

Design of Radio-Frequency Ablation Catheter

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Introduction:

- Radiofrequency (RF) ablation is the treatment for cardiac arrhythmia, that kills unwanted tissue by heat.
- During RF ablation, an electrode is inserted into or steered intravascularly to the target tissue region under medical imaging guidance.
- Then, a tissue volume surrounding the electrode is destroyed by heating via RF electric current.

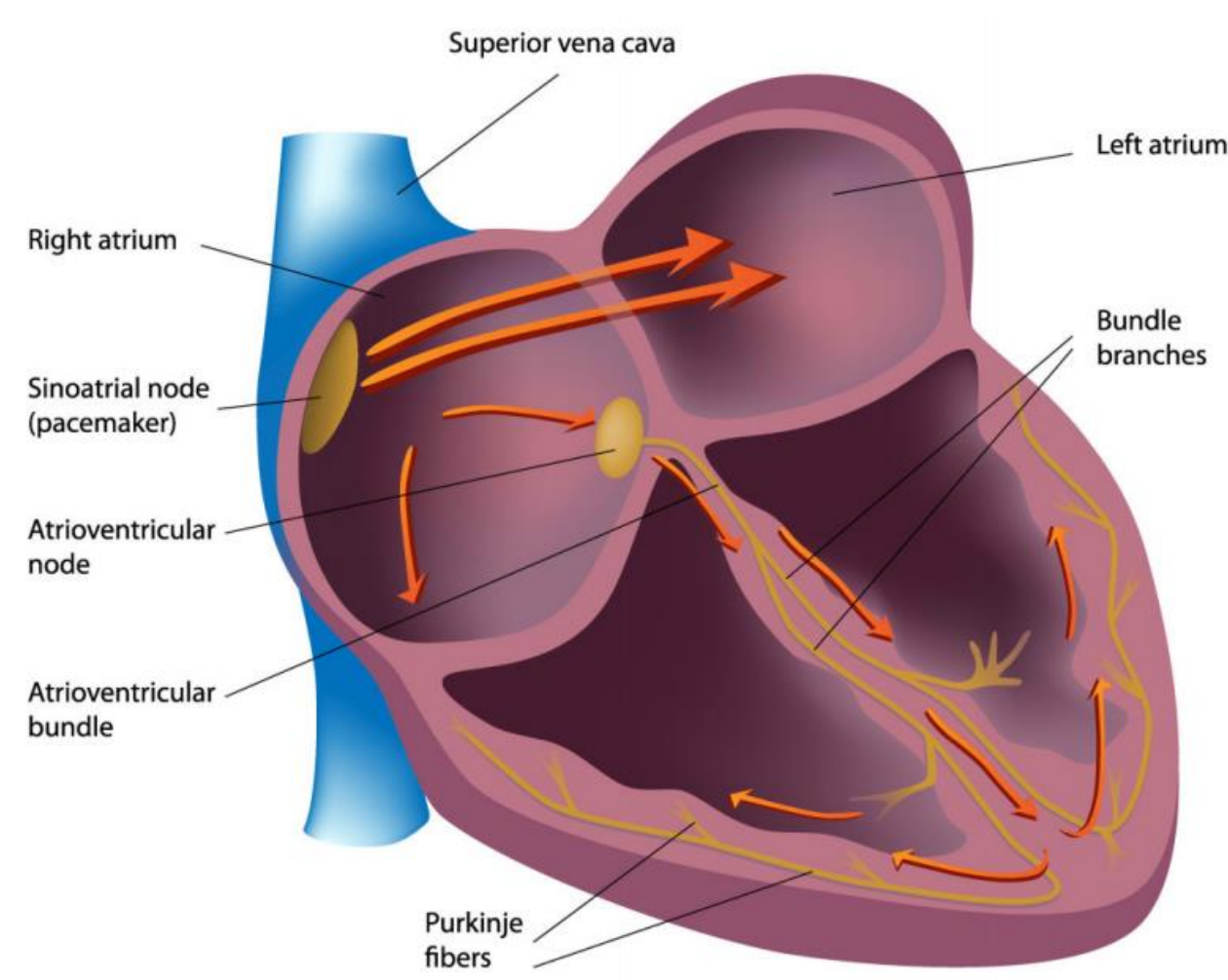


Figure 1. Scheme of the Conduction system of a human heart.

