

REVIEW PAPER

The effectiveness of cleansing solutions for wound treatment: a systematic review

A eficácia das soluções de limpeza para o tratamento de feridas: uma revisão sistemática
La eficacia de las soluciones de limpieza para el tratamiento de heridas: una revisión sistemática

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Abstract

Background: There is a consensus that wound cleansing reduces infection rates. There is, however, some debate in clinical circles about the potential advantages and disadvantages of cleansing wounds.

Objectives: To identify and synthesize the best available evidence on the effectiveness of cleansing solutions for wound treatment.

Review method: This systematic review followed the Joanna Briggs Institute methodology and included studies that considered patients with chronic and acute wounds. Critical appraisal, extraction and synthesis of data were performed by two independent reviewers.

Results: Three randomized clinical trials ($n=718$) were included and the results of the meta-analysis showed no difference in the wound infection for the Tap Water versus Sterile Saline comparison ($OR=0,79$; $95\% CI=0,36-1,72$; $p=0,55$). For acute wounds, the odds ratio was $0,98$ ($95\% CI=0,43-2,25$).

Conclusion: There is no evidence that using tap water to cleanse acute and chronic wounds in adults increases infection or healing rates. There may be a trend towards a lower wound infection rate when povidone-iodine is used in surgical wounds.

Keywords: wound infection; wound healing; review; meta-analysis; sodium chloride; therapeutic irrigation

Resumo

Contexto: Existe consenso de que a limpeza de feridas reduz as taxas de infeção. Contudo, há algum debate na praxis clínica sobre as suas potenciais vantagens e desvantagens.

Objetivos: Identificar e sintetizar as melhores evidências sobre a eficácia de soluções de limpeza para o tratamento de feridas.

Método de Revisão: Seguiu-se a metodologia do Joanna Briggs Institute. Foram incluídos estudos que consideravam doentes com feridas crónicas e agudas. Dois revisores independentes realizaram a avaliação crítica, a extração e a síntese dos dados.

Resultados: Foram incluídos 3 ensaios clínicos aleatorizados ($n=718$) e os resultados da meta-análise mostraram não existirem diferenças nas taxas de infeções quando se compara a água corrente com o soro fisiológico ($OR=0,79$; $IC\ 95\%=0,36-1,72$; $p=0,55$). Para as feridas agudas, o *odds ratio* foi de $0,98$ ($IC\ 95\%=0,43-2,25$).

Conclusão: Não há evidências de que a utilização de água corrente para limpar feridas em adultos aumente as taxas de infeção/cicatrização. Pode existir uma diminuição das taxas de infeção quando é utilizada iodopovidona nas feridas de origem cirúrgica.

Palavras-chave: infeção dos ferimentos; cicatrização; revisão; meta-análise; cloreto de sódio; irrigação terapêutica

Resumen

Marco contextual: Existe consenso en que la limpieza de heridas reduce las tasas de infección. Sin embargo, existe un debate sobre sus potenciales ventajas y desventajas en la práctica clínica.

Objetivos: Identificar y sintetizar las mejores pruebas sobre la eficacia de las soluciones de limpieza para el tratamiento de heridas.

Metodología: Se siguió la metodología del Instituto Joanna Briggs y se incluyeron estudios que consideraron a los enfermos con heridas crónicas y agudas. Dos revisores independientes realizaron el análisis crítico, la extracción y la síntesis de los datos.

Resultados: Se incluyeron 3 ensayos clínicos aleatorios ($n=718$). Los resultados del metanálisis mostraron que no existen diferencias en las tasas de infecciones cuando se compara el agua potable con el suero fisiológico ($OR=0,79$; $IC\ 95\%=0,36-1,72$; $p=0,55$). Para las heridas agudas, la razón de momios fue $0,98$ ($IC\ 95\%=0,43-2,25$).

Conclusión: No hay pruebas de que el uso de agua potable para limpiar heridas en adultos aumente las tasas de infección/cicatrización. Puede existir una reducción en las tasas de infección cuando se utiliza povidona yodada en las heridas quirúrgicas.

Palabras clave: infección de heridas; cicatrización; revisión; metanálisis; cloruro de sodio; irrigación terapéutica

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Introduction

The management of chronic and acute wounds has changed significantly over the last decade. The practice of wound cleansing or antiseptic management has a dichotomous history anchored in tradition and science. It is an integral part of the management of both acute and chronic wounds (Atiyeh, Dibo, & Hayek, 2009; Khan & Naqvi, 2006).

