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Burn & it's treatment & management approach in veterinary practice: A review

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Abstract
Burns are severe forms of injury characterized by fatal health consequences associated with morbidity and mortality in animal population since primordial time. Burn related shock and infection are main causes of death in major burn patients. Management of burn patient is a complex process and requires a lot of therapeutic and managemental efforts. Complete cure of a patient requires a long term care and management plan. Different aspects of management like fluid resuscitation, wound management, prevention of infection, pain management and nutritional support during wound healing should be optimum for the survival of the patient.

Keywords: Burn, pathophysiology, ABCDEF survey, management, fluid resuscitation, skin grafting

Introduction
Burn is an injury of integuments (Skin) & underlying tissues caused by chemical, thermal, electrical, & biological agents with local & systemic repercussions. It's a major cause of mortality and morbidity in animal population (Hettiaratchy & Dziewulski., 2004, Nandi *et al.* 2021) [8, 15]. W.H.O defined- burn is an injury to the skin or other organic tissue primarily caused by heat or due to radiation, radioactivity, electricity, friction or contact with chemicals. Respiratory damages resulting from smoke inhalation are also considered to be burns (Vaughn & Beckel; 2012, Sogebi *et al*., 2017) [24, 22]. Severity of burns can be highly variable in terms of the tissue affected, & the resultant complications. Severity of burn depends on different factors such as cause, depth, extent, location, patient age, and associated factors (Physiological and nutritional status of the patients). Burn is the second leading cause of trauma deaths after motor vehicle accidents. Burn can be classified into two ways depending upon the etiology and depth of bun. Based on etiological factors burn classified as thermal burn (Flames, sunburn), chemical burn (Acid/alkali, petroleum distillates), electrical burn (Electric cord exposure, lightening), radiation burn (Radiation therapy), smoke inhalation burns (inhalation of noxious fumes leads to smoke toxicity which leads to respiratory tract damage; CO toxicity is the main concern in smoke inhalation because it has 200 times greater affinity for RBC than oxygen, which leads to hypoxia). Depending upon the depth burns are first degree (Superficial burn), second degree (Partial thickness burn), third degree (Full thickness burn) and fourth degree burn. healing (Vaughn & Beckel; 2012, Garcia *et al*. 2017) [24, 5].

Classification of Burn
Depending upon the depth & severity of burn classified into- 4 degrees-
1. First degree (Superficial)- Epidermis
2. Second degree burn (Partial thickness)- Epidermis. & Mid dermis
3. Third degree burn (full thickness)- Both epidermis & dermis.
4. Fourth degree burn- Skin & underlying structures (Hanson; 2005, Kagan *et al*, 2009, Basha & Naveen; 2011, Bolenbaucher *et al*, 2016, Sanchez; 2017) [7, 11, 1, 2, 21]

Pathophysiology
The pathophysiology of burn causes both local and systemic response. The severity of burns depends upon factors like cause, extent, patients age, depth, location/tissue involved etc. A major burn injury not only causes destruction of skin which acts as a barrier which provides protection to the patient from the hostile environment, it also produces profound changes in all most all the vital organs. After a severe burn there will be a dramatic cardiovascular change known as "Burn shock" which resembles to hypovolemic shock.

