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Research Article

A Study On Methylene Blue Guided Surgical Debridement Of Diabetic Foot Ulcers

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ABSTRACT

Background: Effective debridement is of utmost importance for Diabetic Foot Ulcer (DFU) to progress through the stages of wound healing. The removal of devitalized tissues is critical in promoting angiogenesis, vasculogenesis, and the development of granulation tissue, which facilitates healing in an accelerated time frame and prepares the wound bed for additional intervention measures.
Methods: A quasi-experimental study of 50 patients with DFU admitted in ward of Department of General Surgery, divided into two Groups A (Methylene Blue dye used) and B (dye not used). Clinical assessment of the ulcers, along with analysis of biochemical, pathology, microbiology reports of these patients were done serially over a course of 6 weeks.
Results: In the following study, we observed a demographic distribution where M/F – 7/3, with mean age of males being 56 years and that of females -57 years. 70 % were on OHA and 30 % on Insulin. Most common ulcer sites were sole and dorsum of foot. Majority of the patients had Wagner's Grade I ulcer, while grade II was seen in 20 % of participants and grade III in 5%. Bacterial isolates predominantly showed pseudomonas. Serial assessment of ulcer size (surface area) shows significant statistical association between reduced progression of ulcer size with use of MB (grp A). Also, the time required for complete elimination of necrotic tissue was less in group A than B, with higher rates of SSG also seen.
Conclusion: Precise surgical debridement with the aid of MB helps in more effective removal of necrotic areas with preservation of viable tissue as compared to conventional technique.

Keywords: *Debridement, Diabetic Foot Ulcer, Methylene Blue.*

INTRODUCTION

Despite great improvements in techniques, precise surgical debridement remains a challenge. Excessive debridement may lead to loss of viable tissue, while incomplete debridement results in necrosis and delayed healing. [(1)]

Methylene blue (MB), an absorbent dye, can help distinguish viable from non-viable tissue due to its redox properties—blue in oxidized form and colorless when reduced. This property helps us distinguish viable from non-viable tissue. [(2)]

Originally developed in 1891, methylene blue (MB) stands as one of the earliest synthetic pharmaceuticals and remains readily accessible. Over the past century, it has undergone extensive study and has found numerous clinical uses. Its pharmacodynamic profile is well-established, and it is widely recognized as a highly safe compound.

In addition, MB exhibits bacteriostatic properties and promotes vasodilation. It meets the essential technical criteria for diagnostic tissue staining and compares favourably with alternative dyes. Its effectiveness has also been demonstrated in the treatment of burn wounds. [(3)]

Managing foot complications in diabetic patients demands considerable resources, both in terms of manpower and financial expenditure, and it places a heavy emotional and logistical burden on families. This challenge becomes even more pronounced in regions with limited healthcare infrastructure and low public awareness about diabetic foot care. Socioeconomic constraints are especially evident among patients who rely on caregivers, further intensifying the strain due to the high cost of prolonged treatment. [4]

Hence, there is a pressing need for cost-effective and efficient treatment strategies for diabetic foot ulcers, particularly in resource-limited settings like those commonly found in our country.

While the technical execution of surgical debridement may appear straightforward, determining which tissue should be excised and which preserved requires significant clinical experience and sound judgment. In this context, the method discussed serves as a valuable and affordable adjunct to improve the precision and outcomes of debridement.

OBJECTIVE

To assess the efficacy of methylene blue-guided surgical debridement compared to conventional debridement

METHODS AND MATERIALS

The study was designed as a quasi-experimental investigation conducted in the General Surgery Department of FAAMCH, Barpeta. The duration of the study was six months, spanning from June 2024 to November 2024. A total of 50 patients diagnosed with diabetic foot ulcers (DFUs) were enrolled and divided into two groups: Group A underwent surgical debridement with the use of methylene blue (MB) dye, while Group B received surgical debridement without the use of dye. The inclusion criteria comprised patients aged between 18 and 80 years who had DFUs and provided informed consent. Exclusion criteria included patients who did not give consent, those diagnosed with peripheral vascular disease, and individuals presenting with grade IV or V ulcers as per Wagner's classification.

RESULTS

A.) Demographics:

The demographic characteristics of the study participants are as follows: The gender distribution showed a predominance of males, who constituted 67% of the sample, while females accounted for the remaining 33% (Figure 1). Regarding age distribution, the majority of patients (60%) were in the 41–55 years age group, followed by 30% in the 56–70 years range. Smaller proportions were observed in other age brackets, with 3% aged 25–40 years, 1% under 25 years, and 6% aged above 70 years, as illustrated in Figure 2.

