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A new apparatus for standardization of experimental burn models

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ABSTRACT

Background: Burns have severe economic burden for families and countries therefore its treatment modalities have utmost importance. Several study both experimental or clinic has been reported accordingly. Although contact burns were frequently used models, most of them were manually designed. The elapsed time was recorded only. However, the real time contact surface temperature (T) and weight force (WF) were fundamental characteristics of a burn model. The aim of this study is to create a standard burn model with recording real time variables on behalf of custom designed apparatus.
Methods: A custom designed apparatus was manufactured in which the variables of real time T, WF and elapsed time could be set and record. A vertical angle was provided to ensure the applied WF.
And hence, Sprague-Dawley rats were randomly divided into four groups: (1) Burned at **60 ±1°C** with **low** WF($G60WF_L$), (2) Burned at **60±1°C** with **high** WF($G60WF_H$), (3) Burned at **80 ±1°C** with **low** WF($G80WF_L$), (4) Burned at **80±1°C** with **high** WF($G80WF_H$).
The healthy skin thickness and burn depth were measured. The percentage of burn depth to healthy skin was used for statistical analysis.
Results: Constant variables T and WF were achieved. The pressure applied on skin was not significant between low *[$G60WF_L$ vs $G80WF_L$, ($p=0.1704$)]* and high *[$G60WF_H$ vs $G80WF_H$ ($p=0.2369$)]* WF groups. However the percentage of burn depth was increasing owing to applied WF in 60°C group *[$G60WF_L$ vs $G60WF_H$, ($p=0.0125$)]* and in 80°C group *[$G80WF_L$ vs $G80WF_H$ ($p<0.0001$)]*. And also the percentage was significantly increasing owing to set T, in low WF group *[$G60WF_L$ vs $G80WF_L$ ($p<0.0001$)]* and high WF group *[$G60WF_H$ vs $G80WF_H$ ($p<0.0001$)]*. Besides neither T nor WF has priority.
Conclusion: Without recording the real time T and WF, it is infeasible to achieve a standard burn model. For a standard depth of burn, variables should be under control, as if our custom designed apparatus.

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1. Introduction

Burn is a devastating injury that may cause cosmetic and social problems during the rest of victim's life [1–3]. It has also severe economic burden for families and countries [4,5]. Several studies have been reported in order to understand the physiopathology of burns. Owing to ethical concerns and the impossibility to study on human being many experimental studies and models have been proposed [2,3,6–8]. However it is still challenging to minimize the morbidity and impaired quality of life [4,5]. Therefore, there is still a need for both clinical and experimental studies to enhance our understanding of burn physiopathology and to develop new treatment modalities accordingly.

Among several experimental burn models; contact and scalding burns have been used frequently [2,9–11]. A hand-operated bar preheated in the water bath or a plate is the most used model in contact burn models [3]. In order to standardize the burn model, burn depth is utmost importance, which is defined by three fundamental characteristics: WF, temperature, exposure time [2,3,8,11]. However, manually designed burn models have the controversies of measuring the real time, contact surface temperature and the WF applied on the skin. Therefore, a standard burn model should include interfering parameters that have impact on burn depth and should be investigator independent.

The main aim of the present study is to design a new apparatus for generating a reproducible, investigator independent, standard experimental burn model and to demonstrate the effect of real time temperature and pressure on burn (Fig. 1).

2. Material and methods

2.1. Burn apparatus

Custom designed apparatus is composed of four main structures (Fig. 1, 2).

2.1.1. Heating device

It is a clamp type 280W of power resistance, manufactured for our custom designed apparatus. The resistance is placed around a copper cylinder. Another copper cylinder burning bar (BB) with a base diameter of 10mm (surface area: 0.79 cm^2) is screwed underside, just at the center of previous one (Figs. 1 and 2). The clamp type resistance heats the bigger copper cylinder and hence the BB. Through a hole that was drilled from the center of all parts (Fig. 2) an electromechanical controller (J type thermocouple-JT) was inserted 3mm above inside of BB contact surface.

During preliminary studies of the apparatus, to confirm the temperatures correlation between the inside of contact surface (ICS) and outside of contact surface (OCS), another JT was placed adjacent to outside of the BB (Fig. 2). OCS temperature was tested before creating all burns.

The system was fixed on a spring-loaded stainless steel platform (Fig. 2). By means of placing and removing additional weights on spring-loaded system manually, an adjustable test time and WF was maintained.

2.1.2. Timer

A digital timer was used for setting the elapsed time.

2.1.3. Weight force unit

A kitchen scale was measure the applied weight with 1gr sensitivity (Soenhle QC—Germany) (Figs. 1 and 2). After obtaining the tare, before heating the device the height of BB and tension of spring was set. Over and above, just at the time of generating the wound, weight (g) applied on the skin was recorded. The WF (g/cm^2) of all groups was calculated according to the measured weight and constant surface area of BB.

2.1.4. Electrical and temperature control unit

The electrical control unit is composed of three special parts (Figs. 1 and 2).

The electrical control unit with a high sensitive Proportion-Integration-Derivation (PID) temperature controller integrated with JT that was inserted from the center of the apparatus as if defined in heating device before (Fig. 2).

Electrical current controller (Fig. 2).

Voltage controller (Fig. 2).

2.2. Animals

After approval of Ethics Committee of Eskisehir Osmangazi University (07.05.2015/458), twenty-eight male, Sprague-Dawley rats (275–300g) were used (N=28, 4 subgroups, each n=7). The study was compiled according to the ARRIVE (Animal Research: Reporting of In Vivo Experiments) guidelines. The animals were housed five days before the procedure and leave 12h light/12h dark cycle. They were fed with standard laboratory chow and had free access to water. The animals were randomly divided into four groups according to applied WF and temperature:

Group 1: Burned at **60±1°C** with **low** weight ($G60WF_L$)

Group 2: Burned at **60±1°C** with **high** weight ($G60WF_H$)

Group 3: Burned at **80±1°C** with **low** weight ($G80WF_L$)

Group 4: Burned at **80±1°C** with **high** weight ($G80WF_H$)

In our preliminary studies, the minimum WF to obtain a complete contact surface of BB was determined as 0.265 ±0.018 kg/cm^2 and has been accepted as low WF (WF_L). The amount of high WF (WF_H) was assigned as 1.250±0.034 kg/cm^2.

2.3. Experimental procedure

Anesthesia was induced with 50mg/kg penthotal Na (I.E. Ulugay, Istanbul, Turkey) injection into the peritoneum. The dorsal skin was shaved, stretched and fixed to a platform to obtain a flat perpendicular contact surface (Fig. 3). Before heating the bar, the rat was subjected to cold pressure, to determine the weight to be applied on spring-loaded system. Thereafter, the BB was heated up to set temperature that was double checked by two thermocouples to be ensure of the ICS and OCS temperature. G60 groups were burned at 60±1°C and at 80±1°C G80 groups, with low ($_L$) or high ($_H$) WF. A constant 10 secs of time were set for all groups. It was repeated in three different back side cranial, middle and caudal of each subject respectively. Round, homogeneous and visible margin burn was created (Fig. 4). One hour after the procedure, the animals