

Current Advances in Treatment and Management of Burn: A Review Article

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Abstract: Burn is one of the most expensive damages that could be happened at any age. Furthermore, extensive burns can lead to death. Over 90% of deaths caused by burns happen in poor countries where preventive programs are less common and the quality of burn management is low. Although most death cases are because of burn shocks and infections, the methods of treating burn patients particularly rehydration method and administration of topical or systemic antibiotics are still faced with serious challenges. The present systematic review was carried out in order to increase awareness and propose appropriate methods to treatment and manage of patient's burn, by searching the databases of PubMed/Medline, Web of Science, Scopus and the Google Scholar using appropriate keywords. In the beginning of the study, 124 Articles were obtained from the electronic search, from among which 63 relevant articles were chosen. Out of those 63, Article, 21 ones were in line with the objective of the present study. Since the breadth and depth of burns play an important role in the rate of the patients' morbidity and mortality and determination of their precaution, the method of calculating them in children and adults and the relevant protocols in dealing with burns were examined and presented. Determining appropriate protocol can differ according to the patient's conditions and it is suggested that clinical trials should be carried out on this issue.

Key words: Burn, burn management, children, morbidity, mortality

INTRODUCTION

Burns are accompanied with irreversible physical, spiritual, mental and socioeconomic consequences. They account for 5-12% of all traumas and events in the world (Olaitan and Olaitan, 2004; Anlatıcı *et al.*, 2002). In recent year, the injuries caused by burns have increased so much that it is taken into account as an important and serious problem (Afrasiabi and Karimi, 2002). Many cases of burns happen in the first 2 decades of life as a result of accidents and can be prevented. At the same time, severe burns are among important consequences and mortality in children and adolescents and burns are the third common cause of death in this age group (Olaitan and Olaitan, 2004). Collecting epidemiological data on burn patients can lead to obtaining significant information in order to design appropriate strategies to reduce the prevalence of the injuries and adopt appropriate methods of care management. In Iran, not only is there no access to comprehensive data on burn epidemiology but also there are no trainings about understanding the causes and necessary measures in dealing with burn patients especially children and adolescents (Panjeshahin *et al.*, 2001; Tabiee and Nakhaei, 2004). Due to the importance of studying burns among children and adults and the limited number of the relevant studies, the present review study

was conducted in order to investigate appropriate approaches of managing burn patients and review different opinions on this issue. The results of the present review can provide valuable information that is the result of various studies over several year, create necessary grounds for appropriate planning and managing this disease and prevent adverse consequences.

MATERIALS AND METHODS

The present systematic review was carried out by searching related English articles in the data bases of Pubmed, Medline and Embase and the library of Cochrane. In this search, keywords like "burn", "burn complications", "burn mortality", "burn treatment", "burn rehydration", "infection in burns", "antibiotics in burns", "burn shocks", "children burns" and "burn consequences" were used to find a subset of the resources related to the study's question. The study inclusion criterion for the articles was the research studies relevant to the issue of burns according to the keywords. In cases where the articles were republished, the newest and complete version of them was chosen. In the beginning of the study, 124 articles were obtained from the electronic search, from among

which 63 relevant articles were chosen. Out of those 63 article, 21 articles were in line with the objective of the present study.

Burn causes

Hot liquids: Boiling water, tea, coffee and turn-over of dishes containing hot food from the tables, heaters, or stoves are among the commonest causes of burn in Iran. Burns caused by flame: Fire in homes caused by stoves, heaters, oil lamps and clothing fire (31.4%). Fire caused by ignition of explosive gases like gasoline, paint thinners, gas leakage, or while filling up oil lamps and water heaters. Burns caused by touching hot objects, melted materials, explosives, chemicals, electric shock and lightning. Self-immolation (28% of all burns). The commonest burn cause is boiling water among children under 3 year, clothing fire among children of 3-14 year, industrial events among individuals of 15-60 year old and burns caused by smoking and home fires among those of over 60 year old (Afrasiabi and Karimi, 2002; Tarim *et al.*, 2005).

