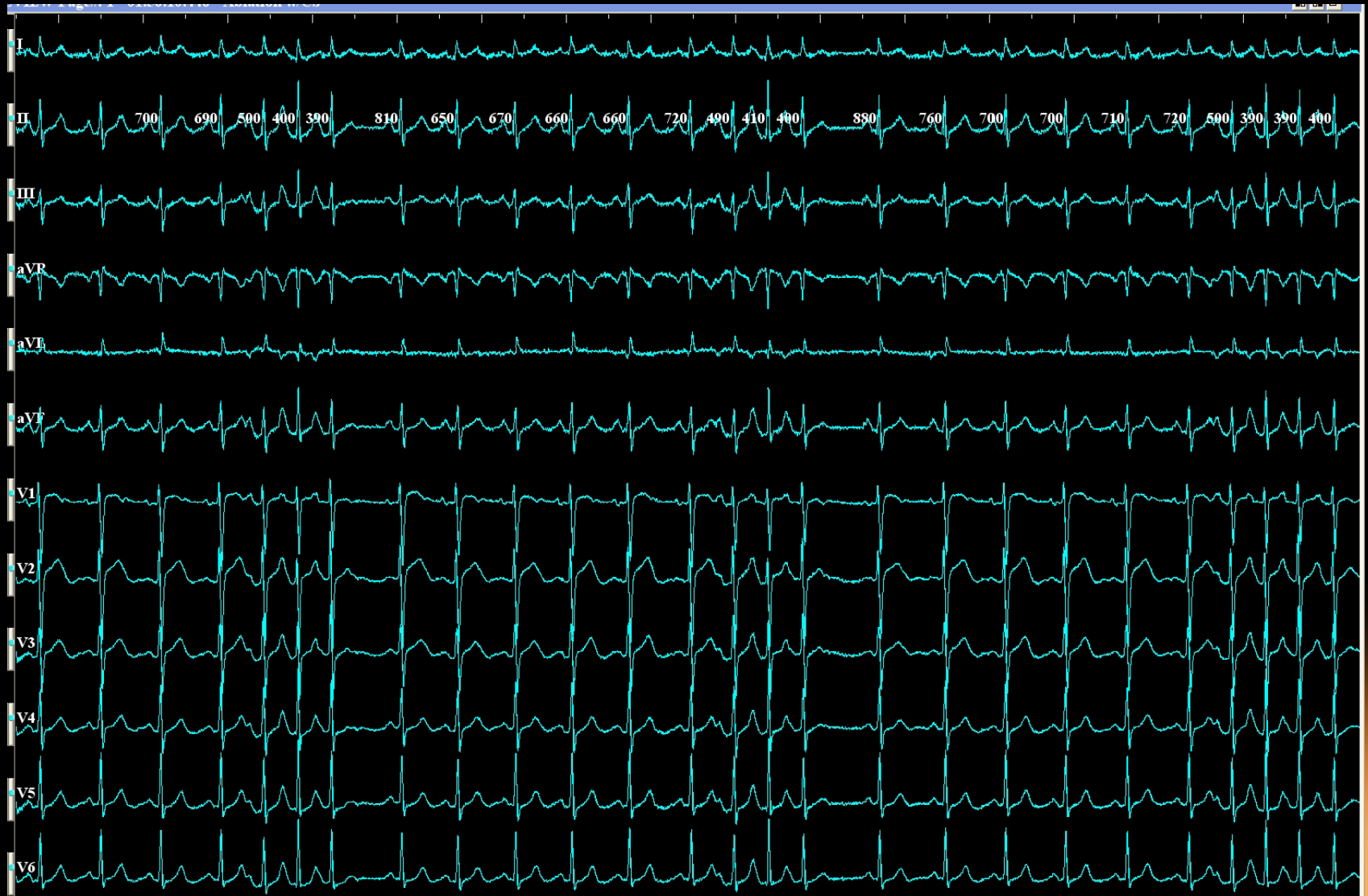


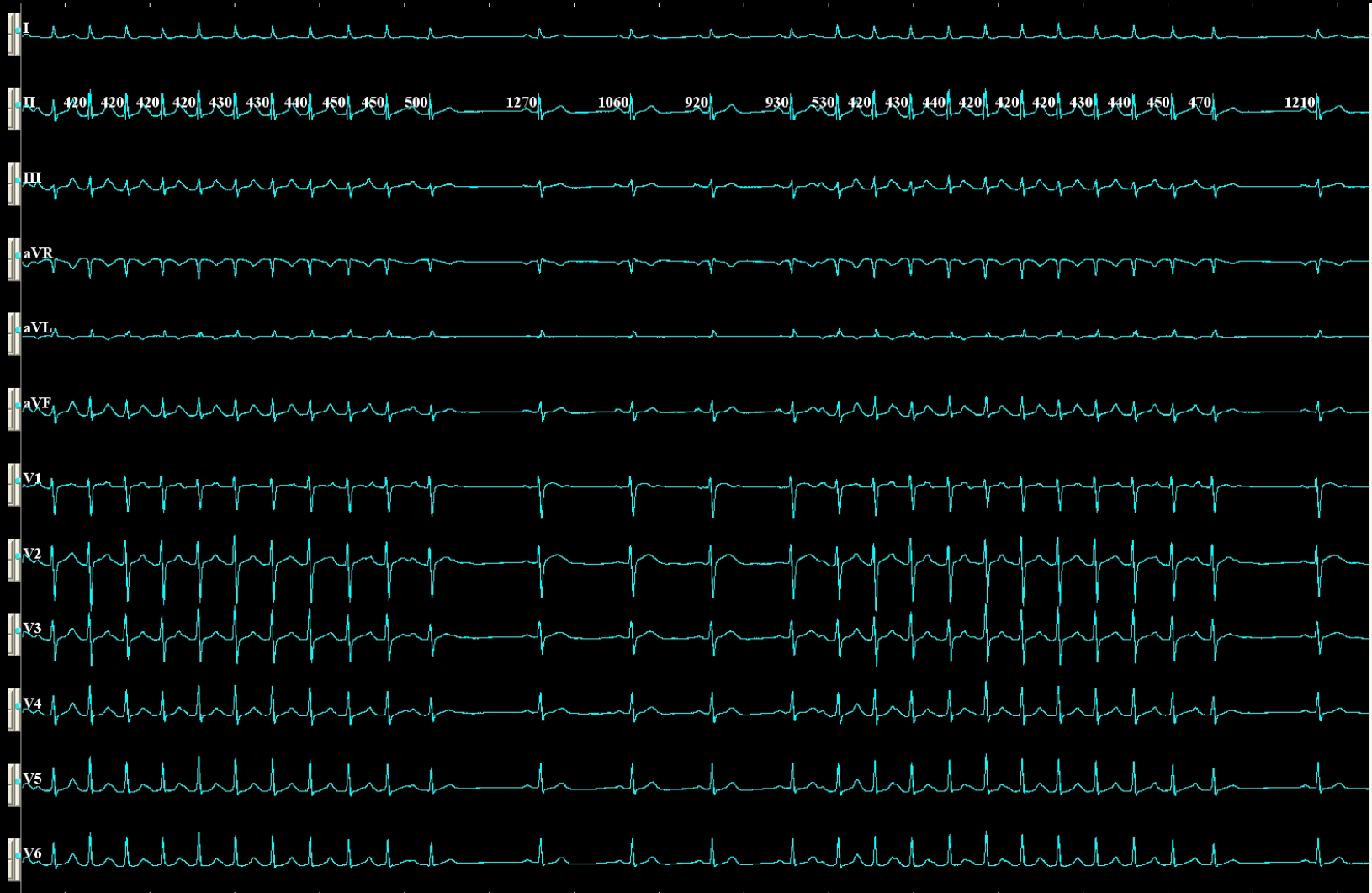
Case presentation

- 28 years old female
- Recurrent palpitations on daily basis
- Increased SOB
- Dizziness
- No family history of cardiac disease

