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The Effect of Vibration Amplitude on Tissue Temperature and Lesion Size When Using a Vibrating Cardiac Catheter

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Abstract : During cardiac ablation, high power delivery for deeper lesion formation is limited by electrode-tissue interface overheating which can cause serious complications such as thrombus. To prevent this overheating, temperature control and open irrigation are often used. In temperature control, radiofrequency generator is adjusted to deliver the maximum output power, which maintains the electrode temperature at a target temperature (commonly 55°C or 60°C). Then the electrode-tissue interface temperature is also limited. The electrode temperature is a result of heating from the contacted tissue and cooling from the surrounding blood. Because the cooling from blood is decreased under conditions of low blood flow, the generator needs to decrease the output power. Thus, temperature control cannot deliver high power under conditions of low blood flow. In open irrigation, saline in room temperature is flushed through the holes arranged in the electrode. The electrode-tissue interface is cooled by the sufficient environmental cooling. And high power delivery can also be done under conditions of low blood flow. However, a large amount of saline infusions (approximately 1500 ml) during irrigation can cause other serious complication. When open irrigation cannot be used under conditions of low blood flow, a new overheating prevention may be required. The authors have proposed a new electrode cooling method by making the catheter vibrating. The previous work has introduced that the vibration can make a cooling effect on electrode, which may result form that the vibration could increase the flow velocity around the catheter. The previous work has also proved that increasing vibration frequency can increase the cooling by vibration. However, the effect of the vibration amplitude is still unknown. Thus, the present study investigated the effect of vibration amplitude on tissue temperature and lesion size. An agar phantom model was used as a tissue-equivalent material for measuring tissue temperature. Thermocouples were inserted into the agar to measure the internal temperature. Porcine myocardium was used for lesion size measurement. A normal ablation catheter was set perpendicular to the tissue (agar or porcine myocardium) with 10 gf contact force in 37°C saline without flow. Vibration amplitude of ± 0.5, ± 0.75, and ± 1.0 mm with a constant frequency (31 Hz or 63) was used. A temperature control protocol (45°C for agar phantom, 60°C for porcine myocardium) was used for the radiofrequency applications. The larger amplitude shows the larger lesion sizes. And the higher tissue temperatures in agar phantom are also shown with the higher amplitude. With a same frequency, the larger amplitude has the higher vibrating speed. And the higher vibrating speed will increase the flow velocity around the electrode more, which leads to a larger electrode temperature decrease. To maintain the electrode at the target temperature, ablator has to increase the output power. With the higher output power in the same duration, the released energy also increases. Consequently, the tissue temperature will be increased and lead to larger lesion sizes.

Keywords : cardiac ablation, electrode cooling, lesion size, tissue temperature
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