Ablation of typical right atrial flutter with a single catheter approach: a pilot study

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April 28, 2020

Abstract

Introduction: The success rate of cavo-tricuspid isthmus (CTI) ablation to treat right common flutter is high, up to 95%, but needs bidirectional block confirmation, requiring 2 or 3 catheters. We describe a new pacing technic using a single catheter to ablate and confirm CTI block with differential PR interval measurements. Methods: We included 61 patients from 5 centers that were referred for CTI ablation. All patients had CTI ablation and the CTI block was confirmed by differential pacing using 2 or 3 catheters. The new method consisted in measuring PR interval on the surface ECG using pacing from the tip of ablation catheter on the lateral side (lateral delay) and septal side (coronary sinus ostium) of the CTI line (difference =delta PR interval) before and after CTI ablation. We analyzed the value of delta PR interval to predict bidirectional CTI block as confirmed by standard methods. Results: Among our patient's population (63±12 years-old), 39 patients were ablated during sinus rhythm while 22 during common flutter. CTI block was achieved in all patients but one. Then, Lateral delay and delta PR interval increased significantly after validation of CTI block (257±42ms vs 318±50ms and 32±23 vs 96±22ms, p<0.0001, respectively). A cut-off [?]70ms of delta PR interval had a 100% of sensitivity and specificity to predict bidirectional CTI block. Conclusion: A single catheter ablation approach to perform CTI line based on surface ECG PR interval measurement is feasible. After ablation, CTI block

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Disclosures : none to declare by the authors for this study

STRUCTURED ABSTRACT

Introduction : The success rate of cavo-tricuspid isthmus (CTI) ablation to treat right common flutter is high, up to 95%, but needs bidirectional block confirmation, requiring 2 or 3 catheters. We describe a new pacing technic using a single catheter to ablate and confirm CTI block with differential PR interval measurements.

Methods:

We included 61 patients from 5 centers that were referred for CTI ablation. All patients had CTI ablation and the CTI block was confirmed by differential pacing using 2 or 3 catheters. The new method consisted in measuring PR interval on the surface ECG using pacing from the tip of ablation catheter on the lateral side (lateral delay) and septal side (coronary sinus ostium) of the CTI line (difference =delta PR interval) before and after CTI ablation. We analyzed the value of delta PR interval to predict bidirectional CTI block as confirmed by standard methods.

Results: Among our patient's population (63±12 years-old), 39 patients were ablated during sinus rhythm while 22 during common flutter. CTI block was achieved in all patients but one. Then, Lateral delay and delta PR interval increased significantly after validation of CTI block (257±42ms vs 318±50ms and 32±23 vs 96±22ms, $p<0.0001$, respectively). A cut-off [?]70ms of delta PR interval had a 100% of sensitivity and specificity to predict bidirectional CTI block.

Conclusion: A single catheter ablation approach to perform CTI line based on surface ECG PR interval measurement is feasible. After ablation, CTI block was systematically obtained when the delta PR interval was higher than 70ms.

Key words: Right atrial flutter; ablation; single catheter; PR interval

INTRODUCTION

Typical right atrial flutter (RAFl) is a common cardiac arrhythmia mainly treated by catheter ablation as a first line therapy (1, 2). This technic is associated with a high success rate around 95% (3). However, the absence of recurrences following the procedure depends highly on the validation of bidirectional cavo-tricupsid isthmus (CTI) block (4, 5). This block is usually validated by differential pacing across the CTI line and needs two or three catheters to be demonstrated (6, 7). Indeed, CTI block is routinely validated by coronary sinus (CS) pacing proving a descending activation of the right atrium (RA) lateral wall. Then, when pacing is performed close to the lateral aspect of the line of block, activation of the infero-septal part of the RA occurs before the septal part of CTI line (8). Finally, CTI line block is confirmed with double potential recorded all along the line during CS pacing (9). The use of multiple catheters, through several venous access, increases procedural cost, and potentially complications. Further, this strategy can be jeopardized by limited venous access (tortuosity or abnormality).

Recently, measurement of PR interval on surface ECG has been proposed as a new and easy endpoint to validate CTI line block (10). Indeed, PR interval measured during atrial pacing from the tip of ablation catheter at different sites of the tricuspid annulus could predict CTI block. We propose to study the predictive value of differential surface ECG PR measurement to assess CTI block to validate a single catheter approach to perform RAFl ablation.

