Original Research Article

A Comparative Study of Conventional Wound Irrigants and Their Effectiveness in Wound Healing

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Abstract

Debridement is essential for wound healing. It accelerates the normal process of wound healing if done properly. Wound irrigation helps to achieve wound hydration, removes deeper debris, and assists in visual examination of the wound. This study aimed to investigate and compare the utility, complication rates, and outcome of chemical wound debridement with different agents commonly used as irrigants viz. sterile water, normal saline (NS), povidone iodine (PI), hydrogen peroxide (H_2O_2), hypochlorite and neutralized superoxidised solution of water (nSOS). In contaminated wounds with co morbid factors nSOS remained the irrigant of choice followed by H_2O_2 and PI. Hypochlorite gave good results in wounds where repeated debridement was required. However, normal saline and sterile water came up to be poor quality irrigants with high complication rates in dirty or contaminated wounds.

Keywords: Wound irrigation, chemical wound debridement, contaminated wound, nSOS, H_2O_2, povidone iodine

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Introduction

Wound debridement is often an essential step for initiation of wound healing. Infection in superficial soft tissues, bones and deep tissues are very commonly found during surgical debridement of a dirty and infected wound (1,2). In highly contaminated and dirty wounds, foreign bodies, toxic metabolites and necrotic tissues delay the normal process of healing. Their removal accelerates the normal process of wound healing to a great extent with excellent results if done properly (3,4). Thus, proper wound care is nothing less than an art to be performed with utmost perfection.

Wound irrigation is described as a steady flow of the irrigant solution across an open wound surface. It helps to achieve proper wound hydration, remove deeper debris, and aids in better visual examination of the wound (5). The irrigant solution also removes toxic metabolites, necrotic debris and pathogens contained in wound exudates or residue from topically applied ointments. It is considered to be the most consistently effective method of wound cleansing and attaining asepsis (6). It facilitates the progression from inflammatory to proliferative phase of wound healing and helps in wound healing from the deeper to superficial tissue layers. It also helps to prevent premature surface healing over an abscess pocket or infected tract (7, 8). Choosing an appropriate irrigant is one of the most critical steps in wound management. Solutions generally used for wound irrigation include topical cleansers, antibiotics, antifungal, antiseptics and anesthetics. Ideally, an irrigant should be isotonic, nonhemolytic, nontoxic, transparent, easy to sterilize, and inexpensive. This study aimed to investigate and compare the utility, outcome in terms of wound healing and complication rate of different chemicals used conventionally as chemical irrigants.

Materials and methods

Over a period of 20 months from May 2010 to December 2011, a total number of 180 patients underwent wound debridement at Medical College, Kolkata, India in Department of General Surgery.

Inclusion criterion - Patients with wounds with slough or pus.
Exclusion criterion – Immunocompromised patients.

Data on the following aspects were compiled– History, co morbid factors, past medical history, history of any addiction, antibiotic exposure, type of antibiotic used, investigations (Hematology, Biochemistry, Microbiology), peri-operative management, presence of infective discharge, presence of systemic symptoms, complications, and final outcome after debridement.

Types of irrigant and categorization of patients:

1. Every 1st case - NS irrigation
2. Every 2nd case - sterile water irrigation
3. Every 3rd case - H2O2 irrigation
4. Every 4th case - PI irrigation
5. Every 5th case - nSOS irrigation
6. Every 6th case - hypochlorite irrigation

The patients were selected from the patients admitted at our hospital for debridement of infected wounds. Linezolid and clindamycin were initially administered to all patients, and then necessary changes made depending on wound culture report. In diabetic patients the blood glucose level was controlled using regular human insulin (soluble). Patients with eczematous lesions near wound site were treated with antibiotic–steroid ointment locally and anti-histaminics. Patients with local fungal infections were given local clotrimazole ointment with systemic fluconazole.

After discharge the patients were reviewed at weekly intervals till two months from the date of last debridement.

Results

Over a period of 20 months from May 2010 to December 2011, a total number of 180 patients were followed up who underwent debridement at our Department. Of these, 138 patients were male and 42 patients were females. The age of the patients ranged from 36-82 yrs.

We followed a distinct protocol to determine the candidate and irrigant material used as stated above. Thirty patients were included in each group of irrigation.

I. Complication rates in presence of co morbid factors

In contaminated and infected wounds in patients with co morbid factors (diabetes, presence of fungal infection /eczema or any other localized or systemic skin disorder) nSOS remained the irrigant of choice followed by H_2O_2 and PI. Hypochlorite was not found to be a very useful irrigant, but it gave good results in cases where repeated debridement and sloughectomy was required. NS and sterile water came up to be poor quality irrigants with high complication rates in infected or contaminated wounds (Table 1).

Complications included persistence of systemic symptoms, thick pus for more than seven days, osteomyelitis, septicemia, renal or cardiorespiratory failure, amputation or death.

