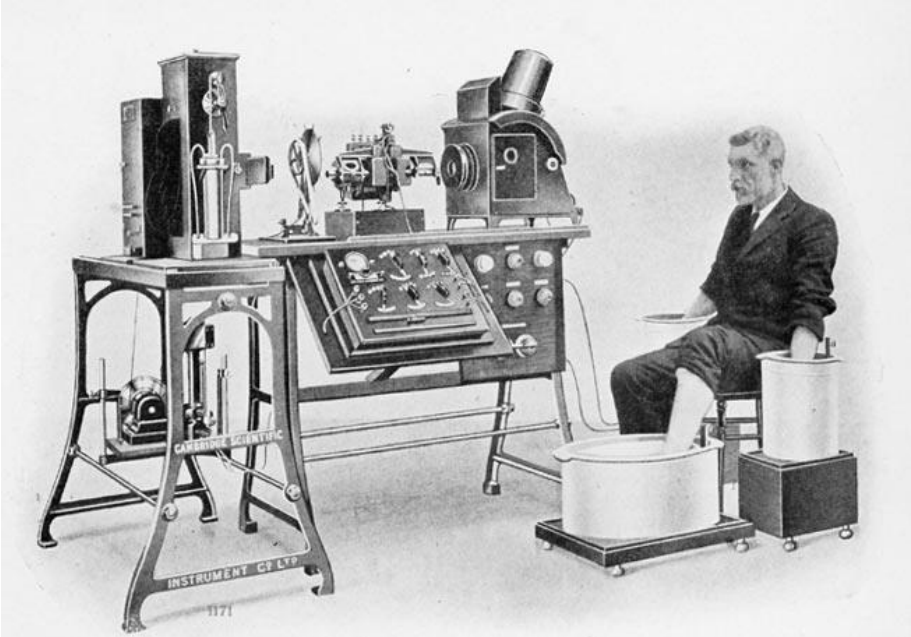
Imperial College London

Imperial College Healthcare NHS Trust

Non-invasive assessment of arrhythmias

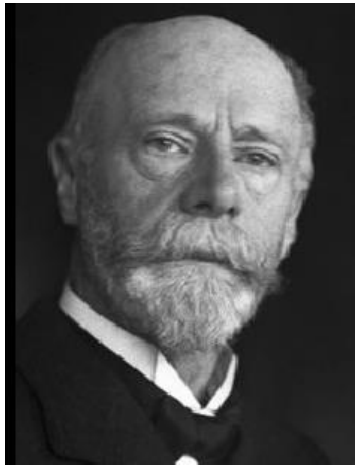
P Boon Lim
Imperial College Healthcare

12 lead ECG – a >100 year old tool



Photograph of a Complete Electrocardiograph, Showing the Manner in which the Electrodes are Attached to the Patient, In this Case the Hands and One Foot Being Immersed in Jars of Salt Solution

Augustus Waller and "Jimmy"
1887 – first recording of heart's activity from the body surface



William Einthoven
1903
First "electrocardiogram"

What is non-invasive assessment of arrhythmia

1. Usual "stuff"
    a) ECG
    b) Holter
    c) Event Recorder
    d) Exercise treadmill test

2. Interesting ? Mechanistic
    a) ILR and ICD traces
    b) Tilt table data
    c) Exercise
    d) Pre-ablation methods of provocation

3. Modern/future developments
    1. AliveCor
    2. Cardioinsight ECG vest
    3. Risk stratification tools (restitution curves)

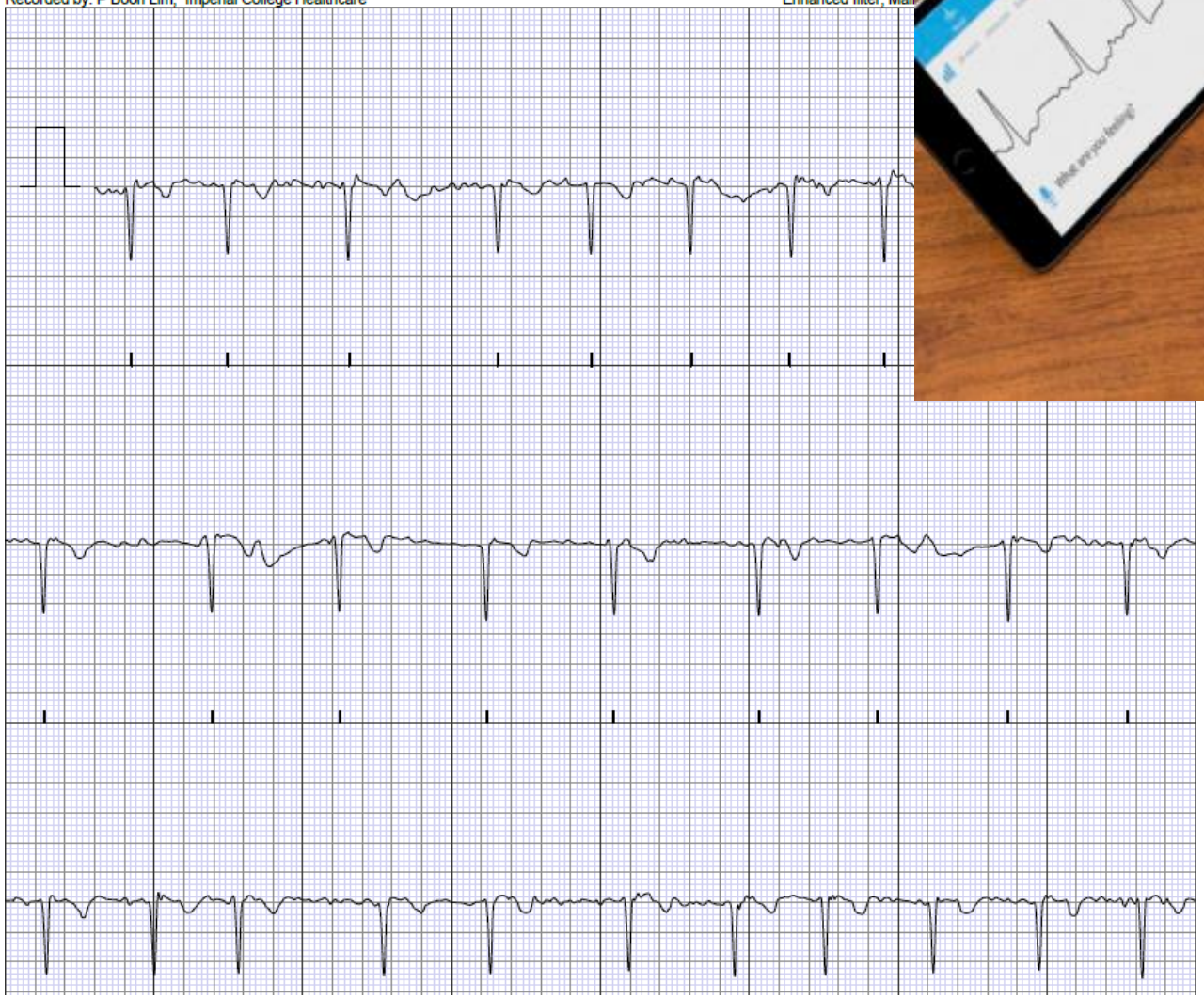
AliveCor

Patient:
Recorded: Thursday, 25/02/2016, 10:39
Heart Rate: 80 bpm **Duration:** 30s

Finding by AliveCor: Possible atrial fibrillation

Recorded by: P Boon Lim, Imperial College Healthcare

Enhanced filter, Mai

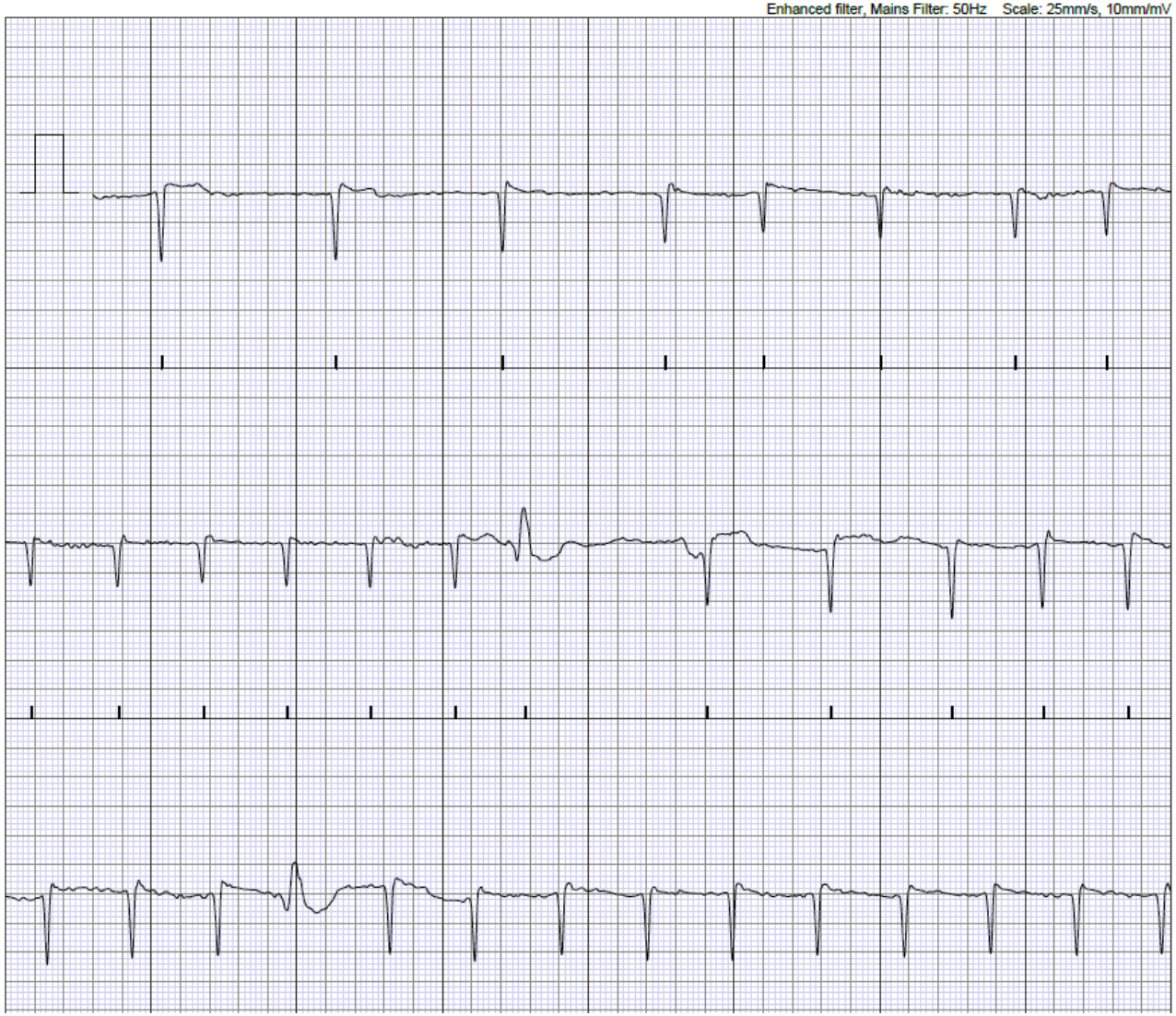


Recorded: Thursday, 15/09/2016, 12:23
Heart Rate: 101 bpm **Duration:** 25s

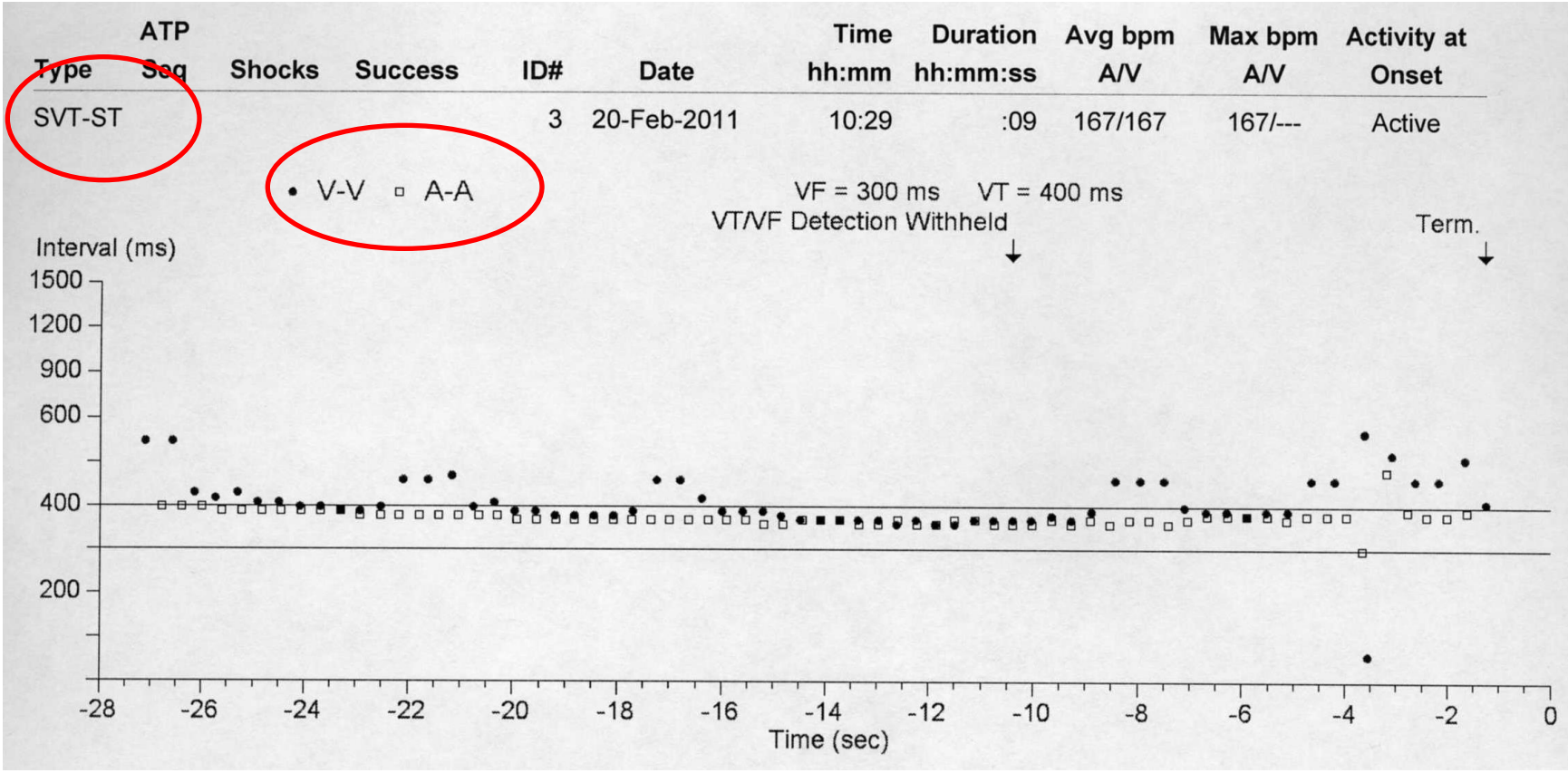
even when your heart rate goes up to fifty reason still the techie cut it's just that it's

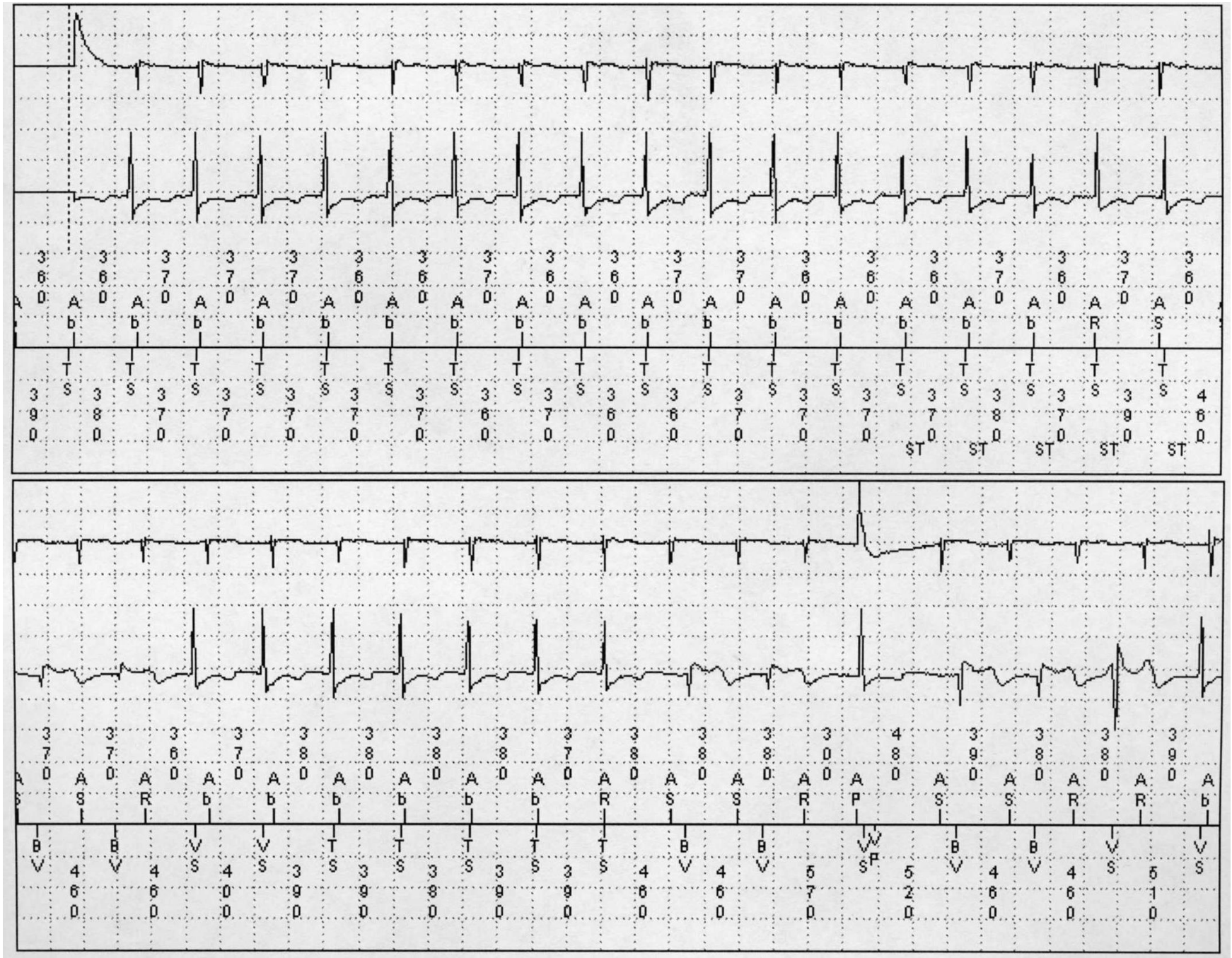
Finding by AliveCor: Short

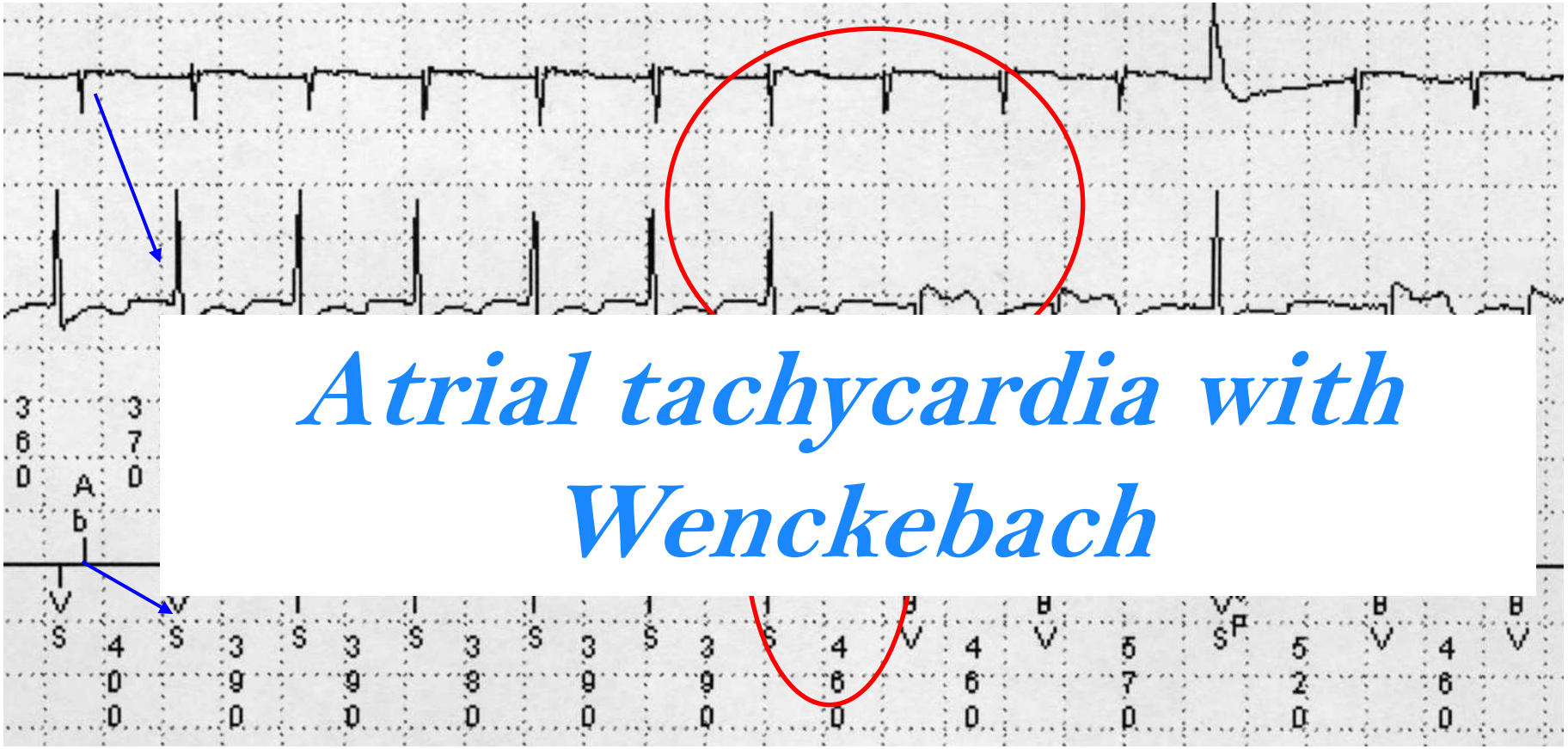
Enhanced filter, Mains Filter: 50Hz Scale: 25mm/s, 10mm/mV



What the diagnosis?

