Wound Management –

The use of a Platform Wound Device for Topical Treatment of Infections and for Delivery of Negative Pressure

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Cleveland Clinic
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Working Clinical Art and Science
New Technologies
Focusing on Patient Needs
Wound Care Today

Dressing
  - Dry
  - Moist
  - Biologic

Pain Control
  - IV
  - Oral
  - Local

Debridement
  - Surgical
  - Gauze
  - Enzymatic
  - Autolytic

Infection control
  - IV
  - Oral
  - Topical

Transplantation
  - Mesh Grafts
  - Micrografts

Scar Treatment
  - Surgical
  - Compression
  - Creams/Gels
  - Steroids
Dressing
Pain Control
Enzymatic Debridement
Infection Control
Negative Pressure Wound Therapy
Fixation/ Dressing for Split-Thickness Skin Grafts - Micrografts
Scar Treatment
A Controlled Optimized Micro-Environment
New Dressing Technology

- Control of Micro-environment
- Multi-Modal delivery capabilities
Pain Control

- Wound pain eliminated by topical delivery of lidocaine
Debridement

- Delivery of debriding agents (enzymes)
Common antibiotics can be delivered in concentrations exceeding 1,000 times MIC (Minimum Inhibitory Concentration) without local or systemic toxicity
Delivery of topical antimicrobials/ antibiotics

- Very precise, slow release topical delivery
- **Not an irrigation system, such as VAC Instil or PICO**
Topical Antimicrobials

- *Iodine, bleach, etc.*
- *0.1% Gentamicin cream - will liquefy in chamber*
- *IV antibiotics*
Wound Model
Acute infection in porcine excisional wounds

Creation of full-thickness excisional wounds

Bacterial inoculation

3 hours

Gentamicin administration (2 mg/mL)

6 hours

Quantification of bacteria in wound fluid and tissue

Euthanasia
Porcine excisional wounds

Quantitative Wound Fluid Bacteriology

Quantitative Wound Tissue Bacteriology
Creation of full-thickness burns

Bacterial inoculation

Incubate for 3 Days

Debridement and Gentamicin administration (2 mg/mL)

Sample daily

Quantification of bacteria in wound fluid and tissue

Terminal biopsy Day 9

Acute infection in porcine burn wounds
Treatment Day 6 from Time of Burn Wound Creation

Enclosed in Chamber
Treated with Gentamicin

Enclosed in Chamber
Treated with Saline
Porcine burn wounds

Quantitative Wound Fluid Bacteriology

Quantitative Wound Tissue Bacteriology

Saline Treatment
Dry Treatment
Gentamicin Treatment
Contraindications to Topical Delivery

- Sensitivity to the delivered agent
Wet Wound Healing

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Wound treatment in a flexible transparent chamber attached to the perimeter of the wound and containing a liquid has been extensively tested in preclinical experiments in pigs and found to offer several advantages. It protects the wound; the liquid medium or saline in the chamber provides in vivo tissue culture-like conditions; and antibiotics, analgesics, and various molecules can be delivered to the wound through the chamber. The wound chamber causes no injury to the wound itself or to the surrounding intact skin. Topical delivery of, for instance, antibiotics can provide very high concentrations at the wound site and with a favorable direction of the concentration gradient. A series of 28 wounds in 20 patients were treated with a wound chamber containing saline and antibiotics. Most patients had significant comorbidity and had not responded to conservative or surgical management with debridement and delayed primary closure or skin grafts. Six wounds had foreign bodies present; four of these were joint prostheses. Seven patients were on corticosteroids for rheumatoid arthritis, lupus, or chronic obstructive pulmonary disease, and four patients had diabetes. Most patients were treated with the wound chamber in preparation for a delayed skin graft or flap procedure, but one was treated with a wound chamber until the wound healed. Twenty-five of the wounds (89 percent) healed, and five wounds (18 percent) required additional treatment.

Burn patients were treated in bathtubs with water for periods of weeks to months. It was noted that pain was reduced and that the survival rate was increased. When patients with major full-thickness burns were removed from the bathtubs, they died. This treatment preceded the use of skin grafting by more than 20 years.

Bunyan, a British naval surgeon, used what he called the “envelope method” extensively during World War II. The injured site, usually an extremity, was enclosed in the envelope containing water with bleach. The solution was changed frequently, making this an irrigation method. Bunyan noted less pain, less tissue destruction, and fewer infections in the patients who received the envelope treatment.

