

## EHRA educational slides on Ablation Techniques

Ablation concepts:  
4mm versus 8mm versus cooled tip

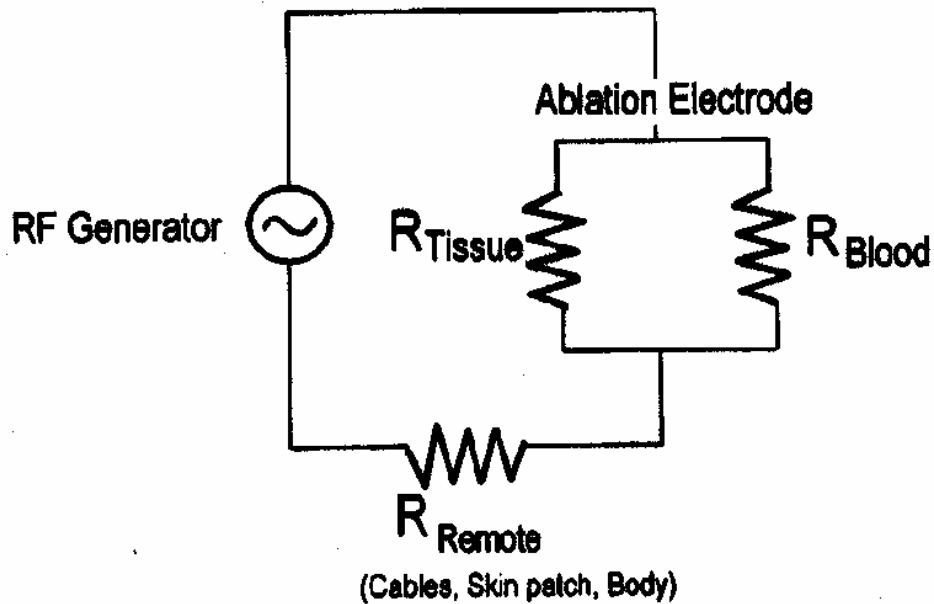


PD Dr. M. Antz, Asklepios Klinik  
St. Georg, Hamburg, Germany

1



# Current flow



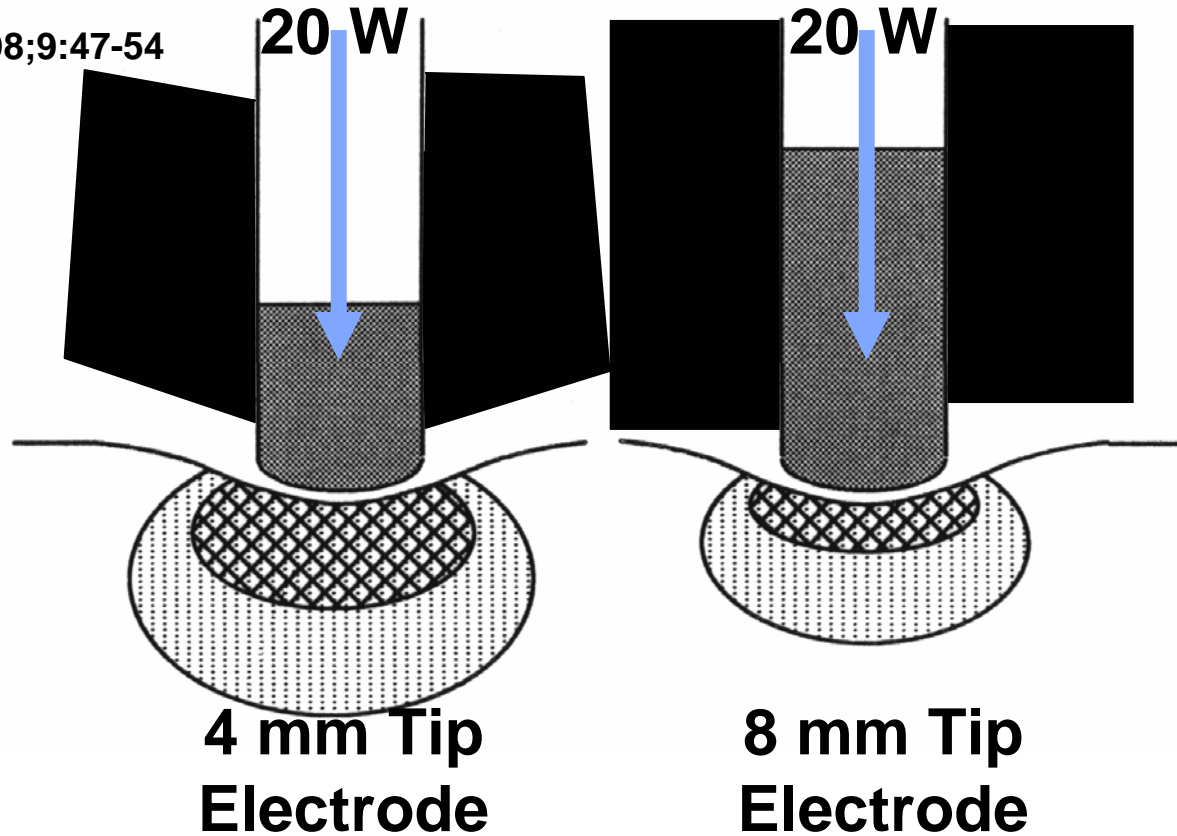
The current follows two pathways: blood and tissue, each with different impedance ( $R$ )



- $R_{\text{Blood}}$  is smaller than  $R_{\text{Tissue}}$   $\rightarrow$  most current is lost to blood
- Large electrode  $\rightarrow$  fraction of surface area in contact with blood is larger  $\rightarrow$  more current is lost to blood

