1. INTRODUCTION

Wounds are the most commonly occurring cases presented in any veterinary establishment. Wound means any breach in the continuity of skin or in other words it is a disruption of the integrity and function of the skin, mucous membrane or tissue surface caused by physical, chemical or biological insult (Tyagi and Singh, 2010). The healing of wound is a biological process showing a definite pattern of cellular and molecular events which ultimately lead to repair of injured tissue (Chandrapuria et al. 1981). Optimum healing of cutaneous wound requires a well orchestrated integration of the complex biological and molecular events of cell migration, proliferation and extracellular matrix deposition, angiogenesis and remodelling (Falanga, 2005).

Dressing is a part of a holistic wound management plan with individualized patient goal like, to provide the optimal environment for healing. The use of dressings in wound management can be traced back to the Egyptians time. In 1862, a papyrus (3000–2500 BC) was discovered by Edwin Smith, an American Egyptologist. When the papyrus was finally translated in 1930 a variety of dressings were recorded. The dressings included grease, resin, honey, lint and fresh meat. Wounds were closed by the use of linen strips with sticky gum. Antiseptics made from green copper pigment were used in open wounds.

The philosophy of ‘conceal and heal’ is no longer applicable. As with all fields of medicine and surgery, wound management has seen advances in the science and art of wound care over the last several years such as in medication, materials and methods that are used in treating and reconstructing injured tissues. Even with substantial advancements in wound dressings, it appears that no single material can produce the optimum microenvironment for all wounds or for all the stages of the wound healing process. Dressing selection should therefore be tailored to the condition of the wound. Recently wound dressings are categorized in the drug tariff, according to the properties of the dressing and there are usually several types of dressings within a category. However, from a clinical perspective there is an
easier way of classifying dressings into groups like wound healing stimulant, moisture retentive and antimicrobial dressings.

Antimicrobial dressings are those dressings that contain antimicrobial agents which are being used and evaluated in Veterinary Medicine. Two such dressings are polyhexamethylene biguanide (PHMB) and silver ion dressings. polyhexamethylene biguanide is a chlorhexidine related agent that destabilizes bacterial cytoplasmic membranes (Campbell, 2006).

The moisture retentive dressings retain the moisture over the wound which in turn enhance the healing. The reasons behind it’s positive effect on wound healing includes cell proliferation and function in the inflammatory and repair stages which are enhanced by the warm moist environment e.g. polyurathane films which are indicated for wounds without or minimal exudates (Campbell, 2006) and calcium alginate suitable for wounds with heavy exudates.

The wound healing stimulators have been reported to soften necrotic tissue, penetrate some of the wound irregularities, nontoxic, without systemic absorption. Moreover, these dressings are effective in infected and non-infected wounds e.g. maltodextrin-d-glucose and collagen which are available as a powder, film and gel (Krahwinkel and Boothe, 2006).

Looking to the need and scarcity of literature on wound healing with different readymade dressing materials, the present work has been planned with the following objective -

**Objective**

To evaluate the healing pattern with therapeutic versus conventional dressings on healing of cutaneous wounds in goats.
2. REVIEW OF LITERATURE

The selection of wound dressing for treatment of wounds destined to heal by second intention or be treated by delayed closure can be important to the outcome. Different dressings have been shown to promote healing during different phases of the wound healing process. Dressing selection should therefore be tailored to the condition of the wound. It necessitates the use of antimicrobial dressing initially, changing to moisture retentive and wound healing stimulators at later stage.

Dressings

Conventional dressing with Povidine Iodine

Rodeheaver et al. (1982) studied the bactericidal activity of povidone iodine solution in contaminated wounds in Hartley guinea pigs with the potential therapeutic benefit and concluded that aqueous iodophors can be used in wounds.

Howell et al. (1993) failed to find any decrease in the wound bacterial count in laceration in guinea pig model following irrigation with povidine idodine in comparision to normal saline.

Kjolseth et al. (1994) compared the effect of six commonly used topical wound agents (bacitracin, sodium hypochlorite, silver nitrate, silver sulfadiazine, mafenide acetate, and povidone-iodine) on epithelialization and neovascularization and concluded their effects.

Advanced Dressings

Chlorhexidine dressing

Is a tulle grass dressing which is impregnated with white soft paraffin B.P. containing chlorhexidine acetate B.P. 0.5 % w/w. This is an antimicrobial dressing which is effective against both gram positive and gram negative. The dressing comes in 10 cm ×10 cm of size.

Chlorhexidine is having broad spectrum bactericidal property. It damages the outer layer of cell causing leakage of cellular components of bacteria.
Sanchez (1988), Payne (1999), Cooper (2004), Katara (2012) and Lee et al. (2004), reported that chlorhexidine dressings are having broad spectrum bactericidal properties than that of povidone dressings. In another study, Cooper and Vowden (2006) found that in chlorhexidine and povidone only iodine is sporicidal.

Ersin et al. (2005) compared silver-coated dressing (Acticoat™), chlorhexidine acetate 0.5%, and fusidic acid 2% for topical antibacterial effect in methicillin-resistant Staphylococci-contaminated, full-skin thickness rat burn wounds. They concluded that Acticoat is a choice of treatment with the particular advantage of limiting the frequency of replacement of the dressing.

Timsit et al. (2009) assessed superiority of Chlorhexidine impregnated sponge dressings regarding the rate of major catheter-related infections in human. They concluded that the interval between dressing changes can be safely extended to more than 3 days but not exceeding 7 days, provided the dressings are closely monitored and changed immediately should separation or soiling be detected. Furthermore, use of CHGIS dressings decrease the rate of major CRI when the baseline rate is lower than 2 per 1000 catheter-days.

**Alginate dressing**

It is made from the salt alginic acid obtained from algae *Phaeophyceae* found in sea weed. Since the dressing is hydrophilic it can absorb up to 20-30 times its weight in wound fluid. This process converts the initial dry felt like material into hydrophilic gel on the wound surface that is easily removed and hence it causes autolytic debridement. The hydrophilic alginate gel forms via a calcium and sodium exchange, providing a moist environment conductive to wound healing. It is available in 2×2, 4×4 and 10×10 cm presentation. It is used in management of epidermal and dermal wounds leads to rapid granulation and re-epithelialisation.

Barnette and Varley (1987), carried trials on large white yorkshire pigs and used non-woven alginate on experimental, full and partial thickness wound models for periods up to 14 days, to assess its effects on wound healing. Good epidermal healing was seen on all wounds although
cellular reactions could be provoked in full thickness wounds without occlusion, if there was an insufficient volume of wound exudate to completely wet the alginate fibres.

Matthew et al. (1994), evaluated the effect of Alginate on haemostasis and wound healing of a proprietary in dogs when applied to a wound of the buccal mucosa of approximately 2 mm depth. He found it effective as a haemostatic mucosal dressing in shallow wounds, but it does not accelerate mucosal wound healing.

Suzuki et al. (1999) found early granulation and epithelisation in the full and partial thickness wounds of pig dressed with calcium alginate than that of control.

Kofler et al. (2004) treated infected wounds and abscesses in bovine limbs with Ligasano-polyurethane-soft foam dressing material based dressing. For this cattle with infected cut, puncture and laceration wounds on the limbs, purulent tarsal hygromas, large abscesses in the tarsal, crural and thigh regions, and purulent tenosynovitis of the digital flexor tendon sheath caused by penetrating puncture wounds were selected. They found Ligasano-polyurethane-soft foam convincing in bovine that now it is used exclusively as primary wound dressing material for treatment of infected wounds.

Paul and Sharma (2004) and Woo et al. (2009) found early reduction in the size of the wounds dressed with calcium alginate than that of control in rats and found complete healing within 10 days.

Stashak et al. (2004) reported in equines, that calcium alginate has no inherent antimicrobial properties but bacteria may possibly become intrapped in gel and removed during dressing change and hence they also help in minimising inflammation.

Murakami et al. (2010) developed a hydrogel sheet composed of a blended powder of alginate, chitin/chitosan and fucoidan (ACF-HS) as a functional wound dressing in order to create a moist environment for rapid wound healing. Early granulation tissue and capillary formation in the healing-impaired wounds treated with ACF-HS on day $7^{th}$, as compared to those treated with calcium alginate fibre and those left untreated.
Prabhusanker (2011), Woo et al. (2012), Tiwari et al. (2013) in humans, Uraloglu et al. (2012) in rats, found reduced inflammation in the wounds, when dressed with alginate in comparison to groups dressed with other dressings like povidone iodine, clinoptilolite, microporous polysaccharide hemisphere, hydrogels and biosynthetic wound dressings.