METHODS

Patient selection and ablation procedure

Sixty-one consecutive patients addressed for typical RAFl ablation were prospectively included in this study from September 2017 to March 2019. These patients were enrolled in five French centersO. At baseline, ECG showed either a common flutter or sinus rhythm (SR). Exclusion criteria were previous right atrial surgery, baseline PR interval > 240 ms or right atrial or ventricular pacing requirement with permanent pacemaker. For all patients, the standard procedure was performed with CTI block confirmation as described below. The single catheter approach was evaluated at the same time with surface ECG PR measurement at baseline for patients in SR or immediately after SR recovery if patient was in flutter at baseline. PR interval was then also measured when CTI block was confirmed with the standard approach (2 or 3 catheters).

Ablation procedure

Informed consent was obtained for all patients and the procedure was scheduled after 4 to 6 hours of fasting. Sedation with intravenous midazolam and buprenorphine was used as necessary during ablation. Bipolar electrograms were filtered through a bandpass of 30 to 500 Hz and recorded at high gains (0.1 mV/cm) at a paper speed of 100 mm/ sec. Femoral venous access was obtained to introduce three catheters into the RA. A steerable quadripolar catheter (Xtrem; Ela Medical, Le Plessis-Robinson, France deflectable quadripolar catheter; Bio) was positioned within the coronary sinus (CS). A Lifewire decapolar catheter 2-8-2 (St. Jude Medical, St. Paul, MN, USA) was positioned on the right atrium lateral wall. A 8mm tip ablation catheter EZ Street 8mm Biosense Webster, Diamond Bar (USA) or Therapy 8mm Abott-StJude medical, St Paul, Minn, (USA) were used to deliver a maximum power of 70 W and a maximum target temperature of 70 degrees. The ablation was performed under fluoroscopy or with 3 dimensional mapping system (Carto 3, Biosense Webster, Diamond Bar (USA) or Precision Abott-StJude medical, St Paul, Minn, (USA)) for patients undergoing concomitant pulmonary vein isolation (PVI) for atrial fibrillation ablation. The validation of the ablation efficacy was assessed after cessation of atrial flutter for patients in common flutter at baseline and after obtaining a stable bidirectional isthmus block at least 20 min after ablation.

Validation of CTI block with standard method (2 or 3 catheters)

The following criteria were used to define bidirectional isthmus conduction block once the patient was in SR:

- During CS pacing, complete reversal of the lateral right atrial (LRA) depolarization sequence from proximal to distal on the decapolar catheter

-During pacing from the distal electrode of the decapolar catheter, activation sequence with atrial signal recorded on the His position before the atrial signal recorded on the CS catheter

-During CS pacing, the presence of double potentials, well separated with an isoelectric line, with a minimum interval of 90 ms along the ablation line

These endpoints were reevaluated after a waiting period of at least 20 min to confirm the persistence of CTI bidirectional conduction block.

Validation of CTI with the single ablation catheter

In SR, the ablation catheter was positioned on the septal part (at the CS ostium) of the CTI line and PR interval was measured on surface ECG from the atrial CS spike to the peak QRS measured on lead II (septal delay, Figure 1). We used this definition to better define the end of PR interval, because the beginning of the QRS can be harder to precisely identify as compared to the peak of the QRS. This measurement was performed during pacing at 800 ms or 10 bpm faster than the baseline patient heart rate. Then, pacing at the same cycle length was performed on the lateral side of the CTI line (lateral delay). PR measurement were recorded before and after the CTI block was confirmed with the standard method. Delta PR interval was obtained by subtracting the septal delay from the lateral delay. Figure 2 shows examples of PR measurement before and after CTI block achievement.

Statistics

Descriptive results are displayed as mean+-SEM or median (interquartile range) for continuous variables, according to the normality of the distributions. Categorical data are described as number (percentage). Continuous variables were compared using the paired Student t-test. Receiver operating characteristic (ROC) curves were constructed to determine the cut-off value, sensitivity (Se), and specificity (Spe) of the delta PR interval. Two-sided p values <0.05 were considered statistically significant. Statistical analyses were performed using SPSS Inc. Released 2007. SPSS for Windows, Version 16.0. Chicago, SPSS Inc.

RESULTS

Baseline Characteristics

As shown in Table 1, patients mean age was 63+-12 years. Hypertension and diabetes mellitus were present in 34% and 11% of cases respectively and beta blockers and amiodarone were the two predominant antiarrhythmic drugs used in 62% and 33% of patients respectively.

