Cardiology Update 2013

The Challenging ECG

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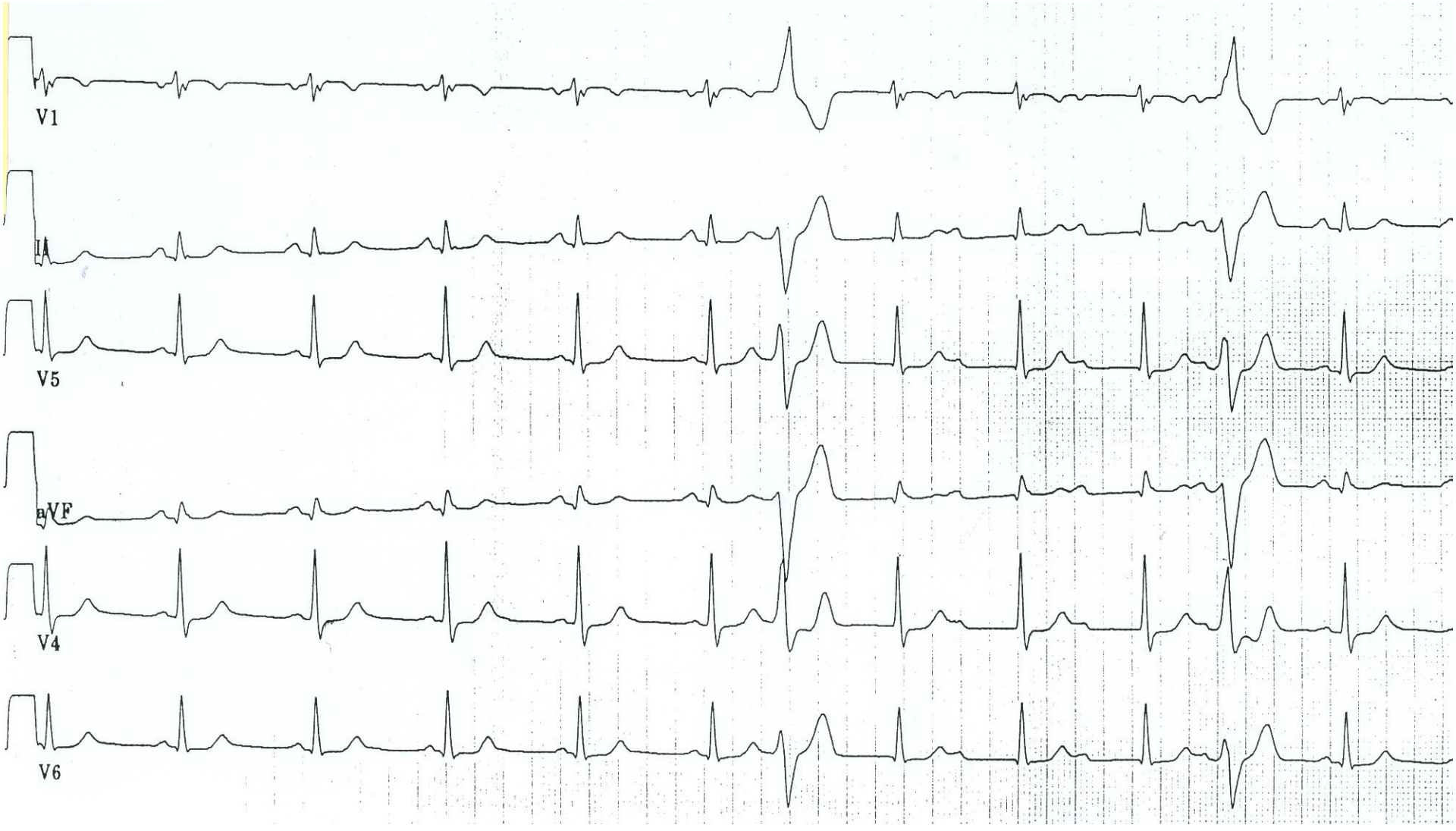
Case 1:

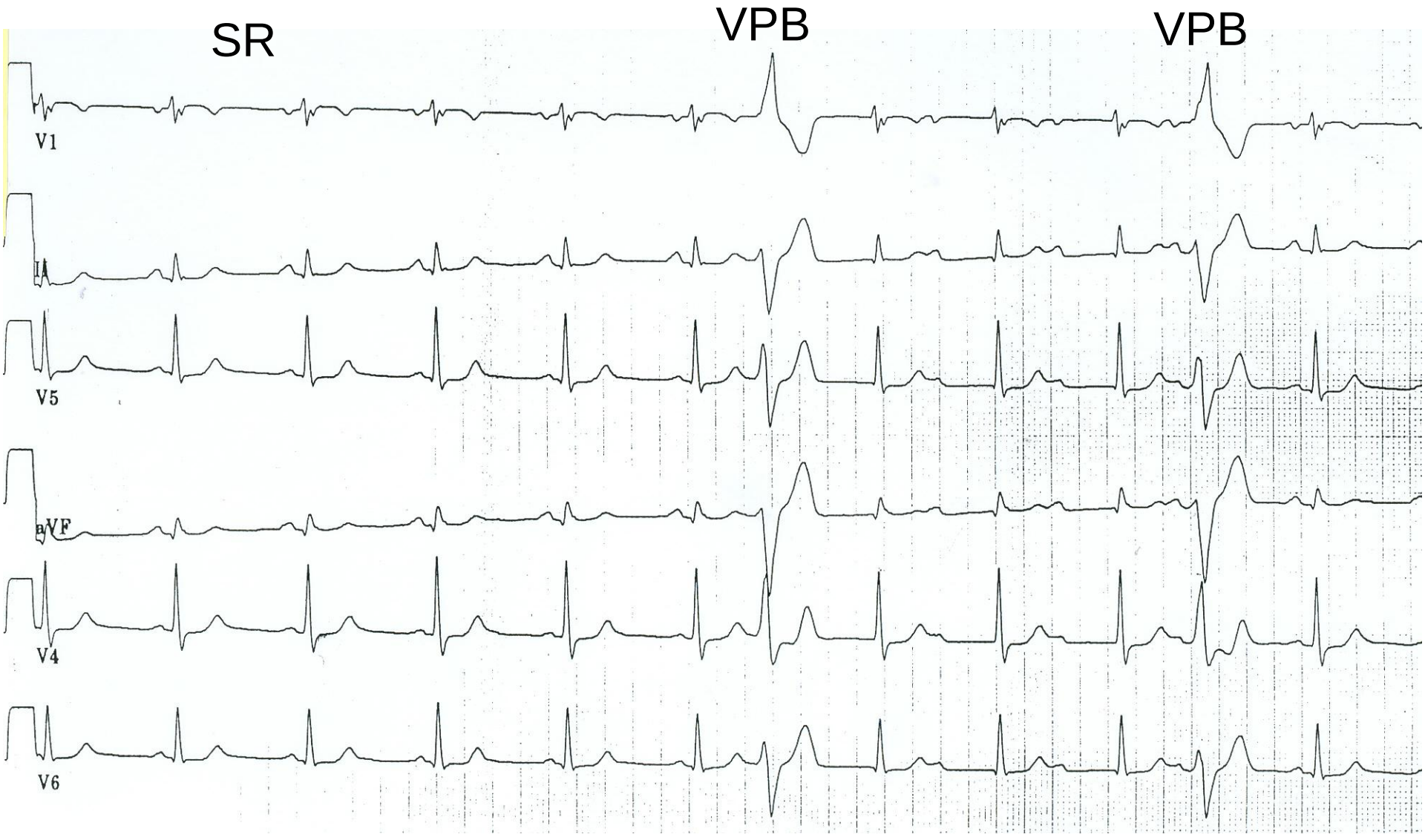
Patient with ventricular ectopic beats

32 year-old patient with history of intermittent palpitations and presyncope

32 year-old patient with history of intermittent palpitations and presyncope



32 year-old patient with history of intermittent palpitations and presyncope



What is the most probable cause for presyncope?

