EFFECTS OF PARASAGITTAL CARBON DIOXIDE LASER APPLICATION ON ERYTHROCYTE DEFORMABILITY

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SUMMARY :

In this study we investigated the influence of laser energy on the rheological properties of blood passing through the superior sagittal sinus. Twenty-two guinea-pigs were used. In the control group craniectomies were done and only the superior sagittal sinuses were exposed. This procedure had no significant influence on haematological factors and erythrocyte deformability. In the experimental group a carbon dioxide laser application was applied to the parasagittal brain tissue. In this group MCH, MCHC values and erythrocyte deformability were found to be changed singificantly.

KEY WORDS:

Lasers, Erythrocyte Deformability

INTRODUCTION

Laser energy found its way into neurosurgical practice after the initial report of Rosomoff and Carroll in 1965 (11).

Many laboratory trials were carried out in the late sixties (3, 15, 19). In these studies the morphological effects of laser energy was investigated mostly (3, 15, 19).

Operating theatres of many centres were equipped with laser machines in the 1980's and data concerning the clinical experience began appearing in the literature (1,2,12,21).

Laser beams are used for the treatment of intracranial mass lesions, vascular lesions and even for performing microvascular anastomosis (2,12). The best indications are benign tumours such as meningiomas. However in recent years, interstitial tissue therapy has been designed for deeply situated malignant glial tumours.

After wide clinical usage, papers appeared in the literature mentioning the unexpected effects of laser energy especially severe cerebral oedema after vaporization or shrinkage of the tumour (6,17). In recent years investigators began to search for the influence of laser energy on dynamic factors such as cerebral blood flow, intracranial pressure, EEG and cerebral water content (8,9,17,19).

In this study the influence of carbon dioxide laser energy on the rheological properties of blood passing through the superior sagittal sinus is investigated. A review of the literature failed to find any other report dealing with this effect.

MATERIALS AND METHODS:

Twenty-two guinea-pigs each weighing 400-500 gm's, were used in the study. They were divided into two groups of eleven. The first group was the surgical control group and the second the experimental group. The subjects were anaesthetized with nembuthal sodium (25 mg/Kg) and midline scalp and transverse incisions were made in anterior cervical region. In all animals the internal jugular veins and carotid arteries were exposed and prepared for obtaining blood specimens. In the parasagittal area craniectomies were done to expose the superior sagittal sinus. To compare the effect of laser energy on red blood cells, samples were taken from the carotid artery and from the jugular vein, because one is the pre-laser area where the latter is postlaser area. Blood specimens were obtained from one jugular vein after the contralateral one was ligated.

In the control group blood samples were obtained from the carotid artery and 30 minutes later from the jugular vein. (Waiting for 30 minutes in order to equalize the interval in both groups, because in the experimental group the laser application took nearly 30 minutes.) In the experimental group after blood samples were taken from the carotid artery, the carbon dioxide laser application was done to the parasagittal brain tissue (Tissue beside superior sagittal sinus).

In a preliminary study the necessary doses were calibrated. Power was 6-8 Watts, exposure time was 0.5 seconds and 10 to 12 shouts were done in each animal (Coherent System 451). Care was taken not to the irradiate superior sagittal sinus. During surgical intervention and laser application the cortical temperature was recorded with the aid of a YSI Tele thermometer and fine needle probe(Yellow Springs Instrument, Kings KM 51-01 fine needle probe). After laser application blood samples were obtained from the jugular vein. This procedure was completed in 30 minutes. In both groups the sagittal sinuses remained open for 30 minutes. Red cell count (RBC), haemoglobin, haematocrit, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and erythrocyte filtrability were measured in heparinized blood samples (15 IU ml). Haematological parameters were determined with an haematology analyser (Colter Counter, Model 5 Plus VI).

Erythrocyte filtrability was measured by the constant pressure filtration technique (7). Heparinized blood was washed 3 times with particle free tris NaCl buffer (pH 7.4), while the buffy coat was eliminated carefully at each step. Packed red cells were resuspended with the same buffer to give a haematocrit of 10 %. 1 ml of suspension was filtered through policarbonate filters (Pore size 4.7 um, Nucleopore-Hemafil, Lot: 54B6A7) under 5 cm H20 pressure and filtration time was determined electronically.

Measurements were perfomed at room temperature and within thirty minutes after the collection of blood specimens. Filtration times of red cell suspensions were divided by the filtration times of the same amount of buffer through the same filter. The index calculated from these measurements was inversely related to the deformability of erythrocytes.

The results obtained before and after surgery were compared with Wilcoxon Paired T-test.

RESULTS

The haematological parameters and erythrocyte deformability indexes are presented in Table 1. In the control group cortex temperatures were recorded as 32-34 degrees centigrade (Mean 33.3+0.9). During laser application cortical temperatures were recorded as 36-38 degrees centigrade (Mean 37.6+0.7).