12 leads ECGs



12 LEADS ECGs

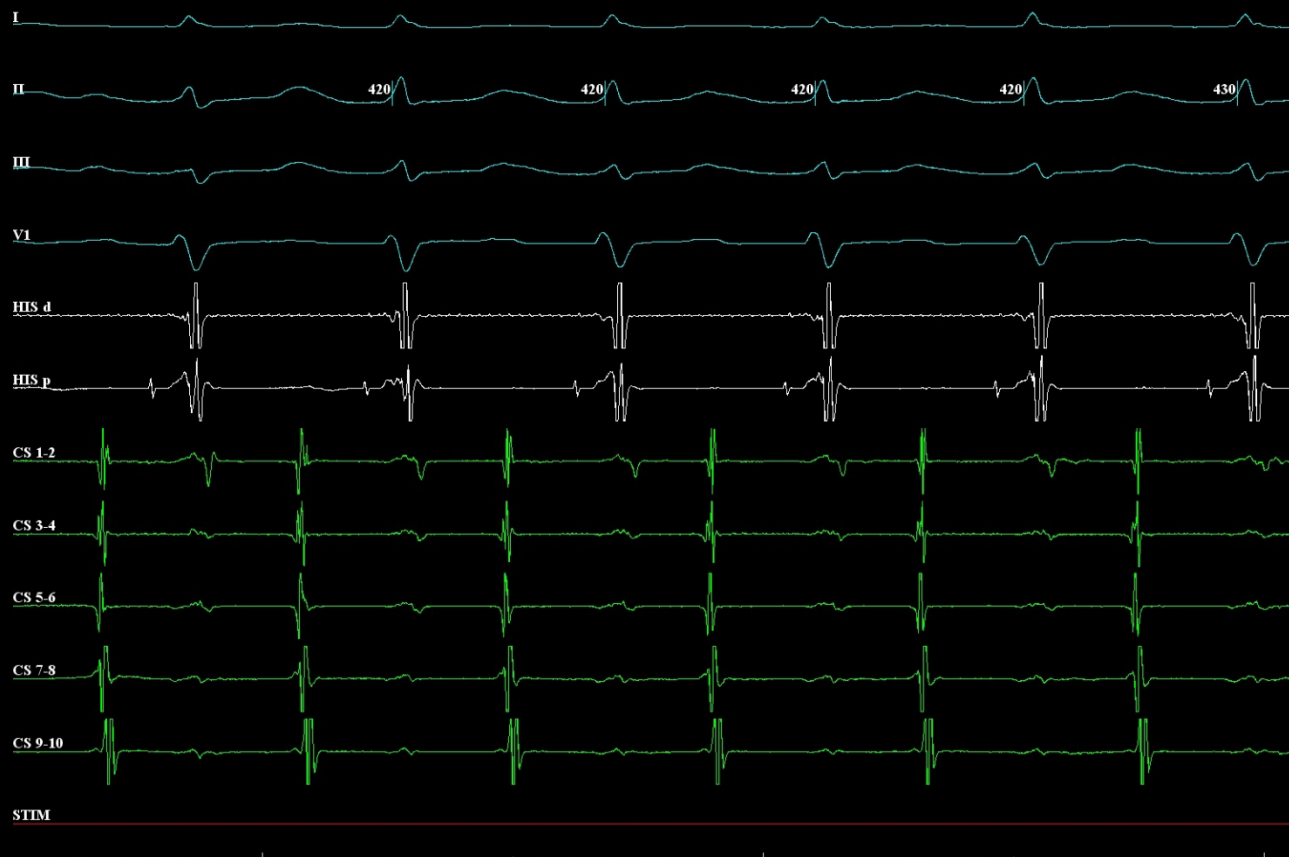


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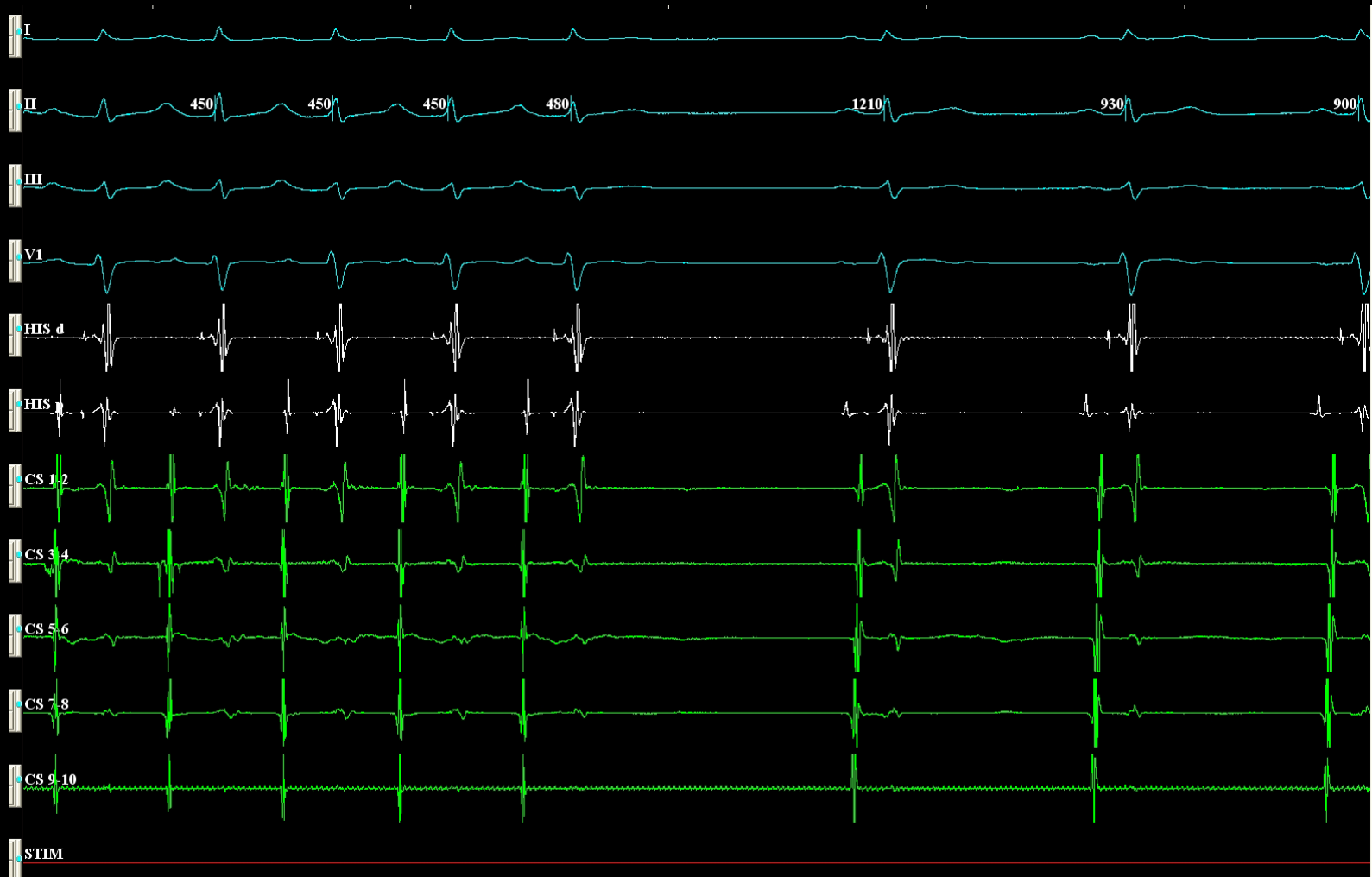
