Right Atrial Collision Time (RACT): A Novel Marker Of Propensity For Typical Atrial Flutter

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Abstract

Introduction: The risk of typical atrial flutter (AFL) is increased proportionately to right atrial (RA) size or right atrial scarring that results in reduced conduction velocity. These characteristics result in propagation of a flutter wave by ensuring the macro re-entrant wave front does not meet its refractory tail. The time taken to traverse the circuit would take account of both of these characteristics and may provide a novel marker of propensity to develop AFL. Our goal was to investigate right atrial collision time (RACT) as a marker of existing or future typical AFL. **Methods:** This single centre, prospective study recruited consecutive typical AFL ablation patients that were in sinus rhythm. Controls were consecutive electrophysiology study patients >18 years of age. While pacing the coronary sinus (CS) ostium at 600 ms, a local activation time map was created to locate the latest collision point on the anterolateral right atrial wall. This RACT is a measure of conduction velocity and distance from CS to a collision point on the lateral right atrial wall. **Results:** 98 patients were included in the analysis, 41 with atrial flutter and 57 controls. Patients with atrial flutter were older, 64.7 ± 9.7 vs 52.4 ± 16.8 years (<0.001) and more often male (34/41vs 31/57 (0.003)). The AFL group mean RACT (132.6±17.3 ms) was significantly longer than that of controls (99.1±11.6 ms) (p<0.001). A RACT cut-off of 115.5 ms had a sensitivity and specificity of 92.7% and 93.0% respectively for diagnosis of atrial flutter. An ROC curve indicated an AUC of 0.96 (95% CI: 0.93-1.0, p<0.01). **Conclusion**: RACT is a novel and promising marker of propensity for typical AFL. This data will inform larger prospective studies. The ability to predict AFL would be of significant clinical value to guide anticoagulation and ablation decisions.

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Conclusion : RACT is a novel and promising marker of propensity for typical AFL. This data will inform larger prospective studies. The ability to predict AFL would be of significant clinical value to guide anticoagulation and ablation decisions.

Key words: Typical atrial flutter; wavefront collision, electroanatomic mapping, ablation, atrial fibrillation, electrophysiological studies.

Introduction

Typical atrial flutter (AFL) is a common atrial arrhythmia that can result in significant morbidity and mortality when left untreated[1, 2]. Catheter ablation is a highly effective, first-line treatment for typical AFL that results in a low recurrence rate and reduction of stroke risk[3, 4]. Whereas ablation of the flutter circuit is indicated in patients with documented AFL, it may also be a reasonable consideration in those without a documented AFL history, but high risk of unrecognized AFL or development of AFL in future[5]. This may allow for attenuation of stroke risk in a group that may eventually present with thromboembolic complications as the first indication of AFL. A simple diagnostic maneuver to determine the existence of a potential AFL circuit, and therefore a risk of occult or future AFL, would be very useful. This could support the decision on whether to empirically ablate a flutter circuit at time of ablation for other rhythms, such as atrial fibrillation. We investigated right atrial collision time (RACT) during coronary sinus pacing as a surrogate marker of a potential right atrial flutter circuit, and thereby a candidate marker of occult or future AFL which may inform anticoagulation and ablation decisions.

Methods

Patients:

Consecutive patients attending in sinus rhythm for evaluative diagnostic electrophysiologic studies for supraventricular tachycardia (SVT) were recruited. Exclusion criteria were absence of documented sinus rhythm, presence of permanent pacemaker or implantable cardioverter-defibrillator (ICD), lack of coronary sinus catheter utilization for any reason, a documented history of atrial fibrillation, lack of electroanatomic mapping system, or continued use of antiarrhythmic drugs within 5 half-lives before the procedure.

The patient cohort was divided into those with a history of documented AFL and controls. AFL patients were defined as subjects with a documented history of typical atrial flutter on 12-lead ECG. Control patients were defined as subjects with a history of SVT, the intended clinical target of the present ablation, but

without history of documented AFL. The study protocol was reviewed and approved by Queen's University Health Sciences and affiliated teaching hospital's research ethics board.

Electrophysiology study:

Diagnostic studies were performed under conscious sedation or general anaesthesia. An electroanatomic mapping system was used in all cases. A diagnostic decapolar catheter (Inquiry, Abbott, St Paul, MN) was placed within the CS with proximal poles positioned at the ostium on fluoroscopy. A deflectable ablation catheter (Tacticath, Abbott, St Paul, MN) or multipolar catheter (Advisor HD Grid, Abbott, St Paul, MN) was used to map the cavo-tricuspid isthmus (CTI) and the lateral right atrial (RA) wall during pacing from the CS at a cycle length of 600 ms. Wavefront collision was defined as the latest point on the lateral RA wall where cranial and caudal wavefronts reproducibly met, as illustrated in Figure 1. Full diagnostic studies were performed in all subjects and ablation was then directed at the SVT or AFL substrate as clinically indicated.

