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# Role of Methylene Blue in Determining the Depth of Burn Wound, Its Reliability and Safety

KEYWORDS: Burn injury, Pathophysiology, Methylene blue guided, Tangential excision of deep dermal burns.

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**ABSTRACT** *Burns is one of the oldest courage's affecting mankind. While its occurrence is common in all parts of the world developed and developing countries. Its effect much more pronounced in developing countries in India. Management of burn injury is always a difficult task to the burn surgeon. The aim of management of burn wound is to achieve the early wound healing and return to normal function. Superficial burns will heal within 2-3 weeks but deep dermal and full thickness burns resist healing due to lack of sufficient dermal elements.*

*This study mainly based on reliability and safety of methylene blue in determining the depth of deep dermal burn wounds for tangential excision and split skin grafting, so as to facilitate early wound healing.*

**INTRODUCTION :**

Burn is a coagulative necrosis of tissues. Various agents may be responsible for tissue necrosis.

Burns are classified as follows

- **Thermal injuries – High temperature** – Flame burns – Partial & full thickness
  Scalds – superficial burns
  **Low temperature** Forstbite - direct damage and vasospasm
  Freezing injury – ice crystal for mation with in this tissue.
- **Electrical burns –** full thickness with deep extension
- **Friction burns** – Heat plus abrasion with deep burn in the centre.
- **Radiation burns** – Lonizing radiation – Early tissue necrosis, later tissue dysplastic changes. These are solar rays, U.V rays and gamma rays
- **Chemical burns** (Acids or Alkalis) – Inflammation,-tissue necrosis and allergic response.

Skin tolerates temp upto $45^0$C , where the changes are reversible. Temp >$45^0$C produce irreversible changes resulting in coagulative necrosis by denaturation of cellular proteins.

**The severity of injury is related to the**

- Intensity of the heat i.e. Temperature,
- The conduction capacity of skin at the site of injury
- The length of exposure

**Criticalness of burn depends upon**

- The age of the patient
- Area involved Eg: Face & Neck, Buttocks & Lower limbs
- Associated injuries & Metabolic disorders like diabetes mellitus, heart disease & epilepsy
- Total burn surface area (TBSA) and

**Pathophysiology burn wound :**

Burn injury occurs as a result of an energy transfer from heat source to the body. This occur by direct conduction, radiation from higher to low temperature.

Thermal destruction results in several local and systemic alterations. Immediately after burn there is cessation blood flow through both arterial and venous channels due to thrombosis vasospasm and occlusion blood vessels.

There is generalised increase in capillary permeability which causes plasma leek from capillaries to interstitial spaces. This is maximum in first 8hrs and persists till 48hrs as the percentage of burn increases loss of large volume of plasma causes hypovolaemic shock. Percentage of burn is calculate by rule of nine and lundbrowder's charts. Burns more than 15% in adults and more than 10% in children needs admission and resuscitation as they may land in hypovolaemic shock.

Phases of burn wound healing is similar if not identical to those of other wounds of the skin.

**Inflammatory phase :**

Characterised by haemostasis followed by inflammatory process with migration of polymorpho nuclear leucocytosis, macrophages and lymphocytes as long as wound remain open without epithelial coverage the wound will remain in the inflammatory process.

**Proliferative phase :**

The granulation tissue that is formed after a burn wound consists of complex tissue which is composed of- fibroblasts capillary network and other infiltrating cells. The first indication are the proliferation of the capillary network at the base and margin of wound which result in the bright red colouration of the tissue. Unlike the regimented arrangement of collagen in normal skin, collagen filament found in burn wound granulation tissue are characteristically irregular and angularly shaped.

**Restoration epidermis :**

The restoration of epidermis is by the mitotic activity of basal cells in the stratum germinativum of undamaged normal epithelium. The cell division occurs at the wound margin are skin appendages like hair follicles, sweat gland

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remnants located within the wound itself. The epidermal mitotic activity becomes apparent within 42hrs after burn with hair follicles appearing to be the most important source of epidermal cells. As new epidermal cells can only migrate an estimated 1cm from the site of cell division.

The large full thickness burn wound that lacks skin ap pendages must be provided source of epidermal cells and this is usually accomplished by split skin grafting proce dures.

**Repair of the dermis :**
Repair of dermis is mediated primarily by the very numer- ous fibroblasts observed in healing tissue. Fibroblasts syn thesise the collagen, glycol proteins and muco polysaccha rides which comprise the dermal fibres and provide tensile strength.

**Maturation phase :**
During maturation phase or remodelling phase of healing, collagen fibres line-up and weave themselves in to a fabric of strength.

**Wound contraction:**
The process in word movement of margins of the wound to effect closure is known as wound contraction.