# Constant power delivery: 4 mm and 8 mm tip electrode

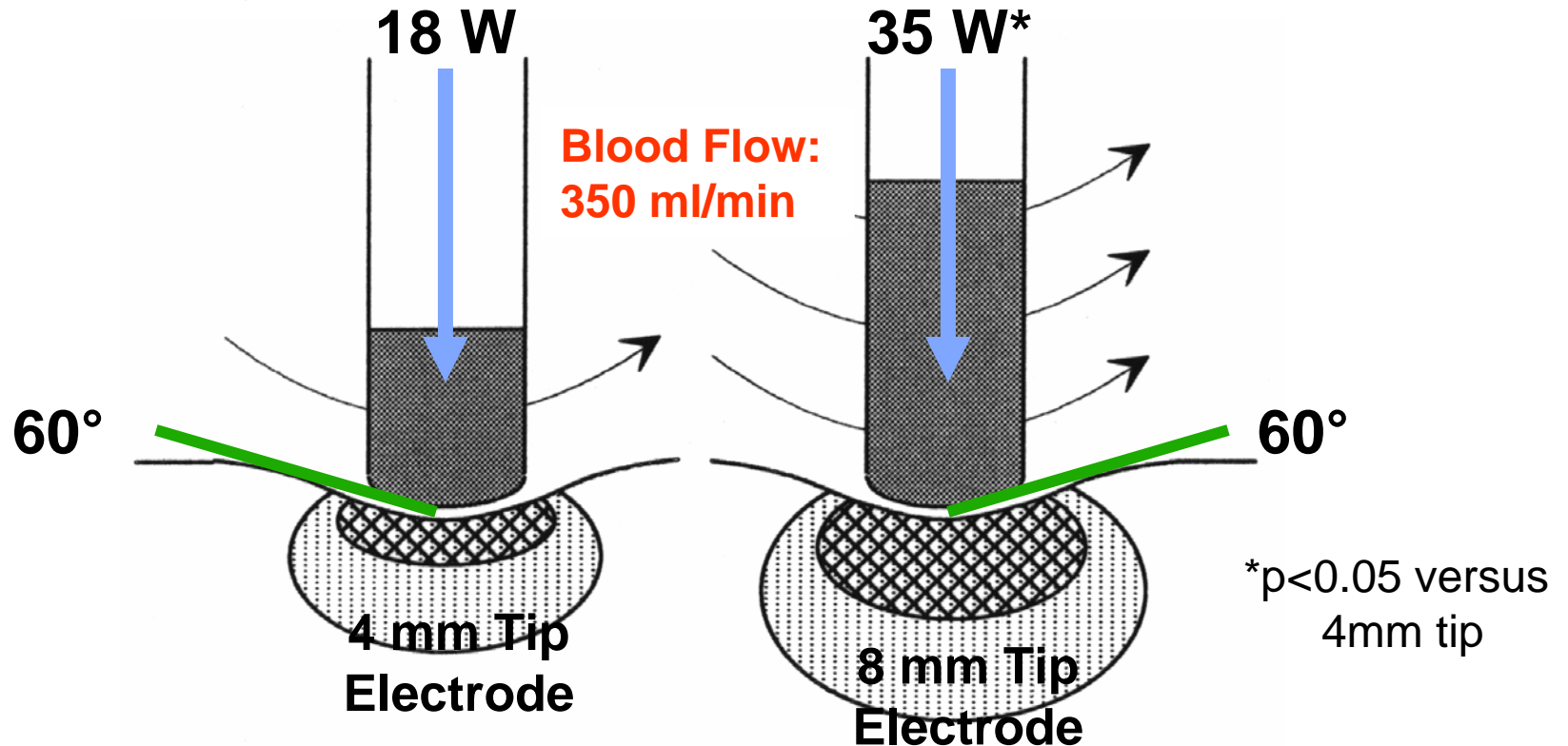
Otomo et al: JCE 1998;9:47-54



- Same power is applied to a 4 and an 8 mm tip electrode
  - more current is lost to blood for the large electrode
  - lesion produced with the 8 mm electrode is smaller

# Temperature controlled ablation: 4 mm and 8 mm tip electrode

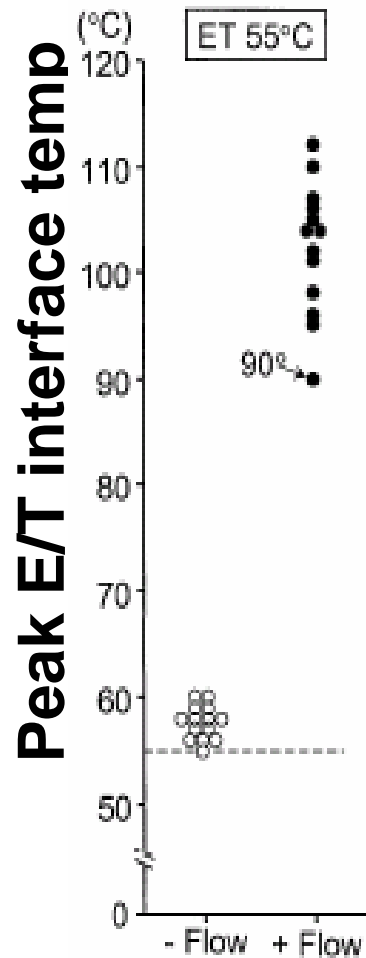
Otomo et al: JCE 1998;9:47-54



- Surface exposed to blood flow is larger for 8 than for 4mm tip electrode  
→ 8 mm tip is cooled more → more power is needed to reach the target temperature → lesion with the 8 mm tip electrode is larger

# High risk of thrombus formation with 8 mm tip electrode

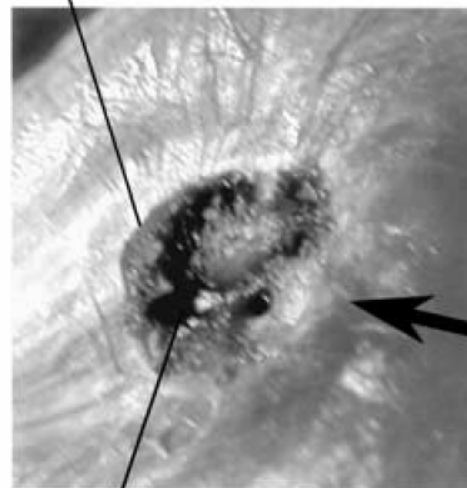
Because there is a significant difference between the average electrode temperature (ET) and the hottest spot on the 8 mm electrode (circles), low target temperatures are needed to avoid thrombus formation



