

TOPICAL REVIEW

Radiofrequency catheter ablation of common-type atrial flutter guided by conventional versus electroanatomical mapping

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Abstract

Radiofrequency catheter (RF) ablation aiming the complete conduction block of the cavotricuspid isthmus has become treatment of choice for common type atrial flutter. Different approaches to guide the ablation procedure are used. For the conventional approach multipolar catheters in the right atrium and in the coronary sinus are required to detect the induction of conduction block via the isthmus. RF current is applied starting at the ventricular site of the cavotricuspid isthmus under fluoroscopic control to recognise dislocation of the ablation catheter and to avoid potential complications.

Three-dimensional electroanatomic (CARTO) activation mapping can be helpful to guide atrial flutter ablation. By the help of a magnetic sensor, embedded in the tip of the mapping catheter, a virtual frame of the cavotricuspid isthmus will be reconstructed. The middle region between the virtual septal and posterolateral border of the cavotricuspid isthmus will be targeted for the ablation lesion line. Both approaches have been shown to be associated with a high acute success rate and a low recurrence rate. The major difference is that the CARTO system leads to a substantial reduction of fluoroscopic time required for atrial flutter ablation. Thus, CARTO-guided ablation directed at the cavotricuspid isthmus represent a modern method for rapid and successful treatment of common-type atrial flutter with low radiation exposure. (Fig. 4, Ref. 16.)

Key words: radiofrequency catheter ablation, common-type atrial flutter, conventional versus electroanatomical mapping.

Common-type atrial flutter describes a macroreentry encircling the tricuspid annulus (1). Conduction in the inferior cavotricuspid isthmus is prerequisite for maintenance the reentry (2). Induction of the complete bidirectional isthmus block has been emerged as the standard endpoint for radiofrequency catheter ablation (RF) of common atrial flutter (3—5). When complete block of the inferior cavotricuspid isthmus is achieved there is a low recurrence rate of atrial flutter observed (6). Functional gaps in the linear ablation line attribute to the development of recurrences of atrial flutter. The ablation procedure is conventionally guided by activation times of various local electrogram under fluoroscopic control (7). Thus, this method is associated with long fluoroscopic times. Novel strategies for guiding the ablation procedure may help to overcome these limitations. A novel method for endocardial mapping based on electromagnetic technology has been reported recently (CARTO Biosense-Webster, Diamond Bar, CA, USA). Initially, the common atrial flutter circuit has been investigated with this technique (8). Recent stu-

dies have demonstrated that for atrial flutter ablation aiming the complete isthmus block using the electroanatomical mapping approach could significantly reduce the fluoroscopic time. The present article describes both techniques for guiding atrial flutter ablation: 1. The conventional approach, 2. The electroanatomic (CARTO) approach.

Conventional mapping strategy

Detection of intraatrial conduction block is achieved by using different multipolar catheters in the coronary sinus and the right