**Concept of the study :**
The concept of management of deep dermal burn wound is early tangential excision with split skin graft to provide better survival of the patient with improved quality of the function. During tangent excise demarcation bet, the dead & living tissue by the appearance of punctuate bleeding. However this needs certain amount of experience and ex pertise. Too deep an excision results in loosing viable der- mis & profuse bleeding on the contrary incomplete exci sion leaves nonviable dermis resulting in loss of skin graft. Thus exact determination of depth of excision is essential methylene blue day was used as a guide for assessing the wound Department of General Surgery, this can be used as an indicator during T.E. (Turkey 1997)[1]. However review of literature did not show much of further follow up about this. Hence the usefulness of MB as an indicator of demar- cation bet dead & living tissue in burn wound during T.E. & converted management of the burn wound was taken up as a study.

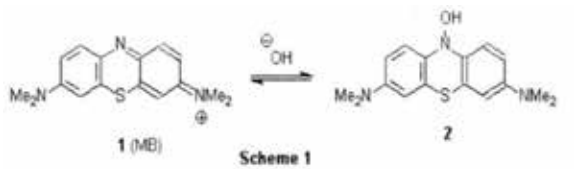
**Materials and Methods :**
We have taken up total 42 patients among which 21 are placed in group-I category in which patients were treated with tangential excision and split skin grafting and 21 cas es in group-II in which burn wounds were managed con servatively.

**Tangential excision was done after 3-5 days**
5% methylene blue applied all over the burn wound. 12hrs after application of methylene blue deep dermal and full thickness burns retain blue staining and superficial burns loss their blue colour as viable tissue metabolise methyl ene blue to leuco methylene by an enzyme Reductase.

**Inclusion and Exclusion criteria :**
Patients between 15-45 yrs age group and TBSA between 20-45% were taken –up for study.

Patients with comorbid conditions were not taken-up for the study.

**STRUCTURE OF METHYLENE BLUE**
**Chemical structure of methylene blue, $C_{16}H_{18}N_3ClS$**



Scheme 1

The metabolism and excretion of Methylene blue in living organisms was the subject of a number of investigations earliest dating back to 1885. Early investigations showed that Methylene blue was eliminated from the body in- un changed form as well as in some leuco-dye forms. A de tailed investigation was carried out in 1972 which con firmed these studies. It was shown that extracts of urine from human patients dosed with 10 mg samples of Methyl ene blue contained Methylene blue but also a leuco-dye form which was converted to Methylene blue upon acidifi cation with 5N Hcl followed by boiling for two minutes in water. The increase in UV/VIS absorption at 660 nm was measured in 1,2-dichloroethane. The structure of the leu co-dye was not determined but these results suggest a leaving group could be attached to the central nitrogen of Methylen blue that can be eliminated upon treatment with acid thus regenerating Methylene blue.

**METHYLENE BLUE USES:**
METHYLENE BLUE has got biological properties like, It can be used to treat urinary tract infections, to distinguish between cancerous and normal tissue' 1301 and as a prophylactic agent for treatment of Alzheimer's disease, and mild antiseptic activ ity against superficial fungal and bacterial infections.

METHYLENE BLUE is used as a diagnostic agent because of its blue staining properties. This is also used in the treatment of cyanide poisoning and methemoglobinemia (a blood disorder). Storage at room temperature between 59 and 86 degrees F (15 to 30 degrees C) away from heat, light and moisture.

**DISCUSSION**
Burn wound is characterized by coagulative necrosis of tis sues, covered with thick eschar and with high propensity for early colonization with bacteria. Because of these char- acteristics it differs from other wounds.

The morphology of burn wound varies with the degree of tem perature, duration of contact of the causative agent and age of the patient. Hence the dept of burn wound is not constant in a patient. Through the initial treatment is simila in all burn patients the further course of management and final outcome depend on the depth of the burn wound. In addition to the clinical assessment, many techniques have been defined to dif ferentiate the depth of the burn wound to manage properly. These are Wound biopsy, pin prick tests, Ultrasound, vital dyes, Laser Doppler perfusion monitoring [LDPM], Laser Doppler im aging [LDI], Magnetic resonance imaging [MRI], and Thermog raphy and light reflectance. All these methods are cumber- some and have their own limitations. So errors in deciding the depth are common even in experienced hands.

Clearly superficial and clearly full thick burns do not cause much difficulty, as clinical differentiation is clear. Problem is with the indeterminant variety in which differentiation is difficult. Quite often in early stages these burns are treated as superficial but cannot heal and do become deeper due to multiple reasons like desiccation, dehydration, or inva sion of infection of the burn wound. In this deep partial

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thickness category the zone of stasis of burn wound consists of biologically active and metabolically inactive cells and these cells are starved due to capillary stasis. This zone of stasis is complex, if left alone it takes an appearance identical to that of coagulation necrosis and usually sloughs as well, where as if appropriate care given at appropriate time this zone will be saved and wound will heal with better cosmetic and. functional results than similar wounds which are permitted to heal on its own.

Best results are obtained by providing and facilitating early healing of burn wound. By providing the suitable environment the Superficial burn wounds heals by its own within 2 to 3 weeks through a process of Re- epithelialization without any scarring. Whereas the deep dermal burn wounds takes longer time to heal because of lack of sufficient dermal elements and heals by scarring. The traditional method of management of deep dermal burn wound is by spontaneous separation of eschar, preparation of granulation tissue and skin grafting and finally wound heals by wound contraction leading to severe contractures with multiple deformities. Hence to minimize such deformities and return to the normal life early wound excision and skin cover is essential.