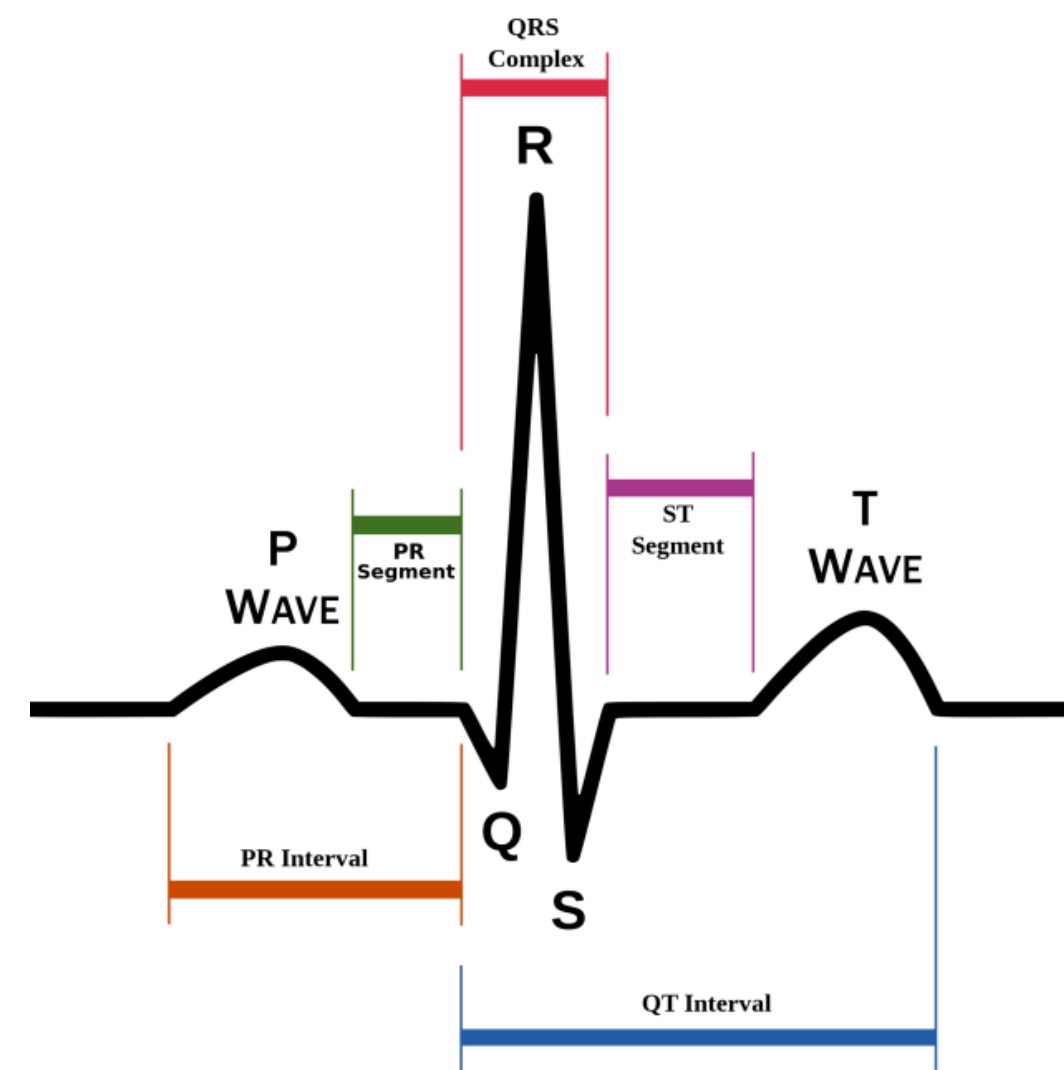


Figure 2. ECG of a healthy human.

The control system of the heart is the heart's conduction system which takes care that the pumping action occurs regularly and effectively.

