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PULSE MODULATED UHF ENERGY ILLUMINATION OF THE HEART ASSOCIATED WITH CHANGE IN HEART RATE

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RECENTLY Frey[3], the Library of Congress[7], and Khclodov[5], reviewed and evaluated data on the central nervous system effects of illumination by energy in the very high frequency (VHF), ultra high frequency (UHF), and super high frequency (SHF) regions of the electromagnetic spectrum. They concluded the data indicate that the energy affects the nervous system when used at low power densities. More recently, Frey[4] showed that illumination of the head of the cat with pulse modulated UHF energy at low power density (30 microwatts/cm^2, average) evoked potentials in the brain stem. These effects would not be expected in terms of current theory. Beyond implications for theory, there are practical implications since UHF energy has become a pervasive environmental agent in recent years.

There are also reports of heart rate change correlated with VHF energy illumination which have similar implications. These reports include clinical observations such as that of Drogichina, Konchalovskaya, Glotova, Sadchikova, and Snegova[1] and experimental investigations such as those reported by Presman and Levitina. In two joint investigations using rabbits, Presman and Levitina[9,10] report finding small reversible changes in heart rate associated with low intensity VHF energy illumination (λ = 10 cm., 12.5 cm.). The effect on rate was a function of the region of the body illuminated. In general, head illumination

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*** An inaccurate Fed. Proc. translation of a 1964 paper exists.
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was associated with tachycardia and body illumination with bradycardia. More recently, Levitina[6***] reported that illumination of intact frogs with low intensity VHF energy (power density 60 $\mu w/cm^2$, $\lambda = 12.5$ cm.) resulted in a change in heart rate similiar to the change observed in rabbits. He suggested that the rate change in the frog was due to an effect on the peripheral nervous system. At the wavelengths he used, one would expect little body penetration of the energy[2,3]. Thus, a skin receptor hypothesis is reasonable. The above cited head illumination data, however, do not fit his hypothesis. The situation is apparently more complex than he suggests.

It seemed likely that the use of UHF energy, which penetrates tissue and is more appropriate as a tool in biological experimentation[3], might clarify the situation. Further, it seemed that if this energy affected the heart, as such, then it would be likely[4] that the effect would appear most clearly when the isolated frog heart was illuminated with low intensity pulsed modulated energy. On a logical basis, the most useful procedure appeared to be sychronization of the UHF energy pulses with the P wave of the ECG in an attempt to induce a positive feedback condition. It was considered possible that this would result in tachycardia, arrhythmia, or fibrillation. Such results did occur as described in the experiment reported below.

Method

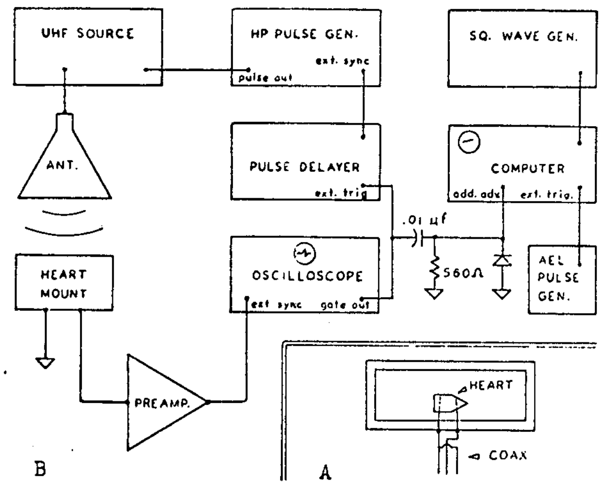
Experimental Design. Twenty-two isolated frog hearts were illuminated with UHF energy pulses that were synchronized with the P wave of the ECG. The UHF source was set to emit pulses 10 sec in duration at a carrier frequency of 1.425 GHz ($\lambda \simeq 20$ cm.). Due to the narrow pulse width, the energy was actually contained within a spectrum centered about the cited frequency. Each ECG P wave triggered a pulse of UHF energy. Hearts were illuminated at the peak of the P wave, 100 msec after the P wave peak, and 200 msec after the P wave peak.