Follow-up:

Post procedural follow up was according to standard of care. The heart rhythm service routinely followed patients at three months post procedure. 12-lead ECG and 48-hour Holter monitor were ordered routinely as standard of care at 3 months in all AFL patients. Control patients had routine 12 lead ECG, and monitoring was ordered if symptoms recurred. Patients with recurrence of typical atrial flutter were offered a repeat procedure, while patients diagnosed with new atrial fibrillation were managed with either medical therapy or a left atrial ablation at the discretion of the electrophysiologist and considering patient's wishes. Recurrence of SVT prompted an offer of repeat ablation. Follow-up data were collected retrospectively by chart review and by contacting physician offices.

Statistical Analysis

Data were assessed for normality using the Anderson-Darling test. Continuous, normally distributed data were compared using a two-sample T test. Categorical data were compared using Chi Square tables. Binary logistic regression was used to create receiver operator curves and for multivariate analysis. Spearman's rank correlation was used to create a correlation matrix. Minitab version 21 (State College, PA) was employed for statistical analysis. Alpha <0.05 was considered statistically significant.

Results

Among 110 consecutive patients screened, 98 met entry criteria and were included in the study. Of 45 patients with documented atrial flutter, 4 were excluded - 1 due to atypical flutter on ECG, and 3 due to lack of electroanatomic mapping. Forty-one AFL patients were therefore included in the analysis. Sixty-five control patients were recruited: 43 with a clinical diagnosis of AVNRT, 14 with AVRT, 2 with ischaemic VT, 6 patients with monomorphic PVCs and one diagnostic study for undocumented symptoms of palpitations. Fifty-seven control patients were eligible for the analysis after applying exclusion criteria.

Patient characteristics are summarized in Table 1. Demographic differences included significant age and sex differences between groups. AFL patients were older, with a higher proportion of male patients. This is related to the high prevalence of AVNRT (42) and AVRT (14) in the control group. AFL patients had a greater proportion of ischaemic heart disease, hypertension, valvular disease and obstructive sleep apnoea. This was reflected in the greater use of cardiac medication in the AFL group. Echo characteristics differed, with greater LA and RA volumes in the AFL group. AFL patients more often presented with reduced LVEF.

Correlation of RACT and demographic variables are illustrated in Table 3. RACT was significantly longer in AFL patients compared with the control group (132.6+-17.3 vs 99.1+-11.6 $p<0.001$) (Table 1). There was no significant interaction of sex and RACT values (Table 2). There was no significant association of RACT with age (Pearson correlation 0.41). On multivariate analysis RACT was independently associated with atrial flutter diagnosis (OR 1.6 (1.1 – 2.4) $p = 0.03$). A RACT value of 115.5ms had a sensitivity of

92.7% and specificity of 93.0% for diagnosis of atrial flutter (AUC 0.96). Increasing the cut off value to 130ms reduced sensitivity to 60.1% and increased specificity to 100% (Figures 2 and 3).

Mean follow-up was 401.9 days (+-239.9). There were no recurrences of atrial flutter, and one recurrence of AVNRT during the follow-up period. Thirteen patients, all within the AFL group, developed clinical atrial fibrillation. RACT was significantly longer in patients who developed atrial fibrillation than those who did not (141.7 +- 21.0ms vs 108.8 +- 18.5ms, p <0.001). When only the AFL group was considered regarding development of AF, RACT value was higher and approached significance (141.7 +- 21.0ms vs 128.4 +- 13.7 ms, p=0.052). Among AFL patients, a RACT value of 135.5ms provided a sensitivity of 75% and specificity of 81.4% for development of AF, and AUC was 0.89. On multivariate analysis including age, BMI, LVEF, RACT, LA and RA volume, only RACT was independently associated with development of atrial fibrillation, (OR 1.1 (1.01, 1.24) p=0.024).

Discussion

Pacing from the coronary sinus typically results in collision of diverging wavefronts at an area remote to the site of pacing, at some point along the lateral aspect of the tricuspid annulus. A multipolar catheter positioned anterior to the crista terminalis, laterally within the right atrium, reflects this collision as a 'chevron' pattern, and is a classical measure in clinical EP[6, 7]. With the increased use of electroanatomic mapping this site of wavefront collision can be more accurately rendered and measured. For the purposes of this study, we assessed the latest point of cranial and caudal wavefront collision (Figure 1). The last point to be activated in this area is reproducible and represents the latest collision site of the inferior and superior wavefronts. The timing and location of this collision point reflects the conduction properties of the atrium, which are altered in patients with a potential atrial flutter circuit or atrial fibrillation[8, 9]. This approach provides a single, straightforward measure that incorporates the heterogenous factors that contribute to conduction delay, whether structural or cellular[10].