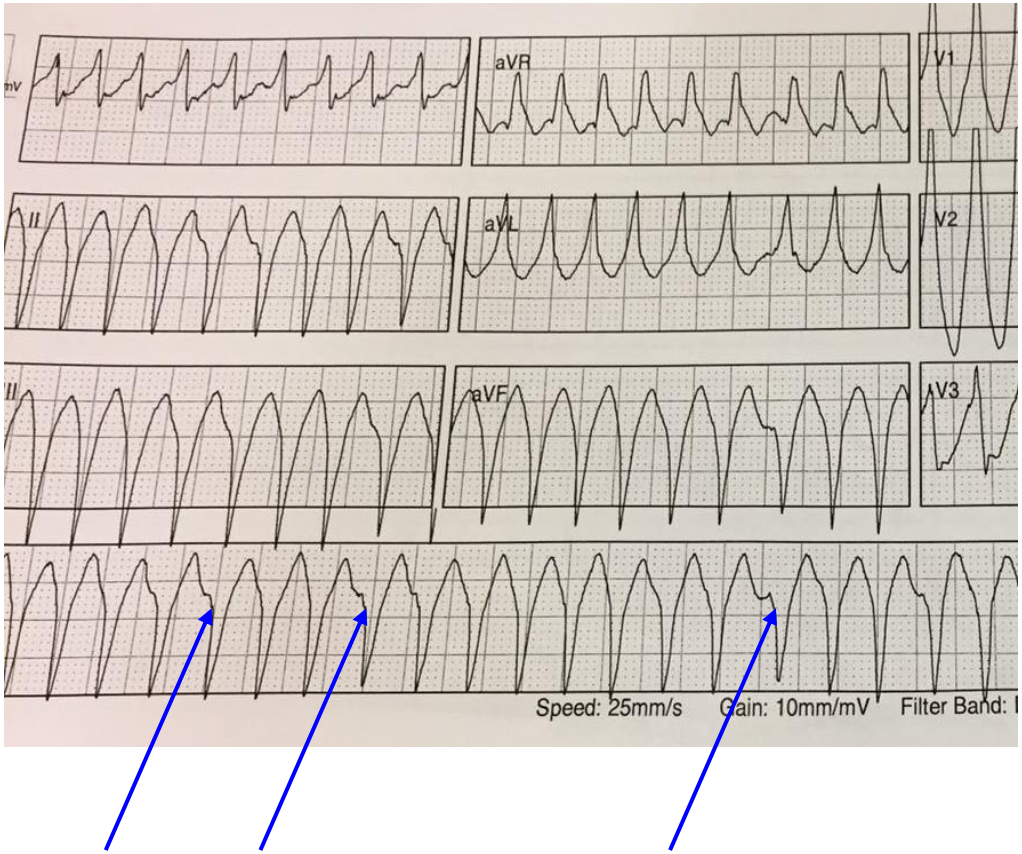




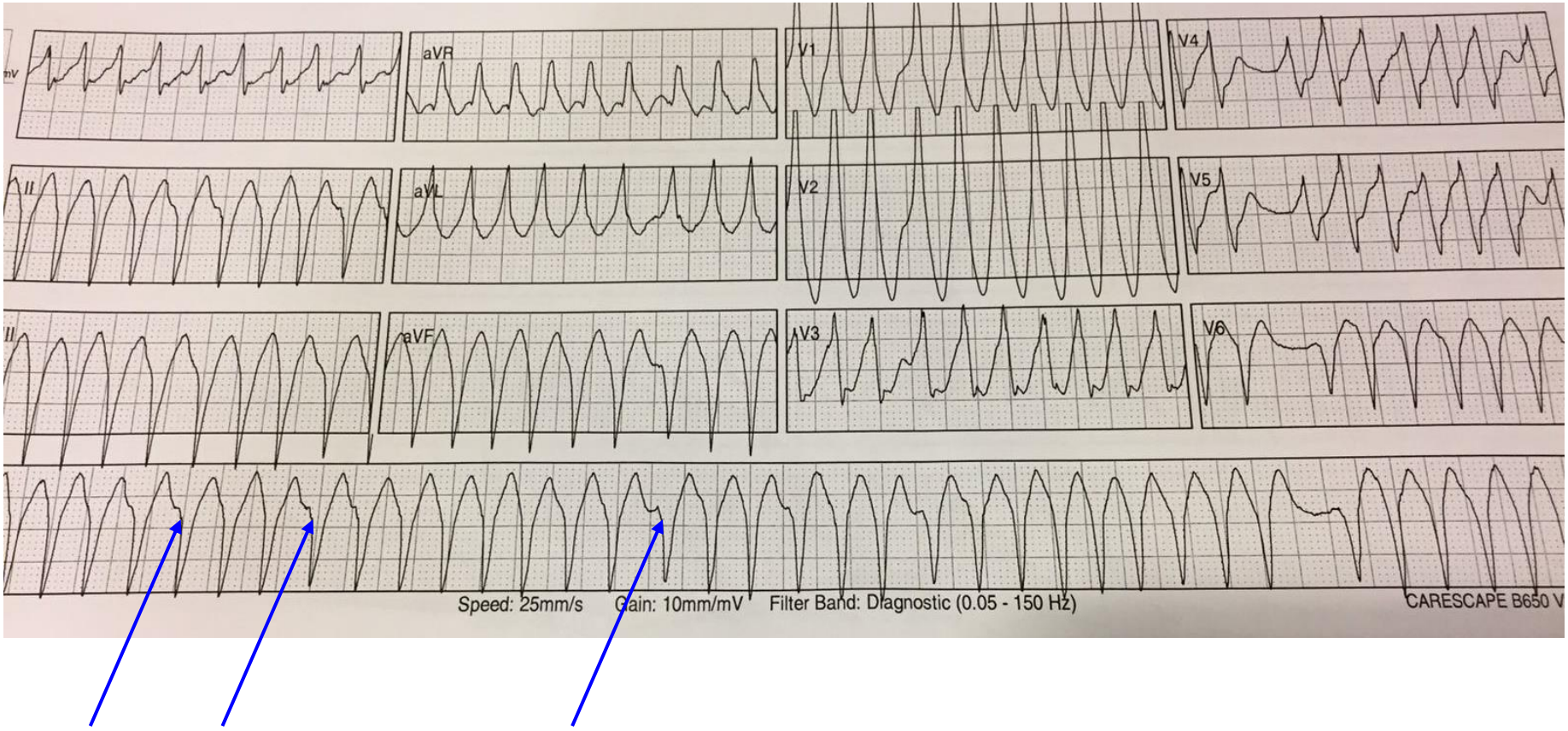


Atrial tachycardia with Wenckebach

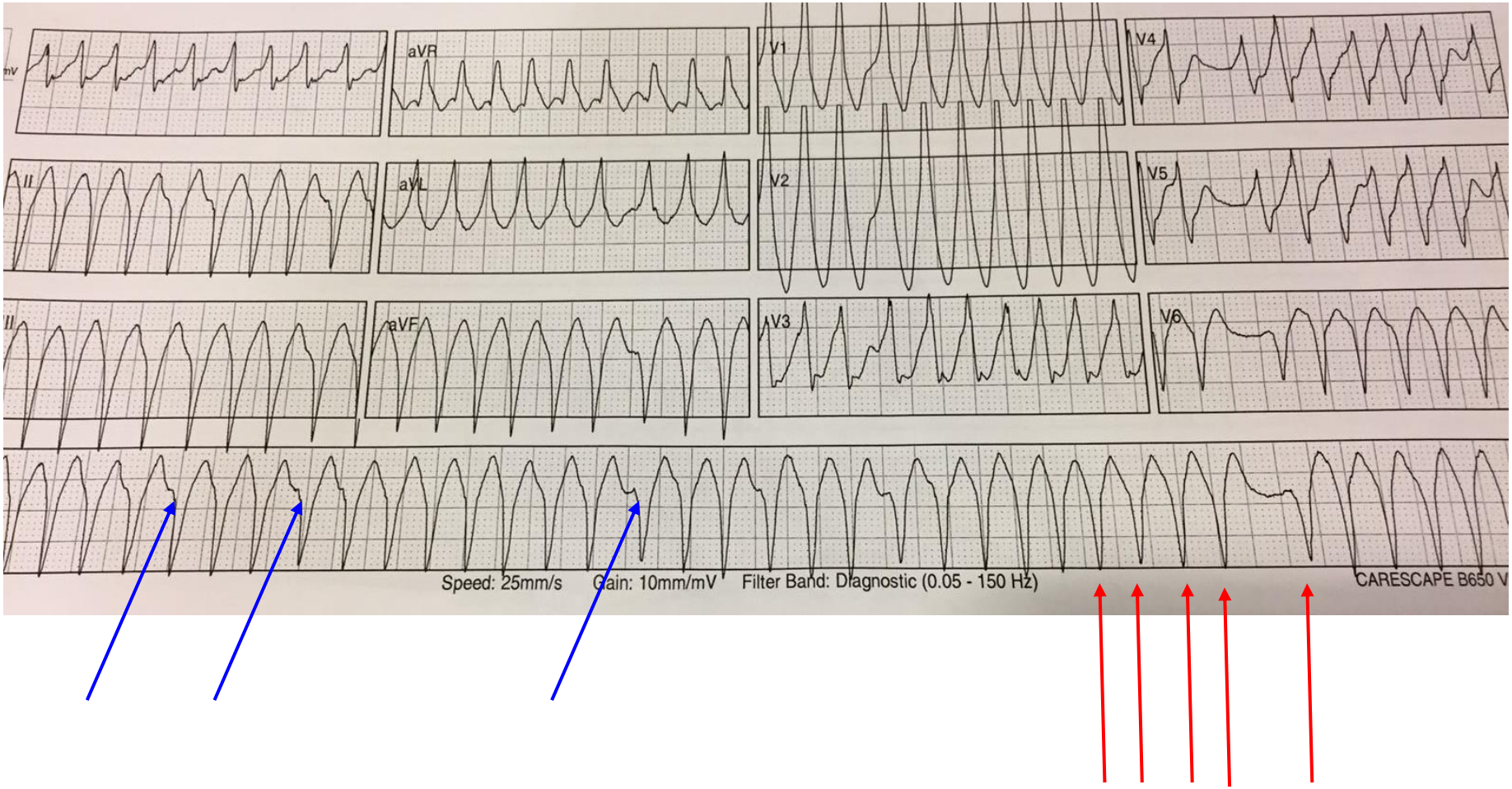
What is the diagnosis?



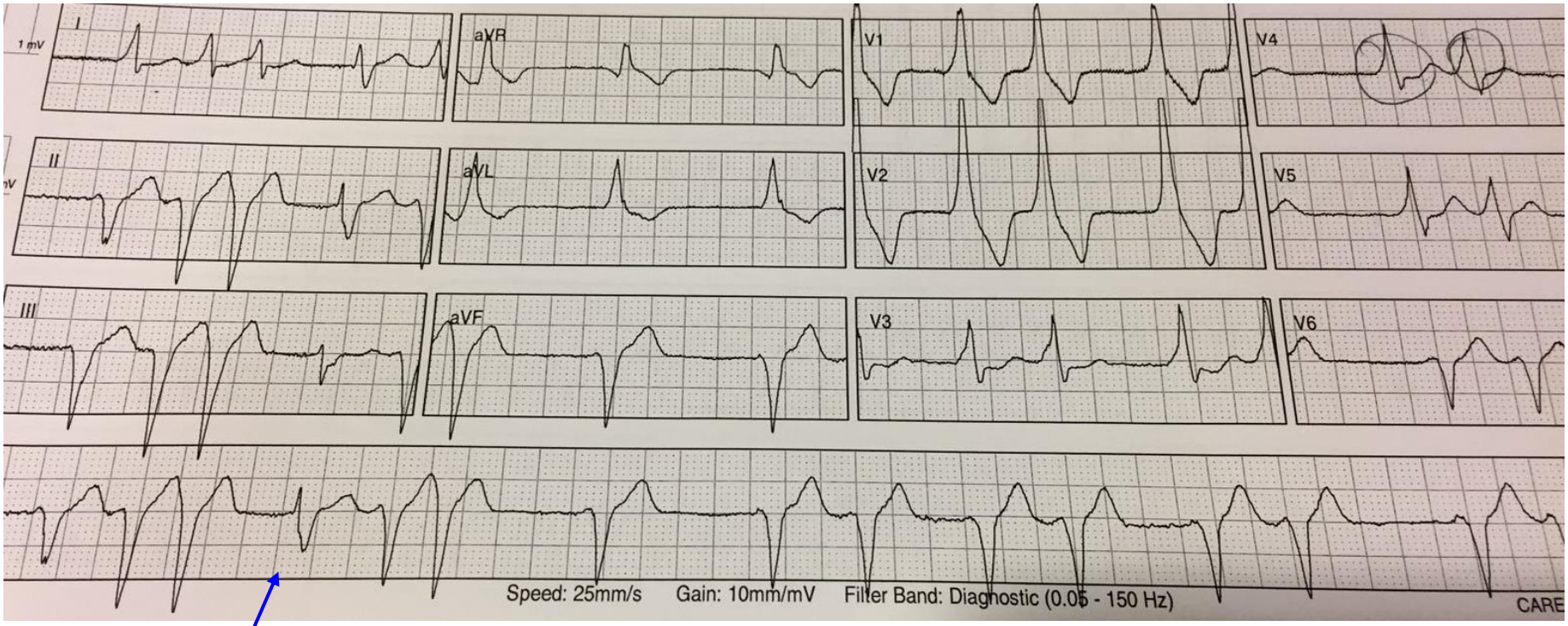
What is the diagnosis?



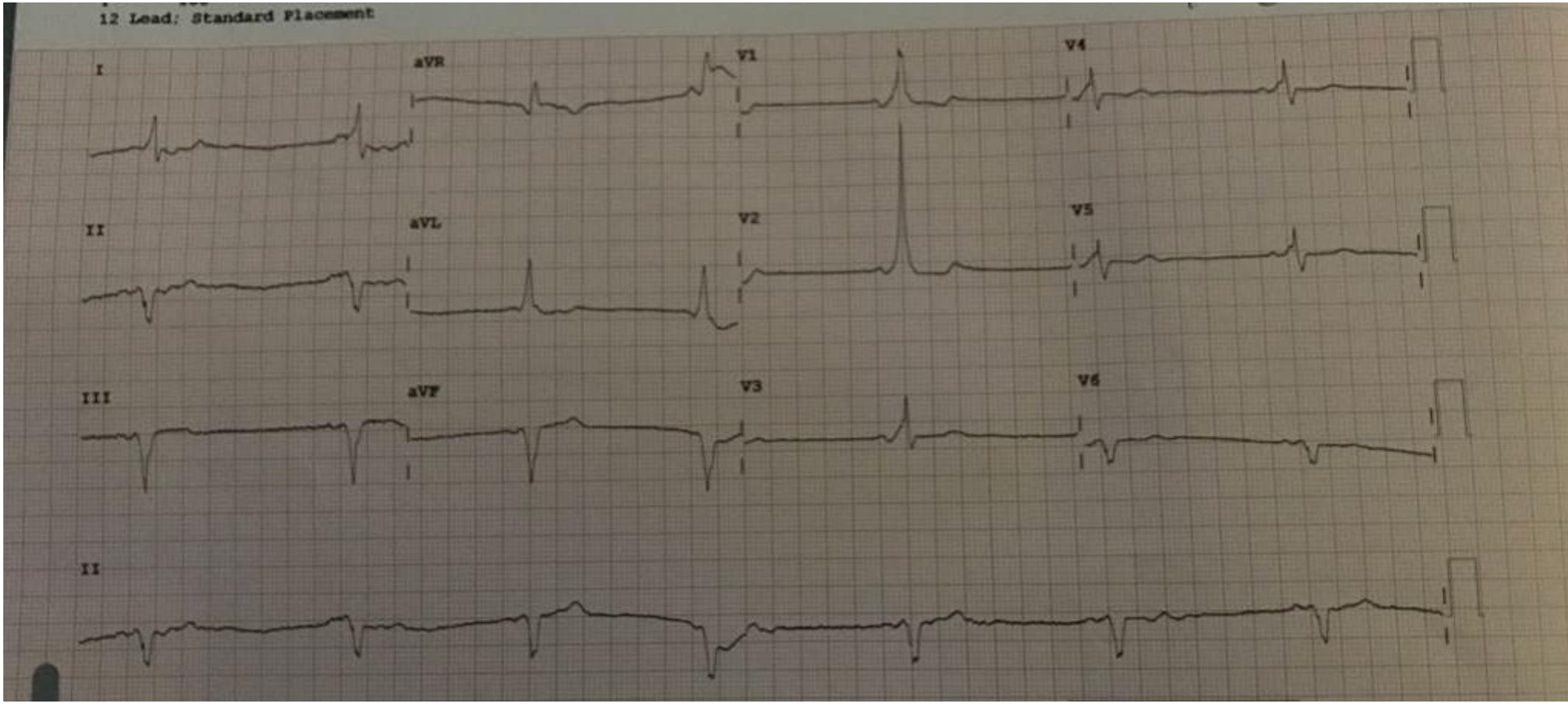
What is the diagnosis?



Spontaneously slowed rhythm



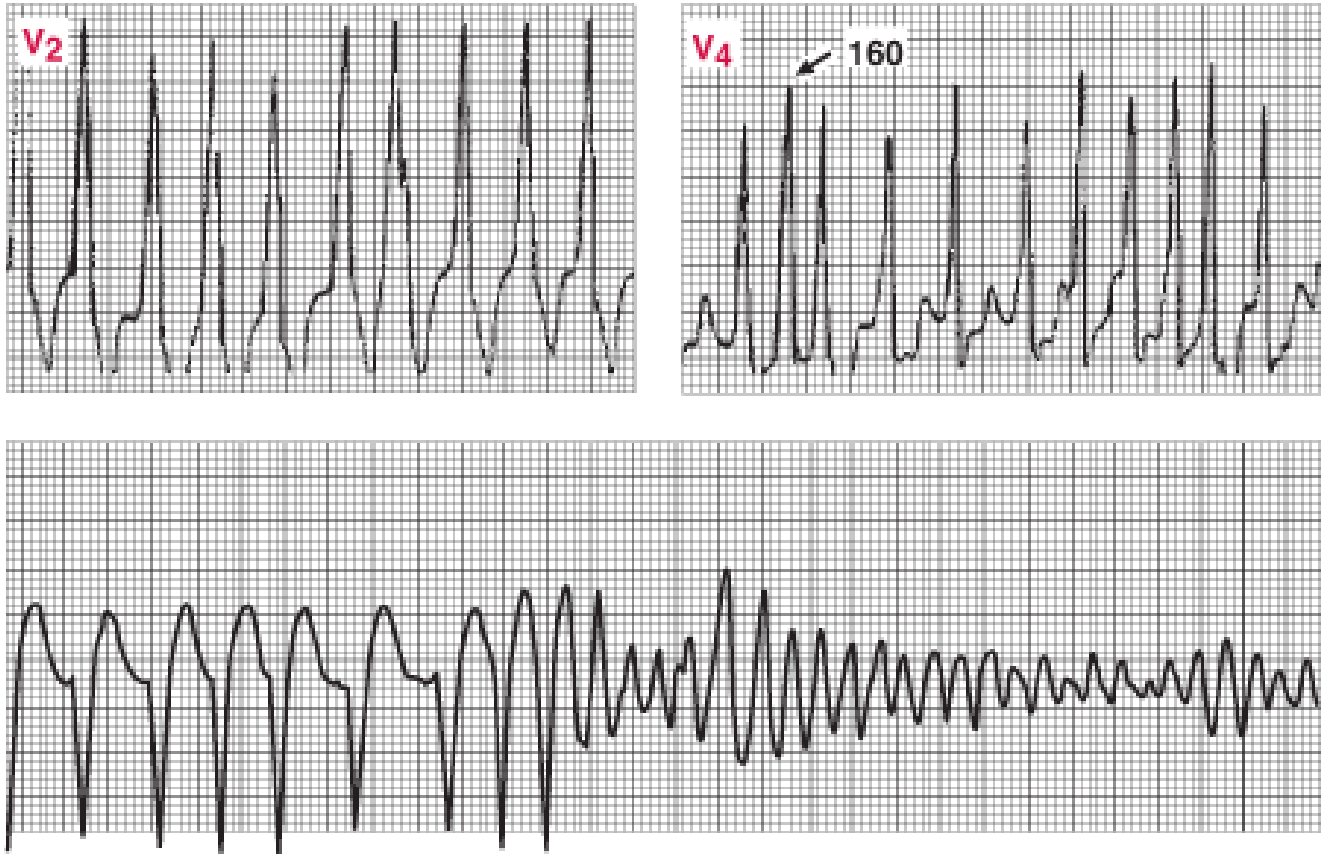
Pre-excited AF. Patient cardioverted



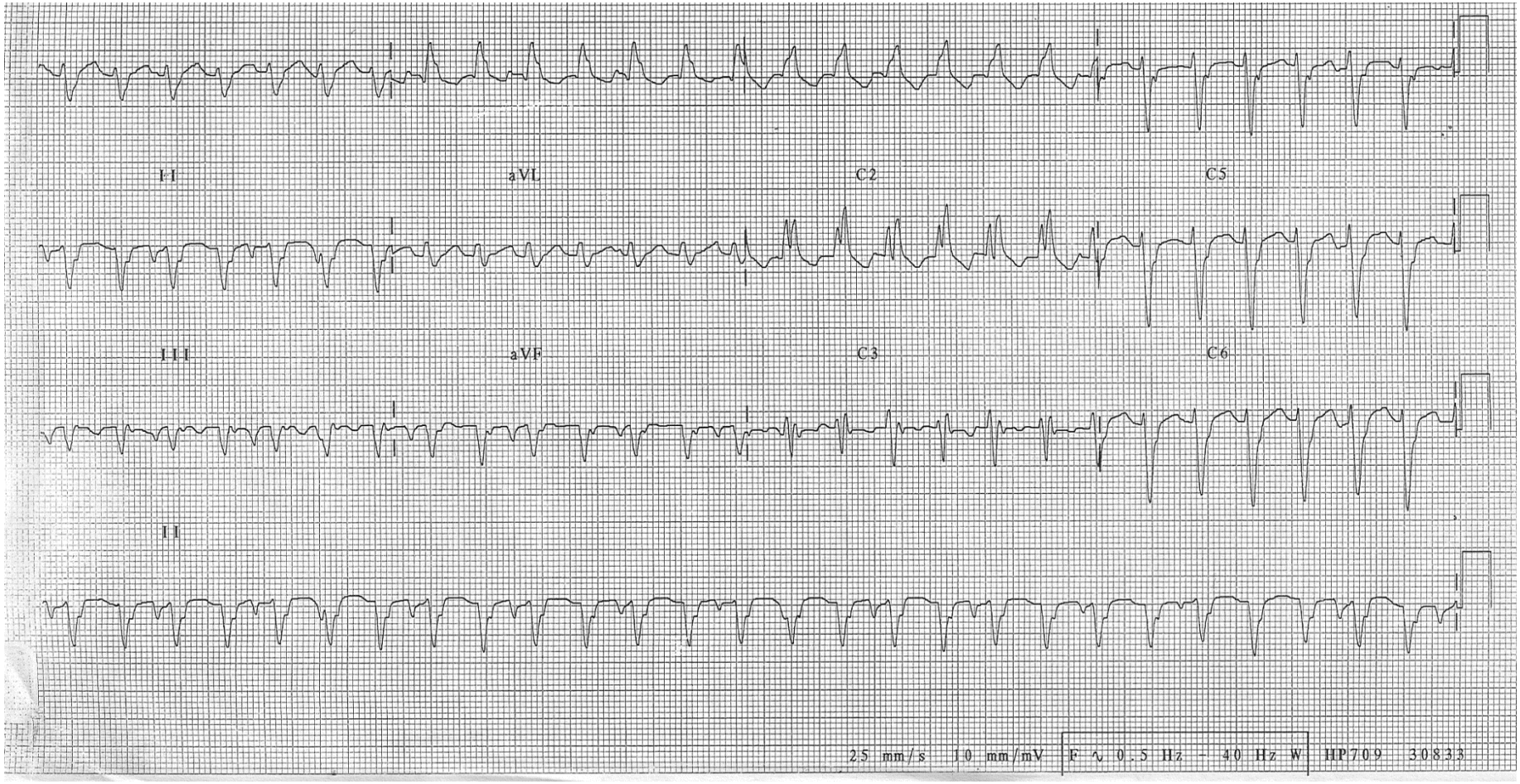
Factors associated with SCD in WPW

- Male 85%
- Short anterograde RP of the AP (<260ms)
- Shortest RR during AF <200ms
- High adrenergic state

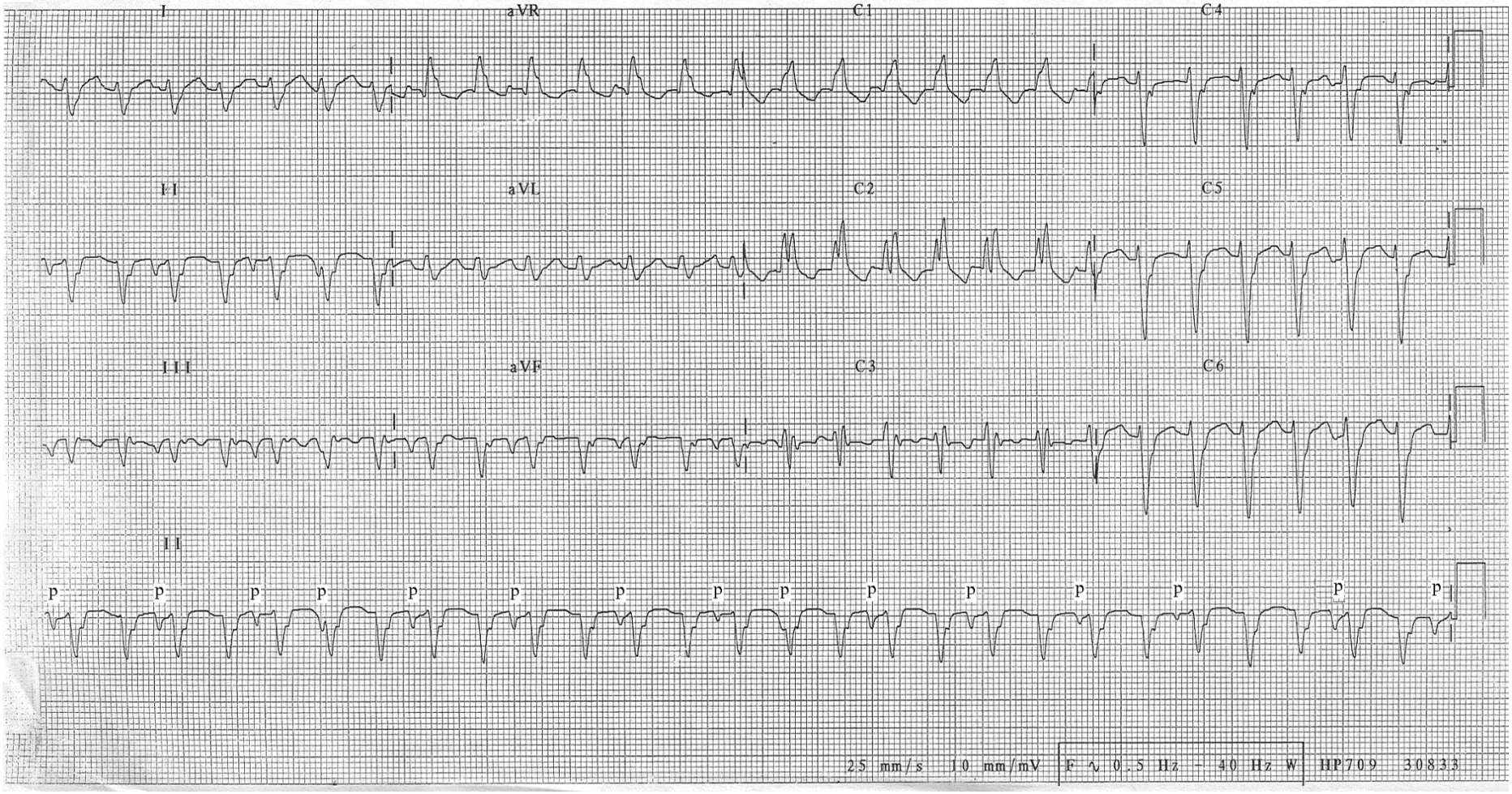
Wellens Circulation 200;112:2201-2216



34yo male, structurally normal heart for ablation of SVT. What is diagnosis?