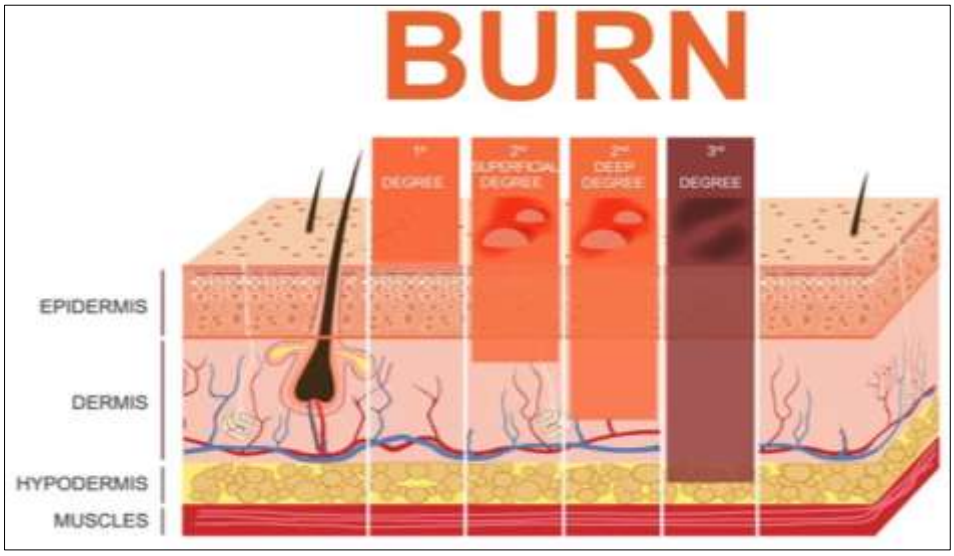

Fig 1: Different degrees of burn

After a severe burn there will dramatically increase in the both local and systemic capillary permeability due to heat and release of cytokines, prostaglandins, histamine etc. Increase in permeability leads to loss of plasma from the intravascular space to extravascular space which ultimately leads to acute reduction in the blood volume in the vascular bed. On the other side due to accumulation of plasma in the extravascular space leads to formation of edema. With reductions in blood volume, myocardial function and decrease in cardiac output peripheral and pulmonary resistance increases and tissue perfusion decreases. All those factors ultimately influence the burn shock to appear. As burn shock appears there will be decrease in blood supply to all the vital organs which ensures the organ failure and ultimately leads to "Multi organ dysfunction syndrome" (MODS) (Hettiaratchy & Dziewulski; 2004, Hanson; 2005, Orgill; 2009, Haberal *et al.*, 2010, Basha & Naveen; 2011, Garcia *et al.*, 2017,) [8, 7, 16, 6, 1, 5].

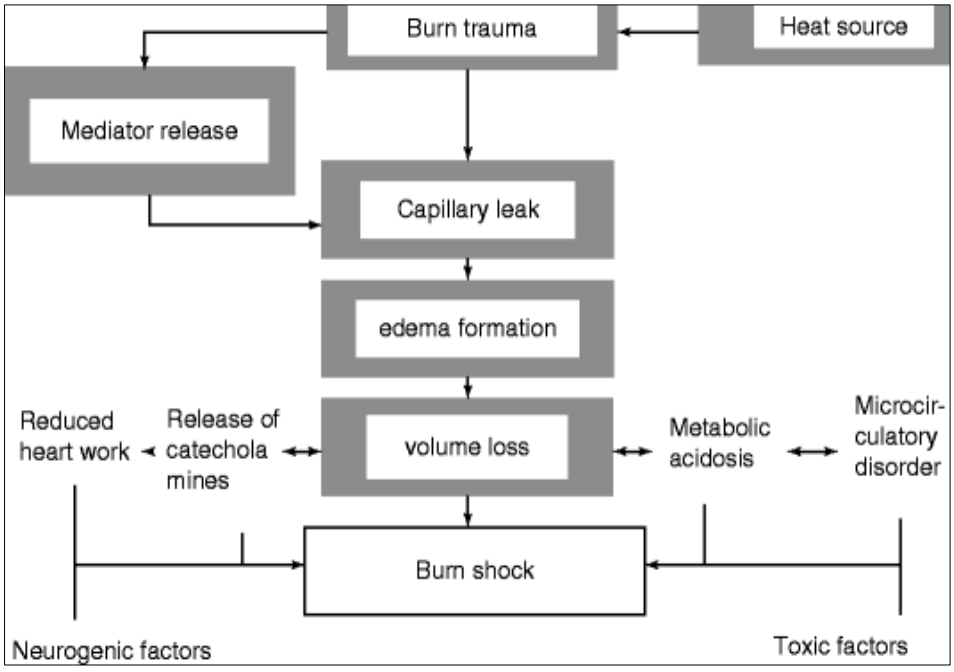

Fig 2: Flow chart of burn Pathophysiology

Symptoms

First degree burn	Partial Thickness (Second degree)	Full Thickness (Third degree)	Fourth degree burn
Involves only epidermis	Epidermis to dermis	Through epidermis, dermis into underlying structures	Muscles & bones are involved
Redness	White to red skin	Thick, dry	Dry & hard skin
Painful	Moist, shiny	Pearly gray or charred black	Sloughing of necrotic tissue
Blanches under pressure	Blisters or vesicle may be present	May bleed from vessel damage	No sensation
swelling, no blisters	Blench to touch	Painless or painful	Pain may be intense or absent
No scarring	Minimal scarring	Require grafting	Grafting required
Heal in ~7 days	Heal in ~7 to 21 days		

Diagnosis

Diagnosis of burn is easy and straight forward if the event is observed directly. Unobserved burns or malicious in nature are more difficult to diagnose. Complete history from the owner or rescuer, Clinical symptoms, Rapid physical examination, and laboratory findings are essential for complete diagnosis of burn (Vaughn & Beckel; 2012, Bolenbaucher *et al.* 2016) [24, 2].