Rehydration and burn shock: Patients with severe burns, particularly those with high level burns will experience irreversible complications if immediate and serious measures are not adopted for them in early hours. Burn shock has a hypovolemia and cellular nature and is characterized by hemodynamic changes including decreased cardiac output, plasma volume, extracellular fluid and oliguria and like in other shocks, maintaining tissue blood supply and immediate returning to the initial status are the first aims. Quick and effective resuscitation of the patient during the first 4-6 h causes the blood flow to return to its normal rate in the liver and the whole body and to lower speeds in the kidneys and small intestines. According to what was stated before, the importance of correct and sufficient rehydration of patients with burns (particularly extensive burns and over 50%), it is clear that applying rehydration measures during the first hours after burn can reduce morbidity and mortality to a remarkable extent. The noteworthy point is that rehydration is also highly significant after surviving the shock and it should be continued. Fluids are administered orally in burns of lower than 20% (except for electric and inhalation burns), both orally and intravenously in burns of between 20-30% and intravenously in burns of over 30%. Rehydration is basically carried out by using crystalloid solutions (the most appropriate of them is Lactated Ringer's solution) and colloidal solutions. Administration of colloidal solutions is not recommended during the first 8 h and it is preferred to use them in 12 or 24 h after the burn.

Dealing with burn injuries: Burn injuries are really painful at their acute phase therefore, relieving the

patient's pain is the first step before taking any measures. Intravenous administration of morphine is the best therapy in extensive and deep injuries. The dosage of the injected morphine should be low so that it can control the patient's pain without reducing his/her blood pressure (usually 2-5 g in adults with 4 replicates every 4-6 h and 0.05-0.1 mg kg⁻¹ in children of over 15 kg). Other painkillers such as methadone, codeine, acetaminophen and non-steroidal anti-inflammatory drug can also be administered after the acute phase. Anti-anxiety medications, sedatives, anti-depressants and sleeping pills like Diazepam (with a dosage of 0.1 mg kg⁻¹) are very useful and reduce the need for opiates. After the patient's pain is relieved, the extent and depth of the injuries should be measured and finally cured. The injury should be washed with mild soap and water or physiological saline and betadine and the debris and separated epidermis should be removed. The hair around the injury needs to be cut up to at least one centimeter. Intact and small blisters should not be touched while torn ones or those containing turbid or bloody fluid need to be removed. All blisters resulted from chemical burns should be removed because penetration of the chemicals into the fluid will deepen the burn injury. Very big blisters that are located in places that cause troubles or limitations to movement can be discharged with syringe and the skin can be maintained as a cover for the injury. Second-degree superficial injuries should be dressed with fatty gauze (Vaseline gauze) or mild antibacterial ointments such as bacitracin or nitrofurantoin and second-degree deep injuries and third-degree ones should be dressed with stronger ointments such as silver sulfadiazine and mafenide (sulfamylon) that penetrate more in burn scars. Dressing should be carried out twice a day in order to prevent infection. In chemical burns, the injury should be washed with a large amount of water at least for 15-30 min. In case of burns with alkaline substances, the injury should be washed for 1-2 h. In burns caused by tar, first, the tar is frozen with cold water. Then tar solvents that are not oil derivatives are applied on the tar and the injury will be dressed and the dressing is changed every 2-4 h, so that the tar is completely solved and removed from the injury. Other materials that can be utilized include paraffin, lanolin 2-3%, baby oil, or butter. The tar that is stuck to the skin should never be picked because it cuts the intact tissue from the injury, too (Kasten *et al.*, 2011; Waitzman and Neligan, 1993) (Fig. 1).

