# RECENT ADVANCES IN SURGIRAL DIATHERMY

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Despite the use of surgical diathermy machines during the second World War for jamming the enemy aircraft directional beams (Jones, 1979), little advance in this field of electronics occurred until the early 1950s when the first valve oscillators appeared on the market. The original spark-gap machines gave excellent coagulation but very poor cutting. Even with the intensity turned to maximum it was difficult to obtain any cutting effect under water and when a successful cut was achieved, the tissues tended to adhere to the electrode which had to be cleaned after almost every cut. With the introduction of a valve oscillator it was possible to achieve much improved cutting and finish with a clean electrode. Furthermore the effect was achieved with a level of intensity which was nowhere near the maximum output of the machine.

In the early 1970s major improvements in diathermy circuitry occurred with the introduction of transistorised oscillators. These have certain advantages: first, that the oscillator component was more reliable; secondly, the generator could be constructed in a much more compact cabinet and, thirdly, experiments could be carried out with these new oscillators to achieve various wave forms as well as different frequencies and a more linear control of the current intensity.

Up to this point it had been thought that the damped wave form of the early spark-gap diathermy was the feature wich gave the best coagulation, while a pure sine wave could give the best cutting current effect. As a result of experiments carried out using the transistorised diathermy generators, it was found that by "chopping" the regular sine wave into bursts of activity while at the same time amplifying the intensity to make up for the gap between the bursts of activity, then coagulation could be achieved equal to that from the old spark-gap machines. By some quirk of' nature the time interval between these bursts proved to be exactly the time interval provided by the old spark-gap machine-namely, about 10 Khz (cycles per sond). The operational frequency for these diathermy machines in simple pure sine wave varies between 500 and 3000 Khz, the majority of them operating between 500 and 1,800 Khz.

Much has been written on the dangers of surgical diathermy (Mitchell and Lomb, 1960). The principal hazards were known to be electrocution, explosion, conflagration on the skin surface and thermo-electrical burns. Electrocution can only occur as a result of a multiplicity of faults within the diathermy generator, whereby the mams circuit makes contact with the output of the machine, usually vla a loose lead or terminal within the metal cabinet. In the modern machine so many faults must occur simultaneously that the chances of an accident such as electrocution are negligible. Explosion must be equally rare today as flammable anaesthetic gasses are rarely used. On the other hand, this tends if anything to increase the hazard because staff are unprepared on those rare occasions when ether or cyclopropane might be preferred by the anaesthetist. To counter the risk of either electrocution or explosion, the nursing staff are advised to ask the anaesthetist before switching on the diathermy machine.

Conflagration on the skin surface is, sadly, one of the commonest accidents reported to the Medical Protection Society or the Medical Defence Union. Preparation solutions for cleaning the skin just prior to surgery are often based on a flammable solvent. If diathermy is used before this solvent has evaporated, then the spirit can ignite and the first thing the surgeon will notice is that the skin may become white or that the surrounding towelling begins to smoulder. The actual flame of the burning spirit is, of course, impossible to see under the light of the theatre lamp. The commonest reported accident of this type is from dilatation and curettage of the cervix, when the diathermy electrode is used for cauterising the os cervix. The burn of the perineal skin will extend over the full area swabbed where the preparation solution has not completely evaporated.

Thermo-electrical burns today are relatively infrequent due to education of the theatre staff, improved indifferent electrode plates and the addition of various monitoring devices (Mitchell, Lumb and Dobbie, 1978). The cause of such a thermo-electrical burn cannot be blamed on the diathermy machine, except under extremely unlikely fault circumstances. In nearly all cases the cause is a failure to apply the plate electrode correctly to the patient.

Two features in particular had to be montored: the first was inadvertent activation of the diathermy machme, and the second was to ensure contact between the patient and the indifferent terminal of the diathermy generator. Monitoring against the risk of inadvertent activation was necessary because the change of spark-gap to valve and later transistor oscillators resulted in a completely quiet machine, with the exception of the click of the on/off relay switch. The buzz of the spark-gap machine was lost and it was necessary to incorporate a hum or buzzing device so that the surgeon knew when the diathermy was active. Today all reputable diathermy generators incorporate a noise as well as a light to indicate activity, and most machines use two different tones, one pitch to signify coagulation and a higher pitch to indicate the change to cutting current.

To monitor the contact of the patient with the indifferent terminal of the generator was a much more difficult problem. In the early stages a simple circuit between the plate electrode and the generator could detect any break in the cable or contact at either end of the cable; although this ensured that the indifferent electrode was at earth potential, it made no guarantee that the earth plate had been correctly applied to the patient .

One of two alternative monitoring devices are employed for detecting faulty contact between the indifferent electrode and the patient. The first is to isolate the circuit so that there is no possibility of a return path for the current to earth. This is described in a variety of terms: 'the isolated circuit', the 'earth-free circuit', the 'closed circuit', etc. The second principle is to monitor the intensity of current passing in the cable of the indifferent electrode against the intensity of current passing in the active electrode cable and if this difference exceeds a specified volume, then current must be leaking to earth and the machine will be inactivated. The trip inactivating the machine will reset automatically when the diathermy plate is correctly fitted.

It should be remembered, however, that the "isolated circuit" came in at approximately the same time as the transistorised oscillators. This does not mean though that all transistorised generators have necessarily an isolated circuit. Some are designed to have alternative switchlg within the same machine for isolation of the circuit or for a fully earthed circuit. Some transistorised machines are supplied simply with a conventinally earthed circuit. Finally, despite the apparently foolproof principle of the isolated circuit, which should feel-safe whenever the surgeon attempts to operate the diathermy without the plate in contact with the patient, there is still one set of circumstances under which the diathermy can still operate, apparently with a monopolar effect. Although no proven case has been reported, it is possible for the nurse to leave the plate electrode resting on top of the diatheiy cabinet, thereby completing an earth circuit (Mitchell, 1980). Under these circumstances, if the patient makes contact with any stray metal on the operating table, such as the leg strirrup, the anaesthetic screen, or a metal arm rest, a thermo-electrical burn will occur at the site of contact.

Diathermy is used in 90% of surgical operations today. Despite all the monitoring devices that have been designed, thermo-electrical burns can still occur. It therefore behoves all of those responsible for the use of diathermy generators, whether it be surgeons, theatre nursing staff, or even operating theatre attendants, to understand the principles of diathermy machines so that they have the knowledge to take appropriate precautions against conflagration on the skin surface and thermo-electrical burns.

Instruction on surgical diathermy should be an integral part of a medical student's curriculum, and every theatre nurse's course; also some reference literature should be available amongst the small collection of books in the office attached to every operating theatre suite.

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**References**

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