Although there is a consensus that wound cleansing reduces infection rates (Khan & Naqvi, 2006) there is some debate in clinical circles about the potential advantages and disadvantages of cleansing wounds. This practice may not always be necessary as the exudate itself may contain growth factors and chemokines which contribute to wound healing (Atiyeh et al., 2009). Until further research establishes its demerits, cleansing will continue to remain an integral part of the wound management process. Despite this, there is a lack of strong evidence to indicate that cleansing wounds per se increases healing or reduces infection (Fernandez, Griffiths, & Ussia, 2008).

This reality is also intensified by the lack of a diagnostic test which would allow healthcare professionals to identify the bacterial load in the wound that is capable of causing wound infections. In addition, the situation is further complicated by studies showing that bacterial colonization of the wound does not necessarily indicate infection and that there is no need to remove bacteria in the absence of clinical signs of infection (Khan & Naqvi, 2006).

Nevertheless, several studies have recommended various cleansing agents for their supposed therapeutic value. It has also been suggested that wound cleansing helps to optimize the healing environment and decrease the potential for infection (Moscati, Mayrose, Fincher, & Jehle, 1998; Moscati, Mayrose, Reardon, Janicke, & Jehle, 2007). It loosens and washes away cellular debris such as bacteria, exudate, purulent material, and residual topical agents from previous dressings (Baranoski & Ayello, 2006). However, in practice, the decisions on which cleansing solutions to use have been based on experience, service policy and personal preference.

In general, the characteristics of an ideal wound cleansing solution are: non-toxic to human tissues; remains effective in the presence of organic material; reduces the number of micro-organisms; causes

no sensitivity reactions; is widely available; is cost-effective; and is stable with a long shelf life (Flanagan, 1997).

Normal saline fulfils all the criteria given above. Normal saline (0.9%) is the favoured wound cleansing solution because it is an isotonic solution and does not interfere with the normal healing process, damage tissue, cause sensitization or allergies or alter the normal bacterial flora of the skin (which would possibly allow the growth of more virulent organisms) (Fernandez et al., 2008; Joanna Briggs Institute [JBI], 2006; Lawrence, 1997).

Tap water is also recommended and has the advantages of being efficient, cost-effective and accessible (Angeras, Brandberg, Falk, & Seeman, 1991; Fernandez et al., 2008). There is now increasing recognition of the safe use of tap water for wound irrigation, especially chronic wounds, and it is worth considering it as an acceptable alternative to other products. Indeed, Flanagan (1997) argues that water has been used for centuries to treat wounds without any reported detrimental effects. Despite this, the two most commonly cited concerns regarding tap water are the possible infection risk and the fact that it is not an isotonic solution.

In this matter, several studies have found no significant difference between the infection and healing rates in wounds irrigated with normal saline or tap water (Angeras et al., 1991; Griffiths, Fernandez, & Ussia, 2001; Moscati et al., 1998). In fact, Angeras et al. (1991) found a higher infection rate in those wounds irrigated with saline. However, clinicians have been cautioned against using tap water to cleanse wounds that have exposed bone or tendon, in which case normal saline is recommended (Fernandez et al., 2008; Lindholm, Bergsten, & Berglund, 1999).

On the other hand, there is no consensus amongst wound care authorities on the advantages of using sterile solutions over non-sterile solutions.

Research has also established that the use of antiseptic solutions may compromise the healing process (Thomas et al., 2009) and, as a result, the use of normal saline as a cleansing solution is widely recommended (Lawrence, 1997).

In fact, preparations with antiseptic properties have also been traditionally used since the earliest times; however, published research has suggested that antiseptic solutions may hinder the healing process. For this reason, several guidelines and various studies

discourage the use of antiseptic solutions, such as povidone iodine, hydrogen peroxide, or sodium hypochlorite, because, in most instances, they do not effectively promote good wound healing. In contrast, most studies showed that their use impaired wound healing, reduced wound strength, or increased infection (JBI, 2006; Kramer, 1999).

The controversy surrounding the use of antiseptics prompted the development of guidelines for the use of antiseptics by wound care experts. These guidelines have also resulted in changes in hospital practice (Fernandez et al., 2008). Concerns are also mounting relating to the use of these products, and the development of bacterial resistance and the possible systemic absorption of antiseptics. In most cases, the selection of these products does not have a solid scientific basis.