- Echo Mild to moderate LV dysfunction (tachycardia induced cardiomyopathy).

NEXT?

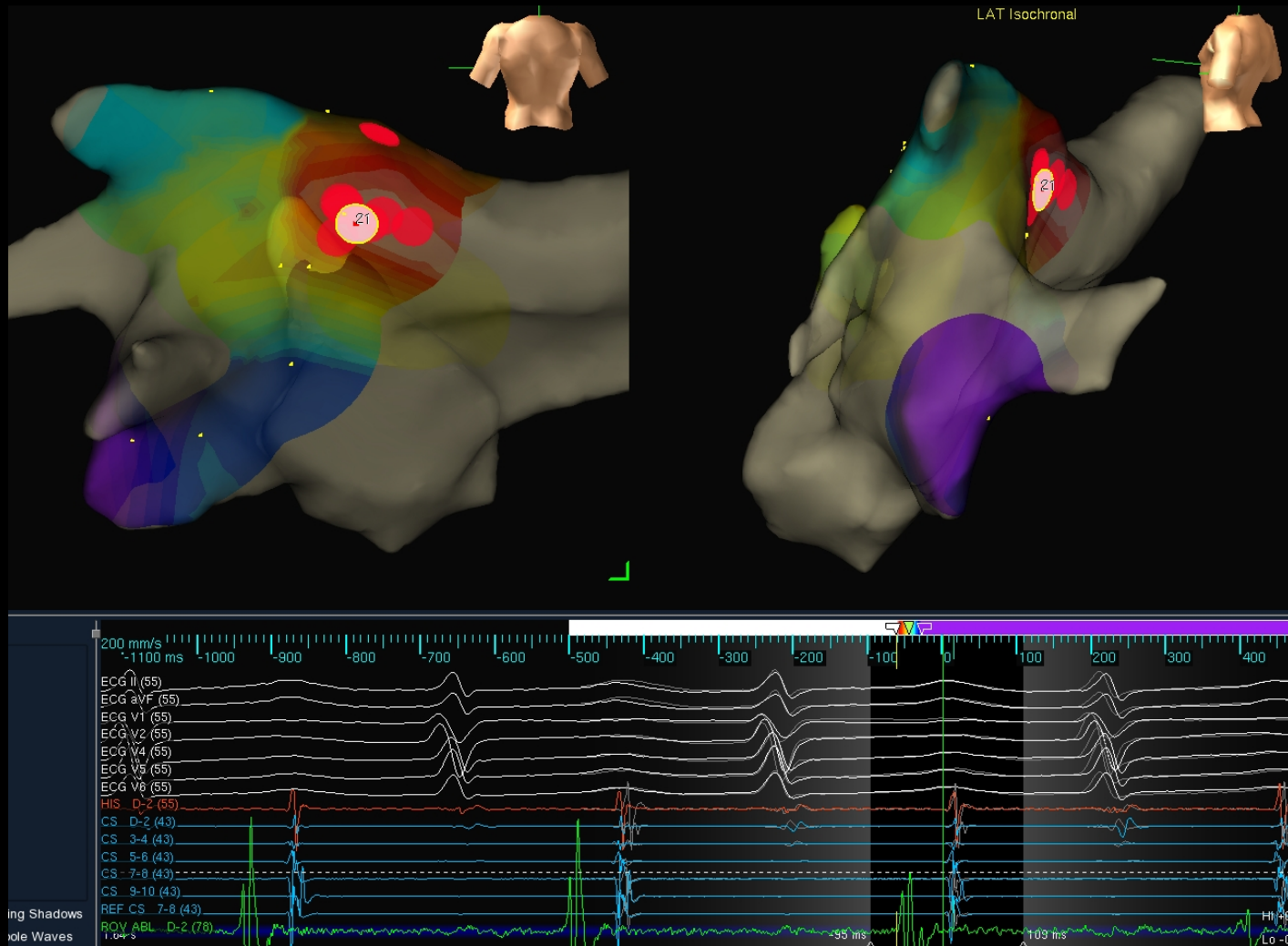
Intracardiac Electrograms during tachycardia



