# Biophysics of lesion creation: focus on cool tip ablation

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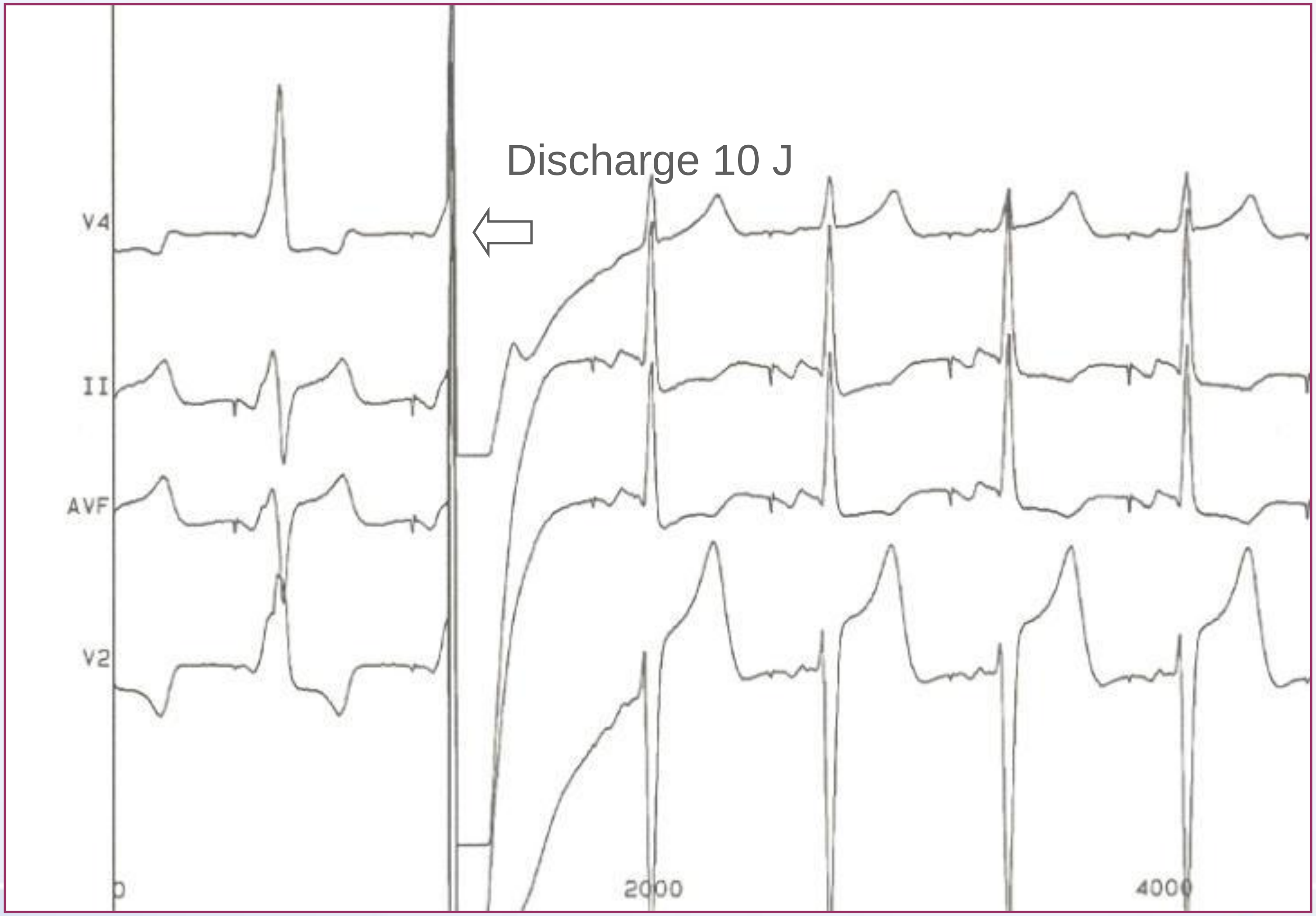
# Catheter ablation using direct current