Still, new cleansing solutions are emerging. Most recently, the new cleansing solution based on polyhexanide and betaine has emerged as a credible alternative to currently available products (Kaehn & Eberlein, 2008; Santos & Silva, 2011). This particular solution is effective for treating colonized/infected wounds, providing optimal conditions for wound healing, reducing healing time, signs of inflammation and/or infection/colonization, and providing greater odour control. It has a painless application and is especially indicated for the treatment of chronic and hard-to-heal wounds (Kaehn & Eberlein, 2008; Santos & Silva, 2011).

An extensive literature review identified several systematic reviews and best practice guidelines. However, despite these publications, rigorous research is still needed to support the identified recommendations (Fernandez et al., 2008; JBI, 2006; Santos & Silva, 2011).

Remarkable advances have been made in wound care and treatment. Despite this, numerous factors impact on this science; thus, managing wounds will continue to be a healthcare concern. Increased life expectancy, frequency of wound development among older people, increased prevalence of diabetes, and considerable monetary and lifestyle costs make the appropriate cost-effective management of wounds an international healthcare imperative. Both acute

care and community-based nurses are in a unique position to provide evidence-based education and interventions to their peers and consumers. Therefore, the purpose of this systematic review is to investigate the effectiveness of cleansing solutions for wound treatment in clinical practice.

The objective of this review is to identify and synthesize the best available evidence on the effectiveness of cleansing solutions for wound treatment in clinical practice and compare the effectiveness of different cleansing solutions in infection and wound healing rates. More specifically, the review focused on the following questions: Does the effectiveness of different cleansing solutions influence infection and wound healing rates?; Which cleansing solution is more effective for reducing wound infection rates?; Which cleansing solution is more effective for increasing wound healing rates?; Is the effectiveness of cleansing solutions affected by wound aetiology?

Systematic Review Method

The review methodology followed the JBI Manual (JBI, 2014). The full version of this systematic review report was published in JBI Database of Systematic Reviews and Implementation Reports (Queirós et al., 2014).

Research Strategy and Identification of the Studies

The search strategy included both published and unpublished studies. A three-step search strategy was used in this review. An initial limited search of MEDLINE and CINAHL was undertaken, followed by an analysis of text words in the titles and abstracts and the index terms used to describe the article. A second search using all identified keywords and index terms was then undertaken across all included databases (Table 1). Thirdly, the reference list of all identified reports and articles was searched for additional studies. Studies published in English, Spanish and Portuguese were considered for inclusion in this review. The search strategy per database encompassed the period between January 1990 and January 2013.

Table 1

Search formula and limiters used by database and the respective search results by database

