HAEMODYNAMIC DISORDERS IN THE COURSE OF ELECTRICAL BURNS. A PRELIMINARY REPORT

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SUMMARY. The results of Doppler haemodynamic investigations in electrically burned patients are described in this paper. A comparison with other burned patients is also provided. The following differences were found between the two groups: 1. diminished compliance of the myocardium in electrically burned patients; 2. markedly elevated ejection time measured by flow time. The results remain unclear and require further long-term investigations.

Introduction

The problem of electrical burns is becoming ever more widespread, particularly in highly industrialized countries. In the course of gaining knowledge regarding the pathophysiology of electrical trauma, the treatment of results has become an interdisciplinary task in which anaesthetic and intensive care procedures occupy an important position.

Electric injury may result from current flow through tissues or from electric arc influence. Current, particularly if of high voltage, causes tissue necrosis as also related disorders, which are significantly related to the heart and the nervous system.

The thermal results evoked by current flow are defined in Joule's formula, which says that the amount of heat created in the course of current flow is proportional to the square of intensity, electric resistance, and duration of affection. The highest risk is with electrocution with alternating current, which in Poland is usually 110,000 V (110 kV).[1]

The results of electric current's effect on the heart are dramatic. In the immediate period after trauma, asystolic or ventricular fibrillation is likely to appear. According to some American authors, in 10-30% of non-lethal cases, various electric heart activity disorders may appear, e.g. atrial fibrillation, right bundle branch block, supraventricular tachycardia, and focal arrhythmia.[1,2]

The American authors emphasize the significance of coronary vasospasm accompanied with endothelium inflammation, whereas Robinson points out the high rate of severe myocardial ischaemia with electrocardiographic features of heart failure coexisting with the electric trauma.[2,3]

These phenomena may significantly influence the efficiency of the heart as a pump, making all stages of the treatment process extremely difficult; they may also become the cause of an unsuccessful outcome in burn disease, i.e. serious disability or even death.

The aim of this study is to compare haemodynamic parameters obtained through Doppler monitoring in patients presenting electrical burns with those observed in a group of burned patients not manifesting any features of electrocution.

Material

The group of patients under consideration consisted of eight patients burned with electric current hospitalized in the Burn Centre in Siemianowice Śląskie in the years 1998-2000.

All the patients were male, of average age 43.6 yr, body mass 69.75 kg, and height 170.5 cm. They had suffered electrocution caused by high-voltage current of variable flow time and presented various rates of tissue damage.

The comparative group of 127 burn patients diagnosed as not presenting electric burn features consisted of 21 women and 106 men. The average age of patients in this group was 43.67 yr, for an average body mass of 71.42 kg and a height of 172.2 cm.

Methods

In both groups the haemodynamic examinations were conducted with a transoesophageal Doppler probe, using an ODM II apparatus (Abbot Laboratories) with continuous signal emission. The probe was fixed at descending aorta level and measurements were made at 10-min intervals.

The values observed were as follows:

1. CO (cardiac output) (ml/min)
2. SV (stroke volume) (ml)
3. HR (heart rate) (u/min)

4. PV (peak velocity) (ml/s)
5. FT (flow time) (s)
6. MA (mean acceleration) (ml/s)
7. SV to FT ratio
8. PV to MA ratio

Examinations were performed during general anaesthesia for surgical procedures of necrosis excision and fascial compartment incision. Anaesthesia was administered with inhalators such as nitrogen oxide and isofluran applied after introducing barbiturates and after analgesia with fentanyl had been guaranteed

Statistical analysis

The statistical analysis of the results was performed with the STATISTICA 6.0 program applying Mann-Whitney's test of the rank sum.

Results

Relating the group of patients presenting electrical injuries to the whole group of patients revealed a number of differences in the range of haemodynamic parameters considered, as shown below:

For FT, $p = 0.00$ with average of 0.23; for MA, $p = 0.00$ with average of 7.88; for PV/MA ratio, $p = 0.00$ with average of 7.8.

For SV, $p = 0.0432$ with average of 37.74; for PV, SV/FT, and CO, p was on the border of statistical significance (see *Tables I-III*).