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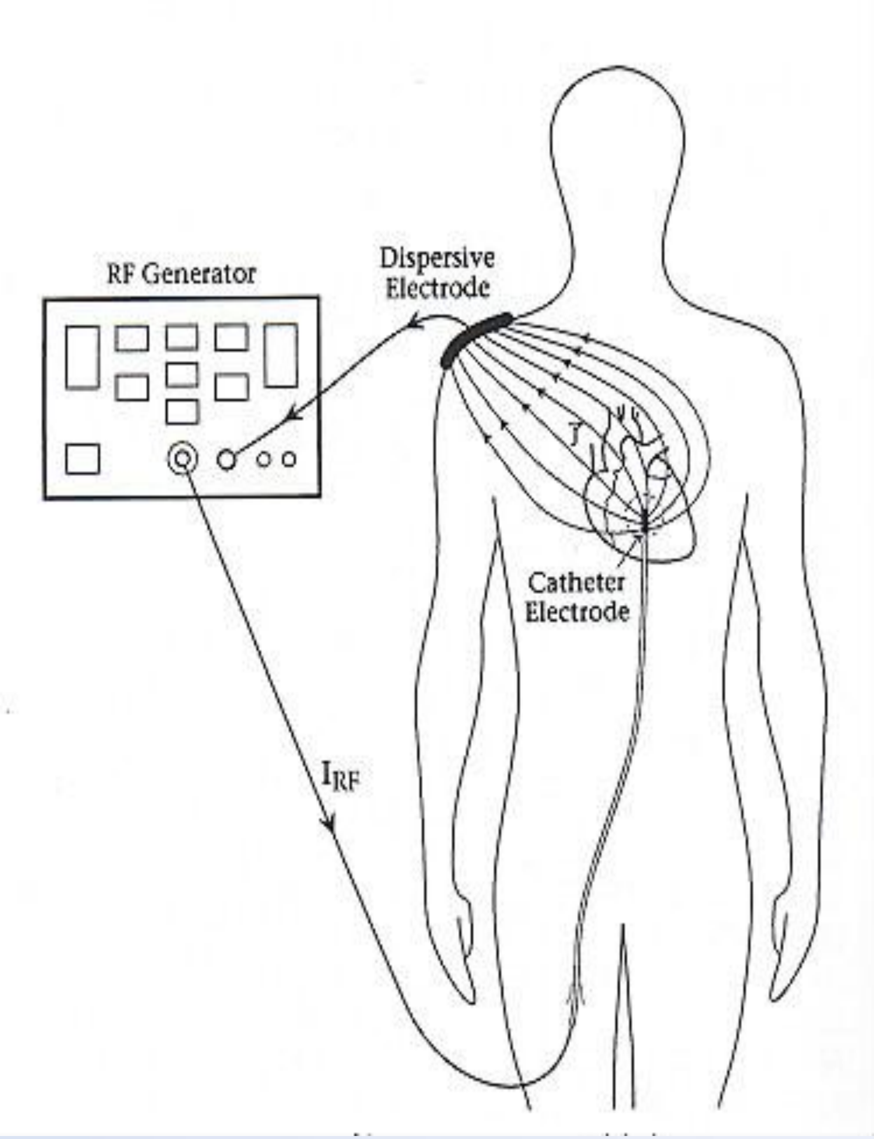
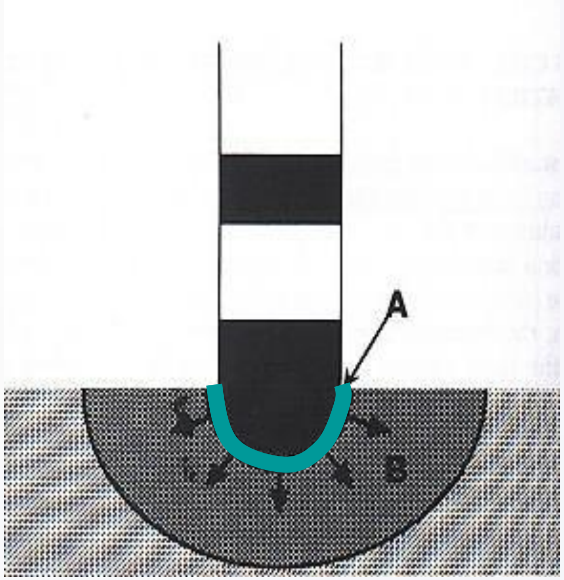
# Catheter RF ablation

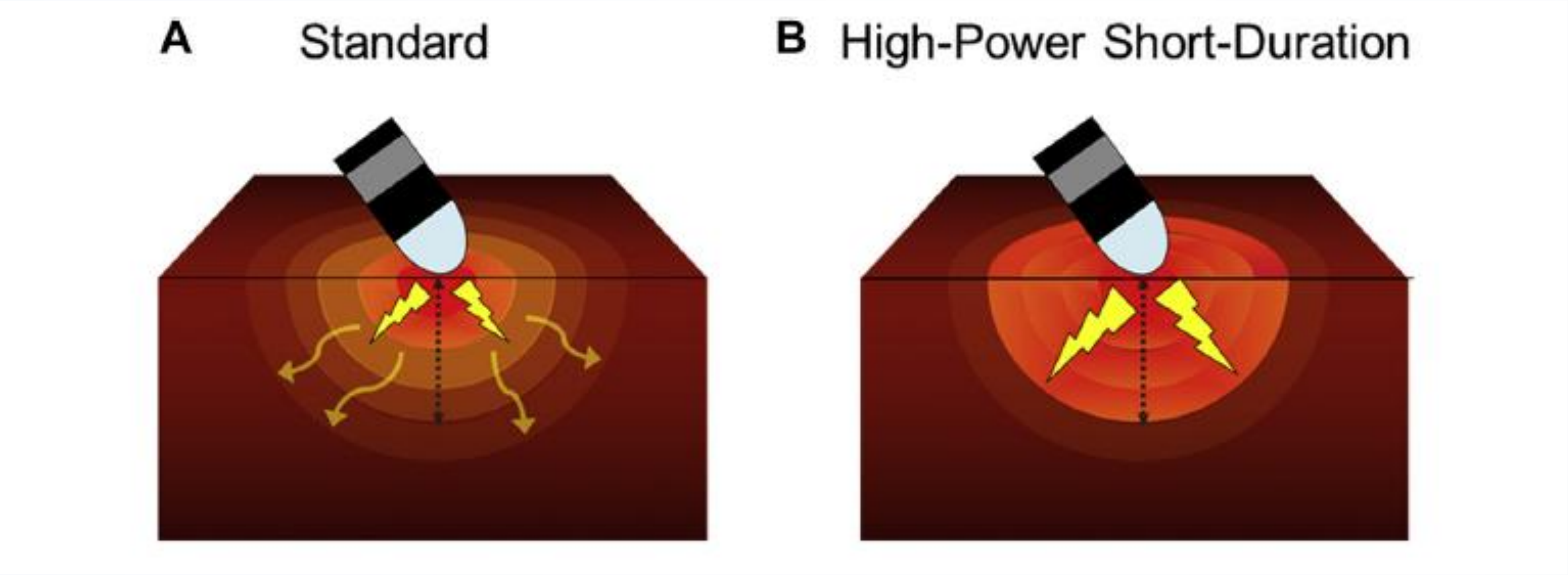



RF energy =

High frequency alternating current (500-750 kHz) generating heat during passing through the tissue with high resistance

# Conductive vs resistive heating




Approximately 90% of delivered power is absorbed within 1-1.5mm of tissue depth (**resistive heating**), the lesion then grow by **conductive heating**.

Maximum lesion can be achieved with 30-60second ablation.

In **high-power short duration** (90W/4sec), the lesions are formed by mainly be resistive heating.