Intracardiac Electrograms during AT and SR



Activation map-earliest site on the roof-left superior pulmonary vein



Outline

- Tachycardia-induced cardiomyopathy(TCM)
- Focal Atrial Tachycardia
- TCM secondary to focal atrial tachycardia,
long-term outcome after catheter ablation

TCM

- Almost any tachyarrhythmia can cause tachycardia induced-cardiomyopathy, including very frequent PVCs(>20,000 /24hours) or recurrent non-sustained VT.
- The duration of arrhythmia, more than the heart rate, is probably a critical factor in TCM.
- Most cases of TCM improve within 3 to 6 months after correction of the arrhythmia

Focal Atrial Tachycardia

- Atrial rate 130-250 bpm
- male=female
- The prevalence: asymptomatic young pts **3/1000**, symptomatic patients **5/1000** .
- Asymptomatic vs palpitation, chest discomfort, dyspnea ,exercise intolerance rarely syncope
- **An abrupt onset and termination** of the tachycardia or **warm-up and cool-down** over 3–4 beats

Anatomy

- Right atrial focus(80%)
 - Crista Terminalis ,appendage, SVC,IVC
- Left atrial focus(20%)
 - Pulmonary vein, atrial septum , mitral annulus, appendage

Mechanism

- Abnormal automaticity
- Triggered activity
- Localised micro-reentry

Aetiology

- Pulmonary disease: COPD, pulmonary hypertension, or chronic hypoxia
- Myocardial ischemia/infarction , heart failure
- Hypokalemia/hypomagnesaemia
- Drugs: Digoxin, theophylline
- Exercise , Caffeine
- Cardiothoracic surgery (especially for congenital heart disease)

Classification

- Benign AT
 - Paroxysmal, regular, NCT at 80–140 bpm
- Incessant AT
 - Permanent, regular, NCT at 100–160 bpm
- Focal AT with an AV block
 - Regular AT with variable VR(Irregularly irregular)
 - Typically seen with Digoxin toxicity
 - Parasympathetic(inhibitory) effects on SA and AV nodes
 - Stimulatory effects on pacemaker cells(increased automaticity)

