Thermal burn during open heart surgery

Oparzenia cieplne podczas operacji na otwartym sercu

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Abstract

**Background:** Electrosurgery helps surgeons to perform procedures faster and with less bleeding.

**Aim of the study:** This paper was designed to illustrate some aspects of electrical burns, their potential causes in our operating room and the method which guided us to the technical solutions of the problem.

**Material and methods:** This case-control study included 129 patients who underwent cardiac operations at a tertiary university medical center. Forty-one patients experienced burn during the operation during this period. The demographic and perioperative characteristics of this group (as case group) were compared to the remainder (88 patients) who had operations on the same days, but had no burns (as control group). Causative factors and preventive measures were reviewed.

**Results:** It was observed that a greater number of patients in the burn group had diabetes and hypertension, were operated on in an emergency setting ($p = 0.001$), and had a longer aortic clamp time. After the assessment of the monopolar electrosurgery equipment and restoring the electrical conditions of the operating rooms, it was determined that the shields covering the operating table were not completely insulated from current.

**Conclusions:** Burning was the result of incomplete insulation of the patients from the operating table. Identifying the pitfalls in dealing with electrosurgery and simple precautions help to reduce such preventable complications.

**Key words:** burn, electric, electrosurgery, operating room.

Streszczenie

**Wstęp:** Elektrokoagulacja pomaga chirurgowi w przeprowadzeniu zabiegu w krótszym czasie i z mniejszym krwawieniem.

**Cel pracy:** W pracy przedstawiono niektóre aspekty oparzeń wynikających z zastosowania urządzeń elektrycznych w warunkach sali operacyjnej oraz propozycje sposobów mających pomoć w unikaniu tego rodzaju powikłań.

**Materiał i metody:** Praca objęła 129 chorych, u których wykonano operację kardiochirurgiczną w ośrodku uniwersyteckim o trzecim stopniu referencyjności. U 41 chorych stwierdzono oparzenia w trakcie zabiegu (grupa badana). Analizowaną grupę porównano pod względem czynników demograficznych i śródoperacyjnych z grupą kontrolną 88 chorych, u których przeprowadzono zabieg w tym samych dniach, ale bez oparzeń.

**Wyniki:** W grupie badanej w porównaniu z kontrolną częściej stwierdzano obecność cukrzycy i nadciśnienia tętniczego oraz konieczność przeprowadzenia operacji w trybie nagłym ($p = 0.001$) z dłuższym czasem zaklemowania aorty. Po dokładnej ocenie monopolarnego sprzętu do elektrokoagulacji i przywróceniu prawidłowych warunków funkcjonowania sal operacyjnych ustalono, że osłony pokrywające stół operacyjny nie gwarantowały pełnej izolacji pacjenta przed prądem.

**Wnioski:** Oparzenia były konsekwencją niepełnej izolacji chorego od stołu operacyjnego. Identyfikacja prostych błędów podczas użytkowania sprzętu do elektrokoagulacji pozwala zmniejszyć częstotliwość występowania tego rodzaju powikłań.

**Słowa kluczowe:** oparzenie, elektryczny, elektrokoagulacja, sala operacyjna.

Introduction

The concept of using heat to decrease bleeding goes back to thousands of years ago, since cavemen found that a burning stick could stop bleeding and seal off a wound [1]. Bovie and Cushing established electrosurgery using high-frequency alternating current in neurosurgical procedures in the 1920s [1]. Electrosurgery helps surgeons to perform procedures faster and with less bleeding, and also allows some previously inoperable patients to be operated on [2-3].

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Currently electrosurgery units are present in almost all operating rooms. However, it is probably the unit least identified by the operating room personnel and physicians [4-5].

The number of accidental injuries voluntarily reported from operating rooms is less tangible in the real world; so awareness of this experience may decrease its rate [6-8]. The purpose of this paper was to state patterns of thermal burn due to using electrosurgery in our operating rooms, potential causes and ways that directed us to solve the problem.

**Material and methods**

Data were collected from the database of the cardiac surgery department at Modarres Hospital, a tertiary affiliated medical university center. Between March 2007 and March 2009, more than 2100 cardiac operations were performed. It was observed that a few patients suffered skin burns in the operating room during this interval. The study was approved by the ethics committee of the hospitals and was conducted in conformity with the Helsinki Declaration.

**Patients**

Forty-one of the patients (1.95%) who underwent cardiac operations had burns. Demographic and perioperative characteristics of these patients (as case group) in four active operating rooms were compared to the remainder (88 patients, as control group) who had been operated on the same days, without burning (with the same anesthetic management, staff and resident of cardiac surgery, and identical electrosurgery machines in the same operating rooms). Burning happened only in patients undergoing surgery with cardiopulmonary bypass (CPB). Standard and identical operative and anesthetic techniques were used in all patients. Moderate systemic hypothermia (28-32°C) was used during CPB.

Because episodes of burning occurred more predominantly in specific periods of time (Fig. 1), basic examination was undertaken to find the causative factor.

**Statistical analysis**

Results are presented as mean ± standard deviation. We used \( \chi^2 \) and Mann-Whitney test to compare the occurrence between the two groups. Variables found to be predictors of burn in the univariate analysis were then entered into a multivariate model using logistic regression to determine the independent predictors of burn. \( P \) value of < 0.05 was considered statistically significant.