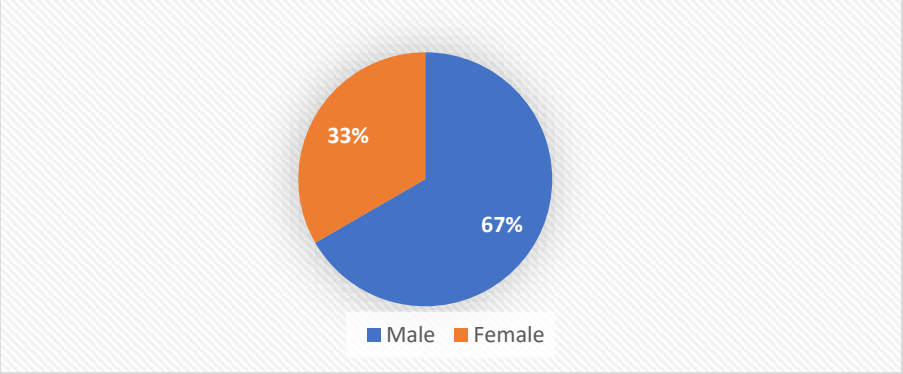

Figure 1: Age Distribution

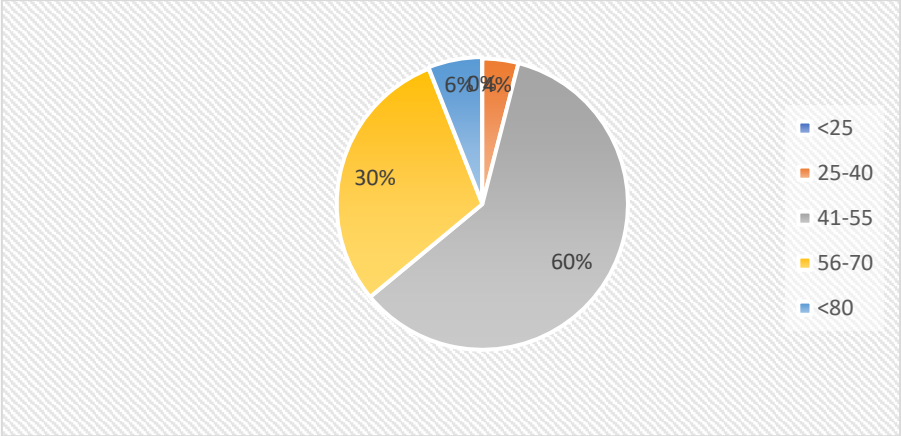

Figure 2: Age Distribution

B.) Comorbities, onset and distribution

The comorbidity profile of the study population revealed that all patients were diagnosed cases of type 2 diabetes mellitus (T2DM). During their hospital stay, 70% were managed with insulin therapy, while the remaining 30% were on oral hypoglycaemic agents. Among other associated conditions, 36% of patients had coexisting hypertension, and 10% were diagnosed with chronic obstructive pulmonary disease (COPD). Regarding the onset of diabetic foot ulcers (DFUs), 45% of cases were linked to a history of trauma, whereas 55% developed spontaneously. The distribution of ulcers is shown in Figure 3, with the majority (40%) located on the dorsum of the foot, followed by 27% on both the dorsum of the foot and sole, 15% on the sole, 10% on both the dorsum of the foot and leg, and 8% on the dorsum of the leg.

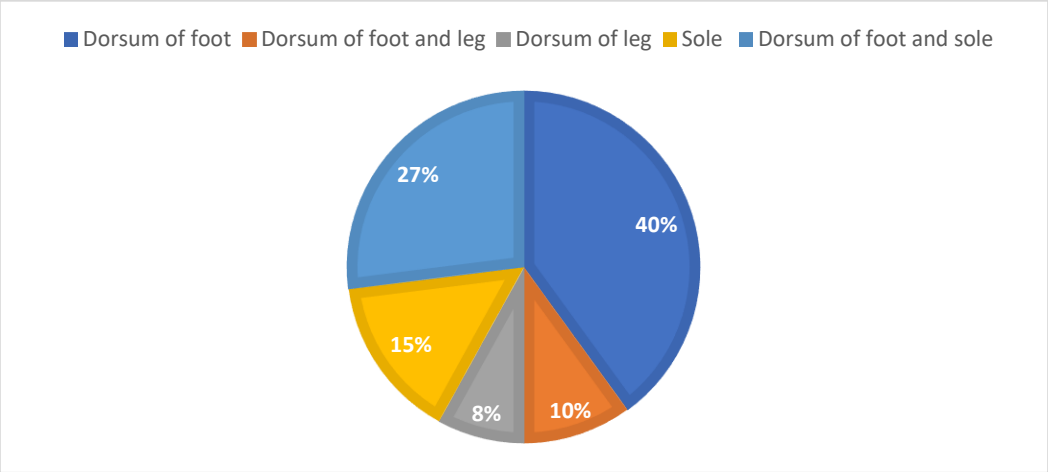

Figure 3: Distribution of Ulcer

C.) Bacterial Isolate from The Wound:

