EVIDENCE-BASED REPORT CARD

Operational Definition of Moist Wound Healing

Laura Bolton

QUESTIONS:

1. What evidence supports an operational definition of moist wound healing?
2. What procedures or dressings provide a moist wound healing environment sufficient to improve clinical healing beyond that experienced with gauze dressings?

Ancient civilizations ameliorated the adverse effects of allowing wounds to dry by adding saps, resins, or ointments to the cloth dressings they applied.1 Thomas Baynton first applied moisture-retentive adhesive tape to venous ulcers in 1797.2 Nearly 150 years later, Oscar Gilje, a Norwegian dermatologist, published scientific confirmation that areas of more than 200 venous ulcers covered with adhesive tape beneath Unna’s boot healed faster than areas of the same ulcers managed without the adhesive tape. Numerous controlled studies in the last 50 years established moist wound healing (MWH) as the best evidence-based practice.3,4 It makes biological sense to provide a moist physiological environment for the cells that do the work of healing by preventing wounded tissue from drying5 or incorporating gauze fibers6 into healing tissue. Dried wound tissue is more prone to complications such as infection,7 scarring,8 or pain9 and heals more slowly10 than moist tissue, placing patients at risk of longer hospital stays or amputations. Yet medical professionals have been slow to adopt this evidence partly because MWH means different things to different professionals. One protocol may call wet-to-dry gauze MWH, whereas another specifies hydrocolloid or film dressings as MWH. Which is right? A major cause of confusion is a lack of a unified operational definition for MWH that is reliably associated with clinical healing outcomes. Biology, physics, and chemistry surged forward with clear operational definitions all could use to test the hypotheses about the way the world works. Imagine what wound care could accomplish if we all spoke the same language and “walked the talk.” The Wikipedia defines “operational definition” as “a description of something—such as a variable, term, or object—in terms of the specific process or set of validation tests used to determine its presence and quantity.” All who repeat the process or set of validation tests should get the same results. For example, an operational definition of an object’s weight in grams is to record the result when it is placed on a scale graduated in grams. This process or operation defines the object’s weight. Therefore, in order to derive an operational definition for MWH, it is necessary to search the literature for processes used to keep a wound moist, and identify those processes that optimize healing outcomes.

Objective

This Evidence-Based Report Card explores the evidence supporting an operational definition of MWH and the healing outcomes associated with that operational definition as compared to nonmoist wound healing modalities.

Methods

The author searched the National Institute of Health’s National Library of Medicine MEDLINE electronic database from January 1966 through October 16, 2006, for the key words “wound dressing measure moisture” to identify support for an operational definition of processes that provide a moist wound environment and “wound healing dressings controlled” to identify controlled English-language studies that reported wound dressing effects on measures of wound healing, as well as derivative references and controlled studies meeting the subject criteria from conference proceedings in available files. Healing efficacy data were summarized from randomized and nonrandomized clinical (Questions 1 and 2) and preclinical (Question 1 only) studies with outcomes evaluated in blind or unblinded fashion, as well as systematic reviews, meta-analyses, and quasi-experimental trials measuring healing effects of wound dressings.

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Results

**Question 1: What Evidence Supports an Operational Definition of Moist Wound Healing?**

**Clinical Evidence for Concept Validity**

The lack of uniform dressing usage, wound assessment, and research methods in the clinical literature does not permit a *bona fide* meta-analysis of low dressing WVTR as an operational definition of MWH in clinical wounds. However, clinical validity of the association of faster healing with lower WVTR was tested by conducting Wilcoxon Signed Rank tests for matched samples pairing dressing categories and healing outcomes within comparative clinical studies to test the consistency of the association of low dressing WVTR with more rapid healing outcomes in clinical wounds. In controlled clinical studies on chronic and acute wounds reporting percent of wounds healed after a standardized duration of treatment, wounds dressed with more moisture-retentive dressings were more likely to heal than those dressed with higher WVTR dressings (Wilcoxon $\alpha = .004$). This finding was true for both partial-thickness and full-thickness venous ulcers, pressure ulcers, and neuropathic foot ulcers. Faster healing with lower WVTR dressing modalities was also found in studies on acute wounds and one partial-thickness pressure ulcer study, which operationally defined clinical healing as “days to heal” (Wilcoxon $\alpha = .016$). Summarizing these findings, there is significant evidence that an operational definition of moisture retention as “lower wound dressing WVTR” is associated with more rapid wound healing in both chronic and acute wounds, regardless of whether healing was quantified as “percent healed after a specified treatment duration” or “days to heal.” These findings were consistent in both clinical and preclinical study settings.