Database (Results by database)	Search Formula and Limiters
<ul style="list-style-type: none"> - Academic Search Complete (335) - CINAHL (534) - MEDLINE (789) - MediciLatina (6) 	(TI wound*) AND (AB infect* OR AB heal* OR AB clean*) AND (AB irrigat* OR AB bath* OR AB shower* OR AB water* OR AB "sodium chloride" OR AB detergent* OR AB povidone-iodine OR AB hydrotherapy OR AB chlorhexidine) Published Date: 19900101-20131231 Language: English, Portuguese, Spanish
<ul style="list-style-type: none"> - Cochrane Central Register of Controlled Trials (147) - Cochrane database of systematic review (12) - Nursing & Allied Health Collection: Comprehensive (63) 	AB (water OR "sodium chloride" OR polihexanide OR detergents OR povidone-iodine OR chlorhexidine OR hydrotherapy OR shower OR bath OR irrigate) AND AB (infect* OR AB heal* OR AB clean*) AND AB wound* Published Date: 19900101-20131231 Language: English, Portuguese, Spanish
<ul style="list-style-type: none"> - Elsevier, via b-on (0) 	TI wound TI ferida
<ul style="list-style-type: none"> - Scopus (1840) 	(TITLE(wound*) AND TITLE-ABS-KEY(infect* OR heal* OR clean*) AND TITLE-ABS-KEY(irrigat* OR bath* OR shower* OR water* OR "sodium chloride" OR detergent* OR povidone-iodine OR hydrotherapy OR chlorhexidine OR polihexanide)) AND SUBJAREA(mult OR agri OR bioc OR immu OR neur OR phar OR mult OR medi OR nurs OR vete OR dent OR heal) AND PUBYEAR > 1989 AND (LIMIT-TO(LANGUAGE, "English") OR LIMIT-TO(LANGUAGE, "Spanish") OR LIMIT-TO(LANGUAGE, "Portuguese"))
<ul style="list-style-type: none"> - Scielo (71) 	Words in the Abstract wound* AND (heal* OR infect* OR clean*) AND (chlorhexidine OR hydrotherapy OR povidone-iodine OR detergent* OR "sodium chloride" OR water* OR shower* OR bath* OR irrigat* OR polihexanide OR polyhexanide)
<ul style="list-style-type: none"> - Lilacs (136) 	Words in the Title, Abstract, Subject (wound*) AND (heal* OR infect* OR clean*) AND (chlorhexidine OR hydrotherapy OR povidone-iodine OR detergent* OR "sodium chloride" OR water* OR shower* OR bath* OR irrigat* OR polihexanide OR polyhexanide) Language: English, Portuguese, Spanish
<ul style="list-style-type: none"> - JBI Library (4) 	TI (wound*) AND AB (infect* OR AB heal* OR AB clean*)
<ul style="list-style-type: none"> - ACP online (55) - ACP Hospitalist (18) - ACP Internist (10) 	with all of the words » "wound cleansing"
<ul style="list-style-type: none"> - 'Grey Literature Report' from New York Academy of Medicine (0) 	Words in the Full text wound* AND (infect* OR heal* OR clean*) Published Date from: 1990-2013
<ul style="list-style-type: none"> - Clinical trials via Mednar (100) - National Library of Medicine via Mednar (0) - National Institute of Nursing Research via Mednar (10) 	Keyword: infect* OR heal* OR clean* / Title: wound* / Beginning Date Range: 1990-01-01 / Ending Date Range: 2013-12-31
<ul style="list-style-type: none"> - BioMed Central via Scirus (49) 	title:wound* AND All text: (infect* OR heal* OR clean*) 1990-2013
<ul style="list-style-type: none"> - Health & Wellness Resource Center (64) - Health Collection National Library of Australia Trove service (151) 	title:(wound*) subject: (infect* OR heal* OR clean*) date:[1990 TO 2013]
<ul style="list-style-type: none"> - ProQuest – Nursing and Allied Health Source Dissertations (79) 	ti(wound*) AND ab (infect* OR heal* OR clean*) AND ab (bath* OR shower* OR water* OR "sodium chloride" OR detergent* OR povidone-iodine OR hydrotherapy OR chlorhexidine)
<ul style="list-style-type: none"> - Banco de teses da CAPES (0) 	Subject = wound*; Start Year = 1990
<ul style="list-style-type: none"> - RCAAP – Repositório Científico de Acesso Aberto de Portugal (0) 	Title (wound*) AND full text (heal* OR infect* OR clean*) Language: English, Portuguese, Spanish

- Embase (843)	(wound*:ti) AND (infect*:ab OR heal*:ab OR clean*:ab) AND (irrigat*:ab OR bath*:ab OR shower*:ab OR water*:ab OR 'sodium chloride':ab OR 'povidone iodine':ab OR hydrotherapy:ab OR chlorhexidine:ab OR detergent*:ab) AND ([english]/lim OR [portuguese]/lim OR [spanish]/lim) AND [embase]/lim AND [1990-2013]/py
- Health Technology Assessment database (2)	(AB infect* OR AB clean* OR AB heal*) AND AB wound* AND (AB (water OR "sodium chloride" OR pol?hexanide OR detergents OR povidone-iodine OR chlorhexidine OR hydrotherapy OR shower OR bath OR irrigate))

Assessing the Methodological Quality of the Studies

Methodological quality was assessed by two independent reviewers using the standardized critical appraisal instrument from the JBI Meta-Analysis of Statistics Assessment and Review Instrument (MAStARI).

Data Extraction

Data were extracted by two independent reviewers using the JBI data extraction form for experimental studies and included participant characteristics, intervention characteristics and study methods.

Data Synthesis

The impact of interventions on infection and healing rates was described in a narrative format within each

intervention. Data from two studies were pooled in a meta-analysis.

Presentation of Results

The search identified 5346 potentially relevant studies. Of these, 2089 were excluded as duplicates; of the remaining 3257, 3160 were excluded after title and abstract assessment; 89 out of the 97 remaining articles were excluded for not fulfilling the inclusion criteria after full text reading. The methodological quality of the remaining eight studies was assessed. Finally, a total of three original articles, which included 718 patients, were included in this review. See Figure 1 for the process described above.