Table 1: Chart for assessment and management of burn patient.

History	Physical examination	Lab. Findings
How long ago?	Check for other trauma injuries	CBC Profile
What caused burn?	Estimate burn and unburned areas	Coagulation profile
Where it has been occurred?	Remove constriction bands	Arterial blood gas
What has been done?	Examine all the clinical parameters	Carboxyhemoglobin test
Past medical history?		Urine analysis for myoglobinuria

Management of Burn

Management of burn is divided into four steps- 1. First aid/pre-hospital care 2. Primary survey & initial treatment 3. Daily treatment & nursing 4. Definitive care. In pre hospital care ensure the safety of both patient and rescuer (Irmak *et al.* 2017) [10]. Stop the burning process immediately by dropping and rolling the patient on ground. A thick blanket can be used to wrap the patient in order to stop the burning. Water also can be use except in electrical burn. Immerse the burn wound with cold water at least for 30 minutes to reduce pain and edema. Provide oxygen to the patient to access respiration. Hypothermia is a major concern in burn patients mostly in young patients so to avoid this hypothermia keep the patient in warm condition by wrapping the patient with a blanket. First 6 hours after injury is critical and important for the survival of the patient so transport the patient to the hospital as early as possible Connie. After hospitalization quick ABCDEF survey should be performed in order to know about the physical and physiological status of the patient (Kagan *et al.* 2009, Stander & Wallis; 2011, Vaughn & Beckel; 2012, Lima & Arias; 2015, Vigani & Culler; 2017, Bolenbaucher *et al.* 2016) [11, 23, 24, 12, 27, 2].

ABCDEF Survey

Table 2: Chart of ABCDEF Survey.

Airway with cervical spine control	Secure the airway first	Assess for signs of inhalation injury	Assess for signs of dyspnea, tachypnea	Intubate if TBSA< 20% in burn
Breathing	Asses for airway support	Assess depth and rate of respiration	Signs of pneumothorax	Mechanical ventilation should be provided
Circulation	Hypovolaemic shock	Monitor CRT, B.P. Pulse rate,	Monitor skin color	Draw blood sample and go for CBC test
Neurological disability	LOC???	AVPU test	Size and position of pupil	Glasgow coma scale score
Exposure	Stop further injuries	Check for hypothermia	Provide comfortable environment	Calculate percentage (%) of TBSA involve in burn
Fluid resuscitation	Calculate volume of fluid required	Fixed IV and urinary catheter	Monitor the fluid therapy	Monitor urine output

Estimation of burn extent

Wallace "Rule of nines" is one of the quickest and easiest method to estimate the total body surface area affected in burns. In this rule of nines, the adult anatomical area is equal to 9 BSA%, which means the adult body is divided into different anatomical areas which represents 9% or multiplies of 9% of the total body surface. In veterinary field rule of nine is not properly able to determine the accurate burn extent but can give a gross view to the veterinarian, how much body surface is involved (WHO; 2007, Orgill; 2009, Vaughn *et al.* 2012, Lima & Arias; 2015, Wohlseim *et al.* 2016, Bolenbaucher *et al.* 2016) [28, 16, 24, 12, 29, 2].

Table 3: Chart of Rule of nine's

Head	9%
Thorax/ Dorsal Body Trunk	18%
Abdomen/ Ventral Body Trunk	18%
Left fore limb	9%
Right fore limb	9%
Left hind limb	18%
Right hinb limb	18%
Neck	1%