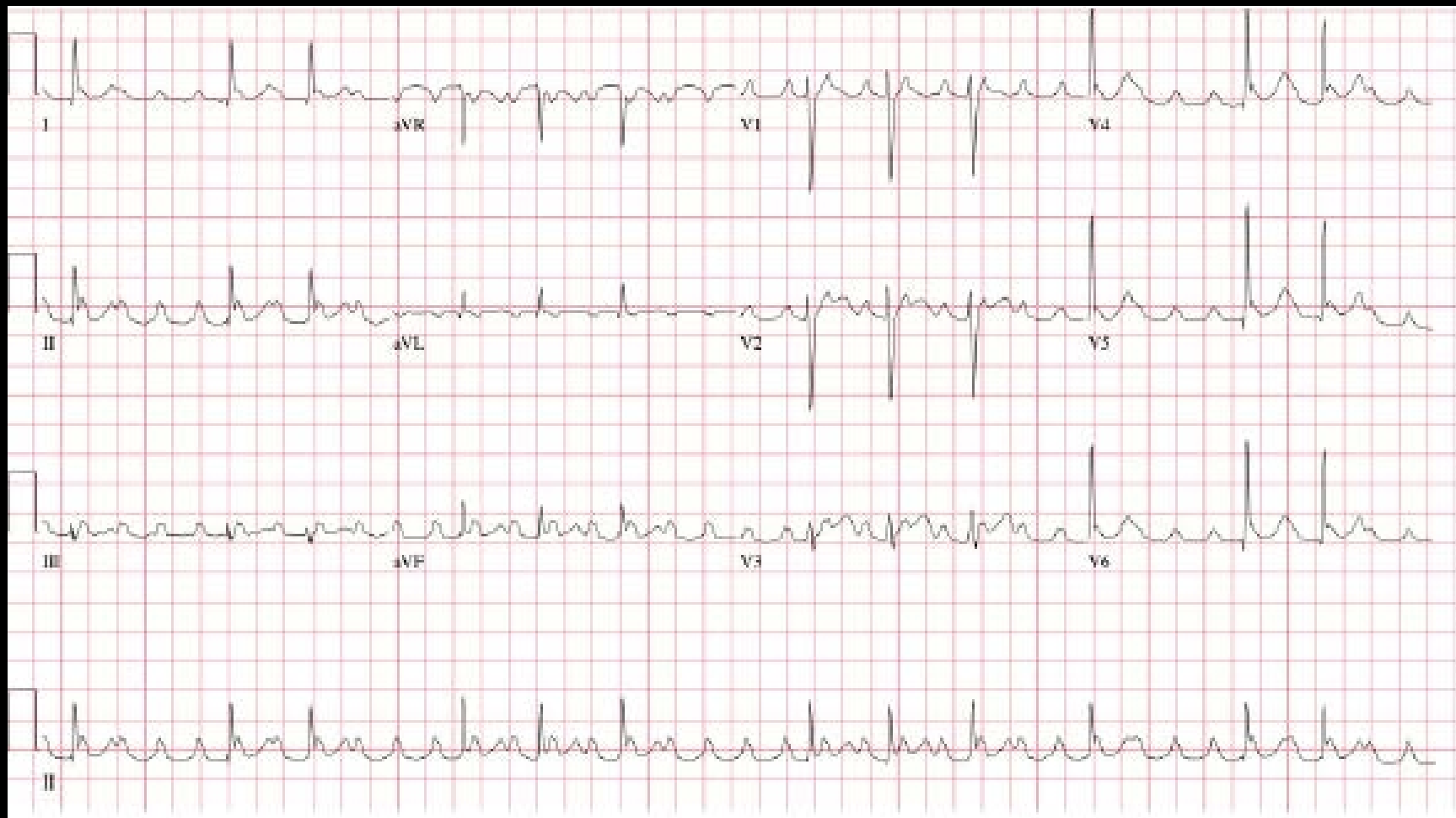
Classification

- Multifocal AT
 - Irregular NCT(100-250 bpm) due to simultaneous activation of multiple foci(>3)
 - Usually occurs during acute medical illness(typically respiratory disease)

Focal AT on ECG

- Long RP(>50% R-R interval)
- Narrow complex QRS(unless it's A/W BBB)
- P wave morphology:
 - Positive or biphasic P in V1 and negative P in aVL:
LA focus
 - Negative P in V1 and Positive or biphasic P in aVL :
RA focus

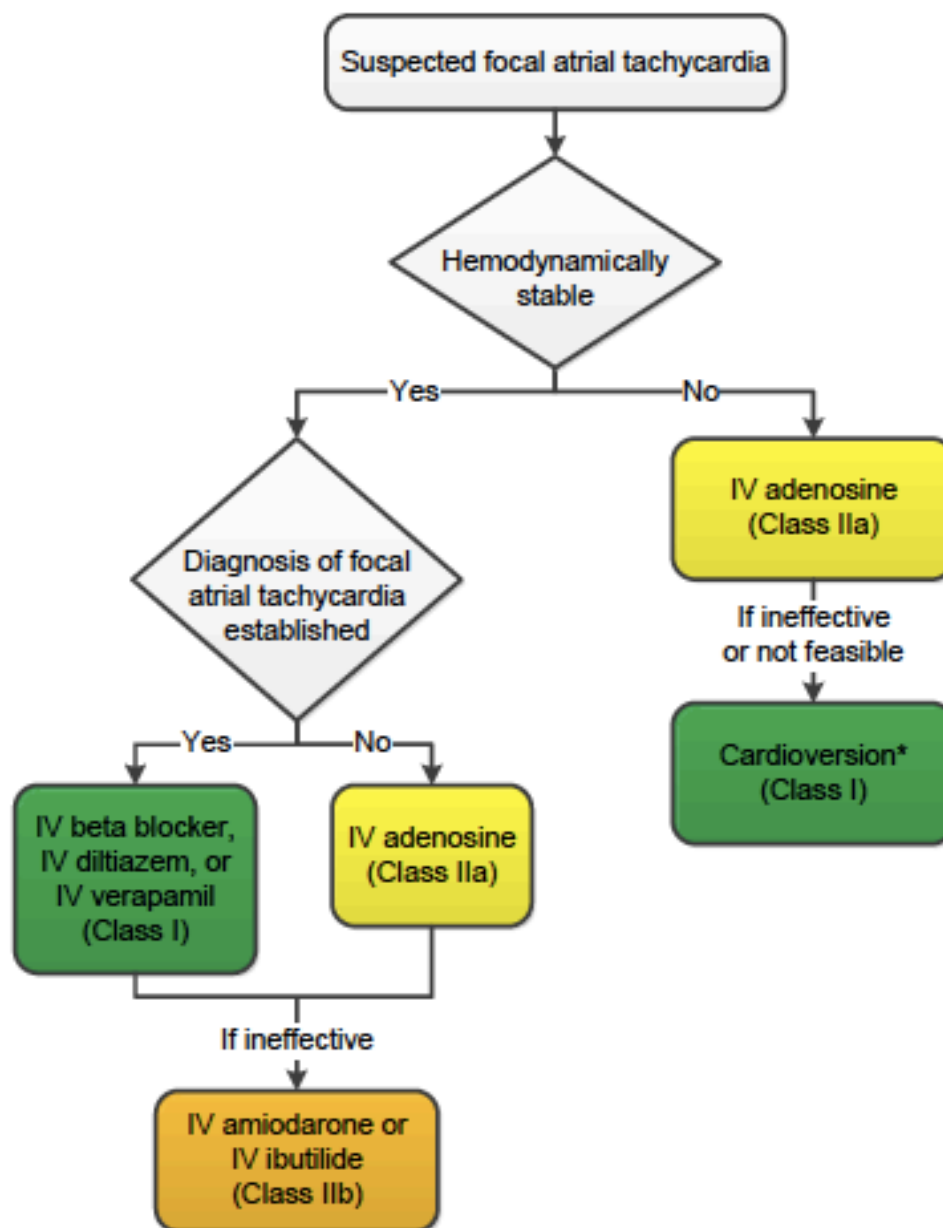
Right Atrium		Left Atrium	
V1: Negative P wave (Spec 100%)		V1: Positive (Spec 90%)	
aVL: Positive or biphasic (Spec 76%)		aVL: Negative P wave (usually)	
High II, III, aVF – positive	SVC	Superior PVs	<ul style="list-style-type: none"> Amplitude in lead II is ≥ 0.1 mV (Sp. 74%) P wave is larger in ectopy than sinus (lead II; Sp. 85%)
	Crista Terminalis <ul style="list-style-type: none"> P wave resembles sinus P is negative in aVR (Spec. 93%) 		
Low II, III, aVF – negative	Inferolateral	Left-sided PVs	<ul style="list-style-type: none"> Notching in lead II (only during ectopy; Spec. 95%) P-wave ratio in lead III:II ≥ 0.8 (Spec. 75%) V1 positive phase ≥ 80 ms (Spec. 73%)
	Inferomedial <ul style="list-style-type: none"> Negative P wave in V5–V6 Apex of Triangle of Koch or Septal <ul style="list-style-type: none"> P-wave duration is shorter than sinus 		
		Right-sided PVs	<ul style="list-style-type: none"> Positive P wave in aVL (Spec. 100%) P-wave amplitude in lead I ≥ 50 mcV (Spec. 99%)



