EFFECTS OF PULSED SHORT WAVES ON CARBOHYDRATE AND LIPID METABOLISM AND ON RENAL FUNCTION. AN EXPERIMENTAL STUDY

Gabriela Bombonica Dogaru, Ioana Stânescu, G. Bódizs
CLUJ-NAPOCA UMPH, CLINICAL REHABILITATION HOSPITAL CLUJ-NAPOCA

Summary
Pulsed short waves are short electromagnetic waves with a fixed duration, emitted intermittently, separated by free intervals with a variable duration. If the favorable effects of short continuous waves are mostly due to the endotissular production of heat (endothropy), the action mechanism of pulsed short waves is more complex, these waves being “athermal”. Pulsed short waves are part of high frequency therapy and through their biological effects, effective therapeutic results and absence of side effects, have many indications: rheumatology, post-trauma, burns, neurology. The aim of the study was to monitor changes in carbohydrate, lipid metabolism, as well as biochemical parameters, creatine kinase, urea, creatinine, and to compare them before and after treatment with pulsed short waves. For the experiment, white female Wistar rats were used, which were assigned to four groups (no.=10 animals in groups 1, 2, 3, no.=5 animals in group 4, control): group 1 exposed to a dose of 1/80 impulses/sec for 10 min/day, group 2 exposed to 4/400 impulses/sec for 10 min/day, group 3 exposed to 6/600 impulses/sec for 10 min/day, 15 sessions, and group 4, control group, unexposed. There were no changes in carbohydrate metabolism, glycemia values after the two weeks of treatment with pulsed short waves in the three doses used were slightly altered, with a slight increase in glycemia values occurring in most of the rats, but the differences were not statistically significant. Regarding lipid metabolism, the values of cholesterol, triglycerides and HDL-cholesterol were slightly changed, with a decreasing tendency in most of the rats of all three experimental groups, without statistical significance, after the two weeks of exposure to pulsed short waves. Creatine kinase values were altered, with a decrease in most of the rats compared to initial values before treatment, but without statistically significant differences. In group 1 (1/80 impulses/sec) and group 2 (4/400 impulses/sec), the mean urea value after exposure decreased compared to the mean value before exposure, with statistically significant differences. In group 3 (6/600 impulses/sec), the mean urea value after exposure decreased, without statistically significant differences. The mean creatinine values in all three experimental groups increased after the two weeks of treatment with pulsed short waves, with statistically significant differences compared to the mean values before exposure, but the increases were within normal limits. In the unexposed control group, there were no changes.

Keywords: pulsed short waves, carbohydrate metabolism, lipid metabolism, cholesterol, urea, creatinine

Introduction
High frequency currents are sinusoidal alternating currents, whose frequency used in therapy is higher than 100,000 Hz (100 KH), reaching the upper limit of 300 GH (Rădulescu, 2004). If the favorable effects of short continuous waves are mostly due to the endotissular production of heat (endothropy), the action mechanism of pulsed short waves is more complex, these waves being “athermal”.

In the case of pulsed short waves, generated by the Diapulse device, the heating of tissues is partial or almost absent, and the therapeutic effects of these pulsed short waves seem to rather depend on the interactions between the electromagnetic field and biological tissue. These processes are not
yet very well understood, although many experimental and clinical studies have been performed so far (Pop, 1985).

The multiple effects caused by pulsed short waves on biological structures suggest complex action mechanisms that reach the infrastructural level, determining changes in cell metabolism. The biological effects of pulsed short waves could be explained according to the majority of the authors by an activation of cellular enzymatic reactions, a stimulation of energy metabolism, a stimulation of hepatic function, of adrenal gland function and the reticulohistiocytic system, changes in cellular permeability, an increase in peripheral blood flow and the enhancement of local vascularization. However, all these require an increased energy consumption from cells and tissues (Pop, 1985).

Changes in some biohumoral parameters under the influence of pulsed short waves were monitored (erythrocytes, leukocytes, thrombocytes, total bilirubin, alkaline phosphatase, transaminases, plasma cortisol). No changes were found, except for a slight increase in leukocytes and alkaline phosphatase (Mindlin et al., 1975).

Changes in the parameters of protein metabolism, lipid metabolism, fibrinolysis coagulation system were also monitored, and an improvement of fibrinolysis and platelet adhesiveness was found in most of the patients, with a decreasing tendency of HDL-cholesterol (Pop, 1985).