Morgan (2012) mentioned that alginate can absorb moisture and exudates twenty times of its weight.

Balakrishna et al. (2013) compared the efficacy of calcium alginate dressings with betadine dressings in the management of non-malignant non-healing ulcers. All parameters were comparable. So they concluded that silver and calcium alginate wound dressings though more expensive have comparable efficacy compared to simple betadine dressings in the treatment of non-healing ulcers.

Collagen dressing

It is a type I sterilized collagen sponge (fish origin) of presentation 10cm×10cm. Collagen is an extra cellular matrix protein playing a major role in connective tissue. It is the most abundant protein in humans and performs multiple functions. In fish the largest concentration of collagen is found in the skeleton, fins, skin and air bladder. Collagen as a biomaterial and its role in wound management is a well–documented subject. Collagen kick start wound healing cascade through deposition and organization of fresh formed fibres and granulation tissues in the wound bed and thus creating conducive environment for wound healing. It provides anti-infective, anti-inflammatory, anti-fibrotic and analgesic properties as well as promote angiogenesis, returning body to its normal state and function and providing a foundation for wound healing.

Lorenzetti et al. (1972), Glasgold et al. (1991) in human reported subjective enhancement of wound closure and cosmesis in wounds dressed with collagen.

Mian (1992), Al-Kateeb et al. (1996), Swaim et al. (2000) and Basha et al. (2011) in dogs, Fleck and Simman (2010) and Sarabahi (2012) in
human, mentioned that chronic wounds treated with topical collagen improves wound healing by laying down a matrix which favours deposition of new tissue and attracts cells necessary for healing. The collagen is thought to be chemotactic for fibroblasts and macrophages and also provide a temporary scaffold to allow in growth of tissue and hence it causes early healing of wounds. Contrary to this Stashak et al. (2004) found no benefit of collagen dressings in equines.

Donaghue et al. (1998) found that wound size reduced significantly in the collagen-alginate dressing group, as compared with the gauze dressing group.

Mridha et al. (2010) in equine found that collagen dressings while acting as a mechanical support also reduce odema and loss of fluids from the wound site. While in another study, Nunes et al. (2011) reported less inflammation in the wounds of group of rats dressed with collagen film containing usnic acid than that of other group had collagen film with empty liposomes.

Singh et al. (2011) compared the efficacy of collagen dressing in treating burn and chronic wounds with that of conventional dressing materials and concluded that Collagen dressing may avoid the need of skin grafting, and provides additional advantage of patient’s compliance and comfort.

Rao et al. (2012) in human, compared collagen dressings with conventional dressings in wound healing. No adverse event was reported in both the groups. This made them to conclude that collagen dressings are effective in chronic wounds and ulcers. It significantly reduce the duration of healing, antibiotic therapy and follow up time.

**Haematological Parameter:**

Gomez et al. (2004), studied three biologic dressings in wounds of horses. They found no significant difference in the parameters evaluated among the treated wounds or between the treated and control wounds. The biologic dressings had no effect on infection, inflammatory response, or healing time.
Li et al. (2006) pointed that generally influx of monocytes and neutrophils into the wound bed is initiated by chemoattractant released during haemostasis such as complement PDGF and TGF-β, as well as bacterial products.

Sibbald (2007), Basha et al. (2011) in dogs and Sinno et al. (2012) in rats, studied the efficacy of fish scales extracted collagen biocasings on cutaneous wound healing. Haematobiochemical studies showed significant increases in platelet count and monocyte count between day 0 and day 3. The hemoglobin level decreased over this time interval. When comparing day 0 with day 7, the haemoglobin level and platelet count appeared to increase, in contrast to the white blood cell count. At day 28, only the monocyte count was elevated. Neutrophil, lymphocyte and eosinophil counts were not different when compared between day 0 and days 3, 7 and 28.

Šitum et al. (2007) compared systemic inflammatory and haematology parameters in normal and genetically diabetic mice during local wound repair. In this study they compared serum amyloid. A protein (SAA), haematological parameters (total white blood cell count, neutrophil and lymphocyte percentage) and interferon-gamma (IFN-γ) concentrations in serum during healing. They concluded that the local tissue regeneration process in mice after local skin injury causes systemic changes in peripheral blood.

**Biochemical Parameter**

Riddle (1964), stated that fibrinogen is the sole precursor of fibrin and as such plays a dominant role in coagulation. It has been suggested that by promoting surface phagocytose fibrinous exudates contribute to antibacterial defences. The peptides released when fibrinogen is acted on by thrombin have a physiological activity on smooth muscle and may help to control the blood flow in the capillary bed. Neutrophils can phagocytise fibrin, fibrinogen, or their breakdown products, and evidence has been presented to show that profibrinolysin is synthesized by the eosinophils of the bone marrow and is then released to the tissues when necessary.
McSherry et al. (1970), determined mean plasma fibrinogen levels in normal calves, bulls, non-pregnant and pregnant cows. These were 508, 505, 660, and 581 mg per 100 ml of plasma respectively. The levels in 233 sick cows were often greatly increased. This appeared to be related to inflammation and tissue destruction. Lower than normal levels were sometimes seen in liver disease and terminal states.

Bradfield et al. (1992), studied behavioural and physiologic effects of inapparent wound infection in rats. They found significant alteration in plasma fibrinogen, serum glucose, total white blood cells and wound histology in bacteria inoculated rats. By this they concluded that there is need for sterile techniques in rat surgery to avoid confounding experimental data.

Francis (2001), mentioned that fibrinogen is found primarily at sites of injury, thrombosis, inflammation, or malignancy. It is having an important role in clot formation and wound healing.

Burns (2003), found that protein plays a central role in wound healing through the production of collagen. Therefore, the goal of nutritional support should be to minimize protein catabolism. Protein depletion can be caused by trauma, sepsis, nephritic syndrome, liver disease, chronic open wounds, and burns. The consequences of protein depletion for wound healing include decreases in angiogenesis and fibroblast proliferation. This results in decreased synthesis, accumulation, and remodelling of collagen.

Sari et al. (2009) conducted a pilot study to evaluate changes in serum and exudate creatinine phosphokinase concentrations as an indicator of deep tissue injury. Rats were divided into control, 6 hours 10-kg and 6 hours 20-kg loading groups. Serum samples were obtained before wounding, and at 8 and 12 hours, and 1, 2 and 3 days after wounding, while exudate samples were obtained on days 2 and 3. Serum CPK levels were markedly increased at 8 and 12 hours after loading compared with the baseline value and control group, but decreased to the normal level on day 1.

ALGani (2011), reported peak value of Creatinine Kinase during early 4-8 hours of acute symptoms of muscle injury and decreased gradually in 3-4 days after injury.
Zapryanova *et al.* (2013) in dogs found that the staphylococcal infection induced gradual and marked increase in fibrinogen concentration since the 6th hour until the 3rd-7th days (maximal values) and thereafter this marker slowly declined. They concluded that fibrinogen is a better marker for the presence of infection and inflammation.
3. MATERIAL AND METHODS

3.1 Location and place of work

The study was carried out in the Amanala Goat Farm, Government Veterinary Hospital, Omti and Department of Veterinary Surgery and Radiology, Teaching Veterinary Clinical Complex (TVCC), College of Veterinary Science and Animal Husbandry, Nanaji Deshmukh Veterinary Science University, Jabalpur (M.P).

3.2 Meteorological data and features of the place

Jabalpur is situated at 23.27° latitude and 79.57° longitude at 410.87 MSL in southern part of the second agro climatic zone, including Satpura plateau and kymore hills. It has a tropical climate having average rainfall of 1241 mm.

3.3 Animals

The clinical efficacy of the advanced dressings in wound healing on goats brought from Amanala Goat Farm, Government Veterinary Hospital, Omti and TVCC, Jabalpur, for treatment of wounds was evaluated.

3.4 Animal management and pre treatment period

The present work was conducted in eighteen clinical cases of adult goats, brought for the treatment of cutaneous wounds. These animals were divided randomly into two groups irrespective of sex, breed, site of the wound and body weight. The complete physical examination of all the animals was carried out to ensure their physical status. Type of wound and history of cases were recorded. The clinical parameters such as degree of inflammation (Visual Score), degree of exudation (Visual score) and healing of the wound (%) were recorded on day 0 and subsequently on day 3,7,10, and 14 post treatment. Blood sample of each animal was collected from the jugular vein with heparin and without heparin for haematological and biochemical analysis respectively like total erythrocyte count (TEC), total leucocyte count (TLC), differential leukocyte count (DLC) ,haemoglobin concentration (Hb), packed cell volume (PCV), total serum protein,serum creatinine kinase and plasma
fibrinogen. The wound margins were marked with black Indian ink and tracings were taken on cellophane paper before starting of the treatment and subsequently on day 3, 7, 10 and 14 post treatment.