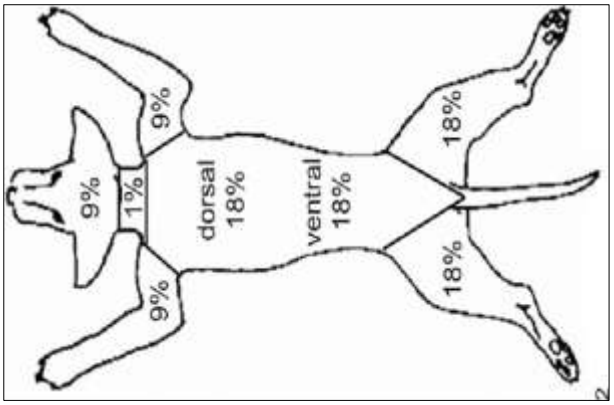

Fig 3: Schematic diagram of a dog to assess the burn extent by using rule of nines

Fluid therapy

Excessive amount of fluid loss in severe burns is one of the greatest threats for burn victims following burn injuries. Extreme amount of fluid loss develops hypovolemia and burn shock, which leads to several pathophysiologic changes in patients. The survival rate of burn patients is greatly depending on appropriate fluid therapy as it directly increases the health condition of the burn victims. The main goal of

proper fluid therapy is to maintain the stable blood plasma volume and to maintain the tissue perfusion at the early stage of burn shock without any adverse effects like Fluid overloading and abnormal compartment syndrome etc. For a successful fluid resuscitation monitoring of the fluid therapy from the beginning to end is important. Several formulas are available to calculate the volume of fluid requires in fluid therapy for a burn patient. Commonly used formulas are parkland formula, Brooke formula, Modified Brooke formula, Evans formula etc. Among all of these parkland formula is most commonly used. Isotonic crystalloids, hypertonic crystalloids, and colloidal solutions can be use. Every solution has their own advantages and disadvantages, none of them are ideal and not superior from other one (Fraser & Venkatesh; 2005, Saffle; 2007, WHO; 2007, Haberal *et al.*, 2010, Stander & Wallis; 2011, Basha & Naveen; 2011, Vaughn *et al.* 2012, Lima & Arias; 2015, Bolenbaucher *et al.* 2016) [4, 20, 28, 6, 23, 1, 24, 12, 2].

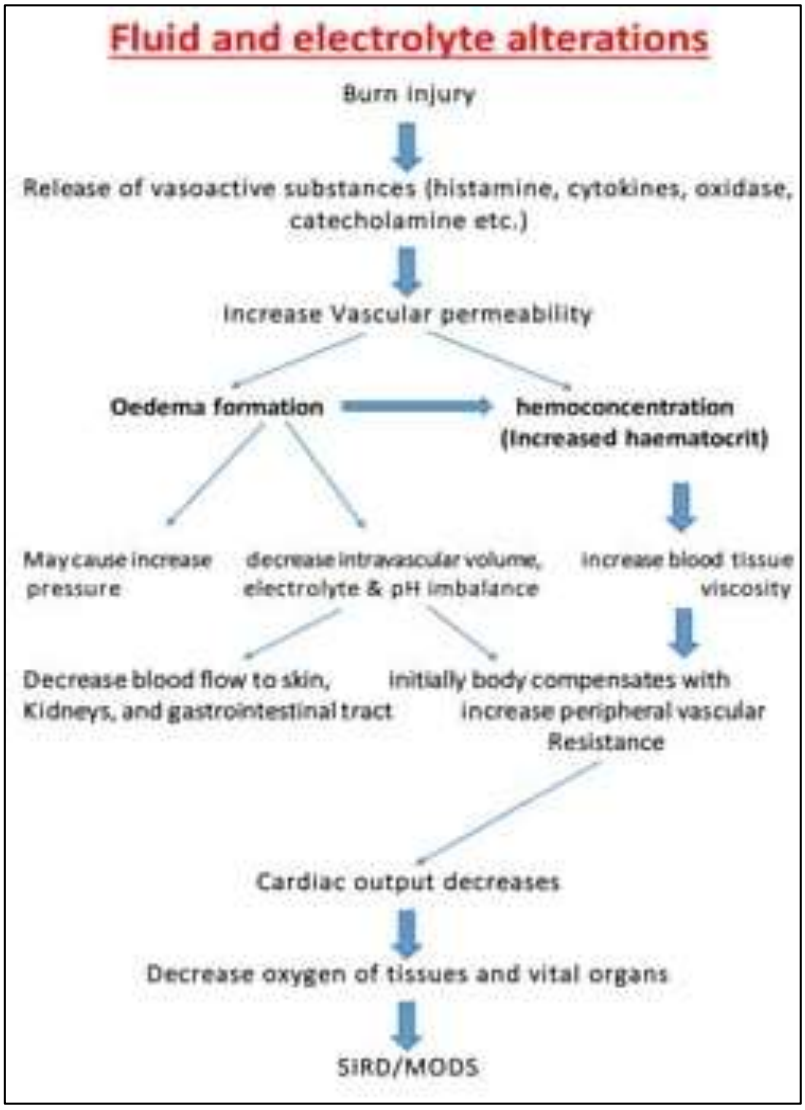

Fig 4: Schematic diagram of fluid and electrolyte alterations in burn & its consequences

Table 4: Commonly used formulas for fluid resuscitation in burn patients.