Pus culture and sensitivity reports were analyzed for bacterial isolates in both study groups. The findings revealed that *Klebsiella* was the predominant organism isolated in both Group A (Dye) and Group B (No Dye). In Group A, the second most common isolate was *Pseudomonas*, whereas in Group B, it was non-fermenting gram-negative (NFGN) bacteria. Among the antibiotics tested, *Doxycycline* and *Amikacin* were found to be the most effective across isolates. On the other hand, *Ceftriaxone* and *Amoxicillin with Clavulanic Acid* showed the highest resistance patterns. These results are illustrated in the accompanying chart.

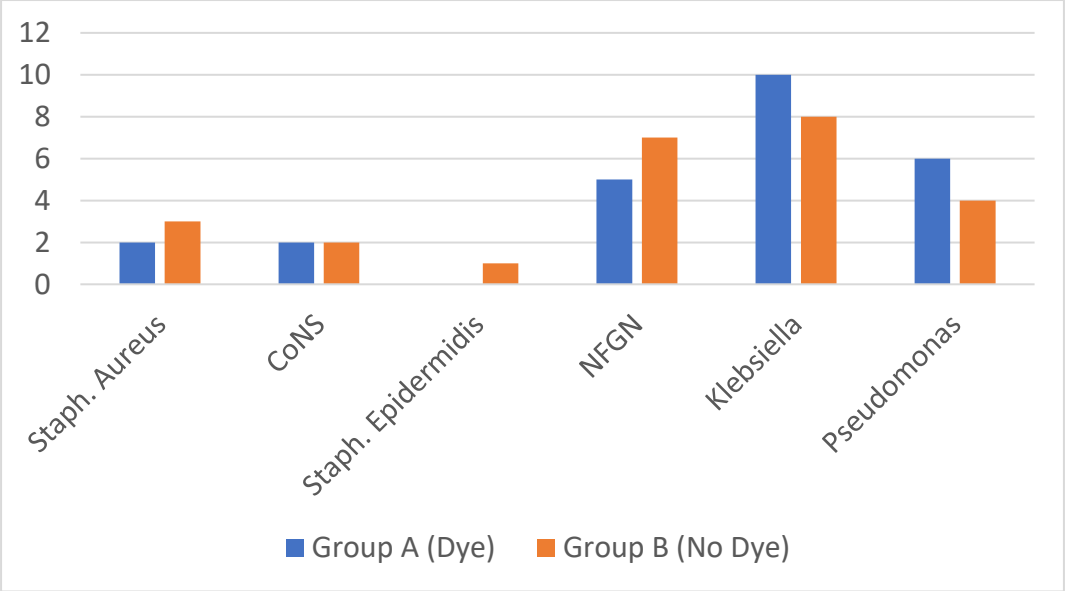

Figure 4: Bacterial Isolate from wound

D.) Ulcer Surface Area

A sequential assessment of ulcer surface area was carried out in both Group A (Dye) and Group B (No Dye) over a period of four weeks following debridement. As illustrated in Figure 5, both groups showed an initial increase in ulcer size; however, Group A demonstrated a more controlled progression. At baseline, the mean ulcer size was slightly larger in Group A (32.97 cm^2) compared to Group B (30.61 cm^2). By the end of Week 1, the ulcer size increased in both groups, but the difference narrowed. In subsequent weeks, Group B showed a more pronounced increase in ulcer area, reaching 41.2 cm^2 by Week 4, while Group A showed a slower increase, reaching 39.57 cm^2. Overall, the trend suggests that the use of methylene blue dye during debridement may help limit ulcer expansion compared to conventional debridement without dye. (Table 1)

Table 1: Sequential assessment of ulcer surface area with debridement.

