

# ULTRASONICS

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Ultrasonics is a form of physical therapy which has been considerably developed in recent years on the Continent, and the European medical press has made great claims for this new type of treatment. This publicity, much of it grossly exaggerated in its claims, has latterly reached the lay press, and hence the patient. We are therefore likely to be asked by the intelligent and well-read patient all kinds of searching questions about this therapy, and for this reason alone, if for no other, it behoves us to have a reasonable knowledge of it and a balanced outlook on the problem. This short paper is designed to present briefly the physics and biological effects of ultrasonics and to give a fair and impartial view of the clinical use and limitations of this method of treatment.

Sonic or sound waves are not electromagnetic waves. They are longitudinal waves and they cannot pass through a vacuum; their velocity varies with the medium (in air, about 700 miles per hour). The human ear is sensitive to frequencies of 16 to 16,000 cycles per second; frequencies above this are inaudible and known as ultrasonic. The dog, however, can detect a higher frequency than the human ear, a principle used in certain dog whistles. The term "supersonics" is sometimes used, but this is an ambiguous term and better

restricted to aeronautics, where it refers to a velocity greater than sound.

Ultrasonics have been used in nature for a long time. The bat uses such waves and their reflection as a form of radar in detecting obstacles in the dark.

As long ago as 1917, Langiven at Toulon Arsenal found that fish were killed instantly when they entered the path of an ultrasonic beam used to signal between submarines. In recent years the powerful effects of ultrasonics have been used in industry (for example, in mixing water and oil into an emulsion) and latterly it has been applied in the treatment of human diseases. Most ultrasonic machines operate at a frequency of about 800 kilocycles, that is, 800,000 cycles per second, but a few operate also at as high a frequency as 3,000 kilocycles.

While ultrasonic waves may be produced by magnetostriction, commercial machines operating at these high frequencies all employ the piezo crystal. If certain quartz or ceramic crystals are placed in an alternating electric field they change shape or oscillate mechanically at the same frequency as the field. This crystal, vibrating mechanically at 800,000 cycles per second, is cemented to a thin metal plate placed at the end of the sound head, which is applied to the patient. The plate and crystal must be insulated to prevent vibrations reaching the operator's hands.

These ultrasonic waves are completely absorbed by a film of air as thin as 0.001 millimetres, and to ensure that the waves reach the patient it is therefore essential to avoid any air gap, no matter how small. This is done by using paraffin oil as the coupling medium between the sound head and the skin, and where it is difficult to ensure even apposition with the skin, subaqueous treatment is used, the energy being conveyed under water to the patient.

#### THE EFFECTS OF ULTRASONICS

Let there be no doubt about its powerful effects. In high dosage it can cause cavitation and necrosis of the tissue, which is confined and localized narrowly to the region of the beam.

In therapeutic dosage it causes a violent shaking or "micro-massage" of the tissues. While the to-and-fro motion of the tissue particles occurs over only a very short distance (0.0001 millimetres), the forces exerted are great. The acceleration of the particles may be as high as 100,000 times the acceleration of the earth, and far surpasses the most rapid centrifuge known.

The effects on the body may be summarized:

1. The mechanical effect of this shaking increases the permeability of cell membranes and increases diffusion. This has been likened by van Senden to the effect of shaking a sieve, which lets fine particles escape through the meshes.

2. It has a thermal effect, as with all forms of energy absorbed by the body. The distribution of this heat is unusual, in that it is concentrated mainly at tissue interfaces and fascial interplanes. This is well exemplified by the periosteal pain felt when the sound head is held stationary over a bony surface.

3. There is also a chemical effect which relates mainly to an increase in oxidation; possibly some large protein molecules are split.

Penetration is strictly limited. At 800 kilocycles (the usual frequency) only half the energy reaches a depth of 3.5 centimetres and only 12.5 per cent. reaches a depth of 10.5 centimetres. At higher fre-

quencies, for example, 3,000 kilocycles, the penetration is much less, half the energy reaching 1.2 centimetres. Analgesic and spasmolytic effects have also been described, but, after consideration of all these effects, it would appear logical that the main use of ultrasonics lies in the promotion of local inflammatory reactions, and particularly in the softening of fibrous tissue deposits by producing hyperæmia and diffusion.

#### THE TECHNIQUE OF TREATMENT

The technique of treatment will not be discussed in detail, but we may perhaps at this point refer briefly to several important practical details.

Treatment varies from four to ten minutes. The sound should be kept moving the whole time. Dosage varies from 0.5 to 2.5 watts per square centimetre and should never exceed 3.0 watts per square centimetres. Discomfort is a sign to reduce dosage. The total dosage from the sound head is 10 to 30 watts, which is large compared with that from a piano (0.2 watts) or an organ (10 watts).

The moving head is necessary not only to prevent discomfort, but also to ensure even dosage, because the energy emerging from the sound head is much greater at the centre than at the periphery. Stationary head technique is only for the experienced operator and should only be used in "pulse treatment" (in special machines, in which the energy is automatically switched on and off, so that energy is available only for one-fifth, one-tenth or one-twentieth of the treatment time). Treatment should not be given over growing bone ends in children, over the heart, eye, gravid uterus or sex glands.

#### THE SCOPE OF ULTRASONICS

We must be absolutely honest about this question. Let me start by saying that my personal experience with ultrasonics both at the Royal Melbourne Hospital and in private is limited. It amounts only to two years, and in no way can I claim to be an expert in this field. I have followed the literature in the matter closely for the past few years and have been in constant personal communication with overseas

authorities in physical medicine, both in England and in the United States of America. I have so often seen harm done by extravagant claims for new modes of treatment that I must counsel caution in fully accepting the naturally enthusiastic claims of the manufacturers of ultrasonic machines. The use of cortisone in rheumatoid arthritis was an outstanding example of this. Despite extravagant claims by all sorts of people that this was the answer to rheumatoid arthritis, I pointed out to you some years ago that it was a step forward and no more, that it was not a satisfactory method for routine treatment on its own, and that it was not the answer to the problem. To his eternal credit, Hench maintained a critical appreciation of his great discovery from the outset, but others were much less balanced. Time has, of course, amply justified our conservatism. With any new form of therapy or discovery it is wise to be sceptical and critical, and this is my attitude to ultrasonics. On the other hand, we must learn all we can about the method and avoid the fatal mistake of condemnation from ignorance.

A study of the physical properties of ultrasonics and its physiological effects on

the body shows that the penetration is limited, but that within this limit the method produces a powerful micro-massage, leading to hyperæmia, to increased diffusion by increasing the permeability of membranes, and to the relief of pain and spasm. It would therefore seem to be of use in coping with relatively superficial lesions, for example, fibrous tissue lesions.

It has been claimed to be of value in neuritis, neuralgia and sciatica, but my own feeling is that its main value lies in the treatment of superficial lesions of fibrous tissues, particularly indolent ulcers, scars, tendinitis and fibrositis associated with underlying osteoarthritis, for example, of hip or knee, and tender painful fibrositis in ankylosing spondylitis. Lastly, let us remember that some at least of these conditions can be treated at least as effectively by other physical means.

It is, I think, fair to say that this is a new method of treatment worthy of consideration. It is not quackery at all, but on the other hand its use would seem to be limited. Within this limited sphere it is well worth trial and has, I think, come to stay. The future may extend its use and we cannot afford to be ignorant of it.