A. Ventricular tachycardia with SHD

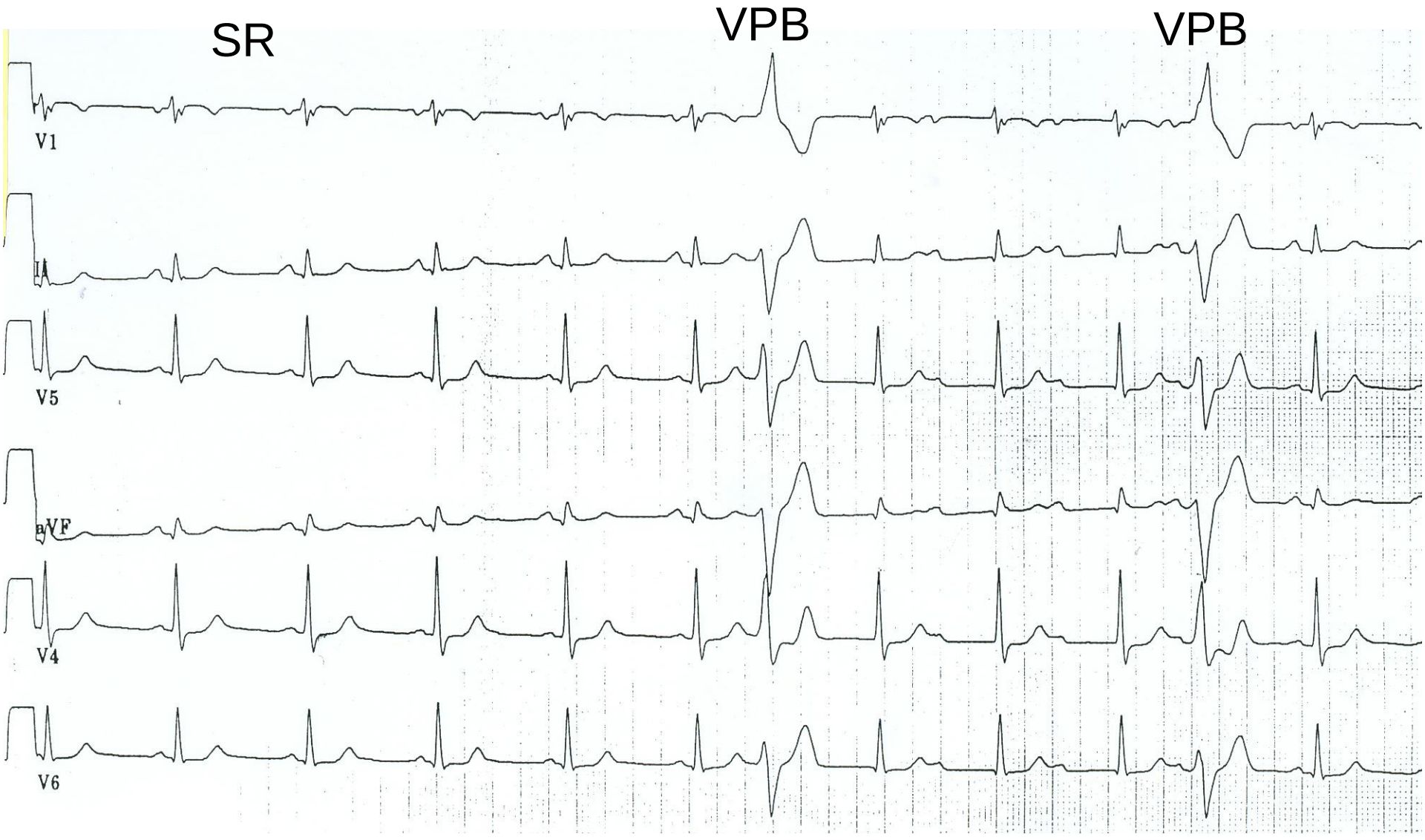
B. Ventricular tachycardia without SHD

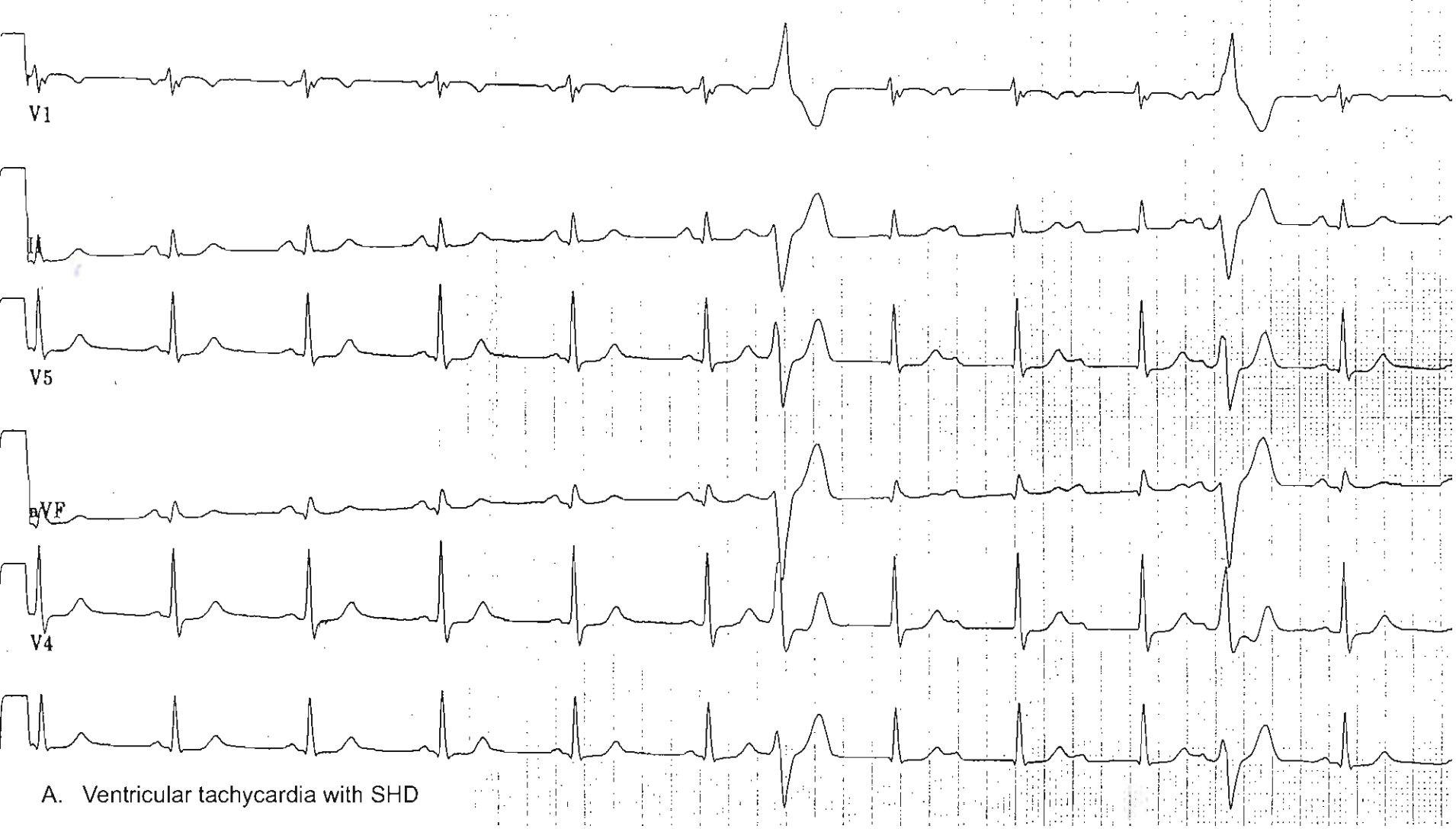
C. Supraventricular tachycardia

D. AV block

E. None of the above

32 year-old patient with history of intermittent palpitations and presyncope





A. Ventricular tachycardia with SHD

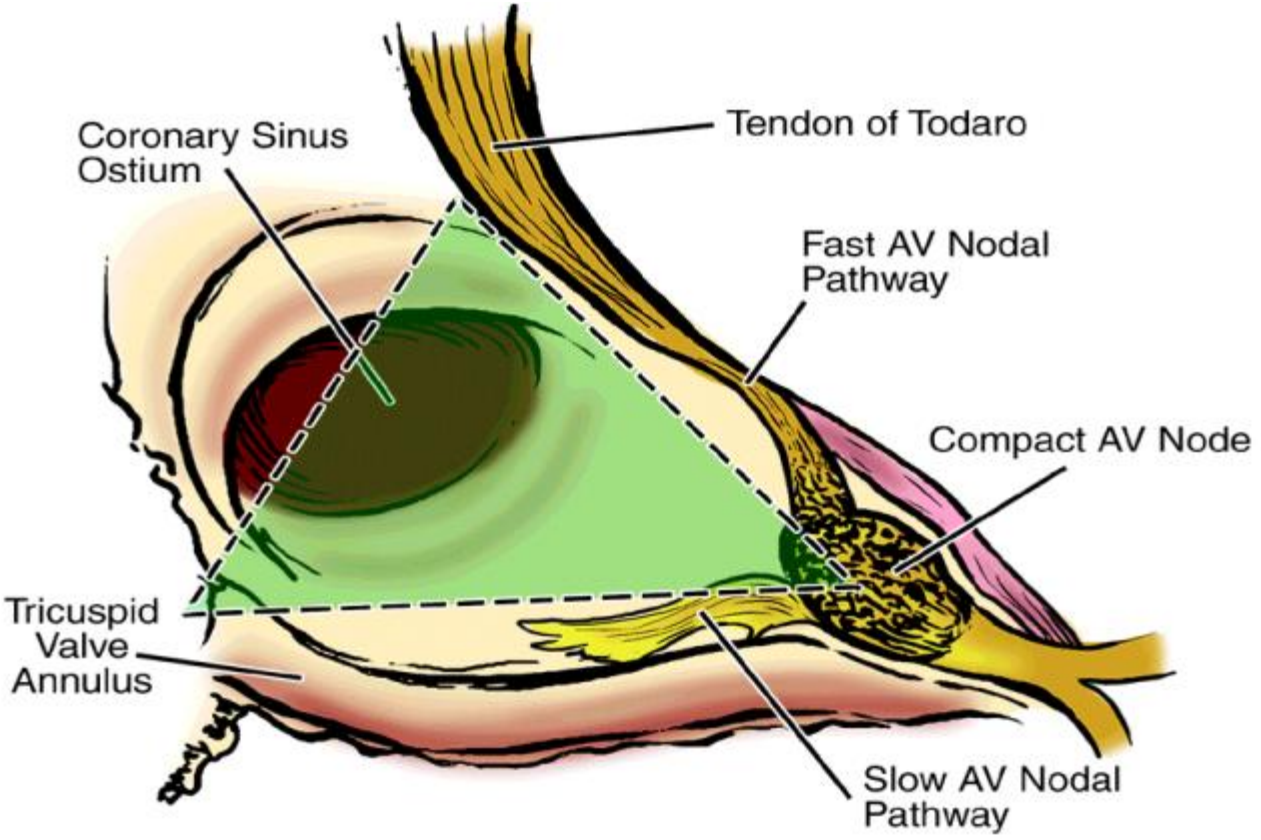
B. Ventricular tachycardia without SHD

C. Supraventricular tachycardia

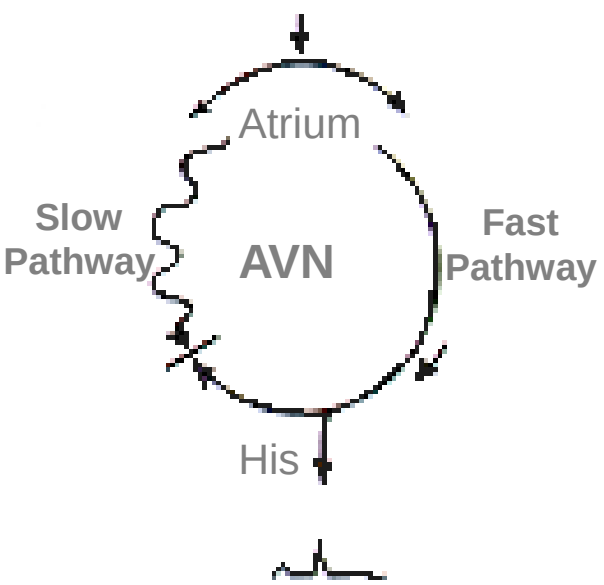
D. AV block

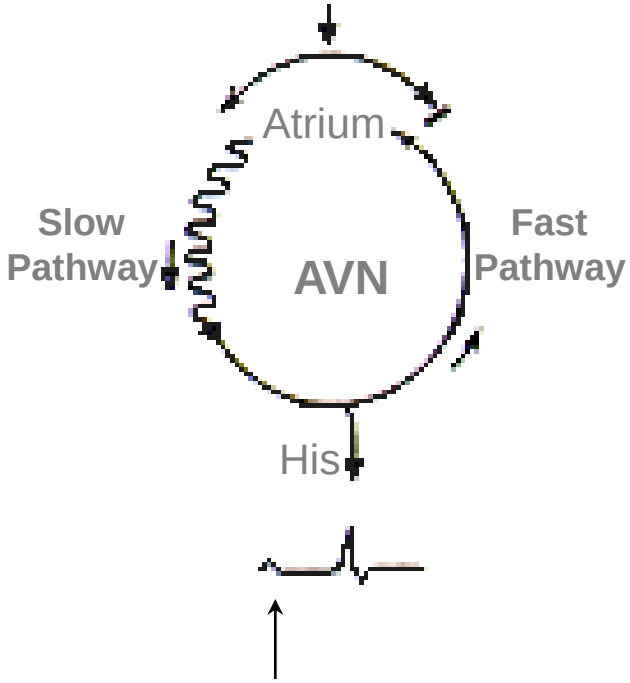
E. None of the above

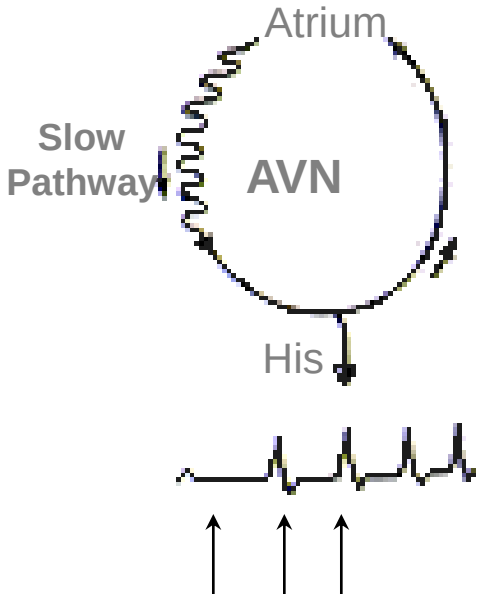
Anatomy of the Human Atrioventricular Node



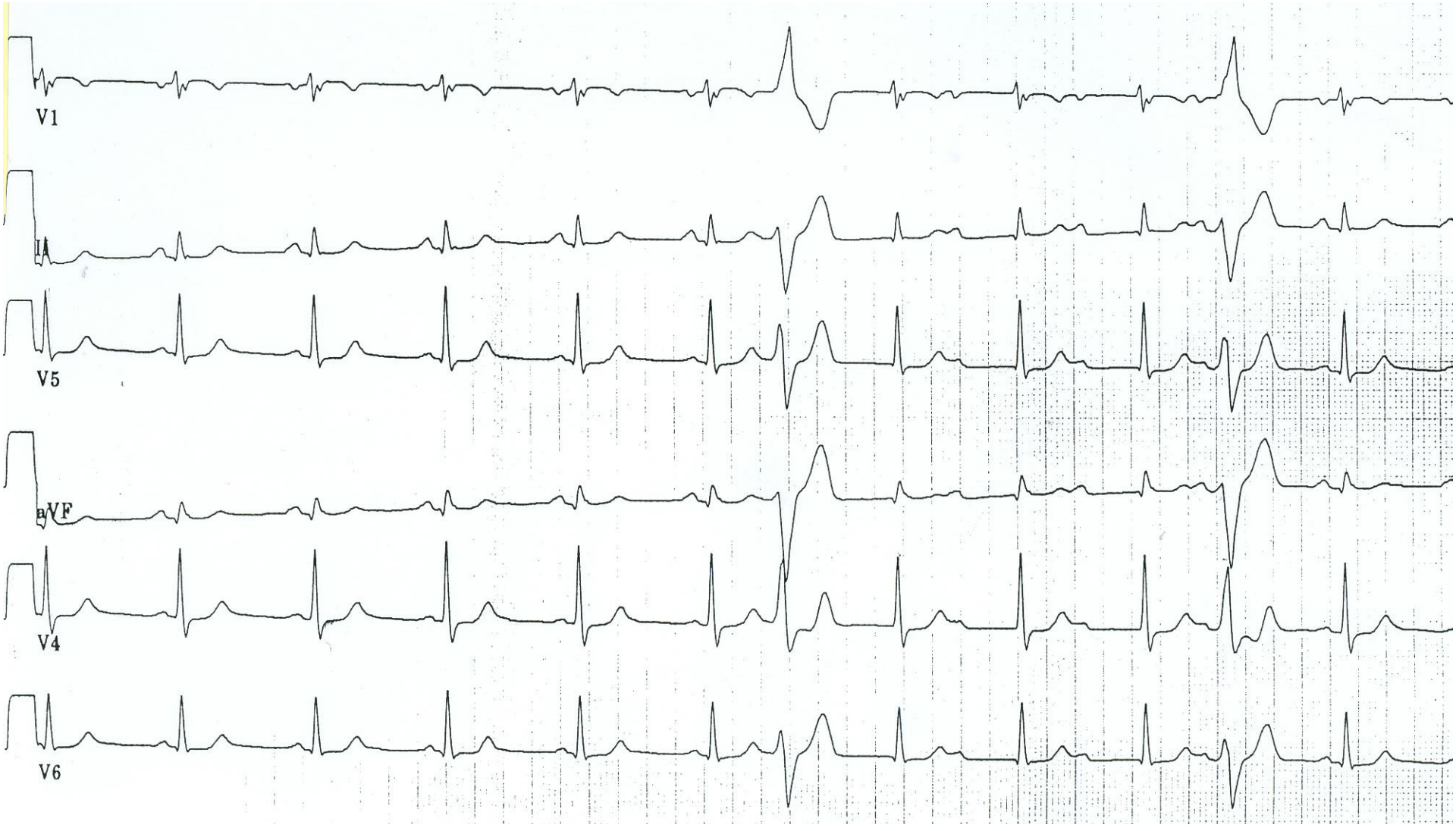
Mechanism of typical AVNRT







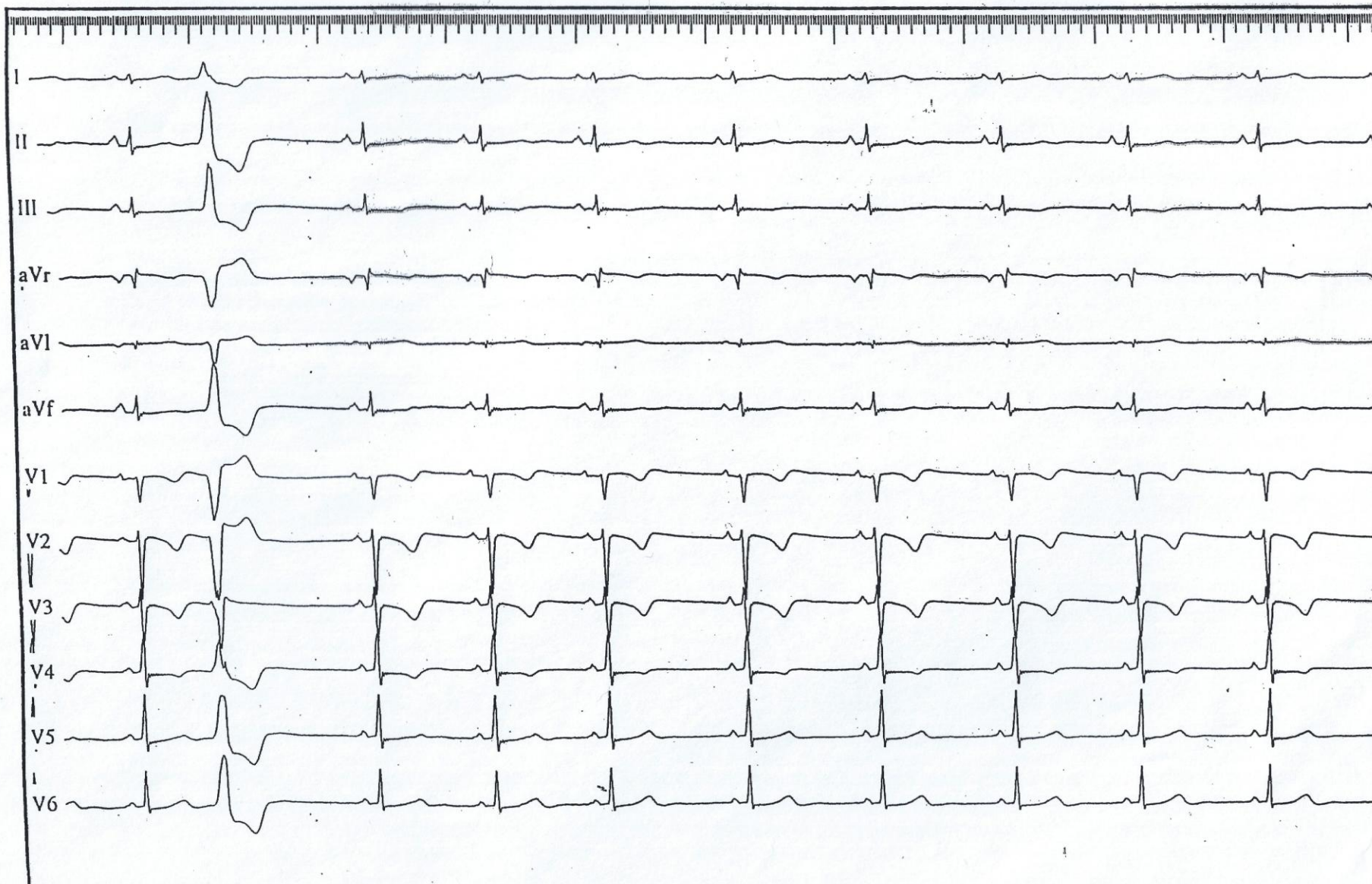
32 year-old patient with history of intermittent palpitations and presyncope



Case 2:

Patient with ventricular ectopic beats

28 year-old patient with history of intermittent palpitations during exercise and chest tightness



What is the most probable cause for the patient's symptoms?