Statistical analysis (by Student t-test) - Incidence of complications was highest with the use of sterile water irrespective of the presence or absence of co morbid factors. The difference in the incidence of complications between the use of sterile water and

Table 1: Incidence of complications

Material	Co morbid Factors (+)	Co morbid Factors (-)
NS	6/13 (46.15%)	7/17 (41.18%)
Sterile Water	7/10 (70%)	12/20 (60%)
H_2O_2	6/12 (50%)	5/18 (27.78%)
PI	6/15 (40%)	5/15 (33.33%)
nSOS	4/14 (28.57%)	3/16 (18.75%)
Hypochlorite	7/15 (46.67%)	7/15 (46.67%)

Table 2: Persistence of systemic symptoms

Material	<2 days	2-4 days	4-6 days	7 days or more
NS	4/30 (13.33%)	6/30 (20%)	10/30 (33.33%)	10/30 (33.33%)
Sterile Water	8/30 (26.67%)	8/30 (26.67%)	9/30 (30%)	5/30 (16.67%)
H_2O_2	16/30 (53.33%)	9/30(30%)	3/30 (10%)	2/30 (6.67%)
PI	15/30 (50%)	7/30 (23.33%)	6/30 (20%)	2/30 (6.67%)
nSOS	18/30(60%)	8/30 (26.67%)	3/30 (10%)	1/30 (3.33%)
Hypochlorite	10/30 (33.33%)	12/30 (40%)	2/30 (6.67%)	6/30 (20%)

nSOS was statistically significant in the presence ($t= 2.20$, $p< 0.05$) as well as absence ($t= 2.81$, $p< 0.05$) of co-morbid factors.

II. Persistence of systemic symptoms

The association of systemic symptoms with infected wounds was studied. This included fever, chills, rigor, reduced urine output, drowsiness etc. Most of patients were relieved of systemic symptoms within 48 hrs when nSOS was used, followed by H_2O_2 and PI (Table 2). Many patients developed persistence of systemic symptoms even after eight days when NS or sterile water was used.

Statistical Analysis (by Kruscal Wallis & Chi square Test) **-** Kruscal Wallis analysis of the table yielded an 'H-Statistic' value of 8.37. Simple approximation of these values to Chi-Square yielded significant results across the different groups of treatment. The difference in persistence of symptoms between < 2 days, 4-6 days, 7 days or more between use of NS and nSOS was statistically significant ($t= 4.3$, $p< 0.05$).

III. Presence of thick pus even after 7 days

Very few patients fell under this category when irrigated with nSOS followed by H_2O_2 and PI. Greater number of patients fell under this category when irrigated with NS or sterile water (Table 3).

Statistical Analysis (by Student t-test)–The difference between NS and nSOS was statistically significant ($t= 2.68$, $p< 0.05$), however there was no significant difference in the result with NS, sterile water and hypochlorite.

IV. Time consumed to render the wound bacteriologically sterile

Routine culture and sensitivity testing from the wound was done on alternate days and followed up till the wound became bacterologically sterile. It was found that nSOS was the best chemical agent for irrigation followed by H_2O_2 and PI to make the wound sterile (Table 4).

Statistical analysis (by Chi-square Test)-The difference was statistically significant between NS, Sterile Water, PI and nSOS in all quadrants.

V. Mortality due to septicemia or need for amputation

Of the patients who died of septicaemia or needed amputation of the involved body part, 16.67% had undergone wound irrigation with NS and 10% with sterile water. The incidence of septicaemia and amputation was moderate with PI and hypochlorite (both 6.67%) and minimum with H_2O_2 and nSOS (both 3.33%).

Statistical analysis (by Student t-test and Chi-square Test)-The difference between NS and nSOS was not statistically significant $Z= 1.05$, $t= 1.78$, $p > 0.05$) as well as the other values.

VI. Cost – Effectiveness

It was found that nSOS, H_2O_2 and hypochlorite were costlier whereas NS or sterile water had minimum cost. But in an intervention like debridement where salvage of the limb or life is of utmost importance, the cost factor appeared to have lesser importance.

All the patients in this study were discharged with a satisfactory wound, except five patients who died of septicemia and nine patients who needed amputation. All patients were followed up regularly for one month. 60% came for follow-up up to two months and 35% came for follow-up up to three months. Most of the patients were discharged from the hospital within two

Table 3: Presence of thick pus after 7 days

Material	No. of wounds with purulent discharge
NS	8/30 (26.67%)
Sterile Water	4/30 (13.33%)
H_2O_2	2/30 (6.67%)
PI	2/30 (6.67%)
nSOS	1/30(3.33%)
Hypochlorite	5/30 (16.67%)

Table 4: Time taken to make wound bacteria-free

Material	<2 days	2-4 days	4-6 days	7 days or more
NS	4/30 (13.33%)	5/30 (20%)	11/30 (33.33%)	10/30 (33.33%)
Sterile Water	7/30 (26.67%)	7/30 (26.67%)	11/30 (30%)	5/30 (16.67%)
H_2O_2	14/30 (53.33%)	9/30(30%)	4/30 (10%)	3/30 (6.67%)
PI	15/30 (50%)	8/30 (23.33%)	4/30 (20%)	3/30 (6.67%)
nSOS	17/30(60%)	9/30 (26.67%)	3/30 (10%)	1/30 (3.33%)
Hypochlorite	11/30 (33.33%)	11/30 (40%)	4/30 (6.67%)	4/30 (20%)

days after last debridement. Thirty six patients needed hospital stay for less than four days, 52 patients needed hospital stay for 4-6 days, 56 patients needed hospital stay for 8-10 days, rest 34 patients needed hospital stay for 12-15 days. A total of sixteen patients needed treatment in Intensive Therapy Unit (ITU) for 5-8 days postoperatively out of which five patients died in High Dependency Unit (HDU) after about 20 days of treatment.