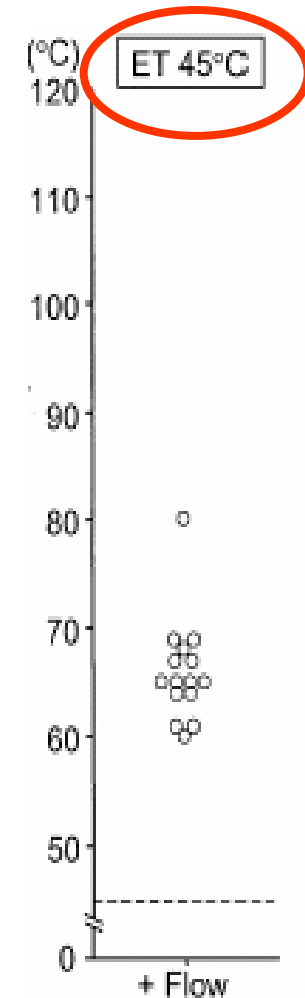
## 8 mm Electrode

- = no Thrombus
- = Thrombus

Thrombus

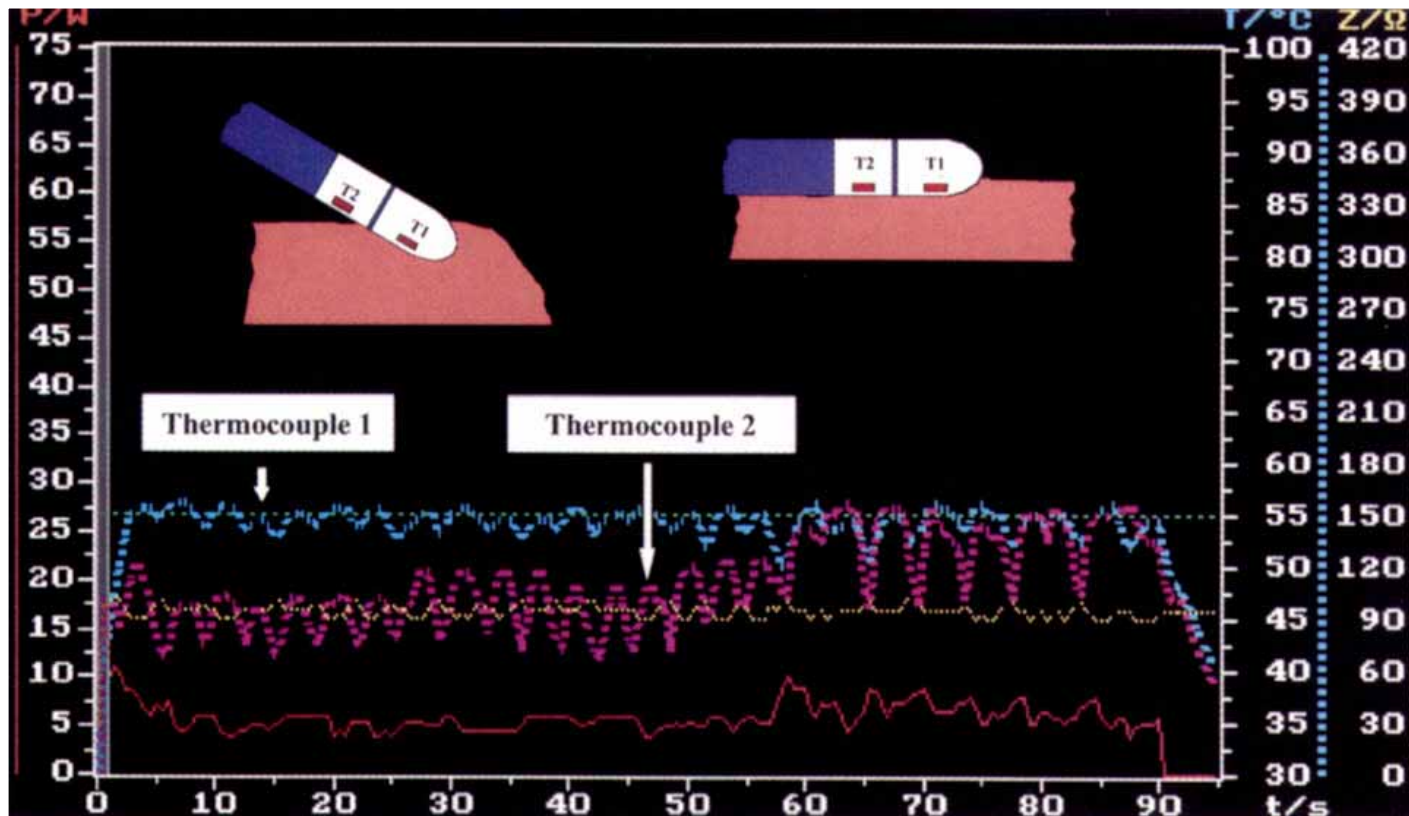


Char



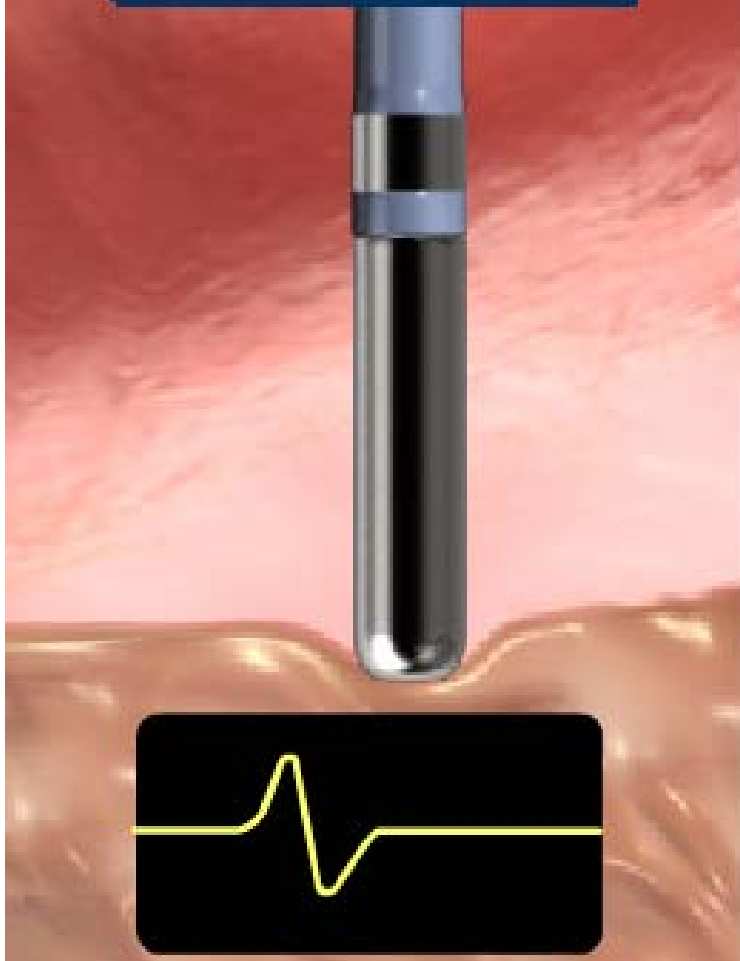
## 8 mm tip electrode with 2 temperature sensors should be used

Two temperature sensors incorporated in the 8 mm electrode tip can predict the orientation of the electrode: on the left the thermocouple 2 is not touching the tissue and therefore measures low temperatures. However, once the electrode is repositioned parallel to the tissue and the proximal electrode is also touching tissue, the temperatures measured by thermocouple 2 rise and are similar to thermocouple 1

