Fast-track articles

Surgical treatment of atrial fibrillation in the beating heart: a novel approach

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Up to 50% of patients undergoing mitral valve surgery have concomitant atrial fibrillation. An epicardial approach may offer the benefit of reducing the aortic cross-clamping time and avoiding an undue left atriotomy. During the last year we have been developing a simple technique to reproduce epicardially the same lesion pattern we had previously achieved endocardially. Two patients with chronic atrial fibrillation received atrial ablation using a microwave energy probe (Flex-10, AFx Inc., Fremont, CA, USA) immediately before undergoing a concomitant cardiac procedure. The procedure is relatively quick to perform and with appropriate care can be conducted with a low risk of perioperative adverse events.

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Introduction

The Maze "cut and sew" procedure, introduced by Cox in the early 1990's, is extremely effective in eliminating atrial fibrillation (AF)[1] but is complex to perform and is associated with relevant perioperative morbidity. Different sources of energy and ablation techniques have been developed in the same years to avoid the surgical incisions and make the procedure easier and more reproducible, thus decreasing the incidence of peri- and postoperative complications[2-5].

Recently, interest in performing beating heart procedures has expanded due to the potential advantages over arrested heart surgery, including a reduced incidence of postoperative complications, a decreased 30-day mortality, and lower associated health care costs[6-8]. Microwave energy probes may offer potential advantages over other energy modes for use in beating heart surgery, most notably the ability to rapidly produce long and narrow lesions without gaps and the high reproducibility in ablation depth and length. Furthermore, it allows the use of a flexible ablating probe, and the possibility of creating transmural lesions with no surface sticking or charring[9].

The term "microwaves" refers to radiofrequencies ranging between about 1 GHz (or 1 billion oscillations per second) and about 300 GHz. For comparison, television transmissions normally occupy frequencies below the microwave region, from about 50 to 600 MHz (1 MHz is 1 million oscillations per second, 1 GHz is 1000 MHz) and mobiles operate in the 800 to 1800 MHz range, again just below microwave frequencies.

Microwave energy generates heat by inducing oscillation of polar molecules such as water. This electromagnetic field is capable of propagating through blood, desiccated tissue and scars, and this characteristic renders it very suitable for atrial tissue ablation. The penetration depth achieved with microwave energy depends upon a number of factors including the dielectric properties of the tissue, the frequency of the microwave energy, and the antenna design.

We describe a technique of performing epicardial ablation on the beating heart prior to the concomitant cardiac procedure.

Technique

AF was treated using a microwave energy ablation system (AFx Inc., Fremont, CA, USA). A malleable probe (Flex-10), which emits microwave energy, was used to produce a set of lesions with the aim of encircling the four pulmonary veins in one single button. The power applied to produce lesions in the pulmonary vein set was 65 W for 90 s. The ablations were completed immediately prior to performing the concomitant cardiac procedure. All procedures were performed via sternotomy and all ablations were limited to the left atrium; the left appendage was ligated (Fig. 1).

The goal is to achieve a complete encirclement of the four pulmonary veins in order to isolate them. Since the procedure is to be carried out without extracorporeal circulation, manipulation of the heart should be avoided as much as possible since it may provoke hemodynamic and cardiac instability. Nevertheless, a continuous linear lesion without any gap must be made if the risk of AF recurrence is to be reduced to a minimum. Finally, great care must be taken to avoid the main coronary stem as, after its origin from the posterior aortic wall, it lies below the left auricle. Both vene cavae are tapered as for the aorta and the transverse sinus. The tip of the probe is introduced in the transverse sinus; once its correct position between the left auricle and pericardial reflection is assessed, it is withdrawn till the last black mark on the probe is visible. It is then grasped with a blunt dissector passing below the inferior vena cava and placed in the oblique sinus. Once again it is withdrawn until the contact between the probe and the inferior pulmonary veins is satisfactory but causes no occlusion of the latter. Finally the loop is closed by passing below the superior vena cava and joining the tip with the last visible mark. At this point the energy is delivered one mark at a time and using the normal settings employed for the usual operations and adopting microwave energy (Fig. 2).

The newly designed probe, a 10 cm long, 0.5 mm in diameter flexible cable which is soft and freely bendable, simplifies the whole procedure. The probe (Fig. 2 shows an image of the probe after it has been positioned) has a thinner and even more flexible tip which facilitates sliding below the atrium. A black mark allows the surgeon to ensure that there is no torsion on the long axis, and to clearly understand where the energy should be delivered (the mark is 180° opposite to the probe's active surface). The energy is not delivered on the whole length of the probe all at once, but only in 4 cm segments that are selected by the surgeon who is manipulating the probe handle. To a great extent the segments overlap and this minimizes the risk of leaving gaps.