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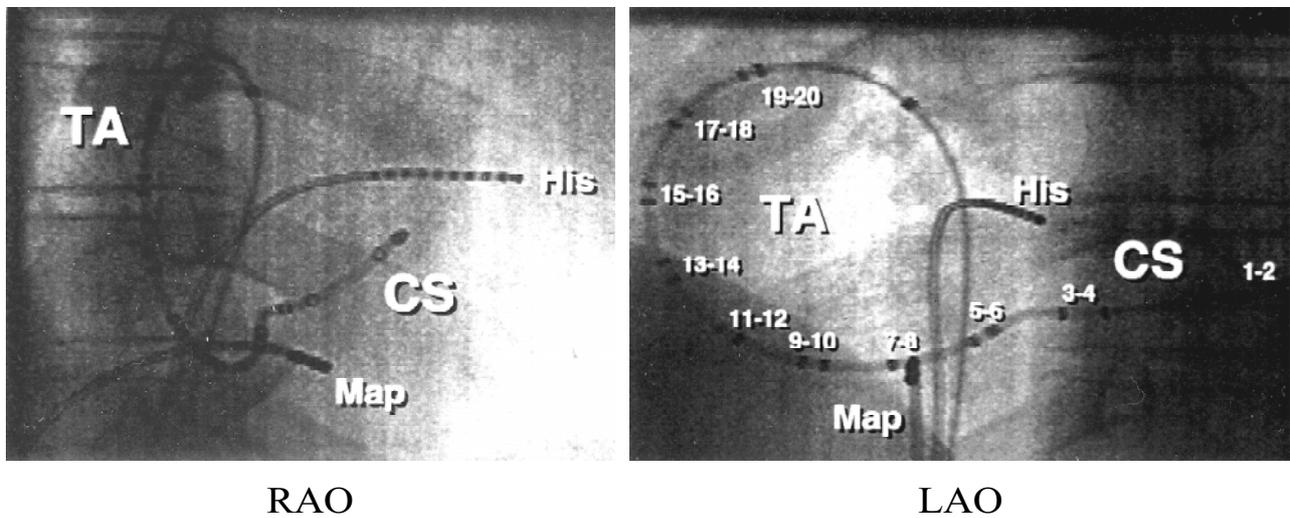


Fig. 1. Fluoroscopic view in RAO (left) and LAO (right) of standard catheter position for conventionally guided RF ablation of the inferior cavotricupid isthmus. The single right atrial and coronary sinus mapping catheter is placed with its distal part in the coronary sinus. The proximal part is placed adjacent to the tricuspid annulus (TA). The ablation catheter as shown in this example was located at the ventricular aspect of the TA, demonstrating a representative starting position for a linear RF current lesion.

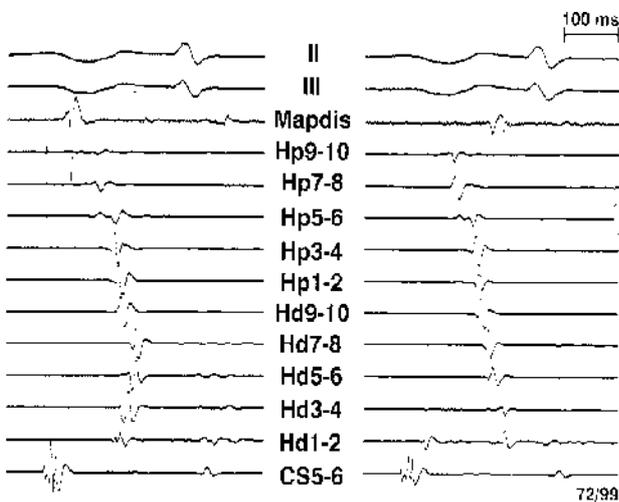


Fig. 2. Conventional local electrogram recording before (left) and following (right) induction of complete isthmus block. The induction of complete isthmus block is demonstrated by a change of conduction fronts obtained the free wall of the right atrium while maintaining constant coronary sinus pacing. The conduction front in the left panel shows bidirectional activation with a collision in the posterolateral region of the right atrium. There was some delay of isthmus conduction detectable due to previous RF applications. After induction of complete isthmus block there was a solely cranio-caudal activation along the free wall (right panel). (Hp: proximal Halo-catheter; Hd: distal Halo-catheter, CS: coronary sinus)

