality (AHRQ)

- Systematic reviews of literature performed

Report Findings

- **ALL systematic reviews**: scarcity of high quality clinical evidence supporting NPWT vs SWC.
- Reviewers relied on low quality retrospective studies to judge NPWT efficacy.
- No studies comparing different components (e.g. gauze vs. foam) were identified.
- Benefits of NPWT for one wound type cannot be assumed for all wound types.

Bottom Line!!

Based on available evidence at time of review… no significant therapeutic difference of any particular NPWT could be identified.

NPWT Indications

- Full thickness / pressure ulcers
  - 20-25% slough; no contact to major organs / blood vessels
- Surgical wounds
  - Dehiscence, no contact to major organs / blood vessels
- Traumatic wounds
  - Amputations, lacerations, acute wounds, clean & free of debris
- Diabetic / Neuropathic
  - Chronic, non-healing, 20-25% slough, treated osteo
NPWT Contraindications

- Necrotic tissue / eschar
- Untreated osteomyelitis
- Unexplored fistula
- Wound malignancy
- Direct contact to major vessels / organs

NPWT Patient Selection

- Factors that effect healing
  - Nutrition
  - Co-morbidity
  - Medication
  - Infection
  - Age
  - Off-loading
- Special populations
  - Pediatrics

NPWT Complications

- Bleeding
  - In 6 deaths reported to FDA*
  - In 17/77 injuries reported to FDA*
- Overgrowth of granulation tissue into foam
- Gossypiboma (retained foreign body)
- Foam retention in 32/83 reports to FDA*
- Enteric fistula...over compromised intestine
- Pain

*FDA Advice for Patients: Serious Complications with NPWT (Alert released 11/13/09 re: death & injury reports associated with NPWT over 2 years [www.fda.gov]...)
Know Your Wound

- Optimize The Wound: D.I.M.E.* S.
  - Debridement
  - Infection / Inflammation
  - Moisture
  - Edges / Environment
  - Support Therapy


Debridement

- Eschar
  - Pro-inflammatory
- Slough
  - Bacterial bug bed
- Senescent cells
- Biofilm
  - Autolytic
  - Enzymatic
  - Surgical
  - Mechanical
  - Ultrasound
  - Biologic
Infection vs Inflammation

- Bacteria
- Biofilms
- Increased temp
- Pain
- Erythema
- Swelling
- Warmth
- Pain

Acute vs Chronic Infection

- Erythema
- Fever
- Warmth
- Swelling
- Pain
- Purulence
- Drainage
- Slow healing
- Discolored tissue
- Odor
- Pain
- Wound breakdown
Moisture

- Inflammatory phase
- Improves granulation
- Tissue proliferation
- Angiogenesis
- Wound contraction
- Improves epithelialization

Edges / Environment

- Tapered edge between the epithelium / granulation tissue
- Epithelialization
- Pearly white extension of tissue on the wound bed
Edges / Environment

- Hypergranulation
- Senescent cells
- Undermined
- Epibole
- Callused
- Macerated

Support Therapy

- P.T.
- Hyperbaric O₂
- Acoustic Sound
- Electrical Stimulation
- Pain mgmt
- Nutrition

NPWT: How does it work?

- Negative pressure gradient is part of all NPWT MOA

NPWT creates negative pressure from pump & through tubing

Pressure decreases through contact material & wound tissue

Area of lower negative pressure is created in peripheral tissue.

Resulting negative pressure gradient causes fluid to move from low to high negative pressure areas
**NPWT: 5 MOAs**

- Removal of wound fluid & desiccated tissue
- Removal of bacteria
- Improvement in blood flow
- Promotion of granulation tissue formation
- Physical stimulation of cells

**MOAs**

- Some MOAs interlinked
- Individual MOAs:
  - Information known
  - Most important MOA?
    - Unknown

**NPWT Interface Material**

- Different materials used to transmit negative pressure evenly across wound bed
  - No conclusive evidence that contact material is relevant to MOA
- Little research available
    - Gauze is at least as effective as foam
    - Gauze & foam equally effective in porcine subjects
MOA 1 – Fluid Removal

- Removal of edema/excess wound fluid
  - Edema caused by increased capillary permeability
    - normal response to injury
  - Edema widens gap between capillaries & wound cells
  - Impacts oxygenation & nourishment of wound

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Fluid Removal

Congested wound bed


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MOA 1 – Fluid Removal

- Removal of desiccated tissue
  - NPWT will remove some sloughy tissue
  - Decreases bacterial proliferation
  - Enhances opportunity for granulation
  - NPWT will NOT remove eschar
MOA 1 – Fluid Removal