**Results**

**Patient characteristics**

Forty-one patients had burn injuries after open heart surgery. There were no differences between the groups in terms of surgeons, residents and operating rooms. The skin injuries were all located in the sacral and gluteal regions (at the place of the return electrode placement), except for 2 patients whose wounds were limited to the occipital region. Both gluteal and foot involvement were seen in three cases. The average lesion size was 15 cm². Thirty-one patients had superficial burns (local tenderness, erythematous change, bulla formation). The rest (10 patients) presented full-thickness burns; 50% of them required surgery, including debridement, or musculocutaneous gluteus maximus flaps, and the remainder were treated conservatively. There was mortality due to this complication too. Death occurred in a patient who had a burn at the return electrode site. Ten days after discharge, he returned to the hospital in septic shock due to necrotizing fascitis. Multiple extensive debridements did not improve the patient’s outcome.

The mean ages were 59.4 ±14.6 in the burn group and 56.6 ±12.7 in the control group (\( P = 0.23 \)). Ejection fraction of the left ventricle as a marker of cardiac output was comparable in the two groups (47 ±10.3% in the burn group and 48 ±9.4% in the control group, \( P = 0.6 \)). More patients in the burn group were operated on in an emergency setting (\( P = 0.001 \)) and they had a longer clamp time and intubation time with lower body surface area (BSA): 1.6 ±0.2 m² vs. 1.7 ±0.2 m², \( P = 0.02 \).

We performed a multivariate analysis using logistic regression to identify the major variables in burning. We found that hypertension, diabetes, prolonged clamp time and intubation predispose patients’ skin to more ischemia, while better peripheral circulation with less BSA and improved oxygenation by blood transfusion had a protective effect in low perfusion states.

**The following steps were taken to eliminate the problem**

Three wires are distributed to all electrosurgery devices in the operating room: a “hot” lead, a neutral or “ground” lead, and a ground wire. The neutral lead is connected to the ground at the point that the electrical wiring enters the building. These two wires connect to the device to power...
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explanation is clear and simple: low perfusion pressure, de-
flect in microcirculation, local pressure and electrical burn.
 Burning events appeared more often in emergency ope-
rations. The cause could possibly be described as emergen-
cy conditions providing opportunities for errors and lack of
complete insulation of the patient from the operating table.

Limitations
The strength of this study is reporting the errors rather
than blaming individuals. Knowledge of the biophysics of
electrosurgery, the mechanisms of electrosurgery compli-
cations, and prevention of patient injuries allows surgical
team members to provide better quality outcomes for
patients. However, this study has several limitations. Our
study was observational, not interventional; it was a sin-
gle institution and retrospective study. It was conducted on
patients undergoing cardiac surgery at an urban, academic
medical center and thus our results may be generalized to
other hospitals.

Discussion
“I shall protect them from all harm”. From the Hippocra-
tic Oath. This means during any intervention, no additional
injury must influence the patient.

The main difference between cardiac surgery and other
types of surgery is the presence of CPB. At first, blood dilu-
tion by adding the prime volume of CPB could temporari-
ly create a state of insufficient oxygen content [9]. On the
other hand, oxygen availability is reduced during hypother-
mia because of the shift to the right of the oxyhemoglo-
bin curve [9]. Regardless of the negative effect of allograft
transfusion on surgical outcomes in literature, multivariate
analysis showed a protective impact of transfusion against
burn [9]. This may be explained by providing better oxygen
content in the lower perfusion state during CPB and in the
setting of peripheral ischemia.

Secondly, CPB prevents normal reflexes and chemo-
ceptor control of the circulation. The reduction in oxy-
gen consumption from surface cooling could be from the
shutting down of the microcirculation of skin and visceral
portions of the body. Clinical information strongly sugge-
sts that blood flow to the skin is severely reduced during
nonpulsatile CPB in humans [10]. The combination of the
patient’s immobility during lengthy procedures and prolong-
ed intubation predisposed patients to develop full thick-
ness burns in areas that were already at lower perfusion
pressure during aortic clamping. The development of in-
creased local pressure at contact points between the patient
and the table (skin over the forehead, iliac crests, and bony
prominences on the arms and legs) causes the skin to be at
risk of damage. So it is reasonable that places of poorly per-
fused skin during CPB are prone to electrical burn. Multiva-
rate analysis showed that hypertension and diabetes were
causative factors in predisposing skin to burn. They cause
alterations of structure and function in the microcirculation
[11]. Diabetic microangiopathy is a very frequent complica-
tion of diabetes mellitus and capillary density is reduced in
hypertensive patients [12]. To address these concerns, the
explanation is clear and simple: low perfusion pressure, de-
flect in microcirculation, local pressure and electrical burn.

The strength of this study is reporting the errors rather
than blaming individuals. Knowledge of the biophysics of
electrosurgery, the mechanisms of electrosurgery compli-
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Summary
Preventable complications are always a concern to the
surgeon. Thermal burns during electrosurgery are not un-
common and constitute the most common electrical ha-
azard in the operating room. It seems that the simplest way
to avoid burns is to educate those who use electrosurgery.

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