Since the isolated heart beats at a slowly decreasing rate of approximately 1 beat/sec and the rate is stable for at least 20 minutes, each heart was used for one session of three periods (250 beats/period). During a session, periods of illumination with UHF energy alternated with periods of no illumination. The experiment was counterbalanced by assigning half the hearts within each group to the sequence UHF, no-UHF, UHF, and half to the reverse sequence. The moment to moment change in heart rate was measured and displayed in histogram form with a Technical Measurements Corp Computer of Average Transients, model 1000.

Two control groups were also included in the experiment. One was intended to answer the question of whether exposure of the preparation to UHF energy was necessary to obtain the effect. Thus, several hearts were used as in a regular session, but with two layers of echosorb AN77 (a UHF energy absorber) interposed between the antenna and preparation. The other group was intended to answer the question of whether the UHF energy could induce currents on the recording electrodes to a degree that would effect the preparations' rate of beating. Though preliminary studies with dead hearts showed that the energy of the current induced on the electrodes was negligible, this control was included. Hearts were used as in a regular session, but with the UHF energy replaced with electrical pulses placed across the electrodes.

Apparatus and Procedure. A mount of lucite, a material which causes minimal distortion of a UHF energy field, was constructed to hold platinum electrodes. These electrodes were used to support and record from the heart (Fig. 1A). The electrodes terminated in a teflon insulated subminiature coaxial cable, type RG 196/U. This cable minimized extraneous electrical pickup which might have interfered with data processing or possibly influenced the heart. The mount was located within a test enclosure of Echosorb AN77. AN77 is a UHF energy absorber which allows simulation of a free field by minimizing UHF energy reflection and field distortion. To further minimize distortion of the UHF field in the enclosure and the possibility of UHF energy pickup, the portion of the coaxial cable within the enclosure was carefully positioned perpendicular to the direction of the E vector (electrical field strength).

The coaxial cable terminated in a Tektronix model 2A61 low level preamplifier used in conjuction with a Tektronix model 565 oscilloscope. The entire data processing system and the UHF illuminating system are shown in schematic form in Fig 1B and in photographic form in Fig 1C.



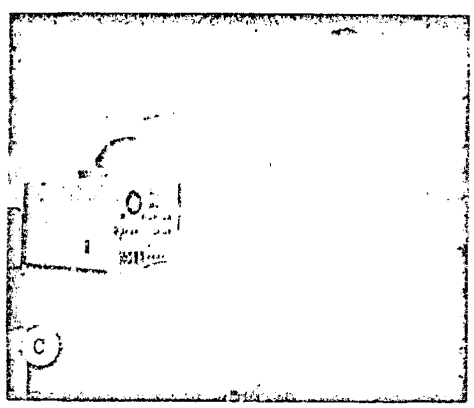


FIG 1

A) Lucite heart mount (view from top) with platinum recording wires terminated in coaxial cable, B) Schematic diagram of data recording and processing system and the UHF illuminating system. All instruments and cable shields were grounded and all cables were coaxial. C) Experimental equipment assembly.

The operation of the systems was as follows: The ECG signal from the heart was amplified by the 2A61 preamplifier. The amplified signal was then inserted into the oscilloscope at the "Ext sync" jack. The oscilloscope sweep triggering level was adjusted so that triggering was synchronized with the peak ofthe ECG P wave and the sweep was completed just before the next P wave occurred. In this way, the P wave was used as a control signal. When the P wave triggered the sweep, a pulse appeared at the oscilloscope "gate out" jack. This was used, after delaying with a Grass model SD5 stimulator (pulse delayer) and shaping and amplifying with a Hewlett-Packard model 212 pulse generator, as a control pulse to initiate the emission of a pulse of UHF energy from the UHF source. The UHF source was an Applied Microwave Lab., inc. model PG1K Signal Source with rf head model L2110C-1115. The UHF energy was conveyed via coaxial cable to a gain standard horn antenna.[11] The "gate out" pulse was also used, after shaping by a differentiator and diode clamp, to advance the computer to the next address.