Formulas	Equations	Rate of giving fluid
Parkland Formula	1St 24hr= body wt. X TBSA% X 4ml No colloids only crystalloids in 1st 24 hr.	½ of total cal. Vol. in 1st 8 hrs, ¼ of the cal. Vol. in next 8 hrs, remaining ¼ vol. in the next 8 hrs.
	Next 24 hr- body wt. X 0.3-1 ml X TBSA% No crystalloids, only colloids and glucose in water for urine output	Colloids given 20-60% of calculated plasma volume. Urine output- @ 0.5-1 ml/kg/hr
Brooke Formula	1st 24 hr.- crystalloids- body wt. X1.5 ml X TBSA% + colloids- body wt. X 0.5 ml X TBSA% + 2000 ml glucose water	½ of the cal. Vol. in 1st 8 hrs. Next ½ cal. vol. in next 16 hrs.
	Next 24 hr- crystalloids- body wt. X 0.5 ml X TBSA% + colloids- body wt. X 0.25 ml X TBSA% + 2000 ml glucose water. 5% albumin used as colloidal solution.	½ of the cal. Vol. in 1st 8 hrs. Next ½ cal. vol. in next 16 hrs. Urine output- @ 0.5-1 ml/kg/hr
Modified Brooke Formula	1St 24hr= body wt. X TBSA% X 2-4ml No colloids only crystalloids in 1st 24 hr.	½ of total cal. Vol. in 1st 8 hrs, ¼ of the cal. Vol. in next 8 hrs, remaining ¼ vol. in the next 8 hrs.
	Next 24 hr- body wt. X 0.3-0.5 ml X TBSA% No crystalloids, only colloids glucose water to monitor urine output	½ of the cal. Vol. in 1st 8 hrs. Next ½ cal. vol. in next 16 hrs. Urine output- @ 0.5-1 ml/kg/hr
Evans Formula	1st 24 hr.- crystalloids- body wt. X 1 ml X TBSA% + colloids- body wt. X 1 ml X TBSA% + 2000 ml glucose water	½ of the cal. Vol. in 1st 8 hrs. Next ½ cal. vol. in next 16 hrs.
	Next 24 hr- ½ of the total calculated volume in initial 24 hr + 2000 ml glucose waster	Urine output- @ 0.5-1 ml/kg/hr

Wound & Pain management

After stabilizing the patient with fluid therapy, the main focus should be on proper wound management and pain management. Wound management is very much important in order to prevent the infection, promote the healing, and prevents further complication chances (Madiha *et al.,* 2010, Vigani & Culler; 2015) [13, 27] At the initial stage burn wounds are sterile, so treatment should be start as early as possible for speedy healing and to prevent infection and septicemia. In initial treatment administer tetanus prophylaxis in all cases. Hair should be removed and excise adherent necrotic tissues and debride all the necrotic tissues over the first several days. Clean the area with 0.25% chlorhexidine solution or 0.1% cetrimide solution or any other mild water based antiseptic solution. Do not use any alcohol-based solutions. A thin layer of antibiotic cream like silver sulphadiazine cream or 0.1% silver nitrate ointment applied over the burn area. Dress the burned area with petroleum gauze or wax pad and cover with dry sterile gauze thick enough to prevent the seepage to the outer layers. Provide broad spectrum antibiotics like (Amoxycillin or Ceftriaxone) to prevent the infection and septicemia. Opiates (Morphine, hydroxymorphone) are mostly used to control the pain. Fentanyl patches are available which is also used to provide analgesia. Daily dressing is very much important to promote the healing. Change the dressing daily; if possible, do the dressing twice daily. In each dressing remove any loose tissue if it is present. Close inspection of the wound should be done to observe any wound discoloration or hemorrhage which indicates infection and septicemia. A course of systemic antibiotics and analgesics should be followed to minimize the chances of infection and pain. Topical antibiotic ointment should be applied in each dressing. Collagen dressing is very good for burn wound healing which is available in both dry and wet forms- can be for daily dressing (Fraser & Venkatesh; 2005, Kagan *et al.* 2009, Basha & Naveen; 2011, Stander & Wallis; 2011, Vaughn *et al.* 2012, Fowler; 2013, Lima & Arias; 2015, Bolenbaucher *et al.* 2016, Sanchez; 2017) [4, 11, 1, 23, 24, 3, 15, 2, 21]