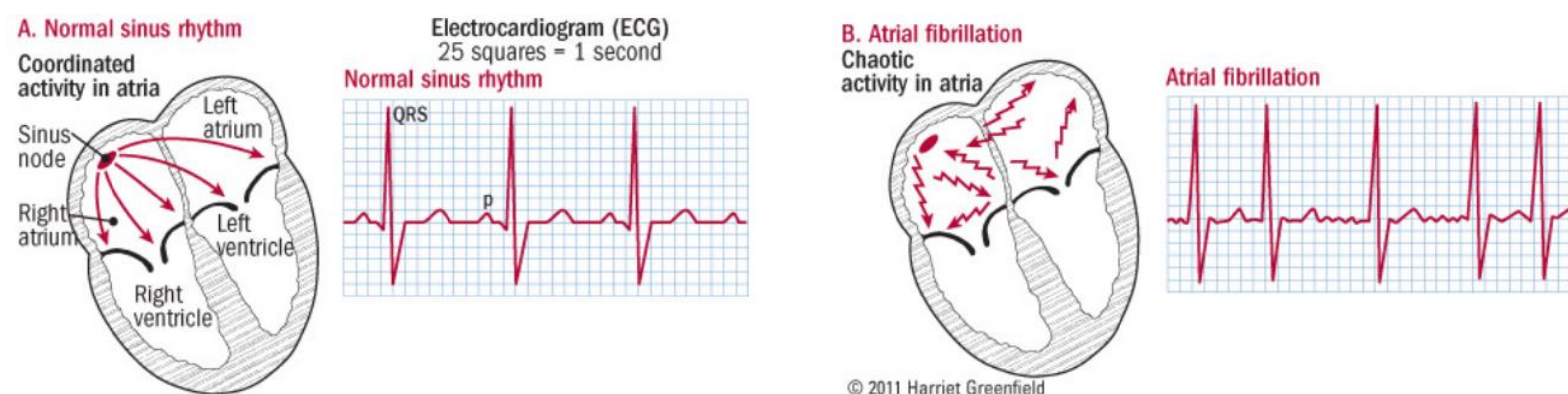


Figure 3. A schematic comparison of a normal sinus rhythm and atrial fibrillation.

Computational Methods:

- The model approximates the body tissue with a box and assumes that its boundary temperature remains at 37 ° C during the entire procedure.
- The tumor is located near the center of the box and has the same thermal properties as the surrounding tissue. The model locates the probe along the center line such that its electrodes span the region where the tumor is located.
- The boundary conditions at the outer boundaries is ground (0 V potential). At the electrode boundaries the potential equals 20 V. Assume continuity for all other boundaries.
- The localized heating is accomplished by inserting an electric probe through which an electric current runs. The electric field is converted into temperature field in the tissue. The heat source resulting from the electric field is known as resistive heating or Joule heating.
- It is important to visualize the region where unwanted cells die, where the temperature has reached at least 50 ° C. In order to visualize this area, an isotherm for 50 ° C. temperature is plotted.

Modeling and Results:

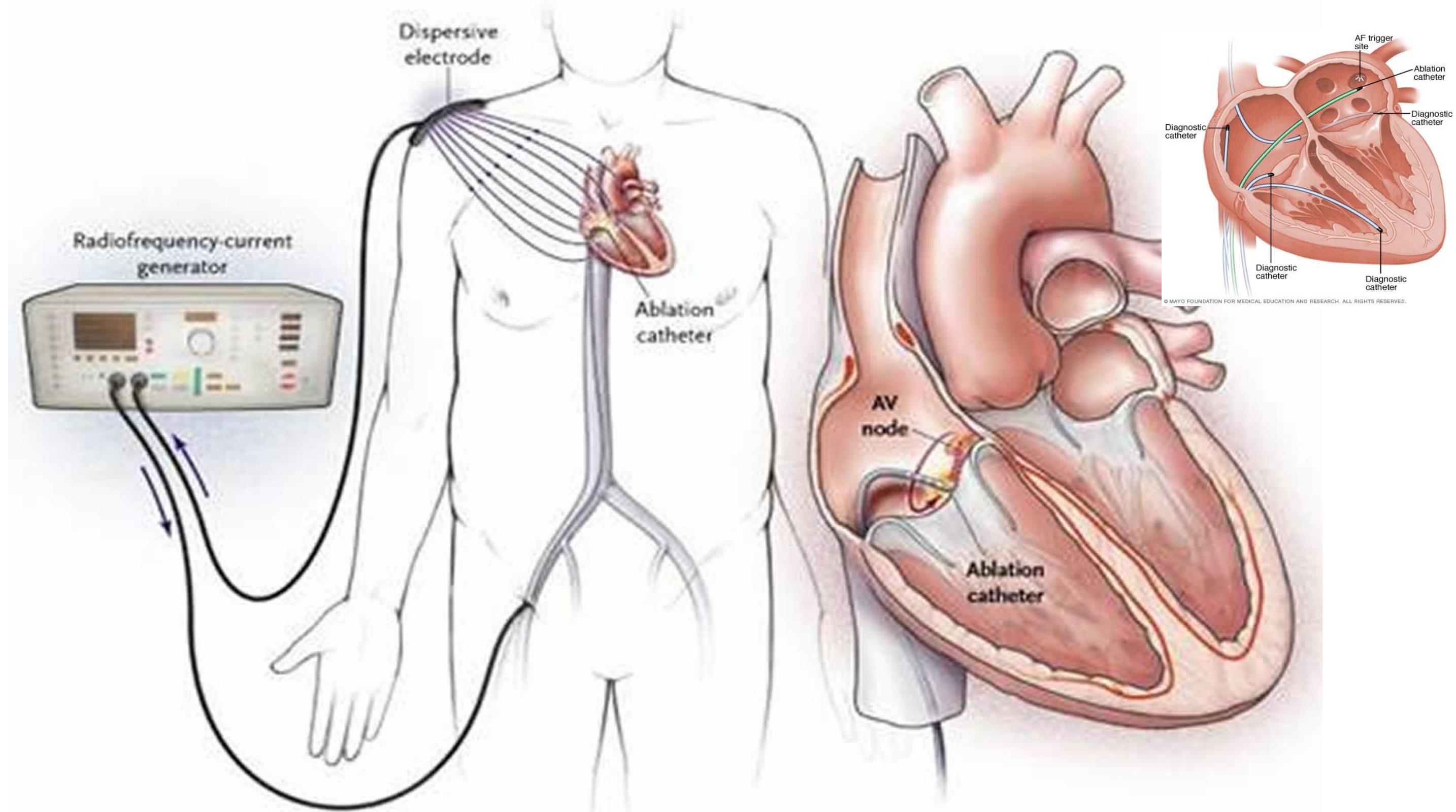


Figure 4. RF ablation catheter is inserted into the femoral vein and snaked up the inferior vena cava until it reaches the heart.