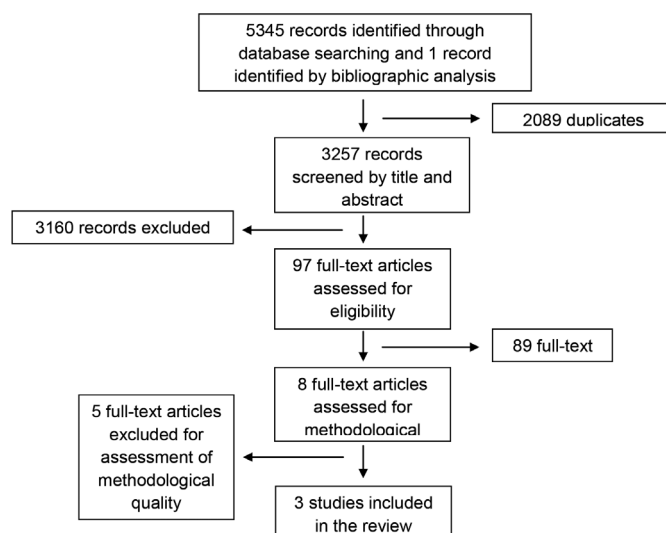


Figure 1. Flowchart of study selection process.

Two independent reviewers assessed for methodological quality the eight studies. Cut-off point for inclusion of a study in the review defined by authors was: "yes" answer to at least six questions in the standardized critical appraisal instrument from the JBI-MAStARI to be included in the review. There was general agreement among the reviewers to include the three final studies

in this review. Two studies (Moscati et al., 2007; Walker & Smith, 2013) demonstrated similarity at baseline between both groups (experimental and control) related to participants' demographic characteristics. Sample sizes of the studies included in this review ranged from 35 to 634 participants. The information related to true randomization is always unclear.

Participant blinding was unclear (Walker & Smith, 2013) or not addressed (Moscati et al., 2007) in two studies. The three studies were randomized clinical trials (Griffiths et al., 2001; Moscati et al., 2007; Walker & Smith, 2013). The timeframe for the included studies was 2001-2013. Additional information about the venue/country where the study was developed was requested from the authors of two included studies (Moscati et al., 2007; Walker & Smith, 2013). One

study was conducted in Buffalo and Minneapolis in the USA (Moscati et al., 2007); one was a study in New South Wales, Australia (Griffiths et al., 2001); and the remaining study was conducted in Hobart, Australia (Walker & Smith, 2013).

Details related to the methods, participants' characteristics, interventions, conclusions and limitations of the included studies are presented in Table 2.

Table 2

Methods, participants' characteristics, interventions, conclusions and limitations of the included studies

Study	Methods and Participants	Intervention A	Intervention B	Conclusions and limitations
Moscati et al., 2007	RCT	Wound irrigation with sterile saline was undertaken by the provider. Wounds were irrigated with a 35 ml syringe using a splash guard.	Wound irrigation with tap water was undertaken by the provider. Wounds were irrigated for a minimum of 2 minutes.	The results showed equivalent rates of wound infection using either tap water or sterile saline. However, compared with sterile saline, tap water for wound irrigation is more cost-effective and appears to be equally safe and efficacious.
	People older than 17 years and with uncomplicated acute skin lacerations requiring staple or suture repair	Standard protocol in both interventions After irrigation, all wound care including closure was in the standard fashion at the discretion of the treating clinician. No prophylactic antibiotics were given. Use of any skin preparations (e.g. povidine-iodine) on the area surrounding the wound, but not inside the wound, was at the discretion of the treating clinician.		Despite these results, there are same limitations. The process of randomization is unclear, as well as if those assessing outcomes were blind to the treatment allocation. The participants were not blind to treatment allocation and the outcomes of people who withdrew were not described and included in the analysis.
Griffiths et al., 2001	RCT	Wound irrigation with sterile normal saline using a 30ml syringe and 20G cannula for a six-week period. Both solutions were delivered at room temperature.	Wound irrigation with tap water using a 30ml syringe and 20G cannula. Both solutions were delivered at room temperature.	The authors concluded that the results support the use of tap water as a wound cleansing agent. The authors believe it will save nursing time, reduce costs and increase patients' participation in their care.
	Patients with acute or chronic non-sutured wounds (grade II or III according to Carville's definition)	Standard protocol in both interventions To maintain uniformity, a standard protocol was followed after the existing dressing was removed. Excess exudate was wiped with gauze, and the wound was irrigated with the solution from the bottle marked with the participant's name. A 30ml syringe and 20G cannula were used. If the patient had more than one wound, all wounds were cleansed with the allocated solution.		However, it is unclear through the process of randomization and if control and treatment groups were comparable at baseline.