A. Ventricular tachycardia with SHD

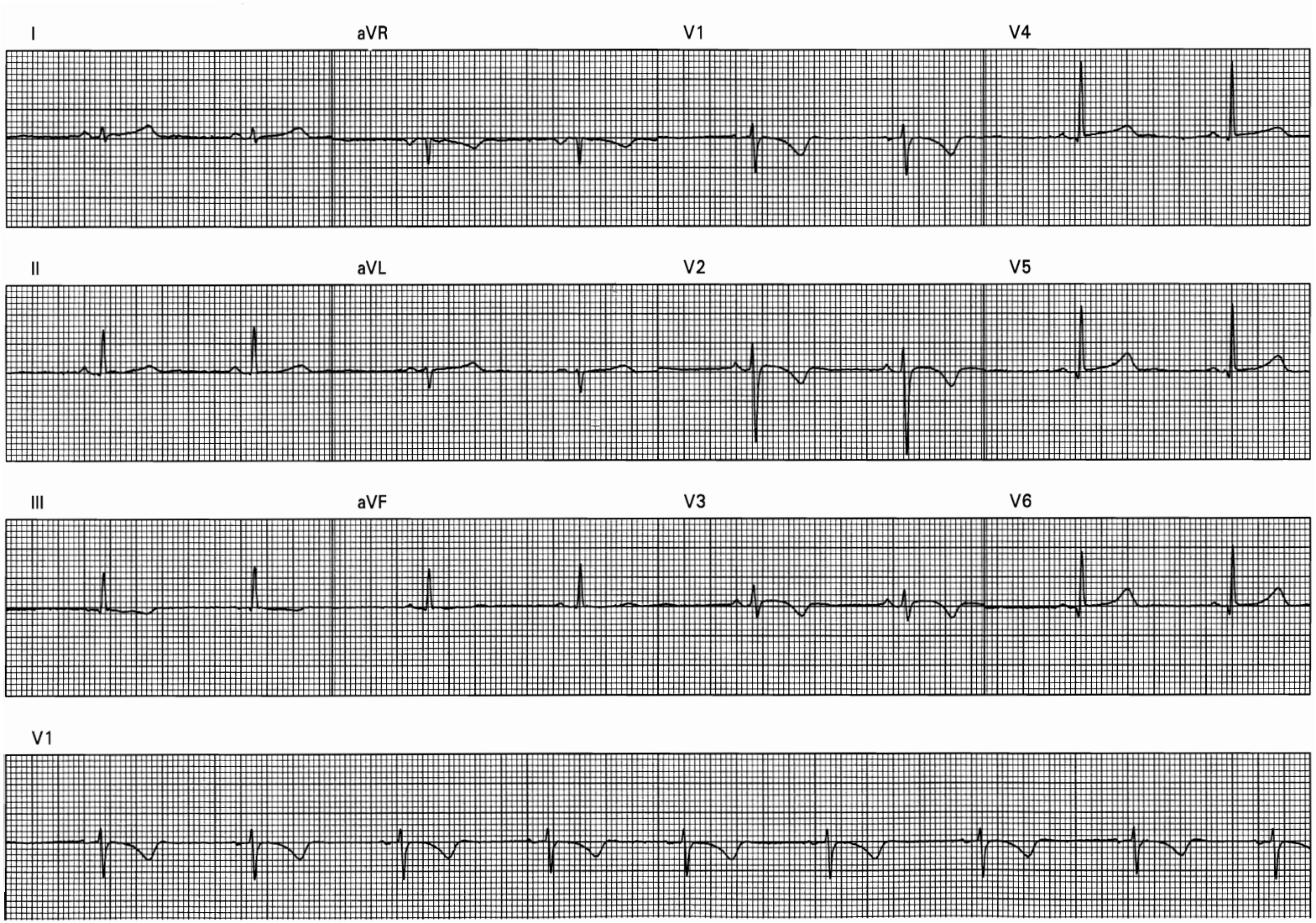
B. Ventricular tachycardia without SHD

C. Supraventricular tachycardia

D. Coronary artery disease

E. None of the above

28year-old patient with history of intermittent palpitations during exercise and chest tightness


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1

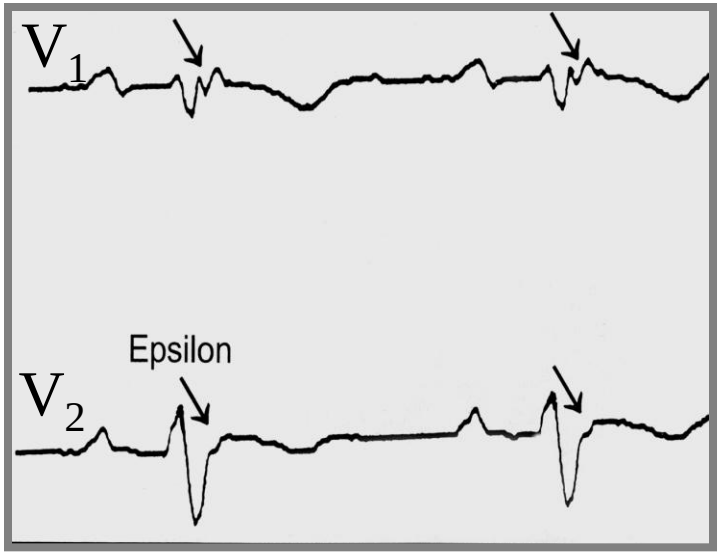
Arrhythmogenic Right Ventricular Cardiomyopathy

Diffuse / segmental loss of myocardium in RV free wall

Replacement by fibrofatty tissue

Arrhythmogenic Right Ventricular Cardiomyopathy

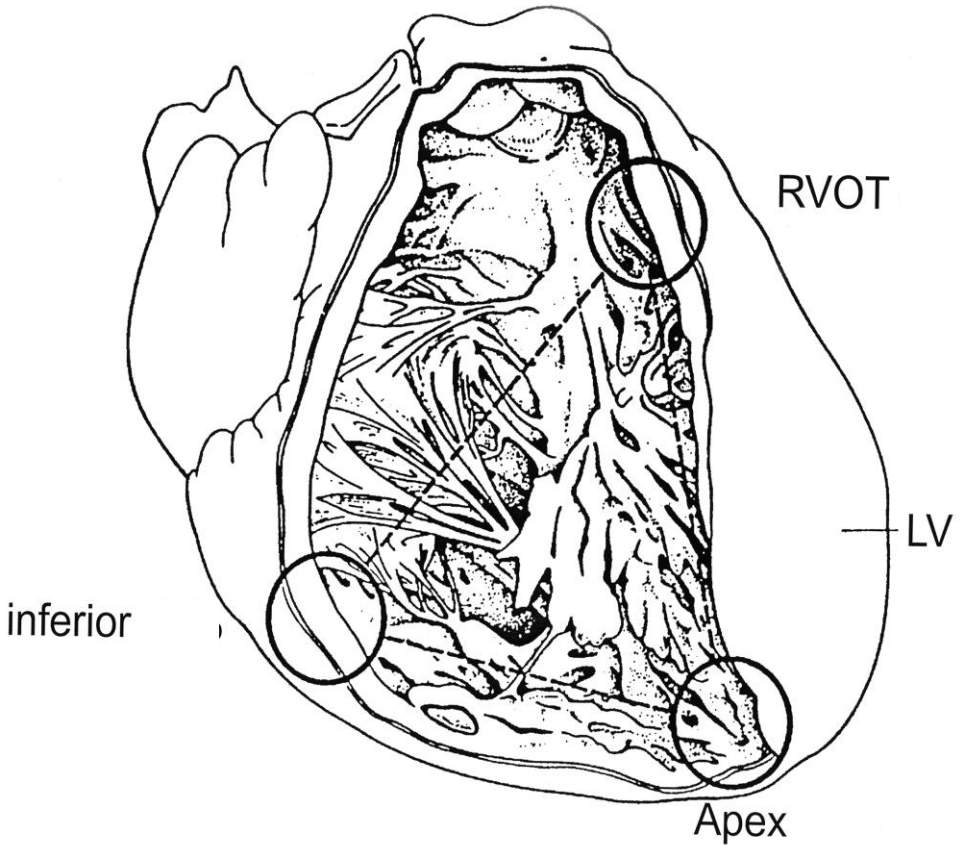
Depolarisation / Conduction abnormalities
QRS prolongation (>110ms)
Epsilon waves
Late potentials

