What is Micro-shock?

Background

This paper refers to a known electrical risk to patients, being treated using medical devices that are inserted into the vascular system or coming into contact with wet tissue. Microshock is the generic term applied to the risk. It is argued that microshock has never been scientifically proven – it can also never be proven because you would have to cause cardiac arrest to prove it which is basically criminal never mind non-ethical. It is not "officially" defined by standards Bodies either!

Discussion

It is widely known among medical engineers that the risk of small **AC** currents passing directly through human heart muscle can disrupt the heart's pacemaker system and cause fibrillation or cardiac arrest.

Many papers try to quantify the scale of risk which isn't wrong but in order to understand or teach the issue, it is better to keep it simple.

The classic simple circuit in literature, which shows current flow through heart muscle, still stands. It is a direct pathway from a medical device to earth. In simple electrical terms, if we design devices to prevent any voltages occurring between the inserted device and earth, the risk to the patient is minimised. In simple terms of values, the basic rule of thumb I use for teaching purposes is that "3 figures" of micro-amps is a risk that is unacceptable. I realise that 99μA is still a risk but it is accepted that 10μA is not a risk. I'll leave others to argue the risk from 10 -99μA.

When teaching, I also describe microshock by calling it "heart pacemaker disruption current".

How do we minimise the risk?

1. Design electrical medical devices so that the patient leakage current is below a value that is a risk. Compliance with IEC 60601 addresses this.
2. Continue to test the device regularly to ensure compliance using either IEC 62353 for portable devices or the manufacturer's tests for permanently installed devices.
3. Use potential equalisation conductors (PEC) if advised by the device manufacturer.
4. Ensure that the room wiring (medical location) complies with BS7671 (2018).
5. Regularly test the medical location for compliance.
6. With new or re-installations, ensure that design engineers ask clinical staff about the devices being used – see my guidance flowchart in my pocket guide. - https://medical-locations.co.uk/about/final-testing

The Science and Reality.

Most people are aware that electricity can cause a “shock” which can burn and kill. The parameters that cause these effects are cause by a direct connection to a voltage that is high enough. You have to appreciate that the maths behind this cannot be absolute because the human skin is normally roughly estimated to be 1kΩ when dry. If the voltage is high enough, this becomes negligible. However, leakage currents from the metal casing of electrical equipment is of no concern because the skin resistance is sufficient to restrict current flow through the body.

In areas or rooms where medical devices with applied parts (as defined by IEC60601) are used, the risks to patients increase.

Devices cannot be designed and tested on humans so instead, the human is electrically represented by a circuit called the Human Body Model. The small currents that leak to the patient from the applied part is measured by inserting a 1kΩ resistor between the applied part and a known good earth path. An AC voltmeter, that has a good dynamic range is used via a low pass filter to measure the AC volt drop across the resistor.

This method is used in IEC 60601 build standard and IEC 62353 test standard for devices.

However, compliance with the electrical wiring guidance should also be considered. This includes a number of issues overlooked such as number/siting of Supplementary Equipotential Bonding Connection Points. These are the studs that you connect device potential equalisation conductors to.

In the UK, the requirement is that from any medical device PE terminal or extraneous earth to the Equipotential Bonding Busbar (EBB) is 0.2Ω. We used to call this the Earth Reference Terminal but the standards people know what is best for us! I think the word Reference should be at least added to EBB. (EBRB?). The “Target” value for designers should more around 0.1Ω although this is not enshrined it is accepted as good practice by a significant majority. Also – THERE SHOULD BE NO LOOPS ON ANY EQUIPOTENTIAL CONNECTIONS TO THE EBB.

It is worth pointing out that in the UK, we augment PEC use by requiring discrete radial equalisation conductors to the EBB from Medical IT socket-outlets. This does mitigate the lack of knowledge (or apathy) towards PEC’s not being used. Also – make sure the links in the Medical IT sockets are removed if using metal back-boxes. To clear another point, Medical IT sockets with no switches, are fitted to reduce the risk of disconnection and apart from the radial earth socket connection, do not minimise microshock because it is an isolated supply.

Author – Ian Chell MSc FSRP