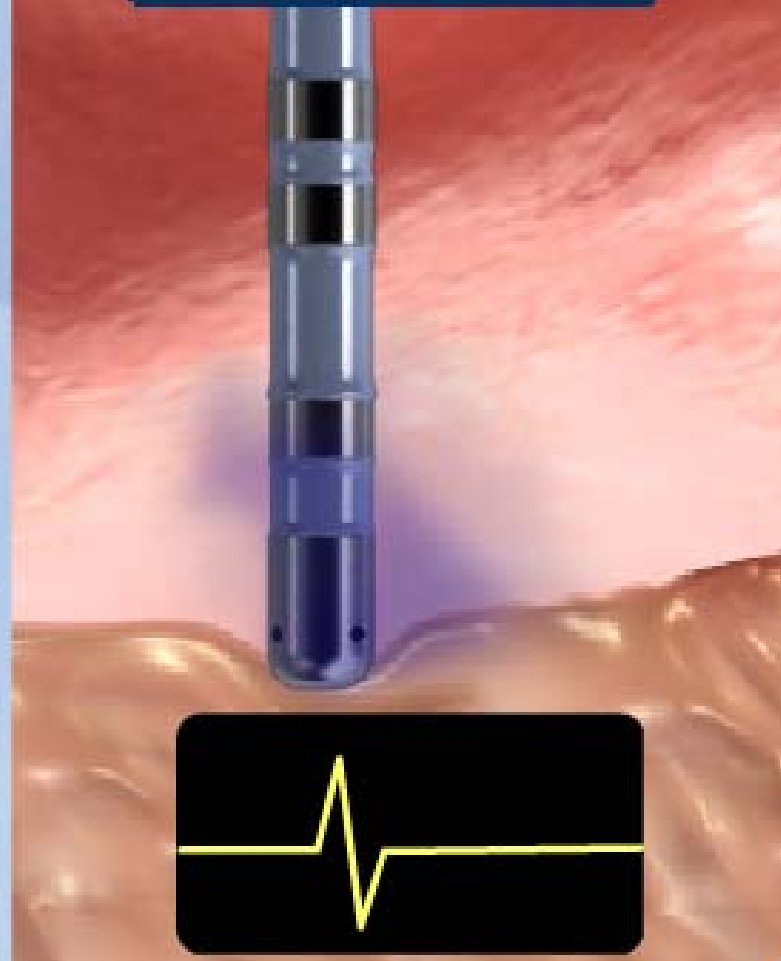


Rodriguez et al, Am J Cardiol 2000;85:109-12

**Large 8mm tip**



**small 4mm tip**

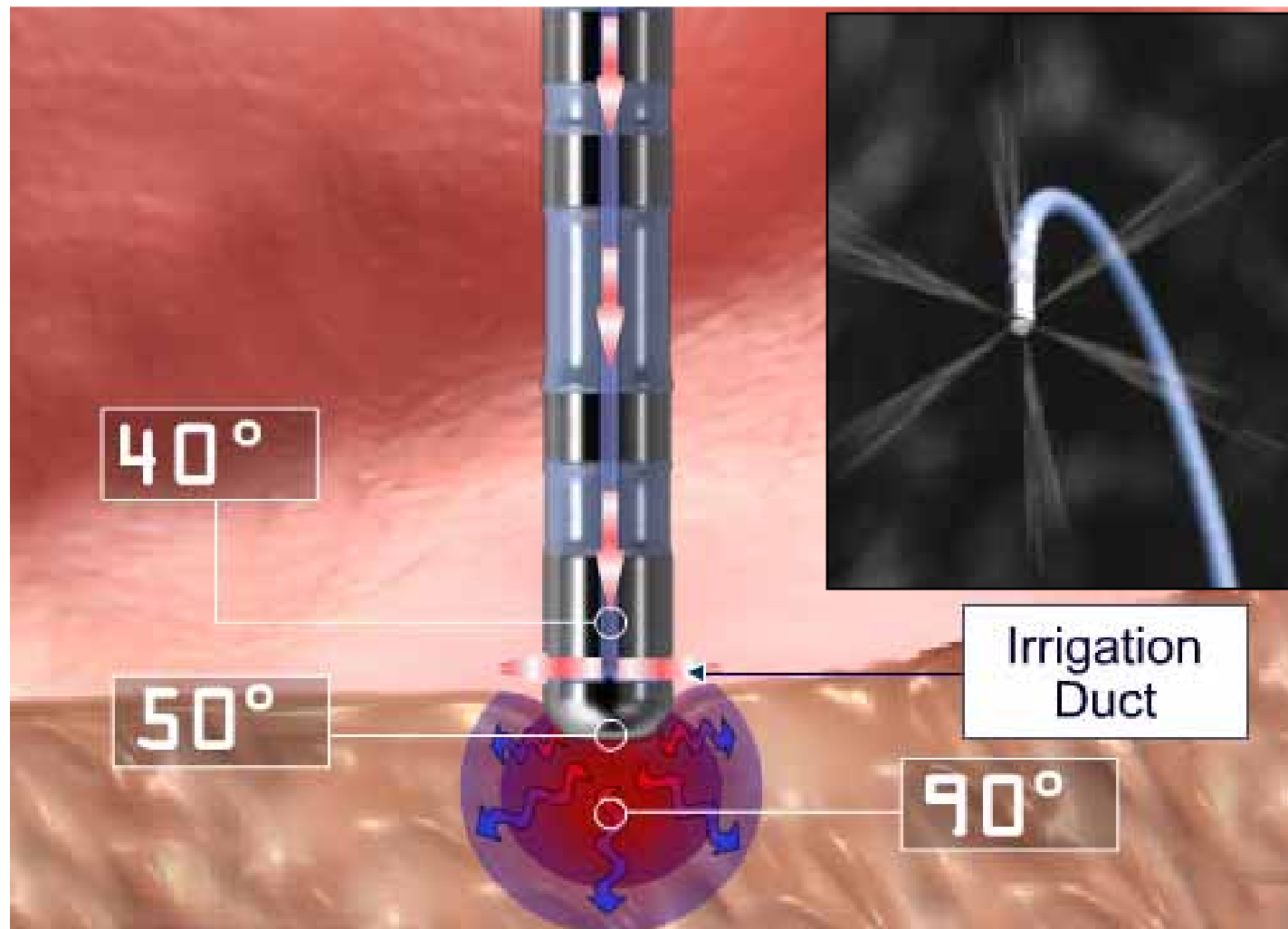


# Summary for conventional 4 and 8 mm tip electrode

- 1. High blood flow allows higher power delivery to the tissue and this results in deeper lesions**
- 2. Larger electrodes provide greater electrode cooling allowing higher power delivery and this results in deeper lesions**
- 3. Small electrodes have a higher recording resolution**