3.5 Plan of experiment:

The total duration of the experiment was six months from January to June 2014. The goats were randomly divided into two groups I and II. Group I was control consisted of 6 animals treated by conventional method of dressing and group II was treatment group in which the wounds were treated with three advanced dressings.

<table>
<thead>
<tr>
<th>Group</th>
<th>Animals</th>
<th>Treatment</th>
</tr>
</thead>
</table>
| I (Control) | 6 | • Cleaning of the wounds with hydrogen peroxide and povidine iodine till complete healing.  
  • Parenteral antibiotic ( inj procain penicillin +benzyl penicillin + streptomycin sulphate @ 10mg /kg b wt ,IM, bid) for five days.  
  • Analgesic (flunixin meglumine @ 2.2 mg/kg b wt ,IM,bid) for first three days. |
| II | 12 | • Dressing of wound with chlorhexidine for three days.  
  • Calcium alginate for atleast two days.  
  • Collagen sponge till complete healing (Plate 01).  
  • Wound was bandaged for better immobilization and protection from contamination especially when it was subjected to mobility.  
  • Parenteral antibiotic and analgesic as in group I. |
3.6 Methodology

Group I

The animals of this group were treated as control, consisting of six animals with cutaneous wounds of size approximately 4 cm to 8 cm which received conventional dressing. Wounds were cleaned with hydrogen peroxide and antiseptic dressing with povidone iodine. Parenteral antibiotic (procaine penicilline + benzyl penicillin + streptomycin sulphate @ 10mg/kg, b wt, IM, bid) for five days and analgesic (flunixin meglumine @ 2.2 mg/kg b wt, I.M, bid) was administered intramuscularly at least for 3 days.

Group II

It consisted of twelve animals with cutaneous wounds of size as in group I which were treated with the advanced therapeutic dressings in phases as follows:

Phase I

On day 0 the wounds were cleaned with normal saline followed by application of antimicrobial dressing for at least 3 days*.

Phase II

On 4th day the first dressing was removed and wound was checked. If it seemed free of infection then alginate dressing was used to remove the debris and necrotic material for 2 days1.

Phase III

On 6th day the second dressing was taken out and collagen dressing was applied till the wound get healed. Administration of parenteral antibiotic and analgesic in all the animals was same as in group I.

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1. The Individual phases were extended or shortened from the scheduled interval on the basis of presence or absence of microbial contamination or necrotic material.
3.7 Parameters of study

3.7.1 History

The complete history of the wound was recorded including breed, age, sex, etiology, site, duration of wound, general body condition and medication (if any, previous dressing used for wound healing).

3.7.2 Assessment of wound healing:

To facilitate the treatment, open cutaneous wounds were further classified as per O’Connor (2005) into:

1) **Aseptic** – No open wound in veterinary patient is considered as absolutely aseptic, but in many cases, if infection is present, its virulence is so slight that it has practically no inhibitory effect on the process of repair. The best example is fresh wound which is surgically created with all aseptic precautions. Such wound heal by First Intention.

2) **Suspicious** – These are the wounds which were otherwise capable of primary healing but with lapse of time now doubted for contamination. Moderate inflammation is present with or without signs of infection.

3) **Septic** – Marked inflammation and suppuration are evident.

Only Suspicious and Septic wounds were selected for the present study and assessed on visual basis for:

- Degree of inflammation (Visual Score)-Scored as absent, mild, moderate, and severe.
- Degree of exudation (Visual Score) - Scored as absent, mild, moderate, and severe.
- Size of wound –The size of the wound was measured by using planimeter (Bhowmick *et al.*, 2013).
- Healing of the wound (%) – Per cent healing was determined by marking wound boundaries with black Indian ink and tracings on
cellophane paper before starting the treatment and subsequently on day 3, 7, 10 and 14 and it was calculated by the method described by Kumar and Tyagi (1972):

\[ H(\%) = \frac{A - B \times 100}{A} \]

Where \( H(\%) \) – Per cent healing

\( A \) -- Area of wound at the beginning of particular period.

\( B \) -- Area of wound at the end of particular period.

### 3.7.3 Haemato-biochemical Estimations

The healing of the wound was evaluated on the basis of hematobiochemical studies. Total Five milliliters of venous blood was collected aseptically from Jugular vein in vacutainer vial containing 10% aqueous solution of EDTA as per the schedule on day 0, 7 and 14 and was processed for haematobiochemical studies.

#### a) Haematological parameters

1. Total erythrocyte count \((x10^6/\mu L)\)
2. Total leukocyte count \((x10^3/\mu L)\)
3. Differential leukocyte count (\%) - Leishman's stain was used for staining slides.
4. Haemoglobin concentration \((g/dl)\)
5. Packed cell volume (%) 

All the Haematological parameters were measured manually as per the method described by Benjamin (2001).

#### b) Biochemical parameters

1. Total serum protein \((g/dl)\)

The total serum protein was estimated by using Erba albumin kit\(^2\) (Biuret Method, end point).
2. Serum creatinine kinase (U/L)

The Serum creatinine kinase in serum was estimated by Erba creatinine kinase kit³.

3. Plasma fibrinogen (g/dl)

The Plasma Fibrinogen was estimated by using Erba fibrinogen kit⁴.

Biochemical – Attributes using semi automatic biochemical analyser (Erba CHEM -5 plus v2) using their respective kits.

c) Microscopic examination – For cytological study a sterilized slide was used for preparation of impression smear by placing it over the wound which was visualized microscopically for the presence of bacteria and cells after staining with Gram’s and Leishman’s stain.

3.7.4 Statistical analysis

The collected qualitative data was placed on an arbitrary score as per standard method and the haematobiochemical data was compared by using ANNOVA between groups (Snedecor and Cochran, 1994).

1. ERBA –Total Protein Kit, Biuret method. Transia Bio Medical Ltd, Daman.
2. ERBA – Creatinine Kinase Kit, NAC. Activate method, Transia Bio Medicals Ltd., Daman
3. SIEMENS- Fibrinogen Kit, Siemens healthcare Diagnostics Inc., Newark, U.S.A.
4. RESULTS

4.1 Anamnesis

The present study was conducted in eighteen adult goats with open cutaneous wounds. The age of the animals included in the study ranged from 9 months to 17 months. Out of 18 goats selected for study two were males (11.1%) and sixteen were females (88.8%). The cases of wounds were found to be more in Sirohi (66.6%) than that of Barbari (22.2%) and Non-descript (11.1%) breed of goats. The wounds of the animals were found mostly near the flank (44.4%), neck (33.3%), base of the ear (11.1%), hind limb (5.5%) and peri-vaginal area (5.5%). Body condition of all the animals was apparently good. No previous treatment was given to the animals except in case 4 where wound was cleaned with hydrogen peroxide and melonex was administered intramuscularly (Table 01).