Surgical management of burn wounds

Surgical management is the definitive care of major burn wounds. Surgical management includes Escharotomy, surgical excision of burn wound and grafting of wound. Escharotomy is a surgical technique where incision is given through the burn eschars. Burn eschars are unyielding, leathery tissues formed by denatured muscle protein and coagulated blood vessels. Eschars produce excessive pressure into the body compartments. Escharotomy is performed if eschars are present in the neck, trunk, chest and limbs. It is indicated to release the pressure from body compartment and combat against burn induced compartment syndrome. The procedure is performed under sedation or general anaesthesia depending upon the species involved and patient's temperament. An incision is given in the healthy tissue 1cm above the eschar and continues the incision through the eschar down to subcutaneous fat and healthy tissue. In limbs to release the pressure incision is given in both lateral and medial sides. Incision should be deep enough to release all the restrictive effects of burn eschar. Wounds should be dressed by sterile absorbent gauze, antimicrobial agent and finally wrapped with light bandage (Kagan *et al.* 2009, Stander & Wallis; 2011, Lima & Arias; 2015, Irmak *et al.* 2017) [11, 23, 12, 10]. Daily dressing of wound along with systemic antibiotic should be follow. Complications like neurovascular damage, excessive bleeding, inadequate or delayed decompression may arise after performing Escharotomy. Surgical excision is a procedure where incision is given through the deep layer of open wounds, this procedure is performed to remove layers of necrotic tissues. Two methods of surgical excision are Tangential excision and Fascial excision. Tangential excision is indicated in deep dermal or 3rd degree burn. In tangential excision repeatedly thin layers/ slices (0.5 mm) of necrotic tissues are removed to provide a viable bleeding surface where graft can be applied. In this technique cosmesis is good and wound coverage is more although bleeding chances is high. Fascial excision is indicated in those burn cases where more than 60% BSA are involved. In this technique all the layers of eschars and damaged underlying tissues are removed to provide a clean, bleeding surface for grafting. Low blood loss one of the advantages of this technique although injury to the joints and nerves are common and due to less grafting possibilities it is not that much used. Skin grafting is a surgical procedure involving transplantation of skin. Transplanted graft material is known as skin graft. Depending upon source; graft materials are auto graft, allograft, Xenograft, synthetic in nature. Skin grafting is classified into two types- Split thickness/ partial thickness skin graft and full thickness skin graft. In split thickness skin graft process only a few layers of outer skin are transplanted. The graft material which is used in this technique only contains epidermis and some of the parts of dermis. Split thickness skin grafting method is most commonly used technique in burn patients as chances of auto rejection in this method is very low and healing is much faster than full thickness skin graft. But during healing due contraction of wound could compromise the function of the graft material. In full thickness skin grafting technique thick skin graft material is used to cover the wound which contains all the skin substances like epidermis, dermis, nerve endings, hair follicle, sweat glands etc. This technique is riskier as high chances of auto-rejection and due to delay healing. (Orgill; 2009, Kagan *et al.* 2009, Sanchez; 2017) [16, 11, 21].