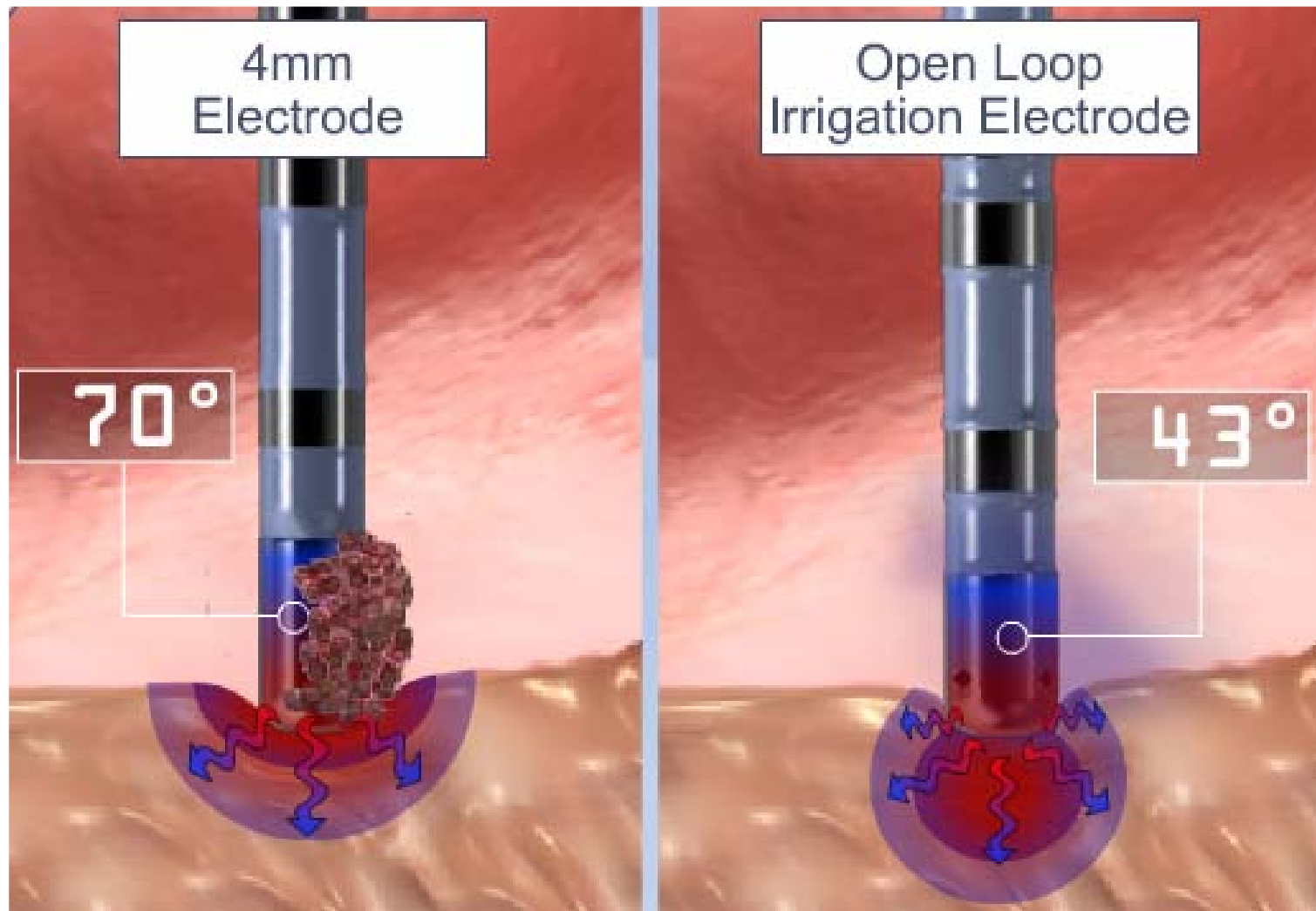
# Irrigated tip technology

In open loop irrigation, saline is flushed through ducts inside the ablation catheter and is released through holes in its tip. As a result, high temperatures inside the tissue are produced by radiofrequency ablation in spite of low electrode tip temperatures



# Irrigated tip technology

In open loop irrigation the electrode temperatures remain low during ablation. This allows high power delivery, prevents hot spots on the electrode surface and avoids thrombus formation



# Irrigated tip technology

When high power is applied to the irrigated electrode, the irrigation rate needs to be increased to avoid thrombus formation. This has been shown experimentally in the thigh muscle preparation, when 50W were applied for 60 sec:

|                        | <b>Irrigation Flow</b> |                  |                  |                  |
|------------------------|------------------------|------------------|------------------|------------------|
|                        | <b>10ml/min</b>        | <b>17ml/min</b>  | <b>30ml/min</b>  | <b>60ml/min</b>  |
| <b>Electrode Temp.</b> | <b>59 ± 6°C*</b>       | <b>47 ± 5°C*</b> | <b>39 ± 3°C*</b> | <b>34 ± 2°C*</b> |
| <b>Thrombus</b>        | <b>85%*</b>            | <b>33%*</b>      | <b>0%</b>        | <b>0%</b>        |
| <b>Impedance Rise</b>  | <b>46%*</b>            | <b>13%</b>       | <b>0%</b>        | <b>0%</b>        |

Matsudaira, Nakagawa et al., NASPE 1999

\* p<0.05 between flow rates

Therefore, clinically, the following irrigation flow rates are recommended:

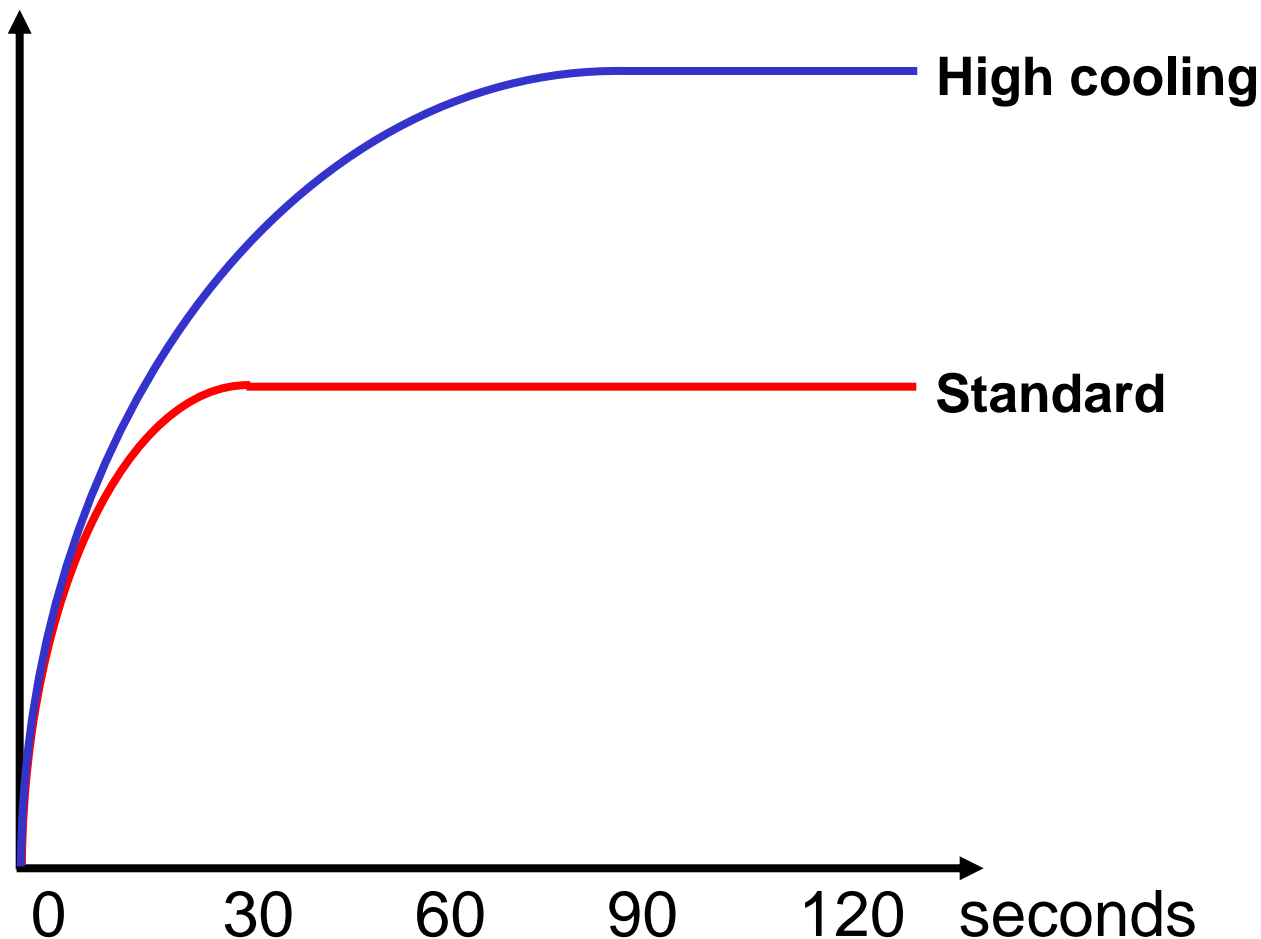
- mapping: 2 ml/min
- ablation: 17 ml/min (<30W)
- ablation: 30 ml/min (≥30W)