Table I - General statistics for electrically burned patients

Parameter	Mean value	SD
CO	3.88	2.39
SV	37.74	24.0
HR	104.5	10.14
PV	62.35	28.77
FT	0.23	0.04
MA	7.88	2.98
SV/FT	152.17	73.57
PV/MA	7.8	1.76

Table II - General statistics for non-electrically burned patients

Parameter	Mean value	SD
CO	4.29	2.83
SV	42.09	28.48
HR	106.42	21.73
PV	62.49	27.46
FT	0.26	0.09
MA	6.81	2.7
SV/FT	148.63	73.51
PV/MA	9.8	4.3

Table III - Group comparison and statistical significance of parameters analysed

Parameter	Non-electric group		Electric-group		*p*
	Mean value	SD	Mean value	SD	
CO	4.29	2.83	3.88	2.39	0.052
SV	42.09	28.48	37.74	24.06	0.0432
HR	106.14	21.73	104.5	10.14	0.0521
PV	62.48	27.46	62.35	28.77	0.9562
FT	0.26	0.09	0.23	0.04	0.000
MA	6.81	2.71	7.88	2.98	0.001
SV/FT	148.62	73.51	152.17	73.57	0.581
PV/MA	9.8	4.32	7.8	1.7	0.000

Discussion

As already said, electrical injuries have an extremely strong effect on the cardiac muscle. This influence is both primary, resulting from features of the muscles, and secondary, resulting from other organic or systemic activity related to electric energy.

Damage to the nervous system includes damage to both the brain and the spinal cord and, according to Christiansen, affects the extrapyramidal tracts, the anterior horns of the spinal cord, and the cerebral cortex. The damage can be manifested by aphasia, hemianopia, and ataxia as also by hemiparesis and peripheral pain syndrome of causalgia type, as well as by phantom disorders.

Symptoms related to vessels and the respiratory system, in the majority of cases, include the onset of more or less significant tissue necrosis together with its functional results. The clinical picture of these disorders also presents features of circulatory insufficiency related to nervous system damage and the development of shock. They constitute a group of secondary disorders of heart activity.[3]

Assuming that FT is a standard of both systolic activity of the left chamber and afterload, and allowing for the significantly lower values of this parameter, it can be concluded that systolic activity of the heart left chamber is much more impaired in electrical injury than in any other kind of burn. Low FT values may point to impairment of heart inotropism, as also to an increase in peripheral vessel resistance. This is consistent with SV values, the decrease of which in the group of electrical burns may suggest progressive diastolic insufficiency. A lack of simultaneous cardiac outbreak increase and insignificant values of HR difference in both groups may suggest the presence of circulation compensation mechanisms other than heart rate acceleration.[4-6]

Competent analysis of the haemodynamic changes associated with burn illness also requires other circulatory parameters, e.g. mean arterial pressure, rate pressure product, and peripheral vascular resistance. Given the general

aim of the present study, these particular results will be published elsewhere.

Cardiac activity after thermal injury is affected by factors connected with the burn itself as also by changes in the cardiovascular system. Heart muscle reaction to a burn reveals itself 5 h after injury and tends to progress towards circulation insufficiency. Its clinical manifestation may be modified to a certain extent by pre-existing pathologies, e.g. ischaemic or hypertensive heart disease. In the material examined here, such distinctions were not present and for this reason it should be assumed that the heart muscle activity described by the above mentioned parameters constituted the mean value, and that its diagnostic significance was additionally limited by the reduced numerical force of the investigation.

The above parameters, which suggest an increase in circulation insufficiency features, are however consistent with the results of experimental studies. On the basis of extensive material in animals, the afore-mentioned authors proved that existing disorders of cardiac diastolic function were based on intracellular calcium kinetic defects, mainly concerning the endoplasmic reticulum.[7-9]

It is difficult to evaluate the role of anaesthesia components in the modification of circulatory reaction to burns. The literature available does not provide valid pharmacological data regarding these problems, particularly in burns. The limited number of burn patients may be a source of statistical error, but our results are at least intuitively promising to such an extent that research should undoubtedly be continued. The conclusions resulting from them may significantly contribute to the improvement of burn patient treatment and require further investigation on the basal and clinical level.

Conclusions

1. Electrical burns impair heart muscle activity more than any other kind of thermal injury.
2. Doppler monitoring appears to be a useful monitoring tool in burns.

RÉSUMÉ. Les Auteurs présentent les résultats des investigations hémodynamiques Doppler qu'ils ont effectuées dans des patients atteints de brûlures électriques. Ils fournissent en outre une comparaison avec une autre série de patients brûlés. Ils ont trouvé les différences suivantes entre les deux groupes: 1. compliance réduite du myocarde dans les patients atteints de brûlures électriques; 2. temps d'éjection notablement élevé mesuré sur la base du temps de flux. Ces résultats restent peu clairs et il faudra effectuer d'autres investigations à long terme.

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