More Vs than As = VT (? Left posterior fascicle)

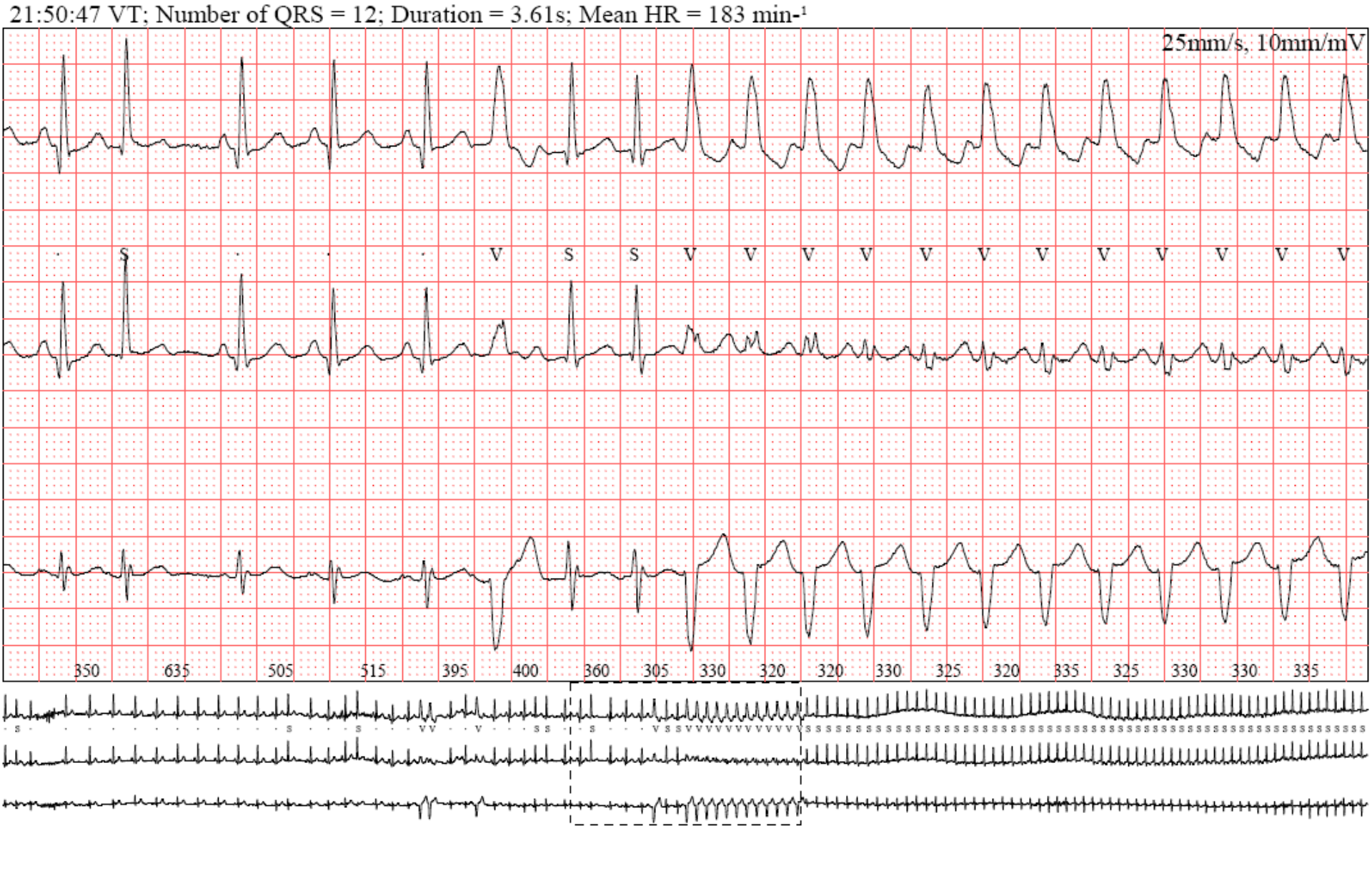


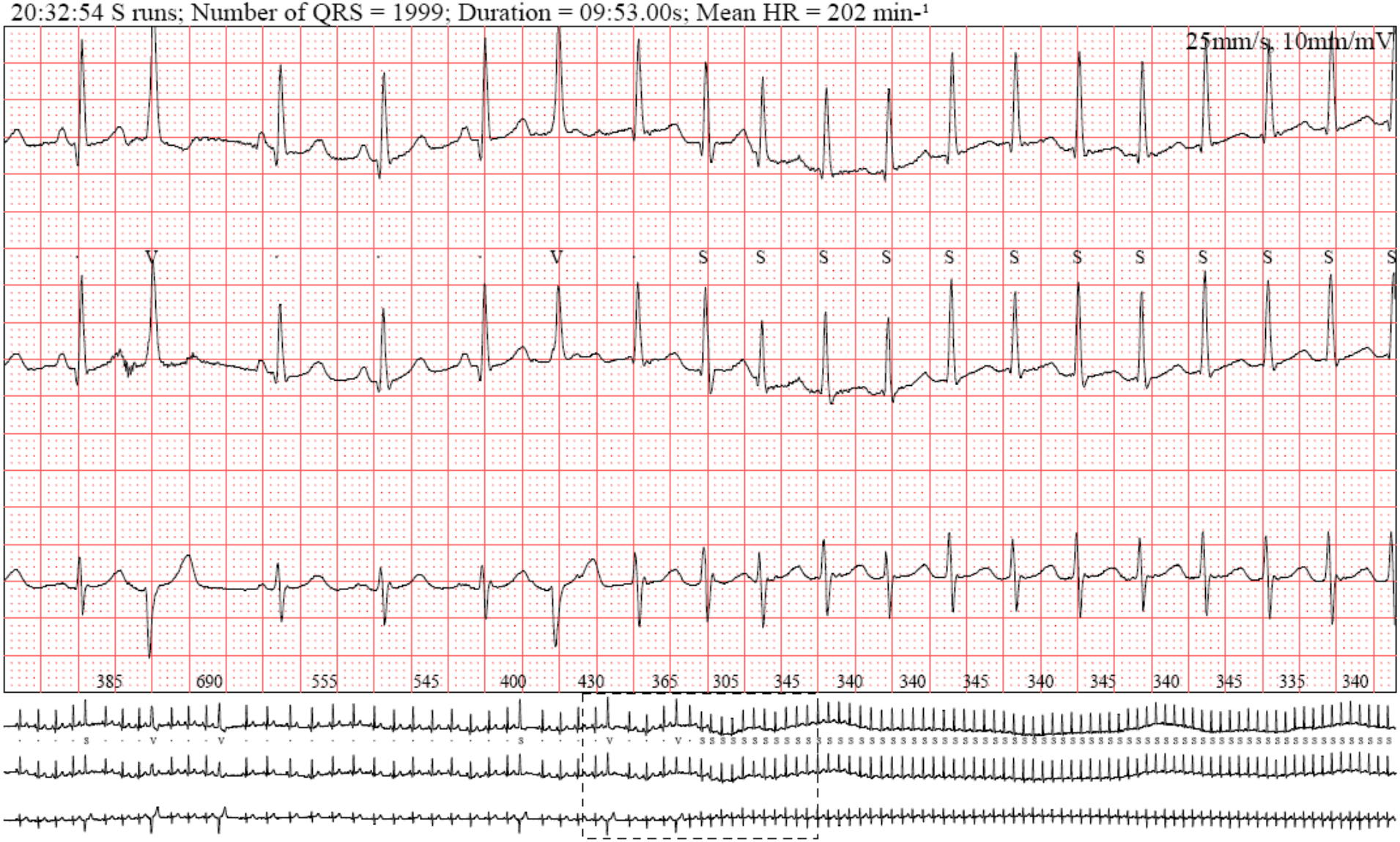
Holter report: 25yo F with palps

NSR with 3 episodes of VT, longest 12 beats
Single, paired and one VE triplet

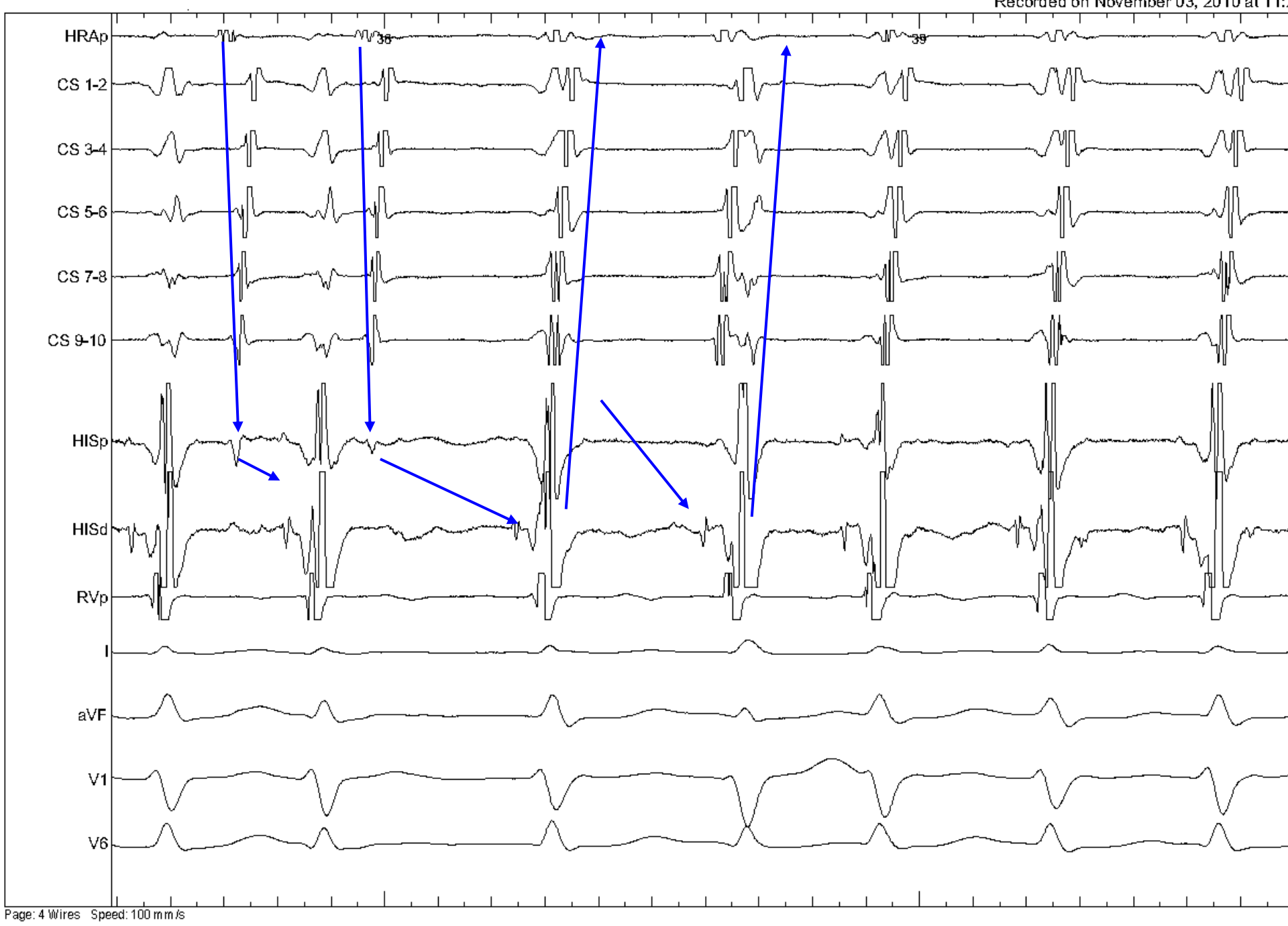
Episodes of NCT, longest 9:53 mins with mean HR 203bpm.

No diary submitted

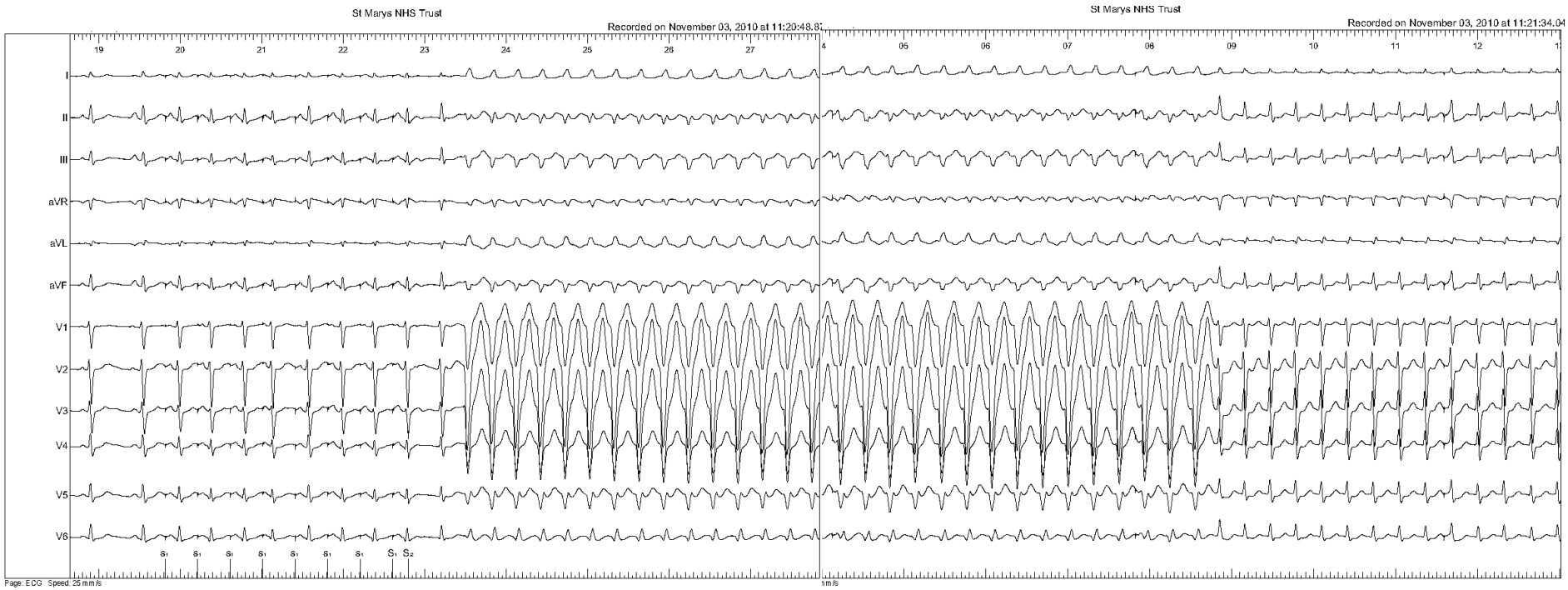

21:50:47 VT; Number of QRS = 12; Duration = 3.61s; Mean HR = 183 min-1
25mm/s, 10mm/mV
S V S S V V V V V V V V V V V V
350 635 505 515 395 400 360 305 330 320 320 330 325 320 335 325 330 330 335


20:32:54 S runs; Number of QRS = 1999; Duration = 09:53.00s; Mean HR = 202 min-1
25mm/s 10mm/mV
V V S S S S S S S S S S S S
385 690 555 545 400 430 365 305 345 340 340 345 340 345 340 345 335 340

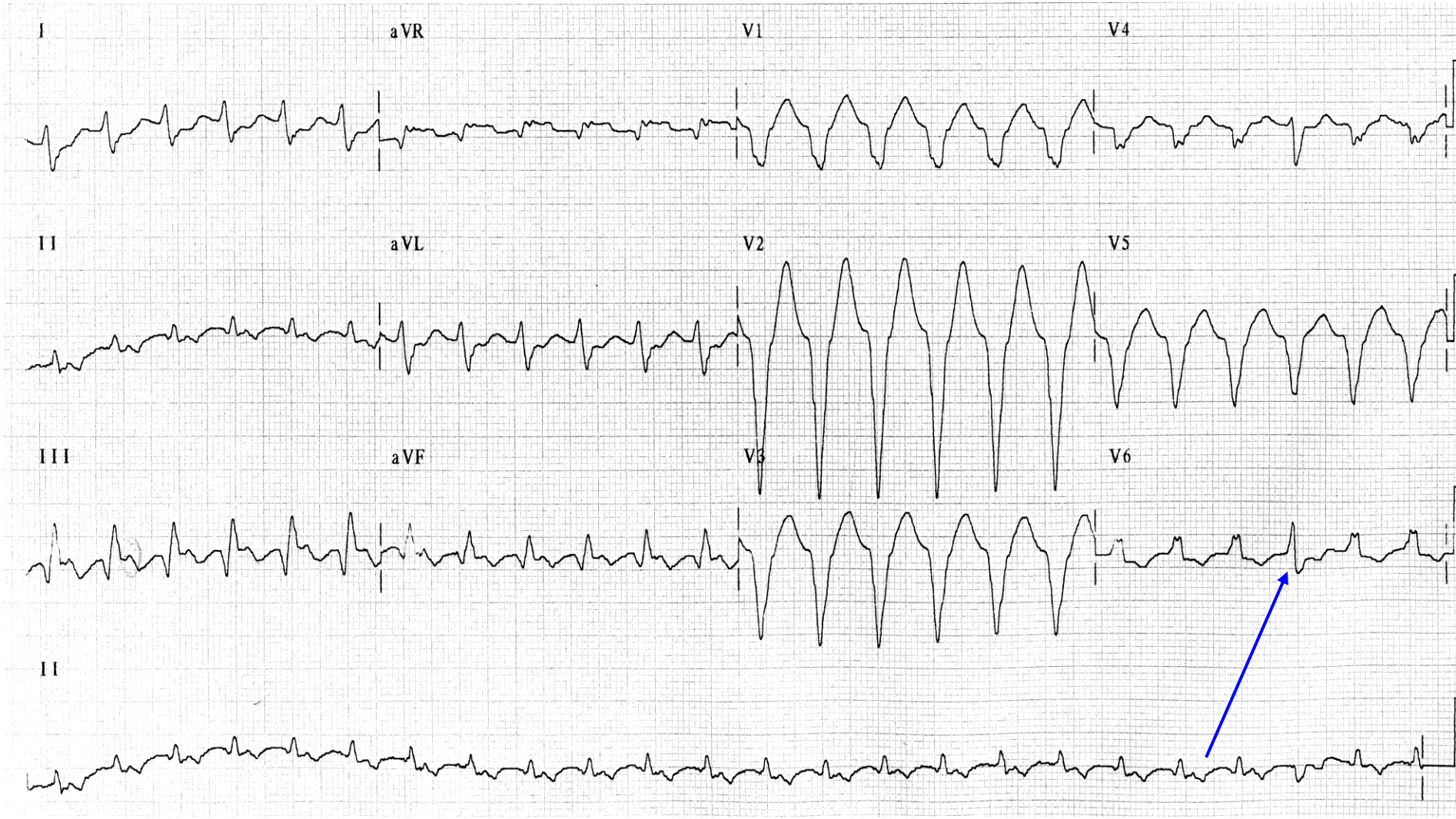
21:50:51 VT changes to Narrow Complex Tachycardia


Recorded on November 03, 2010 at 11:
HRAp
CS 1-2
CS 3-4
CS 5-6
CS 7-8
CS 9-10
HISp
HISd
RVp
I
aVF
V1
V6
38
39
Page: 4 Wires Speed: 100 mm/s

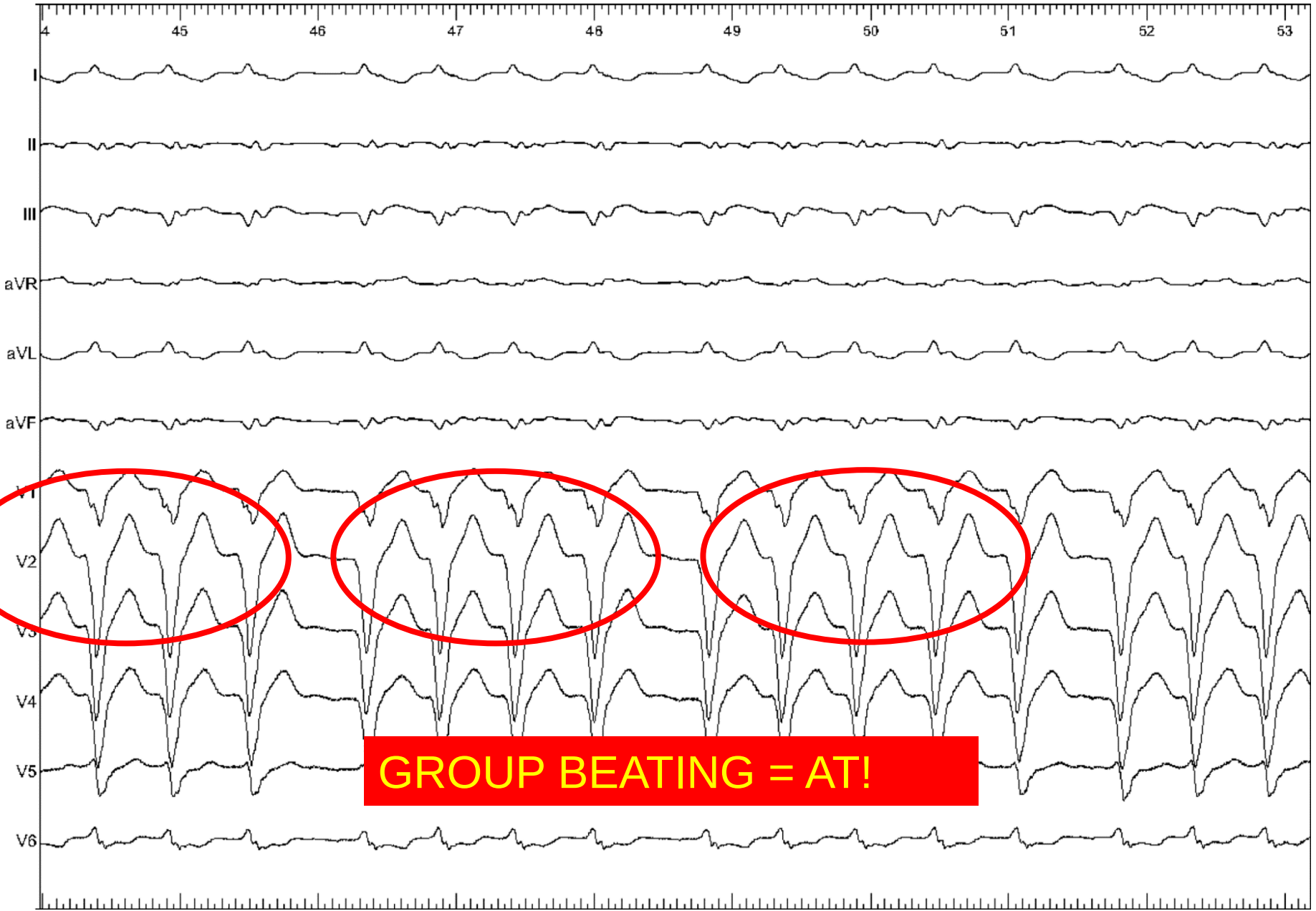
AVNRT


St Marys NHS Trust
Recorded on November 03, 2010 at 11:20:48.87
St Marys NHS Trust
Recorded on November 03, 2010 at 11:21:34.04
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
S1 S1 S1 S1 S1 S1 S1 S1 S2
Page: ECG Speed: 25 mm/s
mm/s

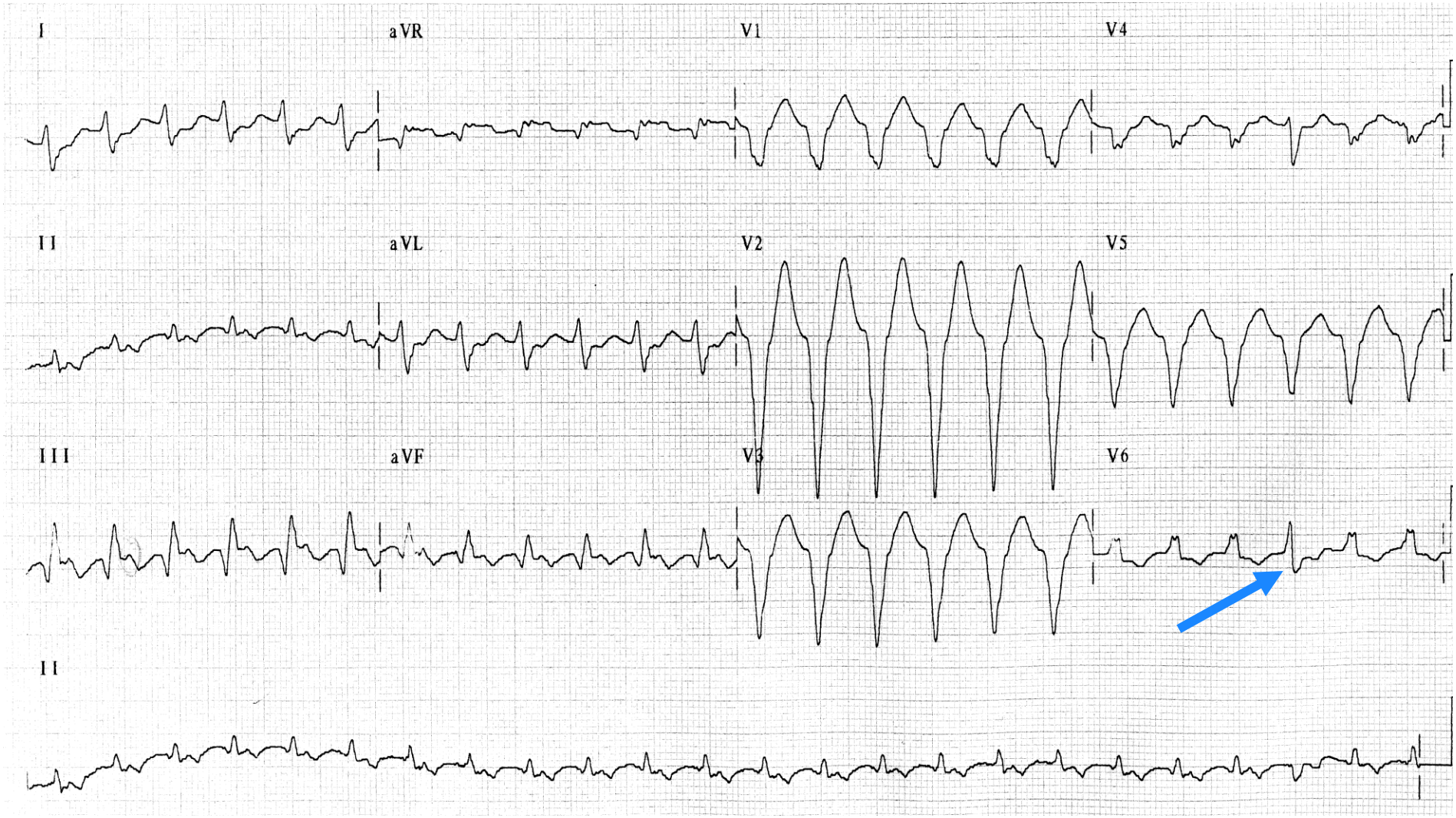
76-year-old male presented with pulmonary oedema and an intermittent broad complex tachycardia: Previously MI x3, CABG and PCIEF of 29%