Acute Mx

- **Carotid Sinus Massage**: usually unsuccessful. increase the degree of AV block and facilitate identifications of P waves.
- **Adenosine**: rarely can terminate it. (in micro-reentry or triggered activity)
- **DCCV** :maybe successful when the mechanism is micro-reentry or triggered activity but is unsuccessful in automatic ATs
- **Overdrive pacing**

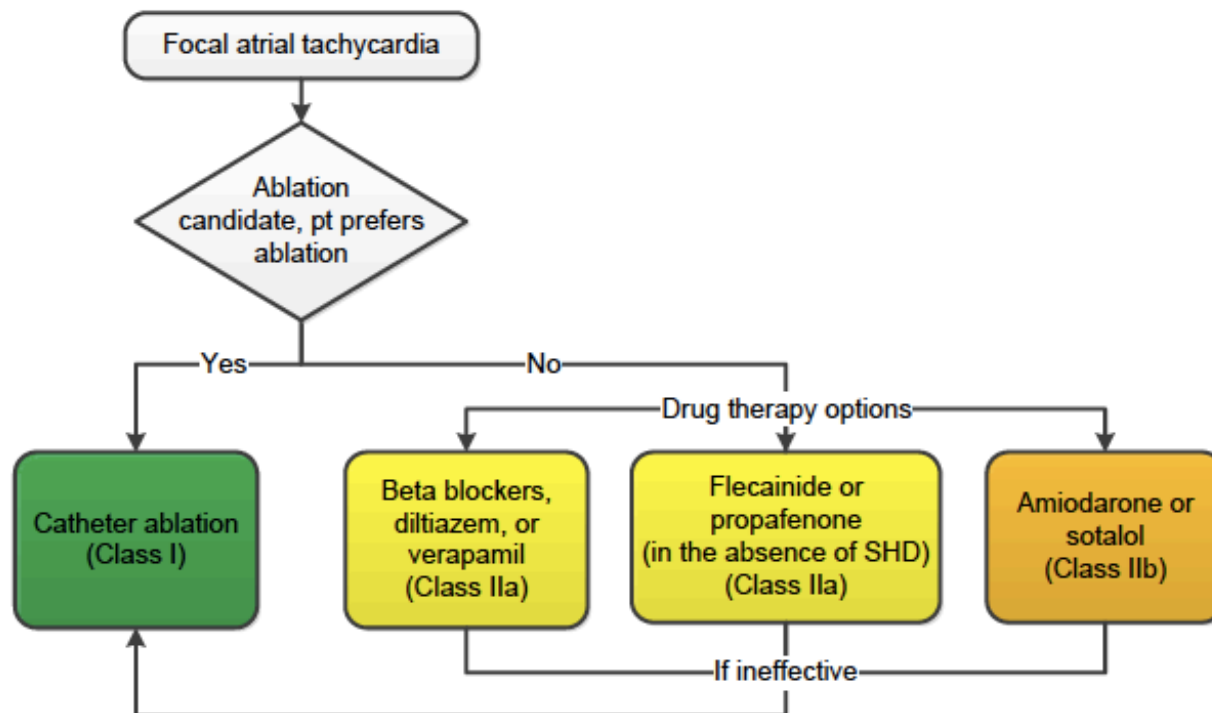
FIGURE 10 Acute Treatment of Suspected Focal Atrial Tachycardia



Mx

	Recurrent Symptomatic	Incessant SVT	Non-sustained Asymptomatic
Nothing	—	—	—
BB/ND-CCB	I	—	—
Disopyramide	IIa	—	—
Flecainide/propafenone	IIa	—	—
Sotalol/amiodarone	IIa	—	—
Ablation	I	I	III

FIGURE 11 Ongoing Management of Focal Atrial Tachycardia



Catheter ablation for focal AT

- **Indications:** symptomatic , recurrent, refractory to medical therapy , first line alternative in patients with structurally normal heart
- **Success rate :80-100%**
- Recurrence rate 8%
- **Highest success rate** with **RA foci**
- **Lower success rate:** males , multiple foci, repetitive forms of AT
- **Higher recurrence rate:** older, multiple foci, structural heart disease
- Anticipated complications: similar to all invasive ablation procedures

Tachycardia-Mediated Cardiomyopathy Secondary to Focal Atrial Tachycardia

Long-Term Outcome After Catheter Ablation

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Objectives

To determine:

- the incidence of TCM among patients presenting with focal AT
- the electrophysiologic characteristics of focal AT associated with the development of reversible LV dysfunction
- the long-term clinical outcome after successful catheter ablation.