**Clinical Evidence for Concept Validity**

The real test of an operational definition of MWH is its performance in healing clinical wounds. Two systematic reviews of randomized controlled trials (RCT) that found insufficient evidence for a conclusive effect of wound dressings on healing outcomes of venous ulcers or surgical wounds healing by second intention leave some issues unresolved. For example, the systematic review of 42 venous ulcer RCT comparing hydrocolloids, alginates, hydrogels, and other dressing effects on healing may have missed significant effects by combining hydrocolloids that have reported significantly different healing effects on at least 1 chronic wound. The resulting high variability of healing outcomes within the hydrocolloid category may have masked statistically significant effects of low-WVTR dressings. The open surgical wound review of 13 RCT comparing gauze, foams, or alginates did not include any studies on the low-WVTR category of hydrocolloid or film dressings, leaving unanswered the question of whether low-WVTR dressings qualified as an operational definition of MWH for clinical wounds. Finally, variations between study treatment durations make these systematic review data difficult to analyze and interpret. For example, significant 4- to 8-week healing advantages of a hydrocolloid dressing as compared to gauze in pressure or venous ulcers may dissipate by 12 weeks as the number of patients declines or gauze-dressed wounds gradually heal within appropriate protocols to alleviate the causes of tissue damage.

One meta-analysis found sufficient numbers of controlled studies measuring healing outcomes on 100 or more venous ulcers or pressure ulcers to analyze healing effects of hydrocolloid dressings vs gauze. Within 8-week protocols of care including adequate sustained compression, one hydrocolloid dressing healed 34.7% of leg ulcers compared to 25.5% healed using gauze primary dressings ($\alpha < .05$). However, there were insufficient data for the effect to reach statistical significance after other intervals of care. Within 6-, 8-, or 10-week protocols of care including pressure alleviation, gauze also delayed pressure ulcer healing as compared to the same hydrocolloid dressing, but not a different hydrocolloid dressing. The only statistically significant effect within this meta-analysis at 12 weeks ($\alpha < .05$) was between hydrocolloid dressing D (65.4% healed) and hydrocolloid dressing C (41.2% healed). Similar significant differences were observed between these same hydrocolloid...
adhesive dressings ($\alpha = .04$) on pressure ulcer healing times in homecare$^9$ and on acute swine donor site epithelization ($\alpha < .01$).$^{12}$ Such findings suggest that different adhesive physical or chemical properties may have different effects on healing independent of dressing WVTR. For this reason, professionals are advised to request product clinical outcome data on wounds similar to the ones they are caring for before selecting a low-WVTR dressing for their protocols.

Table 1 summarizes clinical healing outcomes reported in prospective controlled studies applying dressing categories having low [less than 30 g/(m² h)], medium (30-60 g/(m² h)], and high [more than 60 g/(m² h)] WVTR. The faster reported healing outcomes in each controlled study comparing different WVTR dressing categories are shaded in Table 1 to highlight recognition of the WVTR effect on healing. Shading in the “low WVTR” column indicates evidence supporting low WVTR as an operational definition for clinical MWH. More data are needed before drawing a firm conclusion about clinical healing of wounds dressed with the medium-WVTR category that includes foam dressings and on neuropathic diabetic foot ulcers. Despite these deficiencies in the literature, Table 1 shows that for all 16 WVTR comparison studies on open wounds healing only by second intention, lower WVTR dressings were associated with faster healing than same-study higher WVTR dressings. In no case was a same-study higher WVTR comparator dressing associated with faster healing than a lower WVTR dressing.

### Discussion and Conclusions

An “effective dose” of moisture retentiveness sufficient to provide a MWH environment for most full-thickness or partial-thickness wounds can be defined physically as a dressing that allows low WVTR through the dressing, less than 30 g/(m² h). Low-WVTR dressings are associated with comparatively faster healing outcomes for open chronic wounds such as venous, pressure, or diabetic foot ulcers, as well as acute biopsies or partial-thickness burn wounds. This evidence summary is a modest step toward laying the foundation for an operational definition of MWH. All other variables being equal, a dressing with low WVTR is likely to be associated with faster healing than one with high WVTR.