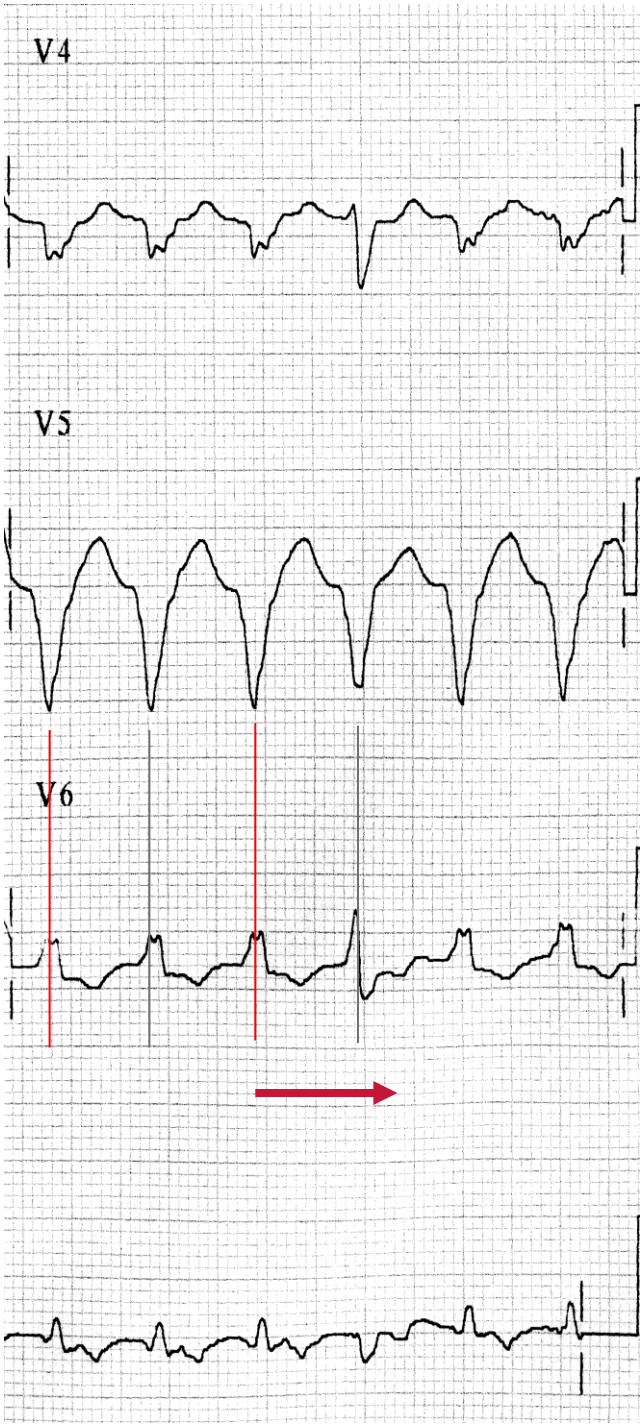


Referred for VT ablation : VT stim negative, but this induced during EPS



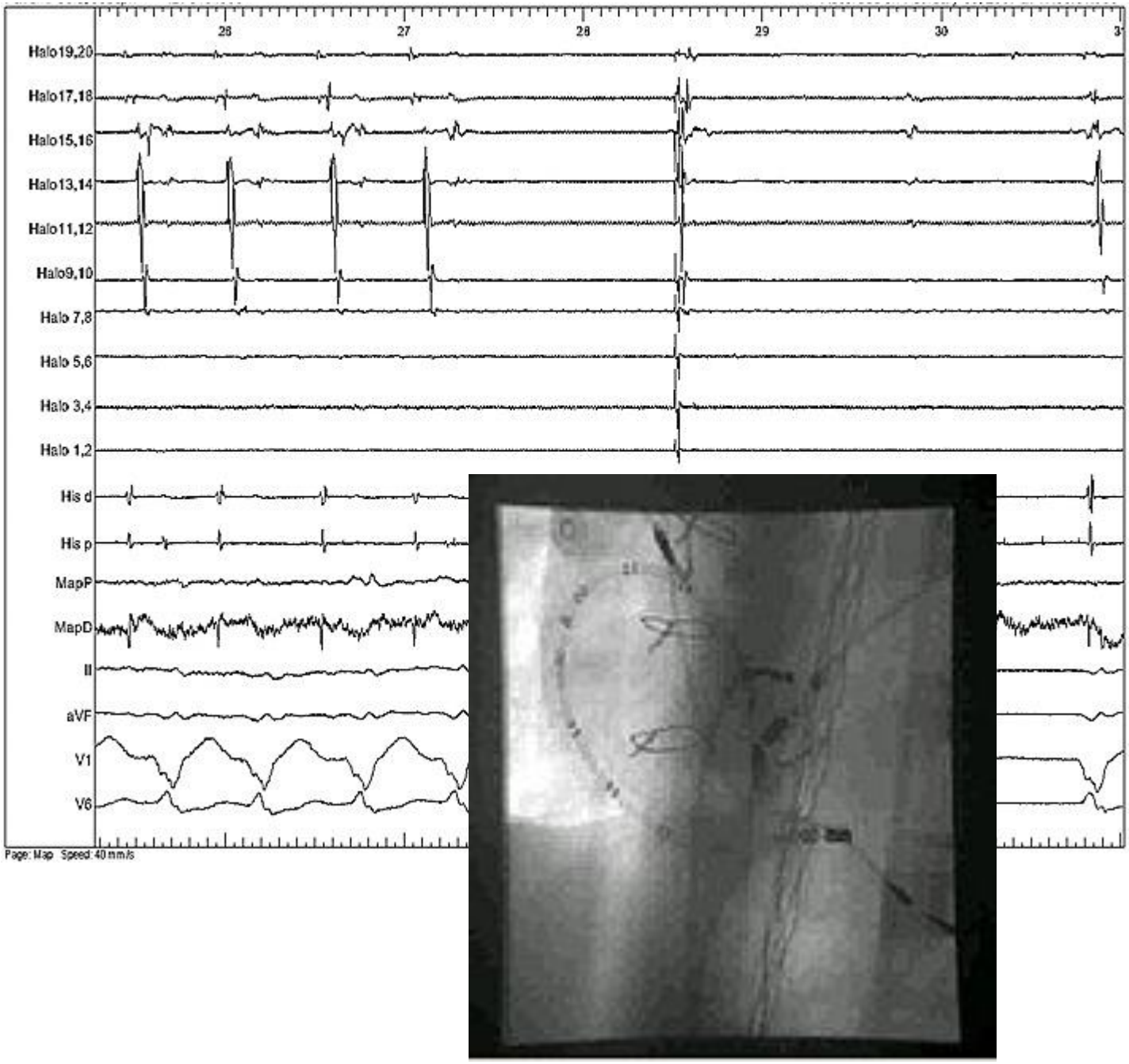
Clinical Tachycardia : how to explain capture beat?



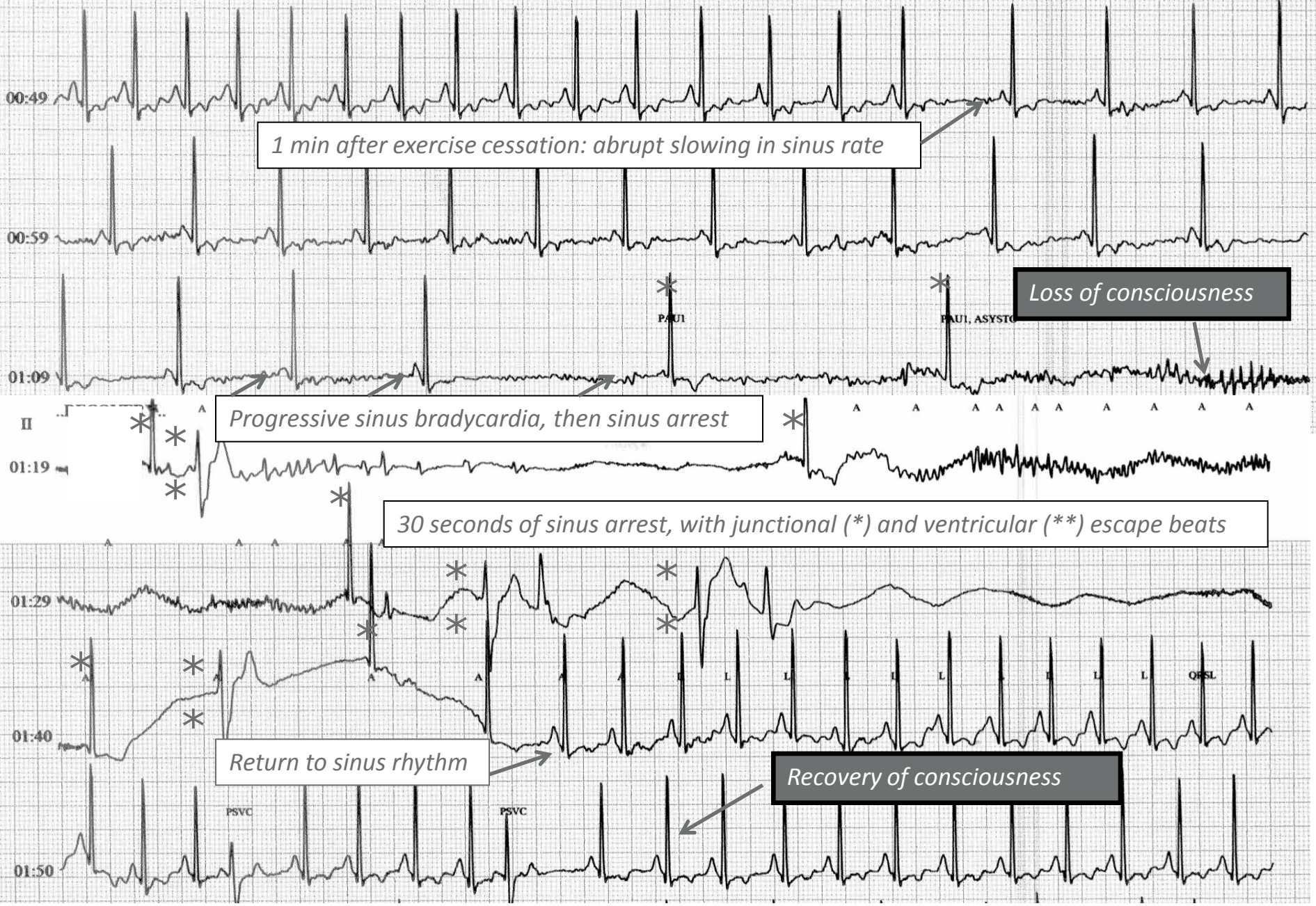


Right bundle delays for one beat, therefore, activates later = in time with the delayed left bundle

Atrial tachycardia



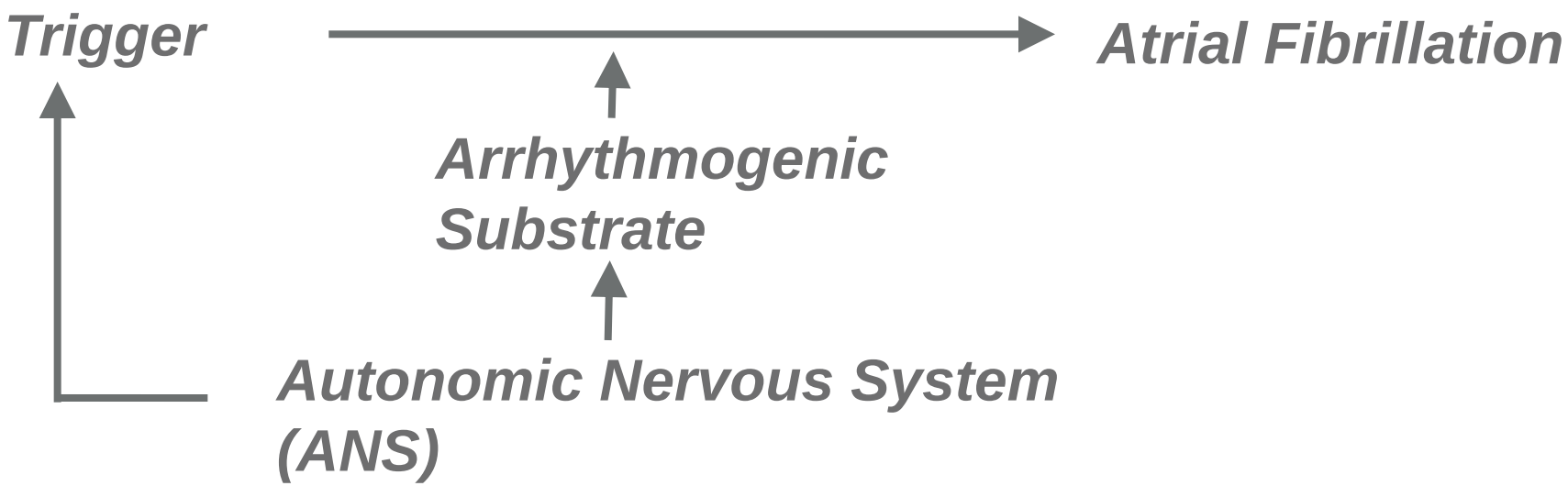
27 yo Lacrosse player with “syncope on exercise”

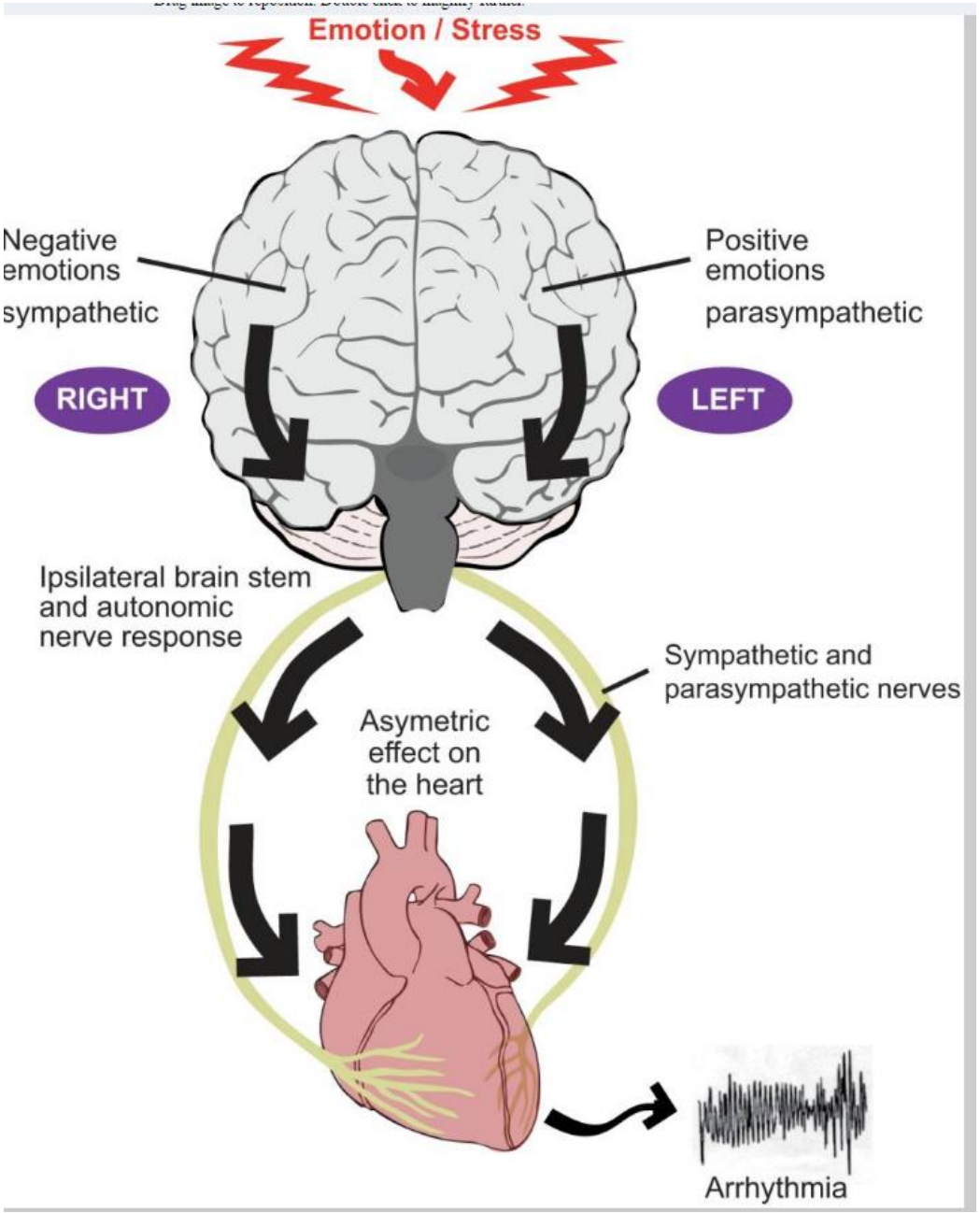

00:49
1 min after exercise cessation: abrupt slowing in sinus rate
00:59
Loss of consciousness
01:09
Progressive sinus bradycardia, then sinus arrest
II
01:19
30 seconds of sinus arrest, with junctional (*) and ventricular (**) escape beats
01:29
01:40
Return to sinus rhythm
Recovery of consciousness
01:50

The role of the autonomic nervous system in arrhythmias

"Every arrhythmia has an autonomic basis"

Philippe Coumel, MD, 1935–2004





Taggart et al. Anger, Emotion and Arrhythmias: from Brain to Heart. Front Physiol 201

Tips and tricks in cath lab

Before sheathing

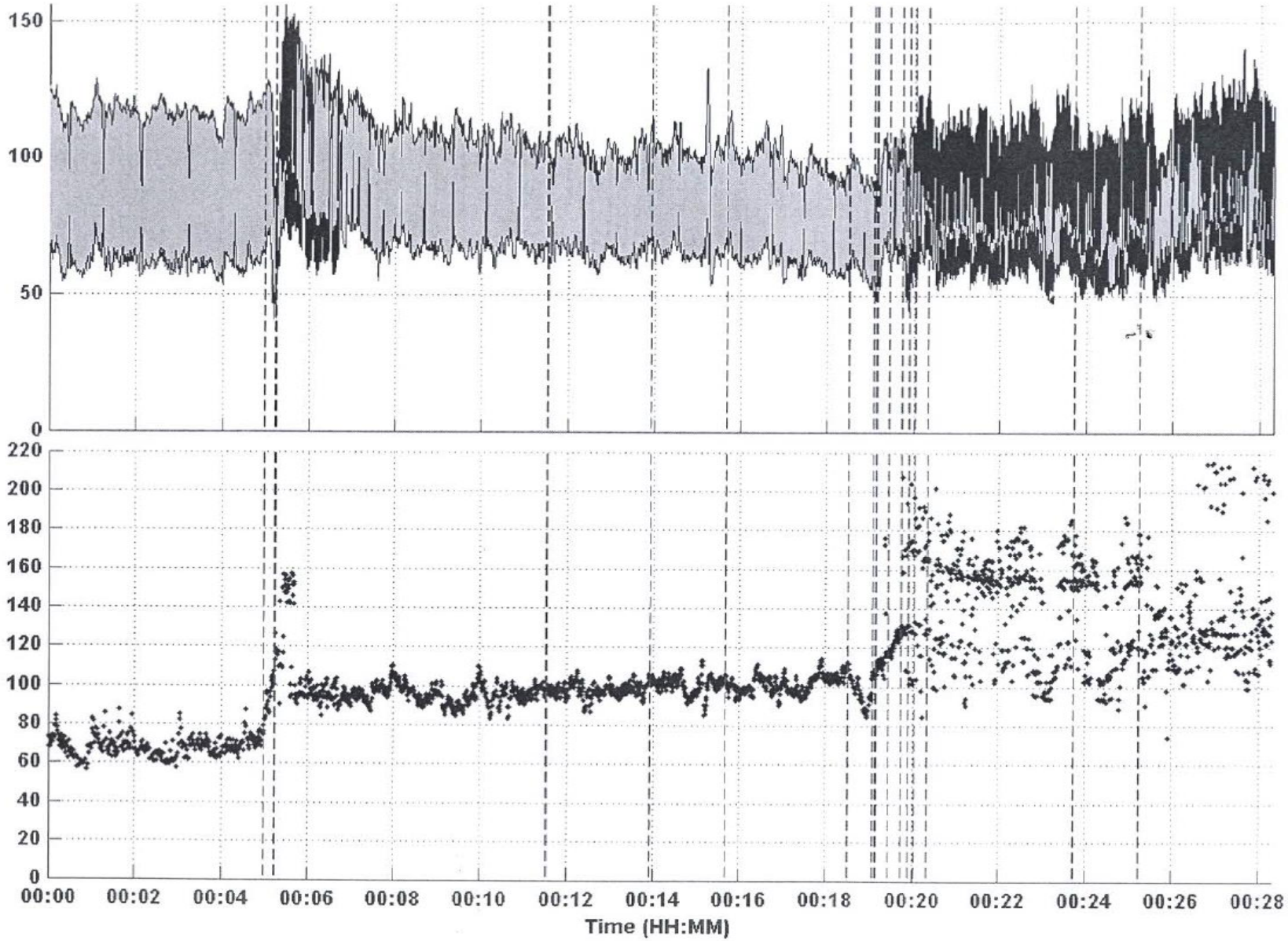
1) Serial 7s, 13s subtraction (Mental Stress) : Lampert Circ 2000.
2) Exercise (Straight leg raising)

Tips and tricks in cath lab

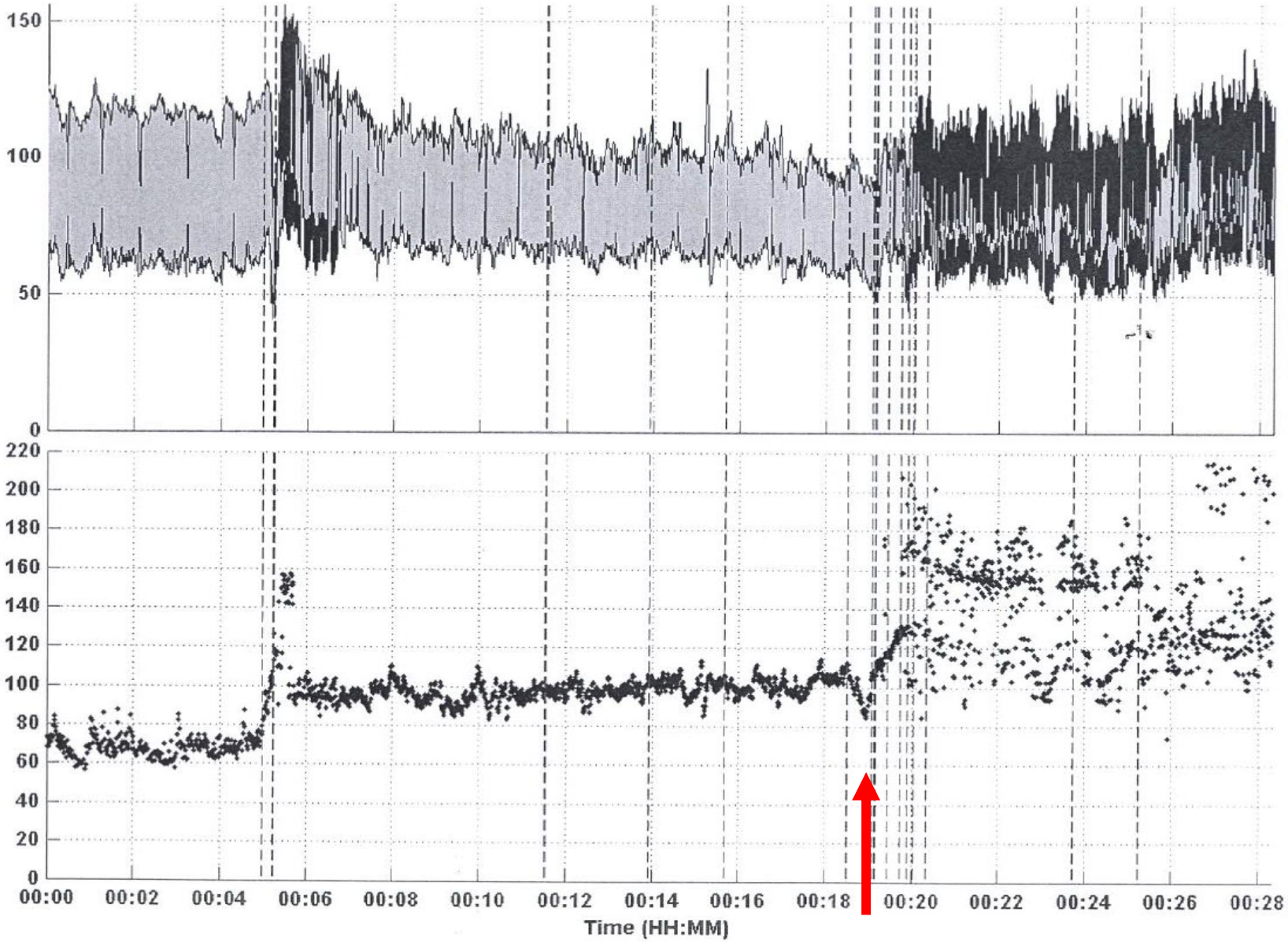
Before sheathing

1) Serial 7s, 13s subtraction (Mental Stress) : Lampert Circ 2000.
2) Exercise (Straight leg raising)
3) Senior colleague's technique.