# Energy application time

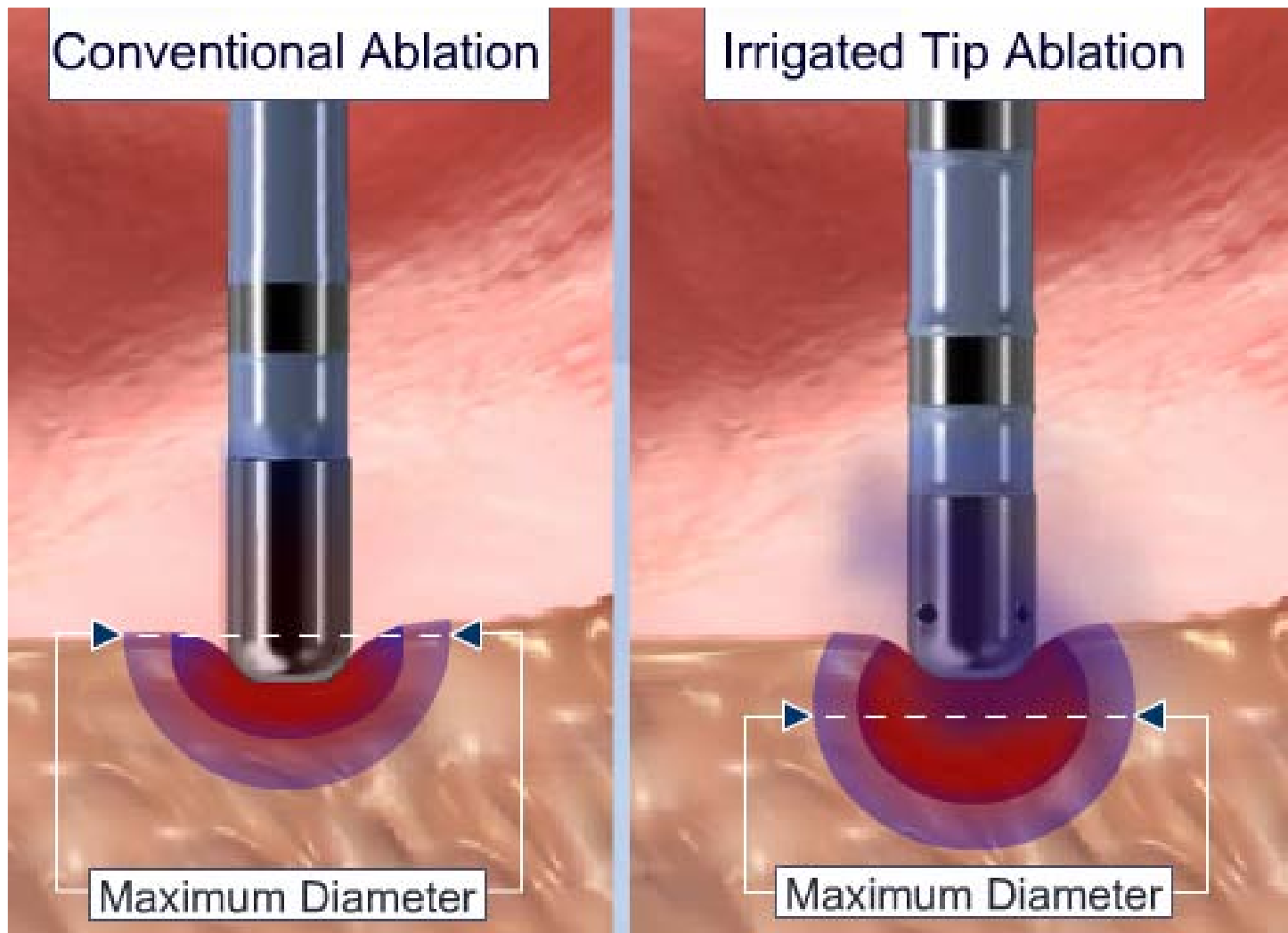
When ablation is performed with a standard tip electrode, radiofrequency application for 60 sec may be sufficient. For irrigated tip ablation, radiofrequency application should be longer, since lesions continue to grow even after 60 sec

## Lesion size



# Irrigated tip ablation- lesion shape

Compared to conventional ablation, lesions produced with the irrigated tip electrode are more “tear drop” shaped with the maximum lesion diameter seen below the tissue surface

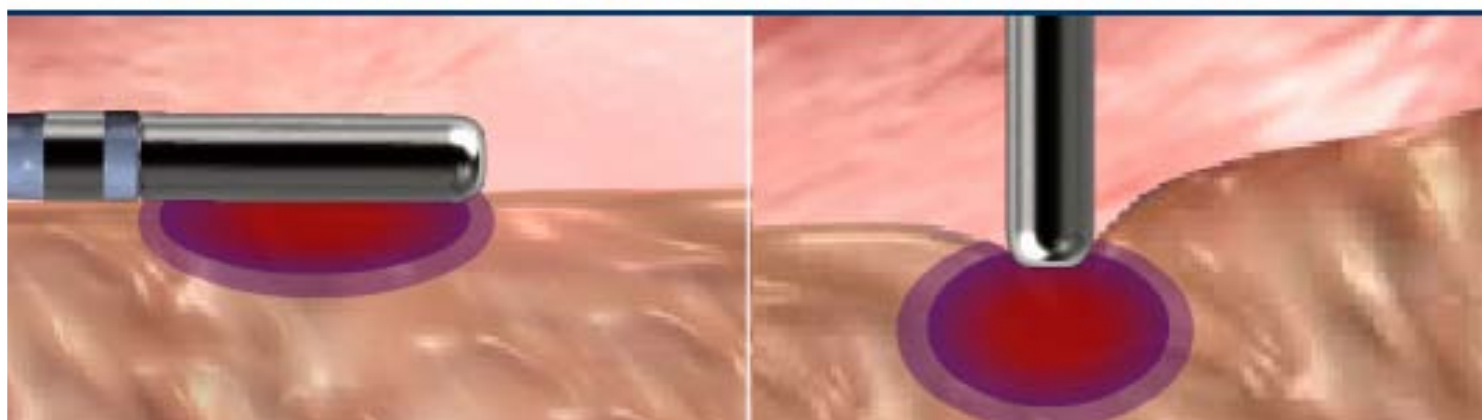


With small tip electrodes the lesion shape is similar in parallel and perpendicular orientations of the ablation electrode. In contrast, with large electrodes lesions are more oval with a parallel orientation of the ablation electrode

**Lesions created with the small tip irrigated electrode**



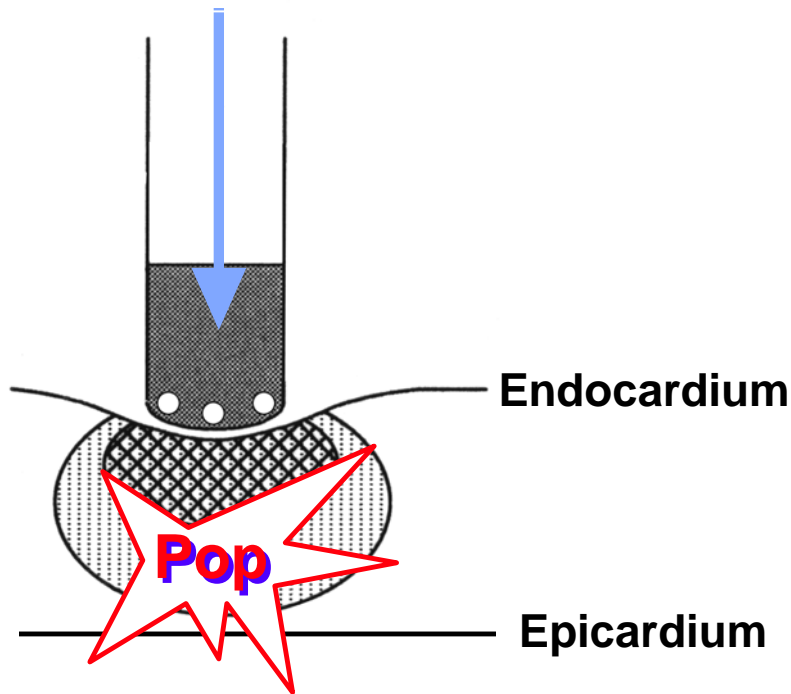
**Lesions created with the 8mm non-irrigated electrode**