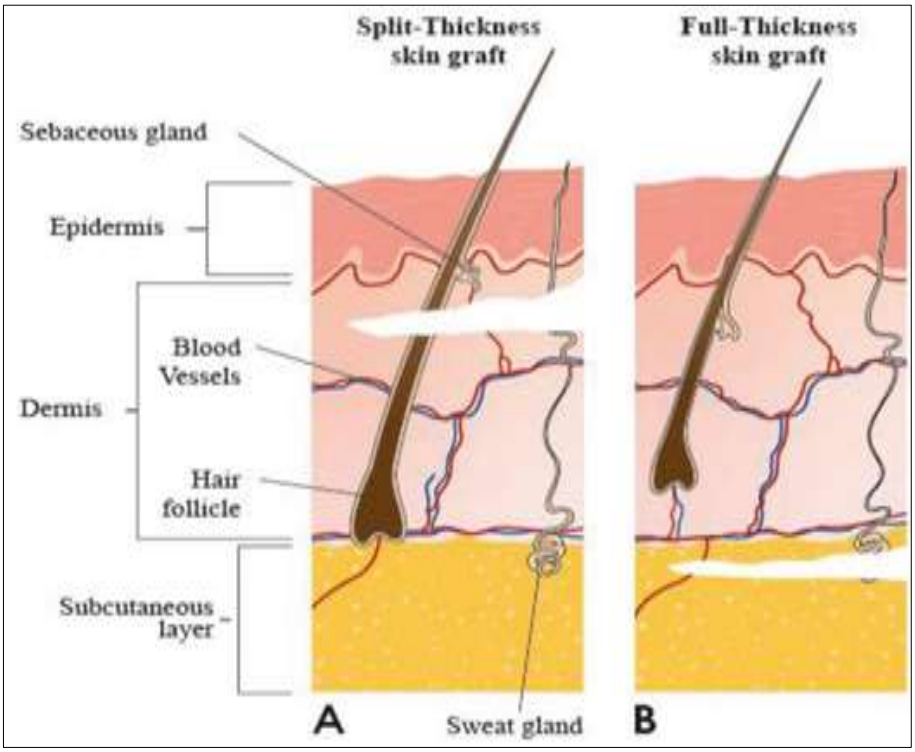

Fig 5: Schematic diagram of (A). Split thickness and (B). Full thickness skin graft

Fish skin Therapy: It is a recent technique used to treat the burn victims. Skin of Nile tilapia fish (*Oreochromis niloticus*) is most commonly used due to their disease resistance property. Skins are collected and sterilized and stored for future use. Marine collagen peptides (MCPs) are prepared from the tilapia fish skin were contains polypeptides with molecular weights less than 5 kDa. After preparing the wound by surgical debridement or excision, fish skins are applied to cover the area followed by a light dressing to keep the fish skin in place. The main reason of applying fish skin is to promote healing. Fish skins are highly rich with collagen and collagen acts as a healing protein. A study on rabbits shows that MCPs from the skin of tilapia were an effective and promising agent for burn care. (Miller; 2016, Osama, M; 2017, Hu *et al.* 2017, Quinton; 2018) [14, 17, 9, 18].

Fig 6: Images of fish skin therapy in animals suffering of burn injury

Nutritional management

Nutritional status is an important factor for the healing of burn wound. Malnutrition prevents the healing and prolong the healing phase Nutritional demand is very high in post burn wound healing stage due high metabolism rate to promote tissue regeneration. Daily requirements of energy and protein increases up to 2-2.5 times more than the normal requirements. Additional supplements of antioxidants, Vitamins, essential amino acids and fatty acids will promote the speed of healing and improves the health status. Nasogastric feeding tube can be indicated if requires. Balance nutritional diet with high calorie and protein should be provided to the patients (Hanson. 2005, Madiha *et al.* 2010) [7, 13].

Complications of burns

As wounds are pruritic in nature self-mutilation (rubbing, pawing, biting, scratching) of wound is one of the common complications in veterinary practice. Uses of Elizabeth collar in small animals and cross tying in large animals are useful to avoid self-mutilation. Poor sanitation and management lead to development of secondary bacterial infection and prolong the healing phase. Nutritional deficiency or malnutrition is also a contributing factor of delay healing or poor epithelialization. Rejection of graft materials is another common problem in those wounds which are corrected with graft materials due severe inflammatory immune response from host immunity system (Hanson; 2005, Madiha *et al.;* 2010, Vaughn *et al.* 2012) [7, 13, 24].

Conclusion

Burns are the most severe form of trauma with fatal health consequences and management of major burns are highly troublesome in nature and for proper management of a burn patient pre-hospital aid, survey of patient, fluid resuscitation, initial treatment, daily management, surgical treatment, nutritional management everything has to be considered. Appropriate fluid resuscitation in burn cases is one of the important points in modern burn management. Although after providing the optimum care to the burn patients till some of the complications may arise with patients but it depends on lots of factors. Further scientific research and clinical trials for better therapeutic management of burn patients are highly required to avoid burn related consequences.

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