Autonomic provocation : tilt testing in 54 yo with palpitations

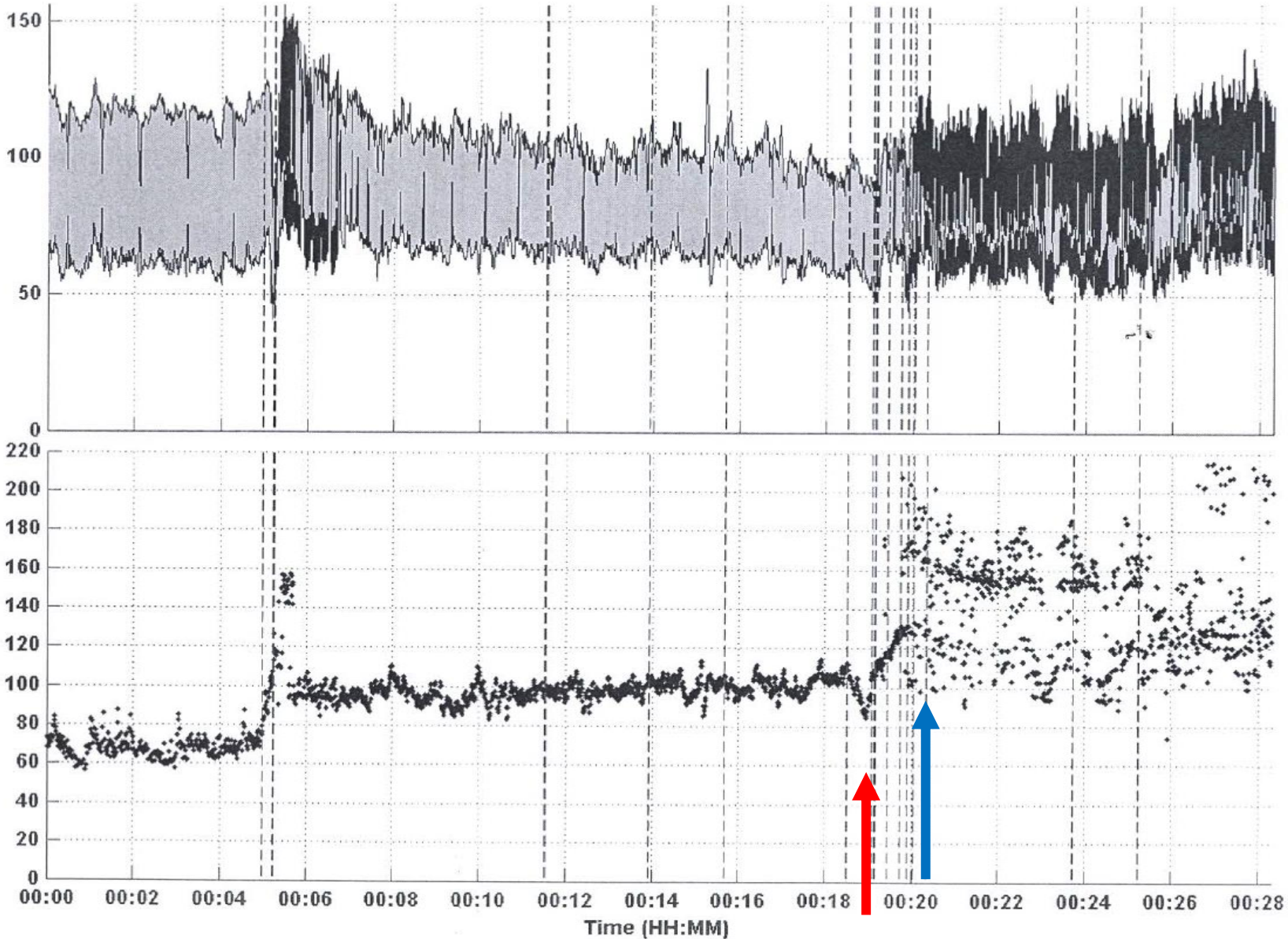


Autonomic provocation : tilt testing



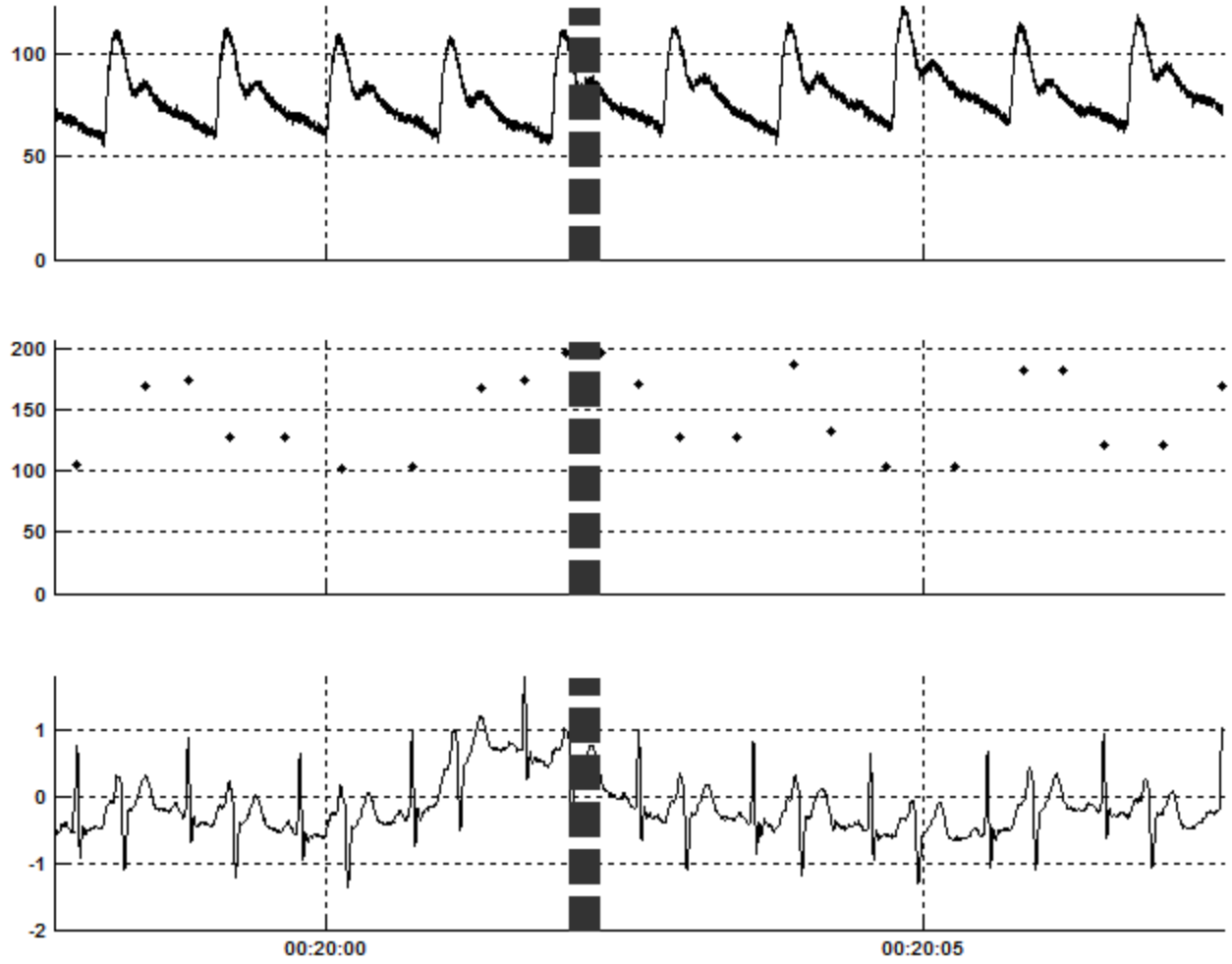
Onset of “vagal” response

Autonomic provocation : tilt testing

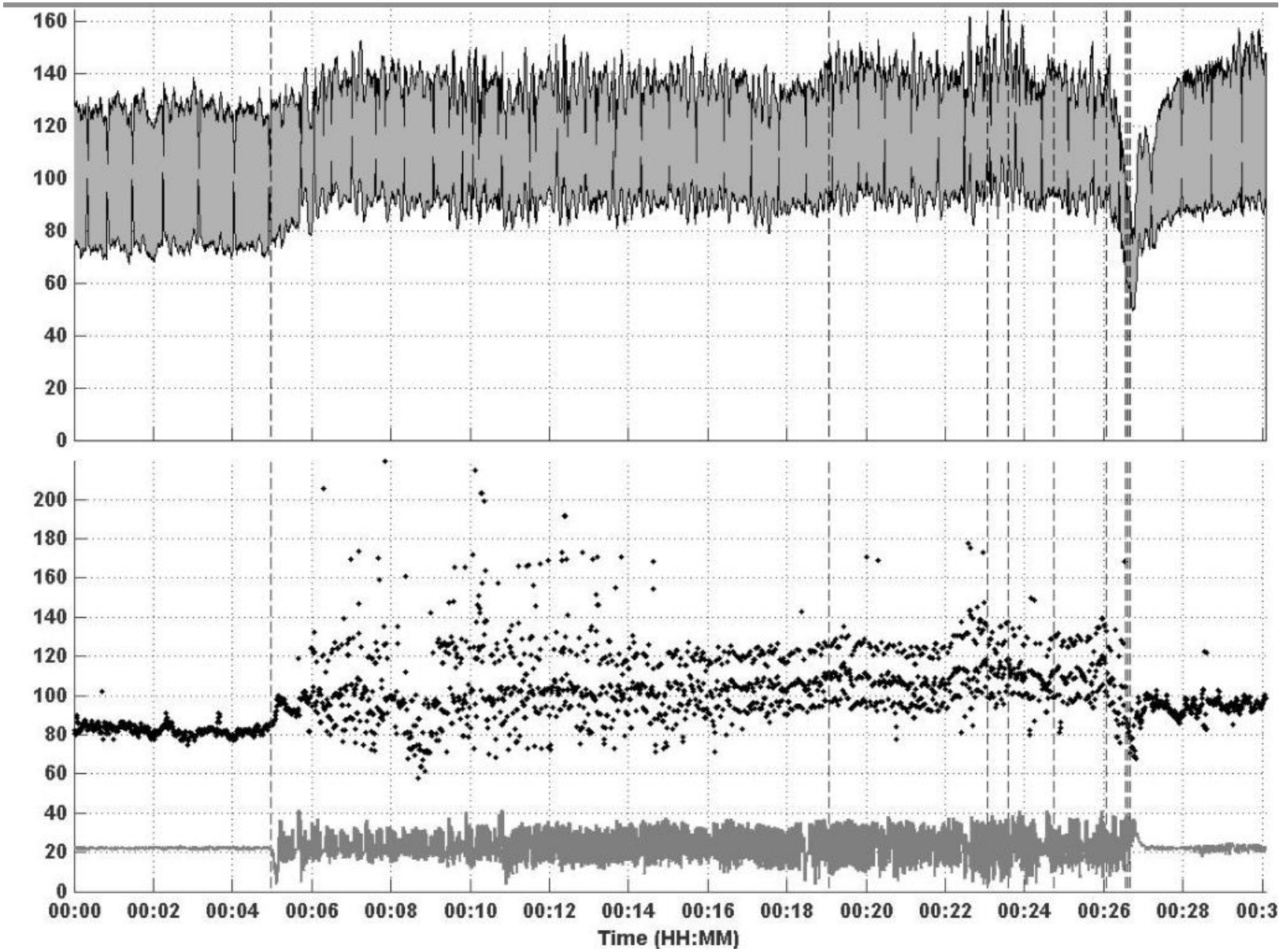


Onset of frequent ectopy thereafter

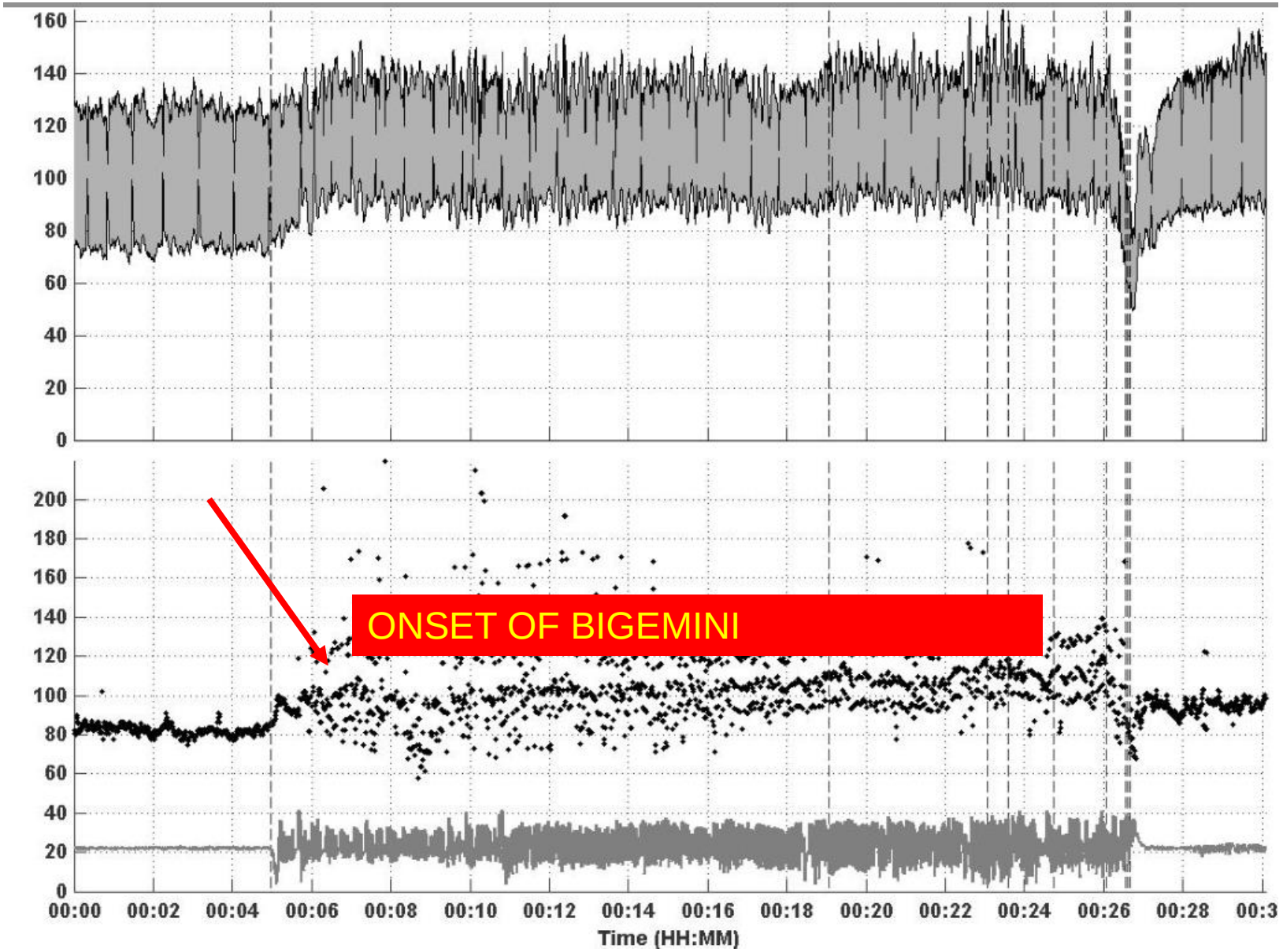
Bigemini following GTN administration response



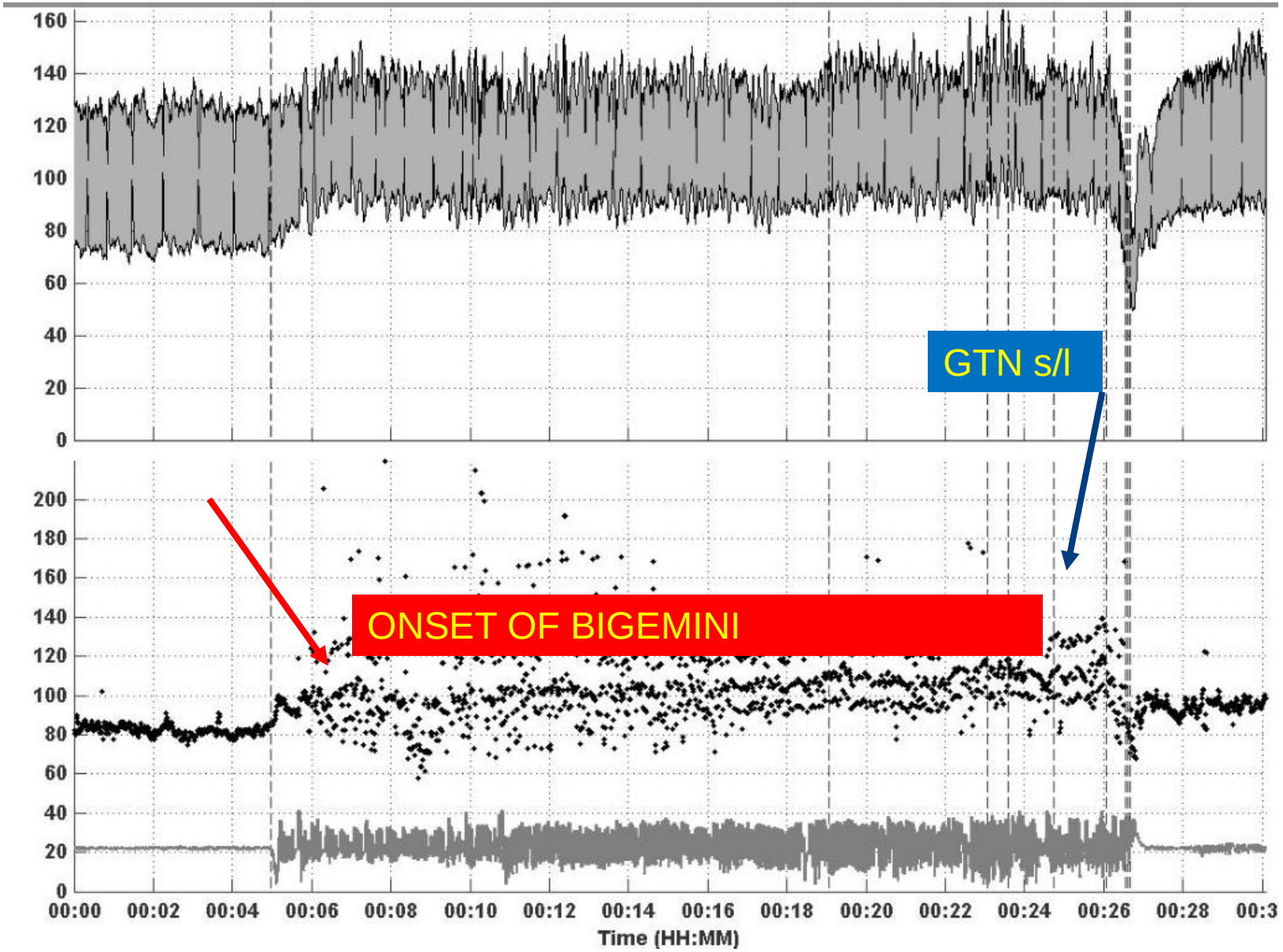
Patient with syncope but without clear palpitations



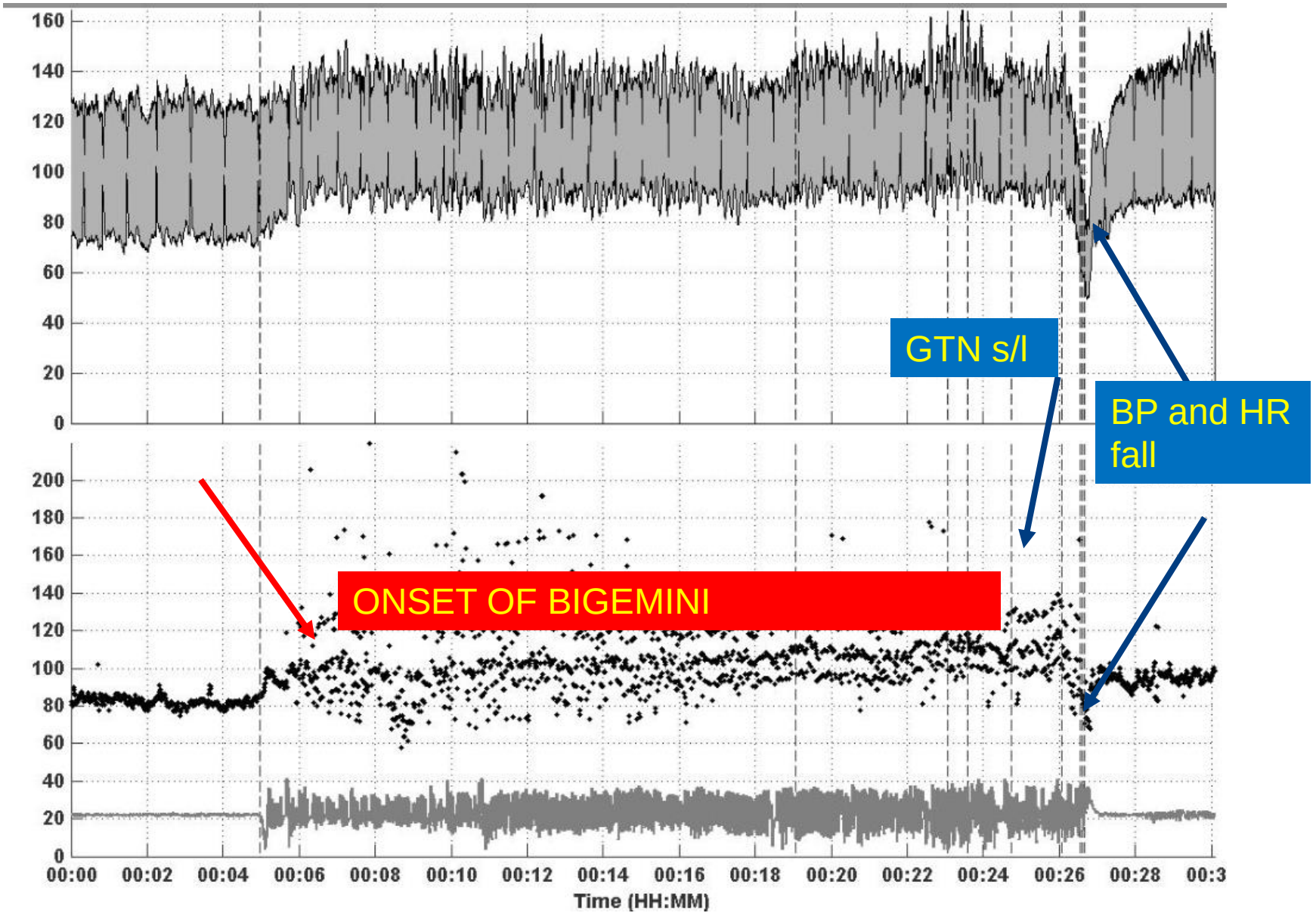
Patient with syncope but without clear palpitations



Patient with syncope but without clear palpitations



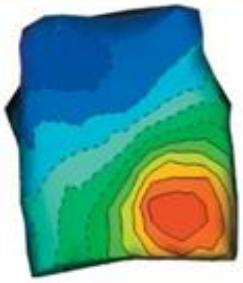
Patient with syncope but without clear palpitations

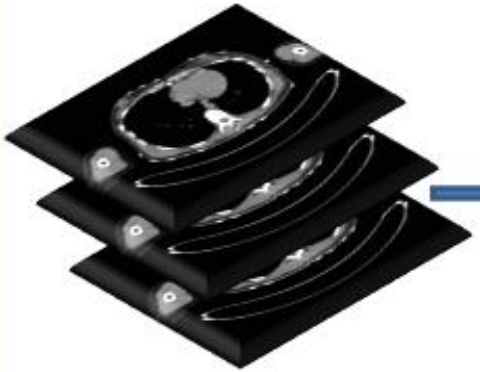


Coupled with Non-Invasive Electrographic Imaging (ECGi)

i) 252 electrode vest

ii) Body surface potentials

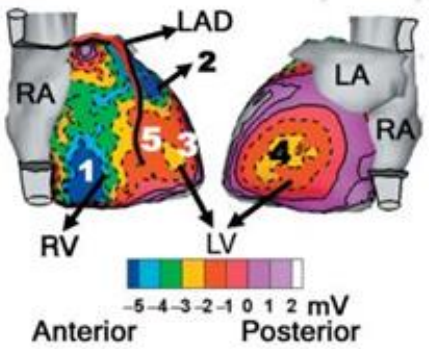


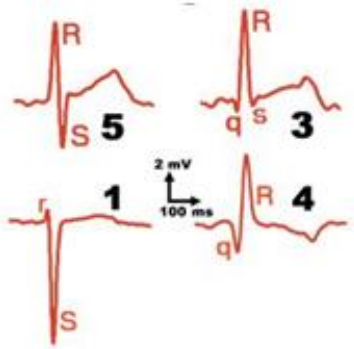


iii) Transverse CT images

iv) Heart Torso geometry

ECGi Software



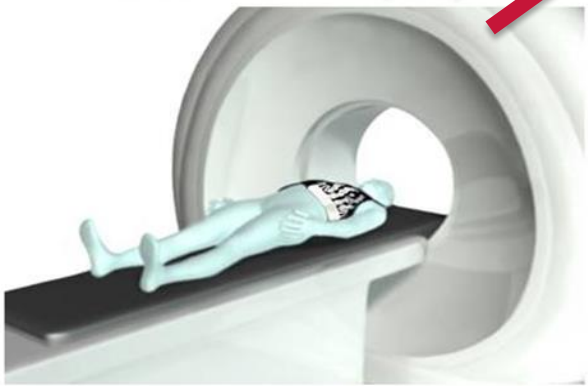


v) Epicardial potential map and reconstructed unipolar electrograms

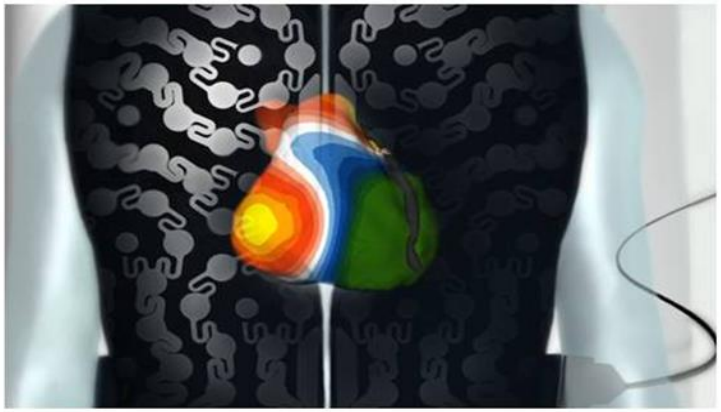
Work-flow at Imperial College

252 ELECTRODE VEST

HEART-TORSO GEOMETRY (CT)



ECM* ALGORITHMS SOLVES "INVERSE PROBLEM"



