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Epicardial Cardiac Ablation Using Laser Energy

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ABSTRACT

We describe epicardial ablation using a new device that utilizes 980 nm wavelength laser energy. The device can be used in both open and minimally invasive approaches and should make ablation therapy safe, effective, and easy to use.

INTRODUCTION

Widespread use of cardiac ablation will depend on the ability to easily, safely, and effectively make requisite lesions from the epicardium of the beating heart. To this end, several devices have been developed using various energy sources and approaches [Prasad 2002; Raman 2002; Garrido 2004; Salenger 2004; Ninet 2005]. The FDA-approved Optiwave 980 (Edwards Lifesciences, Irvine, CA, USA) delivers laser energy at a wavelength of 980 nm, which penetrates myocardial tissue in a uniform fashion and provides controlled ablation of tissue with a relatively uniform temperature gradient. This wavelength is also far less susceptible to the attenuated efficacy when fat is present because very little energy is absorbed by fat compared to myocardium due to the lower extinction coefficient in fat (0.04 in fat versus 0.27 in myocardium). Energy is delivered to tissue via a fiber optic cable coupled to a diffusing tip, which allows for linear ablation of the energy rather than focusing on a single spot (as with a laser pointer). The diffusing tip contains scattering particles in a silicone matrix that directs the energy radially and perpendicular to the fiber direction. The particles have a concentration gradient along the length of the fiber such that the energy distribution is uniform along the entire ablating surface. The device is irrigated to maintain desired temperature. A gold foil is positioned around 180° of the fiber that acts as a mirror and reflects the energy back in the opposite direction, thus allowing ablation in only 1 direction. The diffusing tip of the epicardial device is 4 cm in length and the ablation is performed at 10 W/cm for 75 seconds. The diffusing tip is placed in a sheath designed for safe and easy use. The handle is indexed so the tip can be withdrawn to specific, preset stations that ensure overlap of each subsequent lesion. Seven stations permit ablation of up to 28 cm (4 cm/station) without the need to relocate the device (Figure 1). The tip of the device is a soft, blunt-tipped silastic tube that allows atraumatic placement. Optimal contact with tissue, aimed at the left atrium, is achieved through the self-righting feature of the semi-oval design. The torsional rigidity design eliminates the possibility of functionality following a 180° or 360° rotation, which is critical in blind spots such as the transverse sinus. Visual confirmation of the numbered sheath ensures the device has not been placed upside down.

TECHNIQUE

Device placement is achieved by sternotomy, right thoracotomy, or thoracoscopy. Sternotomy provides good visualization of necessary aspects of the heart for ablation and is preferred during concomitant procedures. We traditionally perform right thoracotomy via an anterior mini-thoracotomy through the fourth intercostal space. In women, the incision is placed in the infra-mammary fold and the chest is entered in the fourth intercostal space. Thoracoscopy involves 4 ports, 2 operative anterior ports (1 inferior and 1 superior) and 2 in the middle (1 anterior for the camera and 1 posterior for the device). Dissection for device placement can be performed from the right side of the chest, but the left side should also be visualized, which we do through a small left thoracotomy or through small ports with either standard thoracoscopic or robotic assistance. This visualization supports the excision or exclusion of the left atrial appendage, which is often the source of thrombus. It also confirms that the device is placed inferior to the left atrial appendage to avoid complications associated with placement on the circumflex artery.

Once the chest is entered and heart visualized, the intra-atrial groove is dissected over its entire length and carried inferiorly to the inferior vena cava (IVC) and superiorly to the superior vena cava (SVC) region and right superior pulmonary vein. During dissection, care is taken to stay close to the left atrium and to follow the superior and inferior surfaces of the right pulmonary vein to optimize contact with the intended target tissue. The pericardial reflection under

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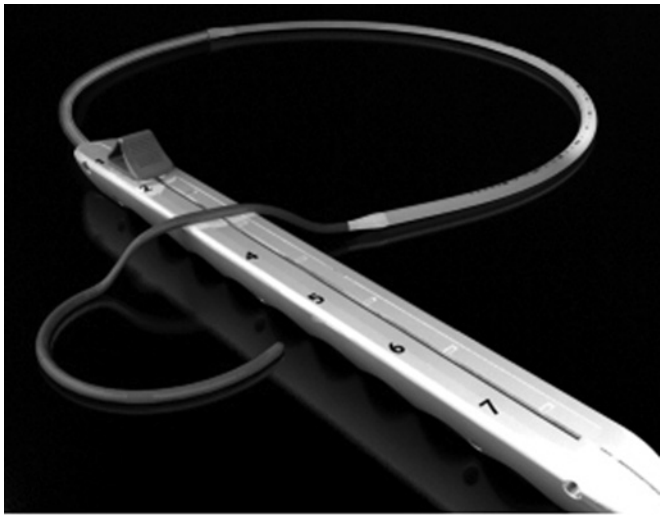