atrium. Either two separated catheters for recording of local electrogram from the coronary sinus and the free wall of the right atrium could be used. Alternatively a single combined mapping catheter for right atrial and coronary sinus mapping (Fig. 1) can be used (9). This technique led to the reduction of catheters and the recording of stable local electrogram during long lasting ablation procedures (9). Furthermore, these catheters give the opportunity to record local electrogram directly in the cavotricupid isthmus. During sinus rhythm stimulation from the posterior to posteroseptal region of the coronary sinus and the posterolateral right atrium is achieved to detect the conduction properties via the isthmus from both sides. This technique provides a continuous recording of local electrogram during a complete ablation procedure. Transient or incomplete effects of isthmus block can be always observed. Infrequently rate dependent isthmus block has been described as well (7). After induction of complete bidirectional isthmus block is achieved by RF delivery (Fig. 2), the immediate recurrences of isthmus conduction can easily be seen during stimulation from both sides of the isthmus. Various investigators have been shown that the conventional approach for guiding isthmus ablation is safe and efficacious (3—6). Using a combined coronary sinus and right atrial mapping/stimulation catheter to guide the isthmus ablation may lead to a reduction of the overall procedure costs (9). On the other hand fluoroscopy time remains high due to the control of the ablation catheter during all RF pulses.

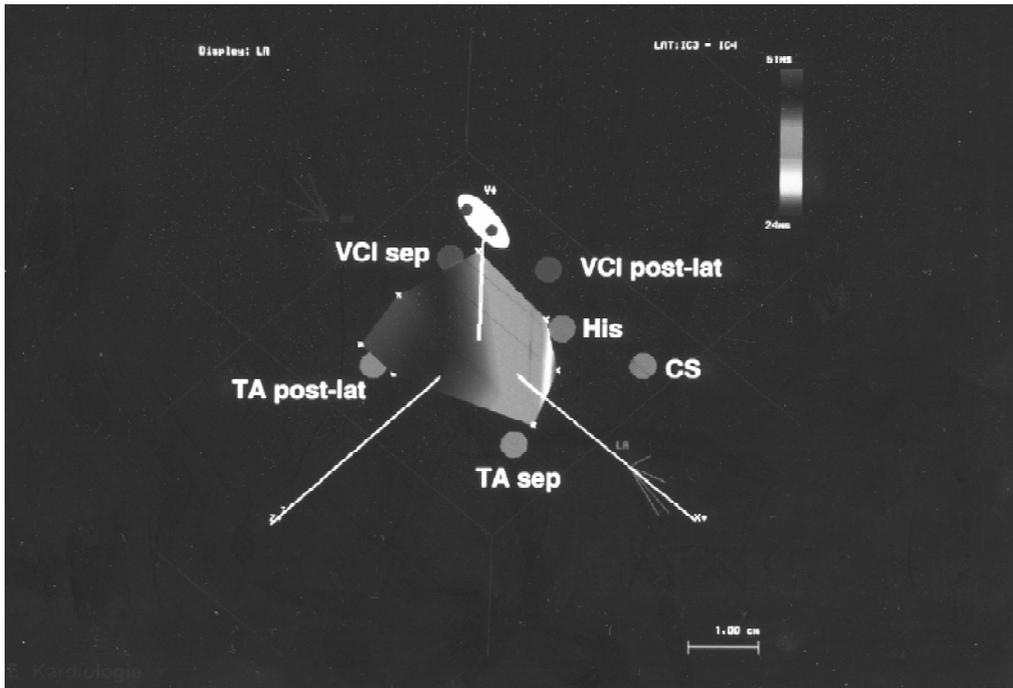


Fig. 3. Three-dimensional reconstruction and electroanatomic map of the cavotricuspid isthmus (left anterior oblique, cranial view). Initially, the coordinates of the isthmus are delineated under additional fluoroscopic guidance. Sequential mapping produces a superimposed color-coded activation map with a homogeneous pattern as seen before induction of isthmus block. Earliest activation time is represented by orange and latest activation by violet and magenta.