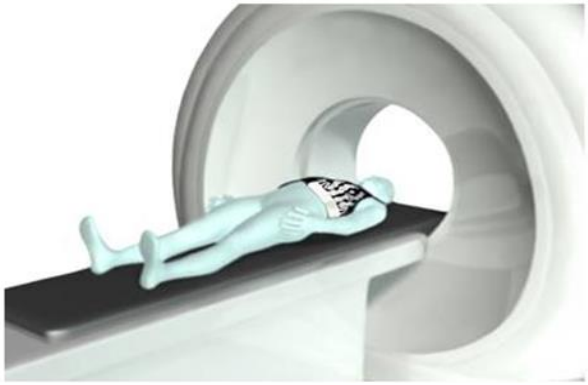
Patients then put through various challenges until clinical ectopy is seen, and pre-procedural mapping performed (up to 6 hours)

Following successful acquisition of ectopy, appropriate planning, including access, etc can be performed

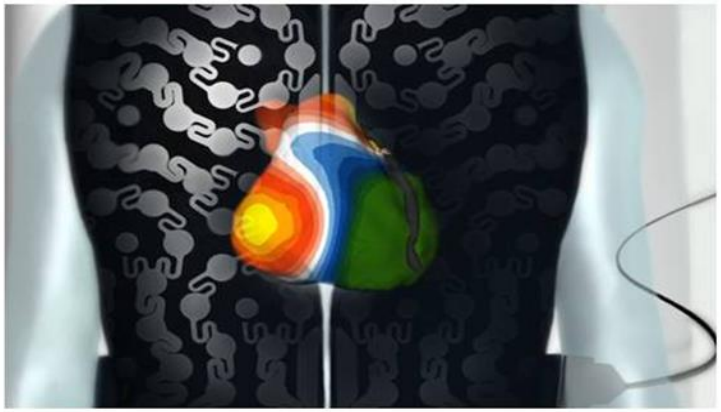
Work-flow at Imperial College

252 ELECTRODE VEST

HEART-TORSO GEOMETRY (CT)



ECM* ALGORITHMS SOLVES "INVERSE PROBLEM"



ECM MAPS

Multi-focal VE's with previous failed ablations

72 yo M, with dilated cardiomyopathy+ severe MR+ atrial fibrillation, normal coros

MV repair + AF surgery, MRI – infero-posterior full thickness scar

ICD implanted

Recurrent therapy for VT

Ablation#1 – intractable unstable VT after induction, CPR+lignocaine, abandoned

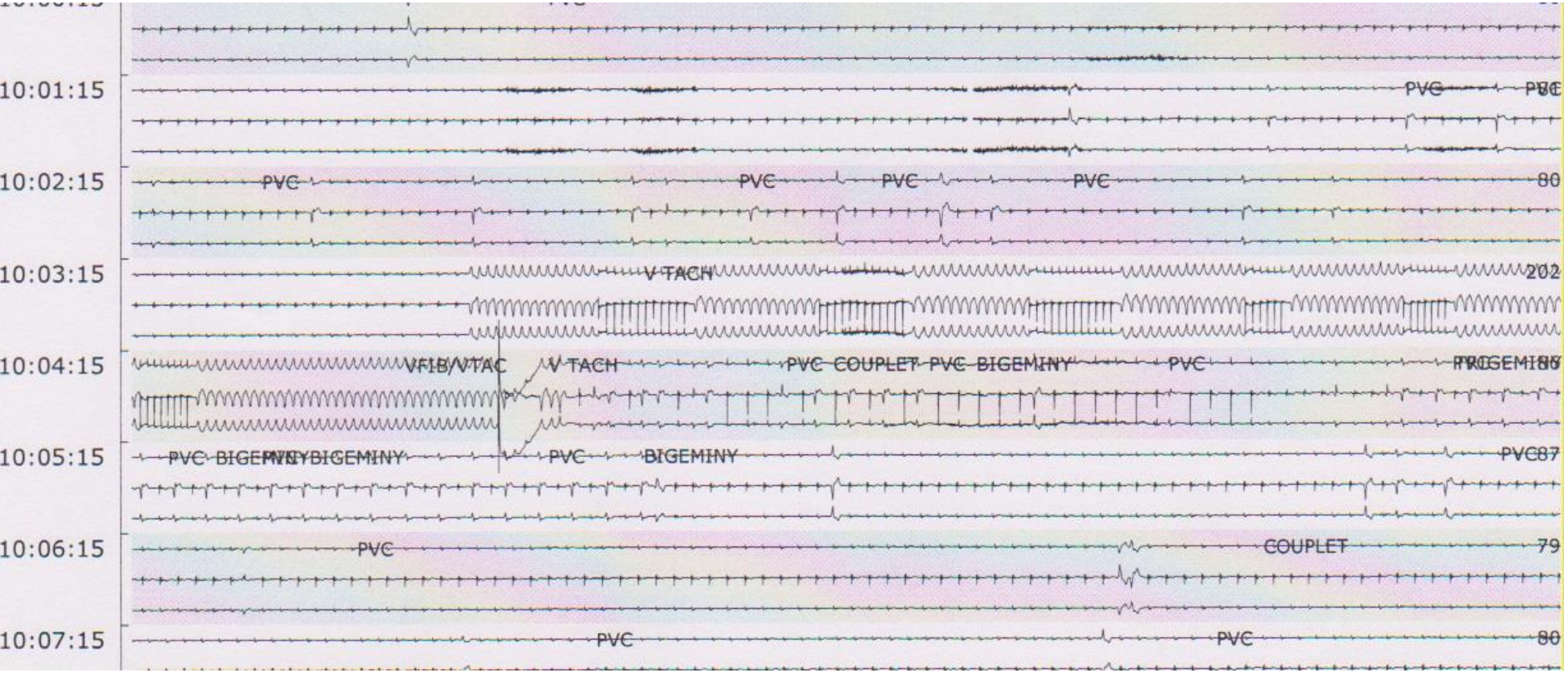
Ablation#2- substrate modification based on pacemap without induction, no VT inducible after ablation

Recurrent therapy for VT

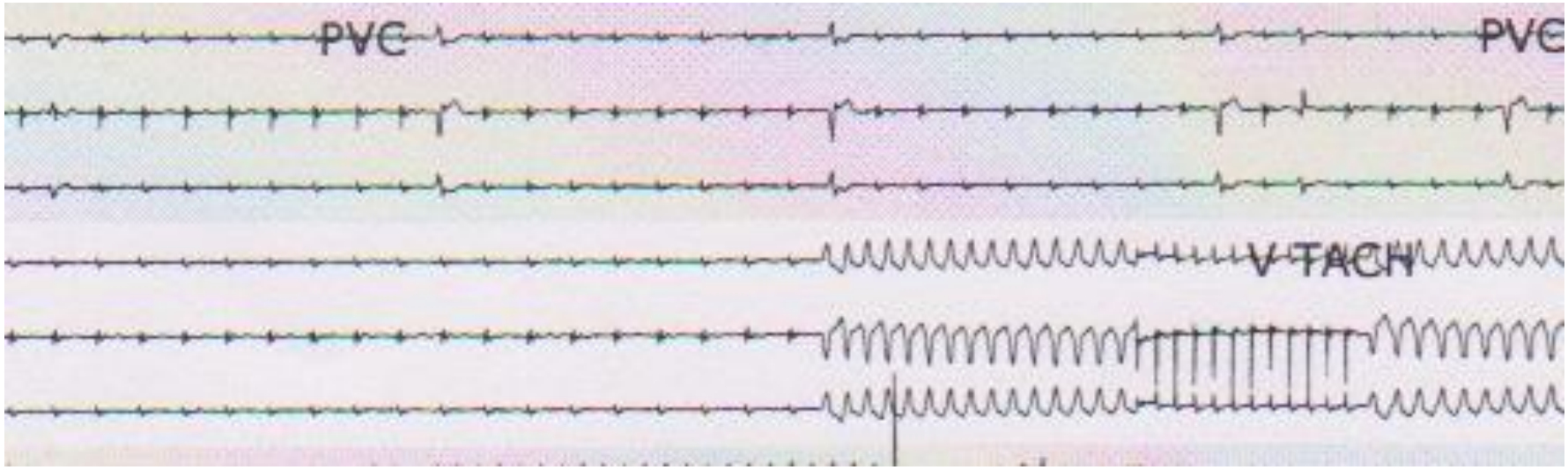
Ablation#3- no VT inducible, no ablation done