CTI ablation data

Thirty-nine patients were ablated during SR at baseline while 22 were ablated in common flutter. PVI was performed concomitantly in 28 patients. CTI block was achieved in all patients but one. Baseline PR interval was measured in 52 patients as 9 patients had already complete block when back to SR. All patients had PR measurement after CTI ablation.

A shown in Table 2, lateral delay and delta PR interval significantly increased after validation of CTI block (from 257+-42 ms to 318+-50 ms and 32+-23 to 96+-22 ms, respectively, $p<0.0001$,).

Finally, a ROC curve was performed to obtain the best cut-off of delta PR interval to predict CTI block. A delta PR interval [?] 70 ms was the best predictor with an AUC of 1. As highlighted in Figure 3, all patients, in whom CTI block was confirmed with the standard method, had a delta PR interval greater than 70 ms (range 71-152 ms), while no patient without CTI block could reach this value (range: 0-68ms) , yielding a sensitivity and specificity of 100% to predict CTI block.

DISCUSSION

This study demonstrated that common RAFl ablation can be performed with a single ablation catheter approach while still enabling CTI block verification. In addition, we found that a difference of 70 ms between PR interval assessed at lateral versus septal side of the line could predict with a 100% sensitivity and specificity the presence of a complete CTI block.

This approach has been recently proposed by Madaffari et al (10). They introduced the possibility to validate CTI block using surface ECG PR interval measured at septal and lateral part of the isthmus. We confirmed their results on a larger series of patients (61 versus 31 patients). However, they used a cut-off of 80 ms of PR increase to validate CTI block. Our cut-off of 70 ms clearly demonstrated as shown in Figure 3 a 100 % of sensitivity and specificity. This slight discrepancy was likely due to the variability of PR interval measurement and the difference in PR interval measurement method. Indeed, we measured PR interval from the atrial spike to the peak of QRS in lead II as it appeared that this method was associated with less variability compared to the beginning the QRS which can be in some cases particularly difficult to assess. In addition in our study, the septal delay was obtained by CS pacing whereas Madaffari et al were pacing from the ablation catheter at 5 o'clock on the tricuspid annulus. We think pacing from the CS ostium is more reproducible than pacing from the septal CTI.

We think that this technic is accurate and could also reduce the cost of this procedure. Indeed, CTI ablation is usually performed with 2 or 3 catheters and we estimate that the use of the single catheter approach could reduce the procedure cost up to 30%. Consistent with this, Pambrun et al (11) also used the single catheter ablation approach to perform PVI with a high success rate and demonstrated a significant reduction in the cost procedure. Further this strategy could potentially reduce vascular complication rates and be used in the setting of venous abnormalities when access is difficult to obtain.

In our approach, PR measurement is critical to validate the block and this measurement can be complex to perform. Then, we excluded for this technic, patients with PR longer than 240 ms at baseline or with permanent atrial or ventricular pacing requirement. Moreover, the pacing rate to measure PR interval is important and we recommend using atrial pacing at 800 ms or 10 bpm faster than the patient spontaneous heart rate if needed.

Finally, limitations associated with our technic include, the fact that CTI block cannot be assessed during ablation as no atrial pacing is performed during ablation, implicating the need to confirm the block after CTI line ablation. This technic provides unidirectional (lateral to medial) validation of the CTI block which appears to be sufficient in the vast majority of cases; and allows for differential pacing maneuvers. Yet, as with most technics used to validate block, a functional block could potentially be misclassified as a complete block when CTI line verification, waiting period or adenosine injection (12) are not carefully performed.

CONCLUSION

CTI ablation line using a single catheter approach based on differential PR interval measurement is feasible. CTI block was always present when PR interval difference measured during atrial pacing between the lateral and the septal side of the ablation line was greater than 70 ms.

