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# The benefits and harms of cleansing for acute traumatic wounds: A narrative review.

--Manuscript Draft--

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| **Abstract:** | This article presents a narrative review on the benefits and harms of wound cleansing in the context of acute traumatic wounds. |
| **Response to Reviewers:** | I thank the reviewers for their constructive comments. I have highlighted areas addressing the comments in yellow on the revised manuscript unless otherwise specified.<br><br>Editor<br>-Reference formatting has been changed to reflect the journal guidelines<br>-The article has been spell/grammar checked using American English conventions<br><br>Reviewer 1:<br>-Sentence on page 3, lines 6-15 has been changed to improve readability.<br>-I have highlighted in green where ‘usual care’ has been mentioned. I agree this is an important issue, many of the studies included in this review however, either did not use a control group, used multiple intervention groups in lieu of a control or didn't define fully what was meant by ‘usual care’. Unfortunately there remains significant variation in clinical practice in this area, possibly due to the lack of a robust evidence base guiding decisions. It is therefore difficult to describe exactly what constitutes ‘usual care’ in a broader sense currently.<br>-I have included two summary tables, one outlining the benefits and harms of different cleansing solutions and one indicating the benefits/harms of irrigation at different pressures.<br><br>Reviewer 2:<br>-I have included the IWII definition of wound infection and added more detail on the importance of recognizing the limitations of wound swabs in the diagnosis of infection.<br>-I have included comments on the economic considerations inherent in the use of irrigation both within the text and in the summary tables.<br>-I have included and referenced an article discussing the issue of irrigation propagating bacteria deeper into wound tissues.<br>-I have included and referenced articles discussing the issue of pain and cooling of the |

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| | wound bed via the use of irrigation.<br>-I have included an analysis of a study investigating the issue of variation in staff training/competence in the use of wound irrigation and how there can be significant variation in pressure dependent on the technique used.<br>-Unfortunately I was unable to find any references supporting the statement about the risk of infection from irrigation splashing in clinicians eyes and/or contaminating the patient's surroundings. I agree that this may be a risk but it could equally be argued that any highly exuding wound or poorly managed clinical area during the cleansing of a wound could equally contaminate the environment. I feel without any evidence indicating the exact nature of this risk and/or its relevance in decision making with regards to wound cleansing I can't include it in this review. Please let me know if you have a reference for this particular issue and I will include this point.<br>-I have referenced best practice with regard to non-irrigation based approaches on page 5 however as per my responses to reviewer 1 it is difficult to describe all of the non-irrigation based approaches due to the variation in practice at present. This is perhaps an issue beyond the scope of this particular review but definitely something I will consider investigating further in future work. |

**Title**: The benefits and harms of cleansing for acute traumatic wounds: A narrative review.

**Abstract**: Acute traumatic wound cleansing is currently a controversial issue demonstrated by the variability in solutions and techniques used to clean wounds in clinical practice. Although there is evidence of improved infection outcomes in wounds cleansed with antiseptics these observations are often undermined by concurrent use of antibiotics in addition to poor study design. Cleansing techniques including pressurised irrigation have also been investigated indicating potential harms including oedema and inconsistencies in irrigation pressures achieved by clinicians. The purpose of this article is to provide a narrative review on the contemporary evidence indicating the potential harms and benefits of wound cleansing in the context of acute traumatic wounds.

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**Abstract**: Acute traumatic wound cleansing is currently a controversial issue demonstrated by the variability in solutions and techniques used to clean wounds in clinical practice. Although there is evidence of improved infection outcomes in wounds cleansed with antiseptics these observations are often undermined by concurrent use of antibiotics in addition to poor study design. Cleansing techniques including pressurised irrigation have also been investigated indicating potential harms including oedema and inconsistencies in irrigation pressures achieved by clinicians. The purpose of this article is to provide a narrative review on the contemporary evidence indicating the potential harms and benefits of wound cleansing in the context of acute traumatic wounds.

