RF current flows into tissue, creating heat.

Heat conducts back to electrode, causing electrode temperature to rise.

Figure 3.1A.
Electrode

Resistive Heating

Ablation

Conductive Heating (lesion growth)

Convective loss to blood or irrigation

Resistive Heating

Figure 3.1B.
Power = I x V
= I^2 x R

Current density: a function of 1/r^2
Power density: a function of 1/r^4

Figure 3.2A.
Figure 3.2B.

- Duration of RF application: 25 Watt, 4mm tip
- Lesion Size: 20 mm
Figure 3.3
Figure 3.4A.

RF Generator

Ablation Electrode

\[ R_{\text{Blood}} \approx \frac{1}{2} R_{\text{Tissue}} \]

\[ R_{\text{Remote}} \approx \frac{1}{3} \text{ overall impedance} \]
Figure 3.4B.

Identical Surface Area

4 mm Electrode

8 mm Electrode

$R_{\text{blood}} \approx \frac{1}{2} R_{\text{tissue}}$

$R_{\text{blood}} \approx \frac{1}{4} R_{\text{tissue}}$
Figure 3.4C.
Figure 3.5A. Courtesy of Drs. Jackman and Nakagawa
Figure 3.5B.

Courtesy of Drs. Jackman and Nakagawa
4 mm Electrode, Electrode Temperature 75°C

Without Blood Flow

Figure 3.6A.
Figure 3.6B.

With Blood Flow (150 ml/min)

Tissue Temperature

Electrode Temperature

Impedance

Power

Electrode Temperature

Tissue Temperature

4 mm Electrode, Electrode Temperature 75°C
Thrombus

No Blood Flow

With Blood Flow

Figure 3.6C.
Figure 3.6D.
Figure 3.7A.

**Highest Electrode-Tissue Interface Temperature** (4 mm Electrode)

- **Elect Temp 55°C**
- **Elect Temp 65°C**
- **Elect Temp 75°C**

**E-T Interface Temp (°C)**

- **No Thrombus**
- **Thrombus**

- 67 °C
- 82 °C
- 102 °C

- IR: Impedance Rise
- No Thrombus
- Thrombus
Figure 3.7B.

Highest Electrode-Tissue Interface Temperature (8 mm Electrode)

Elect Temp
45°C

Elect Temp
55°C

E-T Interface Temp
(°C)

No Thrombus

65 °C

105 °C

Thrombus

Figure 3.7B.
Saline Irrigation

Low Blood Flow (0.1m/sec)

High Blood Flow (0.5m/sec)

Thrombus Threshold 80 °C

No Thrombus, No Pop

No Thrombus, Pop

Figure 3.8A.

Y = 0.747X + 21.36
R = 0.282
p = 0.139

Y = 0.442X + 28.76
R = 0.166
p = 0.393

Courtesy of Drs. Jackman and Nakagawa
Lesion Dimensions

**Low Blood Flow**
- **20 W**
  - Dimensions: 6.2 ± 0.4 mm, 11.1 ± 1.3 mm
  - Volume: 416 ± 80 mm$^3$
- **30 W**
  - Dimensions: 7.7 ± 0.5 mm, 12.3 ± 1.1 mm
  - Volume: 727 ± 148 mm$^3$

**High Blood Flow**
- **20 W**
  - Dimensions: 7.5 ± 1.0 mm, 10.0 ± 0.8 mm
  - Volume: 370 ± 78 mm$^3$
- **30 W**
  - Dimensions: 7.8 ± 0.7 mm, 12.5 ± 0.9 mm
  - Volume: 715 ± 125 mm$^3$

Figure 3.8B. Courtesy of Drs. Jackman and Nakagawa
Figure 3.9A.
Figure 3.9C.
Figure 3.9D.
Figure 3.11.
Figure 3.12A.

Transverse Lesion Radius (mm)

Transmural Lesion Radius (mm)

Electrode Radius (mm)
Power to maintain tissue-electrode interface temperature at 60°C

Figure 3.12B.

- Power
- Electrode Radius (mm)

$p = 0.0001$
$r = 0.84$

7 Fr.
Figure 3.13A.
Figure 3.13B
Figure 3.13C.