Burn in certain areas: Facial burns, especially in superficial cases, should be left open and then they need to be washed with mild soap and water and compressed with physiological saline and finally a mild ointment like Bacitracin should be applied on them. Stronger ointments

such as silver sulfadiazine along with closed dressing are used for third-degree and infectious burns. In ear burns, the face should be placed in a position that no pressure is placed on the ears and the patients should not sleep on them. High levels of pressure result in chondrite in the ears and treatment will be difficult. A layer of Mafenide ointment should be frequently applied and open dressing should be used. In case of eye injuries with chemicals, after ophthalmic anesthetic drop was applied, they eyes should be washed with physiological saline in the form of free fall for half an hour to 1 h. Afterwards, antibiotic ophthalmic drops and ointments are used. In burns of perineal and genital areas, after the area is washed and cleaned, it should be open-dressed with silver sulfadiazine ointment 4-6 times a day and each time the area should be cleaned and the ointment should be applied again. It should be noticed that the injury is not stained with urine and feces (especially in children) (Ngim *et al.*, 1983; Frist *et al.*, 1985).

Tetanus prevention: Burn injuries, even with a small percentage are prone to tetanus; therefore, it is necessary to prevent from tetanus. If vaccination has been carried out over the last 5 year, there is no need for any treatment. If it was carried out 10 year ago, toxoid booster dose is needed. If the vaccination status is not clear or it was carried out over 10 year ago, it is necessary to inject toxoid and tetabulin serums (Karyoute and Badran, 1988).

Infection is burns and antibiotic therapy: Most deaths in burns are caused by infections, because after severe and deep burns, infections and sepsis will be created as a result of a gradual decrease in the body immunity, an increase in contact with pathogenic and opportunistic microorganisms and suitable environment of burn scars for the growth of bacteria. As a result, correct and timely dressings of the injuries, utilization of appropriate topical antibacterial medicines and removal of burn scars (surgical excision) are necessary and basic measures. Inhalation burns, even of a low percentage, can cause higher risks of death and infection; therefore, it is necessary to know the symptoms of infection beginning and sepsis signs. In the beginning, the commonest gram-positive bacteria involved with the infections of burn injuries are staphylococcus aureus and streptococcus pyogenes, but over 80% of the infections are caused by gram-negative bacteria especially pseudomonas aeruginosa. As the burn treatment prolongs and the body immunity decreases severely, viruses such as cytomegalovirus and herpes and fungi such as candida albicans, aspergillus and mucor rhizopus place in the injuries and cause mortality. As far as burns do not have

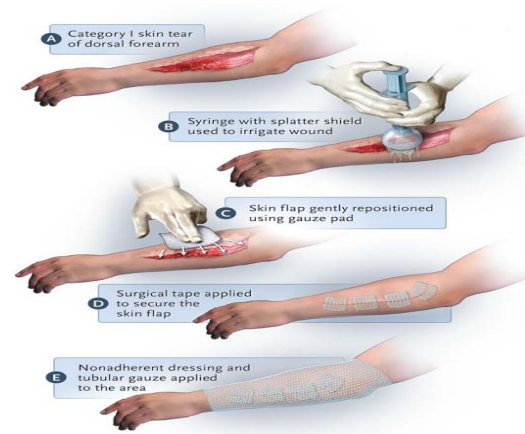


Fig. 1: Dealing with burn injuries

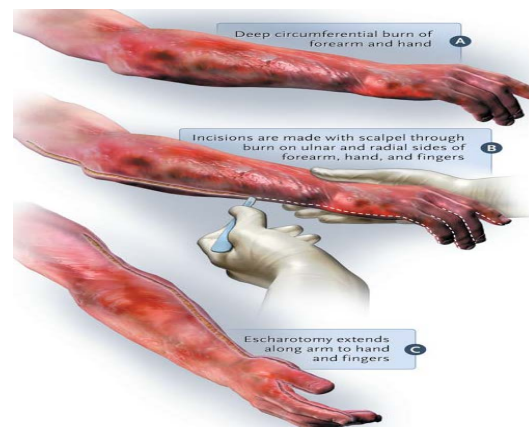


Fig. 2: Infection in burns and antibiotic therapy

symptoms of sepsis in the acute phase, there is no need for administration of antibiotics. For prophylaxis; however, topical antibacterial medicines like silver nitrate 0.5% solution, nitrofurazone ointment and silver sulfadiazine ointment and sulfamylon ointment (mafenide acetate) can be applied on the injuries. Due to its more penetration in burn scars, mafenide ointment is more effective in controlling the infections; however, it should be used with caution due to side effects like acidosis and severe pain. Silver sulfadiazine ointment, on the other hand, is more effective for fungi and causes no pain. In certain cases, more specific antibiotics are used based on the culture and biopsy of the scar and antibiogram preparation (Karyoute and Badran, 1988) (Fig. 2).