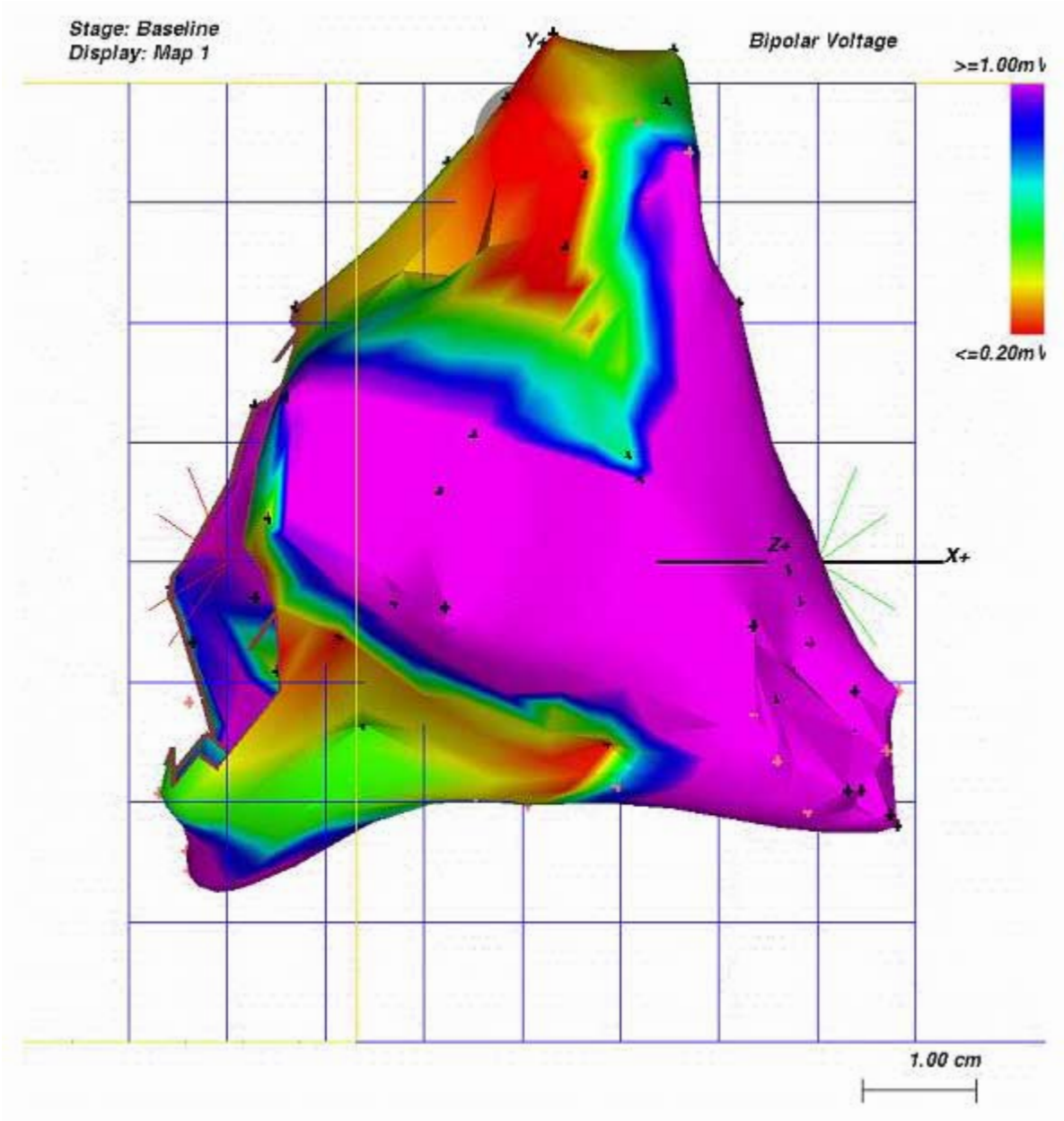


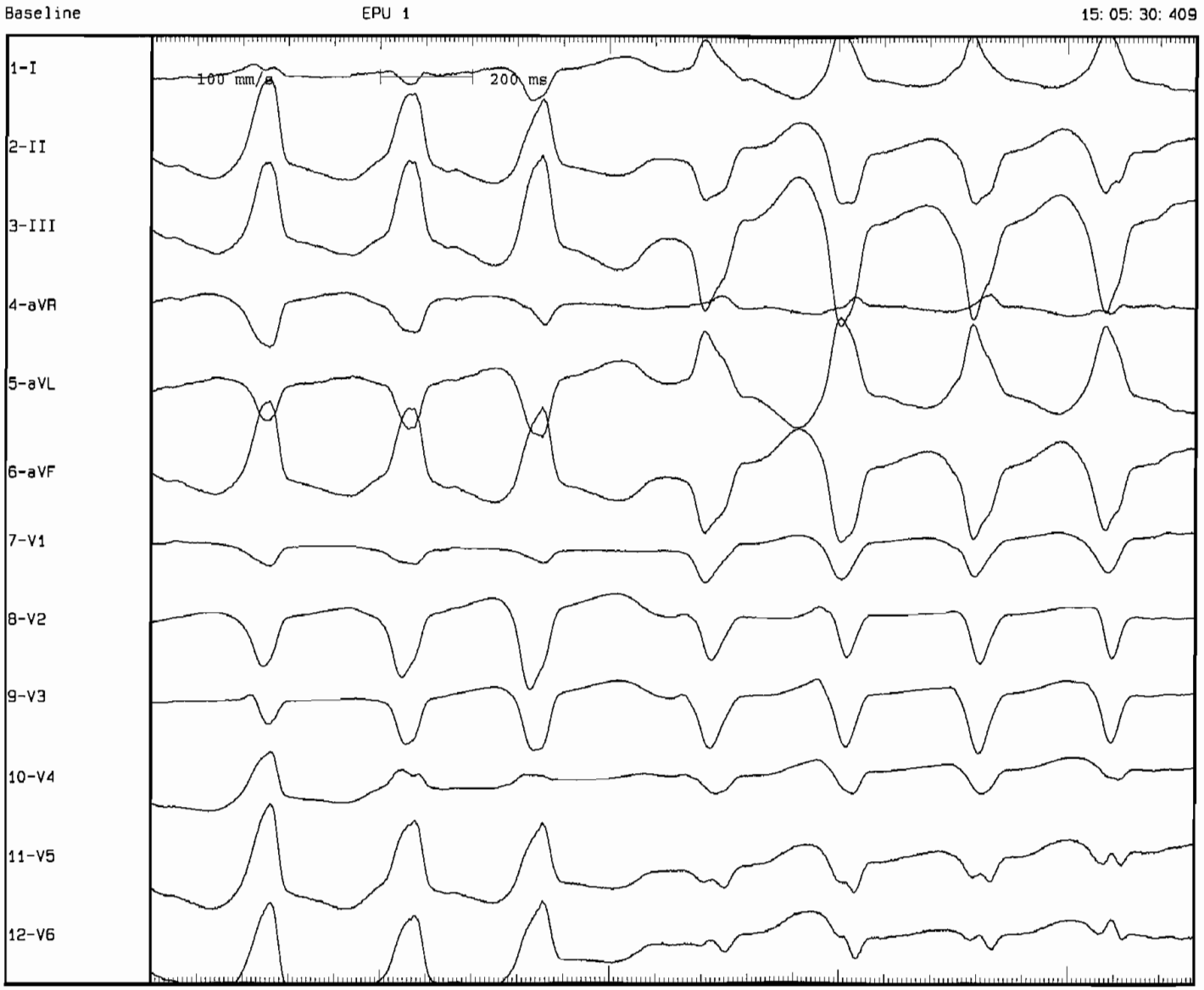
Repolarisation abnormalities
Inverted T waves

Ventricular arrhythmias
Frequent VES to sustained VT (LBBB morpology)

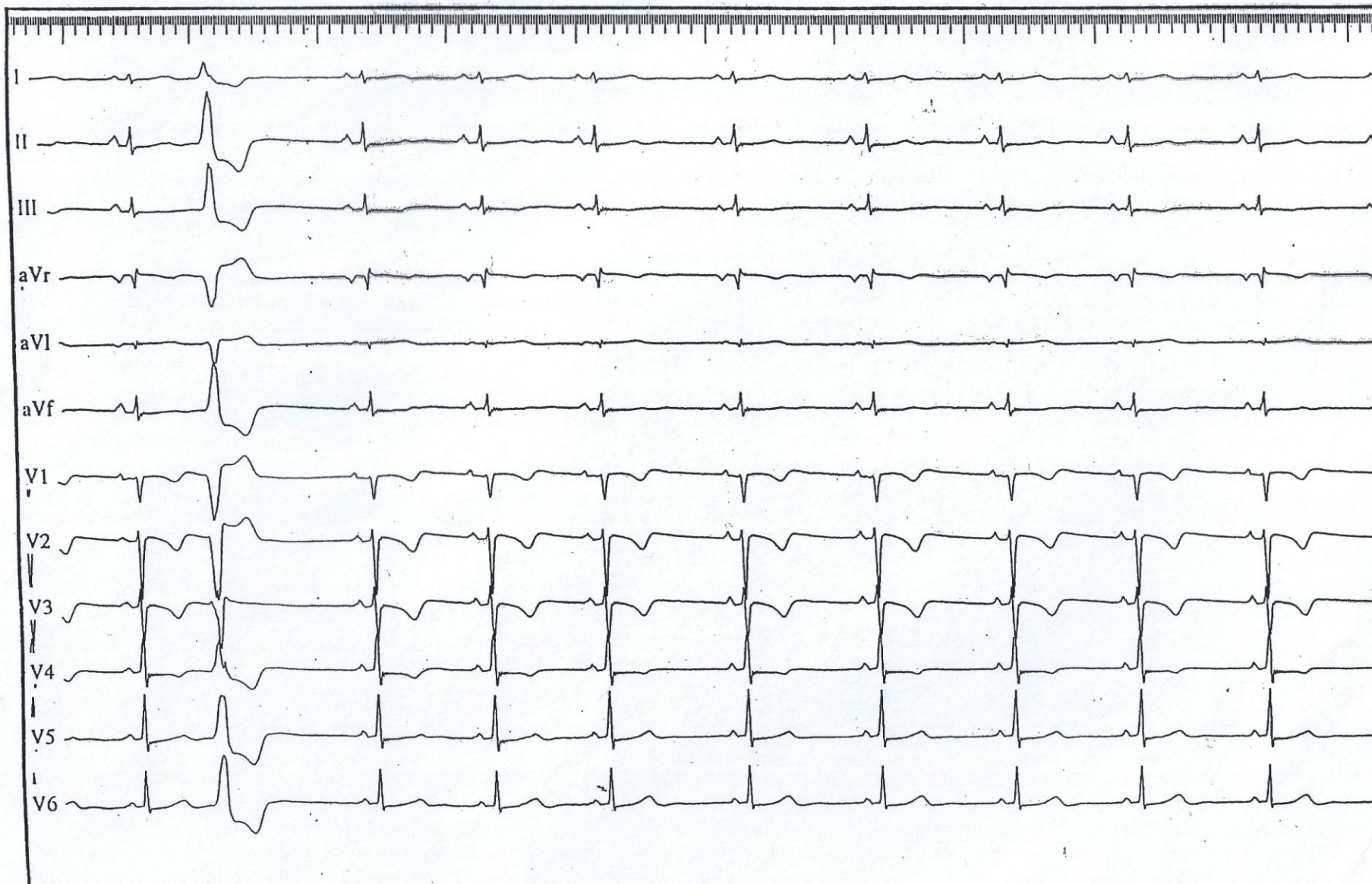
ARVD/C: Classical localisations




Stage: Baseline
Display: Map 1
Bipolar Voltage
>=1.00m V
<=0.20m V
Y+
Z+
X+
1.00 cm


Baseline
EPU 1
15: 05: 30: 409
1-I
2-II
3-III
4-aVR
5-aVL
6-aVF
7-V1
8-V2
9-V3
10-V4
11-V5
12-V6
100 mm/s
200 ms

28 year-old patient with history of intermittent palpitations during exercise and chest tightness

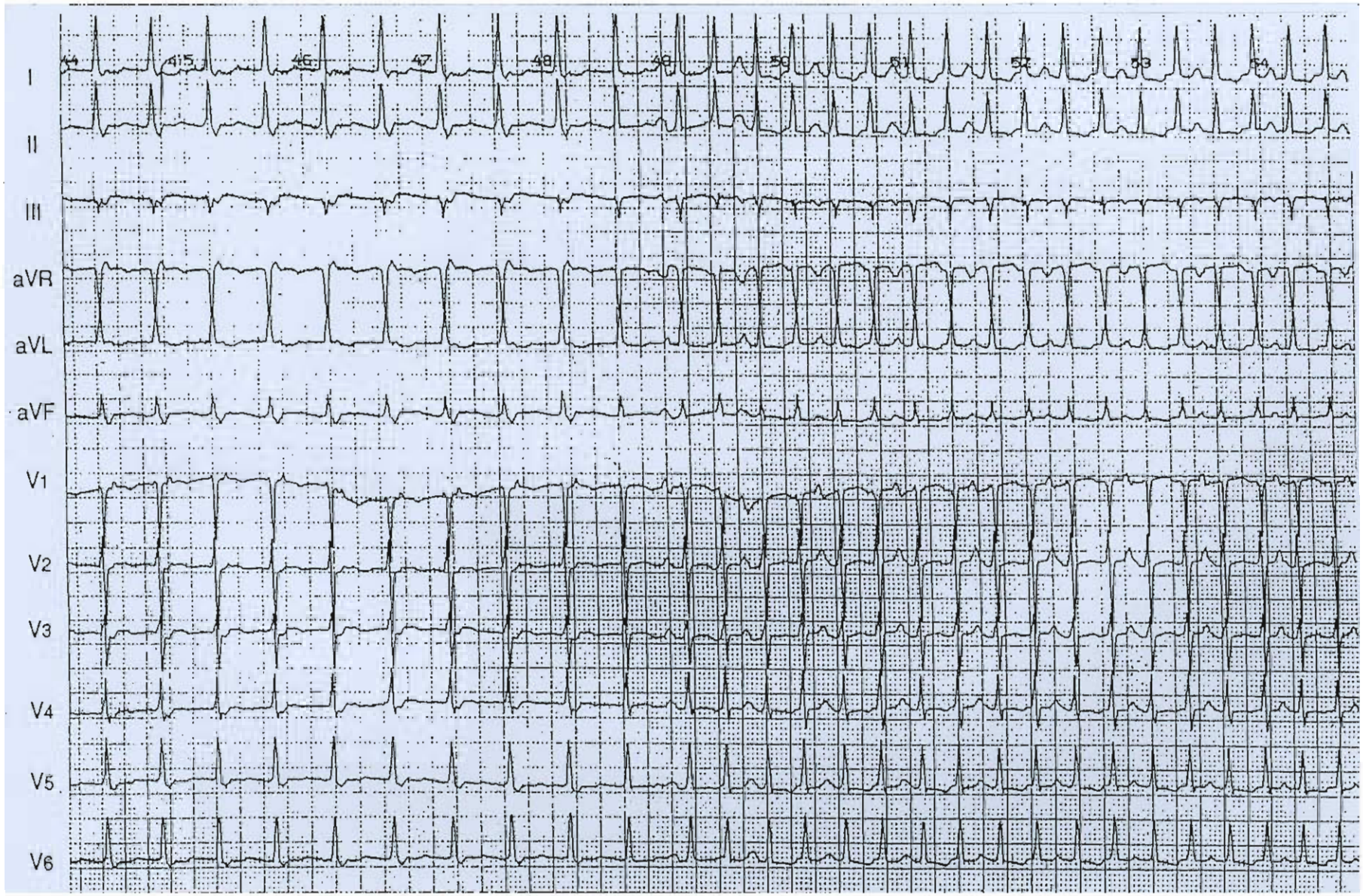


Case 3:

Patient with a tachycardia changing to another tachycardia

A 42 year old female presents with recurrent palpitations.

On admission, 12-lead ECG was performed that showed a tachycardia at a rate of 125/min, which then spontaneously changed to a faster tachycardia.


I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6


I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

A 42 year old female presents with recurrent palpitations.

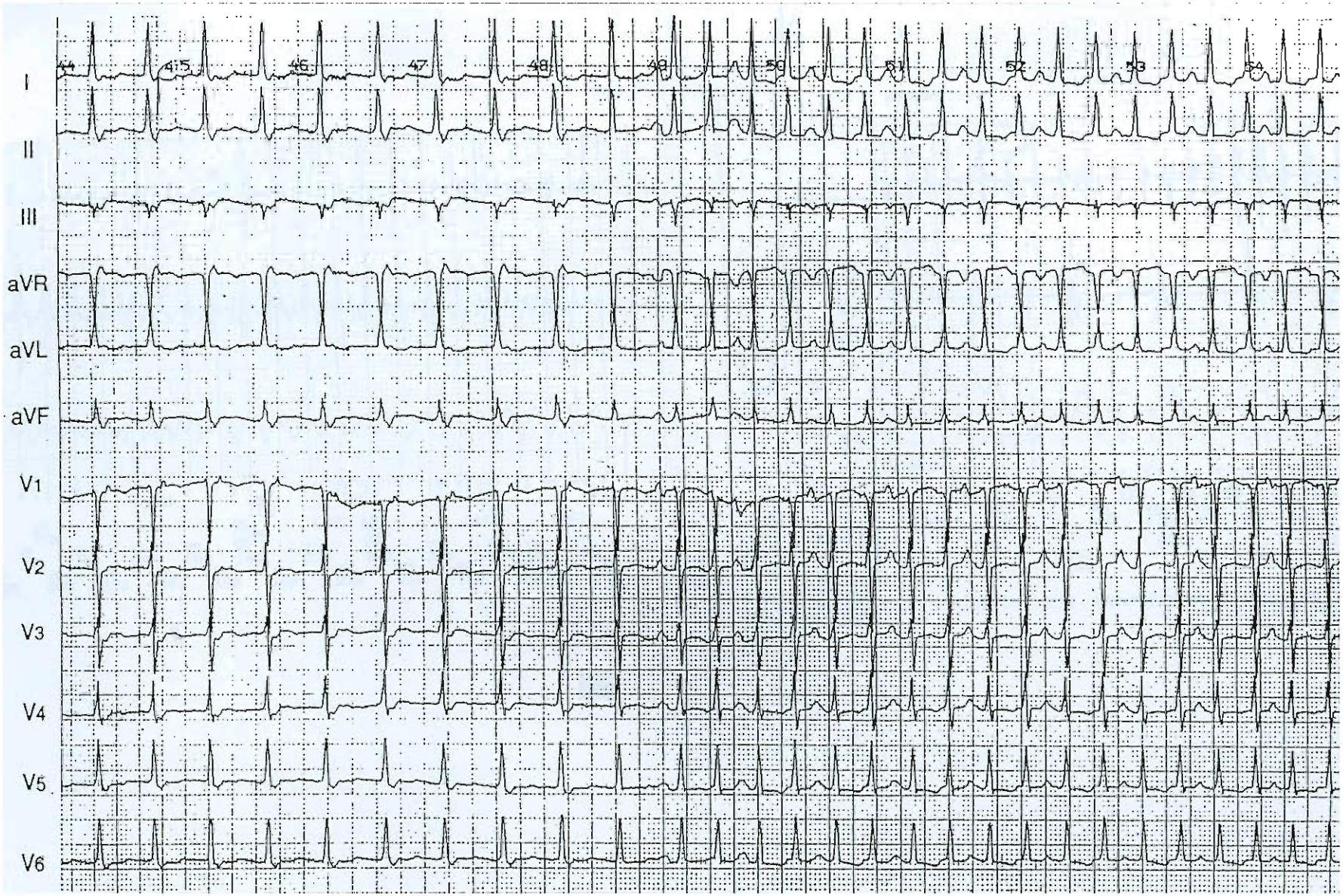
On admission, 12-lead ECG was performed that showed a tachycardia at a rate of 125/min, which then spontaneously changed to a faster tachycardia.