A study of enzymes in the case of wounds caused by burns demonstrated that proteinase activity, LDL-cholesterol and alkaline phosphatase are reduced after Diapulse therapy. The sooner the use of Diapulse is initiated in the affected tissues, the better the recovery of natural enzymatic activity (Ionescu, 1984).

An experimental study monitored serum calcium values after the exposure of the animals to the action of pulsed short waves, in various doses. The mean calcium values on day 16 of treatment were increased in groups I (1/80 impulses/sec), II (4/400 impulses/sec) and III (6/600 impulses/sec), with statistically significant differences (p<0.05). Group IV was not irradiated (Dogaru et al., 2012).

The aim of an experimental study in rats was to monitor, before and after treatment with pulsed short waves in different doses, some hematological parameters - erythrocytes, the hematocrit, hemoglobin, leukocytes, thrombocytes. The mean values of erythrocytes, hemoglobin, hematocrit, thrombocytes were increased following treatment, on day 16, with statistically significant differences compared to day 1, before the initiation of treatment, in groups I (1/80 cycles/sec), II (4/400 cycles/sec) and III (6/600 cycles/sec). The mean leukocyte values increased after exposure, on day 16, but there were statistically significant differences only in group III (6/600 cycles/sec). In the untreated control group, there were no changes (Dogaru et al., 2012).

**Material and method**

The experimental study consisted of the exposure of laboratory animals to the action of pulsed short waves in different doses and the monitoring of changes in carbohydrate metabolism (glucose), lipid metabolism (cholesterol, triglycerides, HDL-cholesterol), of biochemical parameters – creatine kinase, and the monitoring of renal function by the determination of urea, creatinine, and their comparison before and after exposure.

Animals. For the experiment, white female Wistar rats with a weight of 180-280 g were used.

Equipment. The Diapulse device (Diapulse Corporation of America) supplies high frequency currents of 27.12 MHz, with a wavelength of 11.06 m. The frequency of impulses is dosed in six steps, between 80-600 impulses/sec, and penetrance ranges from 1 to 6 (Rădulescu, 2004).

Experimental model. 35 animals were divided into four groups. Group 1 included 10 animals exposed to the action of pulsed short waves in a dose of 1/80 impulses/sec for 10 minutes a day, group 2, 10 animals exposed
to a dose of 4/400 impulses/sec for 10
minutes a day, group 3, 10 animals exposed
to a dose of 6/600 impulses/sec for 10
minutes a day, and the control group formed
by 5 unexposed animals, kept under the same
life conditions as the animals of the first three
groups. The duration of the experiment was
15 days. The entire body of the animals was
exposed to the pulsed short waves. There
were no food or liquid restrictions during the
experiment. All procedures performed in the
animals were according to the Ethical Norms
required by EU regarding the rearing and
killing of experimental animals. Before and
immediately after treatment, 3 ml blood were
taken from the retrobulbar sinus at the
internal angle of the eye of each animal and
collected in heparinized capillaries.

Statistical analysis was aimed at
evidencing statistically significant differences
between the values obtained before and after
treatment in the four groups. The T test for
the comparison of the means in paired
samples, the F test for the comparison of
variations (Drugan et al., 2003), the T test for
the comparison of the means in independent
samples assuming equal variances, the T test
for the comparison of the means in
independent samples assuming unequal
variances were used (Drugan et al., 2010).
Data were collected and analyzed using the
Microsoft Excel 2010 application.

Results and discussion

a. Carbohydrate metabolism (glycemia)
For the 4 groups, the mean, minimum and
maximum glucose values before exposure to
pulsed short waves were calculated.

**Table 1.** Mean, minimum, maximum glucose
values (mg/dl), day 1

<table>
<thead>
<tr>
<th>Glucose mg/dl</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>78</td>
<td>73</td>
<td>80</td>
<td>82</td>
</tr>
<tr>
<td>Maximum</td>
<td>117</td>
<td>126</td>
<td>123</td>
<td>110</td>
</tr>
<tr>
<td>Mean</td>
<td>94.5</td>
<td>98.4</td>
<td>98.5</td>
<td>98.4</td>
</tr>
</tbody>
</table>
| Standard
deviation    | 10.7    | 15.7    | 12.9    | 11.2    |

Glucose values after the two weeks
of treatment were slightly changed, with a
slight increase in glycemia values, within
normal limits, in most of the rats. The
comparison within groups before and after
exposure, performed using the T test for
paired samples, showed no statistically
significant differences (p>0.05 for each
group).

