

Original Research Article

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A prospective comparative study on the use of nanocrystalline silver ion dressing with normal saline dressing in diabetic foot ulcers

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ABSTRACT

Background: A diabetic foot is any pathology that results directly from peripheral arterial disease and/or sensory neuropathy affecting the feet in diabetes mellitus. Proper assessment of the wound followed by an aggressive multidisciplinary approach can reduce the risk of amputation, thereby greatly increasing the patient's quality of life. Wound dressings play a vital role in diabetic foot care management. Nanocrystalline silver ion dressing is a newer modality that has been in consideration for the treatment of diabetic wounds.

Methods: This was a prospective comparative study conducted in the department of general surgery, Sagar hospital-DSI, Bangalore from December 2020 to March 2021. A total of 50 diabetic patients were included in the study and were randomised into the study group and control group. The study group received nanocrystalline silver ion dressings while the control group received dressings with normal saline. Patients were observed for 8 weeks. Data regarding the presence of wound discharge, type of discharge, granulation tissue, presence of slough and changes in the size of the wound was recorded and analysed.

Results: Study group showed statistically significant better outcomes ($p<0.05$) in terms of reduced wound discharge, early granulation tissue, rapid reduction of slough from wounds and reduction in the wound size when compared with the control group. 17 patients responded completely in the study group when compared with the control group, where 8 patients have got a complete response ($p<0.05$).

Conclusions: Wound dressings with nanocrystalline silver ion helps in the early healing of diabetic foot ulcers when compared to normal saline dressings.

Keywords: Diabetic foot ulcer, Nanocrystalline silver ion, Normal saline, Wound dressing

INTRODUCTION

Diabetes is a group of metabolic diseases characterized by hyperglycaemia which may be due to defect in insulin secretion, insulin action or both. The chronic hyperglycaemia of diabetes is associated with long-term damage and dysfunction, which eventually leads to failure of different organs, especially the eyes, kidneys, nerves and heart.¹ Foot ulcers are a significant complication of diabetes mellitus and they often precede

lower extremity amputation. The most frequent underlying aetiologies are neuropathy, trauma, deformity, high plantar pressures and peripheral arterial disease.² India with approximately 42 million cases is ranked first in the list of the ten nations most affected with diabetes.³ Among diabetes mellitus related complications, foot ulceration is the most common, affecting approximately 15% of diabetic patients during their lifetime.⁴ This can be attributed to several social and cultural practices such as barefoot walking, inadequate facilities for diabetes

care and education and poor socioeconomic conditions.⁵ Diabetic foot ulcer is one of the main reasons for morbidity in diabetic patients and it accounts for about 50% of non-traumatic amputations throughout the world.⁶ Proper wound dressing is an integral part of the management of diabetic foot ulcer.

Choosing the optimal dressing for a diabetic wound is an essential element for successful wound healing. The proper wound dressing will help maintain a balanced moisture environment (not too wet or too dry) and allow the wound to heal properly and at the earliest. The location of the wound will also be taken into consideration by the clinician when choosing a dressing.⁷ For optimum healing, ulcers, especially those on the bottom of the foot, must be off-loaded. Offloading helps in reducing the pressure and irritation to the area with the ulcer and help to speed the healing process. The science of wound care has advanced significantly over the past decade. The old thought of let the air get at it is now known to be harmful to healing. We know that wounds and ulcers heal faster, with a lower risk of infection, if they are kept covered and moist.⁸ Appropriate wound management includes the use of dressings and topically applied medications. These range from normal saline ulcer dressings, povidone-iodine, hydrogen peroxide, nanocrystalline silver ion and honey that have been shown to be highly effective in healing foot ulcers.⁹

Nanocrystalline silver ion dressing is an emerging treatment option for diabetic foot ulcer (DFU). It forms an effective antimicrobial barrier composed of an absorbent inner core which maintains a favourable environment optimal for wound healing and outer layers of silver-coated polyethylene nets which prevent wound contamination and exhibit the bactericidal effect.¹⁰ Normal saline is an isotonic and the most commonly used wound care solution due to safety (lowest toxicity) and physiologic factors. It is also used as an irrigating solution to cleanse dirty, necrotic wounds as effectively as other solutions. In this study, we aimed to study whether nanocrystalline silver ion dressings are better for DFU than normal saline dressings.

METHODS

This was a prospective comparative study conducted in the department of general surgery, Sagar hospital-DSI from December 2020 to March 2021. All patients with diabetic foot ulcers aged between 18-75 years, who presented to the general surgery department and willing to participate in the study were included in the study. Patients with age <18 years or >75 years, having septicaemia, osteomyelitis, are on corticosteroids, immunosuppressive drugs or chemotherapy and patients who are contraindicated to silver ion dressing and normal saline dressing were excluded from the study.

A total of 50 patients were included in the study. They were divided into two groups using simple randomisation

namely study group and control group comprising 25 patients in each group. All enrolled patients underwent a detailed history and clinical examination. Complete control of diabetes was done. Blood sugar was monitored and maintained the euglycemic state using insulin and oral hypoglycemic agents during the therapy. All patients were administered broad-spectrum systemic antibiotics.