Discussion

Microbes in the community are becoming increasingly resistant to even higher antibiotics day by day. Newer strains of resistant microbes are evolving at a very high speed (9, 10). *Pseudomonas aeruginosa, Clostridium difficile, Actinobacter species, Escherichia. coli* and many others are developing super strains which are resistant to even superior quality of antimicrobials (11). Patients of highly contaminated wounds often get infected by multiple superbugs simultaneously. Debridement helps to initiate normal wound healing. It also helps to remove tunnels under the skin, bone and other deep tissues when foreign bodies and dead tissues delay the natural process of healing (12,13). The mainstay of wound management in our study was:

1) Altering the aetiological factors viz. pressure, friction, circulatory compromise, and/or neuropathy
2) Providing systemic support for healing (e.g.- blood, oxygen, fluid, nutrition, antibiotics)
3) Appropriate topical therapy (removal of necrotic tissue or foreign body, elimination of infection, obliteration of dead space, absorption of exudates, maintenance of a moist environment, protection from trauma and bacterial invasion, and provision of thermal insulation.

Debridement was mainly sharp, mechanical or by autolysis. Sharp debridement was done for extensive necrosis or for large wounds. Mechanical and autolytic debridement was accomplished with dressings. Autolytic debridement was done with an occlusive dressing so that the moisture was retained in the wound and the white blood cells and enzymes got an opportunity to break down necrotic tissue (14).

In this study our role was to encourage wound healing by taking care of some of the most important parts of wound healing, viz. wound hydration, debridement and sterilization. Total wound healing was not considered as the end point of the study. Hence, the size, nature and aetiology of the wound did not actively interfere with the study. Wound irrigation was the main tool that was used to fulfill this purpose. However many irrigants and antiseptics are cytotoxic, and it was imperative to weigh the risks of cytotoxicity against the benefits of irrigation (15,16). Combined with debridement, irrigation facilitates progression from the inflammatory to proliferative phase of wound healing by removing debris that can impede the healing process. When performed properly, wound irrigation can aid in wound healing from the inside tissue layers outward to the skin surface. It may also help prevent premature surface healing over an abscess pocket or infected tract (17).

In this study we found out that as an irrigant NS and sterile water are safe, effective, readily available, and inexpensive but the outcomes are not so good in infected wounds. The outcome with nSOS is far more beneficial to the ailing patients (18) if appropriate usage protocol is established in hospitals. It can prevent fulminant growth of microbes when used as a skin preparation prior to surgery, as an irrigant during surgery, and as an antiseptic for post-operative care. It is a safe anti-infective agent that quickly eradicates a broad range of pathogens, including antibiotic-resistant bacteria (including MRSA and VRE), viruses, fungi and spores. In addition to eradicating the organisms, it also accelerates wound-healing process by reducing inflammation in the wound and increasing nutrient-rich blood and oxygen flow to the wound bed. H_2O_2 and PI come next in the list. They are good alternatives, but less effective than nSOS. Hypochlorite gives excellent results as an agent of irrigation where sloughectomy is contemplated but the results are not comparable with nSOS when the wound is infected and raw but without formation of slough (19). H_2O_2 solution kills germs on the wound very efficiently with foam or bubbles forming on the wound surface but it may irritate the skin, making the skin look red. However it is the best agent to remove a bad smell from the wound. Hypochlorite solution helps to remove the debris and slough slowly, and may cause irritation on the wound and the skin around it. PI solution helps to quickly dry up necrotic debris and stains the adjacent skin (20).

What makes nSOS so remarkably effective is the way hypochlorous acid works in combination with reactive oxygen radicals. This is similar to the way the immune system’s neutrophils work, through oxidative burst. No microbe can stand up to this oxidative burst, nor can they develop resistance to it (21, 22).

Conclusion

In case of contaminated wounds nSOS remains the irrigant of choice followed by H_2O_2 and PI.

Hypochlorite gives good results in wounds which require repeated debridement. NS and sterile water are poor quality irrigants in dirty or contaminated wounds. With nSOS systemic symptoms disappear within 2-4 days and thick pus from the wound disappears from the wound within a very short period.

Therefore, wound care has to be customized depending on the type of wound, nature of germ load and presence of co morbid factors. It is pertinent to keep in mind that wound irrigation does not heal wounds; it creates the optimum environment so that healing can take place.

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