Recurrent therapy for VT

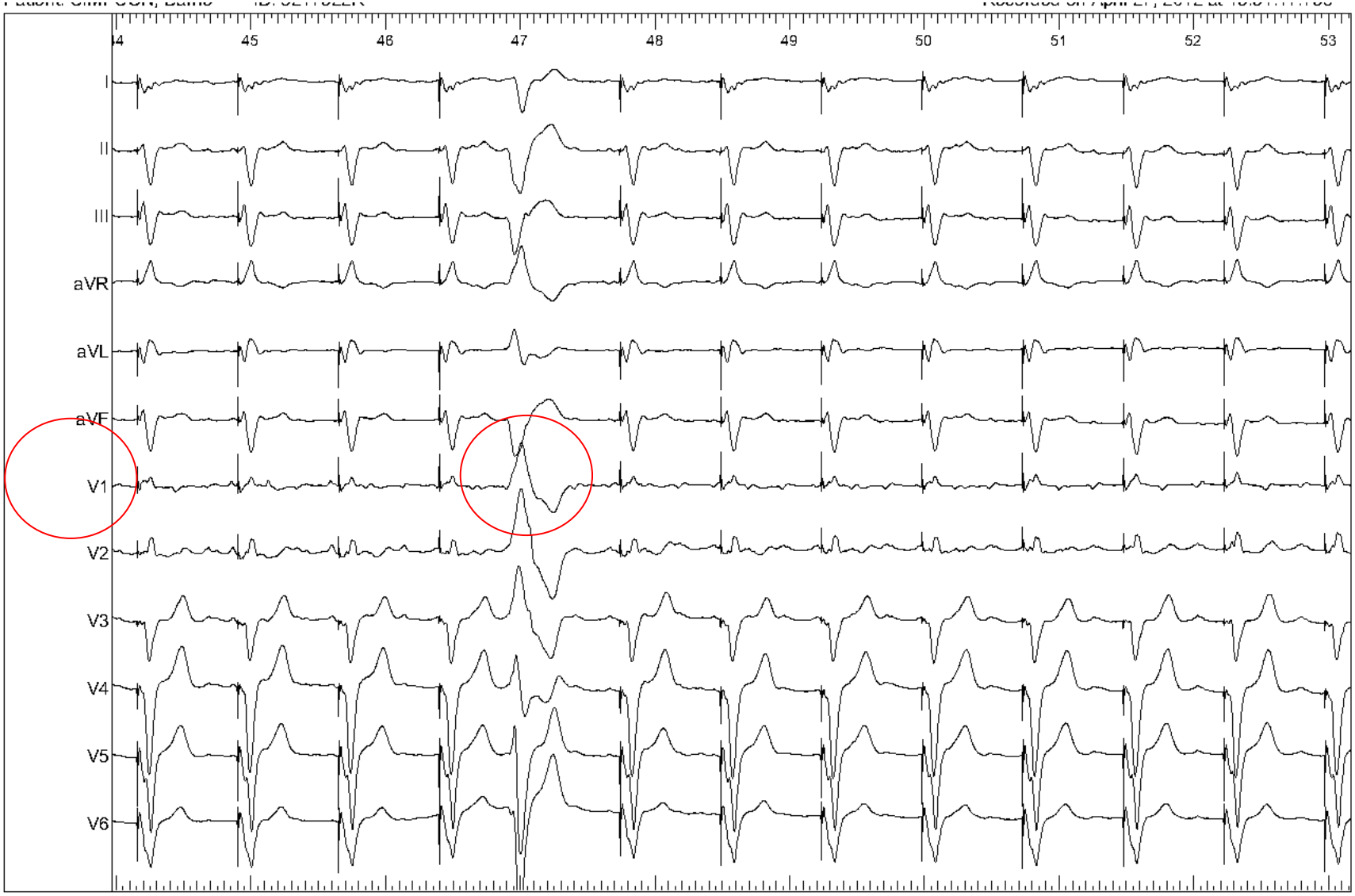
Multi-focal ectopy with VT initiation



Multifocal ectopy with VT initiation

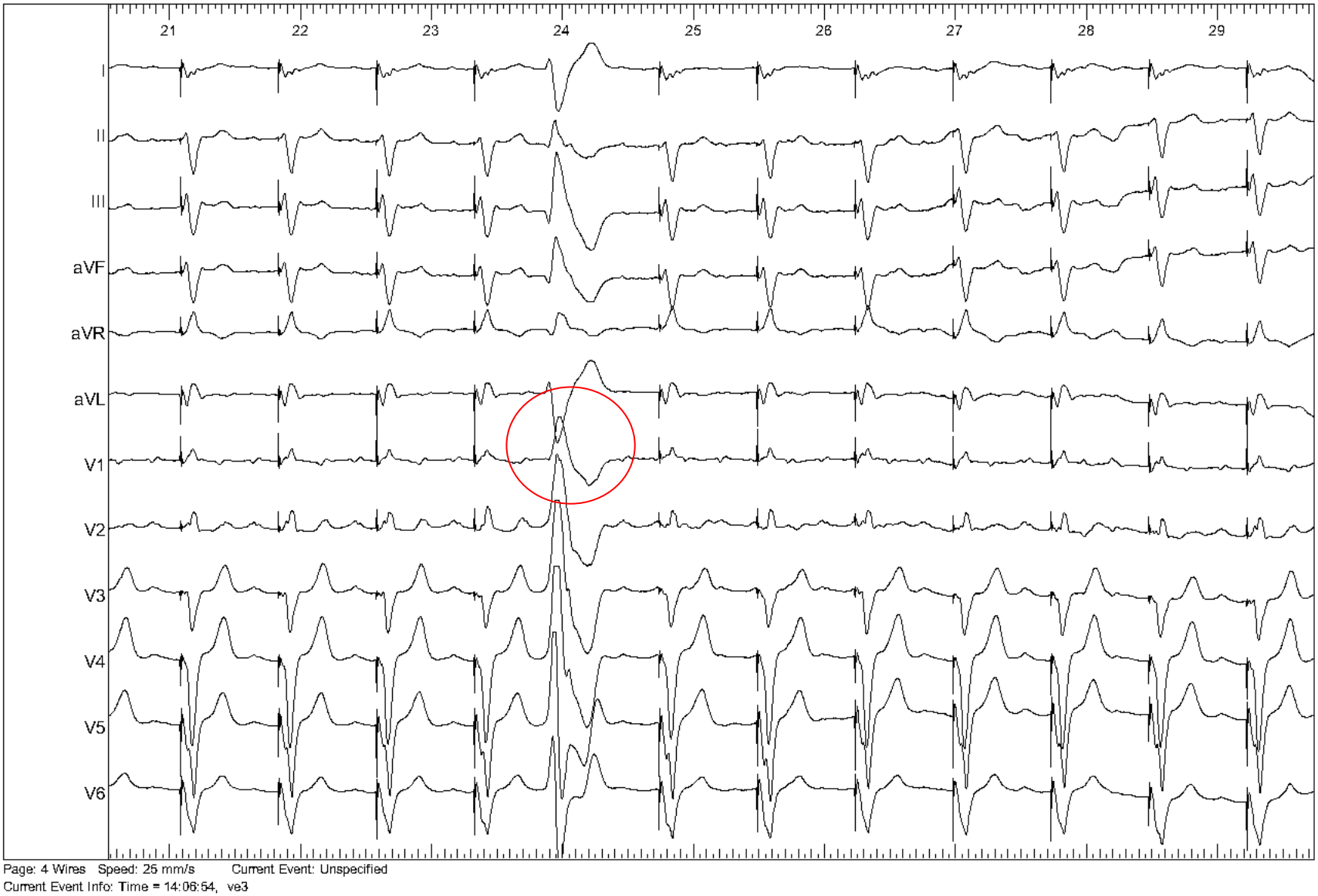


multi-focal VE's with previous failed ablations

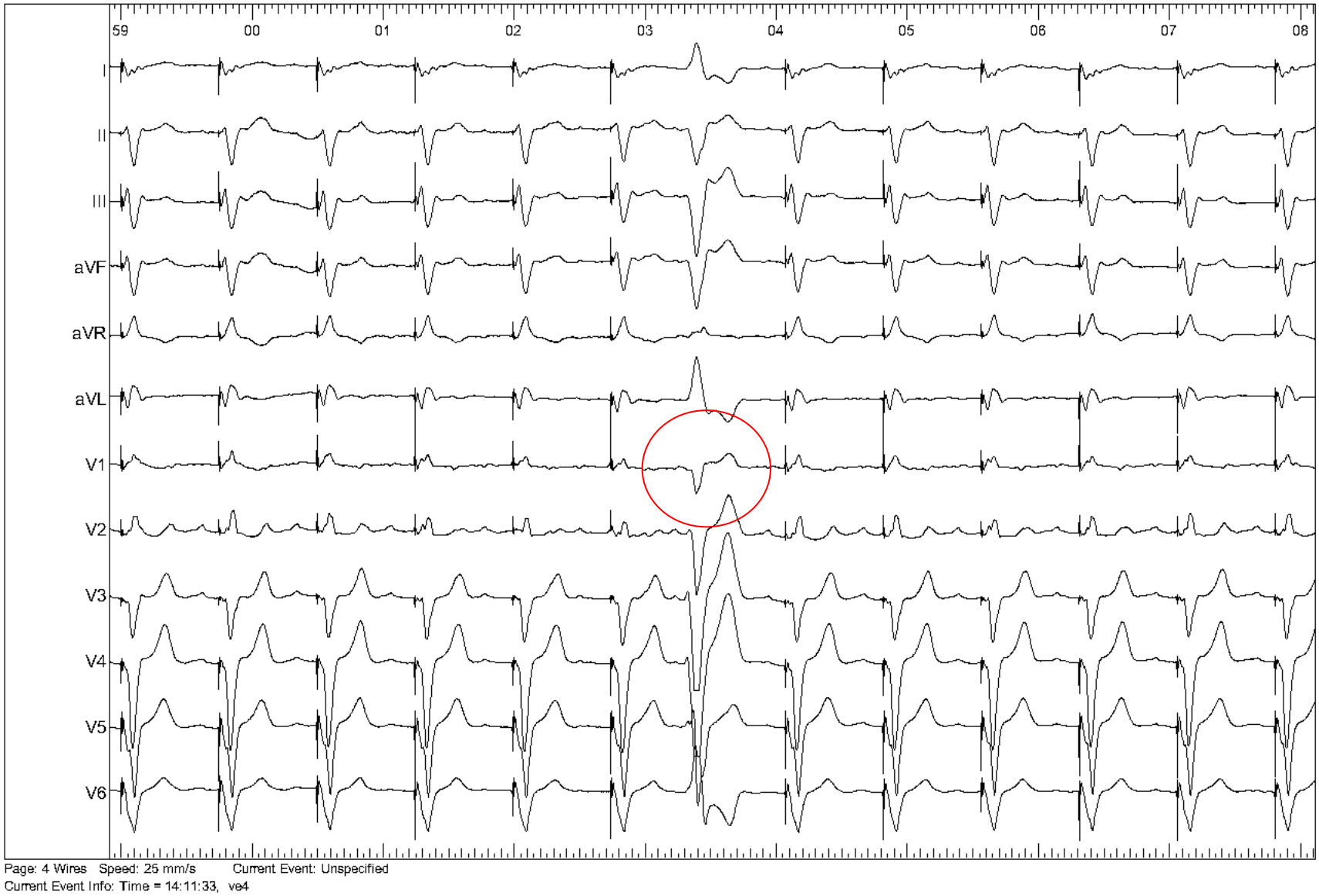


multi-focal VE's with previous failed ablations

multi-focal VE's with previous failed ablations

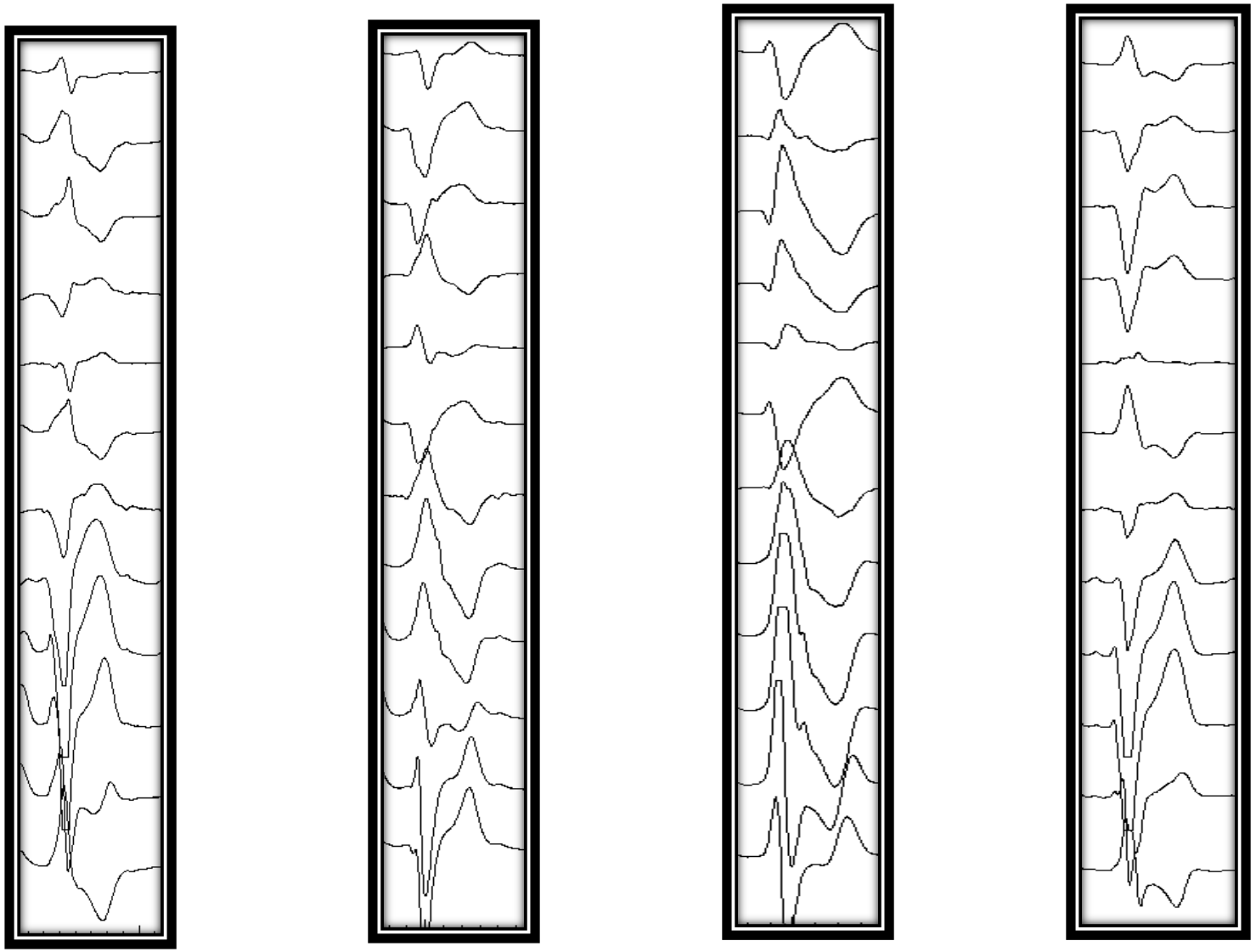


multi-focal VE's with previous failed ablations



multi-focal VE's with previous failed ablations

VE templates

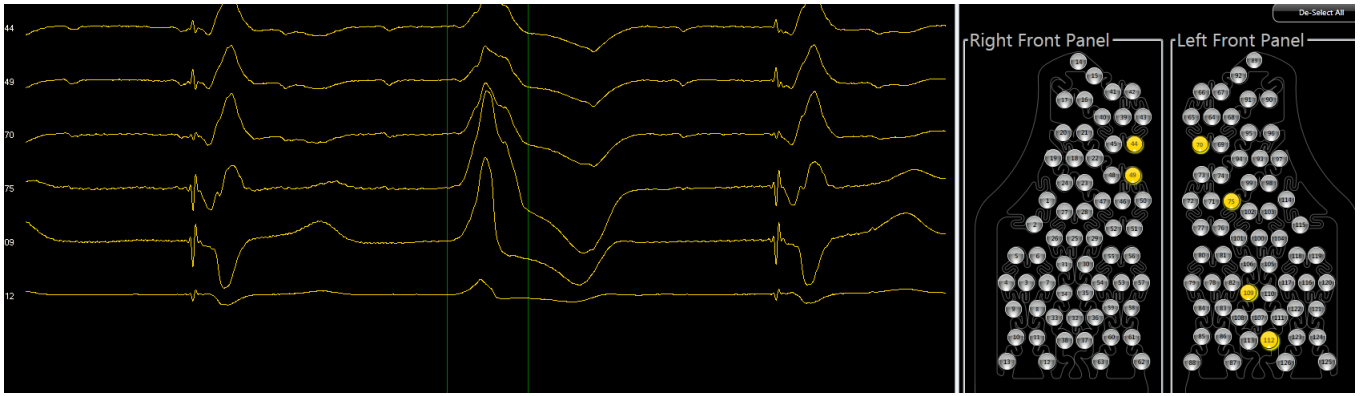


VE1 VE2 VE3 VE4

LV Inferior VE

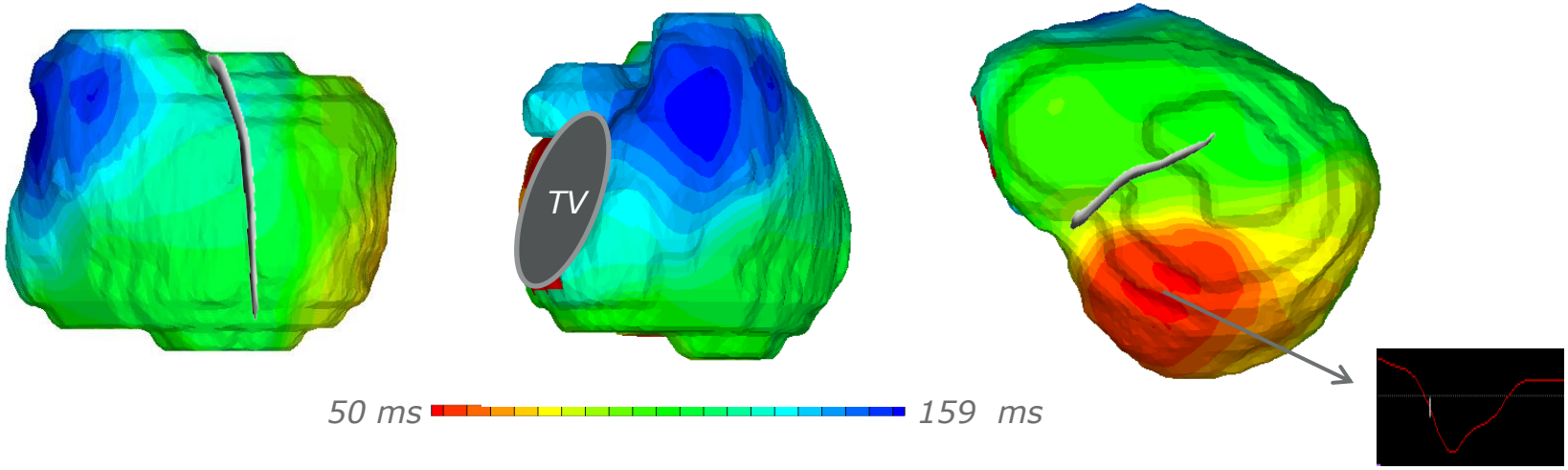
Body Surface Recordings

CLINICAL PVC



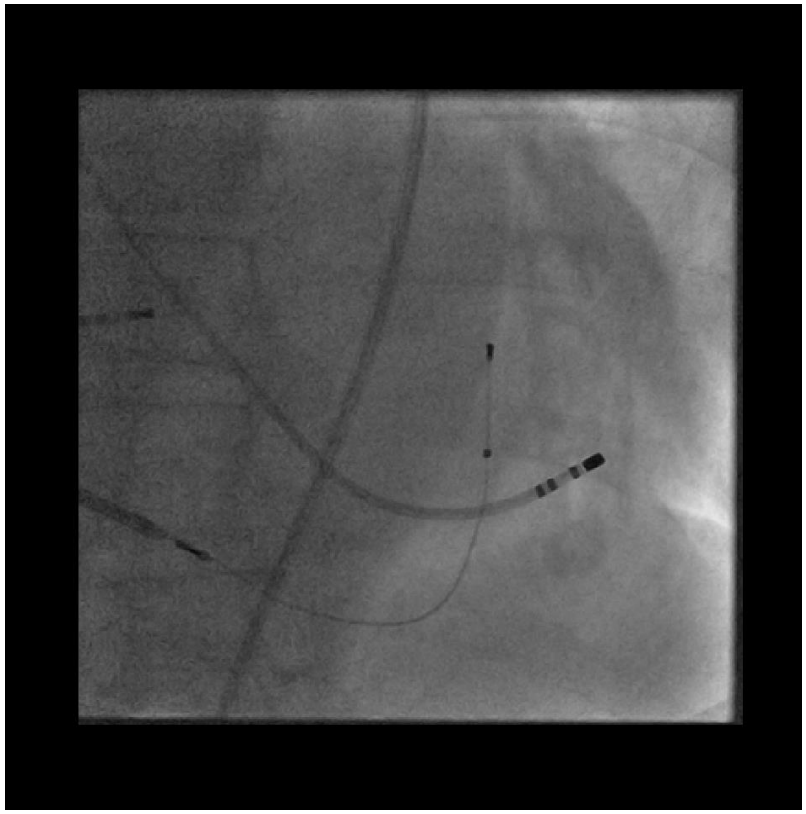
LAO *RAO* *CAUDAL*

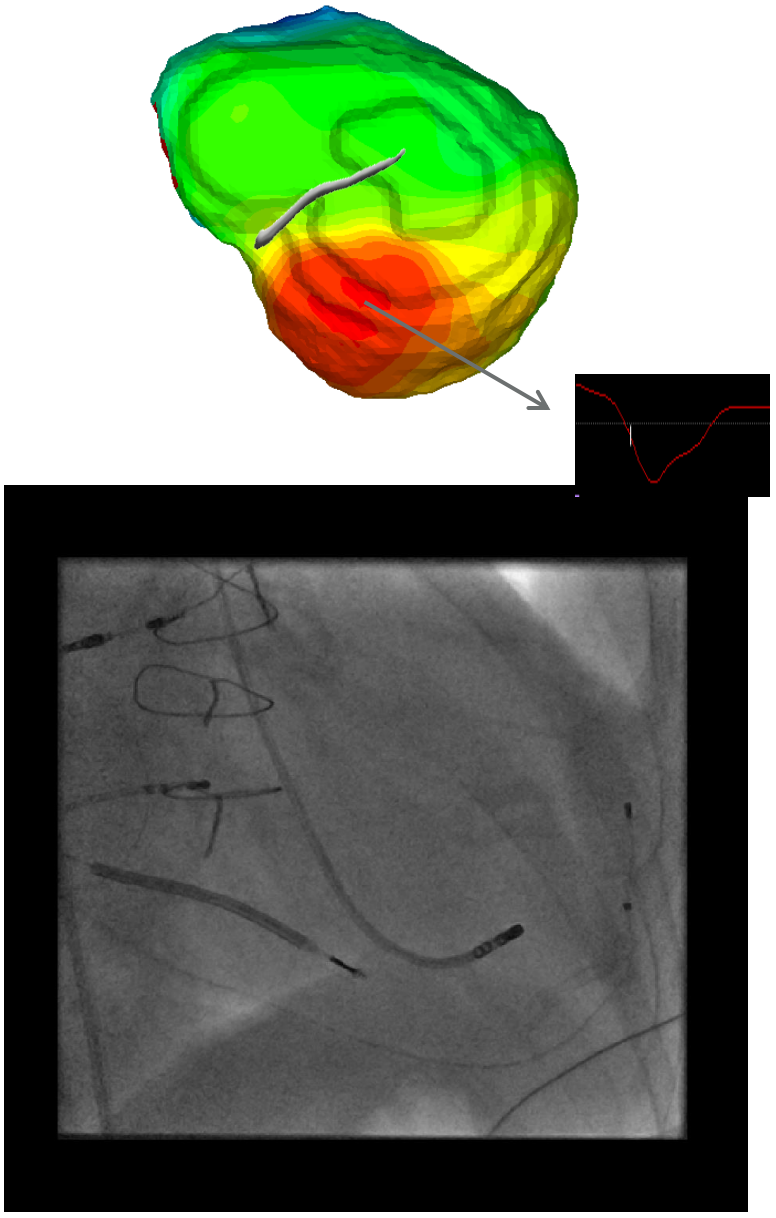
ACTIVATION MAP



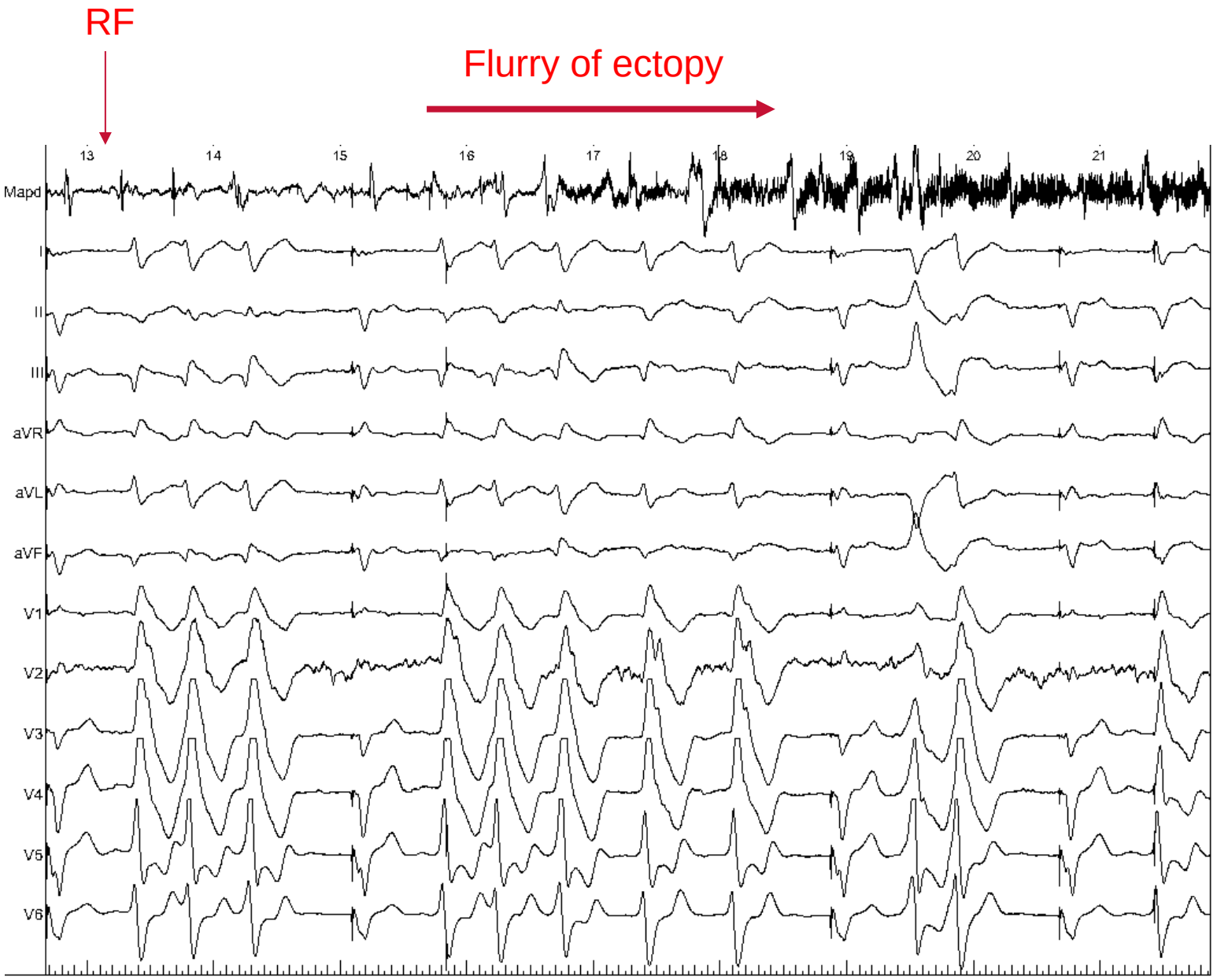
LV Inferior VE

CAUDAL





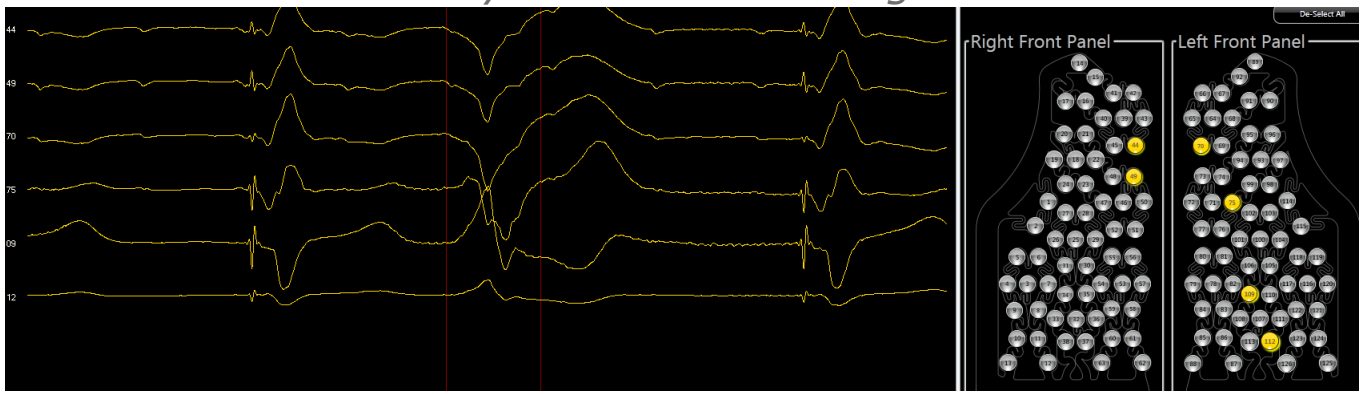
LV Inferior VE – response to ablation



LV Aorto-mitral continuity

CLINICAL PVC

Body Surface Recordings

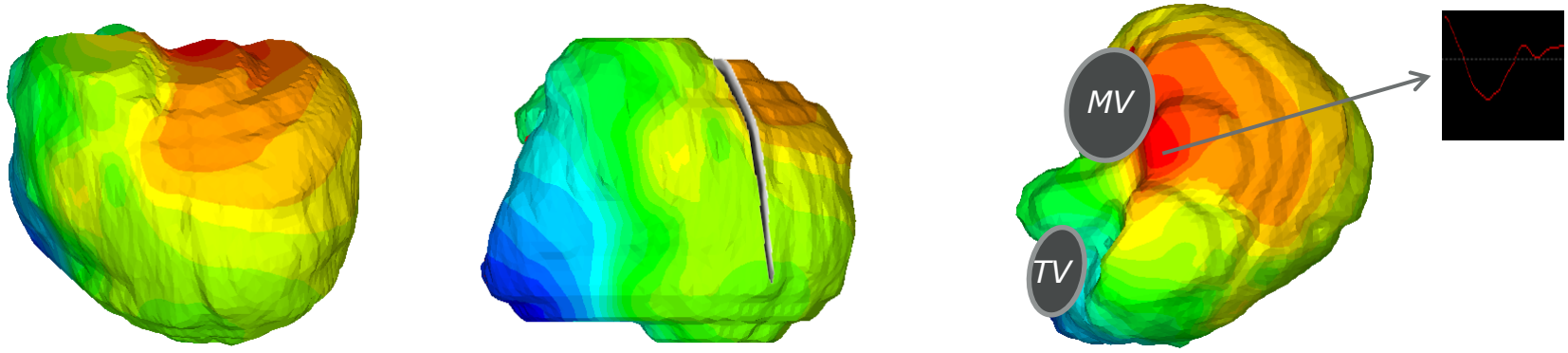


ACTIVATION MAP

LAO

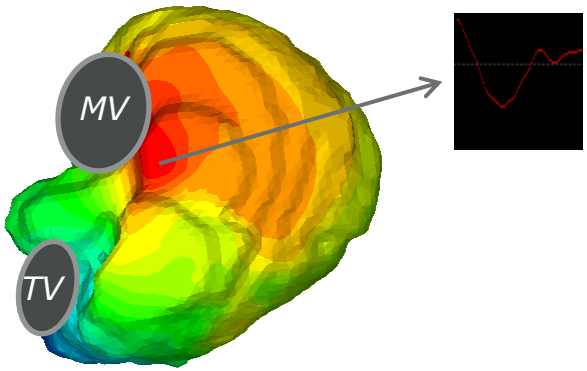
AP

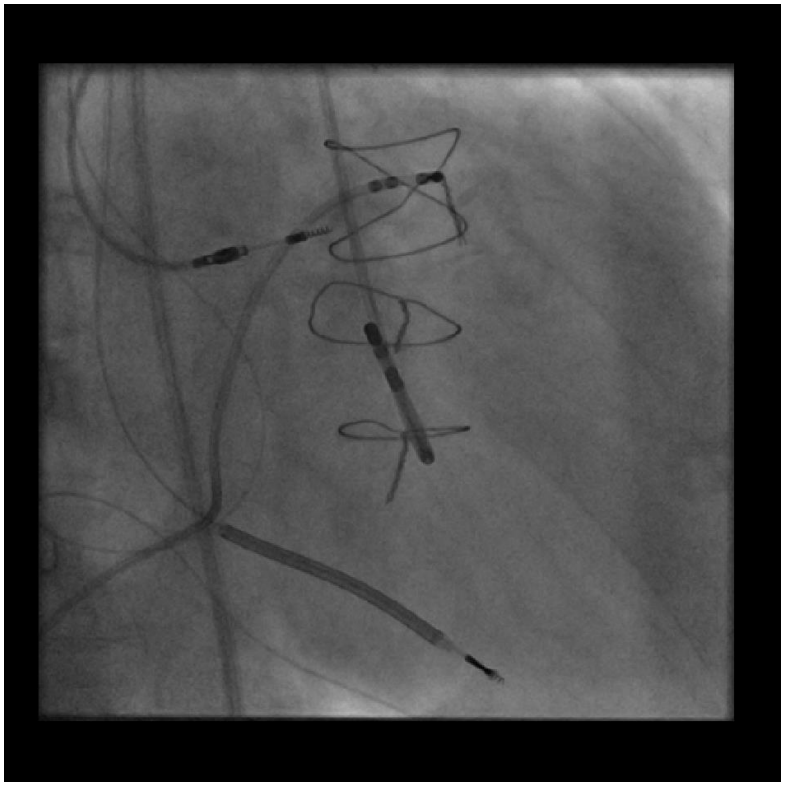
CRANIAL

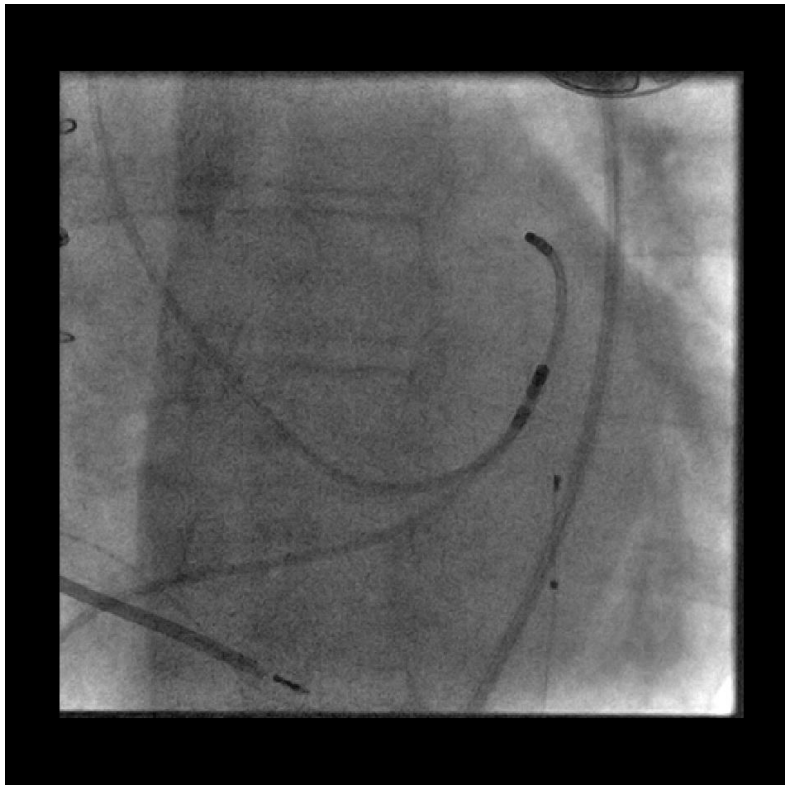


21 ms — 170 ms

LV Aorto-mitral continuity



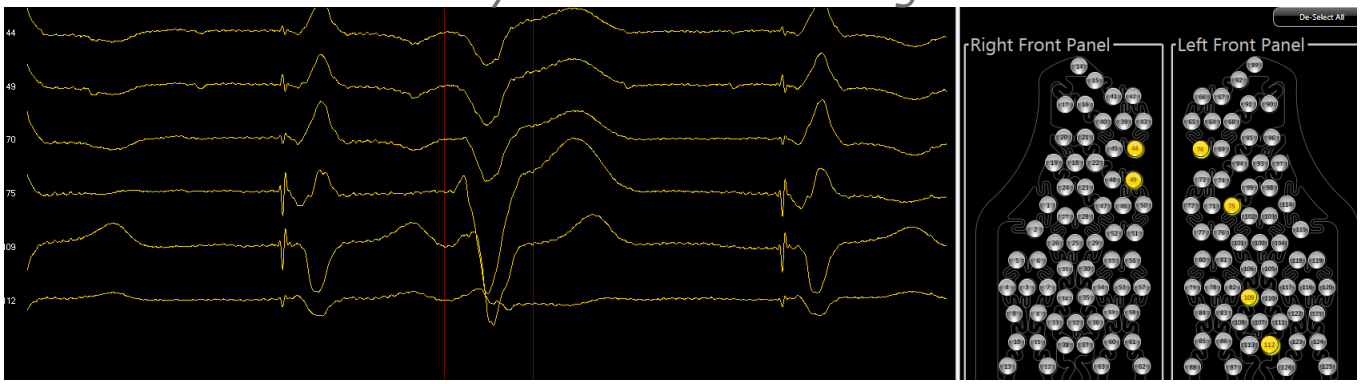




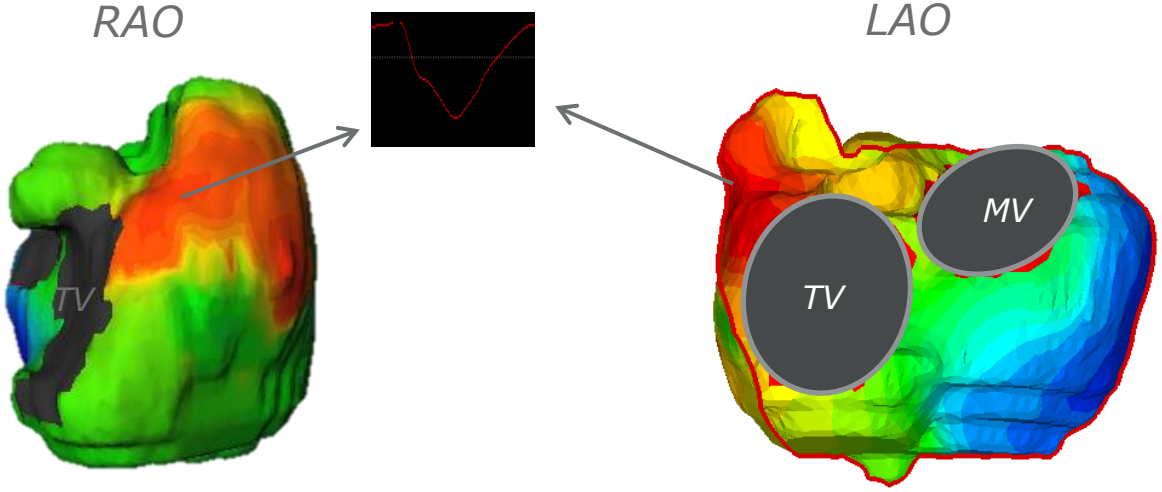
Lateral RV outflow VE

CLINICAL PVC

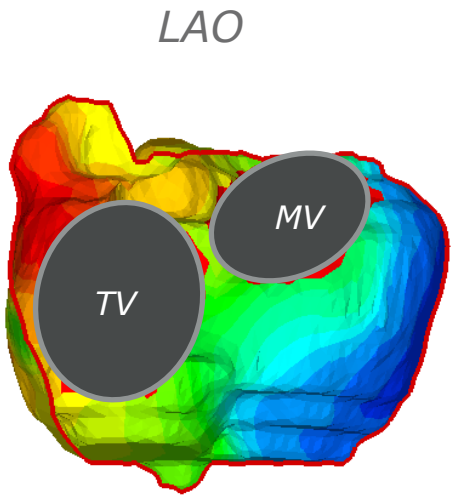
Body Surface Recordings

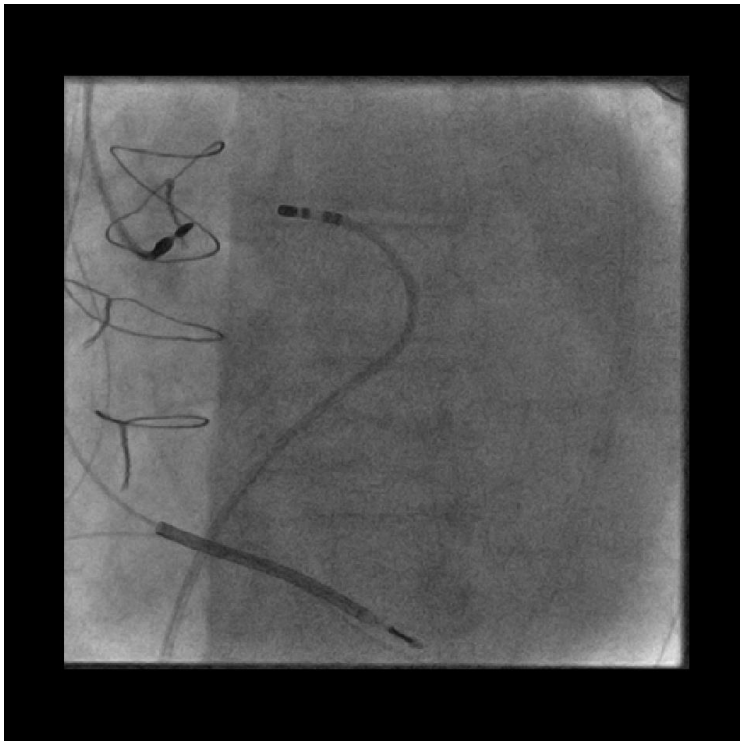


ACTIVATION MAP



Lateral RV outflow VE





multi-focal VE's with previous failed ablations

Successful ablation of at least 3 different ectopic sources

1) Inferoposterior apical LV
2) LV AMC
3) Lateral RVOT

Post ablation, no further therapies for 18 months follow up

Noninvasive electrocardiographic mapping to guide ablation of outflow tract ventricular arrhythmias

Shahnaz Jamil-Copley, MRCP,[†] Ryan Bokan, BSc,[‡] Pipin Kojodjojo, PhD, MRCP,[†] Norman Qureshi, MRCP,[†] Michael Koa-Wing, PhD, MRCP,[†] Sajad Hayat, MD, MRCP,[†] Andreas Kyriacou, MRCP,[†] Belinda Sandler, MRCP,[†] Afzal Sohaib, MRCP,[†] Ian Wright, BSc,[*] David Wyn Davies, MD, FHRS,[†] Zachary Whinnett, PhD, MRCP,[†] Nicholas S. Peters, PhD, FHRS,[†] Prapa Kanagaratnam, PhD, MRCP,[†] Phang Boon Lim, PhD, MRCP[†]

From the [*]Department of Cardiac Electrophysiology, St. Mary's and Hammersmith Hospitals, Imperial College NHS Healthcare Trust, [†]Imperial College London, London, United Kingdom, and [‡]Cardioinsight Technologies, Cleveland, Ohio.

