Influence of Electric Current on Liver Parenchyma of the Rat

J. VOKURKA

First Department of Surgery, St. Anne´s Teaching Hospital, Faculty of Medicine, Masaryk University, Brno

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Abstract

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The aim of this study was to investigate the effects of monopolar electrocautery (MPEC) on hepatic parenchyma in rats. Before and after the MPEC application on hepatic parenchyma, blood samples were taken in order to determine the serum bilirubin values. The evaluation of the results has shown that serum bilirubin level changes in consequence of MPEC application on hepatic parenchyma. However, neither association of the degree of this change with current intensity, MPEC duration nor the time of sampling could be proven.

The degree of injury to the periphery of the liver necrosis resulting due to MPEC is a function of time. Before the 2nd day after MPEC application, the lesions in the hepatic parenchyma have not been fully developed yet. However, the finding of predominantly focal and multifocal necroses with leucocytic and lymphocytic perifocal reaction, occuring between the 2nd and 10th day even in the remote parts of the hepatic parenchyma outside the wedged necrosis as shown by the histological examination, seems important: it can help explain some elevated hepatic enzyme activities after the monopolar electrocautery. The results for the clinical practice is that after application of MPEC onto hepatic parenchyma may be temporary changes of some hepatic function values. These changes shall not be the reason for restricting the use of MPEC in practice.

Monopolar electrocautery, operations

In a questionnaire inquiry performed by the author (J. Vokurka) at 70 surgery departments in the Czech Republic, 170 cases of complications have been reported out of a total of 9280 laparoscopic cholecystectomies. From these, 13 cases were complications caused post-operatively by monopolar electrocautery which is widely used in most surgery departments for control of bleeding from small-diameter vessels during laparoscopic interventions (Kala et al. 2000; Olejník et al. 2003).

Another interesting finding emerging from the questionnaire inquiry has been an elevation of serum bilirubin values in a non-obstructive manner in patients after undergoing succesful laparoscopic cholecystectomy (Šefr et al. 1995). An increase in Bi/S occurring after the intervention was diagnosed in total of 254 patients operated on, i. e. in 2.74% of all cases reported. Interestingly, these have always been patients treated with monopolar electrocautery for hemostasis (Rovný et al. 2002; Vysloužil et al. 2000).

On the basis of the clinical data (Messroghli et al. 1994; Šefr et al. 1995; Krška 2001) the present author decided to carry out experiments in order to establish the effect of monopolar electrocautery on hepatic parenchyma with the aim of reducing the possibility of surgical complications during laparoscopic cholecystectomy (Hoskovec et al. 2003).

Materials and Methods

The experimental work was first prepared theoretically by studying data, then the plan of experiment was submitted to the Committee for Ethics of Medical Experiments at Faculty of Medicine, Masaryk University in Brno for approval. The Committee approved the experimental study.

A total of 108 operated experimental animals were included in the experiment. The experiment was performed on adult healthy rats under general anaesthesia. The weights of individual rats ranged from 150 g to 550 g with a mean value of 314 g.

Address for correspondence:
Doc. MUDr. Jiří Vokurka, CSc.
I. chirurgická klinika, nemocnice u sv. Anny
Pekařská 53, 656 91 Brno
Czech Republic

Phone: +420 543 182 360
Fax: +420 543 182 373
E-mail: vokurka@med. muni. cz
http://www.vfu.cz/acta-vet/actavet.htm

Before the experiment proper a pilot study was performed on a limited part of the experimental set in order to determine the variability of the values measured and also to eliminate extreme values of the cauterizing current applied and the duration of its application on the hepatic parenchyma of the rat.