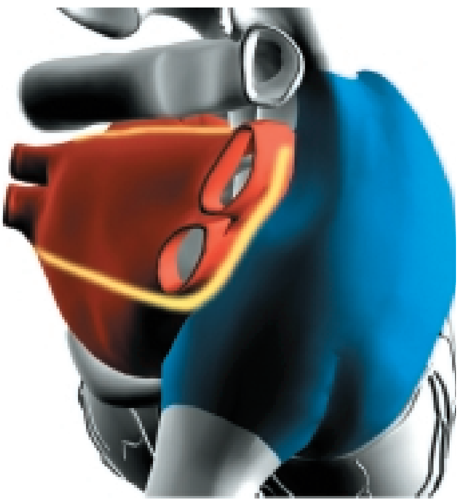

Figure 1. *Ablation pattern as seen from the right side. In* red *the left atrium, in* blue *the right atrium, in* yellow *the ablation line. Reproduced with the permission of AFx Inc.*

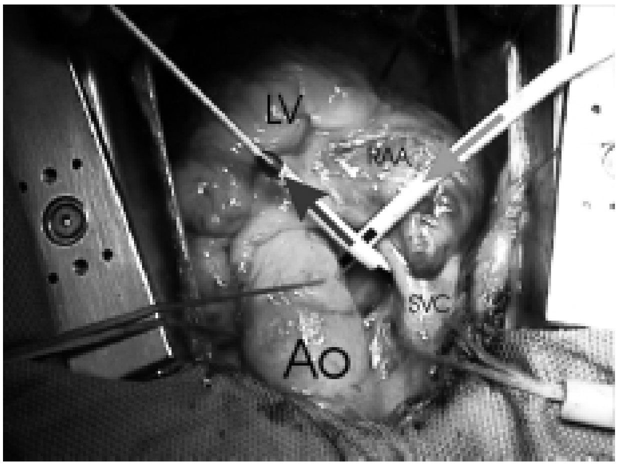

Figure 2. *Surgical view of the probe in situ. Ao = aorta; LV = left ventricle; RAA = right atrial appendage; SVC = superior vena cava.*

Comments

This epicardial ablation approach was successfully completed on the beating heart within 15 min and a prolonged ischemic time and unnecessary left atriotomy were avoided. Individual encirclement of the right and left pulmonary veins, apart from being time-consuming, may expose one to the risk of bleeding from the posterior aspect of the right pulmonary vein, as we encountered in 1/15 patients submitted to this procedure.

Highly significant advantages of this technique in comparison to that proposed by Mazzitelli et al.[5] are that it does not necessitate any tilting of the heart and that no gaps are left. In fact, manipulation of the heart is not always well tolerated in this subset of patients, especially if concomitant coronary lesions are present. A final advantage, entirely due to the length of the new probe, is represented by the continuity of the lesions produced.

Great care must be taken to avoid injury to the main stem and the circumflex artery, assessing the position of the probe with respect to the left auricle and underlying main stem division. We recently reported that this complication had occurred in a previous case of microwave ablation[10]. On that occasion the ablation was performed using a Flex-4 probe, a 4 cm probe which has to be applied for each ablation segment and can be freely rotated on its axes. Thus the energy may be delivered at different angles and on the surrounding structures. With the new Flex-10 probe, the probe is set in place once, it is easy to follow and to understand the angle of energy diffusion, and it cannot be rotated at each segment. The latest version of the probe has a semi-triangular shape designed with the aim of improving further the apposition and of avoiding rotation of the probe in the blind spots. This really does limit the possibility of life-threatening complications.

A follow-up electrophysiological evaluation, to be conducted after completion of the intermediate postoperative remodeling phase, is mandatory to prove the regional cardiac electrical performance.

Clearly too few data are available at this time to permit comparison of this technique with other already affirmed surgical ablation procedures. A larger patient population and a longer follow-up will testify for or against the further development of this approach. Our experience, gained with this and other energy sources, teaches us that only after 1 year is the ablation completely "mature" and the lesion development definitive. Especially when heat generating energies (unipolar or bipolar radiofrequency, microwaves, laser) are applied, the tissue surrounding the ablation lines undergoes a marked inflammatory process, leading to tissue rearrangement and eventually to scar formation. These borders are thought to be very electrically unstable, and may be a site of foci which could induce postoperative AF.

If proven to be efficacious, the indications to microwave epicardial ablation will probably be extended to patients with a low ejection fraction and lone AF, and also to routine use in coronary artery bypass and aortic valve replacement.

A clear understanding of the significance of the risk factors for the postoperative recurrence of AF is beneficial and worthy of further study. The ablation procedure was quick and easy to perform on the beating heart and we did not observe any perioperative adverse events or complications. The possibility of performing a simplified surgical ablation on a beating heart for the successful treatment of AF will provide new opportunities to other AF patient subsets.

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