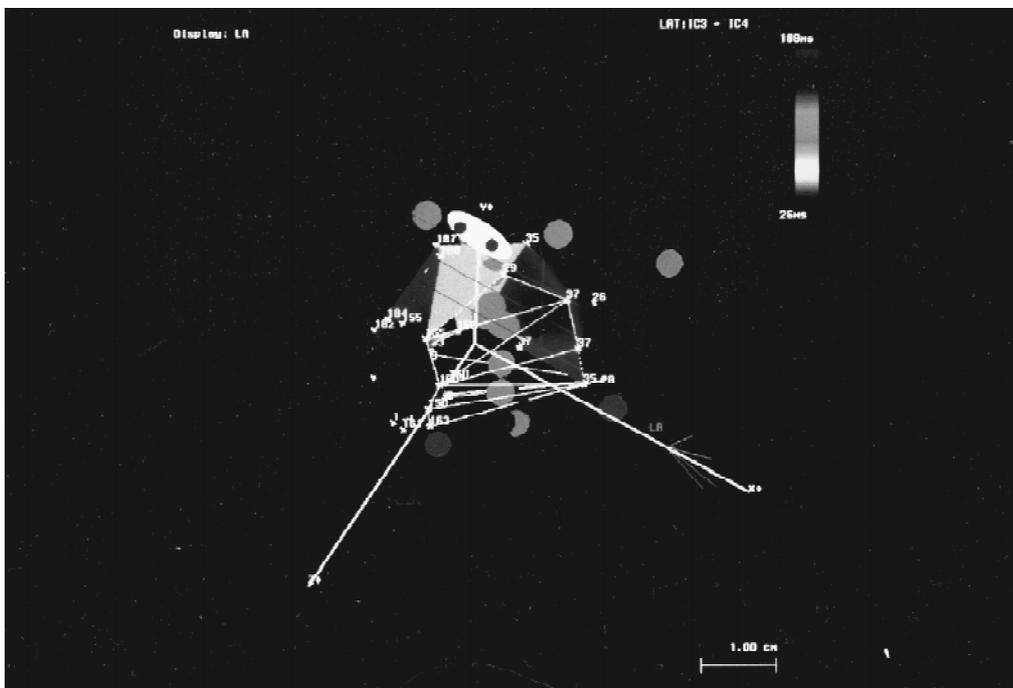


Fig. 4. The CARTO map demonstrates the induction of complete isthmus block (left anterior oblique, cranial view). Consecutively this map shows an abrupt shift of the color scale from orange to blue, purple and magenta. Both areas are separated only by the ablation line surrounded by a grey zone, which signifies the software solution for transition from earliest to latest activation. This zone reflects a time difference of 148 ms or more between both aspects of the entire ablation line.

Electroanatomical mapping technique

Details of the navigation and mapping system (CARTO[®], Cordis-Biosense Inc., HaCarmel, Israel) has been described previously (9—12). Briefly, a miniature magnetic sensor has been incorporated in the tip of a 7-French mapping/ablation catheter (NAVI-STAR, Cordis Webster, Baldwin Park, CA, USA). The ablation catheter has a 4 mm-tip electrode with 1 mm interelectrode distance between the tip and the first ring. Three ultralow magnetic field emitters (using 3 different transmission frequencies) are located beneath the patient providing location and orientation of the mapping/ablation catheter in 6° of freedom (x, y, z, roll, pitch and yaw). The reference catheter (REF-STAR, Cordis Webster, Baldwin Park, CA, USA) is equipped with an identical magnetic sensor and is externally attached on the patient-back, directly behind the heart. To prevent any movement of the reference catheter it has to be taped on the skin. Local activation time from a coronary sinus catheter electrode is normally used as reference for the local activation time of the mapping/ablation catheter. The activation time is color-coded depicted at each mapping site relative to the timing of the reference signal. Both the unipolar electrogram (filtered at 1—400 Hz) and the close bipolar electrogram (filtered at 30—400 Hz) are recorded from the mapping catheter. Initially, the mapping catheter is placed in the right atrium under fluoroscopic guidance at the beginning of the procedure. For anatomic landmarks a HIS-bundle electrogram was obtained in the anteroseptal region and the coronary sinus ostium will be marked via the mapping/ablation catheter. A virtual frame of the boundaries of the cavotricuspid isthmus will be delineated (Fig. 3). For this purpose, septal and posterolateral sites will be visited close to the tricuspid annulus and at the orifice of the inferior vena cava under fluoroscopic guidance. The conduction properties of the isthmus region are investigated during pacing of the coronary sinus (Fig. 3) and the posterolateral right atrium. Various mapping sites within the cavotricuspid isthmus are visited and acquired during stimulation. Each anatomic position of a novel mapping site, as well as the activation time determined from the stimulus artifact to the local electrogram obtained via the mapping catheter, will be incorporated into a three-dimensional reconstruction. Acquisition of each new point will be permitted only if the beat-to-beat variation of the local electrogram was <2 msec and the end-diastolic alteration of the catheter tip was <2 mm, respectively. The „triangle filling threshold“ is a programmable cutoff point at which the computer does not superimpose the activation time between two acquired mapping sites when the preselected anatomic distance is exceeded. The procedure will be started using a “triangle filling threshold“ of 25 to 30 mm and will be continued with a reduced range of 20 to 25 mm whenever higher anatomic accuracy will be required.

