Comparison of Real-Time Contact Surface Temperature of Metal Bars That Are Frequently used ın Experimental Contact Burn Models

Deneysel Temas Yanık Modellerinde Sıklıkla Kullanılan Metal Pabuçların Temas Yüzeylerinin Gerçek Sıcaklıklarının Araştırılması

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Abstract: In the light of experimental and clinical studies, during the second half of 20th century approach to the burns have developed and changed. For understanding the pathophysiology or respond to treatment modalities, different types of scalding and contact burn models have been defined. However, studies are going on to achieve the gold standard. In contact burn models, temperature (T), exposure time and weight force applied while creating the wound are the determinant variables for the depth of burn wound. According to literature, four main types of metals, copper, aluminum, brass and stainless-steel were used for fabricating the burning bar (BB). And due to different thermal conductivity of metals, we believe that real-time contact surface T of burning bar is obscure whereas it could play an important role on the depth of burns. Hence, the aim of the study was to present the differences of real-time T of contact surface accordingly.

Key Words: burns, standardization, experimental

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Özet: Deneysel ve klinik çalışmalar ışığında 20. yy'ın ikinci yarısından sonra yanık hastalarına yaklaşımda gelişmeler ve değişiklikler olmuştur. Bu noktada deneysel ve klinik çalışmaların rolü büyüktür. Gerek fizyopatolojiyi gerekse tedavi alternatiflerini değerlendirmek amacıyla çok çeşitli haşlanma ve temas yanık modelleri tanımlanmıştır. Ancak deneysel temas yanığı çalışmalarında altın standardı arayış devam etmektedir.

Temas yanık modelinde sıcaklık, uygulama kuvveti ve süresi yanık derinliğinde belirleyici faktörlerdir. Literatürde yakıcı pabuçların dört ana metalden (bakır, pirinç, alüminyum ve paslanmaz çelik) yapıldığı anlaşılmaktadır. Ancak metallerin ısıl iletkenliğinin farklı olması nedeniyle gerçek zamanlı temas yüzeyi sıcaklığının özellikle ön ısıtmalı modellerde tahmin edildiği gibi olmadığı düşüncesindeyiz. Bu noktadan hareketle çalışmada, farklı metallerden üretilmiş yakıcı pabuçların gerçek zamanlı temas yüzeyi sıcaklığının karşılaştırılması amaçlanmıştır.

Anahtar Kelimeler: yanık, sıcaklık, deneysel

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1. Introduction

Experimental burn models have played an important role on improvement of clinical burn approach. Therefore, a lot of scalding and contact burn models were defined (1-12). Although scalding burn models could simulate clinical issues better, due to safety of researcher and ease of application, contact burn models were also preferred. However, there is still controversies about the standardization of models whereas studies are going on to achieve the gold standard (2, 4, 7, 8, 13, 14).

In a contact burn model T, exposure time (ET) and weight force (WF) are the variables that are the predictive factors for deepness of the burn (15). Unfortunately, until recently, in most of contact burn models, WF has not been taken into account (3, 10, 16). Furthermore, the real-time T of contact surface was also obscure owing to the model's design. And hence, we suggested a standardized burn model whereas all variables were under control (2).

In our model, we have used a BB made up of copper due to better thermal conductivity in comparison to other metals. When the literature is reviewed, it could have been realized that aluminum, brass and stainless steel were used in contact burn models, besides copper (12). However, particularly in preheated models, thermal conductivity of metals becomes prominent for real-time contact surface T. Because, T is a determinant variable while creating burns (15). Consequently, in this study it was aimed to compare the real-time T of BB made up different kinds of metals.

2. Material and Methods

The real-time T of BB was measured by means of our custom designed apparatus (Figure 1).

A 5 cm clamp type custom designed 280 W of power resistance was fabricated that could be fixed around a 4 cm diameter copper cylinder (Figure 2). From the center of the cylinder a hole was drilled and screw system was achieved to the center of base for screwing on the BB (Figure 3).

Figure 1. *A is the electricity control unit; B WF and contact surface T measuring unit; B red arrow is showing copper BB; B from dark-blue arrow the real-time contact surface T was measured by thermocouple 2 (WF: Weight Force, BB: Burning Bar, T: Temperature)*

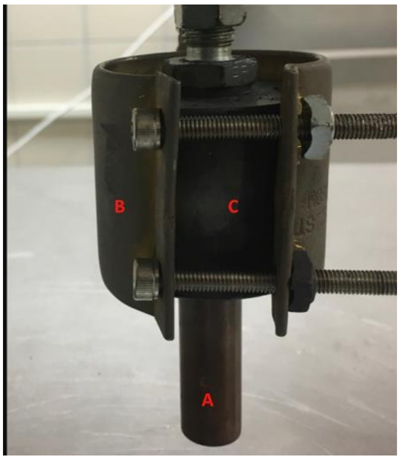

Figure 2. *Copper BB (A), 2 Clamp type resistance (B), 3 Holder copper cylinder (C)*

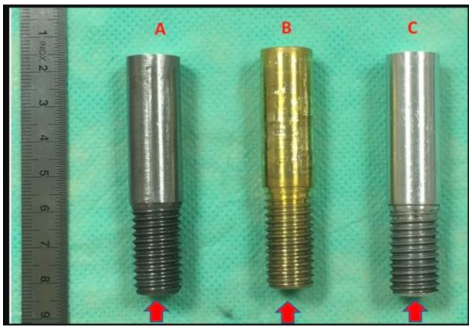

Figure 3. *The other three BB, Stainless-steel (A), Brass (B), Aluminum C, red arrow is showing the hole that is for placing the first thermocouple.*

One cm diameter and 6,5 height cylindrical BB, from the metals (copper, aluminum, brass and stainless-steel) that were frequently used in experimental burn models, had been created (Figure 3). Top of the BB was designed to screw to the copper cylinder-resistance complex centrally and the flat bottom was for contact surface. And also, centrally located hole was drilled until 3 mm proximal inside to the outside contact surface (Figure 2). Thus, was used for measuring the T of BB (K type thermocouple) from the inside center of BB that was close to the contact surface. As mentioned above, four types of BB made of those metals that are all workable with our system had been created. All has similar specifications out of metal used.

