Experimental Production of Very Small Lesions by Electrocoagulation

Lesions in the central nervous system may be made for either of two purposes: (1) for localised *destruction* of nervous tissue (elimination of disordered elements in clinical cases; production of behavioural or histological changes in research work), (2) for *marking* the exact site of the tip of electrodes used in stimulating or recording experiments.

Electrodes used for elimination are generally not very thin, and often have a long non-insulated tip, as fairly large lesions are required. Satisfactory results can then be obtained with alternating currents in the frequency range of a few hundred kc/sec[1,2].

In a number of cases, however, the need for thinner electrodes and smaller lesions arises, either because the brain of the experimental animal itself is very small, or because the experiment involves the use of micro-electrodes (as in single unit recording). I found that alternating currents of the type just mentioned produce lesions of poor quality, or even no coagulation at all.

To identify the factor responsible for these unsatisfactory results, I made 'lesions' in the white of hens' eggs, in which the development of the coagulate can be followed under the microscope. It soon became clear that, when the surface area of the non-insulated tip of the electrode is smaller than a certain size, gas bubbles develop in the coagulate at the current strength necessary to produce a lesion. With very small tip sizes, gas bubbles appear first and no coagulate is formed at all.

I have no definite proof as to the nature of this gas. It does not appear to be combustion gas, for no sparks or other evidence of burning are to be seen when it is formed. It is not likely that the gas is water vapour, for the bubbles do not disappear by condensation when the current is switched off. The most plausible hypothesis seems to be that the gas is formed by electrolysis occuring at the electrode tip above a certain current density. Electrolysis, however, can be restricted by the use of higher frequencies.

Therefore, I investigated the influence of the frequency on the quality of lesions made with small electrodes[3].

The electrodes used were made of electropolished tungsten wire of various diameters, insulated with glass but for the tip, the surface area of which was established microscopically. The lesions were again made in the white of hens' eggs.

In Figure 1 the results of these experiments are plotted for a range of electrode tip areas against the frequencies used. It is clear that for each frequency there is a minimum electrode tip area with which a good lesion can be made, and that this minimum size shifts to smaller values with increasing frequency. Hence for each electrode size the minimum frequency, below which no lesion of good quality can be produced, is fixed (Figure 2) and the use of thinner electrodes is only possible with higher frequencies.

It may seem, therefore, that the higher the frequency of the generator, the broader its field of application. The difficulties of handling high frequency currents, however, increase with the frequency, because more energy is lost over the capacity of the connecting cable, the electrode insulation, and other stray capacities. As it is important to know the energy delivered at the electrode tip, and exact measurement of this energy is only possible if losses are small in comparison, the best generator for a certain purpose is the one giving a frequency just high enough to produce satisfactory lesions with the electrode size used in the particular experiment.

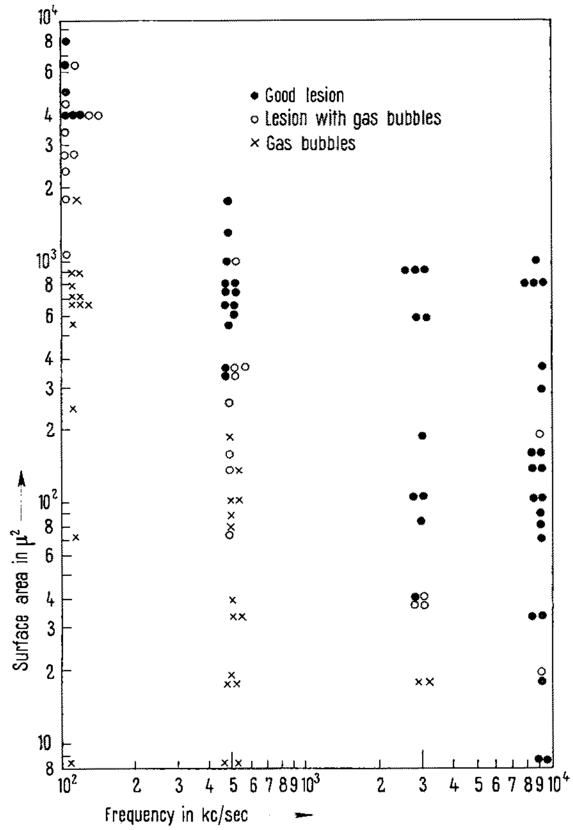

Fig. 1. The quality of a lesion depends on the surface area of the electrode tip and the frequency of the current.

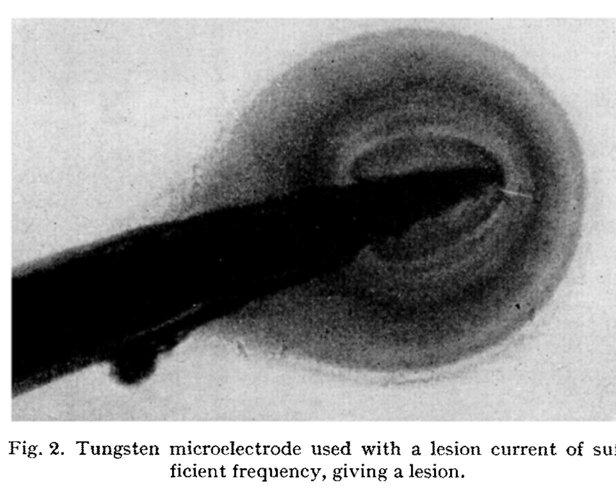

Fig. 2. Tungsten microelectrode used with a lesion current of sufficient frequency, giving a lesion.

Zusammenfassung. Es wird gezeigt, dass Elektrokoagulieren mit kleinen Elektrodenspitzen nur dann möglich ist, wenn hohe Frequenzen gebraucht werden, sonst bilden sich Gasblasen. Je kleiner die Spitze ist, desto höher muss die Frequenz gewählt werden.

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[1] O. A. M. WYSS, Helv. physiol. Acta *3*, 437 (1945).

[2] R. W. HUNSPERGER and O. A. M. WYSS, Helv. physiol. Acta *11*, 283 (1953).

[3] My thanks are due to the Dr. NEHER, Laboratory of the P.T.T. in Leidsendam (Netherlands), where I enjoyed hospitality to do the first experiments.