Table.01: Anamnesis

<table>
<thead>
<tr>
<th>S.No</th>
<th>Breed</th>
<th>Age (Months)</th>
<th>Sex</th>
<th>Body weight (kg)</th>
<th>Etiology</th>
<th>Duration Of wound (days)</th>
<th>Site</th>
<th>Body condition (apparently)</th>
<th>Previous treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Barbari</td>
<td>17</td>
<td>female</td>
<td>30</td>
<td>unknown</td>
<td>2</td>
<td>Flank</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>2</td>
<td>Sirohi</td>
<td>9</td>
<td>female</td>
<td>34</td>
<td>unknown</td>
<td>2</td>
<td>Flank</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>3</td>
<td>Sirohi</td>
<td>12</td>
<td>female</td>
<td>28</td>
<td>Abscess</td>
<td>2</td>
<td>Neck</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>4</td>
<td>Barbari</td>
<td>12</td>
<td>female</td>
<td>38</td>
<td>Fight</td>
<td>2</td>
<td>Neck</td>
<td>Good</td>
<td>Dressing with hydrogen peroxide + melonex I.M</td>
</tr>
<tr>
<td>5</td>
<td>Sirohi</td>
<td>16</td>
<td>female</td>
<td>31</td>
<td>unknown</td>
<td>1</td>
<td>Neck</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>6</td>
<td>Non discrpt</td>
<td>10</td>
<td>male</td>
<td>25</td>
<td>Dog bite</td>
<td>3</td>
<td>Hind limb</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
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<td>28</td>
<td>unknown</td>
<td>2</td>
<td>Flank</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>8</td>
<td>Barbari</td>
<td>10</td>
<td>female</td>
<td>30</td>
<td>unknown</td>
<td>2</td>
<td>Flank</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>9</td>
<td>Sirohi</td>
<td>17</td>
<td>male</td>
<td>37</td>
<td>Fight</td>
<td>3</td>
<td>Neck</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>10</td>
<td>Sirohi</td>
<td>12</td>
<td>female</td>
<td>32</td>
<td>unknown</td>
<td>1</td>
<td>Flank</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>11</td>
<td>Sirohi</td>
<td>15</td>
<td>female</td>
<td>35</td>
<td>unknown</td>
<td>2</td>
<td>Flank</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>12</td>
<td>Barbari</td>
<td>9</td>
<td>female</td>
<td>27</td>
<td>unknown</td>
<td>1</td>
<td>Neck</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>13</td>
<td>Non discrpt</td>
<td>12</td>
<td>female</td>
<td>33</td>
<td>Self inflected injury</td>
<td>4</td>
<td>Peri vaginal</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>14</td>
<td>Sirohi</td>
<td>14</td>
<td>female</td>
<td>35</td>
<td>unknown</td>
<td>2</td>
<td>Flank</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>15</td>
<td>Sirohi</td>
<td>12</td>
<td>female</td>
<td>31</td>
<td>unknown</td>
<td>2</td>
<td>Flank</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>16</td>
<td>Sirohi</td>
<td>9</td>
<td>female</td>
<td>29</td>
<td>unknown</td>
<td>1</td>
<td>Neck</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>17</td>
<td>Sirohi</td>
<td>12</td>
<td>female</td>
<td>34</td>
<td>Fight</td>
<td>2</td>
<td>Base of ear</td>
<td>Good</td>
<td>Nil</td>
</tr>
<tr>
<td>18</td>
<td>Sirohi</td>
<td>16</td>
<td>female</td>
<td>36</td>
<td>Fight</td>
<td>2</td>
<td>Base of ear</td>
<td>Good</td>
<td>Nil</td>
</tr>
</tbody>
</table>
4.2 Clinical observations

Total eighteen adult goats with suspicious (11.1%) or septic wounds (88.8%) were included in the study. The wound was clinically observed on day 0 and subsequently on 3, 7, 10 and 14 following treatment for the degree of inflammation (visual score), degree of exudation (visual score), size of the wound (cm$^2$) and degree of healing(%). The degree of inflammation was assessed visually on the basis of colour, severity of pain and swelling. The size of the wound was measured with the help of planimeter.

4.2.1 Degree of inflammation

In animals of group I the inflammatory signs observed at day 0 were moderate to severe which remained almost same on day 3. On 7th day of observation the inflammation reduced to mild degree and it was absent on 10th and 14th post treatment day.

Similarly in group II the inflammation was moderate to severe at day 0 which subsided to mild on day 3 and was absent on later intervals of observation.

On Comparative evaluation between the groups the animals of group II showed better response in respect of inflammation (Table 02).

Table 02: Degree of inflammation (visual score) at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Moderate to severe</td>
<td>Moderate to severe</td>
</tr>
<tr>
<td>3</td>
<td>Moderate to severe</td>
<td>Mild</td>
</tr>
<tr>
<td>7</td>
<td>Moderate to mild</td>
<td>Absent</td>
</tr>
<tr>
<td>10</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>14</td>
<td>Absent</td>
<td>Absent</td>
</tr>
</tbody>
</table>
4.2.2 Degree of Exudation:

In animals of group I moderate to severe exudation was observed at day 0 which decreased to mild to moderate on day 3. On 7th day post treatment the inflammation reduced to mild degree and it subsided on 10th and 14th day.

Similarly in group two the exudation was moderate to severe at day 0 which subsided to absent to mild on day 3 and was absent at later intervals of observation.

Comparative evaluation between the groups was suggestive of the fact that the exudation level was more in group I than that of II (Table 03).

Table 03: Degree of Exudation (Visual score), at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Moderate to Severe</td>
<td>Moderate to Severe</td>
</tr>
<tr>
<td>3</td>
<td>Mild to Moderate</td>
<td>Absent to Mild</td>
</tr>
<tr>
<td>7</td>
<td>Mild</td>
<td>Absent</td>
</tr>
<tr>
<td>10</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>14</td>
<td>Absent</td>
<td>Absent</td>
</tr>
</tbody>
</table>

4.2.3 Size of wound

The mean values of size of the wounds in animals of group I was found 8.95±0.04 cm² which decreased to 2.52±0.04 cm² on 14th post treatment day.

Similarly, in group II the mean value of size of the wound on day 0 was 8.92±0.02 cm² which reduced considerably to 0.77±0.12 cm² on 14th day following treatment.
The decrease in the mean values of size of the wound was found significant (P<0.05) between the groups. On day 3 the size of the wound in group I was 7.57±0.03 while in group II 6.44±0.19 cm². Similarly, on day 7 it reduced to 6.29±0.03 and 4.19±0.39 cm² in group I and II respectively. Observation on day 10th depicted further reduction to 4.13±0.04 in control group, while in treatment group it was 2.32±0.25 cm². On 14th day the size of the wound reduced to its minimum value that is 2.52±0.04 and 0.77±0.12 cm² in group I and II, respectively. It was found that the size of the wound reduced more in group II than that of group I (Table 04 and Figure 01).

Table 4: Mean values (±SE) of size of the wound (cm²), at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8.95±0.04</td>
<td>8.92±0.02</td>
</tr>
<tr>
<td>3</td>
<td>7.57±0.03*</td>
<td>6.44±0.19</td>
</tr>
<tr>
<td>7</td>
<td>6.29±0.03*</td>
<td>4.19±0.38</td>
</tr>
<tr>
<td>10</td>
<td>4.13±0.04*</td>
<td>2.32±0.25</td>
</tr>
<tr>
<td>14</td>
<td>2.52±0.04*</td>
<td>0.77±0.12</td>
</tr>
</tbody>
</table>

*Significant at 5% level between the groups

4.2.4 Degree of healing

The mean values of degree of healing (%) of the wounds in animals of group I 15.38±0.05 % on day 3 post treatment day which progressed upto 71.82±0.28 % on 14th day (Plate 02 and 03).

Similarly, in group II the mean value of degree of healing (%) of the wounds was calculated 27.88±1.94 % on day 3 which considerably increased upto 91.33±1.28 % on 14th day (Plate 04,05 and 06).

The increase in the mean values of degree of healing of the wound was significant (P<0.05) between the two groups. On day 3 the degree
of healing of the wound in group I was 15.37±0.05 % while in group II 27.88±1.94%. Similarly on day 7, it increased upto 29.74±0.03 and 53.15±0.39 % in group I and II respectively. On day 10, it further increased to 53.87±0.21% in control group while in treatment group it was 74.53±2.68 %. On 14th day the degree of healing increased to its maximum value that is 71.82±0.28 and 91.33±1.28 % in group I and II, respectively. The comparison between the two groups revealed that degree of healing was more in group II than that of group I (Table 05 and Figure 02).

Table 5: Mean values (±SE) of degree of healing (%), at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>15.38±0.05</td>
<td>27.88±1.94*</td>
</tr>
<tr>
<td>7</td>
<td>29.74±0.03</td>
<td>53.15±0.39*</td>
</tr>
<tr>
<td>10</td>
<td>53.87±0.21</td>
<td>74.53±2.68*</td>
</tr>
<tr>
<td>14</td>
<td>71.82±0.28</td>
<td>91.33±1.28*</td>
</tr>
</tbody>
</table>

*Significant at 5% level between the groups

4.2.5 Macroscopic evaluation of the wound

The wounds in group II which were treated with advanced dressing materials exhibited decreased inflammation, exudation, earlier granulation, better organization, compactness and intense epithelial regeneration leading to rapid healing of wounds. The second intention healing with minimal scar at wound site was noticed in all the cases of group II, while in group I the scar was present after healing.

5. Haematological analysis

In present study the hematological analysis was performed in all the 18 animals on day 0, 7 and 14 following treatment to check if the wound dressings affect any of the blood parameters significantly.
5.1 Haemoglobin concentration:

In animals of group I the mean values of haemoglobin concentration was estimated as 10.18±0.58 g/dl at day 0 which decreased slightly under normal range to 09.92±0.59 g/dl on day 14.

Similarly, in group II the mean value of haemoglobin concentration was estimated 10.48±0.38 g/dl at day 0 which fluctuated under normal range to 10.57± 0.38 g/dl on day 14.