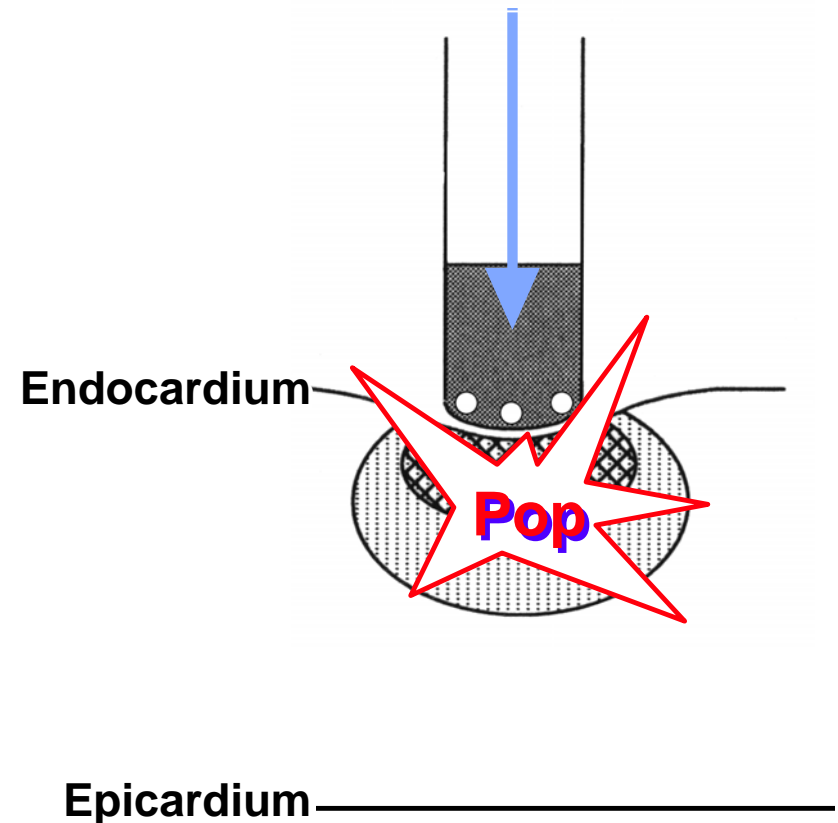
# Risk of steam pops, if high power is applied with irrigated tip

Tissue overheating may result in steam formation inside the tissue. Steam venting towards the epicardium may result in tamponade, steam venting towards the endocardium result in crater formation

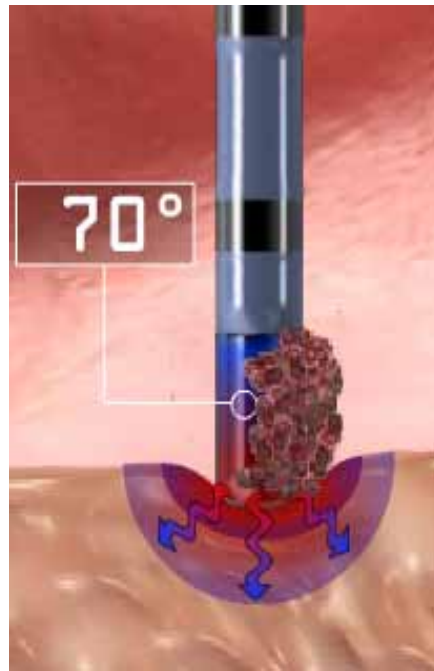
## Perforation



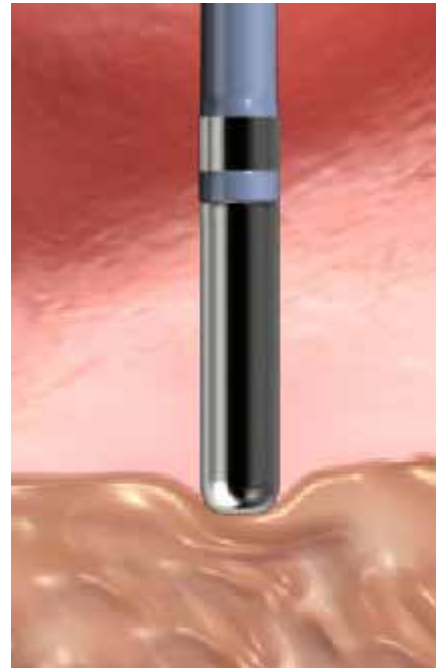
## Crater



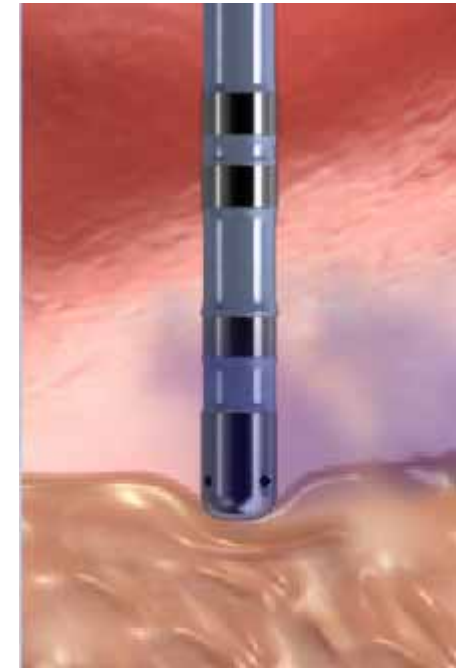
**4mm**



**8mm**



**irrigated**



Recording resolution  
Risk of thrombus  
Large lesions possible

**high**  
**high**  
**no**

**low**  
**highest**  
**yes**

**high**  
**low**  
**yes**

# Comparison of different electrodes in atrial flutter ablation

- Design:**
- randomized, no switch of electrodes
  - 2 thermocouples (Cerablate plus Flutter RF; Osypka GmbH)
  - Temperature control 55°C (max 70W), 90 sec

|                             | Complete ICB | RF (No.) | Procedure (min) | Fluo (min) | Impedance (Ohm) | Power (W) |
|-----------------------------|--------------|----------|-----------------|------------|-----------------|-----------|
| Group II<br>(n = 15)<br>4mm | 14 (93%)     | 27 ± 9   | 179 ± 48        | 45 ± 28    | 97 ± 7          | 26 ± 11   |
| Group I<br>(n = 15)<br>8mm  | 15 (100%)    | 12 ± 4*  | 162 ± 35        | 23 ± 13*   | 72 ± 4*         | 44 ± 15*  |
|                             |              |          |                 |            | *p<0.01         |           |