		Saline-soaked gauze placed in the groin wound.	Betadine-soaked gauze placed in the groin wound.
		Standard protocol in both interventions All patients had a preoperative venous duplex scan to plan surgery. All patients were planned for day case surgery. Upon admission, they received the usual preoperative work up, including record of their weight and height. Their past medical history was recorded. All patients received a preoperative dose of low-molecular-weight heparin (Clexane 20 mg; SanofiAventis, Macquarie Park, Australia) as thromboembolic prophylaxis. No hair removal was used pre- or intraoperatively. All procedures were performed under standard general anesthetic. The groin area and legs were prepared for surgery aseptically using aqueous betadine. No prophylactic antibiotics were used in this study. The surgical procedure in the groin was performed in a standard manner to expose the saphenofemoral junction through a transverse incision by a consultant vascular surgeon or a surgical registrar under direct supervision of the consultant surgeon. The saphenofemoral junction was divided and ligated with an absorbable braided transfixion suture (Vicryl; Ethicon, North Ryde, Australia). All tributaries to the junction were divided and ligated with the same suture material. In all cases, the great saphenous vein was then pin-stripped to the level of the knee.	
Walker and Smith, 2013	RCT Patients undergoing primary saphenofemoral ligation for varicose veins associated with skin changes	This study supports the use of povidone-iodine in reducing wound infections, a particular problem in vascular surgery, and especially procedures in the groin area. There was more than 50% reduction in the risk of a groin wound infection when a povidone-iodine-soaked gauze was placed in the groin wound compared to that with a saline-soaked Gauze. It is unclear through the process of randomization if the participants were blind to treatment allocation and if the allocation to treatment groups was concealed from the allocator. The outcomes of people who withdrew were not described and included in the analysis.	

Results of the Meta-Analysis of Quantitative Research Findings

Only two of the three studies (Griffiths et al., 2001; Moscati et al., 2007) included in data synthesis were eligible for meta-analysis, in a total of 683 patients. Both studies assessed the effectiveness of tap water versus sterile saline and compared wound infection rates. However, Griffiths et al. (2001) also presented the healing rates. In each study, intervention and control groups were compared at baseline and both studies were similar. The only relevant difference between studies was the wounds aetiology. Due to this variation, we performed a meta-analysis by subgroups (Figure 2) and the test for subgroup differences showed a low heterogeneity (heterogeneity Chi squared = 1.45, $p = 0.23$; $I^2 = 31.1\%$), whereby the meta-analytic integration of studies can be accepted (Higgins, Thompson, Deeks, & Altman, 2003).

For acute wounds, the odds ratio of developing an infection when cleansing with tap water compared with saline was 0.98 (95% CI: 0.43, 2.25).

Tap water was more effective than saline in reducing the infection rate in adults with acute and chronic wounds (OR = 0.14; 95% CI: 0.01, 2.92).

The overall analysis estimated that there are no statistically significant differences ($z = 0.59$; $p = 0.55$) between cleansing with tap water and with sterile saline regarding wound infection rates in acute and chronic wounds. Nevertheless, we can still point out that there was a beneficial effect on the tap water group regarding the prevention of infection rates which is supported by the meta-analytic results (OR = 0.79; 95% CI: 0.36, 1.72).

It should also be noted that the study of Moscati et al. (2007) has a higher weight (77.6%) than Griffiths et al. (2001; 22.4%).