Comparative evaluation of the mean values of haemoglobin, revealed non significant difference between both the groups on different time intervals (Table 06 and Figure 03).

Table 06: Mean values (±SE) of haemoglobin concentration (g/dl), at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10.18±0.58</td>
<td>10.48±0.38</td>
</tr>
<tr>
<td>7</td>
<td>10.47±0.59</td>
<td>10.37±0.42</td>
</tr>
<tr>
<td>14</td>
<td>09.92±0.59</td>
<td>10.57± 0.39</td>
</tr>
</tbody>
</table>

Non significant at 5% level between the groups

5.2 Packed cell volume

In animals of group I the mean value of packed cell volume was estimated 31.68±0.98 % at day 0 which increased under normal range to 34.20±1.08% on day 14.

Similarly, in group II the mean value of packed cell volume was recorded 30.32±1.04% at day 0 which increased under normal range to 33.13±0.53 % on day 14.

Comparative evaluation between the groups revealed non significant difference in the packed cell volume on day 7 and 14 between both the groups (Table 07 and Figure 04).
Table 07: Mean values (±SE) of packed cell volume (%), at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>31.68±0.98</td>
<td>30.32±1.04</td>
</tr>
<tr>
<td>7</td>
<td>33.62±1.11</td>
<td>31.89±0.95</td>
</tr>
<tr>
<td>14</td>
<td>34.20±1.08</td>
<td>33.13±0.53</td>
</tr>
</tbody>
</table>

Non significant at 5% level between the groups

5.3 Total erythrocyte count

In animals of group I the mean value of total erythrocyte count was estimated 11.57±0.57 million/µl at day 0 which decreased under normal range to 11.29±0.58 million/µl on day 14.

Similarly, in group II the mean value of total erythrocyte count was 11.25±0.35 million/µl at day 0 which fluctuated under normal range to 11.59±0.56 to 11.19±0.35 million/µl on day 7 and 14 respectively.

Comparative evaluation between the groups, a non significant difference in the total erythrocyte count was found on day 7 and 14 between both the groups (Table 08 and Figure 05).

Table 08: Mean values (±SE) of total erythrocyte count (million/µl), at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>11.57±0.57</td>
<td>11.25±0.35</td>
</tr>
<tr>
<td>7</td>
<td>11.64±0.56</td>
<td>11.59±0.37</td>
</tr>
<tr>
<td>14</td>
<td>11.29±0.58</td>
<td>11.19±0.32</td>
</tr>
</tbody>
</table>

Non significant at 5% level between the groups
5.4 Total leukocyte count:

In animals of group I the mean value of total leukocyte count fluctuated between 10.28±0.24 to 13.09±0.23 thousand/µl from day 0 to 14.

Similarly, in group II the mean value of total leukocyte count was 10.38±0.27 thousand/µl at day 0 which increased under normal range to 12.05±1.74 thousand/µl on day 14.

Comparison of data between the groups on 7th day revealed that the leukocyte count was non significantly more in group I while on 14th day it was more in group I in comparison to group II (Table 09 and Figure 06).

Table 09: Mean values (±SE) of total leukocyte count (thousand/µl), at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10.28±0.24</td>
<td>10.38±0.27</td>
</tr>
<tr>
<td>7</td>
<td>10.54±0.26</td>
<td>10.82±0.22</td>
</tr>
<tr>
<td>14</td>
<td>13.09±0.23</td>
<td>12.05±1.74</td>
</tr>
</tbody>
</table>

Non significant at 5% level between the groups

5.5 Differential leukocyte count

5.5.1 Neutrophil per cent

In animals of group I the mean value of neutrophil per cent was found to be 31.50±1.54% at day 0 which increased under normal range to 32.83±1.54% on day 14.

Similarly, in group II the mean value of neutrophils per cent was 32.83±1.54 at day 0 which decreased on day 14 to 24.33±0.33%.

Comparative evaluation between the groups reveled significantly lower neutrophil per cent on day 14th in group II than in group I (Table 10 and Figure 07).
Table 10: Mean values (±SE) of neutrophil (%) at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>31.50±1.54</td>
<td>32.83±1.54</td>
</tr>
<tr>
<td>7</td>
<td>29.00±1.31</td>
<td>26.92±0.29</td>
</tr>
<tr>
<td>14</td>
<td>32.83±1.54*</td>
<td>24.33±0.33</td>
</tr>
</tbody>
</table>

* Significant at 5% level between the groups

5.5.2 Lymphocyte per cent:

In animals of group I the mean value of lymphocyte per cent was found to be 63.50±1.67% at day 0 and fluctuated between 66.33±1.52 to 64.00±1.53 % on day 7 and 14.

Similarly, in group II the mean value of lymphocyte per cent was 64.42±0.66% at day 0 which increased to 69.83±0.52 % on day 14.

On Comparative evaluation between the groups lymphocyte per cent was non significant on day 7. However on day 14 the mean value of lymphocyte in group II was significantly more than the group I (p<0.05) (Table 11 and Figure 8).

Table 11: Mean values (±SE) of lymphocyte (%) at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>63.50±1.67</td>
<td>64.42±0.66</td>
</tr>
<tr>
<td>7</td>
<td>66.33±1.52</td>
<td>69.67±0.45</td>
</tr>
<tr>
<td>14</td>
<td>64.00±1.53</td>
<td>69.83±0.52*</td>
</tr>
</tbody>
</table>

* Significant at 5% level between the groups
5.5.3 Eosinophil per cent:

In animals of group I the mean value of eosinophil per cent fluctuated under normal range 3.00±0.26 to 2.33±0.21% from 0 to 14\textsuperscript{th} day post treatment.

Similarly, in group II the mean value of eosinophil per cent increased under normal range varies from 2.42 ±0.19% at day 0 to 2.58±0.15% on 14\textsuperscript{th} day.

Comparative evaluation between the groups revealed a non significant difference in the mean value of eosinophil per cent in both the groups on day 7 and 14 (Table 12 and Figure 9).

Table 12: Mean values (±SE) of eosinophil (%) at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.00±0.26</td>
<td>2.42±0.19</td>
</tr>
<tr>
<td>7</td>
<td>2.50±0.22</td>
<td>2.17±0.17</td>
</tr>
<tr>
<td>14</td>
<td>2.33±0.21</td>
<td>2.58±0.15</td>
</tr>
</tbody>
</table>

Non significant at 5% level between the groups

5.5.4 Monocyte per cent:

In animals of group I the mean value of monocyte per cent fluctuated under normal range 1.83±0.30 to 2.33±0.21% from 0 to 14\textsuperscript{th} day post treatment.

Similarly, in group II the mean value of monocyte per cent increased under normal range varies from 1.25±0.13 % at day 0 to 2.16±0.11 % on 14\textsuperscript{th} day.

Comparision of the mean value of monocyte per cent was found non significant between the group I and II on day 0, 7 and 14 (Table 13 and Figure 10).
Table 13: Mean values (±SE) of monocyte (%) at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.83±0.30</td>
<td>1.25±0.13</td>
</tr>
<tr>
<td>7</td>
<td>2.0±0.26</td>
<td>1.58±0.19</td>
</tr>
<tr>
<td>14</td>
<td>2.33±0.21</td>
<td>2.16±0.11</td>
</tr>
</tbody>
</table>

Non significant at 5% level between the groups

6. Biochemical observations

6.1 Total serum protein

In animals of group I the mean value of serum total protein was 7.21±0.02 g/dl at day 0 which decreased under normal range to 7.12±0.14 g/dl on day 14.

Similarly, in group II the mean value of total serum protein found was 7.18±0.02 g/dl at day 0 which increased under normal range to 7.24±0.02 g/dl on day 14.

Comparative evaluation between the groups depicted that the mean value of total serum protein on 7th day was non significant. However, on 14th day the mean value of total protein 7.12±0.14 in group I was significantly lower than 7.24±0.02 g/dl in group II. Total serum protein was significantly high in group II in comparison to group I (Table 14 and Figure 11).

Table 14: Mean values (±SE) of total serum protein (g/dl), at different time intervals

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7.21±0.02</td>
<td>7.18±0.02</td>
</tr>
<tr>
<td>7</td>
<td>7.15±0.02</td>
<td>7.21±0.02</td>
</tr>
<tr>
<td>14</td>
<td>7.12±0.14</td>
<td>7.24±0.02*</td>
</tr>
</tbody>
</table>

* Significant at 5% level between the groups
6.2 Serum creatinine kinase

In animals of group I the mean value of serum creatinine kinase was estimated 101.35±3.18 U/L at day 0 which decreased under normal range 79.41±1.41 U/L on day 14.