Determining the burn extent: In order to treat the burns completely and correctly, it is necessary to determine the burn area. The simplest method is to use the rule of Nines based on which in adults each upper limb is given 9%,

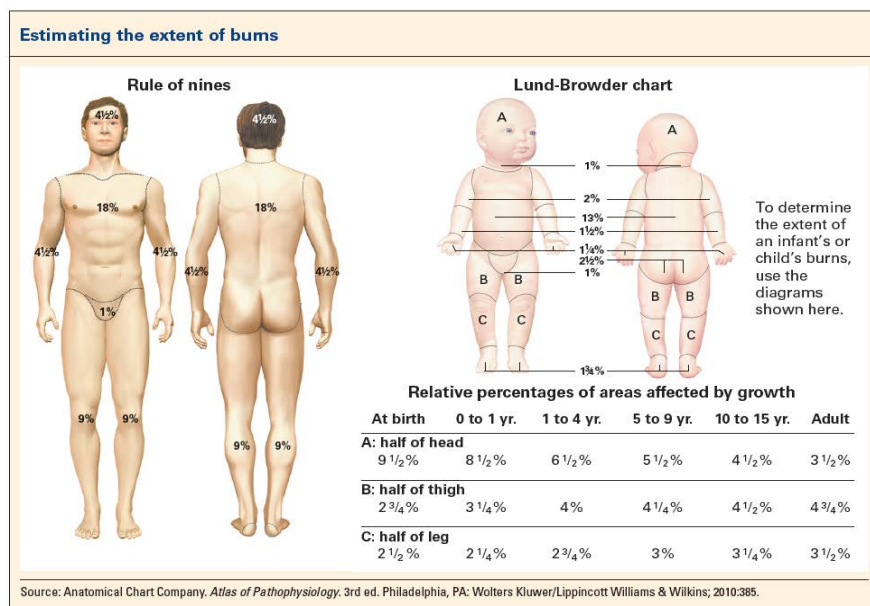


Fig. 3: Estimating the extent of burns

Table 1: The proportion percentage of body parts to the whole body in children

Children	The proportion of body parts to the whole body (%)
Each hand	9
Head and neck	18
Each foot	14
Interior trunk	18
Posterior trunk	18

Table 2: The proportion percentage of body parts to the whole body in children

Children	The proportion of body parts to the whole body (%)
Each hand	9
Head and neck	9
Genitalia	1
Each foot	18
Interior trunk	18
Posterior trunk	18

each lower limb is 18%, the anterior trunk is 18%, the posterior part of the trunk is 18%, the head and the neck are 9% and the vaginal area is 1%. These percentages are different for children Table 1 and 2; Fig. 3 (Collis *et al.*, 1999).

Since Lund and Browder Method measures the burn percentage based on the individual's age, it is more precise (Table 3). For small and spread burns, the patient's palm can be used. The palm including the fingers is 1%.

Determining the burn depth: In addition to the burn extent, burn depth also plays a significant role in the treatment protocol and the rate of morbidity and mortality and in determining precautions. Burn depth depends on

factors such as heat intensity, burning agent, contact time and skin thickness (which is different based on age and body part). In terms of their depth, burns are classified into four groups: First degree: In which, only epidermis is involved. Second degree: It is divided into superficial and deep degrees. Superficial second-degree: It is limited to epidermis and a part of dermis (about one third). Deep second-degree: It involves epidermis and most part of dermis (about three fourth). Third degree: It involves all thickness of the skin (epidermis and dermis). Fourth degree: In addition to all thickness of the skin, the underlying layers including hypodermis, tendons, muscles and even bones (Monstrey *et al.*, 2008; Godina *et al.*, 1977). The characteristics of burn degrees and the causes are presented in Table 4.