**Conclusion:** Using the design above, atrial flutter ablation is more effective using the 8mm tip electrode (less RF applications, less fluoroscopy time) than the 4mm electrode

## Comparison of different electrodes in atrial flutter ablation

- Design:**
- isthmus dependent flutter pts randomized into 4 groups (20 pts each)
  - 5mm tip external irrigation (20-40ml/min): max 50W / 50°C; 120sec
  - 4mm tip internal irrigation (24-36ml/min): max 50W / 50°C; 120sec
  - 8mm tip single sensor: temperature control 60°C (max 70W);120sec
  - 8mm tip double sensor: temperature control 60°C (max 70W);120sec
  - crossover to other irrigated / 8mm elect. after 12 min RF
  - long sheath if needed

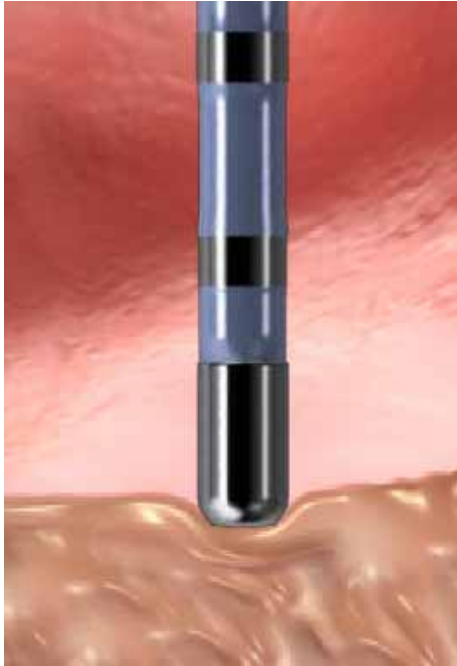
| <b>*p≤0.02</b>           | Isth.-block* | # RF*  | Imp-rise* | Proc. (min) | Fluo (min)* |
|--------------------------|--------------|--------|-----------|-------------|-------------|
| 5 mm external Irrigation | 100%         | 6 ± 4  | 10%       | 38 ± 16     | 7 ± 4       |
| 4 mm Internal Irrigation | 55%          | 11 ± 6 | 55%       | 47 ± 21     | 13 ± 6      |
| 8 mm single sensor       | 85%          | 9 ± 5  | 35%       | 37 ± 16     | 10 ± 7      |
| 8 mm double sensor       | 80%          | 8 ± 6  | 5%        | 45 ± 24     | 13 ± 10     |

Conclusion: Using the design above, atrial flutter ablation is most effective using the externally irrigated 5mm tip electrode

# Sites at which the different electrodes are predominantly used

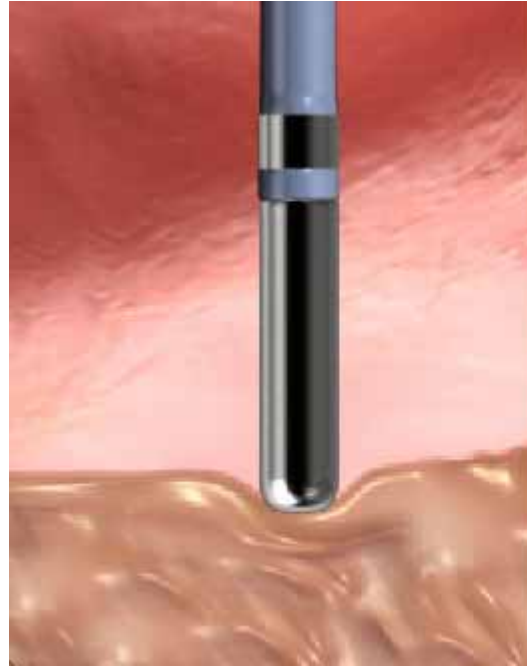
4mm

RA,RV



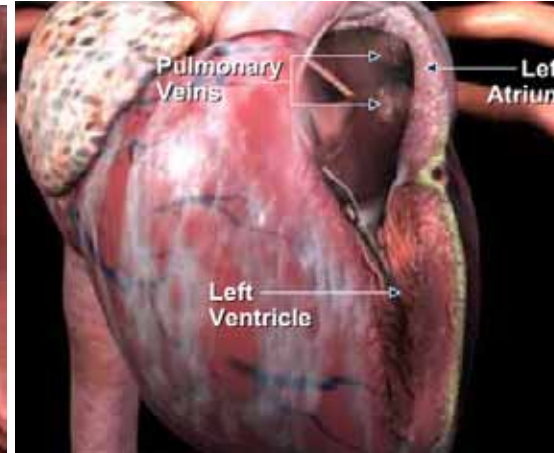
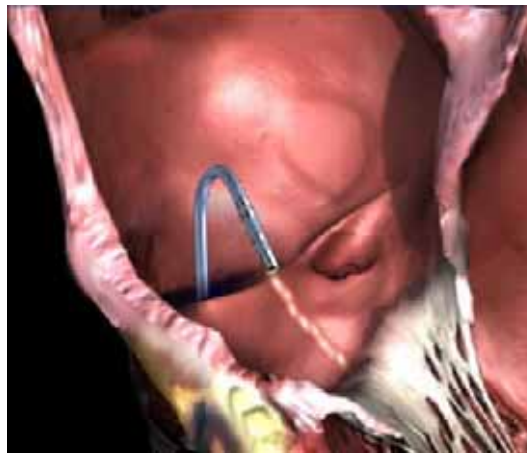
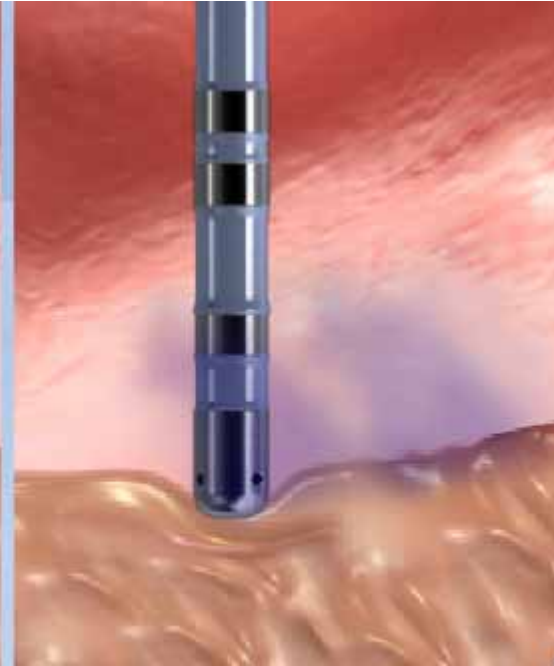
8mm

RA isthmus



irrigated

RA,RV,LA,LV



## **Ablation concepts - summary**

- 1) The 4mm tip electrode is most commonly used, has a good recording resolution, but is limited to smaller lesions and risk of thrombus formation**
- 2) With the 8mm electrode, large lesions can be produced, but its limitation is a lower recording resolution and highest risk of thrombus formation**
- 3) The open loop irrigated tip electrode can produce large lesions, has a good recording resolution and a low risk of thrombus formation. Power delivery should be as low as possible to avoid adverse events such as tissue overheating, which may result in steam pops**
- 4) The 8mm tip electrode and the irrigated tip electrode are superior to the 4mm tip electrode for ablation of isthmus dependent atrial flutter**