Patients in both groups underwent initial wound debridement followed by dressings. Wounds in the study group were dressed using nanocrystalline silver ion, whereas control group wounds dressed using normal saline. Wounds were assessed for the presence of wound discharge, the appearance of granulation tissue, presence of slough and changes in the wound size. Wound size was measured by taking the largest transverse diameter and largest vertical diameter. All patients were followed till 8 weeks. Depending on the findings at the end of the study period the patients were categorized into the categories.¹¹ The categories were complete responders: complete healing of lower limb ulcers, partial responders: 50% or greater reduction in the product of the two longest perpendicular diameters from baseline, non-complete responders: less than 50% reduction in the product of the two longest perpendicular diameters from baseline, non-responders: no reduction or increase in ulcer area over baseline.

Statistical analysis was done using SPSS 20.0 (statistical package for the social sciences) software package for windows and the $p<0.05$ was considered statistically significant.

RESULTS

Total fifty patients with DFU were included in the study. All the patients were followed till the completion of the study. No adverse effects or untoward incidents happened during the period of the study. The demographic data of the patients were given in Table 1. No statistically significant difference observed between the two groups with respect to demographic details.

Out of fifty patients, twenty-five patients were included in the study group, whose ulcer was dressed with nanocrystalline silver ion and the other twenty-five patients were included in the control group whose ulcers were dressed with normal saline.

The rate of reduction of discharge from the wound was assessed and it has been found that in the study group wound discharge reduced significantly ($p=0.024$) when compared with control group. Table 2 shows the presence of wound discharge in both the groups at the end of 2 weeks and 8 weeks.

The presence of granulation tissue was assessed in both the groups. When compared with control group, granulation tissue appearance was statistically significantly better in study group ($p=0.037$) at the end of

8 weeks. Table 3 shows the presence of granulation tissue in both the groups at the end of 2 weeks and 8 weeks.

The presence of slough was statistically significantly lesser in study group when compared to control group ($p=0.045$) at the end of 8 weeks. Table 4 shows the presence of slough in both the groups at the end of 2 weeks and 8 weeks.

When we analysed the wound response to the treatment, 68% of the patients responded completely in the study group. Whereas only 32% of the patients in the control group responded completely to the treatment in the control group. Study group patient's response is statistically significantly better than control group ($p=0.032$). Table 5 shows the treatment response in both the group at the end of 8 weeks.

Table 1: Age and sex distribution of patients in study and control group.

Age group	Study (%)	Control (%)	Total	Chi square value	P value
31-40	1 (4)	3 (12)	4	1.806	0.6137
41-50	7 (28)	5 (20)	12		
51-60	8 (32)	10 (40)	18		
>60	9 (36)	7 (28)	16		
Total	25 (100)	25 (100)	50		
Sex					
Female	4 (16)	7 (28)	11	1.049	0.3057
Male	21 (84)	18 (72)	39		
Total	25 (100)	25 (100)	50		

Table 2: Presence of wound discharge in study group and control group.

Wound discharge	Initial				Chi square value	P value	2 weeks		8 weeks		Chi square value	P value
	Study	Control	Study	Control			Study	Control	Study	Control		
Present	25	25	8	15					3	10		
Absent	0	0	17	10	3.945	0.047	22	15	25	25	5.094	0.024
Total	25	25	25	25					50	50		
			50									

Table 3: Granulation tissue in study group and control group.

Granulation tissue	Initial				Chi-square value	P value	2 weeks		8 weeks		Chi square value	P value
	Study	Control	Study	Control			Study	Control	Study	Control		
Absent	25	25	15	18					5	9		
Present	-	-	10	7	0.802	0.371	20	16	25	25	4.367	0.037
Total	25	25	25	15					50	50		
			50									

Table 4: Presence of slough in study group and control group.

Slough tissue	Initial				Chi square value	P value	2 weeks		8 weeks		Chi square value	P value
	Study	Control	Study	Control			Study	Control	Study	Control		
Absent	-		9	6					17	14		
Present	25	25	16	19	0.857	0.3545	8	11	25	25	4.023	0.045
Total	25	25	25	25					50	50		
			50									

Table 5: Treatment response in study and control group.

Study outcome	Study group (%)	Control group (%)	Total	Chi square value	P value
Complete responders (CR)	17	68	8	32	25
Non-complete responders (NCR)	4	16	6	24	10
Non-responders (NR)					6.907
Partial responders (PR)	4	16	11	44	15
Total	25	100	25	100	50

DISCUSSION

DFU is a major health care concern throughout the world and is one of the common and serious complications in diabetic patients. Treatment of infection in DFU is usually difficult and expensive, especially when patient presentation is delayed. Patients usually need to take long-term medications, get daily dressings done or become hospitalized for an extended period of time. It is estimated that usually 15-25% of diabetic patients develop DFU during their life-time.¹² Regular evaluation and early treatment are the most effective mechanisms to prevent the devastating diabetic foot complications.