Tangential excision has proved its value in providing early skin cover and thus improving the survival and quality of the final results. However assessment of the proper depth of excision is still a tricky decision solely depending upon the experience of the surgeon. Hence any method which helps in proper assessment of the depth of such wound is helpful in managing these wounds for further results.

A simple indicator helping proper assessment of burn wound depth is very much useful during management of burn wound. Such an indicator should be simple to apply over the patient, easy to monitor at bed side, showing the results early , should not alter the body homeostasis, mild antiseptic activity , should not have any adverse effects on the wound, must be nontoxic, non allergic and excreted completely through urine when absorbed, and easily available.

Methylene blue used as an indicator in differentiating the burn wound depth during tangential excision has been tried; {Ref in 1997 at Ankara, turkey}. However review of literature did not show much of further follow up about this. Methylene blue dye has got the functional property of staining the tissue. In nonliving cells the dye is retained because of non metabolization, where as in living cell the dye is metabolized and becomes color less due to conversion of methylene blue in to leucomethylene by an enzyme Reductase. This property of staining cells can be used for assessment of burn wound depth is present in the literature. But there was no reference regarding the reliability of methylene blue in assessment of burn wound depth. There is a need to evaluate the reliability & efficacy of methylene blue as an indicator in burn wound depth. Methylene blue available routinely in the labs for various uses.

In our present study to evaluate the efficacy and reliability of methylene blue in determining the depth of burn wound, we chosen two groups of cases at random as per the inclusion criteria as Group I and Group II. In this study 5% methylene blue is applied all over the burn wound on the day of admission after obtaining the necessary photographs and investigations. Wounds are observed at regular intervals. 12hrs after the application of methylene blue, deep dermal & full thickness burns retains the blue staining; whereas superficial burn wounds lost their blue color and appear colorless.

Between January 2014 to January 2015, 42 patients of mixed flame burns were taken up for study. Among all, 21 patients are belong to Group-I [tangential excision group]. The age group of patients between 15-45 yrs, TBSA between 20-45%, were taken up for tangential excision, among all the highest percentage of deep dermal burn wound underwent methylene blue guided tangential excision was 28%, done between 3rd to 6th post burn day depending up on the general condition and fitness of the patient. During tangential excision it was noted that the blue stained tissue is excised and punctuate bleeders were not seen in a non viable layer, confirmed by biopsy as that the stained cells were showing denaturated collagen with coagulative necrosis of tissues, where as the layer below which is not stained showed normal cell structure. Mean graft take was 84.5%, and blood transfusion given according to necessity in the post op period according to C.B.Pand P.C.V values. During the study period no complications were found in relation to methylene blue application.

In Group-II, Tangential excision is not done and wounds are managed on conventional lines to allow spontaneous healing. Number of cases are 21,the age group &TBSA are same as group-I patients. It was observed that the wounds which are colourless with in 12 hrs of methylene blue healed between 2 to 3 weeks proving that they are superficial. Whereas the wounds which are blue stained [deep dermal & full thickness] are did not heal spontaneously and on separation of eschar resulted in raw area. Eschar separation occurred between 14 to 21 days according to depth of the wound. The residual raw areas were skin grafted. This observation clearly shows that it is only the dead cells of a deep burn wound which are stained by methylene blue confirming the property. . During the study period no complications were found in relation to methylene blue application.

Based on this study it is found that methylene blue is a very good aid in assessing the depth of burn wound .It is helpful especially to the beginners in proper assessment of depth of burn wound and minimizing the graft loss in cases subjected to tangential excision. This property of staining the non viable tissue as blue also constant in both Group 1 & Group 11 cases.

**OBSERVATIONS :**

- Methylene blue staining is better appreciated in early surgery, when compared to delayed surgery.
- Clearance of dead tissue is good.
- Mehtylene blue application 2 to 3 days before surgery shows less demarcation.
- Early tangential excision and auto grafting decreases the morbidity and reduces the incidence of post burn sequels.
- Better functional and cosmetic appearance.
- Decreased duration of Hospital stay and reduced number dressings in tangential excision group.
- Early recovery.

**CONCLUSION :**

Methylene blue is a reliable indicator and acts as a guide in differentiating the viable tissue from nonviable tissue, by using this aid it is easy to assess the depth of the burn wound. It is reliable and safe.

It is a cost effective simple aid in the determination of depth of the burn wound. Methylene blue is a safe and no side effects over the wound as well as over the body homeostasis.

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Group- I Case

Patient : Shankar

Post Burn wound Day -1

Photograph of Tangentiai excision and sphit skin grafft ing

After Methylene blue application Day - 5

Photograph after complete healing

Group- I Case

Patient : Munna

Post Burn wound Dau- 1

Post escherectomy wound after 3 weeks

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**After Methylene Blue Application Day - 4**


**Postoparative photograph of SSG - scar photo after complete healing**

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