What are the arrhythmia mechanisms for Rhythm A and for Rhythm B ?

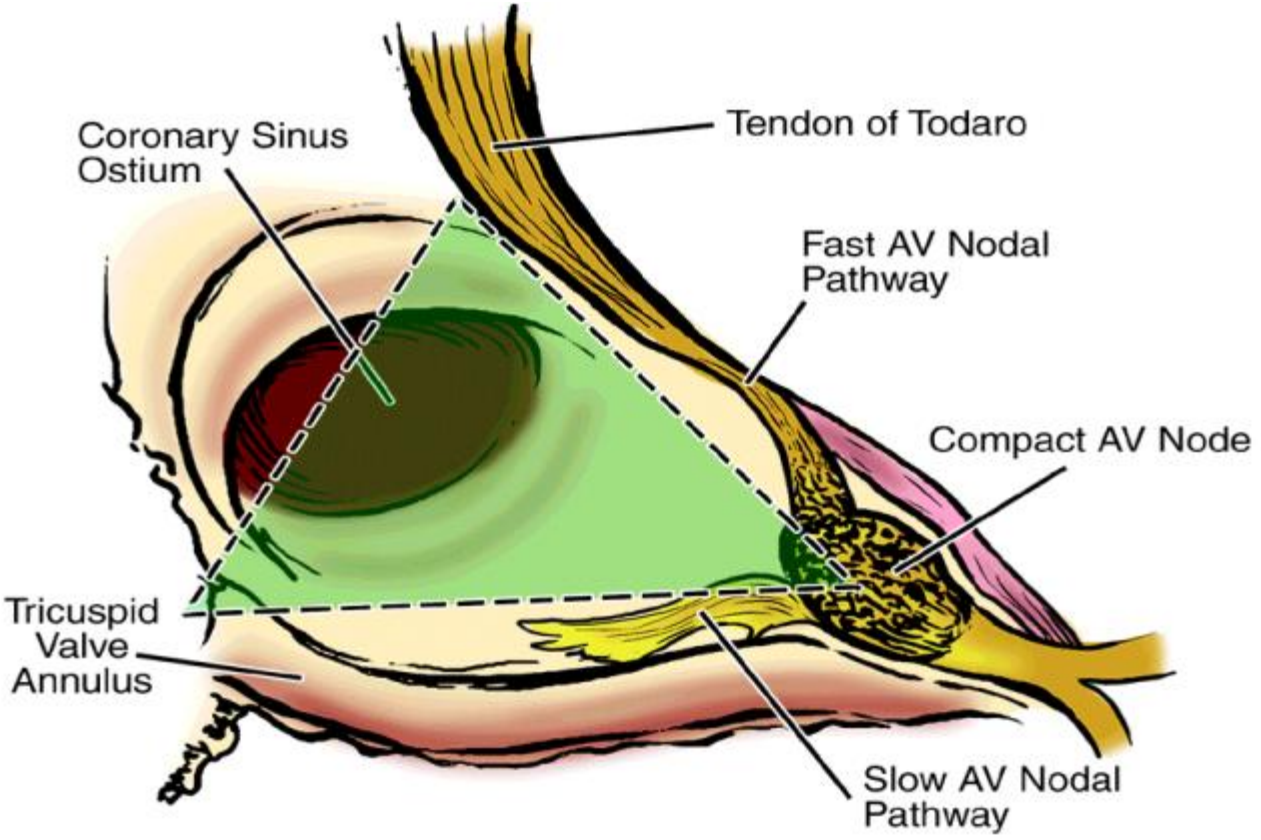
What is the likely diagnosis ?

A. SVT and VT
B. SVT and SVT
C. SVT and atrial flutter
D. SVT and atrial fibrillation
E. SVT and artefact
F. None of the above

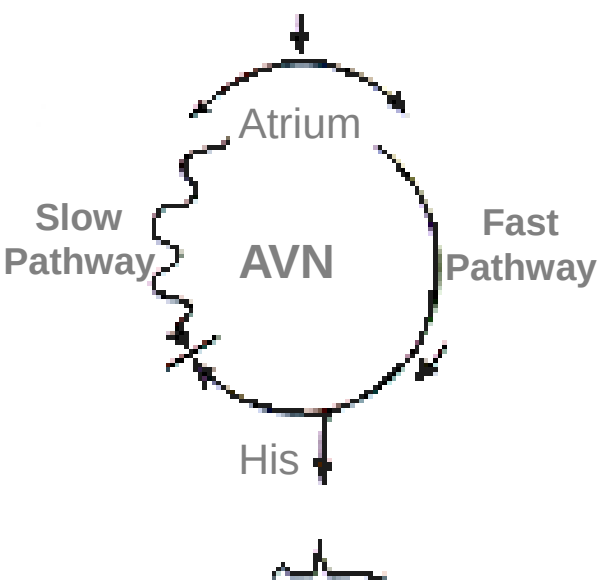
A. SVT and VT
B. SVT and SVT
C. SVT and atrial flutter
D. SVT and atrial fibrillation
E. SVT and artefact
F. None of the above

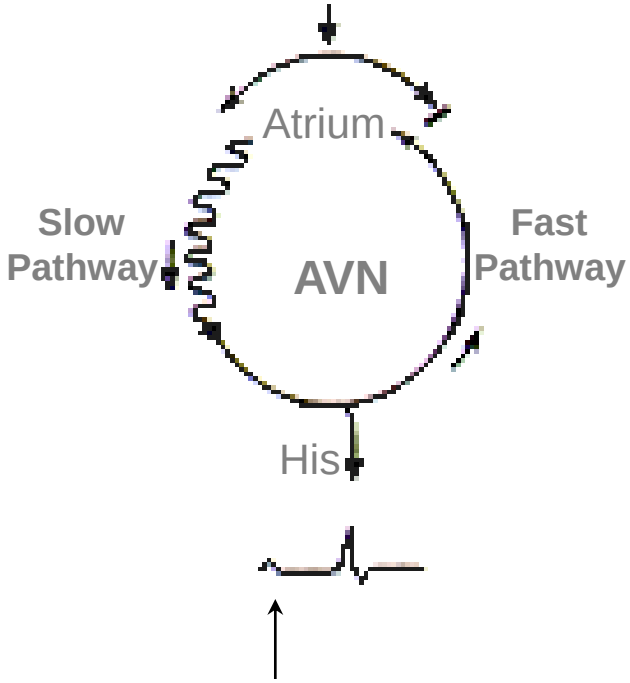

I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
45
46
47
48
49
50
51
52
53
54

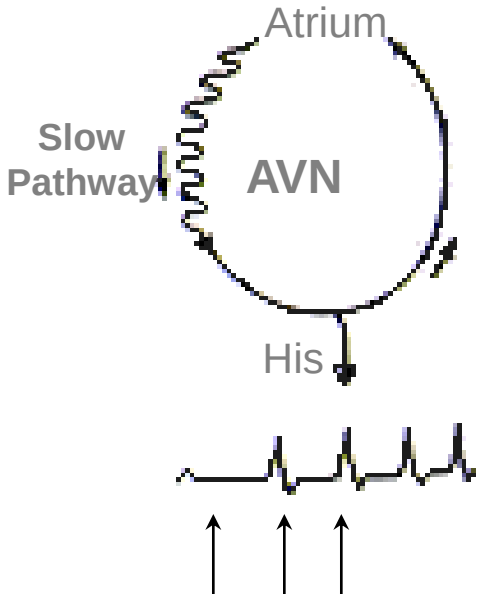
Anatomy of the Human Atrioventricular Node



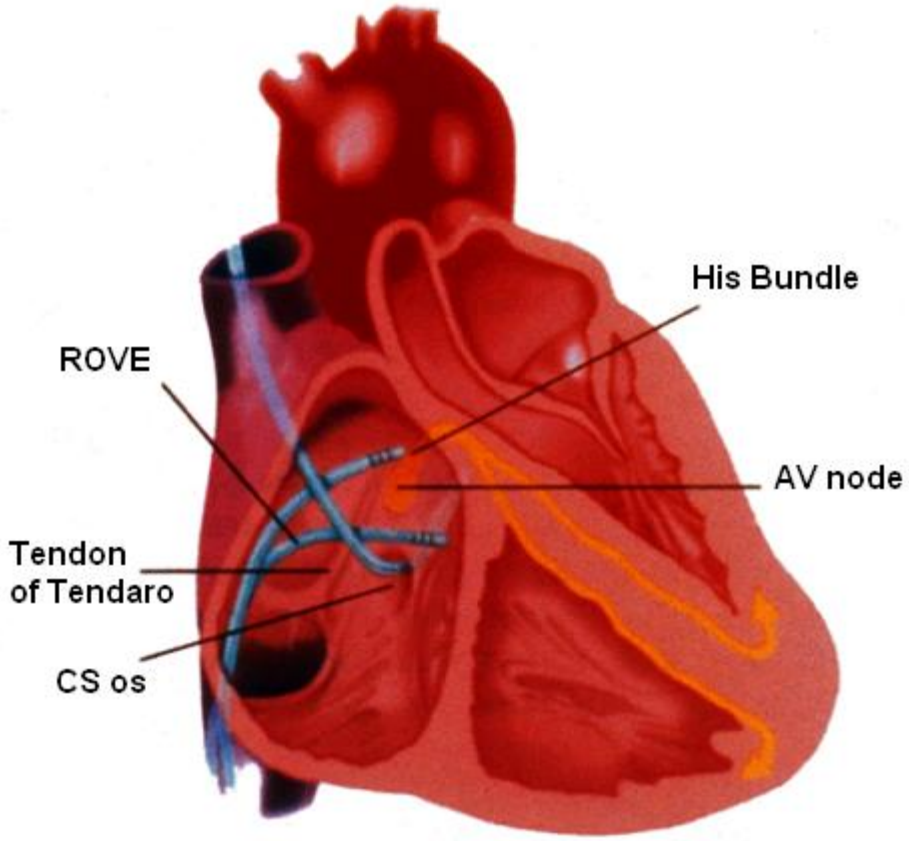
Mechanism of typical AVNRT







Site of Slow Pathway Ablation

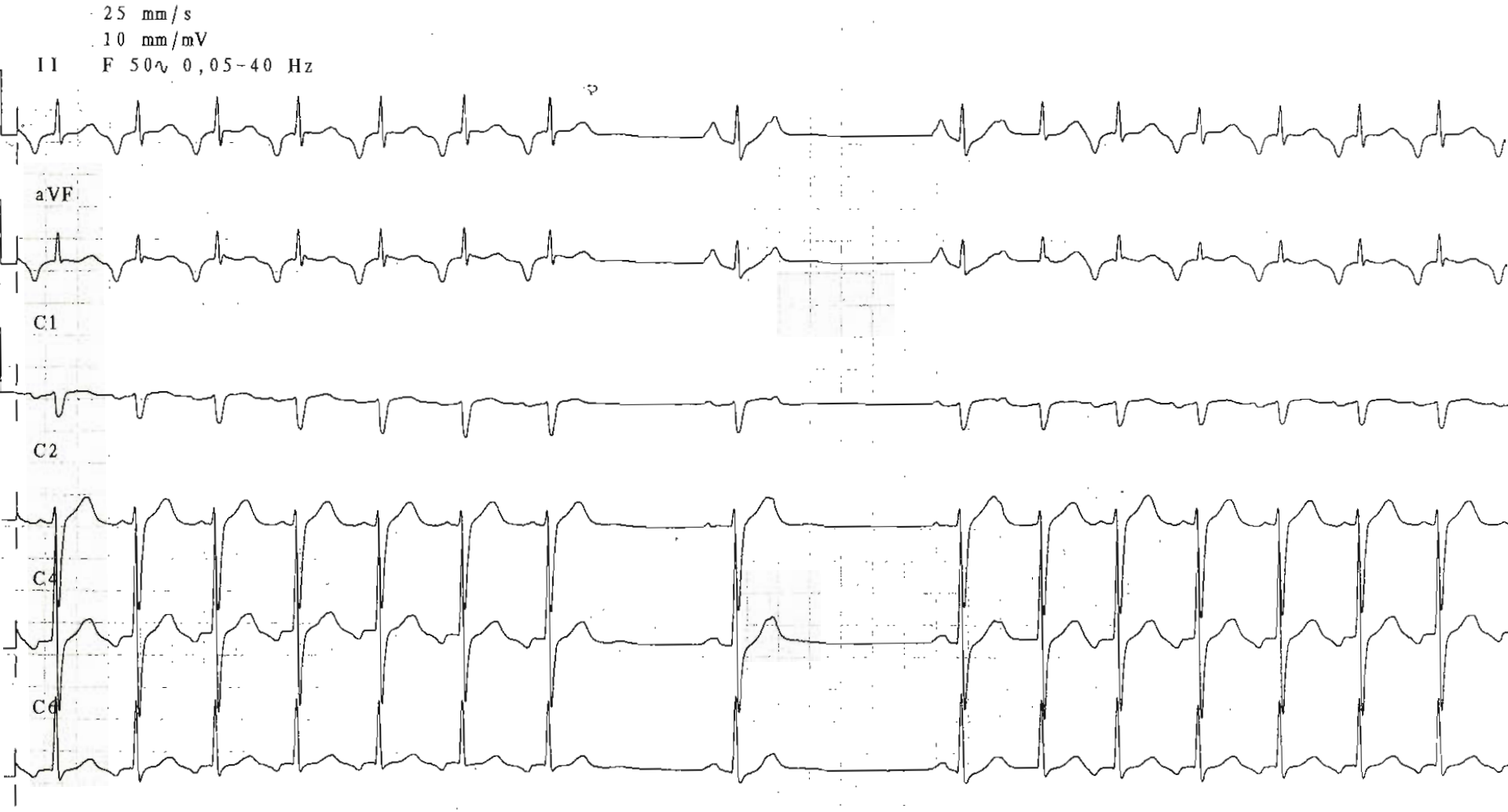


Case 4:

Patient with progressive dyspnea

24 year-old male with progressive dyspnea

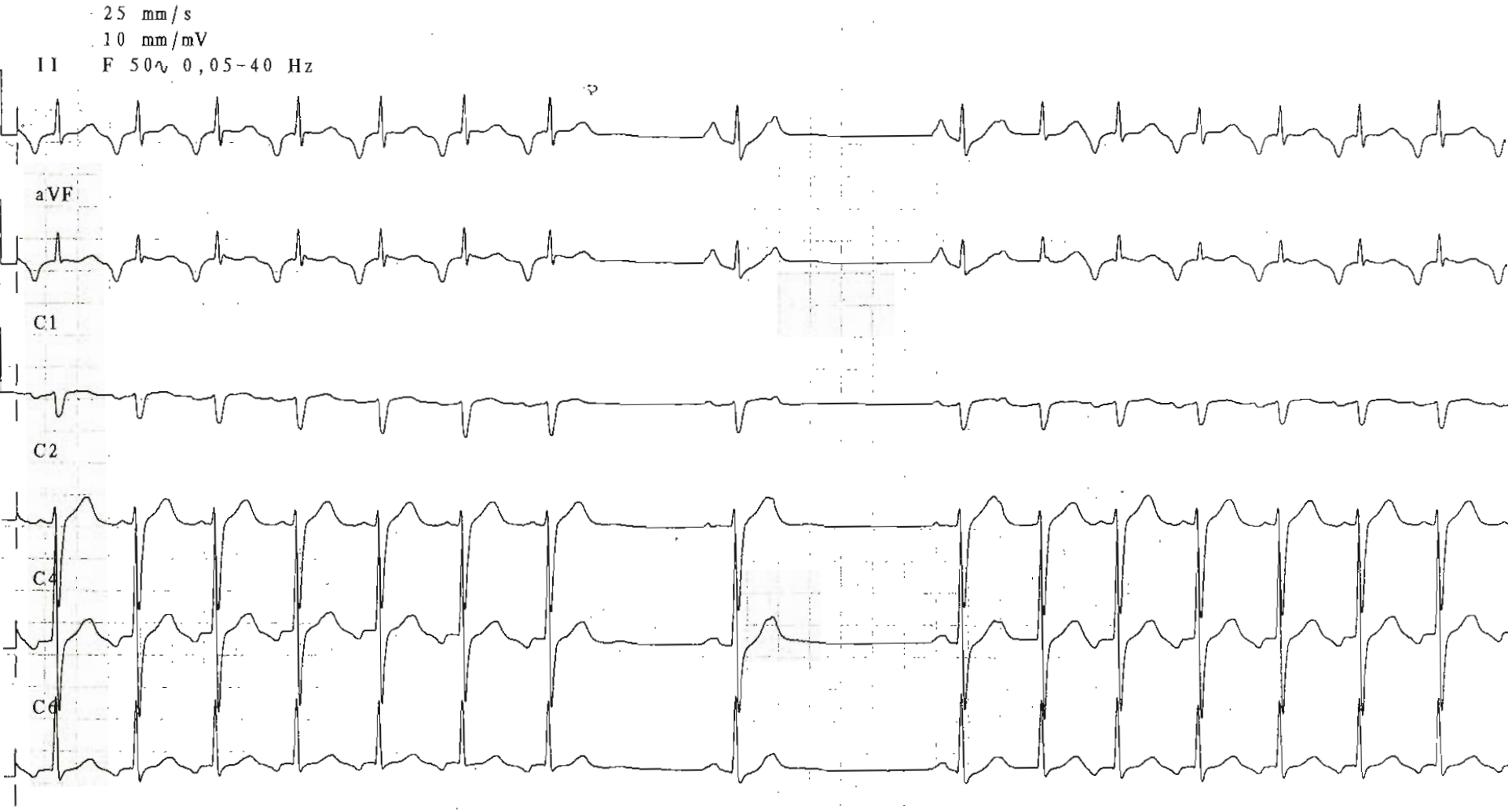
He complains of a rapid heart rate at 120bpm for several months


25 mm/s
10 mm/mV
I I F 50∿ 0,05-40 Hz
aVF
C1
C2
C4
C6

24 year-old male with progressive dyspnea

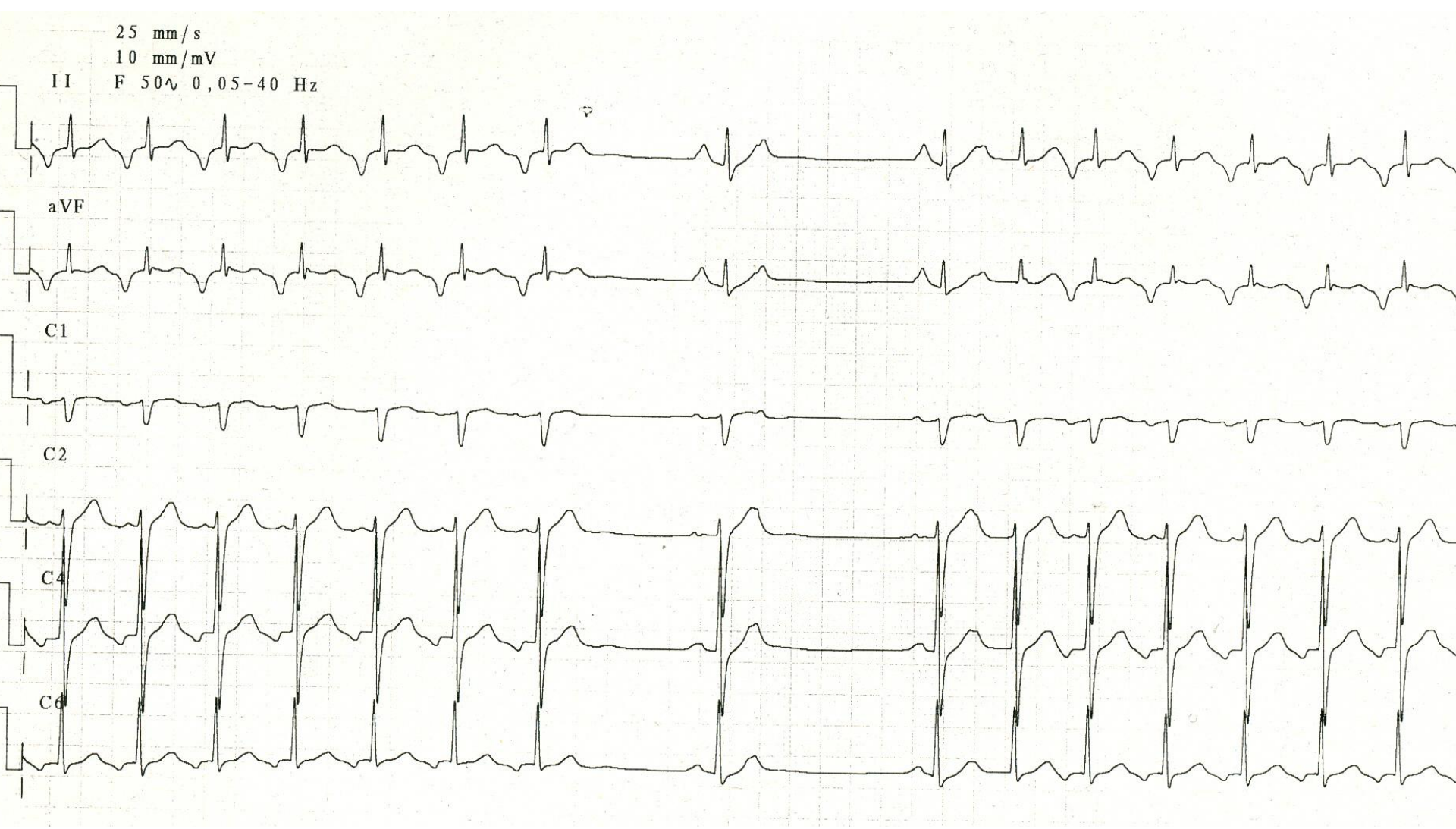
He complains of a rapid heart rate at 120bpm for several months

What is the most likely diagnosis ?


25 mm/s
10 mm/mV
I I F 50∿ 0,05-40 Hz
aVF
C1
C2
C4
C6

What is the most likely diagnosis ?

A. Atrial tachycardia
B. Typical AV nodal reentrant tachycardia
C. Atypical AV nodal reentrant tachycardia
D. Typical AV reentrant tachycardia (accessory pathway)
E. Atypical AV reentrant tachycardia (accessory pathway)



A. Atrial tachycardia
B. Typical AV nodal reentrant tachycardia
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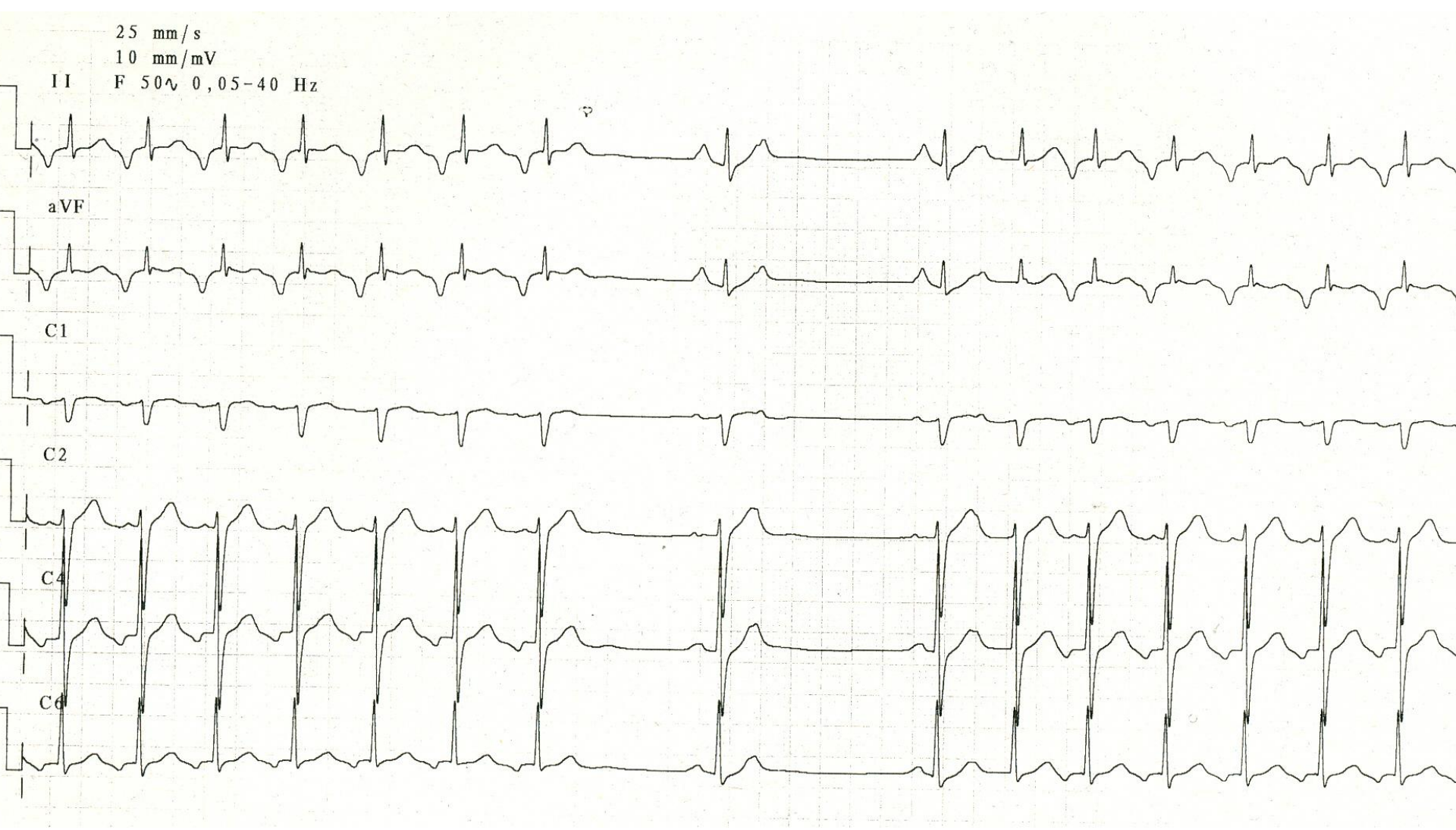
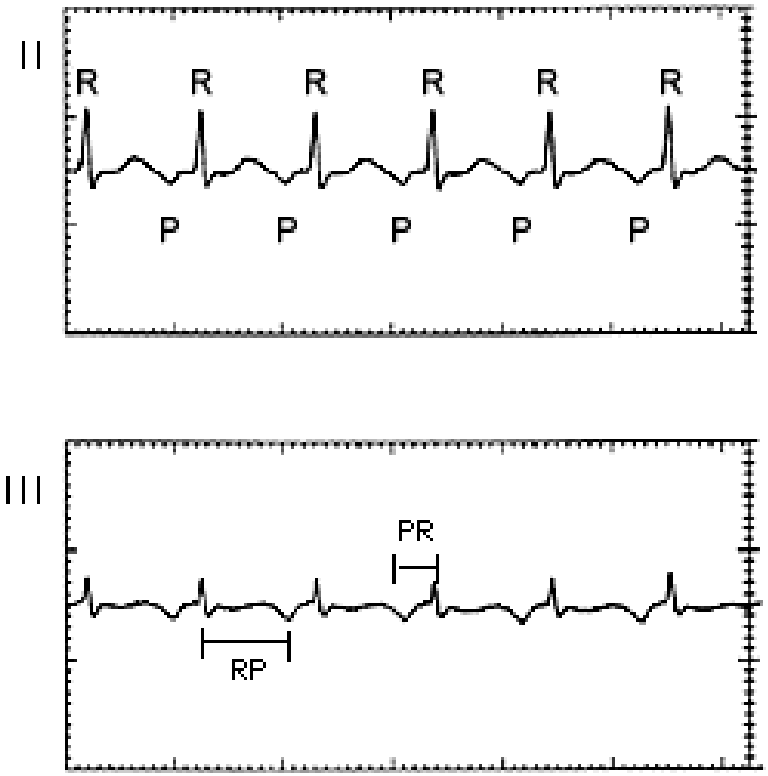