Wittkampf PACE 2006;29:1285-1297

# Biophysics of RF ablation

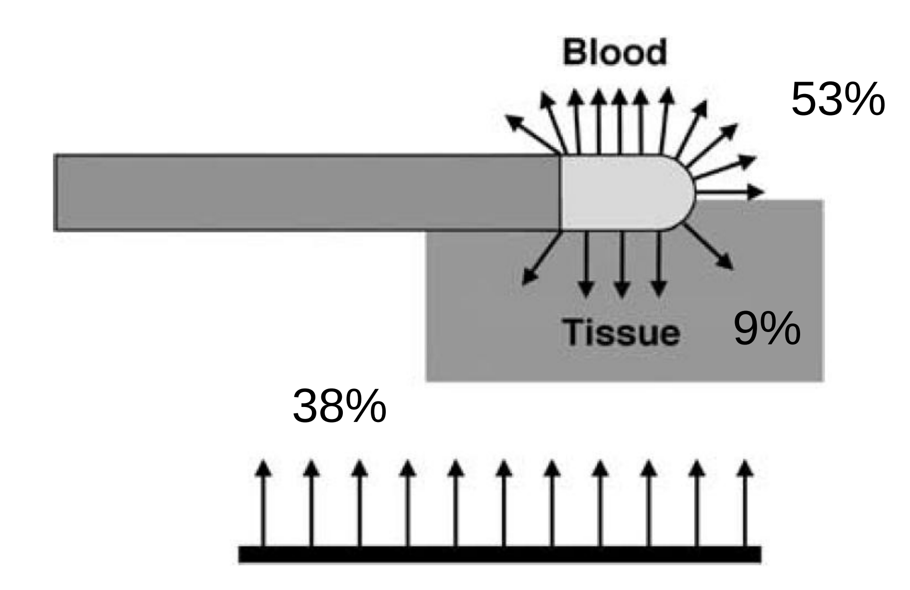
## Not all the power is delivered to tissue

**Blood** is better conductor and more RF current goes to blood than to tissue

- Variability of catheter tip coverage (ablation in small vein vs limited contact on ridge)

**Patient** - current passes through the thorax to the indifferent electrode

- Net energy can be increased by lowering the patient impedance by enlarging patch or putting patch closer to heart



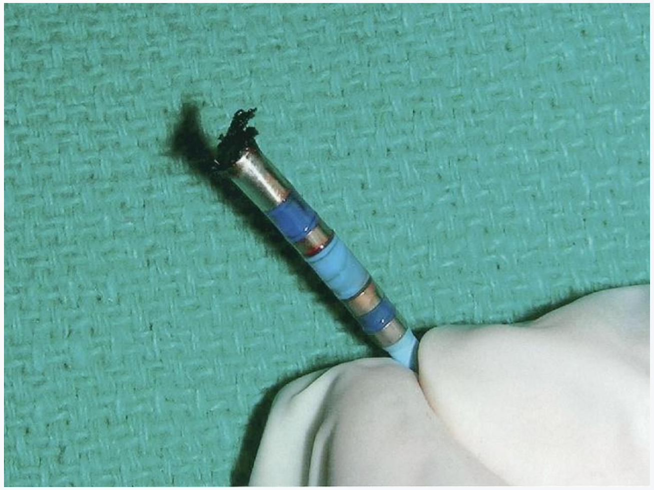

If 50W is applied and assuming 25% catheter coverage:

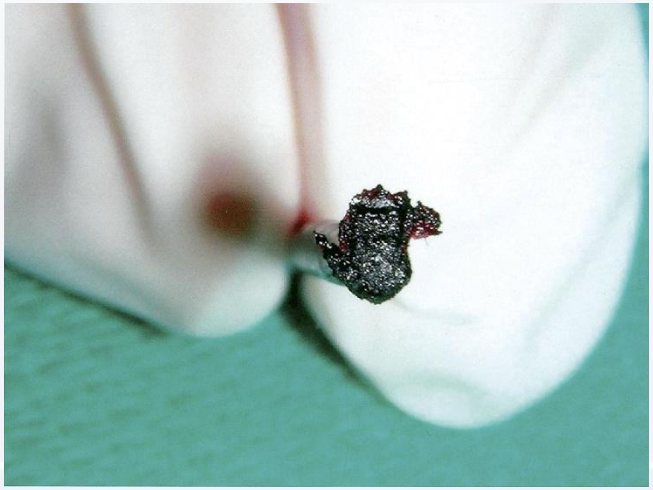
- 38% is lost to the patient
- 53% is lost to blood (6:1)
- **9% goes to the tissue (i.e. 4.5W)**