Burn therapeutic goals: A burn team consists of a burn surgeon, nurses, rehabilitation department, dietitians and psychotherapy team members. They attempt to reach the following goals: Minimizing the risk of infection, Faster healing of the injuries, Maintaining the physical movement of the organs, Minimizing the consequences and beauty deformities, Faster regaining of physical strength and mental health and getting prepared to return to normal life and Preventing the patient's death in extensive and intense burns.

Dealing with the patient in the first medical center: Primary survive which should be carried out as soon as possible and factors that endanger the patient's life

Table 3: Lund and Browder Method (determining the burn percentage based on age)

Body part	0-1 year	1-2 years	5-9 years	10-12 years	15 years	Adults
Head	19.0	17.0	13.0	11.0	9.0	7.0
Neck	2.0	2.0	2.0	2.0	2.0	2.0
Interior trunk	13.0	13.0	13.0	13.0	13.0	13.0
Posterior trunk	13.0	13.0	13.0	13.0	13.0	13.0
Right buttock	2.5	2.5	2.5	2.5	2.5	2.5
Left buttock	2.5	2.5	2.5	2.5	2.5	2.5
Genitals	1.0	1.0	1.0	1.0	1.0	1.0
Right arm	4.0	4.0	4.0	4.0	4.0	4.0
Left arm	4.0	4.0	4.0	4.0	4.0	4.0
Right wrist	3.0	3.0	3.0	3.0	3.0	3.0
Left wrist	3.0	3.0	3.0	3.0	3.0	3.0
Right hand	2.5	2.5	2.5	2.5	2.5	2.5
Left hand	2.5	2.5	2.5	2.5	2.5	2.5
Right thigh	5.5	6.5	8.0	8.5	9.0	9.5
Left thigh	5.5	6.5	8.0	8.5	9.0	9.5
Right leg	5.0	5.0	5.5	6.0	6.5	7.0
Left leg	5.0	5.0	5.5	6.0	6.5	7.0
Right foot	3.5	3.5	3.5	3.5	3.5	3.5
Left foot	3.5	3.5	3.5	3.5	3.5	3.5

Table 4: The characteristics of burn degrees and the causes

Burn characteristics	First-degree burn	Superficial second-degree burns	Deep second-degree burns	Third-degree burns	Fourth-degree burns
Burn thickness	Epidermis	Epidermis and about one third of dermis	Epidermis and about three fourth of dermis	All thickness of epidermis and dermis	All thickness of the skin and the underlying layers
Burn cause	Sunburn Low radiation U.V. generators Infrared	Hot fluids Flame Chemical	Very hot fluids Extreme heat Flame Gas explosion U.V.	Flame, Burn with chemicals and electricity Prolonged contact with hot object Bright or dark waxy white, leather-like, coal-like with thrombosis vessels	Electric especially with high voltage, Chemical burn, Touch burns caused by touching very hot fluids for a long time Brown, germ-like, black and coal-like, sometimes the burned bones and muscles emerge
Color and appearance of scars	Red (Erythematous)	White to pink Cherry red	Whitish pink	Dry and like leather and without blisters	Dry and coal-like and dented
Burn area	Dry without blisters	Humid with small and big blisters	A little dry without blister or with small blisters	Without pain, edema, slight edema low elasticity or elasticity	Without pain, edema, or elasticity, breakable
Sensitive to pain and skin combination	Painful and sensitive skin,	Very painful and elasticity	Low pain or without pain,	It does not recover spontaneously, it needs skin grafting	It does not recover spontaneously, it needs reconstructive surgery It sometimes leads to amputation
Recovery	2-3 day, a max of one week	It becomes epithelialized within 2-3 weeks	It becomes epithelialized within 4-6 weeks	Given the therapy method, different consequences	It is accompanied with different deformities and defects
Consequences	Without consequences	Usually without consequences (Sometimes skin color change)	Hypertrophic scars after recovery, Hyper- or hypopigmentation is		

should be eliminated. Secondary survive which refers to the evaluation of the patient from head to toe.

Primary measures: Primary measures for burned patients are like other patients with trauma. These measures are respectively as follows.