**Introduction:**

Acute wounds are disruptions to the integumentary system with an aetiology that occurs suddenly but usually heals within a normal timeframe.[1] Acute wounds are often associated with infection and consequently are cleansed using a range of solutions and techniques.[2]

Wound cleansing is proposed to remove debris, exudate and metabolic waste from tissues to remove biomaterials which may hinder wound healing by becoming a focus for infection or an obstruction to healing processes.[3] However, the evidence base supporting wound cleansing or choice of irrigant are poor according to a meta-analysis conducted by the Cochrane Collaboration reporting potable water is associated with no significant variances in infection or healing rates compared to other solutions in traumatic and surgical wounds.[4]

However, the microbiological challenges associated with acute traumatic wounds are varied dependent on the mechanism of injury.[5] Blast and gunshot injuries in particular are associated with high levels of infection, up to 26% has been reported and are usually due to the presence of foreign bodies within the wounded tissues as well as anaerobic bacteria and fungal species not usually found in superficial or chronic wounds.[6] Infection in trauma wounds is also associated with poorer cosmetic outcomes and a greater need for scar revision surgery which carry additional risks.[7] In addition to the impacts on the functionality of the affected tissues and the risk of infection, traumatic wounds are associated with psychological stress and in extreme cases stress disorders.[8] These stress responses to traumatic wounding can paradoxically worsen wound healing outcomes and increase the probability of infection.[9]

**Wound cleansing and infection**

Wound infection is considered to be the presence of microbes in sufficient numbers or virulence to trigger a local or systemic host response.[1] Wound cleansing remains part of standard practice in the care of acute wounds due to its widely perceived ability to reduce the probability of infection developing.[10] The value of wound cleansing has been reviewed extensively in recent years highlighting gaps in the literature base as well as the identification of issues affecting the relative value of wound cleansing in different wound presentations.[11] According to a recent consensus document from the International Wound

Infection Institute wound infection can be defined as '*the presence of microbes in sufficient numbers or virulence to cause a host response locally and or systemically*'.[1] Diagnosis of infection is based primarily on clinical signs and symptoms in combination with data from microbiological investigations, the results of wound swabs alone are insufficient to diagnose infection. The diagnosis of wound infection remains challenging due to limited assessment and diagnostic processes.[1]

A recent study investigating the differences in the assessment of wound infection when biopsy culture results were available versus wound swabs, reported that the culture method did not affect the assessment outcomes of experts significantly (up to 96% agreement) however, agreement between expert assessments was at best 42.2% when biopsy data was available.[12] This demonstrates the potential for subjective assessments to undermine outcome data relating to wound infection. This issue important to consider in acute traumatic wounds due to the unique microbiological challenges associated with them in clinical practice.[13] For example, in a review on the management of traumatic wounds it was reported that sharp inflicted wounds caused by blades or glass were highly resistant to infection due to the limited area of contact between the causative material and the wound tissues.[10] Whereas wounds resulting from crush injuries were associated with compromised vasculature and therefore more likely to become infected.[10] Ultimately, these factors are essential to consider when evaluating the value of wound cleansing; crucially the comparison of cleaning solutions in wounds that are aetiologically associated with a low risk for infection are unlikely to illustrate the potential value of cleansing on infection rates.[13]

**Cleansing solution choice and wound infection**

According to an early review on wound cleansing, infection rates are a common primary outcome measure of studies investigating the value of wound cleansing solutions.[2] The authors of this review reported on trials investigating a mixture of tap water vs saline and saline vs antiseptic solutions including iodine and pluronic f-68 used to clean acute traumatic wounds. Notably not all the studies were conducted in humans which may limit the extrapolation of results from those trials into human subjects. The results of multiple trials investigating the value of irrigation using normal saline compared to no irrigation or irrigation using the antiseptics 1% povidone iodine or pluronic f-68, yielded no statistically significant differences in infection rates ($p>0.05$).[2] The results of this review suggested that the cleaning solution used is not a major factor influencing infection outcomes in

patients with traumatic wounds. However, the authors acknowledged that many of the trials included did not use control groups or describe the nature of the wounds studied and used unclear definitions of wound infection.[2] Ultimately this study did not indicate any clear benefit to using antiseptic cleaning solution for the purposes of treating or preventing infection.