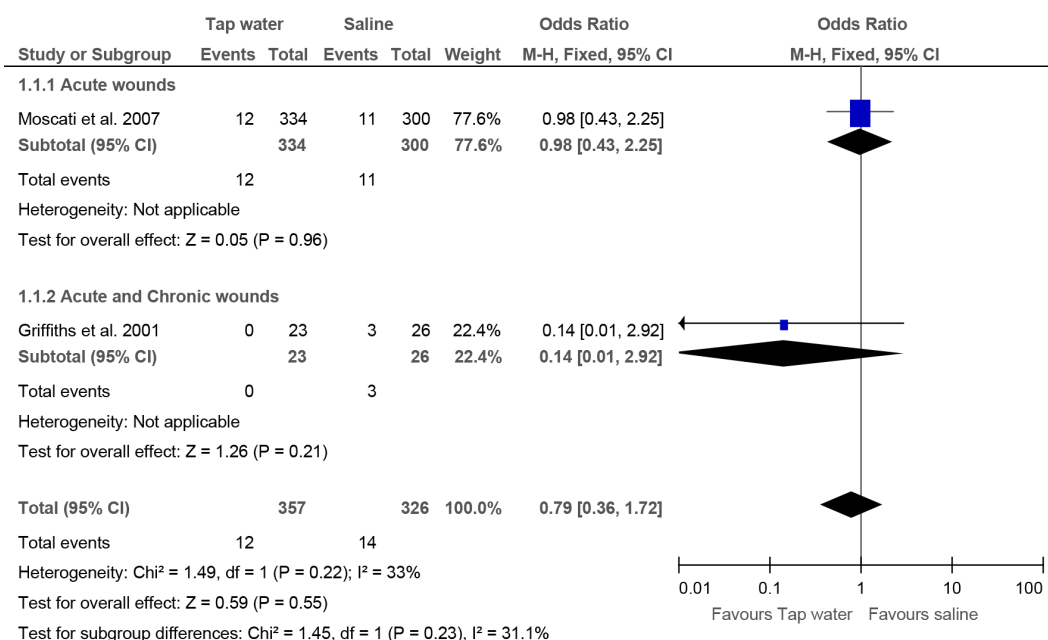


Figure 2. Forest plot of tap water versus sterile saline on the infection rates of acute and chronic wounds.

All studies provided results related to the main review question “Does the effectiveness of different cleansing solutions influence infection and wound healing

rates?” However, there are some results related to other review questions, as described in Table 3.

Table 3

Answers to the review’s questions presented by study

Study	Does the effectiveness of different cleansing solutions influence the infection and wound healing rates?	Which cleansing solution is more effective for reducing wound infection rates?	Which cleansing solution is more effective for increasing wound healing rates?	Is the effectiveness of cleansing solutions affected by wound aetiology?
Moscatti et al., 2007	Twelve (4%) subjects in the tap water group had wound infections, compared with 11 (3.3%) in the saline group. The results showed equivalent rates of wound infection using either tap water or sterile saline.	Compared with sterile saline, tap water for wound irrigation is more cost effective and appears to be equally safe and efficacious. Tap water should be considered in emergency departments as a reasonable alternative to sterile saline for wound irrigation.	Healing rates were not an outcome of this study. No evidence.	The results allowed no conclusions.
Griffiths et al., 2001	The results demonstrated that there was no significant difference between infection and healing rates in wounds irrigated with normal saline or tap water.	Although there was no statistically significant difference between healing and infection rates in the wounds from both groups, tap water can be considered a safe and cost-effective alternative.		The results allowed no conclusions.

Walker and Smith, 2013	There was a reduced incidence of groin wound infections in those randomized to Betadine (3 versus 1), but this was not statistically significant ($p=0.4$). This study supports the use of povidone-iodine in reducing wound infections, a particular problem in vascular surgery and especially procedures in the groin area.	Although there may be a trend towards a lower wound infection rate when povidone-iodine is used in surgical wounds, this is not significant for varicose vein surgery.	Healing rates were not an outcome of this study. No evidence.	The results allowed no conclusions.
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Interpretation of Results

This systematic review found three clinical trials confirming the effectiveness of cleansing solutions for wound treatment. These solutions were: tap water versus sterile saline and povidone-iodine-soaked gauze versus saline-soaked gauze.

Excluded studies by search strategy and assessment of methodological quality reported other solutions used for wound cleansing: super-oxidized solution, 2% hydrogen peroxide, 2% chlorhexidine gluconate, polyhexanide (phmb), and betaine (Kaehn & Eberlein, 2008). Thus, for these particular solutions, further strong and well-designed RCTs are needed to examine the effects on the wound itself and the effectiveness on various types of wounds.

The included studies showed that there were no statistically significant differences between the healing and infection rates in the wounds cleansed with tap water or normal saline (Griffiths et al., 2001; Moscati et al., 2007). Therefore, tap water can be considered a safe and cost-effective alternative. They also showed that there might have been a trend towards a lower wound infection rate when povidone-iodine was used in surgical wounds, but this was not significant for varicose vein surgery.