Similar to the above trend, in group II the mean value of serum creatinine kinase was 97.05±1.90 U/L at day 0 which decreased to 75.69±0.66 U/L on day 14.

Comparative evaluation depicted a non significant difference in the mean value of serum creatinine kinase in both the groups on 7\textsuperscript{th} and 14\textsuperscript{th} day interval. However, it decreased more in group II than that of group I (Table 15 and Figure 12).

**Table 15: Mean values (±SE) of serum creatinine kinase(U/L), at different time intervals**

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>101.35±3.18</td>
<td>97.05±1.90</td>
</tr>
<tr>
<td>7</td>
<td>87.10±1.10</td>
<td>83.31±1.16</td>
</tr>
<tr>
<td>14</td>
<td>79.41±1.41</td>
<td>75.69±0.66</td>
</tr>
</tbody>
</table>

Non significant at 5% level between the groups

6.3 Plasma fibrinogen

In group I the mean value of plasma fibrinogen was 4.55±0.12 g/L at day 0 which decreased under normal range 3.77±0.05 g/L on day 14.

Likewise in group II, the mean value of plasma fibrinogen was 4.42±0.06 at day 0 which decreased to 3.45±0.01 g/L on day 14.

Comparative evaluation between the groups, the mean value of plasma fibrinogen was found significantly lowered in groups II on day 7 and 14 (Table 16 and Figure 13).
Table 16: Mean values (±SE) of plasma fibrinogen (g/L), at different time intervals, in two groups of goats.

<table>
<thead>
<tr>
<th>Interval (Days)</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.55±0.12</td>
<td>4.42±0.06</td>
</tr>
<tr>
<td>7</td>
<td>4.20±0.07*</td>
<td>3.69±0.04</td>
</tr>
<tr>
<td>14</td>
<td>3.77±0.05*</td>
<td>3.45±0.01</td>
</tr>
</tbody>
</table>

*Significant at 5% level as between the groups

7. **Microscopic Evaluation**

The microscopic evaluation of the wound was performed in animals of both the groups for the presence of cells and bacteria on different intervals of wound healing.

For this purpose the impression smears were prepared from both the groups of wound on day 0 (before treatment) and subsequently on day 7 and 14 (after treatment) and stained with Gram’s and Leishman’s stain. On day 0 leukocyte infiltrations visually scored as marked for both the groups which decreased to moderate in group I and absent in group II on day 7. On day 14 it was mild in groups I and absent in group II.

On day 0 gram positive bacteria visually scored as marked for both the groups which decreased to moderate in group I and absent in group II on day 7. On day 14 it was mild in groups I while absent in group II (Table 17 and Plate 07).

**Table 17: Impression smear of wounds at different time intervals**

<table>
<thead>
<tr>
<th>Intervals (Days)</th>
<th>Group 1</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leukocytes</td>
<td>Bacteria</td>
</tr>
<tr>
<td>0</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>7</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>14</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

+++ marked, ++ moderate, + mild and - absent
5. DISCUSSION

Wound dressings have undergone an evolutionary process from natural materials that simply covered and concealed the wound to materials that focused on better management and recently, to materials that either deliver active ingredients or interact directly with cells or specific chemicals in the local wound environment. Advances in dressing’s technology have led to a new proliferation of topical products that can facilitate the healing process as well as address specific issues in wounds. Dressings may play an important adjunctive role in concert with overall efforts to manage the underlying causes for faster and effective healing.

In present investigation the advanced dressings like chlorhexidine, calcium alginate and collagen were applied phase wise and their effect on healing was evaluated and compared on the basis of clinical, hemato-biochemical and microscopic observation.

Degree of inflammation

In both the groups, moderate to severe inflammation was observed at day 0 before the start of the treatment. On day 3\textsuperscript{rd} moderate to severe inflammation was still persisted in group I, whereas in group II it was only of mild degree. On day 7\textsuperscript{th} a mild inflammation was observed in group I, while in group II, it subsided from 3\textsuperscript{rd} day onwards. On day 14\textsuperscript{th} the inflammation was absent in both the groups. The maximum decline in inflammation was observed in group II.

Inflammation is a body’s immediate response to a tissue injury, often injury caused by invading pathogens, eventually leading to a tissue repair and restoration. It is characterized by increased blood flow to the tissue causing increased temperature, redness, swelling, and pain. These are referred as the cardinal signs of inflammation. The redness and heat is due to hyperemia to the area of injury. The swelling (edema) is due to increased extra vascular fluid and phagocyte infiltration to the damaged area. The action of pyrogens (pathogens, bacteria and their toxins) favours maximal metabolic activity of the leukocytes, and lowers the pH slightly, which tends to inhibit the
multiplication of many microorganisms. The pain is caused by local tissue
destruction and irritation of sensory nerve receptors during muscle damage. If
a whole organ or tissue is involved, loss of function may even occur (Todar,
2008).

Sanchez (1988) and Timsit et al. (2009) reported that
chlorhexidine dressings are having more bactericidal properties than that of
povidine iodine dressings. In another study, Vowden and Cooper (2006)
demonstrated that chlorhexidine and povidine iodine inhibit a wide range of
bacteria, few fungal species and viruses, but only iodine is sporicidal. Both
have been shown to inhibit antibiotic-resistant strains of bacteria. Payne
(1999), Cooper (2004) and Katara (2012), found that chlorhexidine dressings
results into early reduction of inflammation.

Swaim (2000) and Basha et al. (2011) in dogs, Gopinath et al.
reported that hydrolysed collagen dressing, cleanse contaminated wounds
with the body’s homeostatic fluids and hence decrease the inflammatory
response.

Stashak et al. (2004) in equines, reported that calcium alginate
has no inherent antimicrobial properties but bacteria may possibly become
entrapped in gel and removed during dressing change and hence they also
helps in minimising inflammation. He further proposed that chlorhexidine
dressing during inflammatory phase with high concentration of bacteria,
facilitate debridement and drainage.

Bhuyan et al. (2008) in goats, found earlier decline of
inflammation in animals treated with omental flap than that of povidine
iodidine.

Prabhusanker (2011), Woo et al. (2012), Tiwari et al. (2013) in
human and Uralog Lu et al. (2012) in rats, found reduced microbial count and
inflammation in the wounds dressed with alginate in comparison to groups
dressed with povidine iodine, clinoptilolite, microporous polysaccharide
hemosphere, hydrogels and biosynthetic wound dressings.
The degree of Inflammation might have subsided earlier in group II because of the antimicrobial property of advanced dressings which in turn helped to control inflammation earlier than control group.

**Degree of exudation**

The degree of exudation was found moderate to severe on day 0. It subsided to mild to moderate in group I, it was absent to mild in group II on day 3. On 7\(^{th}\) day the exudation was absent to mild in group I and absent in group II. On day 14 exudates was absent in both the groups. The group II showed better result in terms of degree of exudation in comparison to group I.

The exudation is the escape of fluid, cells and cellular debris from blood vessels and their deposition in or on the tissues, usually the result of inflammation. It’s normal during the inflammatory stage of wound healing and smaller amounts are considered normal wound drainage. In chronic wounds the inflammatory response is altered owing to an uncontrolled expression of inflammatory mediators with a concurrent increase in vascular permeability and the amount of extra vascular fluid. If the wound becomes infected, abrupt increases in exudates volume may be seen initially, followed by further quantitative and qualitative changes. This has been attributed in part to specific bacterial virulence mechanisms that result in vasodilatation and extravasation (Wilson, 2002).

The results obtained in the present study is in accordance with Gilchrist and Martin (1983), Suzuki et al. (1999) in pigs, Kannon (1995) in humans, Stashak et al. (2004) in equine, Morgan (2012) and Sarabahi (2012) in human who found that calcium alginate absorb the exudates twenty times of its weight and minimise the bacterial contamination.

Mri et al. (2010) found that collagen dressings while acting as a mechanical support also reduce odema and loss of fluids from the wound site.

The early diminution in exudation in group II could possibly be due to antimicrobial and anti-inflammatory properties of dressings used and also the highly absorbent property of the calcium alginate.
Size of the wound

The decrease in the mean values of size of the wound was found highly significant between the groups. On 14th day the size of the wound was reduced to its minimum value $2.522\pm0.035$ in group I and $0.772\pm0.116$ cm$^2$ in group II. It was found that the size of the wound reduced more rapidly in group II than the group I.

The results obtained in the present study are in agreement with Lorenzetti et al. (1972), Glasgold et al. (1991) in human and Basha et al. (2011) in dogs, who reported subjective enhancement of wound closure and cosmesis in wounds dressed with collagen.