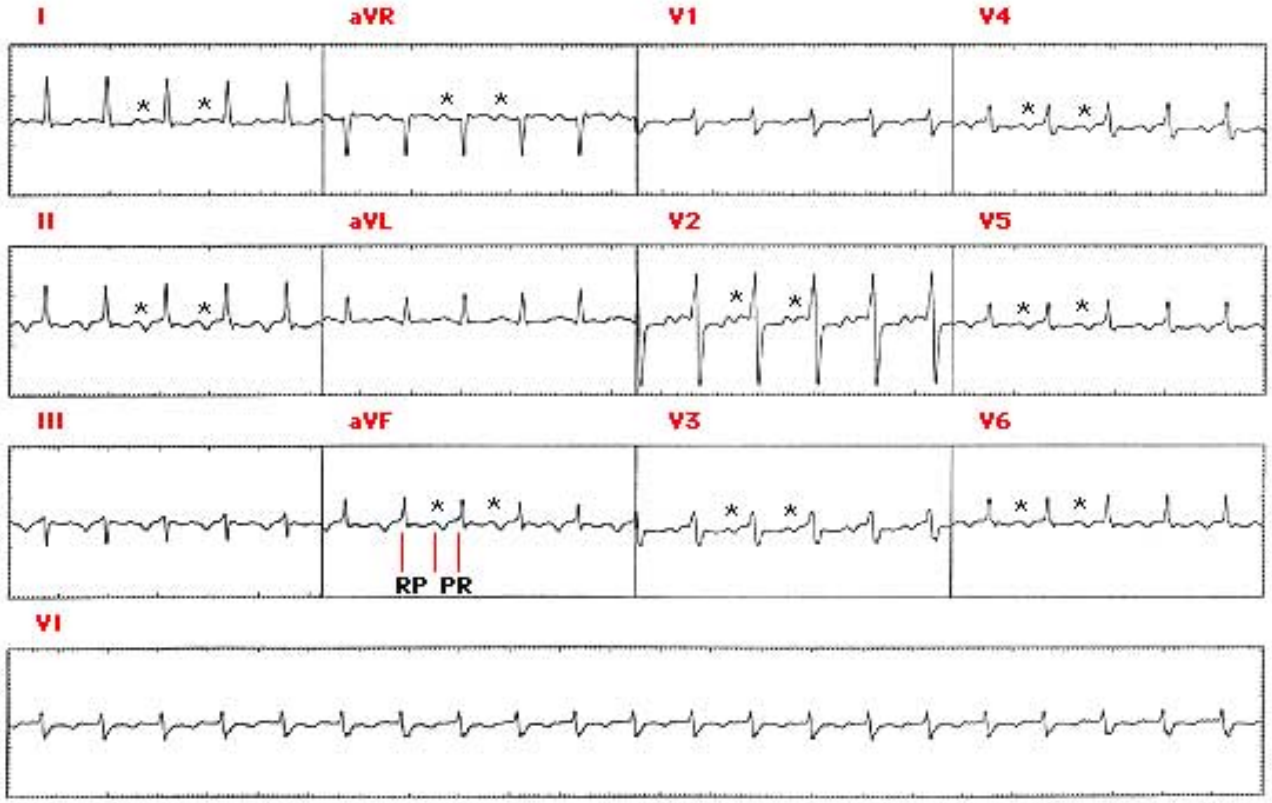
Narrow complex tachycardia with a CL of 500ms (HR 120bpm)

P-waves are relatively narrow (septal) and are neg. in II and aVF

The RP interval ist longer than the PR interval

Long RP' Tachycardia




I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
RP
PR
VI

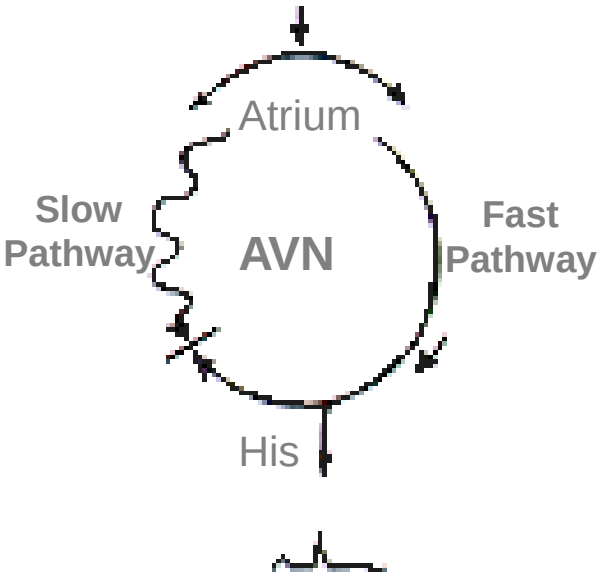
PR > RP

RP > PR

PR > RP

RP very short (<70 ms) → AV nodal reentrant tachycardia (typical AVNRT; slow-fast type)

Mechanism of typical AVNRT ?



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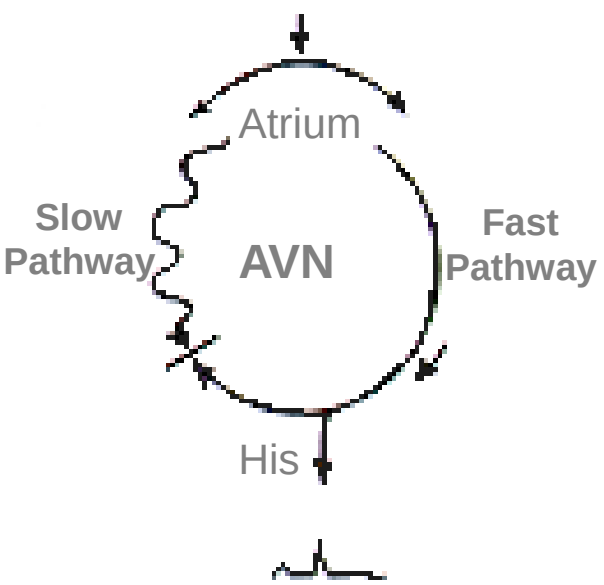

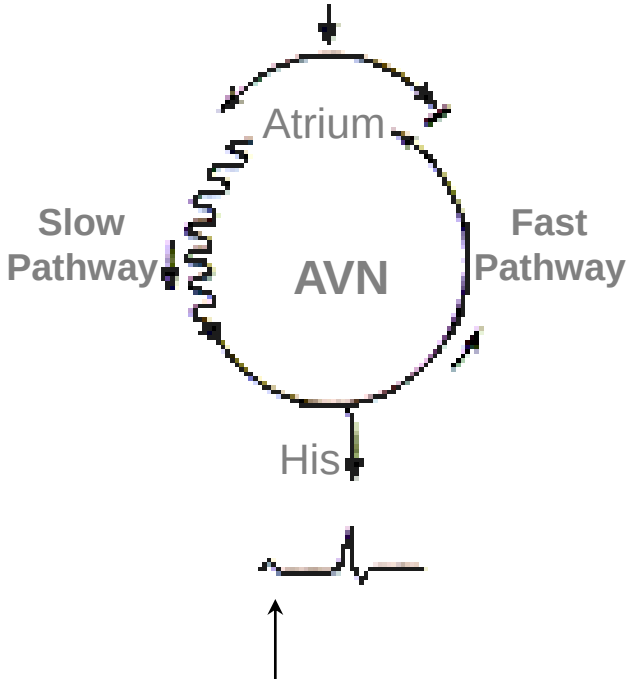

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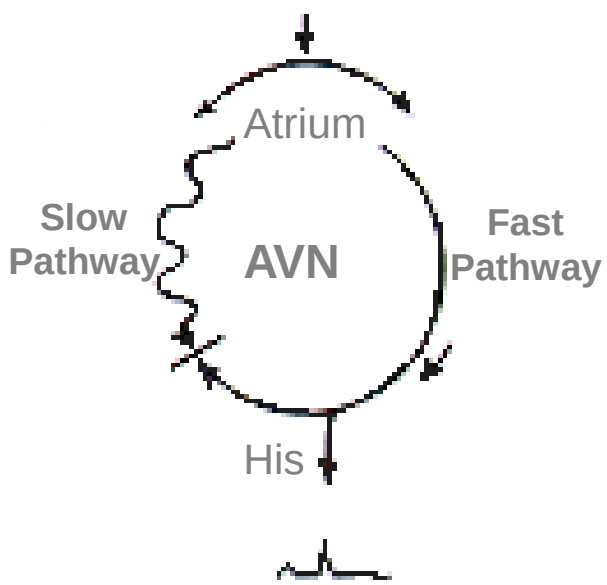
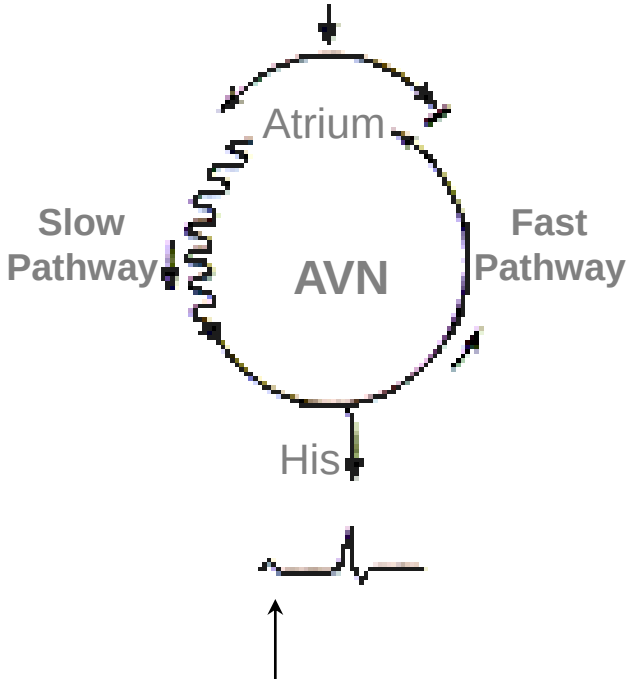
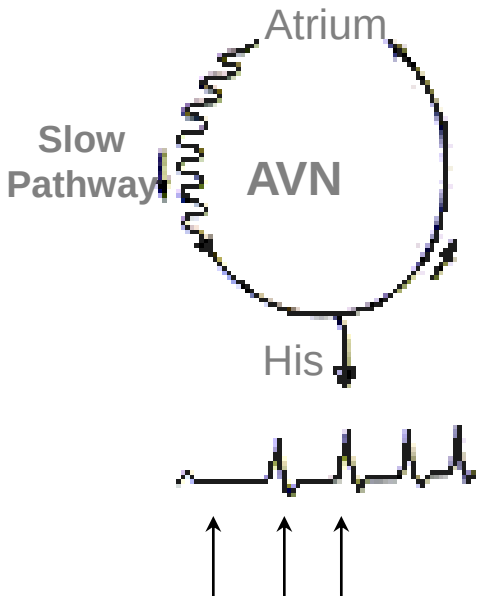




