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The Relationship Between Catheter Tip Electrode Size and Radiofrequency Generator Power Requirements

INTRODUCTION

Large tip electrode (8mm and 10mm) ablation catheters have become the standard of care for the ablation of type 1 atrial flutter and have established an excellent record of safety, efficacy, and efficiency.[1] This paper examines the relationship between ablation catheter tip electrode size and radiofrequency (RF) power requirements and explains why larger tip electrodes require more power.

DISCUSSION

During RF ablation, cardiac tissue is heated via resistive heating. Tissue is heated as the electrical (RF) current flows through it because it offers resistance to the current. The amount of electrical current flowing into the tissue is directly related to the amount of the power delivered by the RF generator and the impedance (resistance) encountered.

Equation 1

$$\text{Total amount of current delivered into tissue} = \sqrt{\frac{\text{Power (W)}}{\text{Impedance }(\Omega)}}$$

The intensity of tissue heating is related not just to the amount of current delivered, but primarily to how much current passes through a given area. This is determined by the current density. The average current density at the ablation electrode is defined as the total amount of current divided by the surface area of the electrode.

Equation 2

$$\text{Average current density of electrode} = \frac{\text{Total amount of current delivered into tissue}}{\text{Surface area of electrode}}$$

Equations 1 and 2 can be combined to show how the average current density of the tip electrode is related to the RF generator power setting, the tip electrode surface area, and system impedance.

Equation 3

$$\text{Average current density of electrode} = \frac{\sqrt{\frac{\text{Power (W)}}{\text{Impedance }(\Omega)}}}{\text{Surface area of electrode}}$$

Using Equation 3, the assumption can be made that given the same power and impedance, a tip electrode with a *larger surface area* will have a *lower current density* than a tip electrode with a smaller surface area. A *lower current density* produces a *lower intensity of resistive heating within tissue,* reducing the potential for lesion formation.

Therefore, an electrode with a *larger surface area* requires more power to create the *same intensity of resistive heating* as an electrode with a *smaller surface area.*

[1] Feld G, Wharton M, Plumb V, Daoud E, Friehling T, Epstein L. Radiofrequency catheter ablation of type 1 atrial flutter using large-tip 8- or 10-mm electrode catheter and a high-output radiofrequency energy generator. J Am Coll Cardiol 2004;43:1466-72.

PRACTICAL APPLICATION

Tip Electrode Size	Typical Impedance Range (Ω)	Tip Electrode Surface Area (in^2)
7F/4mm	100-120	0.050
8F/8mm	60-80	0.098
8F/10mm	50-70	0.123

In clinical use, typical impedance ranges seen during an ablation procedure range from 50Ω to 120Ω. A table relating current density at a given power level for various tips sizes can be created using the information above and Equation 3 from the previous page. This table illustrates that ***as ablation tip electrode surface area increases, it is necessary to increase power to maintain equivalent current densities and therefore, resistive heating intensities.***

Catheter Size	Electrode Surface Area	Impedance (Ω)	Current Density (amps/in^2)	Power (W) 20	30	40	50	60	70	80	90	100
7F/4mm	0.050	100		8.9	**10.9**	12.6	14.1					
8F/8mm	0.098	60		5.9	7.2	8.3	9.3	10.2	**11.0**	11.7	12.5	13.1
8F/10mm	0.123	50		5.1	6.3	7.3	8.1	8.9	9.6	10.3	**10.9**	11.5

Note: This table represents only average current densities, assuming delivery into an electrically homogeneous medium. Current density at any given point will vary depending upon a number of factors, including electrode geometry, contact with tissue, impedence of surrounding media, etc.

CLINICAL IMPLICATIONS

1. When comparing the power requirements of small tip catheters to larger tip catheters, equivalent current densities can be used as an approximate indicator of equivalent resistive heating intensity.

2. When using an 8-10mm tip electrode catheter, higher power levels are required to achieve the same average current density/resistive heating intensity, as using a 4mm tip electrode at a lower power level. The difference in power required may be more than 2x.

3. 10mm tips require higher power than 8mm tips to achieve a given current density.

4. 70W with an 8F/8mm electrode yields a similar average current density to that of a of 7F/4mm electrode at 30W.

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