The aim of the wound dressing is to provide relatively clean wound with low bacteria count that provides favourable environment for healing.¹³ DFUs have different characteristic in term of polymicrobial nature of infection, loss of sensation, compromised tissue vascularity and potentially deep-seated infection.¹⁴ An aggressive approach to the wound management may be required to save the limb in many cases. Patient education, good glycaemic control, offloading, debridement, infection control and adequate perfusion are some of the mandatory measures to be taken in the management of DFU. Selection of an appropriate dressing with timely replacement can expedite the healing.

Silver-based compounds have been using in wound care since early 1970. Among them, silver nano compounds attracted recently as silver nano particles may enter into the cell via pinocytosis and endocytosis. Nanotechnology using silver ions offers greater antimicrobial property. The smaller silver particles are lesser toxic to human tissue cells due to increased surface area to volume ratios.^{15,16} The early disappearance of discharge and slough from the study group and also the early appearance of granulation tissue in the study group point towards a quicker healing in DFU as compared to conventional normal saline dressings. The results drawn could be attributed to the potent and rapid antibacterial activity of nanocrystalline silver ion as shown by Wright et al, Yin et al and Voight et al.¹⁷⁻¹⁹

Limitations

The major limitation of our study was relatively lesser sample size and short study duration, hence, further studies with large cohorts are required to validate the results of our study.

CONCLUSION

Our study concluded that wound dressings with nanocrystalline silver ion helps in early healing of DFU when compared to normal saline dressings. Nanocrystalline silver ion dressings is an effective agent in the early intervention of diabetic foot ulcers.

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REFERENCES

1. American Diabetes Association. Standards of Medical Care in Diabetes-2014. *Diabetes Care*. 2014;37(1):14-80.
2. Frykberg RG. Diabetic foot ulcers: pathogenesis and management. *Am Fam Phys*. 2002;66(9):1655.
3. Ramachandran A, Ma RC, Snehalatha C. Diabetes in Asia. *The Lancet*. 2010;375(9712):408-18.
4. Viswanathan V, Shobhana R, Snehalatha C, Seena R, Ramachandran A. Need for education on footcare in diabetic patients in India. *J Assoc Physic Ind*. 1999;47(11):1083-5.
5. Shobhana R, Rao RP, Lavanya A, Viswanathan V, Ramachandra A. Cost burden to diabetic patients with foot complications-a study from southern India. *JAPI*. 2000;48(12):1147-50.
6. Alexiadou K, Doupis J. Management of diabetic foot ulcers. *Diabetes Ther*. 2012;3(1):4.

7. Fong J, Wood F. Nanocrystalline silver dressings in wound management: a review. *Int J Nanomed*. 2006;1(4):441.
8. Kirsner RS. Matrix metalloproteinases in normal and impaired wound healing: a potential role of nanocrystalline silver. *Wounds*. 2002;13(3):4-12.
9. Jones V. Selecting a dressing for the diabetic foot: factors to consider. *Diabetic Foot*. 1998;1:48-54.
10. Vimbela GV, Ngo SM, Fraze C, Yang L, Stout DA. Antibacterial properties and toxicity from metallic nanomaterials. *Int J Nanomed*. 2017;12:3941-65.
11. Singh N, Armstrong DG, Lipsky BA. Preventing foot ulcers in patients with diabetes. *JAMA*. 2005;293(2):217-28.
12. Vermeulen H, van Hattem JM, Storm-Versloot MN, Ubbink DT, Westerbos SJ. Preventing foot ulcers in patients with diabetes. *JAMA*. 2005.
13. Hayward PG, Morrison WA. Current Concepts in Wound Dressing. *Aust Presscr*. 1996;19(1):11-6.
14. Steed DL, Donohoe D, Webster MW, Lindsley L. Effect of extensive debridement and treatment on the healing of diabetic foot ulcers. *Diabetic Ulcer Study Group. J Am Coll Surg*. 1996;183(1):61-4.
15. Chaloupka K, Malam Y, Seifalian AM. Nanosilver as a new generation of nanoproduct in biomedical applications. *Trends Biotechnol*. 2010;28(11):580-8.
16. Sibbald RG, Browne AC, Coutts P, Queen D. Screening evaluation of an ionized nanocrystalline silver dressing in chronic wound care. *Ostomy Wound Manage*. 2001;47(10):38-43.
17. Wright JB, Lam K, Burrell RE. Wound management in an era of increasing bacterial antibiotic resistance: a role for topical silver treatment. *Am J Infect Control*. 1998;26(6):572-7.
18. Yin HQ, Langford R, Burrell RE. Comparative evaluation of the antimicrobial activity of ACTICOAT antimicrobial barrier dressing. *J Burn Care Rehabil*. 1999;20(3):195-200.
19. Voigt DW, Paul CN. The use of Acticoat as silver impregnated telfa dressings in a regional burn and wound care center: the clinicians view. *Wounds*. 2001;13(2):11-20.

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