Table 1 : Results obtained from the control group and from the experiment group.

		Carotid	Juguler	Wilcoxon P	
	RBC	4.32 + 1.13	4.48 + 0.53	$p > 0.05$	
	Hb	12.90 + 2.21	12.92 + 1.18	$p > 0.05$	
	Hct	37.43 + 6.96	36.72 + 3.82	$p > 0.05$	
	MCV	81.67 + 4.60	82.09 + 2.98	$p > 0.05$	
	MCH	27.94 + 1.41	28.98 + 2.46	$p > 0.05$	
	MCHC	33.91 + 2.10	35.30 + 3.11	$p > 0.05$	Control Group
	DEF.IND.	1.51 + 0.20	1.62 + 0.20	$p > 0.05$	
	RBC	4.39 + 0.72	4.00 + 0.56	$p > 0.05$	
	Hb	12.40 + 2.36	12.25 + 1.67	$p > 0.05$	
	Hct	36.09 + 6.41	33.17 + 3.97	$p > 0.05$	
	MCV	82.00 + 1.73	83.22 + 6.38	$p > 0.05$	
	MCH	28.17 + 1.41	30.90 + 4.60	$p < 0.05$	
	MCHC	34.34 + 3.11	37.00 + 4.62	$p < 0.05$	Experiment
	DEF.IND.	1.55 + 0.20	2.16 + 0.50	$p < 0.05$	Group

DISCUSSION

Erythrocyte deformability is mainly affected by the volume, haemoglobin concentration and shape of the test erythrocytes (16). With currently used techniques, it is possible to detect minimal changes (16). In the present study, the effects of laser energy on erythrocyte rheology at the parasagittal area was tested. In order to detect the local changes, one must know the rheological properties of the blood entering and coming out from the test area. In this study specimens were obtained from the carotid artery and jugular vein. In order not to dismiss the blood from the sagittal sinus, blood was obtained from one juguler vein after the contralateral one has been ligated. No attempt was made to obtain blood from the sagittal sinus direct because of the relatively small calibre of the sinus in guinea-pigs which may be influenced by veni-puncture. The results showed that the rheological properties of the whole blood before and after laser energy was not influenced.

The intrinsic factors influencing erythrocyte deformability are the cell geometry, cytoplasmic viscosity and membrane viscoelasticity (16). Mean corpuscular hemoglobin and mean corpuscular hemoglobin concentrations were influenced significantly. These findings indicate the intrinsic changes in erythrocytes which are consistent with those of Glassberg (4) who showed a dose-dependent lysis of haemoglobin in erythrocytes. Because MCHC is an important deter-

minant of cytoplasmic viscosity, there must be other factors which influenced this as well as the cell shape.

The first factor may be effect of laser energy on cerebral microvasculature. Carbon dioxide laser application of 4 Watts for 2 seconds causes wedge-shaped lesions composed of charred layer and around this an oedematous layer appears (9). It was clearly demonstrated by Kuroiwa et al. that (9), in more than 80 percent of animals, there was evidence of extravasation of red blood cells and sometimes massive haemorrhagies. When the dosage was increased to 8 Watts they observed dilatation and sometimes thrombosis of the vessels (9).

Tiznado et al (17), also found a lesion of 15 millimetres on the cortical surface. Using a power of 40 Watts for a total of 4 seconds, they found that these lesions, composed of haemorrhagies and necrosis, extended to a depth 5 millimetres (17).

As seen from this data the influence of carbon dioxide energy of 6-8 Watts for a total of 5 to 6 seconds on the cerebral microcirculation, may be one of the factors which caused changes in hematological factors.

The second factor may be the rise in temperature. The heat effect of carbon dioxide laser energy initially proposed by Stellar (14), has also been observed by clinicians (10,18) and written by others (2,13).

It is a well known fact that heat treatment causes red blood cells to change their morphological and mechanical properties (5,14,20). Snabre (14) indicates the critical thermal denaturation range as 46 degrees Centigrade and 51 degrees Centigrade. At higher temperatures, red cells are transformed into spherocytes, they exhibit budding and they undergo fragmentation (14,20). Although there may be changes in erythrocyte deformability between 24 to 37 degrees Centigrade, the deformability decreases dramatically between 48 to 50 degrees Centigrade. In the initial study although increases in cortical temperature were recorded, these were found relatively low, so heat could not be accused of being the only factor causing the changes. This study was designed to search for the oedematous effects of laser energy.

In summary the study showed the influence of carbon dioxide energy on erythrocyte rheology. But as a preliminary conclusion we can state that in clinical practice, in order to avoid damage, low doses of laser energy must be utilized and care must be taken near the vital structures. Disturbance of microcirculation and erythrocyte deformability may be one factor causing 'unexpected' cerebral oedema during laser application.

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