After the administration of an anaesthetic agent (xylazine with ketamine hydrochloride) a blood sample from the retroorbital space was taken for biochemical examinations (Schneiderka et al. 1995). After uppermedian laparotomy and a revision of the organs in the abdominal cavity, the liver was carefully disengaged into the laparotomic wound. Monopolar electrocautery (MPEC) was applied to the liver convexity with an active electrode. In all cases, only one and the same electrode was used in order to eliminate any possible influence of different electrode surfaces on the results of the experiment. After the MPEC application on the hepatic parenchyma, the abdominal cavity was sutured and experimental animal was put into a cage for monitoring and feeding. After various pre-set time intervals, the experimental animals were euthanized by Thiopental injection intothe thoracic cavity and the hepatic tissue was taken, including the site treated by monopolar electrocautery. The hepatic parenchyma was then cut by a sharp razor and the samples, stored in 10% formaldehyde, were used for histological examination. In animals with pre-operative blood withdrawal, next blood samples were taken immediately before euthanasia.

Number of days up to the taking of samples for histological examination was 0, 2, 9 and 10.

A mobile electro-surgery apparatus, equipped with a high-frequency generator was ussed for the experiment. The maximum output of the instrument is 400W.

For the statistical evaluation and computer processing of the results, the following software was used: CSS: Statistica version 3.1 StatSoft Tulsa OK 74104, U. S. A., company manual.

Results

The difference of Bi/S values before and after MPEC application on hepatic parenchyma is statistically highly significant ($p < 0.001$), see Table 1.

Table 1
The difference in Bi/S values before and after electrocautery

css/3 basic stats		Single t-Tests N. of Cases=58 (from 108)	
	t	p	n
VAR 5 – VAR 6	-5.7844253634394	0	58

VAR 5 – Bi/S values before MPEC application on hepatic parenchyma
VAR 6 – Bi/S values after the MPEC application

The changes in Bi/S values are not significantly associated with any of the variables. The Bi/S values are affected neither by the conditions of MPEC application nor by the time of sampling, within the range of the sensitivity of the method.

The Bi/S values are changed after the MPEC application on hepatic parenchyma, but no association of this change with current intensity, MPEC duration or time of sampling could be found.

Cross-tabulation (Table 2) shows the frequency of cases of various classified degrees of hepatic parenchyma lesions in relation to the time of sampling, and MPEC intensity and duration.

Table 2
Cross-tabulation – the frequencies of different degrees of injury to hepatic parenchyma in dependence on the time of sampling, intensity and duration of monopolar electrocautery

css/3: tables VAR 3 VAR 4		Crosstabulation (count) For VAR2=1 VAR 1=1 0: 1	1: 2	2: 1	3: 0
0:	1	1	0	0	0
2:	2	0	2	0	0
9:	1	0	0	1	0

VAR 3 – number of days up to the taking of samples for histological examination after MPEC application
VAR 4 – degrees of histological lesion in hepatic parenchyma:
0 – no lesion
1 – monocellular lesion
2 – focal groups of injured cells
3 – multifocal lesions

The average degree of injury to the hepatic parenchyma around the necrosis in dependence on the time of sampling is shown in Table 3.

Table 3
Average degree of injury to the hepatic parenchyma around the necrosis in dependence on the time of sampling

css/3: general manova	MEANS
VAR 3	VAR 4
0	0.454546
2	1.741935
9	2.244444
10	2.100000

The results of histological examinations of samples taken on day 0 differ statistically significantly from all others: the samples of hepatic parenchyma on day 0 immediately after MPEC application show minimum lesions.

Between the 2nd and 9th day, the degree of injury to the periphery of the liver necrosis is statistically significant but the condition of the 2nd day was not significantly different from the 10th day.

Discussion

The passage of the electric current through the tissues is, to a large extent, influenced by the tissue´s anatomical, histological and molecular structure (Tucker et al. 1992; Vokurková 1999). The tissue, as a heterogeneous medium, is a very complicated current conductor (Lange et al. 1996). With regard to electric current conductance, the cells and the extracellular liquid have different properties. Cell membranes represent a high resistance to a low-frequency current. High-frequency currents, however, easily pass through cellular membranes owing to the membranes´low capacitance resistance at high frequencies. The mechanism of biological effects of high-frequency currents is based on the conversion of the absorbed electric energy into heat (Ziprin and Darzi 2002).