Wittkampf PACE 2006;29:1285-1297

# Why we need cool tip ablation?

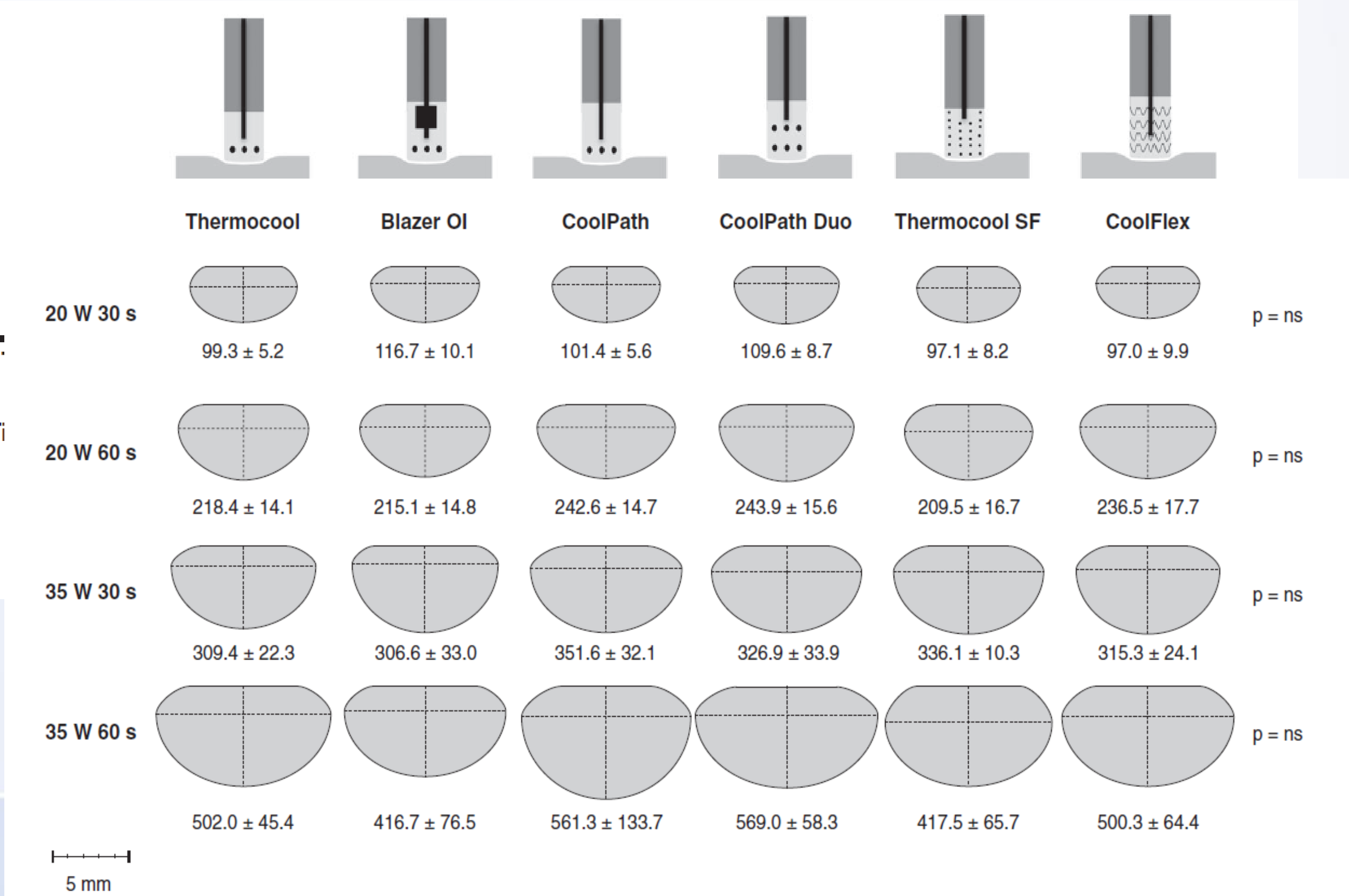
- Temperature 50°C is necessary for lesion creation
- However, at temp 70-80°C denaturation of blood proteins may occur and creation of „thrombus“ and charring on tissue and catheter
- This is more likely to occurr in areas of „low flow“
- Thus, nonirrigated ablation is limited in power delivery





Wittkampf PACE 2006;29:1285-1297

# Available cool tip designs

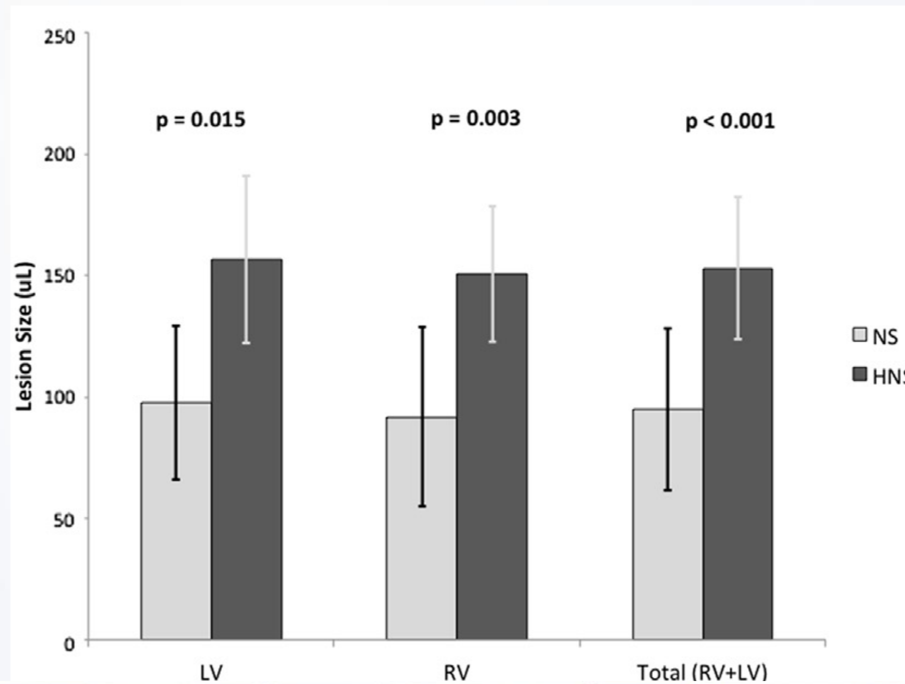


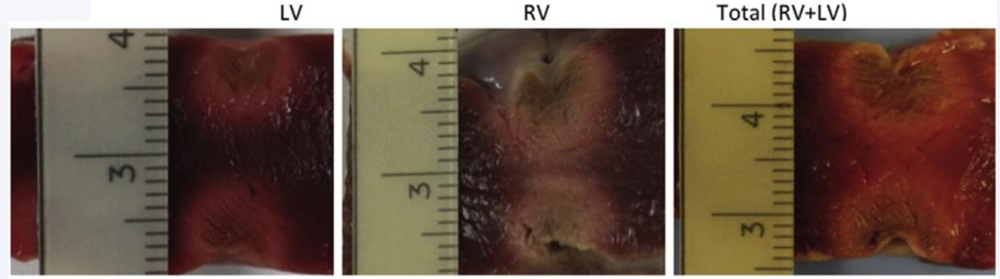

Guerra et al. JCE 2013

# Half-saline cooling solution

## Enhancing the lesion

- Externally irrigated RF ablation with a lower ionic concentration (half saline, 5% dextrose) produced larger lesions.
- Higher incidence of steam pops were noted with 5% dextrose.
- Sequential unipolar ablation with HNS created similar lesions as bipolar lesions with NS.



