A virtual reconstruction of the geometry of the esophagus was produced using an electroanatomical mapping system and a specially designed catheter in 20 consecutive patients undergoing circumferential pulmonary vein isolation. The course of the esophagus, its motion and its proximity to the predicted lines of application of radiofrequency energy to the left atrium were evaluated. Thirteen (65%) were located centrally (ie, >10 mm from the ostium), 69 (30%) laterally (ie, <10 mm from the ostium), and 1 (5%) obliquely. No movements larger than 10 mm occurred during the procedure. Conventionally, the radiofrequency ablation lines are configured such that, in 50% of patients, radiofrequency energy is applied to areas adjacent to the esophagus. In order to decrease the potential risk associated with this procedure, either the position of the ablation lines was altered to bring them closer to the ostium (by 15%) or the power was reduced (by 35%). Although there was no significant movement of the esophagus during the ablation procedure, its course was variable. Consequently, the ablation strategy was altered in a substantial number of cases.

**Key words:** Atrial fibrillation. Catheter ablation. Mapping.

### INTRODUCTION

The thoracic esophagus is situated between the right and left pulmonary veins (PV) in direct contact with the left atrium (LA), and displays great interindividual anatomical variability. During circumferential pulmonary vein isolation (CPVI) in patients with atrial fibrillation (AF), radiofrequency lesions are produced in the LA and potentially lethal esophageal lesions can develop. This complication may be prevented by assessing the position of the esophagus during CPVI. We describe the use of a catheter designed for 3D reconstruction of the esophagus that enables analyzing its course and movements during the ablation procedure. We investigate alterations to the ablation strategy in areas close to the esophagus to reduce the risk of injury.

### METHODS

The study included 20 consecutive patients undergoing CPVI for AF resistant to conventional treatment. Computerized tomography (CT) of the thorax was performed to assess the thickness and diameters of the esophagus in axial slices. Sedation was achieved with remifentanil and anticoagulation...
with sodium heparin. A circular mapping catheter for recording PV electrograms (Lasso, Biosense-Webster) and a 3.5-mm irrigated-tip ablation catheter (Navi-Star Thermocool, Biosense-Webster) were introduced into the LA via transeptal puncture. Reconstructions of the LA and PV were produced with independent maps using an electroanatomical mapping system (CARTO XP, Biosense-Webster) and the PV ostium identified according to changes in impedance and electric and fluoroscopic parameters.3

Mapping the Esophagus

Anatomical mapping of the esophagus was conducted using a dedicated catheter (Esophastar, Biosense-Webster) introduced via a naso-esophageal approach and withdrawn postero-cranially, thereby constructing a point-by-point 3D map and a virtual esophageal tube. The dimensions of the map and virtual tube, procedural time and concordance were compared to the CT measurements in each reconstruction.

To determine the position of the esophagus in relation to the LA, we selected the view offering the greatest elongation of the posterior LA starting from a posteroanterior projection of the 3D map. From the midmost portion of the right and left PV ostia, we measured the distance to the homolateral border of the esophagus. The courses were classified (Figure 1) as right or left lateral if they were located at least 10 mm from the PV and central otherwise. If they were less than 10 mm from the PV and crossed the center of the area of interest—defined as the point equidistant to the contralateral PV—the course was considered oblique. The esophageal catheter remained in place until the end of the procedure and reconstruction performed at the beginning, during and at the conclusion of the procedure. Movement of the esophagus was suspected if the catheter tip crossed the boundary of the initial map, and was considered significant if >10 mm. Patient tolerance to the catheter was measured on a 1-5 scale (1 = no discomfort; 5 = unbearable).

Ablation

All patients underwent CPVI by homolaterally encircling the PV at more than 5 mm from the ostium (margin of ablation), until the atrial electrogram voltage decreased by >90% or to <0.05 mV, delivering radiofrequency energy applications of 35 W at a maximum temperature of 45°C. We altered the ablation lines individually to locate them more than 5 mm from the border of the virtual esophagus (safety margin). In the lateral or oblique courses, due to inability to stay within these margins, we decreased the energy application to 25 W and the pulses to less than 20 s. When we could not obtain complete PV isolation (the aim of the ablation procedure) via encirclement, we applied it within the circlet.

The SPSS 14 statistical package was used in all cases. ANOVA or the Student t test were used to identify statistically significant differences between means, and χ2 or Fisher’s exact test for qualitative variables.

RESULTS

Table 1 shows the population characteristics. It was possible to introduce the catheter in all the patients with a good level of tolerance—median, 2 [p25-75, 2-3]—and without complications. The position of the esophagus varied, with 13 central courses (65%; minimum distance to PV, 17 [3] mm), 6 lateral—4 right (20%; distance, 6.7 [2.3] mm) and 2 left (10%; distances 7 mm and 5 mm)—and 1 oblique (5%; minimum distance, 6 mm) (Figure 1). There was no association between the course of the esophagus and the anatomical, clinical or demographic variables analyzed. In the CT, the esophagus presented elliptical morphology in axial slices; the lateral
In 7 (35%), we reduced the radiofrequency energy and application time; this involved 6 lateral courses (2 left and 4 right) in the entire posterior part of the homolateral circle and in 1 oblique in the posterolateral part only (Figure 2B). During a follow-up of 4 (2) months, there were no complications and 70% of the patients remained free from arrhythmias.

**DISCUSSION**

Esophageal 3D cartography using a dedicated catheter provides the exact location of the esophagus during CPVI in a simple and well-tolerated way, which aids in confirming its stability during the procedure. Altering the ablation strategy to reduce potential risk without changing the aims of ablation is very common.

Damage to the esophagus has been recently described as a complication of LA ablation. This is due to the thermal lesion caused by radiofrequency energy applications in atrial regions in direct contact with the esophagus, and can range from minor local lesions to atrio-esophageal fistulas. Although the incidence of fistulas is rare, they are a difficult complication to diagnose and have high mortality, and thus avoiding the LA regions adjacent to the esophagus has become a widely used approach for minimizing the risks involved in ablation.

Different imaging techniques have been used to locate the esophagus, but all of these involve limitations. The incorporation of esophageal anatomy into 3D maps provides accessible and real information. Previous studies have validated this...
In conclusion, 3D monitoring of the esophagus demonstrates its great anatomical variability and confirmed its stability during CPVI using mild sedation. Point-to-point esophageal maps are more accurate than tubes standardized for movement. Guiding the radiofrequency energy applications according to the esophageal anatomy involves altering the ablation strategy in a large number of cases.

REFERENCES