Methods

- 345 consecutive patients undergoing radiofrequency ablation for focal AT between January 1997 and July 2008.
- All had documented either **paroxysmal or incessant focal AT**.
- Definitions:
 - **Incessant tachycardia**: Continuous tachycardia or continuous paroxysms of tachycardia separated by <2 sinus beats
 - **Acute procedural (RFA) success**: by the absence of tachycardia or ectopy 30 min after ablation despite infusion of isoprenaline and burst atrial pacing.

Methods

- Patients had failed therapy with a mean of 1.5 \pm 1.2 AADs before RFA
- All had TTE before EPS/RFA
- Definition of LV dysfunction: LVEF <50%

Exclusion Criteria

- LV dysfunction in the context of known:
 - significant coronary artery disease
 - valvular heart disease
 - congenital heart disease
 - inherited cardiomyopathy
- Cardiomyopathy had been documented before the onset of tachycardia
- Segmental LV dysfunction

Follow up

- The treating electrophysiologist
- Telephone interview.
- Recurrent tachycardia was documented
- The patients with LV dysfunction underwent repeat echocardiography after successful ablation.

Table 2**Clinical Characteristics
of Patients With and Without TCM**

	TCM (n = 30)	No TCM (n = 301)	p Value
Age, yrs	39 ± 22	51 ± 17	0.0006
Male	60	38	<0.001
Incessant/very frequent paroxysmal	100	20	<0.001
Antiarrhythmic drugs	1.4 ± 1.3	1.5 ± 1.1	0.7
Symptom duration, yrs	6 ± 7	6 ± 8	0.9
TCL, ms	502 ± 131	402 ± 105	<0.0001
HR, beats/min	117 ± 21	141 ± 33	0.0007
Pre-ablation LVEF, %	35 ± 11	59 ± 1	<0.0001

TCM group (30 pts)

- 27 of 30 (90%) in incessant AT(114 ± 16 bpm) at the time of baseline (pre-ablation) echo
- 3 of 30 (10%) in SR(69 ± 9 bpm)
 - 2 patients : very frequent paroxysmal AT
 - 1 patient :incessant atrial ectopy

Localisation of the atrial focus

1. Electrophysiology study
2. P-wave morphology on surface ECG
3. Right atrial endocardial activation sequence during tachycardia
4. Conventional point by point mapping
5. 3-D electroanatomic mapping

Foci

- Right atrium

- ✓ the crista terminalis
- ✓ tricuspid annulus
- ✓ ostium of the coronary sinus
- ✓ the perinodal region.

- Left atrium

- ✓ predominantly at the pulmonary vein ostia
- ✓ less commonly at the mitral annulus, LAA, and left-sided septum.

Table 1 Clinical and Tachycardia Characteristics In Patients With Tachycardia-Mediated Cardiomyopathy

Anatomic Site	Age (yrs)	Male	Symptom Duration (yrs)	TCL	Ventricular Rate	Pre-Ablation LVEF
PV (n = 8)	36 ± 24	63 (5)	7 ± 8	407 ± 121	125 ± 14	34 ± 11
AA (n = 8)	24 ± 7	88 (7)	3 ± 5	616 ± 137	103 ± 19	34 ± 10
Perinodal (n = 2)	61 ± 28	100 (2)	0.8 ± 0.4	502 ± 45	123 ± 11	38 ± 11
CS (n = 1)	67 ± 0	100 (1)	5 ± 0	N/A*	89†	36
CT (n = 3)	41 ± 4	0 (0)	5 ± 5	413 ± 54	145 ± 23	40 ± 9
TA (n = 3)	44 ± 22	33 (1)	10 ± 13	406 ± 115	151 ± 49	45 ± 0
Multifocal (n = 5)	49 ± 28	40 (2)	7 ± 9	522 ± 32	116 ± 6	34 ± 13

Results

- Incessant AT occurred in 82 of 331 (25%) patients with focal AT.
- TCM occurred in 30 of 82(37%) patients with incessant tachycardia.
 - Incessant AT occurred most commonly from AAs and PVs foci

Table 3 **Anatomic Sites of Origin of Focal Atrial Tachycardia for Entire Study Population**

	PV (n = 44)	MA (n = 13)	AA (n = 19)	Perinodal (n = 40)	CS (n = 27)	CT (n = 85)	TA (n = 53)	Multi (n = 28)
Male	50 (22)	8 (1)	79 (15)	45 (18)	59 (16)	18 (15)	47 (25)	36 (10)
Age, yrs	38 ± 16	53 ± 16	33 ± 18	50 ± 14	40 ± 22	56 ± 13	48 ± 20	57 ± 14
Incessant	59 (26)	0 (0)	84 (16)	20 (8)	11 (3)	6 (5)	32 (17)	25 (7)
Tachycardia-mediated cardiomyopathy	18 (8)	0 (0)	42 (8)	5 (2)	4 (1)	4 (3)	6 (3)	18 (5)

Radiofrequency ablation(RFA)

- Attempted in 303 of 345 patients.
- Was not attempted in the remaining (n=42)
 - insufficient activity (n=22)
 - close proximity to the AV node (n=12)
 - multiple changing morphologies (n=8)

RFA

- Acute success was achieved in 272 of 303 (90%) patients.
- In patients with TCM, success without use of medication was achieved in 26 of 30 (87%) patients at mean follow-up of 23+/-21 months.
- Recurrent FAT
 - 3 patients , successful control with drugs
 - 1 patient underwent AVN ablation and PPM insertion

Recovery of LV function

- LV function returned to normal in 29 of 30 (97%) patients at 2.8 ± 2 months after successful catheter ablation
- No syncope or SCD in TCM treated with RFA at a mean follow-up of 20 ± 28 months