A later review reported on the relative value of different antiseptic cleaning solutions and their impact on pathogenic microbes.[14] Such cleaning solutions have gained popularity and widespread use primarily due to their demonstrable effects against microbes and the low risk of antimicrobial resistance.[15] According to Atiyeh et al[14] many antiseptics have limited action against certain microbial agents, specifically few antiseptics are effective against gram negative bacteria, fungus and bacterial spores. This may indicate potential limitations of cleaning with certain antiseptics in the context of acute traumatic wounds which may be contaminated with microbes unsusceptible to common antiseptics.[10] Notably a recent review of combat-related trauma wounds found that 61% of wound infections were polymicrobial and gram-negative bacteria were predominant among these infections.[16] Ultimately it is unclear what impact the use of an antiseptic that is selective for particular types of microbe may have on the overall wound flora and whether this is conducive to a reduction in infection risk or whether it may instead be selective of virulent microbial species.[14]

More recent reviews on the nature of antiseptic resistance have suggested that due to the multimodal action of antiseptics little research priority is given to the surveillance of microbial resistance or clinical efficacy of these agents which may be at the cost of future outcomes in infected wounds.[17,18] Concerns about antiseptic resistance have already come to fruition with bacteria showing resistance to chlorhexidine.[19] In addition, chlorhexidine has been demonstrated to create genetic mutations which create secondary resistance to antibiotics used systemically which has clear negative implications for outcomes in patients with infected wounds.[20] The development of resistance in these cases has been attributed to the use of varied concentrations of chlorhexidine dependent on the context for which it is used including mouthwash, wound cleansing or skin preparation.[20]

Two recent studies have attempted to provide clarity on the efficacy of wound cleansing with antiseptics in improving infection outcomes in traumatic wounds.[21,22] A randomized controlled trial investigated the efficacy of polyhexamethylene biguanide (PHMB)

compared with Ringers solution in the cleansing of acute traumatic wounds.[22] The trial had strong elements including double-blinding and a statistically powered sample size however there were methodological flaws limiting its overall applicability to clinical practice or indication of the benefits of wound cleansing using PHMB. For example, the patients included were not followed until wound closure and ultimately the development or otherwise of wound infection which limits any conclusion regarding the efficacy of PHMB in reducing infection incidence despite the statistically significant log10 reductions in bacteria ($p<0.001$).[22] Although the reduction in bacteria observed over the one-hour trial period may suggest a reduction in wound infection, earlier reviews have indicated that this may not necessarily lead to improved outcomes.[2] Confounding this the solutions were applied to the wounds in the trial via soaked sterile cotton compresses and left on the wounds for one hour, this is atypical of routine clinical practice which states that antiseptics should be allowed around 15 minutes contact time with the wound tissues following thorough wetting.[23] Ultimately it remains unclear what impact cleansing using antiseptics may have on infection rates due to the lack of long term follow up or repeated swabs to indicate if the observed log 10 reductions in bacteria are sustained throughout treatment or are a short-term effect. Some authors suggest that dressing materials containing antiseptics may be more effective as they allow greater contact time with the wound tissues.[23] This suggests that wound cleansing using antiseptics may be redundant in cases where antiseptic dressing materials are in use; with wound cleansing only acting as a process to remove devitalised tissue and debris in the wound bed which may hinder healing rather than being an active part of infection prevention or treatment.