It should be acknowledged that this operational definition still leaves the healing contribution of many dressing and wound management variables to be explored. Its limitations include the fact that dressing WVTR may vary with hydration, saturation, swelling, or other testing conditions,$^{44}$ as well as application techniques such as stretching. This Evidence-Based Report Card uses a clinically relevant published measure of WVTR as measured with the dressing equilibrated during 24 hours on swine wounds in vivo and previously correlated with clinical outcomes. It remains to be determined whether simpler in vitro laboratory tests can simulate real-wound environments sufficiently to yield clinically relevant in-use wound dressing WVTR measurements. Fluid-absorbing primary dressings or other forms of exudate management may be needed in combination with moisture-retentive secondary dressings to manage highly exuding phases of healing while maintaining a moist environment.$^{45}$ The literature search was limited to dressings with prior published WVTR levels during use on wounds. The categories of “biologic dressings” such as living skin equivalents or allografts and “fibrous dressings” such as alginates, hyaluronic, or sodium-carboxymethylcellulose dressings were omitted from the summary of clinical outcomes because their WVTR levels were unknown. For perspective in a RCT of 240 venous ulcers, 32% of those managed with bioengineered skin reportedly healed in 8 weeks as compared to 10% of those dressed with gauze, with percents healed at 24 weeks increasing to 47 for bioengineered skin and 19 for gauze.$^{46}$ In a 12-week RCT of highly exuding venous ulcers, 46% were reported to be healed with sodium carboxymethylcellulose primary dressings ($n = 69$) as compared to 20% of those dressed with an alginate ($n = 67$).$^{47}$ Among 30 exuding stages II—IV pressure ulcers managed for 8 weeks with sodium-carboxymethylcellulose primary dressings, 27% healed as compared to 18% of the similar 28 pressure ulcers dressed with gauze.$^{48}$ These studies place bioengineered skin venous ulcer healing outcomes on a par with those of low-WVTR dressings and fibrous dressing outcomes for venous and pressure ulcers in the same time frames on a par with those reported$^{10}$ for high-WVTR gauze dressings. The clinical implication of this perspective is that moist healing outcomes may be optimized by applying secondary low-WVTR dressings, like hydrocolloid or film dressings, over fibrous primary dressings used to manage excess chronic wound exudate.

Variables other than dressing WVTR that affect healing outcomes should be carefully considered in future meta-analyses or studies. For example, full-thickness wounds generally take nearly twice as long to heal than same-etiology partial-thickness wounds.$^{49}$ Wide variability in healing time results from combining both full-thickness and partial-thickness wounds in a systematic review or meta-analysis, reducing the likelihood of identifying significant effects of dressing moisture retention on wound healing. Aggressive dressing removal techniques or adhesive differences within a category, such as hydrocolloid dressings, may cause differences in patient withdrawal or adverse events by inflicting physical or chemical trauma to the wound surface.$^{50}$ For these reasons, readers are encouraged to scrutinize the literature on healing outcomes for wounds similar to the ones they treat and to avoid assuming equivalence of dressings in each major category.

Clinically translating MWH into practice requires more than simply applying a dressing.$^{51}$ First, it requires an accurate diagnosis and enduring alleviation of the cause of tissue damage. Second, it requires a valid, reliable assessment of the wound and the surrounding skin$^{52}$ to determine how to meet each of the wound’s needs if applicable: cleansing,
# TABLE 1.

**Dressing Moisture Retention Effects Reported in Controlled Clinical Wound Healing Studies (Dressing Average WVTR Values As Recorded After 24 Hours In Situ on Fresh Swine Donor Site Wounds)**12