Sequential Unipolar Ablation NS

Sequential Unipolar Ablation HNS

Bipolar Ablation NS

Nguen JCE 2015, Nguen JACC EP 2017

# Cool tip designs

## Biosense Webster

- Open irrigation is superior over close loop irrigation*
- <u>Thermocool design</u>
  - 6holes, cool rate 15-30ml/min
  - Limitations:
    - high volume of fluid, nonuniform irrigation for variable tip orientation, „edge effect“
- <u>Surround flow (SF) design</u>
  - 56holes, cooling rate 8-17ml/min
  - Improvements:
    - Uniform cooling regardless tip orientation, prevention of thrombus formation at proximal edges of the cath tip

[redacted]

*Yokoyama et al. *Circulation* 2006

# THERMOCOOL SF (BW)

## Clinical benefit

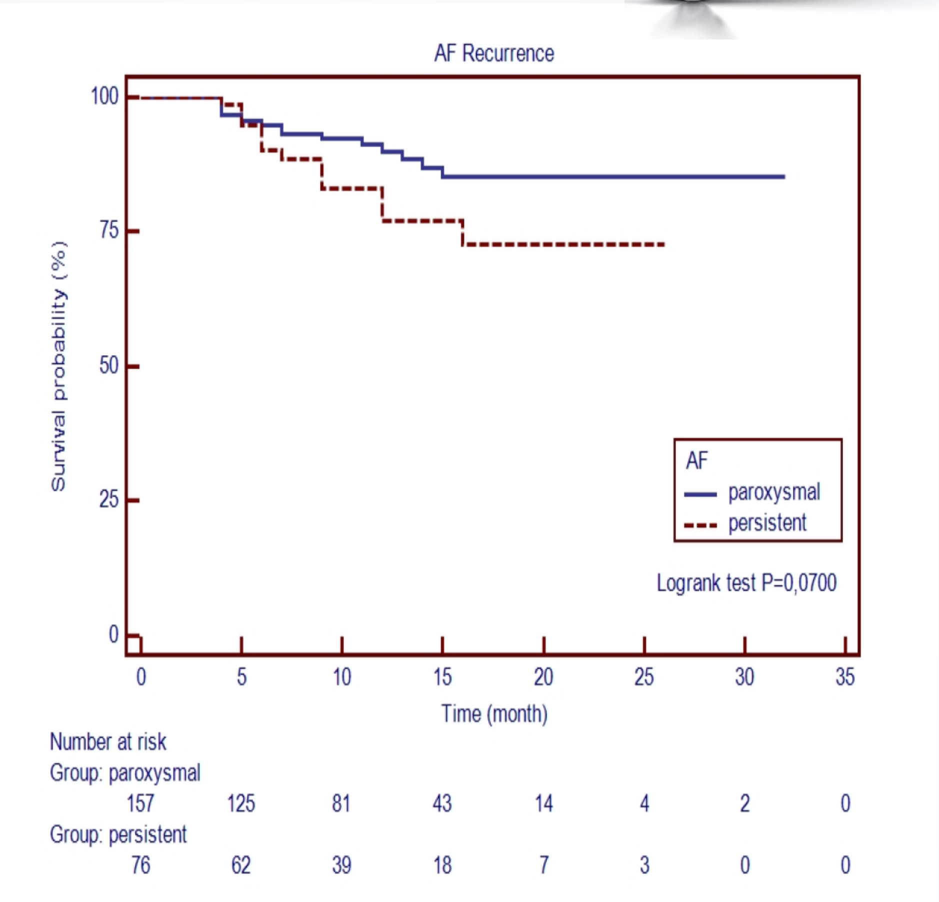
- **Surround flow** catheter was introduced to provide uniform cooling and reduce risk of thrombus formation
  - In studies it lowered amount of fluid (by 40%), shortened time to PV isolation and total RF time, early reconductions, No effect on silent embolic injury
- Commercialization of SF catheter has been associated with higher rate of complications
  - SAE occurred in centers that targeted an electrode tip temperature above safety cut off



Biosense Webster data Thesis, et al. JCE 2015;26:956-962

# Surround Flow
# Clinical experiences

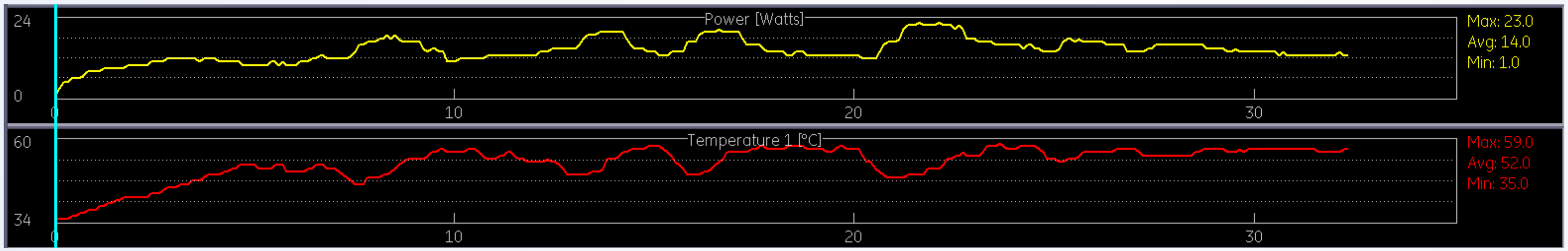
- 233 pts from 4 centers
- Mean procedure time 100±42min, mean fluoro 6±5min, mean ablation time 31±15min
- Complications: one pericardial effusion and 5 groin hematomas reported



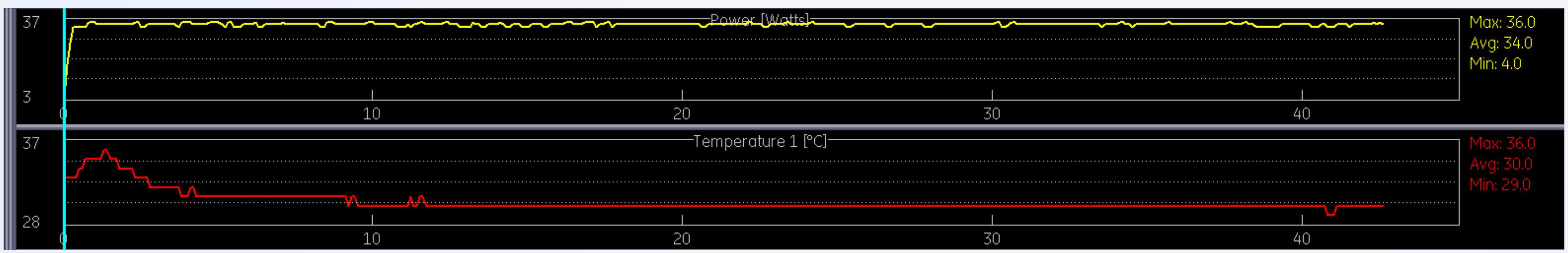

Stabile G JCE 2017, Bertaglia, JCE 2013, Scalione JCE 2012, Park JCE 2013,

# Ablation data
# Irrigated vs Nonirrigated tip

- Nonirrigated tip - Power 25W, T 55$^{0}$C




- Irrigated tip - Power 35W, T 43$^{0}$C




Increased disparity between tissue and catheter tip during ablation!