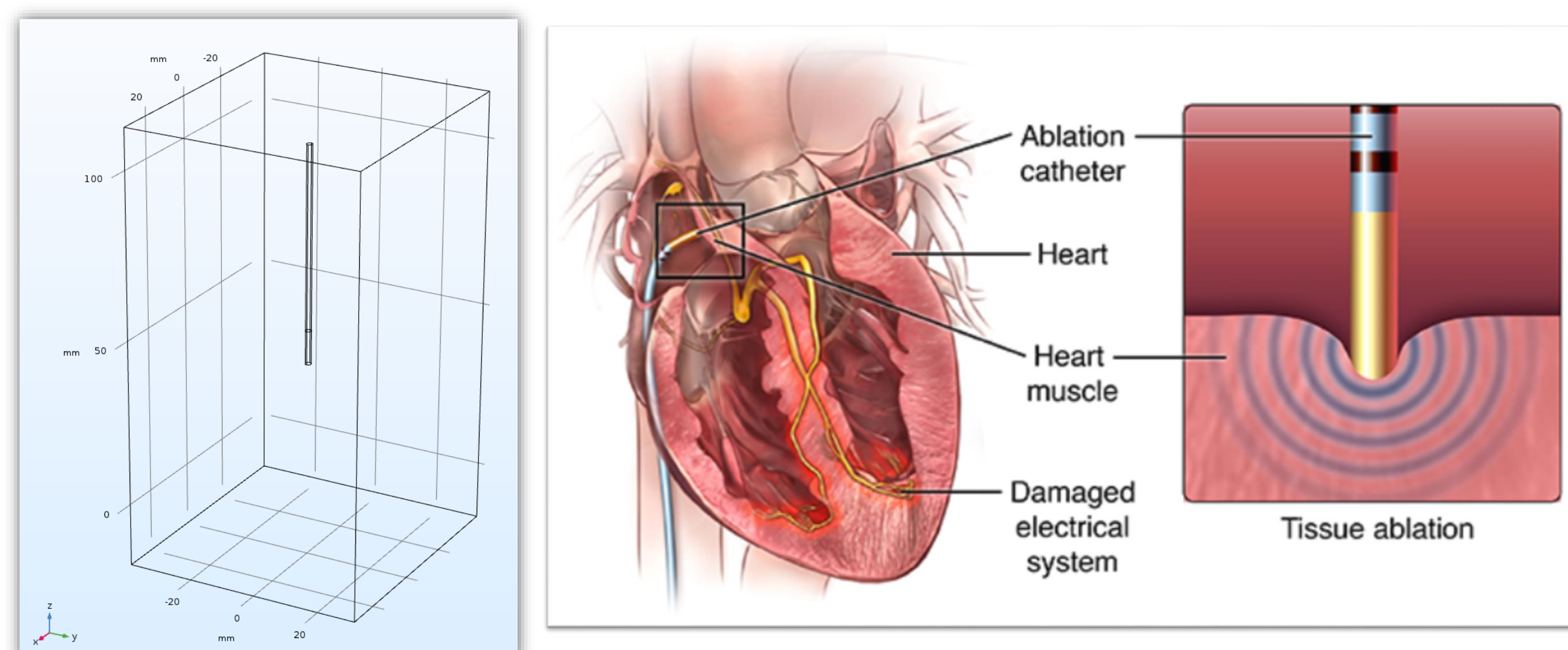


Figure 5. FE Model

Figure 6. Ablation process

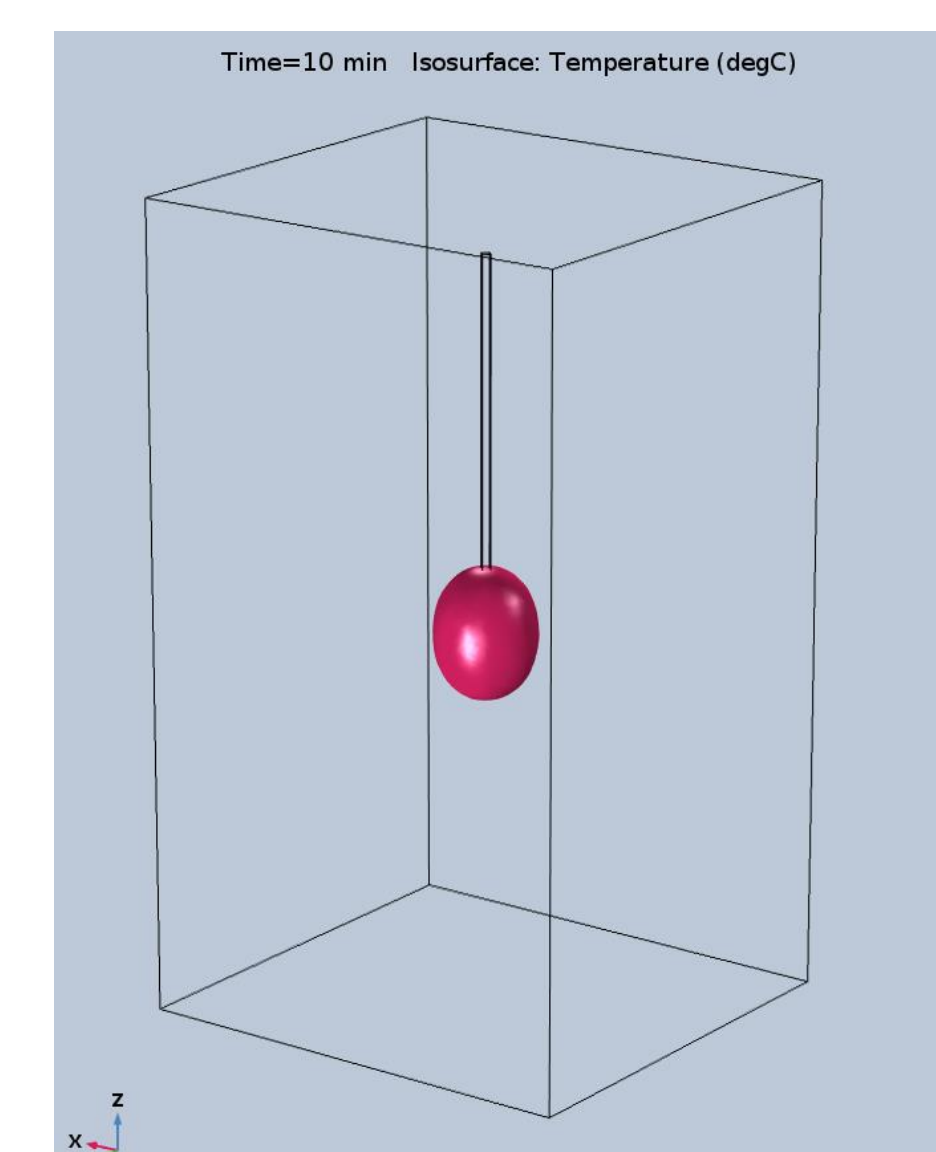


Figure 7. Isotherm

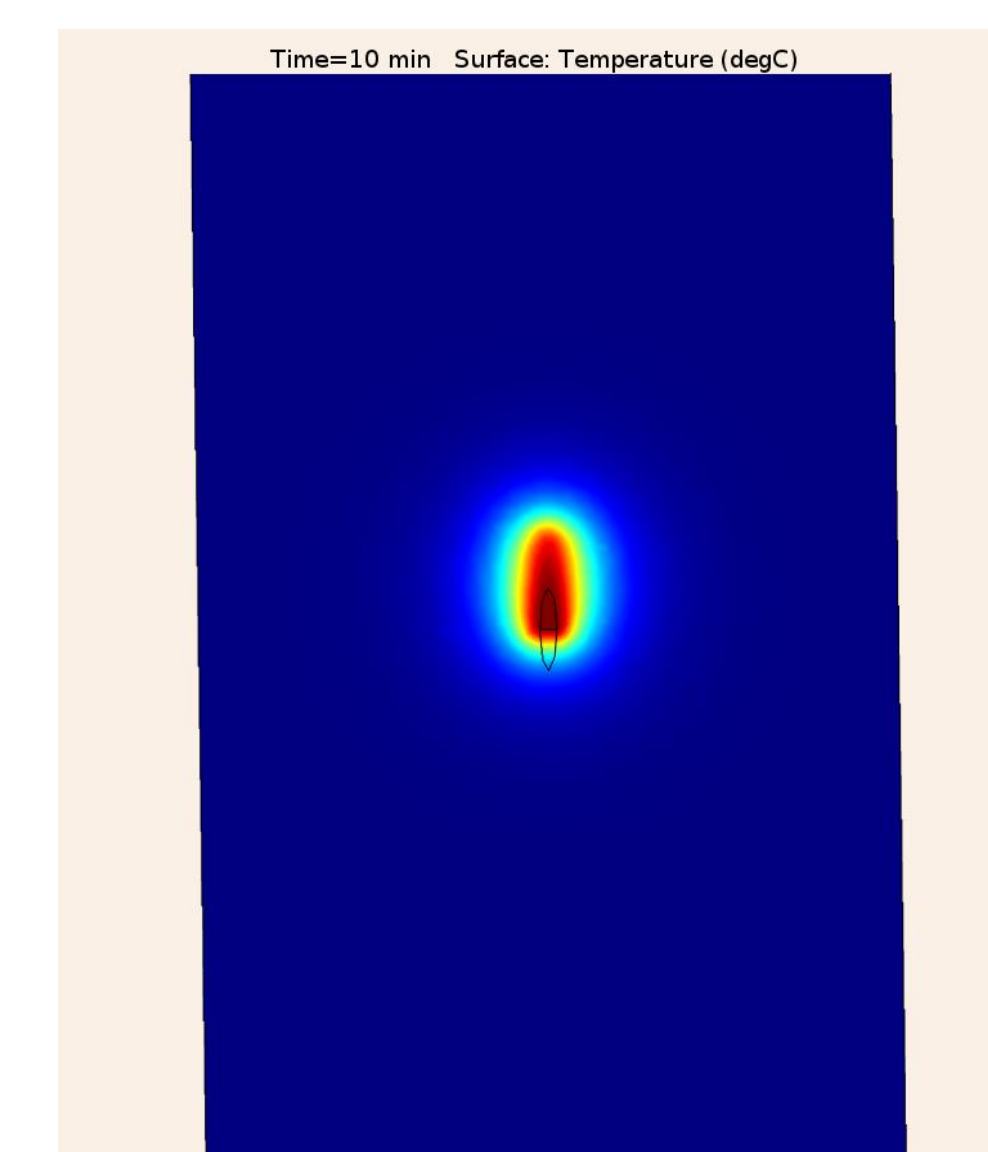


Figure 8. Thermal Gradient

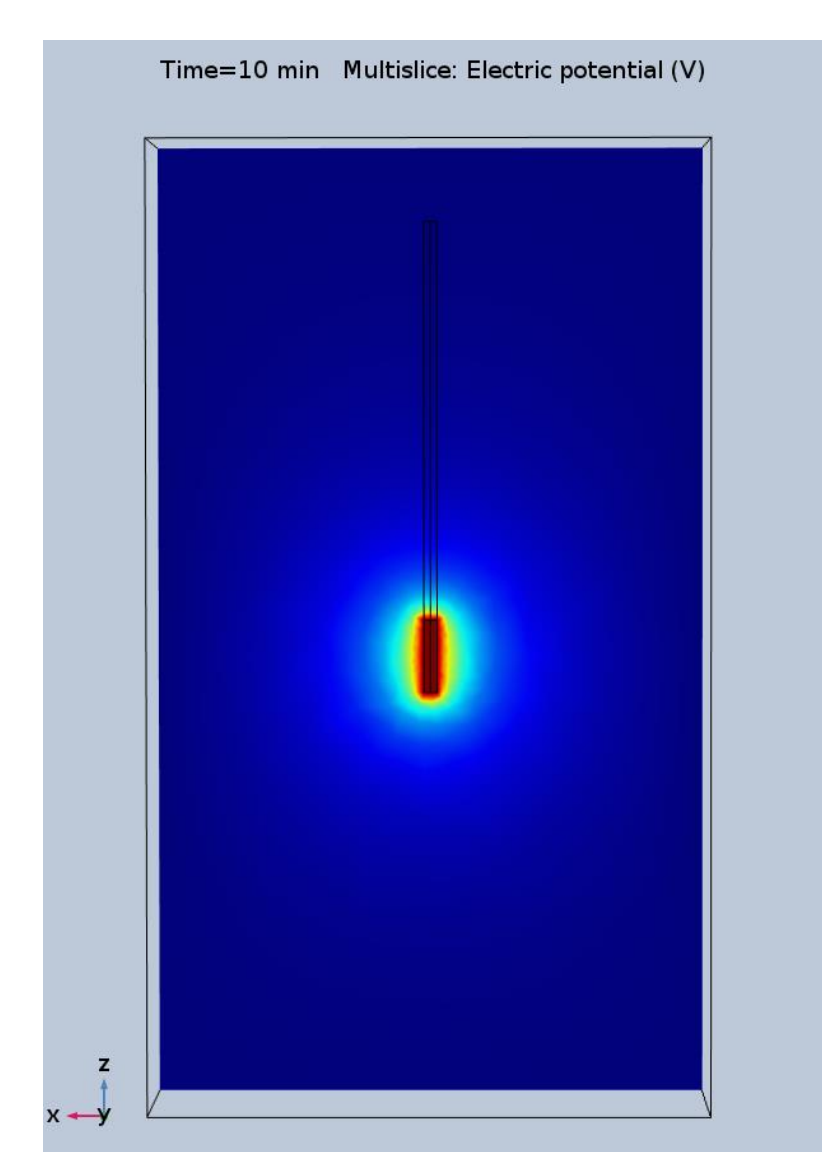


Figure 9. Electric field

Conclusions:

- RF ablation allows localized tissue destruction by heating. Image guidance allows identification and visualization of the target region, and guidance of the procedure.
- Improvement of imaging modalities will allow for improved accuracy of RF ablation and thermal therapies.
- COMSOL Multiphysics® tool plays a major role during the design and development of an RF ablation catheter.

References:

- In-Vivo Feasibility Study and Developments for Cardiac Arrhythmia Ablation using Scanned Carbon Ions (2017)
- Dieter Haemmerich, Biophysics of radiofrequency ablation