Paying attention to the openness of the airways, breath, blood circulation and immobilization of cervical vertebrae. Therefore, in the first encounter with the patients with burns, the following measures should be taken: Giving 100% wet oxygen to all patients, even to those who do not have burn symptoms, Examining respiratory tracts and placing endotracheal tube if

necessary (for unconscious patients and severe cases of edema of glottis), Examining the chest and conducting escharotomy if it does not open well, It is sometimes difficult to control blood pressure but controlling the pulse is possible and more useful and Immobilizing the neck in patients who are injured as a result of explosions or are decerebrated (Hettiaratchy and Dziewulski, 2004; Hermans, 2005).

Secondary measures: Examining the patient from head to toe and exactly determining injuries, Collecting data on the history of previous diseases, medicines, allergies and how the injury occurred, starting and 4th line (this can be delayed if the patient is brought to the hospital under

60 min). In case of starting an 4th line, Lactated Ringer's solution should be applied (250 mL h^{-1} in children of over 5 year and 500 mL h^{-1} in adults, covering the burned area with a clean cloth (burn ointment or traditional substances like toothpaste, potatoes, etc. should not be used), Administrating painkillers (certainly intravenously with low dosage) to relieve the pain, covering the patient with a clean blanket to prevent the loss of body heat, 8), transferring to the nearest hospital: only in very severe cases, the patient should be transferred to the hospital before the situation becomes stabilized, in other cases, taking primary measures until stabilization are prior to fast transfer of the patient to the hospital (Breden and Laguerre, 2008; Allwood, 1995).

RESULTS AND DISCUSSION

Evaluation and immediate treatments in the first hospital:

Measures and evaluations are like the ones before the patient is transferred to the hospital and the main difference lies in the presence of more facilities and measures for diagnosis and treatment. These measures are as follows: examining the airway, breath and blood circulation, examining the patient from head to toe (it is necessary to take off all clothes and jewelries of the patient), getting the patient's exact history and how the event happened, examining the inhalation lesions, Conducting routine examinations (blood sugar, blood count, electrolytes, BUN and creatinine) and blood gases and chest radiography and Examining the extremities precisely to see if they have pulse, especially in burns that cover all of the body. The pulse should be monitored until 48 hours after the incident. Evaluation of blood flow is carried out with clinical symptoms like stiffness, paleness, severe swelling and positive result of Pinprick Test. If there is no pulse, escharotomy should be carried out (Breden and Laguerre, 2008; Allwood, 1995).

Outpatient management or referral to burn centers: If the following cases are observed, the patient will be treated on an outpatient basis. Lack of burn complications like inhalation injury, completion of rehydration, Stable progress of the patient in the hospital, consumption of sufficient food, enough pain tolerance, lack of predicted infectious complications and the ability of the patient's family to carry out dressings, personal care, exercise, suitable nutrition, implementation of medical and treatment prescriptions and the possibility of transfer to burn and physiotherapy centers.

Cases where the patient is referred to burn centers: second- and third-degree burns in over 15% of the whole body in patients under 10-50 year old and over, second- and third-degree burns in over 20% of the whole body in other age groups, second- and third-degree burns

of face, hands, feet, perineal and genital areas and main joints, third-degree burn in over 5% of the whole body in all age groups, electrical burns ranging from electrical shocks and damages caused by lightning, chemical burns, Inhalation injuries including smoke inhalation and Carbon monoxide (CO) poisoning, injuries caused by burns such as bone fractures, blunt and penetrating trauma and brain injury, burns in patients who have other severe diseases such as diabetes, chronic alcoholism, cirrhosis, heart and respiratory diseases, AIDS, etc., burns in patients who need certain social and psychological support, including addicts, mental patients and the homeless, Burns in children that are victims of mistreatment or negligence in care, Third-degree burns that can be best managed by removing the burn scars (excision) and skin grafting and Severe syndromes of losing an extensive part of skin what needs quality care by burn centers such as Steven Johnson and Epidermal Necrolysis.