Our laboratory has studied healing in a liquid over the past 15 years. The wound has been enclosed in a sealed, watertight, transparent, vinyl chamber glued to the periphery of the wound.
Fig. 1. Patient 1, wound 3. *(Left)* Hip prosthesis infected with methicillin-resistant *Staphylococcus aureus*. *(This illustration is from a similar case. The original photograph was lost.)* *(Second from left)* Radiograph of the infected hip prosthesis. *(Second from right)* Before chamber treatment, the wound was debrided and closed, except for the inferior 4 cm, to fit the opening of the wound chamber. A Z-plasty was used to strengthen this partial wound closure. After 21 days of treatment with wound chamber and antibiotics, the skin wound was excised and closed. *(Right)* Healing was achieved without recurrence.
Fig. 4. Patient 6. (Above, left) Infected wound 3 weeks after crush avulsion trauma to the lower leg. A Salter Harris II fracture is treated with an external fixator. (Above, right) The lower leg was treated in a wound chamber for 9 days. (Below, left) Medial and (below, right) lateral lower leg 3 weeks after split-thickness skin graft.
Fig. 2. Patient 2, wound 3. (Above, left) Chronic ulcer at the lower thigh in a patient with a history of 95 percent full-thickness burn. (Above, right) Wound chambers applied to the same and a second wound in the thigh area (wounds 3 and 2 in Table 1).
Next Generation Negative Pressure Wound Therapy (NPWT)
Principles of Action

- **Embosed Pattern** is configured to directly contact the wound

- **Embosed Pattern** provides micro-mechanical forces and primary distribution of negative pressure (Box 1)

- Folds in redundant membrane create secondary distribution of negative pressure (Box 2)
EXISTING PRODUCTS

- Complex Multi-piece Assembly
- Time Consuming
- Multi Component Application

PLATFORM FOR WOUND CARE

- Platform Technology
- Time Saving
- Easy one step Application
In a pilot series of porcine studies, a poly-vinyl chamber designed to fit over a 6 cm diameter excisional wound was applied onto an open wound for a period of 7 days prior to skin graft application and compared to two different negative pressure devices (KCI Wound VAC and an embossed poly-vinyl chamber connected to negative pressure) (Figure 5). The expression of IL-8 and IL-1β was markedly decreased in the wound bathed in moist solution containing antibiotic compared to the conventional negative pressure dressing. The degree of recipient bed inflammation was similar between the conventional KCI wound VAC and the embossed poly-vinyl chamber connected to 125mmHg of negative pressure.
Porcine Study
PWD with NPWT for 4 Days Post Debridement

Day 0 Burn

Day 3 Post Debridement

Day 7 Terminal Biopsy

Day 7 Terminal Biopsy
Embosed NPWT - Human Case

- **Patented** Embossed Wound Chamber
- **Clinical evidence** in porcine study proves equivalent in generating granulation tissue to the VAC
- Oversized superstructure **allows for use in deep wounds** as material redundancy creates folds and creases during the application of NPWT and the embossed micro-structures are pulled into contact with all points of the wound
- Single piece design enables **ease of application** and pain free device removal
A compare between myocardial topical negative pressure levels of -25 mmHg and -50 mmHg in a porcine model
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Abstract

Background: Topical negative pressure (TNP), widely used in wound therapy, is known to stimulate wound edge blood flow, granulation tissue formation, angiogenesis, and revascularization. We have previously shown that application of a TNP of -50 mmHg to the myocardium significantly increases microvascular blood flow in the underlying tissue. We have also shown that a myocardial TNP levels between -75 mmHg and -150 mmHg do not induce microvascular blood flow changes in the underlying myocardium. The present study was designed to elucidate the difference between -25 mmHg and -50 mmHg TNP on microvascular flow in normal and ischemic myocardium.

Methods: Six pigs underwent median sternotomy. The microvascular blood flow in the myocardium was recorded before and after the application of TNP using laser Doppler flowmetry. Analyses were performed before left anterior descending artery (LAD) occlusion (normal myocardium), and after 20 minutes of LAD occlusion (ischemic myocardium).

Results: A TNP of -25 mmHg significantly increased microvascular blood flow in both normal (from 263.3 ± 62.8 PU before, to 380.0 ± 80.6 PU after TNP application, * p = 0.03) and ischemic myocardium (from 58.8 ± 17.7 PU before, to 85.8 ± 20.9 PU after TNP application, * p = 0.04). A TNP of -50 mmHg also significantly increased microvascular blood flow in both normal (from 174.2 ± 20.8 PU before, to 240.0 ± 34.4 PU after TNP application, * p = 0.02) and ischemic myocardium (from 44.5 ± 14.0 PU before, to 106.2 ± 26.6 PU after TNP application, *** p = 0.01).