Normal glycemia values for Wistar
rats range between 50-135 mg/dl.

b. Lipid metabolism - cholesterol,
triglycerides, HDL-cholesterol

**Table 2.** Mean, minimum, maximum
cholesterol values (mg/dl), day 1

<table>
<thead>
<tr>
<th>Cholesterol mg/dl</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>43</td>
<td>56</td>
<td>41</td>
<td>51</td>
</tr>
<tr>
<td>Maximum</td>
<td>72</td>
<td>92</td>
<td>91</td>
<td>94</td>
</tr>
<tr>
<td>Mean</td>
<td>60.1</td>
<td>71.2</td>
<td>70.5</td>
<td>73.2</td>
</tr>
</tbody>
</table>
| Standard
deviation    | 8.6     | 12.5    | 16.5    | 16.1    |

**Table 3.** Mean, minimum, maximum
triglyceride values (mg/dl), day 1

<table>
<thead>
<tr>
<th>Triglycerides mg/dl</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>92</td>
<td>78</td>
<td>61</td>
<td>68</td>
</tr>
<tr>
<td>Maximum</td>
<td>244</td>
<td>311</td>
<td>312</td>
<td>233</td>
</tr>
<tr>
<td>Mean</td>
<td>155.2</td>
<td>164.1</td>
<td>168.3</td>
<td>164.6</td>
</tr>
</tbody>
</table>
| Standard
deviation    | 49.0    | 61.5    | 76.0    | 68.4    |

**Table 4.** Mean, minimum, maximum HDL-
cholesterol values (mg/dl), day 1

<table>
<thead>
<tr>
<th>HDL-cholesterol mg/dl</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>19</td>
<td>27</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Maximum</td>
<td>34</td>
<td>43</td>
<td>44</td>
<td>37</td>
</tr>
<tr>
<td>Mean</td>
<td>29.6</td>
<td>32.2</td>
<td>32.7</td>
<td>32.2</td>
</tr>
</tbody>
</table>
| Standard
deviation    | 4.3     | 5.1     | 8.2     | 6.5     |

Cholesterol, triglyceride and HDL-
cholesterol values after the two weeks of
treatment were slightly changed, with a
slight decrease in most of the rats, after the
two weeks of exposure to pulsed short
waves. However, the comparison within groups before and after exposure, performed using the T test for paired samples, showed no statistically significant changes ($p>0.05$ for each group). Normal total cholesterol values for Wistar rats range between 40-130 mg/dl.

c. Creatine kinase

**Table 5.** Mean, minimum, maximum creatine kinase values (u/l), day 1

<table>
<thead>
<tr>
<th>Creatine kinase u/l</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>453</td>
<td>339</td>
<td>190</td>
<td>272</td>
</tr>
<tr>
<td>Maximum</td>
<td>3614</td>
<td>3606</td>
<td>3536</td>
<td>962</td>
</tr>
<tr>
<td>Mean</td>
<td>1291.2</td>
<td>1245.5</td>
<td>908.2</td>
<td>492.2</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>954.8</td>
<td>948.4</td>
<td>983.1</td>
<td>280</td>
</tr>
</tbody>
</table>

Creatine kinase values after the two weeks of treatment with pulsed short waves were changed, with a decrease in most of the rats. However, the comparison within groups before and after exposure, performed using the T test for paired samples, showed no statistically significant differences ($p>0.05$ for each group).

d. Evolution of renal function.

**Table 6.** Mean, minimum, maximum urea values (mg/dl), day 1

<table>
<thead>
<tr>
<th>UREA mg/dl</th>
<th>Mean</th>
<th>StDev</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>47.8</td>
<td>8.64</td>
<td>35</td>
<td>62</td>
</tr>
<tr>
<td>Group 2</td>
<td>45</td>
<td>7.63</td>
<td>37</td>
<td>57</td>
</tr>
<tr>
<td>Group 3</td>
<td>47.9</td>
<td>6.57</td>
<td>36</td>
<td>61</td>
</tr>
<tr>
<td>Group 4</td>
<td>43</td>
<td>5.57</td>
<td>36</td>
<td>50</td>
</tr>
</tbody>
</table>

It was checked whether the groups were comparable, if there were differences between the experimental group and the control group. The checking was done using the T test for independent variables with equal variances. Group 1, 2, 3 vs control group, $p>0.05$, so the groups were comparable. The effect of exposure was checked using the paired T test.