<table>
<thead>
<tr>
<th>Clinical Wound</th>
<th>Low (&lt;30) WVTR Dressings (HCD = Hydrocolloid; F = Film)</th>
<th>Medium (30-60) WVTR Dressings (Foam Dressings)</th>
<th>High (&gt;60) WVTR Dressings Gauze or Impregnated Gauze</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venous ulcers (with adequate sustained graduated compression)</td>
<td>(HCD) 38% in 13 weeks ( (n = 50) )20</td>
<td>34% in 13 weeks ( (n = 50) )20</td>
<td>2 of 15 (13%) venous or arterial ulcers healed in 6 weeks21</td>
</tr>
<tr>
<td></td>
<td>(HCD) 7 of 15 (48%) venous or arterial ulcers healed in 6 weeks21</td>
<td></td>
<td>(Gauze + compression stockings) 12% of venous ulcers healed during an episode of care in home or physician office care settings and did not recur23</td>
</tr>
<tr>
<td></td>
<td>(HCD + compression stockings) 87% of venous ulcers healed during an episode of care in home or physician office care settings and did not recur23</td>
<td></td>
<td>39% of 223 venous ulcers healed in 12 weeks in a meta-analysis of literature19</td>
</tr>
<tr>
<td></td>
<td>(HCD) 51% of 530 venous ulcers healed in 12 weeks in a meta-analysis of literature19</td>
<td></td>
<td>(Impregnated gauze) 35 patients healed in a mean of 8 weeks23</td>
</tr>
<tr>
<td></td>
<td>(HCD) 35 patients healed in a mean of 7 weeks22</td>
<td></td>
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<tr>
<td></td>
<td>(HCD) 55% of 164 &gt;27-month duration venous ulcers healed in 12 weeks with or without thromboxane antagonist treatment24</td>
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<td></td>
<td>(F) Granulation tissue replaced yellow slough as measured chromatically or clinically in 14 days, faster with a gel under the film than with exogenous enzymes25</td>
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<tr>
<td>Pressure ulcers (with pressure relief, reduction or redistribution; stage III or IV are full-thickness wound; stage II is partial-thickness wound)</td>
<td>(HCD) 33% of stages II and III healed in 6 weeks ( (n = 49) )20</td>
<td>20% of stages II and III healed in 6 weeks ( (n = 50) )21</td>
<td>23% of full-thickness pressure ulcers healed in 16 weeks with 100 µg/g rHBB-PDGF ( (n = 31) ) vs 0% healed in 16 weeks with placebo gel ( (n = 31) )29</td>
</tr>
<tr>
<td></td>
<td>(HCD) Median time to healing for 16 stage II pressure ulcers was 9 days26</td>
<td>40% of 20 stages II and III pressure ulcers healed in a median of 32 days27</td>
<td>14% of 14 stages II and III pressure ulcers healed in 12 weeks28</td>
</tr>
<tr>
<td></td>
<td>(HCD) 42% of 19 stages II and III pressure ulcers healed in a median of 17.5 days24</td>
<td>42% of 24 stages II and III pressure ulcers healed in 12 weeks28</td>
<td>51% of 102 stages II and III pressure ulcers healed in 12 weeks in a meta-analysis of literature19</td>
</tr>
<tr>
<td></td>
<td>(HCD) 61% of 281 (or 48% of 136 with a different hydrocolloid dressing) stages II and III pressure ulcers healed in 12 weeks in a meta-analysis of literature10</td>
<td></td>
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</tr>
<tr>
<td>Neurapathic ulcers (with appropriate off-loading) Acute biopsies</td>
<td>(HCD) 80% of 36 diabetic and 10 Hansen’s disease patients with neuropathic ulcers healed in 10 weeks with consistent off-loading with a total contact cast20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** WVTR = Water Vapor Transmission Rate; HCD = Hydrocolloid; F = Film.
<table>
<thead>
<tr>
<th>Study Description</th>
<th>Weighted Outcome (n)</th>
<th>Mean Healing Time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>moist wound healing: 88.1% of 84 foot ulcers in 45 patients</td>
<td>88.1% of 84 foot ulcers in 45 patients healed in a mean of 14 weeks. (HCD) 88.1% of 84 foot ulcers in 45 patients with insulin dependent or non-insulin dependent diabetes healed in a mean of 14 weeks. (HCD) Retrospectively measured probability of developing infection was 2.5%12</td>
<td>14 weeks</td>
</tr>
<tr>
<td>HCD 100% of full-thickness biopsies healed in 48 days for stressed caregivers vs 39 days for non-stressed34</td>
<td>HCD 100% of full-thickness biopsies healed in 48 days for stressed caregivers versus 39 days for non-stressed. No significant difference in healing times of 25 shave biopsies randomized to HCD dressing compared to 25 randomized to a conventional adhesive bandage plus antibiotic ointment.35</td>
<td>48 days</td>
</tr>
<tr>
<td>(HCD) 100% of 7 shave biopsies healed in 2 weeks; 36% of full-thickness punch biopsies healed in 2 weeks36</td>
<td>(HCD) 100% of 7 shave biopsies healed in 2 weeks; 36% of full-thickness punch biopsies healed in 2 weeks</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Acute burns or traumatic wounds</td>
<td>(HCD) 22 partial thickness burns healed in 10.2 days37</td>
<td>10.2 days</td>
</tr>
<tr>
<td>(HCD) 48 trauma wounds, lacerations, or sutured wounds had less pain, used less anesthesia than gauze-dressed wounds and healed in similar times39</td>
<td>(HCD) 48 trauma wounds, lacerations, or sutured wounds healed in 10.2 days; film-dressed halves healed in a mean of 13.8 days40</td>
<td>10.2 days</td>
</tr>
<tr>
<td>Acute split-thickness skin graft donor sites</td>
<td>(HCD) 100% healing of 15 patients with mirror image donor sites healed in 9 days9</td>
<td>9 days</td>
</tr>
<tr>
<td>(HCD) mean healing time 9.54 days or 9.47 days with film dressing48</td>
<td>(HCD) mean healing time 9.54 days or 9.47 days with film dressing</td>
<td>9.54 days</td>
</tr>
<tr>
<td>HCD-dressed half of 13 donor sites healed in 7.1 days; film-dressed half healed in 14.3 days50</td>
<td>HCD-dressed half of 13 donor sites healed in 7.1 days; film-dressed half healed in a mean of 14.3 days</td>
<td>7.1 days</td>
</tr>
<tr>
<td>Film-dressed donor sites healed in 14 days in a RCT42</td>
<td>Film-dressed donor sites healed in 14 days in a RCT</td>
<td>14 days</td>
</tr>
<tr>
<td>All 50 mirror image film-dressed donor sites healed by day 1143</td>
<td>All 50 mirror image film-dressed donor sites healed by day 1143</td>
<td>11 days</td>
</tr>
</tbody>
</table>