Figure 1. The Optiwave 980 epicardial encircle device (Edwards Lifesciences, Irvine, CA, USA).

the IVC is opened at the level of the intra-atrial groove dissection, allowing entry to the posterior pericardium near the entrance to the oblique sinus. Superiorly, the intra-atrial groove dissection is completed by opening the space posterior to the SVC, inferior to the right pulmonary artery and just superior to the right superior pulmonary vein, along the dome of the left atrium, bringing the superior dissection in continuity with the transverse sinus. Following dissection, a vessel loop or something similar is placed around the SVC and/or IVC to help guide probe placement and maintain the correct plane. The blunt tip of the probe is inserted under the SVC, fed into the transverse sinus, and advanced until it reappears inferiorly or until the visualization is picked up on the left side (Figure 2). Once the probe is advanced beyond the transverse sinus, it is wrapped around the atrium anterior

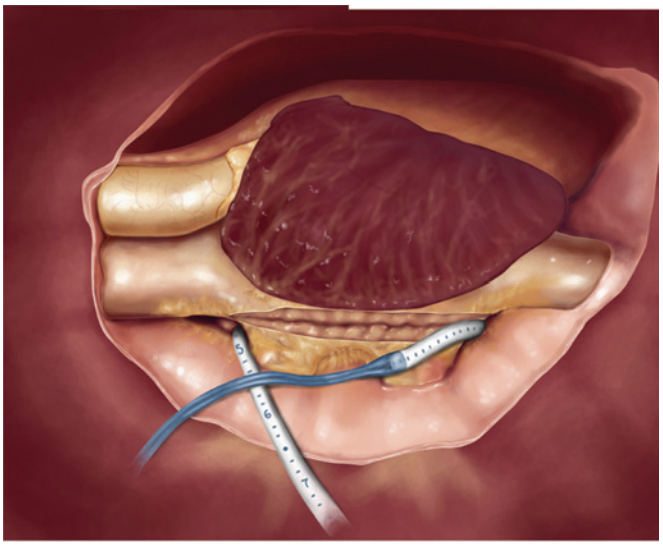

Figure 3. The probe is passed under the inferior vena cava, bringing it back into the right chest.

to the left pulmonary vein. Care must be taken to ensure the probe passes posterior to the left atrial appendage to avoid positioning on the aortic valve (AV) groove, which could result in ablation of the circumflex artery. At this time, the left atrial appendage can be excised or closed [Garcia-Fernandez 2003; Gillinov 2005]. The probe is passed under the IVC, bringing it back into the right chest (Figure 3). This maneuver can be done by placing tubing (eg, a red rubber catheter) under the IVC to the left side when the initial probe is placed through the transverse sinus. When visualization is performed from the left chest, the probe can then be attached to the catheter and simply pulled into position from the right side. Some surgeons may prefer this step instead of dissection of the intra-atrial groove. Although there is no

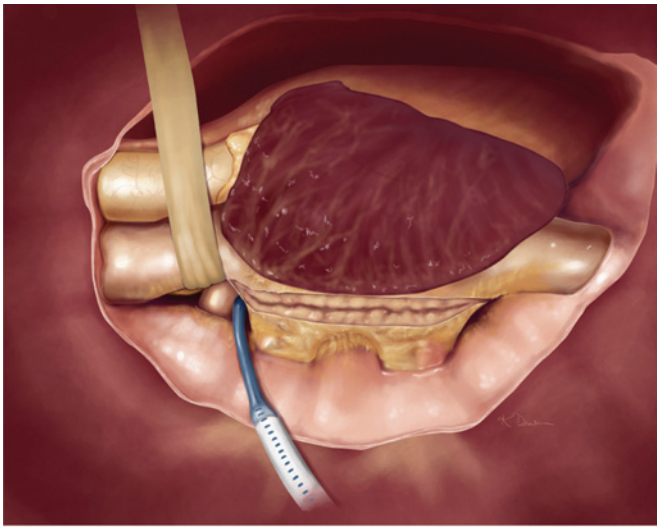

Figure 2. The tip of the probe is inserted under the superior vena cava, fed into the transverse sinus, and advanced.