In group 1 (1/80 impulses/sec), the mean urea value after exposure decreased, being equal to 41.8 ($P=0.01<0.05$), with a statistically significant difference. In group 2 (4/400 impulses/sec), the mean urea value after exposure decreased, being equal to 39.99 ($P=0.03<0.05$), with a statistically significant difference. Normal urea values for Wistar rats range between 30-42 mg/dl. In group 3 (6/600 impulses/sec), the mean urea value after exposure decreased to 47.8 ($P=0.94>0.05$). There were no statistically significant differences. In group 4, the control group, the mean urea value after exposure was 40.4 ($P=0.53>0.05$), without a statistically significant difference.

e. Creatinine

**Table 7.** Mean, minimum, maximum creatinine values (mg/dl), day 1

<table>
<thead>
<tr>
<th>CREATININE mg/dl</th>
<th>Mean</th>
<th>StDev</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>0.59</td>
<td>0.05</td>
<td>0.49</td>
<td>0.68</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.58</td>
<td>0.04</td>
<td>0.52</td>
<td>0.62</td>
</tr>
<tr>
<td>Group 3</td>
<td>0.65</td>
<td>0.09</td>
<td>0.55</td>
<td>0.78</td>
</tr>
<tr>
<td>Group 4</td>
<td>0.63</td>
<td>0.09</td>
<td>0.52</td>
<td>0.76</td>
</tr>
</tbody>
</table>

It was checked whether the groups were comparable, if there were differences between the experimental group and the control group. The checking was done using the T test for independent variables with equal variances. Group 1, 2, 3 vs control group, $p>0.05$, so the groups were comparable. The effect of exposure was checked using the paired T test. Two weeks after exposure to pulsed short waves, the mean creatinine value increased in groups 1 (1/80 impulses/sec), group 2 (4/400 impulses/sec), group 3 (6/600 impulses/sec), with statistically significant differences compared to the mean values before exposure, but the increases were within normal limits. In the unexposed control group, there were no statistically significant changes.
Normal creatinine values for Wistar rats range between 0.2-0.8 mg/dl.

<table>
<thead>
<tr>
<th>Creatinine mg/dl</th>
<th>Mean creatinine before exposure</th>
<th>Mean creatinine after exposure</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>0.586</td>
<td>0.754</td>
<td>P=0.00007&lt;0.05</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.58</td>
<td>0.725</td>
<td>P=0.001&lt;0.05</td>
</tr>
<tr>
<td>Group 3</td>
<td>0.645</td>
<td>0.739</td>
<td>P=0.006&lt;0.05</td>
</tr>
<tr>
<td>Group 4</td>
<td>0.628</td>
<td>0.664</td>
<td>P=0.41&gt;0.05</td>
</tr>
</tbody>
</table>

**Conclusions**

The biochemical results obtained before and after the 15 days of treatment with pulsed short waves evidence some differences, the values obtained depending on the irradiation doses used (1/80, 4/400, 6/600 impulses/sec).

There were no changes in carbohydrate metabolism, glucose values after the two weeks of treatment with pulsed short waves in the three doses used were slightly changed, with a slight increase in glycemia values in most of the rats, within normal limits, without statistically significant differences (p>0.05 for each group).

Regarding lipid metabolism, cholesterol, triglyceride and HDL-cholesterol values after the two weeks of treatment were slightly changed, with a slight decrease in most of the rats of all three experimental groups after the two weeks of exposure to pulsed short waves. However, the comparison within groups before and after exposure, performed using the T test for paired samples, showed no statistically significant differences (p>0.05 for each group).

Creatine kinase values after the two weeks of treatment with pulsed short waves were changed, with a decrease in most of the rats compared to initial values before treatment, but there were no statistically significant differences (p>0.05 for each group).

Renal function was assessed by determining urea and creatinine values. In group I (1/80 impulses/sec) and group II (4/400 impulses/sec), the mean urea value after exposure decreased, with statistically significant differences compared to the mean value before exposure. In group 3 (6/600 impulses/sec), the mean urea value after exposure decreased, but without statistically significant differences. The mean creatinine values in all three experimental groups increased after the two weeks of treatment with pulsed short waves, with statistically significant differences compared to mean values before exposure. The increases were within normal limits.

In the non-irradiated control group, there were no statistically significant changes.

**References**