- Removal of pro-inflammatory mediators
  - In acute wounds, cytokines mediate wound healing cascade
  - In chronic wounds, cytokines are not “switched off”
  - Results in chronic inflammatory state

MOA 2 – Bacteria Removal

- Excessive bacteria will delay wound healing
  - Contributing factors:
    - Depth of bacteria
    - Type/mixture of organisms
    - Underlying disease
    - Quality & level of tissue perfusion
    - Patient’s immune status

MOA 2 – Bacteria Removal

- Signs of critical colonization or infection:
  - Pain, redness, heat
  - Swelling, discolored wound tissue
  - Friable granulation tissue
  - Abnormal odor, increased exudate
  - Static wound margins
**NPWT Bacteria Removal Mechanisms**

- Physical bacteria removal
  - Negative pressure gradient moves bacteria out of the wound
- Improved blood supply
  - NPWT improves wound perfusion
  - More phagocytes delivered to wound
  - Reduced edema
- NPWT reduces wound edema
  - Bacteria more accessible to WBCs
- Sealed system
  - Prevents new bacteria from entering the wound

**MOA 3 – Enhanced Blood Flow**

- Adequate wound perfusion essential for tissue repair
- Blood supply required for delivery of cells, factors & elements
  - Platelets
  - Neutrophils
  - Monocytes
  - Nutrients
  - Oxygen
- Peripheral blood supply essential

**NPWT Effect on Blood Flow**

- NPWT improves blood flow by three mechanisms
  - Reduces edema
    - Reduces gap between capillaries & cells
    - Improves blood flow to cells
  - Physically increases blood flow
    - Interstitial pressure falls below capillary pressure – capillaries reopen – blood flow restored
  - Stimulates endothelial proliferation & angiogenesis
Effects of Blood Flow on Wound Healing

- Helps fight infection
  - By delivering phagocytes to the wound
    - Neutrophils: phagocytes
    - Monocytes: become macrophages
- Delivers O₂ & nutrients

Blood Flow: Angiogenesis

[Image of wound healing process]

MOA 4 - Granulation Tissue Formation

- Granulation tissue
  - Formed via fibroplasia & angiogenesis
    - Collagen-rich connective tissue
    - New vascular structure
    - Extracellular matrix (ECM) cells

Prevented in chronic wounds by:
- Up-regulated pro-inflammatory cytokines
- Inflammatory cells (e.g., neutrophils)
- Bacteria & proteases
- Increased collagen breakdown
- Decreased collagen deposition
- Poor tissue perfusion

NPWT & Granulation Tissue Formation

- Intermittent therapy
  - 40% more granulation tissue than continuous therapy
- Rate of granulation tissue formation under NPWT
  - Higher than wounds treated with growth factor

MOA 4 - Granulation Tissue Formation

MOA 5 - Cell Stimulation

- Cell stimulation: effect of mechanical force on cells
- Applied forces deform extracellular matrix
- Cells within stretched tissues also deformed
- Tissue & cell deformation causes stimulation of growth factor pathways
- End result = increased cell mitosis & production of new tissue

Cells Affected by Cell Stimulation

- Fibroblasts
  - Found in dermis
  - Produce collagen, elastin
- Endothelial cells
  - Form new vessels
  - Endothelial lining
- Keratinocytes
  - Major cell type in the epidermis (90% of epidermal cells)
  - Fundamental to production of new epidermis
Growth Factors

- PDGF (platelet-derived)
- FGF (fibroblast)
- VEGF (vascular endothelial)
- EGF (epidermal)
- TGF-β (transforming)

Cell Stimulation & Intermittent NPWT

- Cell stimulation may be linked to intermittent NPWT
- Research has shown:
  - Mitosis is further increased when mechanical cell stimulation (strain) is applied in a cyclic fashion
  - Cyclic strain stimulates proteins related to keratinocyte growth and differentiation (Takei, 1997)
  - Cyclic mechanical stretching increased proliferation of human fibroblasts & production of collagen type I (Yang, 2004)
  - Four-fold increase in epidermal cell proliferation in 8 hours when cyclic tension applied (Pietramaggiore, 2007)

Task

Noun:

1. a definite piece of work assigned to, falling to, or expected of a person; duty.
2. any piece of work.
3. a matter of considerable labor or difficulty.
Manage

Verb:
- 1. to bring about or succeed in accomplishing, sometimes despite difficulty or hardship:
- 2. to take charge or care of

http://dictionary.reference.com/browse/manage