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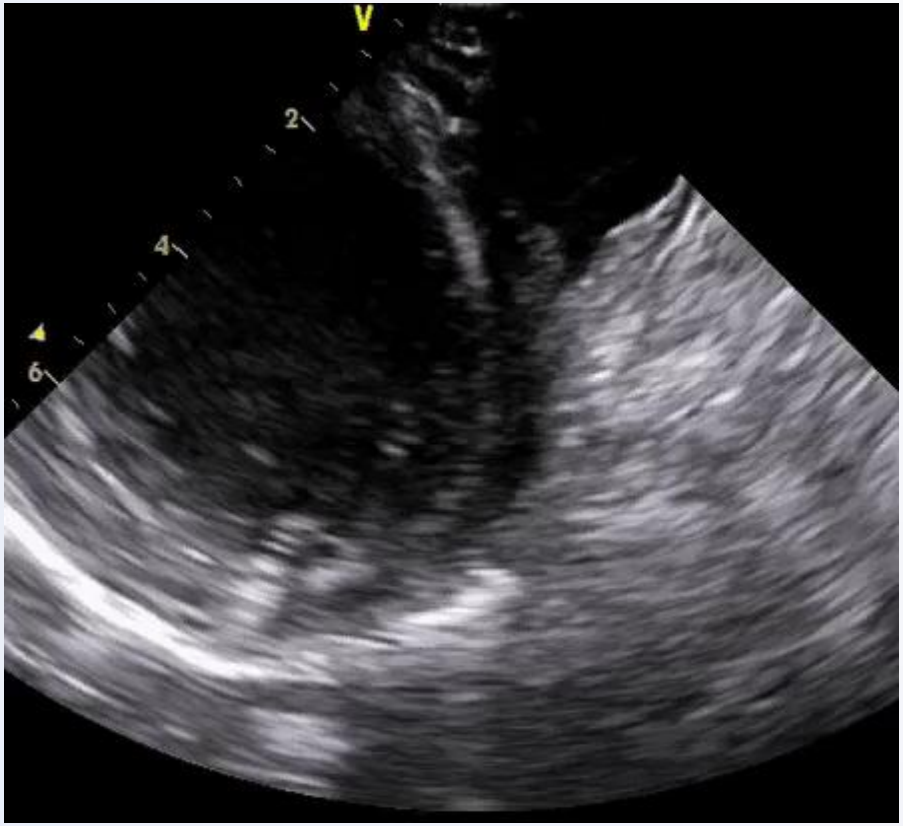
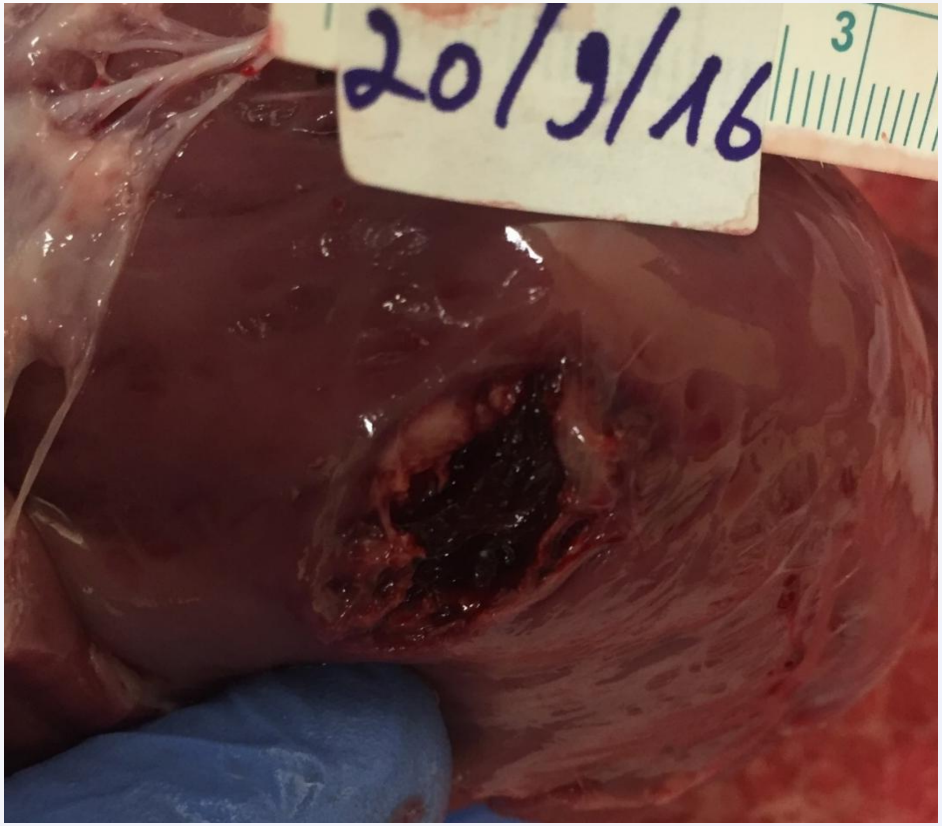
# High power may have serious consequences

## Lessons from animal work



ICE during „pop“ in LV apex




Gross anatomy at „pop“ site

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# High power requires better control