We hypothesised that the collision point measure would reflect these differences in patients with atrial flutter compared with a control group without atrial flutter or fibrillation. In the population as a whole we observed a large range of values, from 97 msec to 197 msec. The vast majority of control patients had collision time of less than 120msec when pacing from the coronary sinus at 100bpm. Only 3 AFL patients had a RACT of < 115msec, two were younger than 50 years of age, and an older male with a history of VSD repair that may have influenced conduction time. The marked difference that was observed between the two groups fits with the physiologic requirement of longer conduction times to maintain a re-entrant AFL circuit with an excitable gap[11]. Shorter conduction times, as observed in the control group, would allow the wavefront to encounter the refractory 'tail' of the circuit and extinguish conduction. Variation in RACT was not related to sex, age or BMI. Larger atria, however, were associated with longer RACT (Pearson 0.53, p<0.001), suggesting that RACT may reflect an atrial myopathic process that can lead to atrial arrhythmias, and that this can be directly measured in at-risk individuals. Supporting this notion was the association of longer RACT and incidence of AF during follow-up. Atrial fibrillation occurs in many patients who initially manifest only atrial flutter and the observation that a third of our AFL cohort developed AF is in keeping with our previous findings[2]. The fact that the RACT value was significantly longer in these patients may be helpful to guide anticoagulation decisions during follow up, as related to risk of future atrial fibrillation after AFL ablation.

The notion that RACT might provide a measure of atrial myopathy risk for both atrial flutter and atrial fibrillation warrants further prospective study in light of our compelling findings of association. In the interim, RACT may have a role in assisting clinical decision making at time of diagnostic study and when considering empiric cavotricuspid isthmus ablation in the setting of ablation for atrial fibrillation.

Limitations

Our study is single centre and has relatively small numbers with both prospective and retrospective aspects. Groups were not well matched by demographics, and it remains possible that these differences in RACT were influenced by confounding factors. Missing data on RA and LA volumes prevented more conclusive data

interpretation. Atrial flutter is predominately diagnosed in male subjects and women were underrepresented in our sample. Although no statistical sex difference was observed, this should be interpreted with caution given the small sample size.

Conclusions

RACT is a novel and promising marker of a potential right atrial flutter circuit and thereby the propensity for clinical atrial flutter. A value of 115.5 ms has a sensitivity and specificity of 92.7 and 93.0% respectively for the diagnosis of typical atrial flutter. This simple electrophysiologic marker presents opportunity for further study as a marker of future AFL risk and potential utility of tricuspid isthmus ablation at time of EP study.

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Legends

Table 1

Continuous data presented as mean +- standard deviation. Age in years, LA Vol and RA vol in ml/m2. RACT in msec. * represents missing data (Controls: 30, 25 and 22 missing values for RAvol, LAvol rand LA diameter respectively. Flutter: 16, 9 and 7 missing values for RAvol, LAvol and LA diameter respectively).

Table 2

Right atrial collision time in msec for control and flutter subjects by sex.

Table 3

Correlation matrix for RACT and demographic variables. Spearman rank correlation.

Figure 1:

Left panel: Surface ECG leads I, II and V1. Coronary sinus electrograms proximal to distal and right ventricular lead electrograms. Digital calipers denote time from pacing spike to latest activation point illustrated inn right panel. Right panel: Local activation time map of the right atrium during pacing from the proximal coronary sinus. The left atrium geometry is rendered for illustration. SVC denotes superior vena cava; IVC denotes inferior vena cava. Latest activation time at the RACT is 86msec.

Figure 2:

Receiver operator curve plotted for RACT and diagnosis of atrial flutter.

Figure 3:

Right atrial collision values in msec for control (red dot) and flutter (black square) subjects plotted against age in years. Reference lines values for RACT in msec. See text for further details.

Tables:

Table 1

	Flutter	Controls	P-Value
Demographic	Demographic	Demographic	Demographic
Age	64.7 ± 9.7	52.4 ± 16.8	<0.001
Female	7/41	26/57	0.003
Hypertension	22/41	12/57	0.001
Diabetes Mellitus	7/41	3/57	ns
Ischaemic heart disease	10/41	3/57	0.006
COPD	4/41	2/57	ns
Dyslipidaemia	8/41	4/57	ns
BMI	29.6 ± 6.8	29.0 ± 5.4	ns
OSA	11/41	5/57	0.017
LVEF	52.7 ± 13.3	61.5 ± 8.7	0.001
LAvol*	35.9 ± 10.5	25.8 ± 7.6	<0.001
RAvol*	29.0 ± 14.2	18.3 ± 6.5	0.002
LA diam*	4.1 ± 0.6	5.3 ± 7.4	ns
Significant valvular disease	4/41	0/57	0.016
EP diagnosis			
CTI dependent flutter	41/41	0	
AVNRT	0	43	
AVRT	0	13	
EPS only	0	1	
Medications	Medications	Medications	Medications
Betablockers	26	5	<0.001
ACE/ARB	14	11	ns