	Baseline	Week 1	Week 2	Week 3	Week 4
Group A (Dye)	**32.97 cm^2**	**36.78**	**38.46**	**39.01**	**39.57**
Group B (No Dye)	**30.61 cm^2**	**35.71**	**37.91**	**40.12**	**41.2**
Difference	**2.36**	**1.07**	**0.55**	**-1.11**	**-1.63**

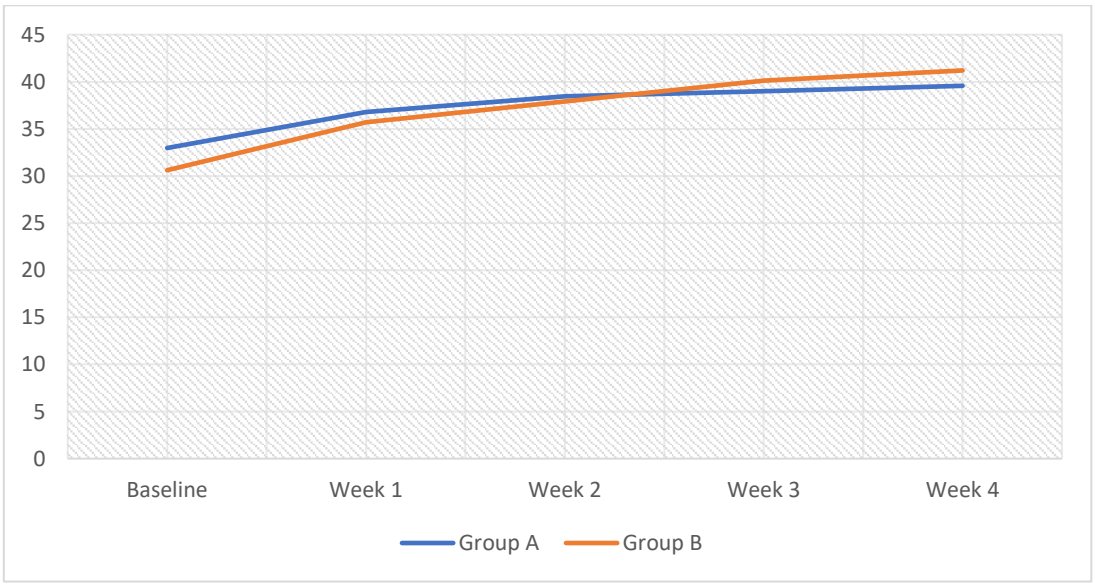

Figure 5: Time Interval and Ulcer size Association (with ongoing debridement)

E.) Granulation tissue coverage and Split thickness skin grafting

A granulation tissue coverage of approximately 75–100% is regarded as a sign of a healthy wound bed and indicates progressive healing of the ulcer. In this study, it was observed that patients in Group A achieved this level of granulation

by the end of the third week or early in the fourth week. In contrast, patients in Group B reached similar coverage only after four weeks, suggesting a relatively slower healing process.

Following development of favorable characteristics split-thickness skin grafting (SSG) was subsequently performed in approximately 65% (16 patients) in Group A, compared to about 52% (13 patients) in Group B.

Figure 6: Sequential Application of methylene blue dye to paint the damaged tissues on the surface of ulcer before surgical debridement. The blue-staining tissues were totally removed.

DISCUSSION

Majority of the patients were male (67%) in the 41–55 age group.

70 % were on Insulin therapy for better glycaemic control during the hospital stay. HTN was the 2nd most common comorbidity present in these patients along with T2DM.

Distribution of DFUs was majorly seen in dorsum of the foot, dorsum and sole, sole of the foot.

With respect to the ulcer size, it was observed that as we progressed through the weeks in Group A (dye used) the difference in ulcer size relatively reduced as compared to Group B. The mean size was greater in Group B as compared to Group A at the end of 4 weeks. The following observations are suggestive of a more precise and better would healing by preserving normal tissue and removing devitalized tissue, seen with MB guided surgical debridement.

Onset of granulation tissue coverage was also observed to faster in case of Group A as compared to Group B (75-100% coverage seen by 4 weeks).

The results are concurrent with other studies as well, “Margolis et al. in her study described the predictive capacity of 61% area reduction at 4 weeks by formation of granulation tissue.” [5] “Sheehan et al, through his work also proposed a

50% wound closure at 4 weeks by granulation tissue as a good surrogate for final healing and thus a decision point in a foot ulcer management algorithm." [6]

Split thickness Skin Grafting rate were higher in Group A as compared to Group B.

CONCLUSION

We believe that the topical application of methylene blue on open wounds is a safe and effective method for staining granulation tissue and eschar, allowing for clearer distinction between viable and non-viable tissue, as well as between epithelialized and non-epithelialized areas. While this technique enhances visualization and supports more accurate wound assessment, it is not a substitute for surgical expertise. Instead, the methylene blue method should be considered a valuable adjunct to clinical judgment, aiding in the precision of excisional wound debridement

LIMITATIONS OF STUDY

The study was conducted in a single center, which may not reflect variations in patient profiles or healthcare practices in other settings. Secondly, sample size was relatively small, with only 50 participants, which may limit the generalizability of the findings. Also the follow-up period was limited to four weeks, which may not fully capture long-term healing outcomes, recurrence rates, or complications.

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