Donaghue et al. (1998), Uralog lu et al. (2012) and Woo et al. (2009) and Woo et al. (2012) and Ausili et al. (2013) in human, found that wound size reduced significantly in the alginate dressing group, as compared with the dressings like clinoptilolite, microporous polysaccharide hemosphere, hydrogels and biosynthetic wound dressing.

Sinno et al. (2012) in rats found a significant increase in the wound tensile strength from 3rd to 7th day and from day 3 to day 28. Although size of the wound decreased was non significant between the groups but it decreased more in group II.

The early reduction in the size of the wound might have resulted due to early and effective control of infection, the greater fibroblast proliferation, collagen formation, granulation tissue re-epithelisation and neo-vascularisation achieved by phase wise use of advanced dressing.

Degree of healing

The mean values of degree of healing (%) of the wounds in animals of group I was calculated $15.377\pm0.05$ % on day 0 which increased upto $71.822\pm0.280$ % on 14th day. Similarly, in group II the mean value of degree of healing (%) of the wounds was $27.879\pm1.940$ % on day 0 which considerably increased upto $91.329\pm1.28$ % on 14th day.

The increase in the mean values of degree of healing of the wound was found highly significant between the groups. The comparison between the groups revealed that degree of healing was more in group II than that of I.
The degree of healing enhanced with haemostatic effect, interaction with platelets, fibrinoectin and effective control of exudates.

Sanchez (1988) found rapid healing of wounds treated with chlorhexidine acetate than that of povidine iodine dressings in dogs.

Mian (1992), Al- Kateeb et al. (1996) in human and Nunes et al. (2011) in rats, Fleck and Simman (2010), Basha et al. (2011) in dogs and Sarabahi (2012) mentioned, that chronic wounds treated with topical collagen improves wound healing by laying down a matrix which favours deposition of new tissue and attracts cells necessary for healing. The collagen is thought to be chemotactic for fibroblasts and macrophages and also provide a temporary scaffold to allow ingrowth of tissue. It can provide anti-inflammatory, anti-fibrotic and analgesic properties as well as angiogenesis returning the body to its normal state and function and provide foundation for wound healing. Contrary to this Stashak et al. (2004), found no benefit of collagen dressings in equines.

Paul and Sharma (2004), Prabhushanker (2011) in human and Woo et al. (2009) in rats, found early reduction in the size of the wounds dressed with calcium alginate than the vaseline and povidine iodine dressings.

Significant increase in the degree of wound healing dressed with advanced dressings may have resulted to decreased inflammatory phase, release of factors responsible for stimulation of proliferative phase, repair and increased collagen formation as also reported by various workers in their studies as above.

**Macroscopic Evaluation**

The wounds in group II which were treated with advanced dressing materials exhibited decreased inflammation, exudation, early granulation, better organization, compactness and intense epithelial regeneration leading to rapid healing of wounds. The second intention healing with minimal scar at wound site was noticed in all the cases of group II as compared to group I.

Swaim et al. (2000) and Basha et al. (2011) in dogs, Mrinda et al. (2010) and Singh et al. (2011) in dogs, reported that collagen dressing cause early granulation, epithelialization and vascularisation in wound.

In the present study decreased inflammation and exudation, earlier regeneration of granulation tissue and intense epithelialization was observed in group II which might have resulted due to antimicrobial, fibroblastic and debridement effect of advanced dressings on wound healing also reported by various workers.

**Haematological Evaluation**

No significant change was noticed in haematological parameters except in neutrophil and lymphocyte per cent which showed significant difference between both the groups. On 14th day the neutrophil per cent was more in group I than group II. Lymphocyte per cent elevated significantly on day 7 and 14 in group II as compared to group I. Rest of the parameters fluctuated within normal range in both the groups at different intervals.

Generally influx of monocytes and neutrophils into the wound bed is initiated by chemoattractant released during haemostasis such as complement PDGF and TGF-β, as well as bacterial products (Li et al, 2006).

Neutrophils are first cells to arrive at the wound site, phagocytosing bacteria and preventing infection through the release of degrading enzymes and oxygen–derived free radical species. Mostly neutrophilic infiltration lasts for a couple of days and decline towards later part of inflammation.
Polymorph nuclear cells are reported by monocytes and extravasate from the blood transforming into phagocytic macrophages at the wound site (Enoch and Price, 2004).

Similar findings were also noticed by Sibbald (2007), Situm et al. (2007) in mice, Basha et al. (2011) in dogs, Pereira (2011), Sinno et al. (2012) and Bhowmick et al. (2013) in calves.

In the present study an increase in lymphocyte count was observed in group II dressed with advanced dressings, which is indicative of better immune response while the decrease in the neutrophil per cent in the same group indicates that the advanced dressings enhances the wound healing by reducing the inflammatory stage of wound repair. Neutrophil per cent increased on day 14th in group I would be the chemotactical alteration by the presence of devitalized tissue.

Biochemical Evaluation

Total Serum Protein

Comparative evaluation between the groups depicted a non significant increase in the mean value of total serum protein on 7th day in group II. Significant difference in the mean value of total protein was found between the groups where 7.12±0.14 and 7.24±0.02 g/dl were the values found on day 14th of group I and II, respectively. Total serum protein was significantly high in group II in comparison to group I.

In terms of nutrition, protein plays a central role in wound healing through the production of collagen. Therefore, the goal of nutritional support should be to minimize protein catabolism. Protein depletion can be caused by trauma, sepsis, nephritic syndrome, liver disease, chronic open wounds, and burns. The consequences of protein depletion for wound healing include decreases in angiogenesis and fibroblast proliferation. This results in decreased synthesis, accumulation, and remodelling of collagen (Burns, 2003)

Serum proteins are affected by capillary permeability, drugs, impaired liver function, and inflammation and a host of other factors. Albumin levels may be falsely high in dehydration due to decreased plasma volume. It is also a negative acute phase reactant: levels decrease during the acute phase inflammatory response (Banh, 2006).
Similar findings were found by Breslow (1993) in human, Basha et al. (2011) in dogs and Bhowmick et al. (2013) in calves.

The decrease in total serum protein in group I might be the result of more exudation and inflammation persisted for longer duration of time in comparison of group II.

**Creatinine Kinase**

In animals of group I the mean value of serum creatinine kinase estimated was 101.35±3.18 U/L at day 0 which decreased under normal range 79.41±1.41 U/L on day 14.

Likewise in group II the mean value of serum creatinine kinase was 97.05±1.90 U/dl at day 0 which decreased to 75.69±0.66 U/L on day 14.

On Comparative evaluation between the groups the mean value of serum creatinine kinase was found more in groups I than the group II on 14th day interval.

An increase in serum creatinine kinase may be caused by myocardial disease or a skeletal muscle lesion. Creatinine kinase activity found greatest in skeletal muscle, followed by heart, brain and smooth muscle. Its elevation appears within 6 hours of acute episode. At the time of maximum activity ,approximately 10-20 hours after the onset of the infarct, the creatinine kinase activity attains levels between 160 and 2000 U/L.Creatinine kinase returns normal after 3-4 days.

These finding are in accordance with the findings of Singh et al. (2011) in dogs and Bhowmick et al. (2013) in calves, who also got the similar findings.

ALGani (2011) in human, reported peak value of Creatinine Kinase during early 4-8 hours of acute symptoms of muscle injury which decreased gradually in 3-4 days.

In the present study high values of serum creatinine kinase level in group II may be due to depth of wounds and more muscular damage. Low values of creatinine kinase at 14th day interval may be resulted due to faster healing of wounds as observed in the present study, which could be responsible for decrease in serum creatinine kinase level.
Plasma Fibrinogen

On Comparative evaluation between the two groups a highly significant decrease in the mean value of plasma fibrinogen was found in both the groups on day 7 and 14. However, it decreased more in case of group II than that of group I.

Fibrinogen is a plasma protein and sole precursor of fibrin which plays a dominant role in coagulation. Plasma fibrinogen is reported to increase in inflammation, tissue destruction, liver disorders, peritonitis and pericarditis (Riddle, 1964).

The decrease in the level of fibrinogen is in agreement with McSherry et al. (1970) who determined mean plasma fibrinogen levels in normal calves, bulls, non-pregnant and pregnant cows. It appeared to be related to inflammation and tissue destruction. It was recognized that in many sick animals its value is significantly elevated from normal. The very high values encountered in apparently normal cattle are undoubtedly due to undetected inflammatory processes. They considered fibrinogen as a positive acute phase protein and showed that the fibrinogen concentrations are useful for the diagnosis and the follow up of a bacterial infection. Its value returns to normal after recovery.