However, data analysis regarding wound infection was difficult due to a lack of consistency in the criteria used to assess wound infection. In addition, variance data for the healing outcomes were only reported in one study (Griffiths et al., 2001). The use of a standardized and validated tool for the measurement of wound infection and healing and an assessor blinded to the intervention would have enhanced the accuracy of the trials and strengthened the evidence. In the future, other outcomes such as patient comfort, pain and satisfaction should be measured. We recommend that these variables should be included in the studies' protocols.

Another important issue was cost management because the availability and cost of resources could also have determined which solution was used for cleansing wounds in different settings. So this was an increasingly important issue in all aspects of health care. In this matter, the study of Moscati et al. (2007) showed that tap water was more cost-effective than saline and that could help to reduce the potentially significant cost of wound care (Griffiths et al., 2001). Using tap water could also have reduced the risk of body fluid contamination due to splattering as it did not require the provider to be in close proximity to the patient during the irrigation process (Moscati et al., 2007).

Another limitation was the low sample size in two of three included studies (Griffiths et al., 2001; Walker & Smith, 2013) and the lack of data about power analysis and effect size to provide information on the magnitude of the intervention's impact. Thus, a small sample size could have led to an underestimation of the treatment's effectiveness. All of these weaknesses could have limited the synthesized process and the results of this systematic review.

In this review, we only included articles published in English, Portuguese and Spanish. Thus, articles published in others languages could also have been important to this review and this was another limitation.

As previously stated, the meta-analysis was only possible in two studies. Nevertheless, we can consider that there is no evidence that using tap water to cleanse acute and chronic wounds in adults increases infection or healing.

There seems to be a reduction in wound infection rates when povidone-iodine is used in surgical wounds. On the other hand, these findings have extreme relevance for clinical practice, and they should be put into practice and considered by physicians, nurses and all health professionals who are interested in

wound treatment. Prospective randomized controlled trials in this area need to be more robust in order to assist clinicians and policy makers in making informed decisions about the appropriate use of solutions for cleansing wounds.

Conclusion

The included studies provide results about the effectiveness of cleansing solutions for wound treatment in adults. The interventions included in this systematic review were tap water versus sterile saline and povidone-iodine-soaked gauze versus saline-soaked gauze. Data from two studies reporting the effectiveness of tap water versus sterile saline, which compared wound infection rates, were pooled in a meta-analysis.

All the studies included and the results of meta-analysis suggest that there is no evidence that using tap water to cleanse acute and chronic wounds in adults increases infection or healing with some evidence that it reduces infection when compared to saline. There may be a trend towards a lower wound infection rate when povidone-iodine is used in surgical wounds, but this is not significant for varicose vein surgery.

However, due to the small number of studies by interventions (few cleansing solutions), the evidence is not strong enough to produce a best practice.

Implications for Practice

The interventions considered in this systematic review are effective and may be useful in practice to reduce the infection rate in adults with acute and chronic wounds and promote wound healing through cleansing.

Tap water was more effective than saline in reducing the infection rate in adults with acute and chronic wounds (Level of Evidence 1.a – Systematic Review of RCTs).

There is no evidence that using tap water to cleanse acute and chronic wounds in adults increases healing (Level of Evidence 1.c – RCT).

There may be a trend towards a lower wound infection rate when povidone-iodine is used in surgical wounds (Level of Evidence 1.d – Pseudo-RCT).

As the evidence is of high quality, health professionals may deliver the above interventions for wound treatment in adults (GRADE A).

Implications for Research

To strengthen the current evidence base on the effectiveness of cleansing solutions for wound treatment, additional high quality RCTs (using CONSORT guidelines, for example) are required in order to update the sensitive subject meta-analysis.

In future researches, the needed sample size, power analysis and effect size have to be calculated to better address the study's methods, results and conclusions. We recommend the use of a standardized and validated tool for the measurement of wound infection and healing, an assessor blinded to the intervention, the performance of RCTs or the use of other solutions for wound cleansing: Super-oxidized solution, 2% hydrogen peroxide, 2% chlorhexidine gluconate, polyhexanide (PHMB) and betaine. We also recommend examining the effects on the wound itself and the effectiveness on various types of wounds, comparing between them, and measuring other outcomes such as patient comfort, pain and satisfaction.

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