The computer was operated as follows: Both the sweep rate (address time) and the trigger selector were set to "external" and the computer was placed into the start mode. The computer sweep could then be started by one pulse (pulse width = 50 μsec., pulse amplitude 10 V.) from the American Electronics Lab model 104 stimulator, used as a control device. The first address in the computer memory then accepted counts from the computer input; in this case, 1 kc square waves from an RCA model WA44C sine and square-wave audio generator, and accumulated them in that address. When a shaped gate pulse arrived at the computer address advance jack, indicating the occurrence of a P wave in the ECG, the computer advanced to the next address and began depositing counts there instead of in the previous address. At the next P wave, the computer advanced to the next address, and so forth. This continued until the desired number of addresses were used, 250 for each treatment (UHF or no-UHF) period.

From the above, it can be seen that the number of counts stored in a particular address is proportional to the time between the occurrence of the P wave which moved the memory to that address and the next P wave. The height of each computer generated light dot on the CRT display indicated the number of counts in each address. Thus, a record of moment to moment change in heart rate was obtained.

The experimental procedure began with the decapitation of a grass frog and removal of the heart. The heart was placed on the mount, dorsal side up, with its longitudinal axis parallel to the E vector. It was moistened with frog Ringer solution, and its condition evaluated by an ECG displayed on an oscilloscope. After ascertaining that the beat rate was stable, the experimental sequence was initiated.

The UHF power density was measured between experimental runs with a quarter wave dipole connected in series with a Hewlett-Packard model 477B thermister mount and a Hewlett-Packard model 430C power meter. This measurement assembly is one of the few that is not grossly inaccurate at UHF [8]. The peak power density used was 60 mw/cm^2. At the rate of one 10 μsec pulse/sec the average power density was negligible, i.e., 0.6 microwatts/cm^2. Due to the fact that the preparation and even the dipole measuring instrument disturb a UHF field, measurements of power density are considered to have order of magnitude accuracy.

Results

When the heart was illuminated 200 msec after the P wave, about the time the QRS complex occurred in our experimental situation, the beat rate increased. This increase was statistically significant at the .01 level (The two tailed Wilcoxon matched-pairs signed-rank test was used. Heart arrhythmia or cessation during illumination after rate increase was considered the extreme of rate increase). In half the cases, arrhythmias occurred and they were associated with illumination. On occasion, the heart ceased after a period of arrhythmia. These data are shown in Table 1.

It could be argued from the remaining data that illumination at the occurrence of the P wave or 100 msec after it also effected heart rate. The investigators, though, consider the data on the 0 delay and 100 msec delay to be inconclusive. If an effect exists, it requires more than a small number of preparations to tease it out and to reach statistical significance.

The results of the control sessions in which the possibility was tested

TABLE 1

Relative change of beat rate in isolated frog hearts (arbitrary units) observed during periods of UHF illumination (circled) and nonillumination. The UHF energy illuminating pulses occurred 200 msec after the ECG P wave. Comparisons should be made across the table. The comparisons are between circled and noncircled data with heart arrhythmia (ARR) and cessation (CES) considered the extreme of increase. Note that on some occasions the heart could not recover from arrhythmia after the UHF energy was turned off.

Heart	Recording period		
	I	II	III
A	20	ARR	ARR
B	67	18	33
C	17	67	8
D	25	22	67
E	18	ARR	CES
F	ARR	15	ARR
G	20	ARR	CES
H	7	20	12

that induced currents on the electrodes caused the effect, indicate that the effect can not be attributed to induced currents. This possibility was explored even to the point of using, at the same time, voltages 10^2 higher and 10^3 longer than the maximum that the UHF energy induced on the electrodes.

The results of the control sessions for determining if illumination with UHF energy is necessary to induce the effect, indicate that illumination is necessary. When echosorb shielding was interposed between the antenna and preparation, no effect appeared.

Discussion

This report was written in order to bring this phenomena to the attention of investigators interested in the cardiovascular system. It is a limited extension of our work on the CNS. The result should be considered to be specific to this particular experimental situation. The only conclusion that is warranted.

is that this data, considered with the data cited in the introduction, provide reason for a more complete investigation of the affect of modulated UHF energy on the heart. Such a complete investigation may well show that this energy can be a useful tool in the study of cardiac function.

Summary

Recent reports indicate that illumination with UHF energy affects the heart and CNS. Isolated frog hearts were illuminated with pulse modulated UHF energy in this investigation. The pulses were synchronized with the ECG in an attempt to induce a positive feedback condition. Statistically significant changes in heart rhythm were associated with the UHF illumination. It was concluded that more extensive investigations are warrented.

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