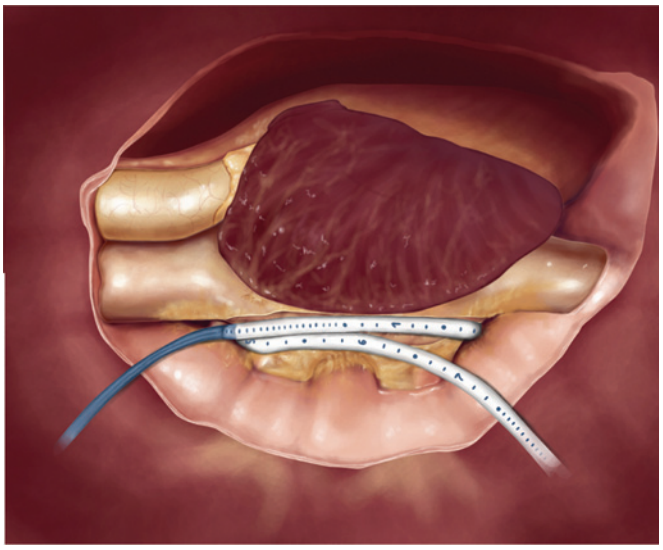

Figure 4. Probe placement is completed by overlapping the probe.

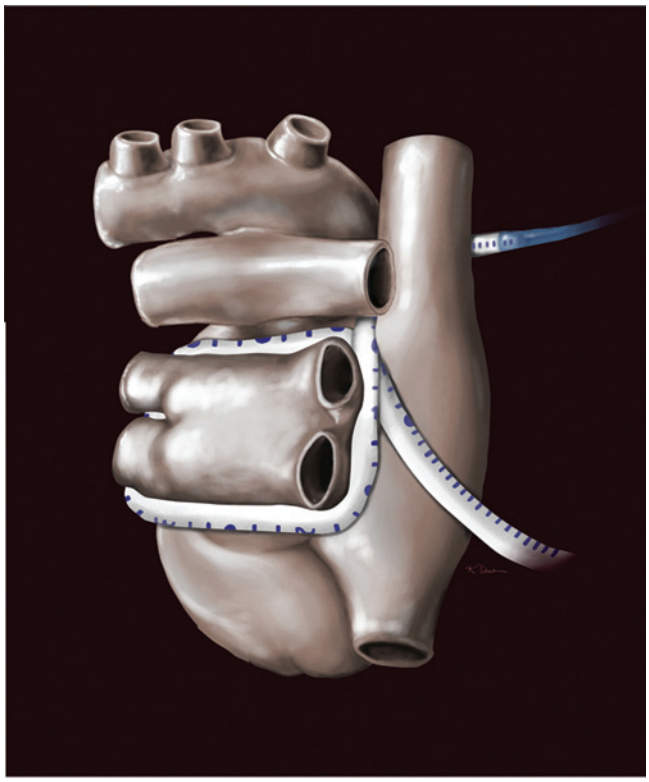

Figure 5. The probe may be passed under the superior vena cava a second time to help maintain the probe position.

data to suggest one approach over the other, we believe lesions will be more favorable if dissection is performed. With dissection, the probe will sit in better opposition to target tissues and reduce risk of the right lateral ablation line sitting on the right pulmonary veins, which may lead to stenosis. Probe placement is completed by overlapping the probe (Figure 4). To aid in the overlap, the probe may be passed under the SVC a second time to help maintain the probe position for optimal lesion sequencing (Figure 5). After placing the probe, the ablations are performed according to the indexed stations visible on the probe surface. After each 75-second ablation, the probe is serially withdrawn 1 station at a time until the final station in contact with the tissue is ablated. Upon completion, the probe is carefully withdrawn. Lesions can then be grossly inspected. Due to the nature of the optimized laser tissue interface, surface indications are not always evident even when transmurality and conduction block have been effectively achieved. Confirmation can be achieved through pacing across the pulmonary veins.

COMMENTS

The 980 nm diode laser is well suited for epicardial ablation due to its excellent tissue penetration. Other energy sources focus at the device-tissue interface, thereby relying solely on conductive heating for ablation. This distinction is central to epicardial ablation where the convective cooling from the flowing endocardial blood on the far surface acts as a "near-infinite" heat sink, making effective ablation difficult. This energy source and device features should make ablation therapy safe, effective, and easy to perform.

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