The apparatus has a double controlled electromechanical (K type thermocouple) system for measuring the real-time T of BB where as one of them was rigid and placed from the central hole of the system (Figure 2) until the 3 mm above the contact surface. The other one that was flexible was placed to the contact surface of BB (Figure 2).

All BBs were adapted to the system similarly and T measured with the same methods. Furthermore, in order to reduce the effect of surrounding T, the apparatus was placed in air-conditioned laboratory room in which the room T was strictly under control (23-24°C).

Statistics

After Shapiro-Wilk normality distribution test, groups were compared using the two-way ANOVA test. P value less than 0.05 were considered as statistically significant.

3. Results

In the light of our previous study with the copper BB at 60 and 80°Cs, there were 9°C difference between inside and outside T. And, we begin with copper BB and the inside thermocouple was set to 69°C. By increasing 10°C in each measurement up to 209°C the contact surface T was recorded respectively that is tabulated in Table 1.

Table 1.
T1: Temperature measured from inside. T2: Temperature measured from the contact surface.

T1 (°C)	T2 (°C) Copper	Aluminum	Brass	Stainless-steel
69	60	59	57	54
79	70	67	63	61
89	80	74	70	68
99	90	82	75	75
109	100	94	83	83
119	109	101	92	89
129	119	108	101	97
139	128	119	107	104
149	137	123	116	111
159	146	132	122	118
169	154	142	131	121
179	164	151	145	129
189	171	156	153	138
199	181	165	160	149
209	190	175	163	157

Table 2.
Marginal averages of metals

Metals	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Stainless-steel	103,600	1,109	101,362	105,838
Brass	109,200	1,109	106,962	111,438
Copper	126,600	1,109	124,362	128,838
Aluminum	116,533	1,109	114,296	118,771

Table 3.
Two-way ANOVA analysis of groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	78846,383[a]	17	4638,023	251,481	,000
Intercept	779532,017	1	779532,017	42267,422	,000
Process	74400,733	14	5314,338	288,152	**,000**
Unit	4445,650	3	1481,883	80,350	**,000**
Error	774,600	42	18,443		
Total	859153,000	60			
Corrected Total	79620,983	59			

4. Discussion

Fluid resuscitation and respond to treatment modalities particularly in burns have been changed on behalf of both clinical and experimental burn studies during the second half of 20th century. Experimental approach is a little bit more beneficial than the clinical studies due to controllable nature by researcher. For a universal experimental model, one side is the decision of kind of animal and the other side is the strictly controlled steps of experiment. Although there are some metabolic differences, due to ease of reproduction and maintenance of animal's survival, rodents are mostly used animals (1, 17). Moreover healthy, naturally occurring, teratogen induced, surgically created and transgenic animals could have been in use nowadays (1, 17, 18).

As we reported in our previous study, without controlling variables of T, WF and ET, it is impossible to obtain a reproducible constant depth of burn wound (2). When the contact burn literature is reviewed, it could be noticed that similar depth of burns was achieved by means of preheated BB in most (1, 3, 17). According to thermodynamic rules for a constant T the apparatus should have heating and cooling cycles. And solely, we have obtained a constant T with ±1°C SD by an apparatus that has such a mechanism. However, without additional electricity power-controlled mechanism the ±1°C SD of T could not have been achieved (2).

To our knowledge, in contact burn models, out of stressed variables (T, ET and WF) there is an important issue on real-time contact surface T that is the type of BB. Owing to different thermal conductivity of metals we believe that it should change accordingly. Over all, on behalf of literature review, it was figured out that the BBs were fabricated from different kinds of metals; i.e. Meyer and Silva has used a BB that have been made of brass in their study concerning the contact burn standardization; Singer et al. has used aluminum bar in their study for standardization of their burn model; Campelo et al. has used copper bar in their study of optimization; Cai et al. has used BB made of stainless-steel for creating the consistent burn wound; Venter et al. has used aluminum BB; Kim et al. has used stainless-steel block for their novel rapid reproducible burn study; Sakamoto et al. has used Teflon-treated copper BB in their study of new device for experimental burn studies; Singh et al. has used aluminum block in their precise experimental burn model (3-5, 8, 9, 13-15).

We speculate that besides heating-cooling cycles and controlled electricity power, owing to different thermal conductivity of metals, the real-time contact surface T of BB could have been changed. From the point of view, we hypothesized that the real-time contact T of four types of BB (copper, aluminum, brass and stainless-steel) should be different.

And results of the study have pointed out that copper is the best metal for thermal conductivity. In comparison of four metals, the discrepancy of T between inside and contact surface was the lowest in the BB that was made of copper. Another important outcome of the study was, the gap T of BB between two sides was increasing by means of increasing T. However, again the BB that was made of copper was the better one ($p<0,001$). And also, due to specifications of metals, we believe that the elapsed time for obtaining constant T of BB should have been different. However, thus was out of aim of the study and could not change the result, so it was not recorded.

In conclusion for standardization of an experimental model, all details should be taken into account and should be under control. Otherwise, reliability of the study will be damaged. For obtaining a standardized burn contact model, the BB should have manufactured from copper for obtaining more constant real-time contact surface T.

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