**Benefits and harms of wound irrigation**

An early study reported that clay soil in wounds may interact with antibiotics limiting their bactericidal effects.[24] This observation stimulated research into the ability of pressurised irrigation using cleansing solutions to remove soil and bacteria from wounds to prevent and manage infection.[10] According to a later study ‘high pressure’ (7psi) irrigation can remove 80% of soil infection-potentiating factors from wounds however, this may result in oedema making the wound unsuitable for primary closure and therefore at a potentially increased risk of infection. These assertions are supported by the findings of an earlier review which concluded that irrigation using saline at pressures between 5-8psi can reduce the bacterial count in both animal and human models.[2] However, the use of the same irrigation pressures and solutions did not translate into statistically or clinically

significant reduction of infection rates in real traumatic wounds.[2] This may be explained in part by a study which identified that there is large variation in irrigation pressures when nurses were observed using the same technique. Most of the sample (n=14) achieved lower than optimum pressure, with 13 achieving optimal pressure and 1 achieving above the optimum.[25] This indicates the risk of harm to patients receiving wound irrigation who may receive irrigation pressures (8psi<) potentially leading to oedema or alternatively, inadequate pressure to remove debris from the wound. It has also been suggested that higher pressures can potentially propagate bacteria deeper into unstable wound beds thereby creating infection deeper in the tissues although there is no empirical evidence to support this.[26]

A recent consensus study by the Academy of Emergency Medicine recommended that all acute traumatic injuries 'at high risk' of infection should be treated irrigated with saline and treated using systemic prophylactic antibiotics.[27] This may ultimately mask the benefits or harms of wound irrigation as it would be unclear whether the irrigation or the antimicrobial therapy contributed to the presence or absence of infection. This indicates that current clinical practice may potentially compromise effective observation of the benefits of wound irrigation. However, there is currently little data to confirm this.

A longitudinal cohort study sought to provide data on the longer-term impact of wound irrigation on clinical outcomes, conducted over 30 years comparing wound outcomes following irrigation using PHMB, Ringers solution, povidone-iodine and hydrogen peroxide.[21] This study had many strengths including a large sample (n=7104) and the investigation of several antiseptic solutions. The results showed that irrigation using 0.04% PHMB lead to statistically significantly reduced incidence of surgical site infection ($p<0.001$) (SSI). However, this conclusion is potentially flawed for two key reasons. PHMB was the final irrigant to be tested up until the end of the trial in 2005; the reductions in SSI may therefore be a result of improved surgical, medical and nursing care throughout the 30-year period. Secondly, PHMB was tested on 46% (n=3264) of the study participants compared to 9% (n=645) for ringers or hydrogen peroxide (n=643) indicating a methodological flaw in the statistical comparison of outcomes. It is well established that unbiased statistical analysis is best achieved in groups that are equal in size and produced via a randomisation process to provide evidence of a true cause and effect relationship between intervention and outcome.[28]

The authors also did not account for differences in surgical technique, the wound care provided by non-surgeons or the impact of varied definitions of infection used to assess

the trial participants over the study period.[21] Statistical analyses of longitudinal studies can be compromised where the analyses do not adopt a multivariate methodology to account for the numerous factors impacting the outcomes observed.[29]

The cost of irrigation equipment also needs to be considered, in addition to the costs of staff training which may make irrigation a non-cost-effective cleansing method especially given the poor evidence supporting its use. It is also important to consider patient experience including the potential for pain when using higher pressures for irrigation, however there is currently little literature looking at patient experience as an outcome measure in studies on wound irrigation with most studies focussing on infection or healing outcomes. Finally, the temperature of the irrigant may impact the overall healing of the wound, lower temperatures are associated with decreased perfusion and therefore reduced oxygen levels and fewer leucocytes which may allow the proliferation of bacteria.[30] The harms and benefits of differing wound irrigation pressures can be seen in table 1.

**Cytotoxic effects of antiseptics**

An experimental study investigating the toxicity of various commonly used wound antiseptics demonstrated the deleterious impact of these cleaning agents on vital cellular processes in wound healing.[31] Notably it was demonstrated that iodine-based antiseptics (10% concentration) and hydrogen peroxide (3% concentration) were highly toxic to fibroblasts and keratinocytes which has implications for the regulation of all four phases of wound healing.[32] This was subsequently supported in a clinical study which reported that 10% iodine and 3% hydrogen peroxide had been observed to significantly delay healing and created wound environments comparable to chronic wounds in a prolonged inflammatory phase.[33] Notably silver based solutions were observed to create potentially beneficial increases in proliferation at bactericidal levels.[33] However, a more recent review on the use of silver nanoparticles in wound care suggests that a lack of standardisation in cytotoxicity bioassays may cause variation in the results of studies comparing the toxicity of antiseptic wound products.[34] Ultimately the impact of wound cleaning solutions on wound healing depends on the concentration, exposure time and mechanism of cleaning used by the clinician which can vary significantly between health professionals.[30]

The relative harms and benefits of different antiseptic solutions can be seen in table 2.