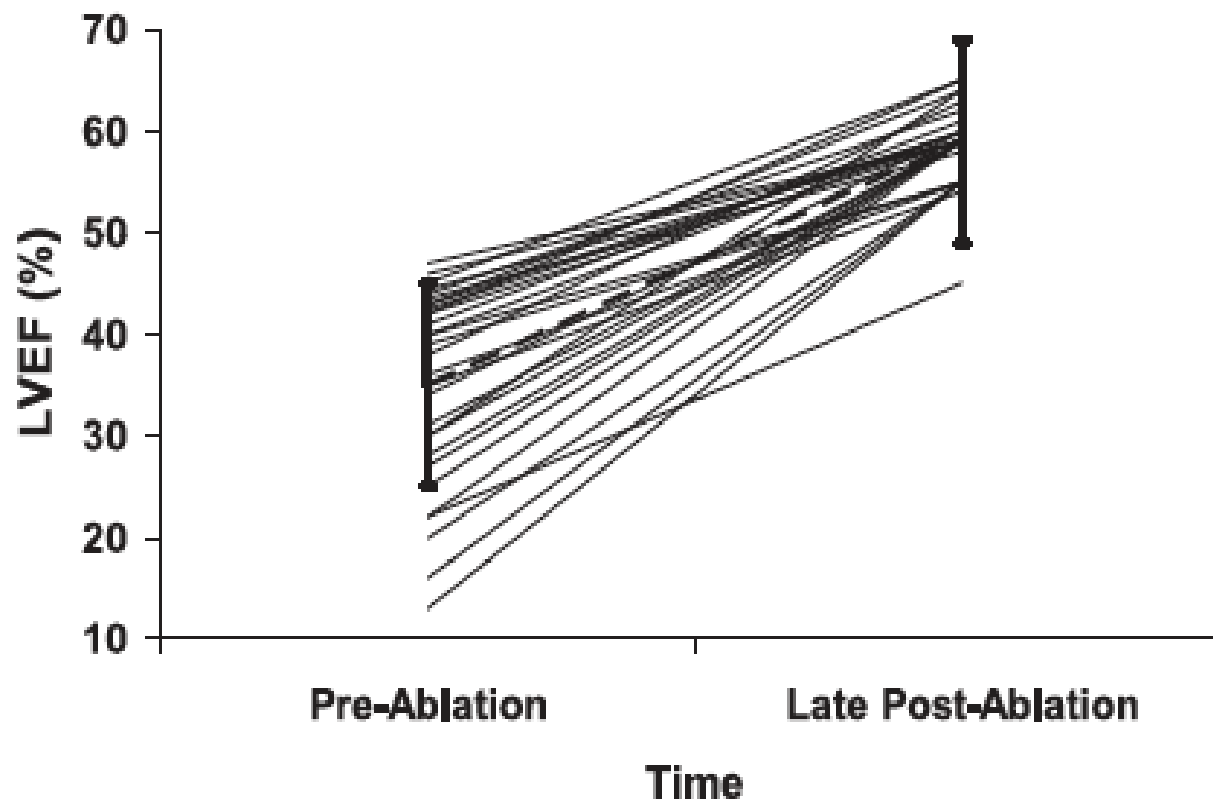


Figure 2

LVEF Before and After Ablation In Patients With TCM

A total of 27 of 30 patients with tachycardia-mediated cardiomyopathy (TCM) were in tachycardia during the initial echocardiographic assessment of left ventricular function. Pre-ablation left ventricular ejection fraction (LVEF) was $35 \pm 11\%$, improving to $59 \pm 3\%$ at 2.8 ± 2 months post-ablation.

Discussion

Bench to bedside translation

- **Animal model of TCM:**
 - an increasing rate, longer duration , and type of tachycardia are primarily responsible for the development of myopathic change.
 - TCM was induced by fixed rate constant RV pacing
- **In contrast, tachyarrhythmias in humans**(even when incessant)
 - significant variability related to diurnal variation and autonomic tone.
- However, animal studies have provided important insights into pathophysiology of TCM.

Discussion

Human studies of TCM

- Well described as an important cause of reversible LV dysfunction
- 50 % of unexplained CMs classified as “idiopathic”
- **The incidence:** poorly defined and likely underestimated

Relation between HR and TCM development

- In the present study:
 - 1/3 of pts with incessant AT developed TCM
 - In this group atrial and ventricular response TCL were longer than the group did not develop TCM
 - Fast AT, more likely symptomatic, received RX early , possibly prevented TCM

FAT site and risk of TCM

- In this study , incessant AT more likely raised from **AAs and PVs**
- No significant difference in the likelihood of TCM developing according to site of origin if tachycardia was incessant.
- **The incessant nature of the focus** rather than the anatomical site of origin plays the major role.

Predisposition to LV dysfunction

Alternate factors beyond tachycardia rate
(and possibly duration)?

- Genetic factors?
 - Deshmukh et al reported **Angiotensin-converting enzyme gene polymorphisms** , resulting in elevated concentrations of ACE and angiotensin II, association with TCM

Study limitation

- The calculation of LV systolic function in the presence of tachycardia (shortened diastolic filling time) may result in an underestimate of LVEF.
- In 27 of 30 (90%) patients, the echocardiography determination of baseline LV function was performed during tachycardia.
- They included the findings from 12 patients in incessant AT who underwent an early repeat echocardiogram within 48 h after the restoration of sinus rhythm by catheter ablation.

Conclusion

- TCM occurred in 10% of patients with focal AT.
- Incessant tachycardia is necessary for the development of TCM.
- TCM was seen in approximately one-third of the total population of patients with focal AT.
- Incessant tachycardia originated from atrial appendages and pulmonary vein ostia, more likely to have significantly longer total cycle length and association with TCM development
- Long-term restoration of LV function can be achieved with successful elimination of tachycardia in the majority of patients

Don't be
tachy