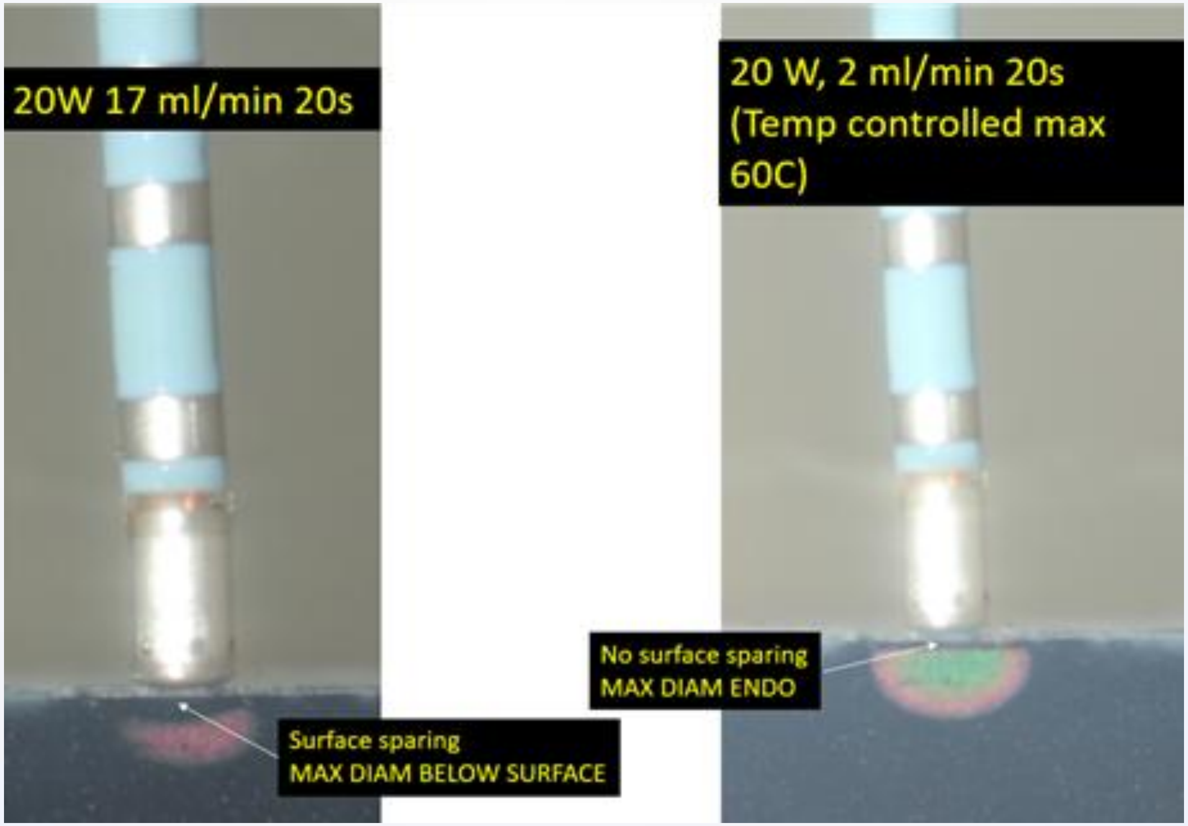
# When the cooling is too much…

## Ablation of posterior LA with low flow

Animal experiments and human data from 166pts

<u>Low flow protocol in LA:</u>
25W temperature control mode 2ml/min
Duration: 6-10sec
Inter-lesions distance 5mm
Contact force 15g

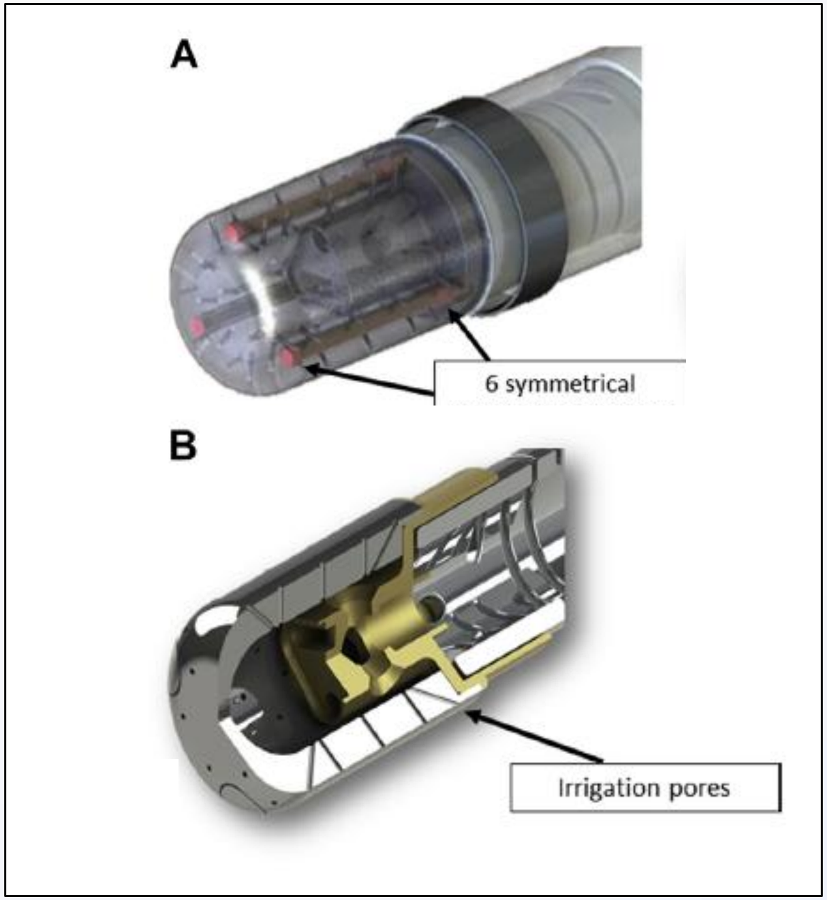
Compared to 17ml/min, low flow provided favourable lesion without increasing risks




