PROGRESS AND PROBLEMS IN THE NEUROLOGICAL APPLICATIONS OF FOCUSED ULTRASOUND*

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IN THE application of focused ultrasound to research and therapy in neurology, two primary problems confront us: (1) How to select dosage factors so that lesions of a standard size and character may be made anywhere in the nervous system. (2) How to produce reversible functional changes in the absence of histological damage. This communication is concerned with provisional answers to these questions, formulated in the course of studies on the following systems: the Edinger-Westphal nucleus in the cat, a spinal reflex in the cat and the blood-brain barrier in the cat. Pulse-dosage and depth-dosage studies of the size and placement of the lesion in the brain of the cat will also be reported. Finally, a study of patients with painful subcutaneous neuromata treated with dosages of pulsed focused ultrasound, arrived at by "calculated guesses," will be discussed.

We shall attempt to show: (1) that an excellent correlation exists between ultrasonic dosage and size of the lesion; (2) that there is a high degree of uncertainty with regard to occurrence of a lesion within a range of dosage values which may be called a "threshold band"; (3) that "threshold bands" can be established for many alternative sets of parameters.

Of particular interest is the fact that dosages of focused ultrasound have been found that result in reversible functional changes that occur in the absence of associated histological damage. Fry et al. have also reported on reversible functional changes but no histological confirmation of the absence of tissue damage was presented. Lastly, an attempt will be made to explain the finding that treatment of patients suffering with painful subcutaneous neuromas with focused ultrasound results in relief of pain but not loss of sensation.

EXPERIMENTAL PROCEDURE

A view of the basic experimental arrangement is shown in Fig. 1, the core of which is a Bridgeport milling machine. On the bed of the "miller"
rests a standard Horsley-Clarke stereotactic apparatus. In place of the 
arbor, a rotatable drum and post serve to hold the irradiation head. The 
machine has five degrees of freedom and provides reproducible positioning 
to tolerances of ±0.0001 inch. The irradiation head consists of a crystal 
holder, quartz crystal and polystyrene lens making up what might be called 
a single beam irradiator. Output from the transducer is calibrated before 
each experiment according to a method developed by Fry and modified by 
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One method for coupling the ultrasonic output to the brain of the cat is 
shown in Fig. 2. Following craniotomy the loose scalp is fixed to a ring on 
the irradiation pan which is filled with degassed saline. By means of a pointer 
of known length the position of the focal region of the beam of ultrasound is 
established with relation to the stereotactic zero. From this set of co-ordi- 
nates, the presumptive focal region is moved to a new position which will 
correspond to the target area. Location of targets is based upon co-ordinates 
given in Jasper and Ajmone-Marsan's atlas of the cat brain and on empirical 
corrections made in our laboratory in the course of many experiments. A yet 
more compact experimental arrangement is seen in Fig. 3.