	Flutter	Controls	P-Value
Calcium antagonist	8	7	ns
AADˆ	12	0	<0.001
OAC	36	2	<0.001
RACT	132.6 ± 17.3	99.1 ± 11.6	<0.001

Table 2

	Flutter	Control	P-Value
Male	131.8 ± 18.1	99.8 ± 13.0	<0.001
Female	136.4 ± 12.7	98.3 ± 9.8	<0.001
P-Value	0.44	0.61	

Table 3

Sample	N	Correlation	95% CI for ρ	P-Value
Age	98	0.407	(0.227, 0.561)	0.000
BMI	98	0.097	(-0.104, 0.289)	0.344
LVEF	95	-0.326	(-0.495, -0.133)	0.001
RA Vol	49	0.533	(0.296, 0.708)	0.000
LA Vol	60	0.582	(0.385, 0.729)	0.000

Figures

Figure 1

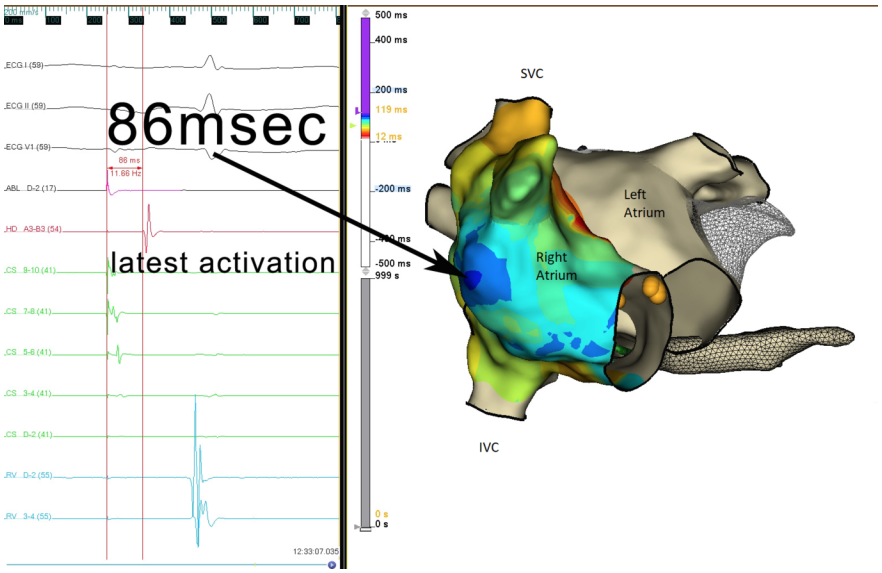

Figure 2

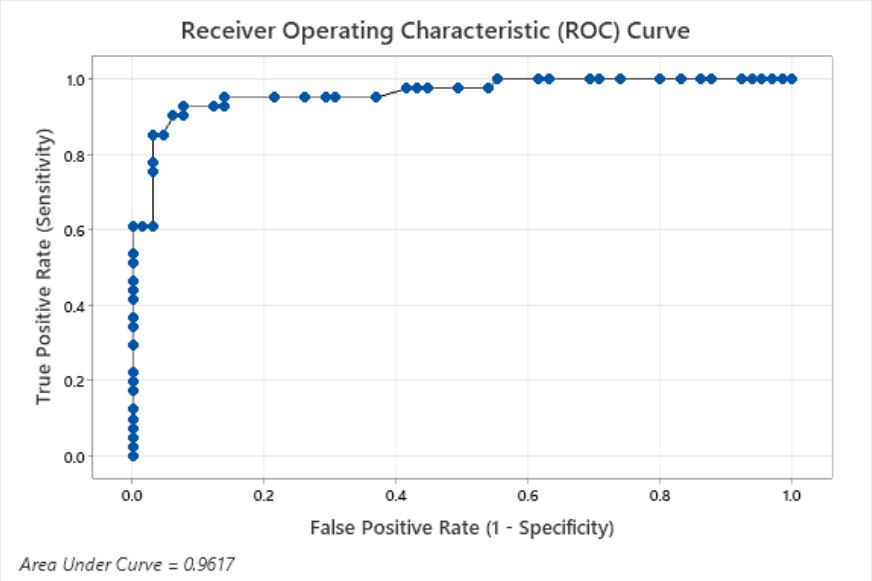

Figure 3