Bradfield et al. (1993) in rats and Francis (2001) found increased level of fibrinogen at site of injury, inflammation, exudation, fibrosis, thrombosis, malignancy and odema due to the presence of bacteria. It has having an important role in clot formation and wound healing.

Zapryanova et al. (2013) in dogs, found that the staphylococcal infection induced gradual and marked increases in fibrinogen concentrations since the 6th hour until the 3rd - 7th days (maximal values) and thereafter this marker slowly declined. They concluded fibrinogen as a better marker for the presence of infection and inflammation.

The decrease of plasma fibrinogen from day 0 to 14th could be possibly explained on the basis of reduction in the inflammation and infection as the fibrinogen is an inflammatory marker which remains high when infection and inflammation is present. In present study the inflammation and infection
were significantly lower in group II on day 7 and 14 which might be the reason of significant decreased plasma fibrinogen level in group II in comparison to group I.

**Microscopic Evaluation**

The microscopic evaluation of the wound was performed in both the groups of animals for the presence of cells and bacteria on different intervals of wound healing.

For this purpose the impression smears were prepared from both the groups of wound on day 0 (before treatment) and subsequently on day 7 and 14 (after treatment) and stained with Gram’s and Leishman’s stain. In group I and II leukocytes and bacteria visually scored as marked were observed at 0 day which decreased to moderate in group I and absent in group II on day 7. On day 14 it further decreased to mild in group I while it was absent in group II.

It is recognized that wound contaminated with bacteria can have a negative influence on the ability of a wound to heal through the release of bacterial toxin products that further stimulate the inflammation response (Halbert et al., 1992).

An integral part of wound care is to control bacterial bioburden within the margins of wounds.

The colonized microflora remained constant over the wound healing trajectory regardless of the change in size. Similarly, quantitative bacteriology performed on wound fluid sample and tissue biopsies demonstrated no significant difference in healing and non healing wounds (Terngove et al., 2000).

These results suggested that observed changes in the wound healing may be independent of bacterial levels on wounds.

Sanchez (1988) and Timsit et al. (2009) reported that chlorhexidine dressings have more bactericidal properties than that of povidine iodine dressings. In another study, Vowden and Cooper (2006), demonstrated that chlorhexidine and povidone inhibit a wide range of bacteria, few fungal
species and viruses, but only iodine is sporicidal. Both have been shown to inhibit antibiotic-resistant strains of bacteria. Payne et al. (1999), Cooper (2004) and Katara (2012) found that chlorhexidine dressings results into early reduction in inflammation.

Hansson et al. (1995), isolated 69 bacterial species from the wound surface of 58 patients and none of them displayed any signs of infection. In another study Trengove et al. (1996) investigated that the presence of four or more types of microorganisms at wound site correlate with infection and delayed healing.

Swaim (2000) and Basha et al. (2011) in dogs, Gopinath et al. (2004), Gomez et al. (2004) in equines, Nunes et al.(2011) in rats, reported that hydrolysed collagen dressing, cleanse contaminated wounds with the body’s homeostatic fluids and hence decrease the inflammatory response.

Stashak et al. (2004) in equines, reported that calcium alginate has no inherent antimicrobial properties but bacteria may possibly become entrapped in gel and removed during dressing change and hence they also helps in minimising inflammation. He also stated that chlorhexidine dressing is best proposed during inflammatory phase with high concentration bacteria, it facilitate debridement and drainage.

Uraloglu et al. (2012) in rats, Prabhusanker (2011), Woo et al. (2012) and Tiwari et al. (2013) in human found reduced microbial count and inflammation in the wounds dressed with alginate in comparison to groups dressed with povidone, clinoptilolite, microporous polysaccharide hemosphere, hydrogels and biosynthetic wound dressings.

In present study the leukocytic infiltration and presence of bacteria was diminished earlier in group II might be resulted due to effective control of infection and inflammation by the chlorhexidine, calcium alginate and collagen dressings.
6. SUMMARY CONCLUSION & SUGGESTIONS
FOR FURTHER WORK

6.1 Summary

The present study was undertaken on 18 adult goats of the Amanala goat farm, Teaching Veterinary Clinical Complex and Government veterinary hospital, omit, Jabalpur for the treatment of open wounds, selected irrespective of their breed, body weight and sex. The healing of the cutaneous wound was evaluated and compared with conventional and advanced dressings.

The goats were randomly divided into 2 groups. The group I was treated as control in which the wounds were treated with hydrogen per oxide, povidone iodine followed by parenteral administration of antibiotic (inj. procaine penicillin + benzylpenicillin + streptomycin sulphate @10 mg/kg, i/m, b wt) for five days and analgesic (Inj. flunixin meglumine @ 2.2 mg/kg bid b wt) for first three days, while in groups II wound was dressed with advanced dressing materials as per the requirement of the wound. The chlorhexidine dressing was applied for three days followed by calcium alginate dressing for at least two days and collagen dressing was applied till complete healing. Parenteral antibiotic and analgesic administration was same as in goats of control group I.

The clinical parameters like appearance of the wound, degree of inflammation (visual score), degree of exudation (visual score) and size of the wound (cm$^2$) were recorded on day 0 and subsequently following treatment on day 3, 7, 10 and 14 in all goats of both the groups while degree of healing was measured on 3rd, 7th, 10th and 14th post treatment days.

Moderate to severe inflammation was observed in both the groups before the start of the treatment on day 0, whereas on day 7 no inflammation was observed in group II while, mild inflammation was present in group I. The inflammation was completely subsided in both the groups on day 14. On Comparative evaluation between the groups, group II showed better response in respect of inflammation.
On day 0 there was moderate to severe exudation present in both the groups. On 3rd day group II showed only mild exudation whereas mild to moderate exudation was recorded in group I. The exudation was completely ceased on day 7 in group II while it was mild in group I. On day 14 the exudation was subsided completely in both the groups.

Significant decrease in the size of the wounds was observed in the control as well as in treatment group. The maximum reduction in the size of the wound was recorded in group II. Highly significant decrease in the size of the wound was observed between day 3 to 14 in group II than that of group I.

The values of degree of healing showed highly significant increase from day 3 to 14 in group II that that of group I. The complete healing was observed within 14 days in group II while it took 19-22 days in group I.

The haematological and biochemical attributes namely haemoglobin concentration (g/dl), packed cell volume (%), total erythrocyte count (million/µl), total leukocyte count (thousand/µl), differential leukocyte count (%), total protein (g/dl), creatinine kinase (U/L) and plasma fibrinogen (g/L) were also recorded on 0, 7th and 14th day after treatment.

Haematological observations showed non-significant variation in the values of hemoglobin concentration in both the group at different time intervals. A non-significant variation in the values of packed cell volume was observed between both the groups. A non significant change in the values of total erythrocyte count was observed between treatment and control group. Total leukocyte count fluctuated non significantly between both the groups. It was slightly higher in group I than that of group II.

In differential leukocyte count, neutrophil per cent was significantly more on day 14 in group I while lymphocyte per cent was significantly higher on day 7 and 14 in group II in comparison to group I. Monocyte, eosinophil per cent showed non-significant variation between the groups.
The total protein concentration revealed significantly high values of total protein concentration on day 14 in group II compared to group I.

Low values of serum creatinine kinase level were observed in both the groups of animals on day 14 as compared to 0 day values and comparison between the groups showed non significantly lowered value of serum creatinine kinase level in the group II as compared to group I.

Decrease in the plasma fibrinogen level was highly significant in group II than that of I on 7th and 14th day interval.

Microscopic evaluation was done by making impression smear on 0, 7th and 14th post treatment days. It revealed marked leukocyte score on day 0 in both the groups which reduced to mild on day 7 in group II whereas it was moderate in group I. On day 14 the leukocytes were absent in groups II and mild in group I. The bacterial score on day 0 was marked in both the groups. The gram positive bacteria were absent on day 7 in group II while bacterial score was moderate in group I. On day 14 the bacterial score was zero in group II while it was mild in group I.
6.2 Conclusions

On the basis of results obtained in the present study, it is concluded that:

- In group II inflammation and exudation subsided earlier, marked granulation tissue with scarless healing was observed, it fulfils the requirement of the wound without any adverse effect, and also easy to apply and cost effective.

- The changes in clinical, haematological and biochemical parameters were transient in nature and within the normal physiological range.
6.3 Suggestions for Further Work

• These dressings can be tried on other species like canine, bovine and equine.

• Histological and histochemical analyses can be done for better evaluation of healing.

• It can be tried on other types of wounds like burn and ulcers etc.
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