Classification of burns to facilitate transfer to medical centers

Cases that require hospitalization in burn centers: Major burns including:

- Second-degree burns of over 25%
- Third-degree burns of over 10%
- Burns in hands, feet and perineal area
- Inhalation injuries and accompanying injuries and
- Electrical and chemical burns

Cases that require hospitalization in general hospitals:

Average burns including:

- Second-degree burns of between 15-30% except for in the head, face, hands and perineal area
- Third-degree burns of below 10%

Cases that require outpatient therapy: Second-degree burns of below 15 and 10% in adults and children, respectively and Third-degree burns of below 2% in Fig. 4.

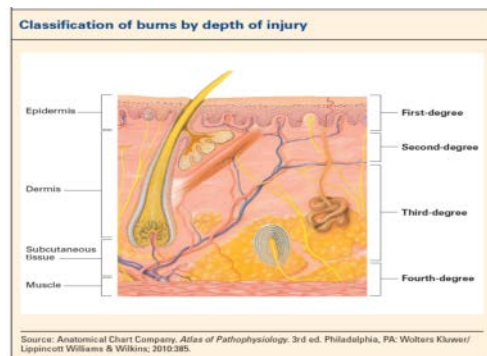


Fig. 4: Classification of burns by depth of injury

CONCLUSION

The present study was an attempt to examine the causes of burn in children and adult and medical measures to deal with patients with burns. Many cases of burn over the first two decades of life are caused by accidents which can be controlled. On the other hand, severe burns are important causes of complication and mortality among children and adolescents and burn is the third commonest cause of mortality in this age group (Foglia *et al.*, 2004). Furthermore, to manage burns, a special team is required that consists of a burn surgeon, trained nurses, rehabilitation department, dietitians and a psychotherapist. Moreover, therapy, rehabilitation and the patient's absence from work or school cause rely high the hospital and social costs. According to these points and the preventability of most burn cases by generally training adults and children through special programs in the media or schools, it seems necessary to plan for this purpose. In addition, planning aimed at preventing burns is the only effective solution to solve this problem. The first step in this planning includes collecting epidemiological data on burn patients and providing important information in order to design appropriate strategies and reduce the prevalence of injuries and adopt appropriate methods of medical management. The demographic, social, economic and cultural structure is different from one society to the other and in most cases the results cannot be generalized; therefore, it is necessary to conduct investigations into burn cases among children and adolescents in every single region. Burns with hot and boiling fluids among toddlers, playing with matches among primary school children and electrical injuries among adolescents are directly effective in occurrence of burns (Clark and Lerner, 1978; Koumbourlis, 2002).

The results of previously conducted epidemiological studies indicated that most burn cases happening at the age of below 4 were caused as a result of contact with boiling water or flame. Therefore, in regard to preventing thermal burns in this age group especially burns caused by boiling water in homes (as a result of turn-over of kettles, samovar or pots containing boiling water), necessary trainings should be provided and certain measures should be adopted. In some countries, regulated heat production equipment that raise the heat to a certain temperature, gas stove protector and special training methods are utilized. These measures are effective in reducing the number of burns caused by boiling water (Kliegman *et al.*, 2007). Similar to this age group, conducting epidemiological studies in different regions can make it possible to prevent burns by determining risk

factors involved in causing burns in different age groups. While discussing the issue of burns and their causes in Iran, the festival of Chaharshanbe Suri (The Iranian Festival of Fire on the last Wednesday of the year) cannot be neglected. This festival is also one of the commonest causes of burns and the related injuries in Iran. By making appropriate culture, this festival should be changed in a way that it will involve fewer risks and the authorities need to utilize creative tactics to provide people with a pleasant time and reduces the financial and life costs by replacing dangerous antisocial behaviors with healthy activities.

Furthermore, since the extent and depth of burns play a significant role in morbidity and mortality rates and determination of the patient's precaution, the method of measuring them among children and adults and determining relevant protocols is highly important. Burn trauma and infection are the commonest causes of death and adverse events in burns, in this regard, rehydration method to prevent and treat burn trauma especially in children and also the method of using systemic or topical antibiotics are faced with serious challenges. However, determining appropriate protocol is different given the patient's conditions and it is recommended that this issue should be focused on clinical trial studies.

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