BACKGROUND Localizing the origin of outflow tract ventricular tachycardias (OTVT) is hindered by lack of accuracy of electrocardiographic (ECG) algorithms and infrequent spontaneous premature ventricular complexes (PVCs) during electrophysiological studies.

OBJECTIVES To prospectively assess the performance of noninvasive electrocardiographic mapping (ECM) in the pre-/periprocedural localization of OTVT origin to guide ablation and to compare the accuracy of ECM with that of published ECG algorithms.

METHODS Patients with symptomatic OTVT/PVCs undergoing clinically indicated ablation were recruited. The OTVT/PVC origin was mapped preprocedurally by using ECM, and 3 published ECG algorithms were applied to the 12-lead ECG by 3 blinded electrophysiologists. Ablation was guided by using ECM. The OTVT/PVC origin was defined as the site where ablation caused arrhythmia suppression. Acute success was defined as abolition of ectopy after ablation. Medium-term success was defined as the abolition of symptoms and reduction of PVC to less than 1000 per day documented on Holter monitoring within 6 months.

RESULTS In 24 patients (mean age 50 ± 18 years) recruited ECM successfully identified OTVT/PVC origin in 23/24 (96%) (right ventricular outflow tract, 18; left ventricular outflow tract, 6), sublocalizing correctly in 100% of this cohort. Acute ablation success was achieved in 100% of the cases with medium-term success in 22 of 24 patients. PVC burden reduced from 21,837 ± 23,241 to 1143 ± 4039 ($P < .0001$). ECG algorithms identified the correct chamber of origin in 50%–88% of the patients and sublocalized within the right ventricular outflow tract (septum vs free-wall) in 37%–58%.

CONCLUSIONS ECM can accurately identify OTVT/PVC origin in the left and the right ventricle pre- and periprocedurally to guide catheter ablation with an accuracy superior to that of published ECG algorithms.

KEYWORDS Ventricular tachycardia; Premature ventricular complex; Outflow tract tachycardia

ABBREVIATIONS **CT** = computed tomographic; **EF** = ejection fraction; **ECG** = electrocardiographic; **ECM** = electrocardiographic mapping; **EPS** = electrophysiological study; **LV** = left ventricular/ventricle; **LVOT** = left ventricular outflow tract; **OTVT** = outflow tract ventricular tachycardia; **PVC** = premature ventricular complex; **PVS** = programmed ventricular stimulation; **RV** = right ventricular/ventricle; **RVOT** = right ventricular outflow tract; **VT** = ventricular tachycardia

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Summary: non-invasive assessment of arrhythmias

ECG remains gold standard

But think of using all modalities – including hand-held devices!

Autonomic provocation can be helpful

Summary: non-invasive assessment of arrhythmias

LISTEN AND LEARN FROM YOUR CHIEF PHYSIOLOGIST

Imperial College London

Imperial College Healthcare NHS Trust

Non-invasive assessment of arrhythmias

P Boon Lim
Imperial College Healthcare

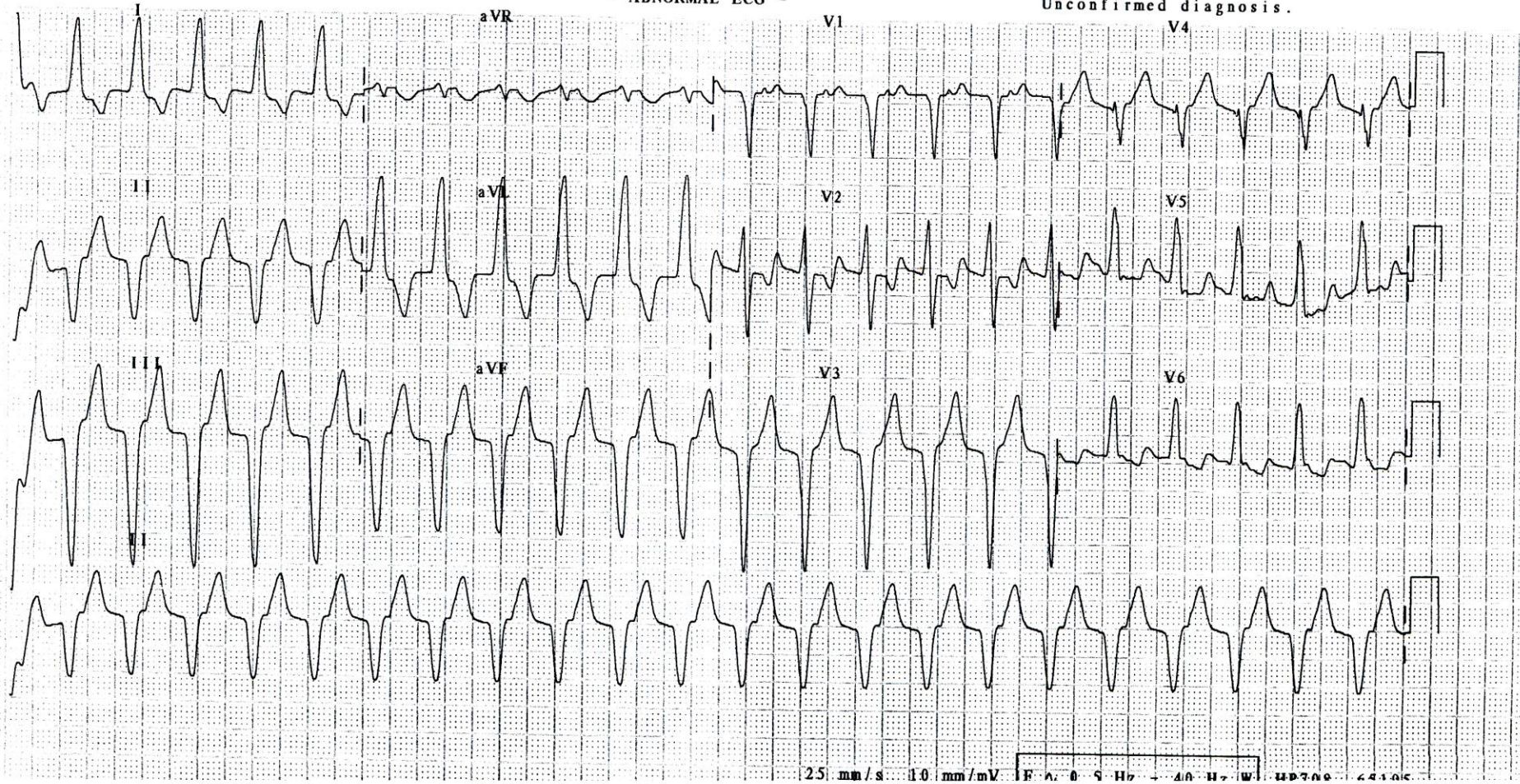
30-Dec-2007 17:36:38

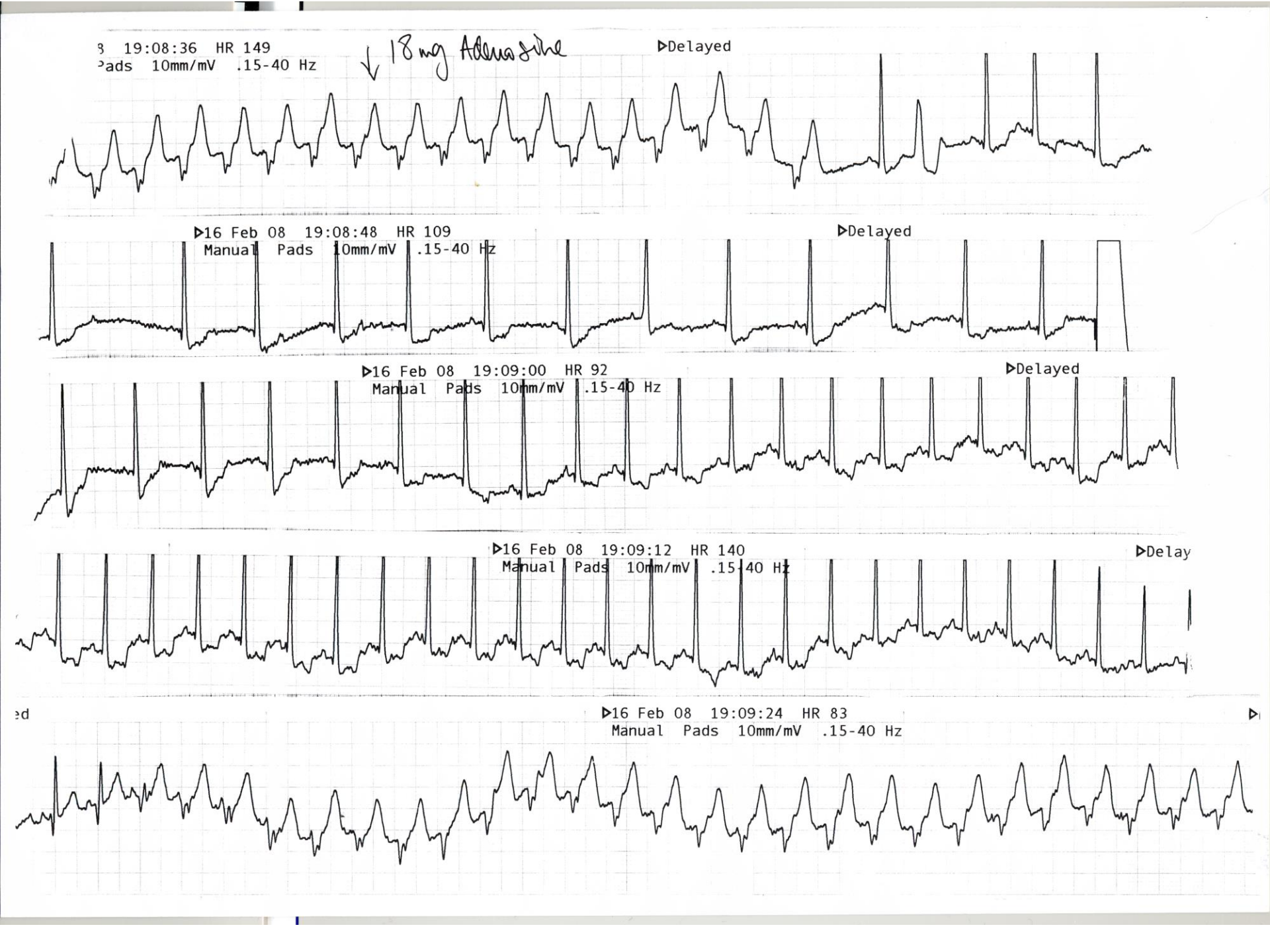
F

Rate	135	. Tachycardia, ? origin, rate 135
PR	0	. Left axis deviation
QRSD	117	. Incomplete left bundle branch block
QT	341	. LVH with ST-T abnormalities
QTc	511	. Inferior infarct, possibly acute
		. Consider Anterior infarct
--Axis--		
P		
QRS	-58	
T	104	

- ABNORMAL ECG -

Unconfirmed diagnosis.




19:08:36 HR 149
Pads 10mm/mV .15-40 Hz
18 mg Adenosine
Delayed
16 Feb 08 19:08:48 HR 109
Manual Pads 10mm/mV .15-40 Hz
Delayed
16 Feb 08 19:09:00 HR 92
Manual Pads 10mm/mV .15-40 Hz
Delayed
16 Feb 08 19:09:12 HR 140
Manual Pads 10mm/mV .15-40 Hz
Delay
16 Feb 08 19:09:24 HR 83
Manual Pads 10mm/mV .15-40 Hz

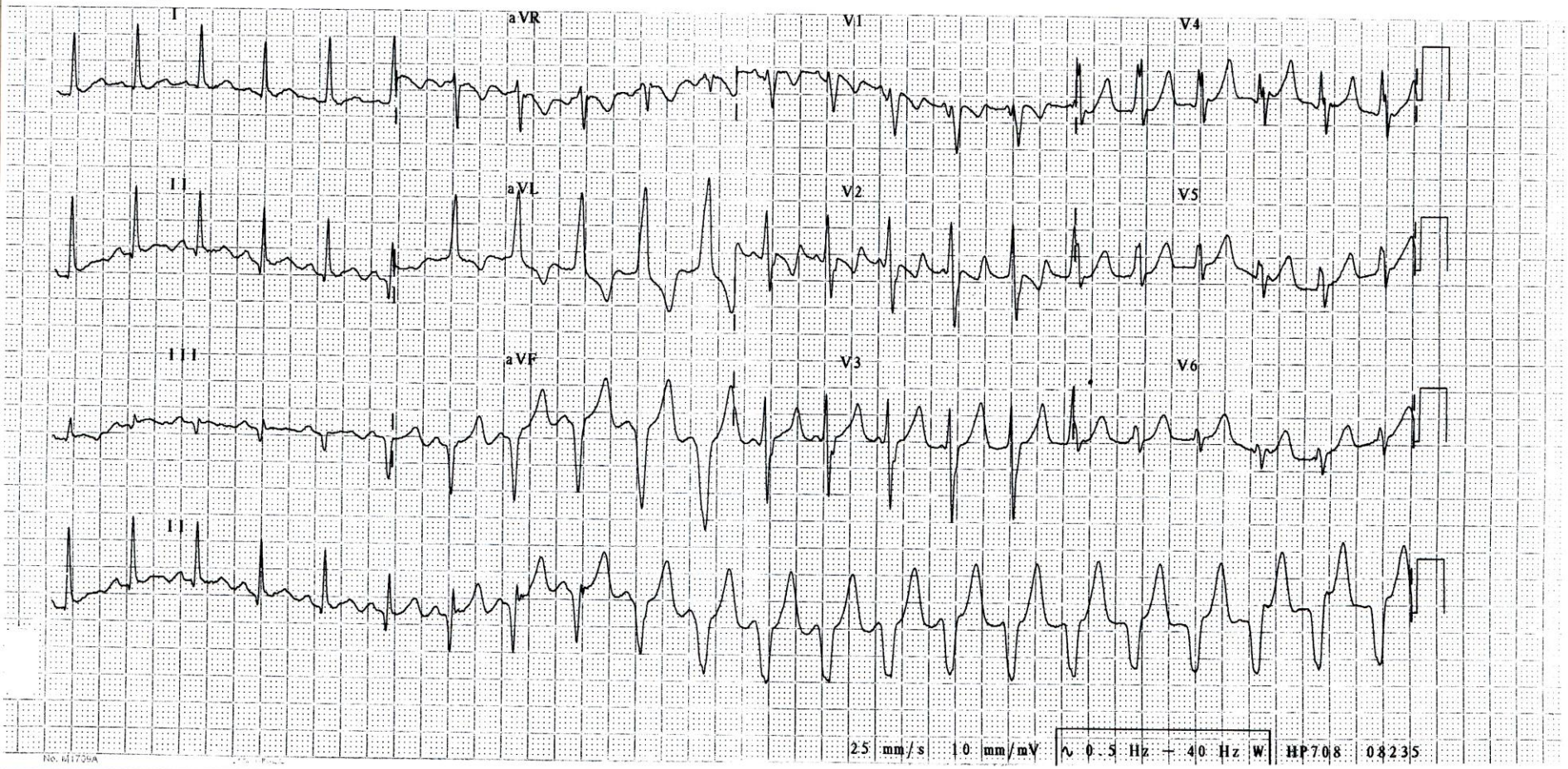
16-Feb-2008 22:08:52

Rate	129
PR	112
QRSD	108
QT	326
QTc	478

--Axis--

P	75
QRS	-7
T	68

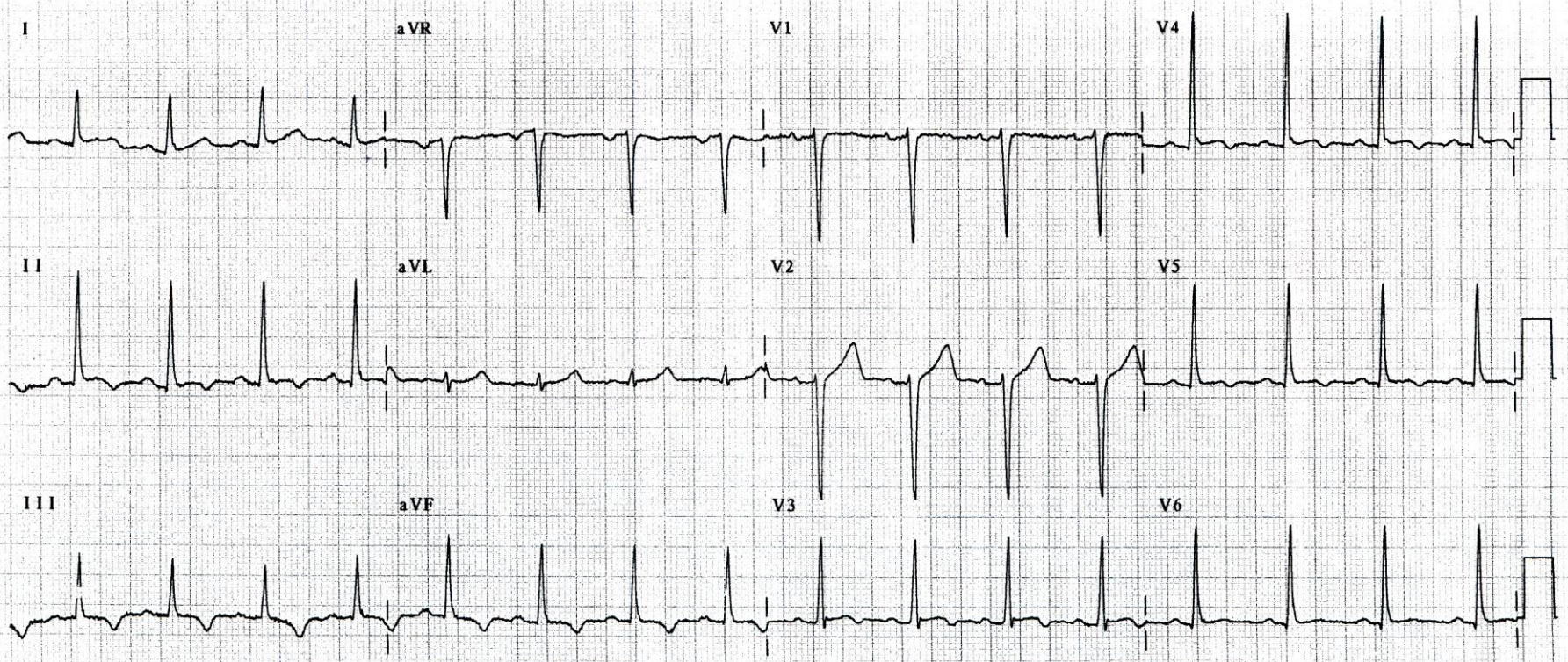
Adenosine 18mg given
30 seconds earlier



Rx :
Dx : 31/12/07

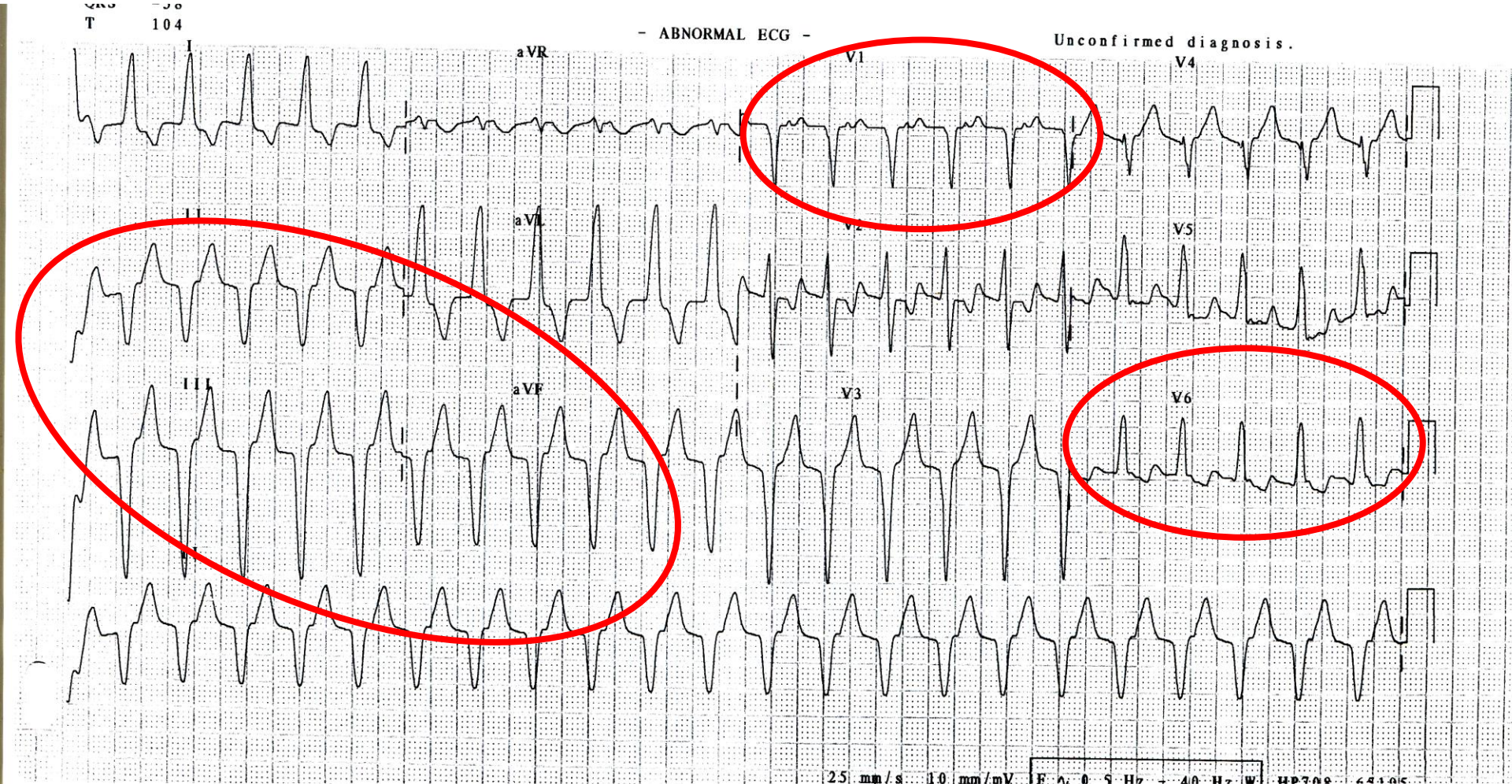
Oper :

Requested by:

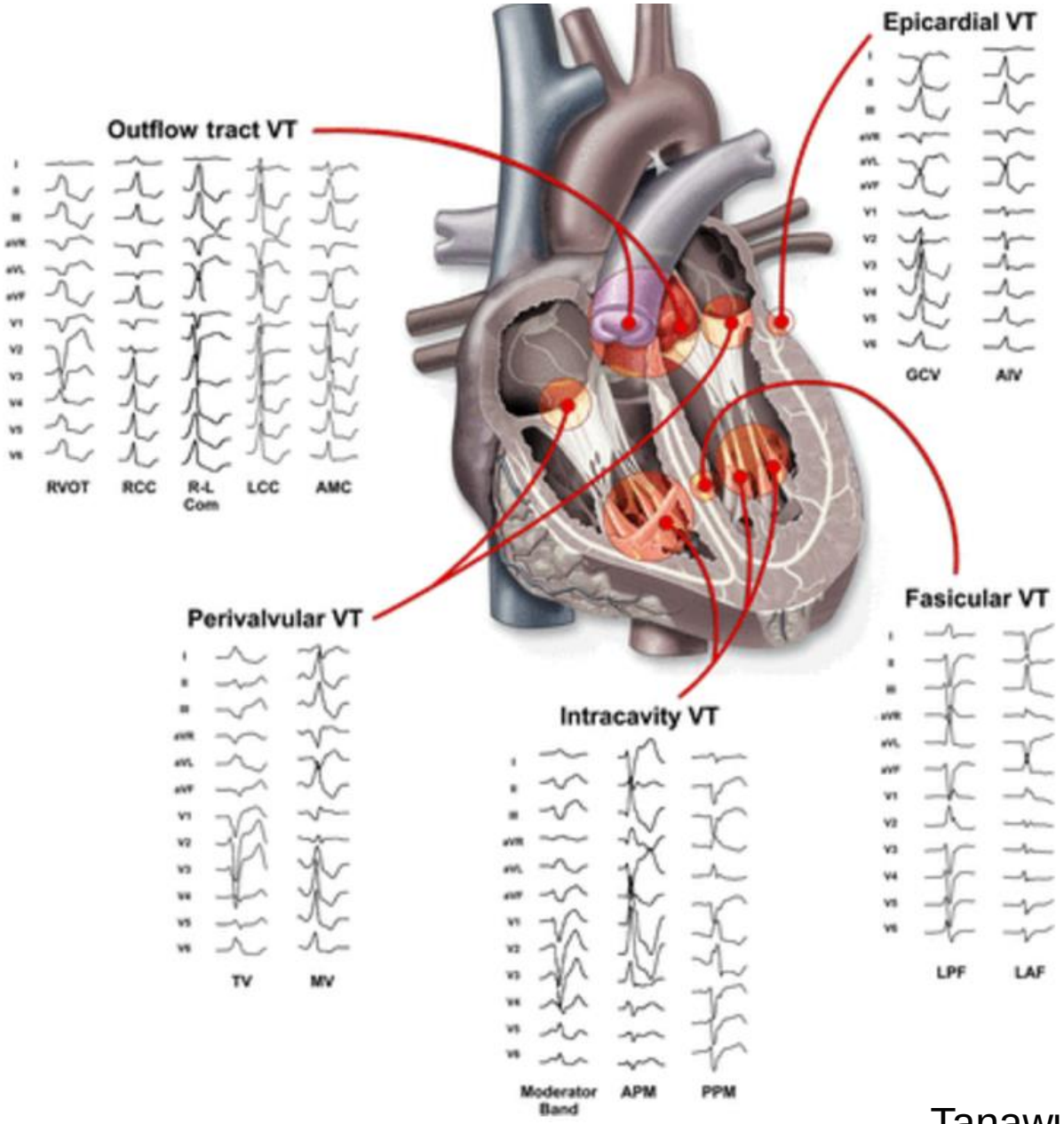


Diagnosis = VT (from where?)

RV (from inferior wall)



Localisation of VT



Tanawuttiwat,.. Calkins. EHJ 2015