50% of 123 patients treated with 100 µg/g rHBB-PDGF healed in 20 weeks vs 35% with gauze and placebo gel (n = 127)31
Retrospectively measured probability of developing infection when dressed with gauze was 6.0%32
61% of 49 patients healed after 20 weeks with platelet releasate versus 29% of 21 patients managed with saline gauze33

63% of 16 shave biopsies healed in 2 weeks; 7% of 14 full-thickness punch biopsies healed in 2 weeks36

20 partial thickness burns dressed with 1% silver sulfadiazine gauze healed in 15.6 days57
11 days for 20 second degree burns managed with film of C. axillaris extract vs. 17 days for 19 managed with saline gauze58
48 trauma wounds, lacerations, or sutured wounds dressed with non-adherent gauze had similar healing rates to HCD-dressed wounds59

100% of the opposing mirror image control donor sites on 15 patients healed in 18 days9
Mean healing time 11.07 to 12.79 days41

Impregnated gauze-dressed sites healed in 19 days62
All 50 mirror image same-subject donor sites dressed with impregnated tulle gauze took more than 22 days to heal63

Shaded areas indicate best within-study healing.
alleviating pain, debriding necrotic tissue, filling deep wounds, and adding moisture to dry wounds or managing excess moisture. Determining the goals of care from the wound assessment helps generate the action plan for managing the wound, which should also consider patient, social, and economic factors, such as reducing pain or the frequency of dressing changes to minimize costs or interruptions of normal activities. Once assessment-based goals are determined and an evidence-based treatment plan is implemented to meet these goals, wise professionals will monitor progress toward the goal(s) of care to assure wound improvement rather than deterioration. When these steps were taken using protocols of care to alleviate causes of tissue damage and less than 5% high-WVTR gauze dressings in a real-world cohort study, 61% and 77% of partial-thickness pressure and venous ulcers, respectively, healed in 12 weeks as compared to 36% and 44% of full-thickness pressure and venous ulcers. These results approximate 12 weeks as compared to 36% and 44% of full-thickness pressure and venous ulcers. This finding is consistent with the research regarding optimal dressing WVTR for wound healing.

The approach of choosing wound dressings on the basis of evidence that they perform clinically needed MWH functions may seem awkward to professionals accustomed to basing dressing selection on material content, such as alginate, film, foam, gauze, hydrocolloid, etc. However, it is an important first step in focusing attention on meeting clinically assessed functional patient and wound needs rather than focusing on the material from which a dressing is made. Moist wound healing is only one of the many functional wound needs identified in a thorough wound assessment. These needs change as the wound heals or deteriorates. The evidence base and operational definitions for products meeting each clinical wound and patient need should be carefully considered when planning a protocol of care to achieve each patient’s wound care goals.

**KEY POINTS**

- Significant evidence exists that “lower wound dressing WVTR” is associated with more rapid wound healing outcomes in both chronic and acute wounds (Strength of Evidence: Level 1).
- Lower WVTR dressings were associated with faster healing than higher WVTR dressings (Strength of Evidence: Level 1).

**References**


**J WOCN □ January/February 2007**