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Figure Legends

Figure 1: Pacing manoeuvers to prove bidirectional block with the single catheter approach and method for delta PR measurement before and after CTI ablation

Figure 2: Examples of delta PR measurement before and after CTI block

Figure 3: Repartition of delta PR interval in patients before (0) and after (1) CTI block

Table 1: Patient's baseline characteristics

Patient characteristics	All patients n=61
Age, years	63±12
Male gender, n (%)	43 (70)
Risk factors, n (%)	
Hypertension	21 (34)
Diabetes mellitus	7 (11)
Cardiovascular history, n (%) Heart failure	12 (20) 6 (10) 28 (46) 1 (2) 32 (52) 39 (64)
Coronary artery disease Associated atrial fibrillation Previous pacemaker Paroxysmal flutter Patient in SR at baseline **Echocardiographic parameters** LVEF (%) LA enlargement (>45ml/m2) n (%) **Electrocardiographic parameters** PR interval (ms) Atrial Flutter Cycle lenght (ms)	56.3±10.7 19 (31) 177±32 249±28
Drugs n (%) Flecainide Betablockers Sotalol Amiodarone Calcium inhibitors	10 (16) 38 (62) 0 (0) 20 (33) 0

Table 2. Evolution of Electrical Delays before and after CTI ablation

	Before CTI blocked	After CTI blocked	P value
Septal Delay (ms)	220±38	222±49	0.58
Lateral Delay (ms)	257±42	318±50	<0.0001
Clockwise Delay (ms)	86±24	150±22	<0.0001
Counterclockwise Delay (ms)	89±25	157±31	<0.0001
Delta PR interval (ms)	32±23	96±22	<0.0001

Septal Delay = Delay from CS pacing spike to peak QRS on lead II

Lateral Delay = Delay from Ablation distal at 7 o'clock pacing spike to peak QRS on lead II

Clockwise Delay = Delay from CS pacing spike to RA lateral catheter on distal electrodes

Counterclockwise Delay = Delay from RA lateral catheter on distal electrodes pacing spike to CS proximal

Delta PR interval = Lateral Delay – Septal Delay

Figure 1

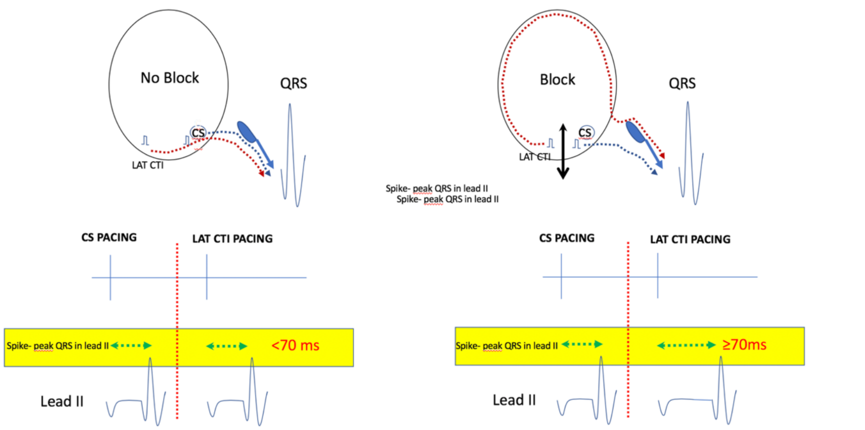

Figure 2

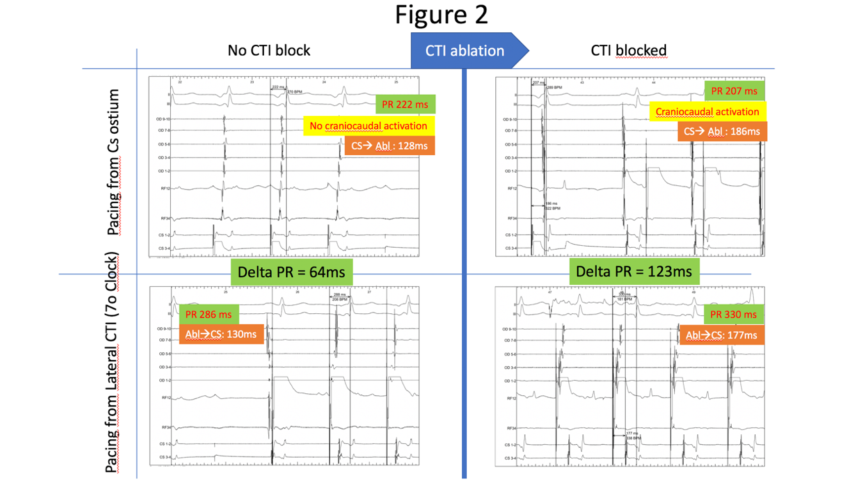

Figure 3