## Conclusion

Cleansing of acute wound in clinical practice remains heavily dependent on tradition rather than robust clinical evidence.[11] The evidence base supporting the benefits of wound cleansing remains limited due to methodological and pragmatic issues in obtaining definitive data on the efficacy of wound cleansing agents and techniques. Specifically, studies frequently do not control for wound aetiology which is crucial in measuring common primary outcomes in wound cleansing studies.[10] Confounding this the observation of wound cleansing on infection rates may be limited by the frequent concurrent use of systemic antibiotics however this does follow current consensus.[27]

Studies have sought to demonstrate the influence of antiseptic solutions on key wound healing processes reporting that iodine and hydrogen peroxide inhibit the effective function of fibroblasts and keratinocytes indicating a potential harm associated with cleansing using antiseptics.[31] This harm was later demonstrated by a clinical study reporting delayed healing in wounds cleansed using iodine and hydrogen peroxide.[33]

There remains little consensus on which cleaning technique should be used although studies have demonstrated the risks associated with irrigation and the inconsistencies in irrigation pressures used in clinical practice.[10,25] However, the evidence suggests if optimal irrigation pressures are achieved (7psi) up to 80% of soil infection-potentiating factors may be removed from the wound tissues thus potentially reducing infection risk.[10] This indicates the need for careful risk assessment and attention to irrigation techniques to ensure beneficial outcomes in patients receiving irrigation.

Future studies should focus on establishing the relative benefits of different cleansing solutions and techniques using methodologies less conducive to bias using wound infection as a primary outcome measure. Establishing the most effective use of antiseptic cleansing solutions may also help reduce further antimicrobial resistance as observed in recent studies.[19,20]

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Table 1. Potential harms/benefits of irrigant pressure on wound healing/infection

| **Irrigation Pressure** | **Potential Benefits** | **Potential Harms** |
|---|---|---|
| <7 psi | • Removal of debris from wound bed<br>• Unlikely to cause oedema[2,10] | • Insufficient pressure to overcome bacterial bonds with wound tissue[10]<br>• Potential cooling of wound bed leading to hypoxia and immuocompromise[30]<br>• Costs of equipment/training |
| >7psi | • Removal of debris from wound bed<br>• Removal of 80% of infection-potentiating bacteria[10] | • Little evidence of statistically or clinically significant reductions in infection[2,21]<br>• Oedema in tissues[10]<br>• Propagation of bacteria deeper into wound tissues[26]<br>• Potential cooling of wound bed leading to hypoxia and immuocompromise[30]<br>• Costs of equipment/training<br>• Pain |

Table 2. Potential harms/benefits of different irrigant solutions on wound healing/infection

| **Choice of irrigant** | **Potential Benefits** | **Potential Harms** |
|---|---|---|
| Water | • Cheap/accessible<br>• Non-cytotoxic[2] | None[2] |
| Saline | • Cheap/accessible<br>• Non-cytotoxic[2] | • Not sterile[2] |
| 1% povidone iodine<br>Pluroninc f-68<br>Chlorhexidine<br>Polyhexa-methylene biguanide (PHMB) | • Reduction in bioburden[2] | • Cytotoxicity[1,2]<br>• More expensive than saline/water<br>• May be ineffective in polymicrobial infections often present in traumatic wounds[16]<br>• Poor evidence indicating ability to prevent/treat infection[2]<br>• Evidence of bacterial resistance in Chlorhexidine[19] ,potentially contributing to resistance in other antibiotic drugs[20] |