Sequential “point-by-point“ application of single RF pulses starts at the ventricular aspect of the tricuspid annulus when a stable electrogram with a small atrial and large ventricular amplitude can be recorded. Navigation of the ablation catheter can be obtained at this phase of the mapping procedure solely on the

basis of the CARTO system. The middle region between the virtual septal and posterolateral border of the cavotricuspid isthmus will be targeted for the initial application. Subsequently, the anatomic location of each ablation site was acquired and superimposed on the previously generated frame. The ablation catheter will be withdrawn slightly after each application in order to produce the most linear and continuous lesion until the ostium of the inferior caval vein has been reached. After completion of a linear ablation line in the cavotricuspid isthmus a complete map of the ablation will be performed. For detection of a complete isthmus block either no potential or double potentials separated by >100 msec had to be recorded at all sites of the lesion line. If this is the case a repeat electroanatomic map of the isthmus has to be obtained. This map requires at least two lines of multiple mapping points parallel to the RF lesion at the septal and the lateral aspect. A solely lateral-to-septal propagation of the color-coded activation sequence at the lateral aspect of the ablation line during coronary sinus stimulation was mandatory to meet the criteria of conduction block (Fig. 4). Additionally, a time interval >100 msec measured between both aspects along the entire ablation line was assumed to be consistent with the conduction block. Both, the activation map before and the “remap“ after RF ablation has to be performed as well as during pacing from the coronary sinus as pacing the posterolateral right atrium.

The complete ablation procedure and the remap after completion of the RF lesion line can be obtained solely under the guidance of the electroanatomic mapping system. This cause a significant reduction of fluoroscopic time required for the complete ablation procedure and could be recently demonstrated in randomized studies (13—14).

The cavotricuspid isthmus frequently has a heterogeneous anatomy with a high prevalence of nonuniform arrangement of trabecular muscles (15). Thus, three-dimensional reconstruction with the CARTO system should improve adjustment of the ablation line with respect to the individual anatomic configuration of the target region. Furthermore, the mapping system facilitated renavigation of the electrode after achieved transient effect (15—16).

RF ablation of common-type atrial flutter by delivery of linear applications in the area of the cavotricuspid isthmus has been introduced as the method of choice for treatment of atrial flutter. Induction of complete bidirectional isthmus block detected by conventional atrial mapping techniques has been established as a predictor associated with long-term success after acute successful ablation. Long X-ray exposure times of up to almost two hours reported in previous studies must be considered. The long fluoroscopic duration can be attributed mainly to the need to carefully monitor the electrode position during the RF applications to avoid catheter dislocation and potential complications.

The reduction of X-ray exposure required for the ablation procedure is of major clinical impact with respect to health of patients and medical staff.

However, the modern CARTO technology incorporated in the system will increase the overall costs for RF ablation procedures.

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