The results of our experiment demonstrate a statistically highly significant difference between the Bi/S values before and after the MPEC application on the hepatic parenchyma in rats ($p < 0.001$) in spite of the well-known and considerable inter-individual and intra-individual variability of biological and biochemical indicators in the experimental animal, including the basic biochemical analytes in the serum (Schneiderka et al. 1995).

The results of the histological examination of the samples of hepatic tissue on day 0, immediately after the MPEC application are very significantly different from all other results: the hepatic parenchyma shows only minimum lesions. In the histological picture, only dystrophic changes of hepatocytes with accentuation of vascular dystrophy can be found. As far as actual necrotic changes are found, they can only be characterised as acute mollecular lesions.

In the period between the 2nd and 9th day of sampling, the degree of lesion in the periphery of the liver necrosis was significant but on the 2nd day, the lesion is not statistically significantly different from that on the 10th day.

In samples taken on the 2nd day after MPEC application on the hepatic parenchyma of the rat, the histological picture shows a wedged extensive coagulation necrosis of hepatic parenchyma exceeding the size of individual lobes. Furthermore, further intraparenchymal alterations outside the subcapsular extensive necrosis can be proved. These are focal or multifocal necroses having no relation to the polarity of the lobe. These findings demonstrate

that the hepatic parenchyma can be affected by MPEC even outside the subcapsular localisation where the cautery was immediately applied and also deeper than that.

The histological structure of hepatic tissue samples taken after 9 days after the MPEC application confirms the finding of extensive wedged subcapsular necrosis of hepatic parenchyma; this is, however, already organized by a predominantly fibroblastic reaction. An important finding are multifocal necroses with leucocytic and lymphocytic perifocal reaction in distant parts of the hepatic parenchyma outside the wedged complete necrosis. Another finding are round-cell infiltrations in distant portal fields. The findings of focal and multifocal necroses in the histological picture of the samples examined can serve as a basis for the explanation of why some hepatic enzyme activities are elevated after MPEC.

The results for the clinical practice is that after application of MPEC onto hepatic parenchyma may result to temporary changes of some hepatic function values. These changes shall not be the reason for restricting the use of MPEC in practice.

Monopolární elektrokoagulace a jaterní parenchym u potkana

V naší experimentální práci jsme zkoumali účinky monopolární elektrokoagulace na jaterní parenchym u potkanů. Před aplikací i po aplikaci monopolární elektrokoagulace na jaterní parenchym byly provedeny odběry hodnot bilirubinu v séru. Hodnocením výsledků bylo zjištěno, že hladina bilirubinu v séru se mění vlivem aplikace monopolární elektrokoagulace na jaterní parenchym, ale nebyla prokázána souvislost velikosti této změny s intenzitou proudu, dobou monopolární elektrokoagulace ani dobou odběru vzorku. Stupeň poškození periferie nekrózy jater vzniklé působením monopolární elektrokoagulace je funkcí času. Do 2. dne od aplikace monopolární elektrokoagulace na jaterní parenchym však není poškození plně rozvinuto. V histologickém obraze je závažný nález převážně fokálních a multifokálních nekroz s leukocytární a lymfoidní perifokální reakcí i ve vzdálenějších částech jaterního parenchymu mimo kompletní klínovitou nekrózu. Tyto nekrózy mohou být podkladem pro výklad některých enzymatických jaterních elevací po monopolární elektrokoagulaci jaterního parenchymu. Pro klinickou praxi vyplývá, že po aplikaci MPEC na jaterní parenchym může dojít k dočasným změnám některých hodnot jaterních funkcí. Tyto změny však nemohou být důvodem k omezení používání MPEC v praxi.

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