Kumar et al *JACC EP* 2017

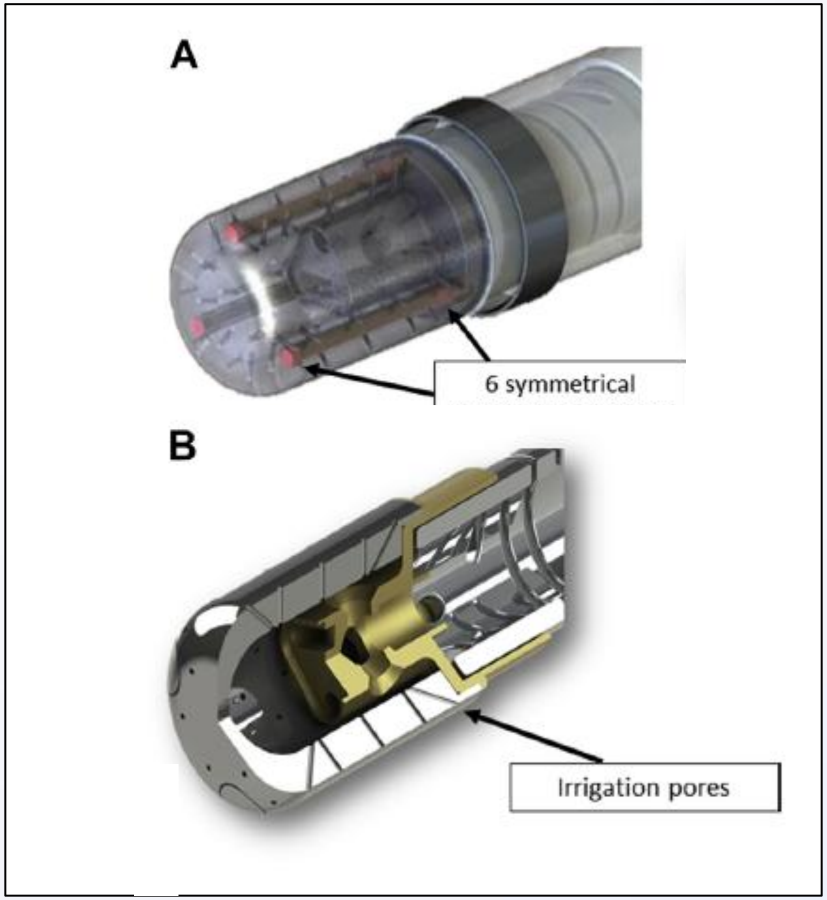
# QDOT – Biosense Webster

- Improved temperature sensing by 6 thermocouples embedded in the circumference of the tip electrode
  - Distal 75μm from tip
  - Proximal 3mm from tip
- Improved irrigation system allowing adequate irrigation at low rates



# QDOT – Biosense Webster **workflow**

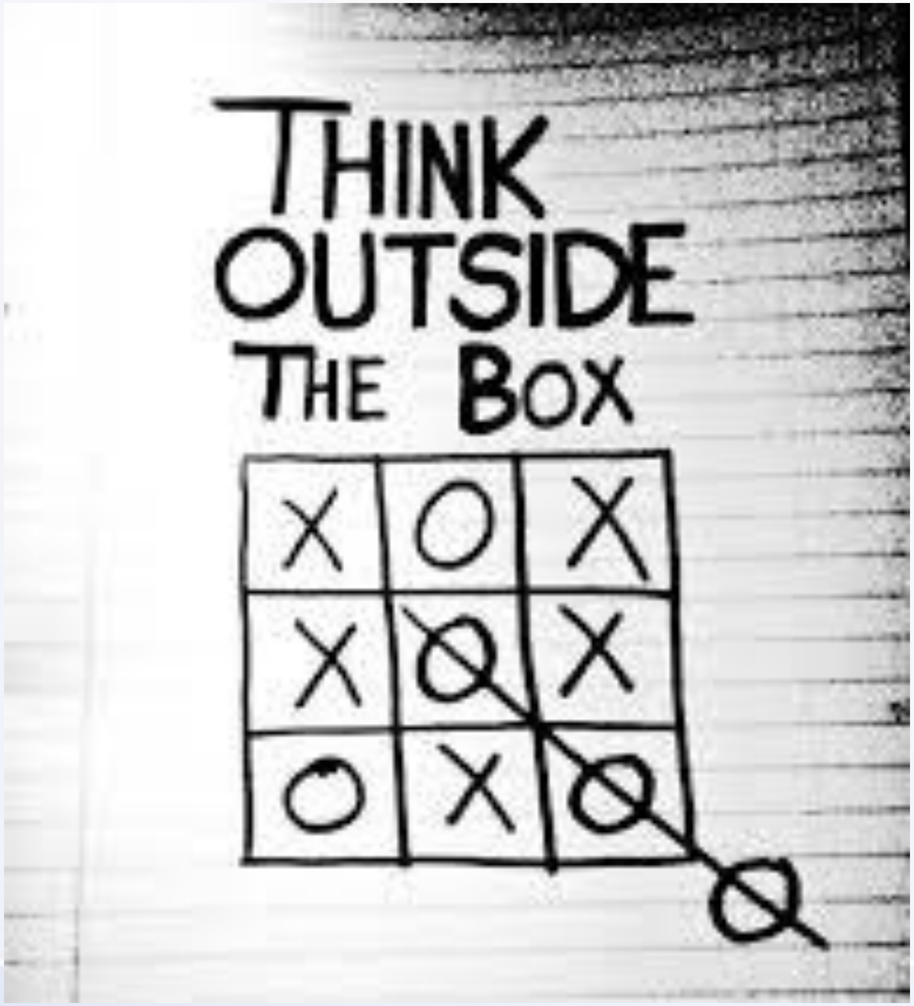
- RF energy modulation to reach the selected target temperature ($47^0$C, max $50^0$C)
- **QMODE** Irrigation titration:
  - Power <35W irrigation 4ml/min, when temp >$47^0$C irrigation increased to 15ml/min
  - Power >35W irrigation 15ml, when temp <$42^0$ irrigation decreased to 4ml/min



# Conclusions

- Biophysics of lesion creation is complex and many parameters affects final lesion size
- Active electrode cooling allows the use of higher RF power and longer application time to produce deeper lesions, while preventing coagulum formation and an impedance rise
- Improved cool tip design may enable temperature sensing during irrigated ablation

# Thank you for your attention!

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