Conclusion: Topical negative pressure of -25 mmHg and -50 mmHg both induced a significant increase in microvascular blood flow in normal and in ischemic myocardium. The increase in microvascular blood flow was larger when using -25 mmHg on normal myocardium, and was larger when using -50 mmHg on ischemic myocardium; however these differences were not statistically significant.
Reduction of Myocardial Ischemia-Reperfusion Injury by Mechanical Tissue Resuscitation Using Sub-Atmospheric Pressure

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Abstract Background: Reperfusion-induced injury after myocardial infarction is associated with a well-defined sequence of early and late cardiomyocyte death. Most present attempts to ameliorate this sequence focus on a single facet of the complex process in an attempt to salvage cardiomyocytes. We examined, as proof of concept, the effects of mechanical tissue resuscitation (MTR) with controlled negative pressure on myocardial injury following acute myocardial infarction. Methods: Anesthetized swine were subjected to 75 minutes of left coronary artery occlusion and three hours of reperfusion. Animals were assigned to one of three groups: (A) untreated control; (B) −50 mmHg, or (C) −125 mmHg. Results: All three groups were subjected to equivalent ischemic stress. Treatment of the ischemic area with MTR for 180 minutes significantly (p < 0.001) reduced infarct size (area of necrosis/area at risk) in both treatment groups compared to control: 9.3 ± 1.8% (−50 mmHg) and 11.9 ± 1.2% (−125 mmHg) versus 26.4 ± 2.1% (control). Total area of cell death was reduced by 65% with −50 mmHg treatment and 55% in the −125 mmHg group. Conclusions: Treatment of ischemic myocardium with MTR, for a controlled period of time during reperfusion, successfully reduced the extent of myocardial death after acute myocardial infarction. These data provide evidence that MTR using subatmospheric pressure may be a simple, efficacious, nonpharmacological, mechanical strategy for decreasing cardiomyocyte death following myocardial infarction, which can be delivered in the operating room. doi: 10.1111/j.1540-8191.2009.00972.x (J Card Surg 2010;25:247-252)
# Examples of Current Bio-Sensors

## Table 2: Examples of commercial fiber-optic biomedical sensors by type

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Fiso, LumaSense, Neoptix, OpSens, RJC</td>
</tr>
<tr>
<td>Pressure</td>
<td>Fiso, Maquet, OpSens, Samba Sensors, RJC</td>
</tr>
<tr>
<td>Coronary imaging</td>
<td>InfraRedx</td>
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<tr>
<td>Oxygenation</td>
<td>ISS</td>
</tr>
<tr>
<td>Pulse oximeter</td>
<td>Nonin</td>
</tr>
<tr>
<td>Blood flowmeter</td>
<td>ADInstruments</td>
</tr>
<tr>
<td>Shape/position</td>
<td>Hansen Medical, Intuitive Surgical, Luna, Measurand, Technobis</td>
</tr>
<tr>
<td>Force</td>
<td>EndoSense</td>
</tr>
<tr>
<td>EKG/EEG</td>
<td>Srico</td>
</tr>
</tbody>
</table>

Bio-Senor Integration and Monitoring

- **Wireless Configuration**
- **Fiber Optic**
- **Flexible & embedded into polyurethane during extrusion**

- DARPA/ NIH development to create dissolvable wireless sensor
- Could have applications for wounds
- Transmitting capability well established
- Our challenge is integration into our platform
- Temperature and Pressure readings

United States Government Collaboration
<table>
<thead>
<tr>
<th>PLATFORM FOR WOUND CARE</th>
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<tbody>
<tr>
<td><strong>Impermeable membrane that is completely sealed to the perimeter of the wound</strong></td>
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<tr>
<td><strong>Small pump or manual suction can be used for small wounds or transport</strong></td>
</tr>
<tr>
<td><strong>Provides fixation for transplanted skin micrografts</strong></td>
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<tr>
<td><strong>Adaptable for limbs, face, and head</strong></td>
</tr>
<tr>
<td><strong>CLEAN TECHNOLOGY - NO FOAM OR GAUZE REQUIRED</strong></td>
</tr>
<tr>
<td><strong>Continuous suction not necessary</strong></td>
</tr>
<tr>
<td><strong>Target operation range 80mmHg or lower</strong></td>
</tr>
</tbody>
</table>
Thank You