Atrial ES

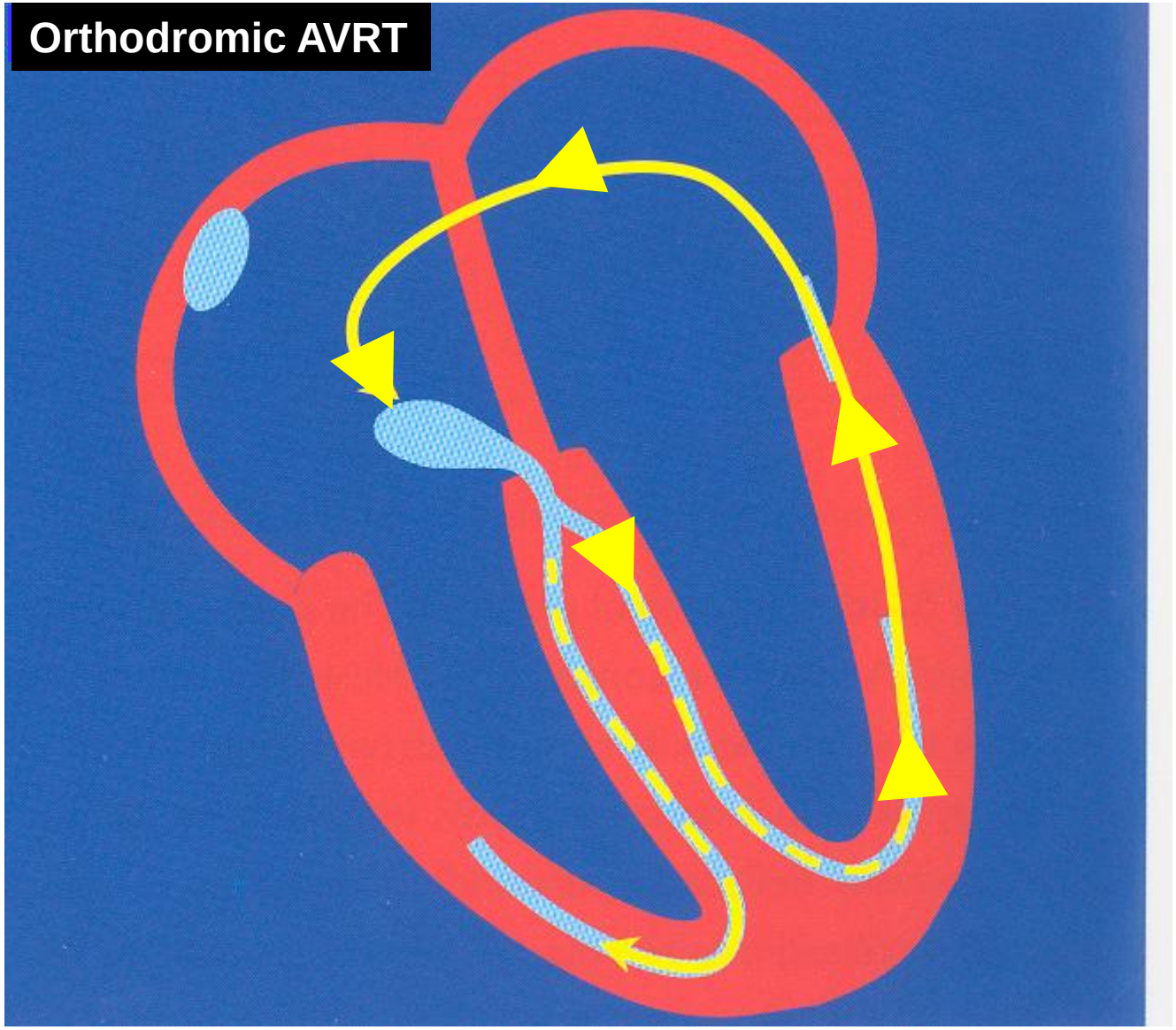


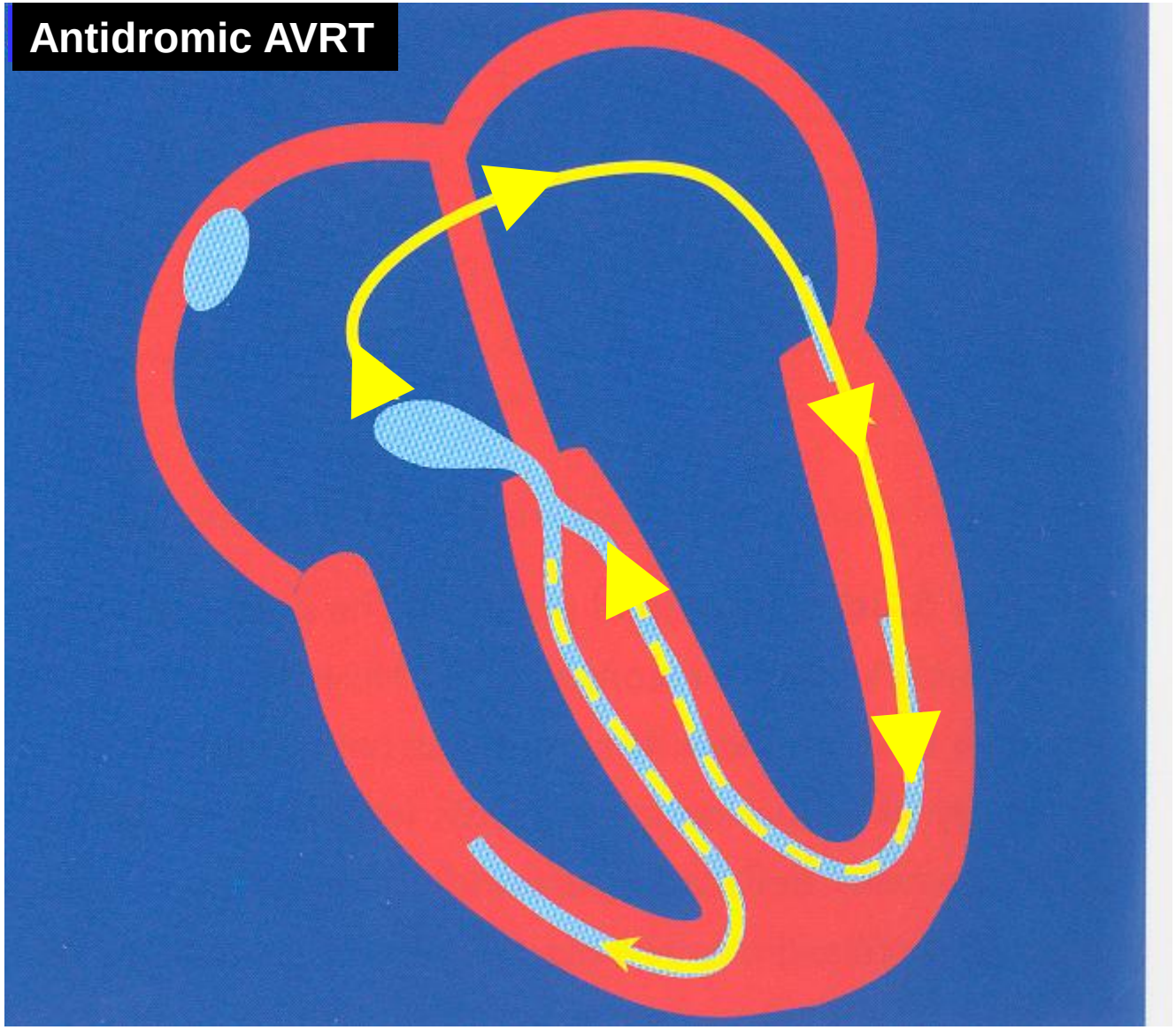
Typical AVNRT

PR > RP

RP very short (<70 ms) → AV nodal reentrant tachycardia (typical AVNRT; slow-fast type)

RP >70 ms → AV reentry tachycardia (with an accessory pathway; orthodromic)


Orthodromic AVRT


Antidromic AVRT

PR > RP

RP very short (<70 ms) → AV nodal reentrant tachycardia (typical AVNRT; slow-fast type)

RP >70 ms → AV reentry tachycardia (with an accessory pathway; orthodromic)

→ Atrial tachycardia (with AV block)

PR > RP

RP very short (<70 ms) → AV nodal reentrant tachycardia (typical AVNRT; slow-fast type)

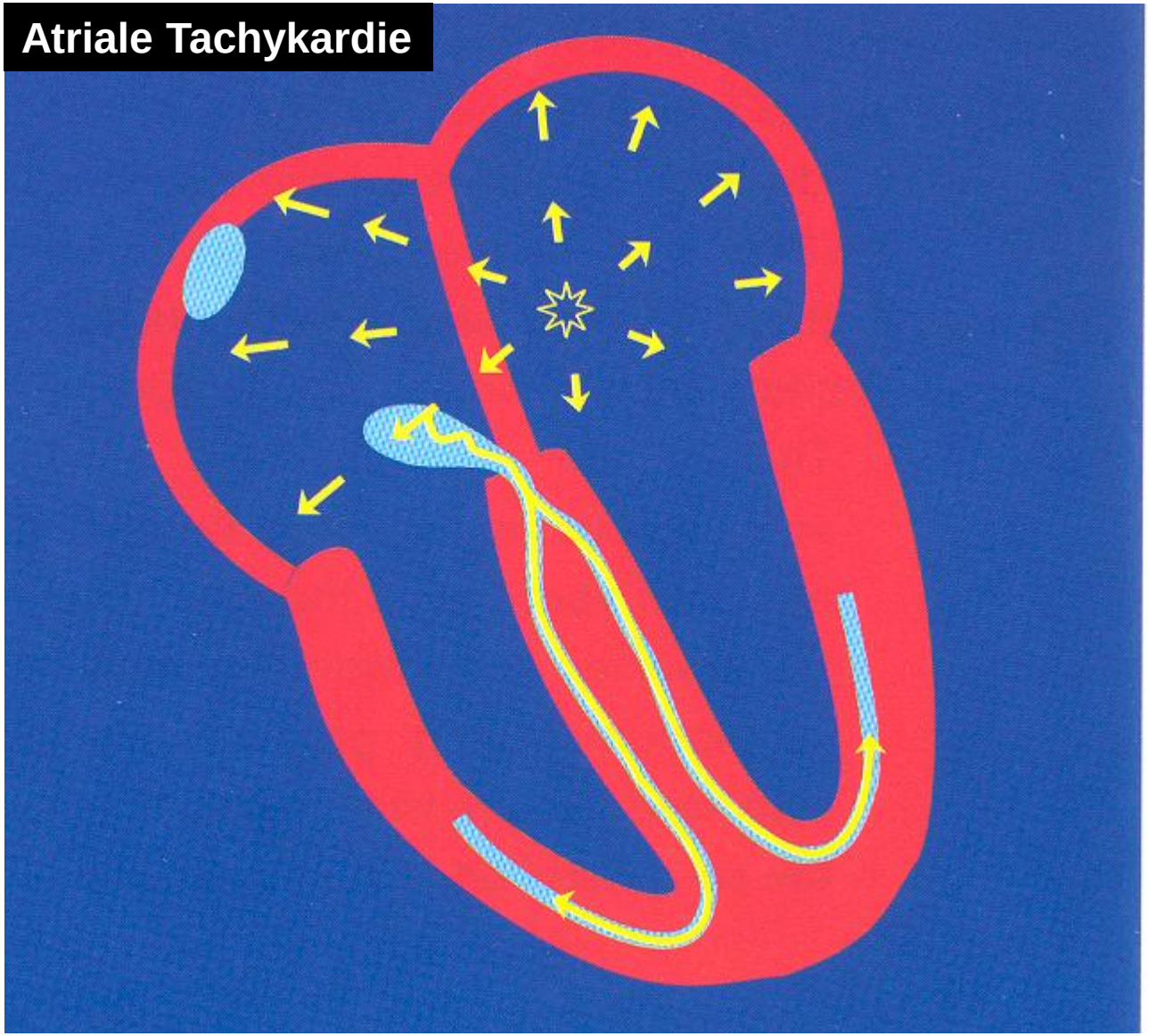
RP >70 ms → AV reentry tachycardia (with an accessory pathway; orthodromic)

→ Atrial tachycardia (with AV block)

RP > PR

→ Atrial tachycardia

Atriale Tachykardie



PR > RP

RP very short (<70 ms) → AV nodal reentrant tachycardia (typical AVNRT; slow-fast type)

RP >70 ms → AV reentry tachycardia (with an accessory pathway; orthodromic)

→ Atrial tachycardia (with AV block)

RP > PR

→ Atrial tachycardia

→ Atypical AVNRT

AV Nodal Reentrant Tachycardia

90% typical AVNRT

- **slow-fast type**

10% atypical AVNRT

- **fast-slow type**
- **slow-slow type**

PR > RP

RP very short (<70 ms) → AV nodal reentrant tachycardia (typical AVNRT; slow-fast type)

RP >70 ms → AV reentry tachycardia (with an accessory pathway; orthodromic)

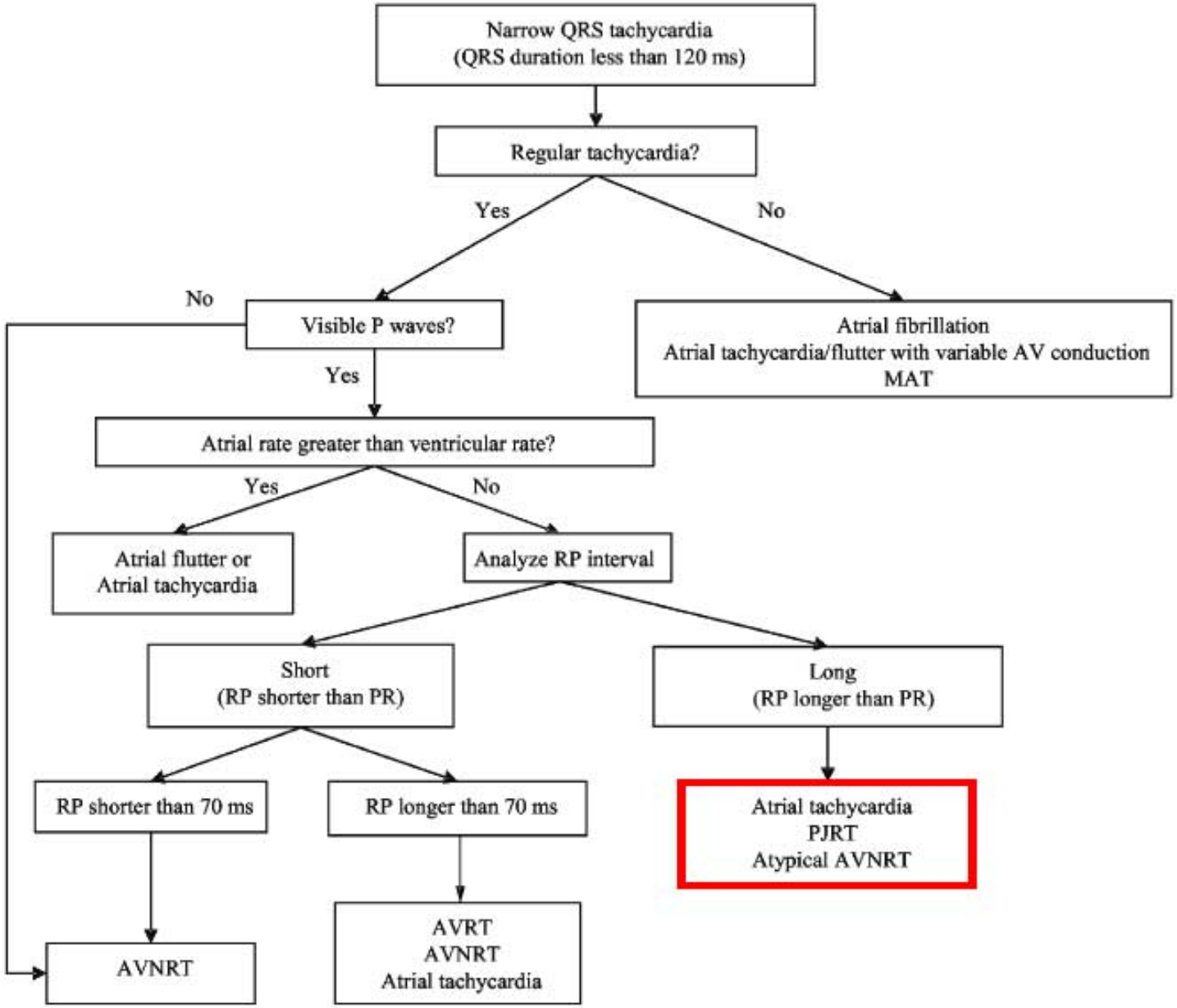
→ Atrial tachycardia (with AV block)

RP > PR

→ Atrial tachycardia

→ Atypical AVNRT

→ Atypical AV reentry tachycardia


Narrow QRS tachycardia
(QRS duration less than 120 ms)
Regular tachycardia?
Yes
No
Visible P waves?
No
Yes
Atrial fibrillation
Atrial tachycardia/flutter with variable AV conduction
MAT
Atrial rate greater than ventricular rate?
Yes
No
Atrial flutter or
Atrial tachycardia
Analyze RP interval
Short
(RP shorter than PR)
Long
(RP longer than PR)
RP shorter than 70 ms
RP longer than 70 ms
Atrial tachycardia
PJRT
Atypical AVNRT
AVNRT
AVRT
AVNRT
Atrial tachycardia

PJRT

PJRT = permanent junctional reciprocating tachycardia

PJRT = permanent junctional reciprocating tachycardia

Macroreentry

- **Antegrade conduction via AV node & His bundle**
- **Retrograde conduction via accessory pathway**

PJRT = permanent junctional reciprocating tachycardia

Macroreentry

Antegrade conduction via AV node & His bundle

Retrograde conduction via accessory pathway

No preexcitation suring sinus rhythm (no delta wave)

The accessory pathway has decremental conduction

***decremental* = AV node like, and therefore → RP > PR**

The accessory pathway has posteroseptal location

→ superior axis

→ narrow, septal P-waves

PJRT = permanent junctional reciprocating tachycardia

Young patients (children, adolescents, young adults)

PJRT = permanent junctional reciprocating tachycardia

Young patients (children, adolescents, young adults)

The tachycardia is incessant (present 50-100% of the time)

PJRT = permanent junctional reciprocating tachycardia

Young patients (children, adolescents, young adults)

The tachycardia is incessant (present 50-100% of the time)

Relatively slow tachycardia

Tachycardia-induced cardiomyopathy is not rare

PJRT = permanent junctional reciprocating tachycardia

Acute therapy:

- **Vagal maneuvers**
- **Adenosine**
- **Verapamil**
- **Betablockers**
- **Class I AA (Flecainide)**
- **Overdrive Pacing**
- **Cardioversion**

PJRT = permanent junctional reciprocating tachycardia

Acute therapy:

- **Vagal maneuvers**
- **Adenosine**
- **Verapamil**
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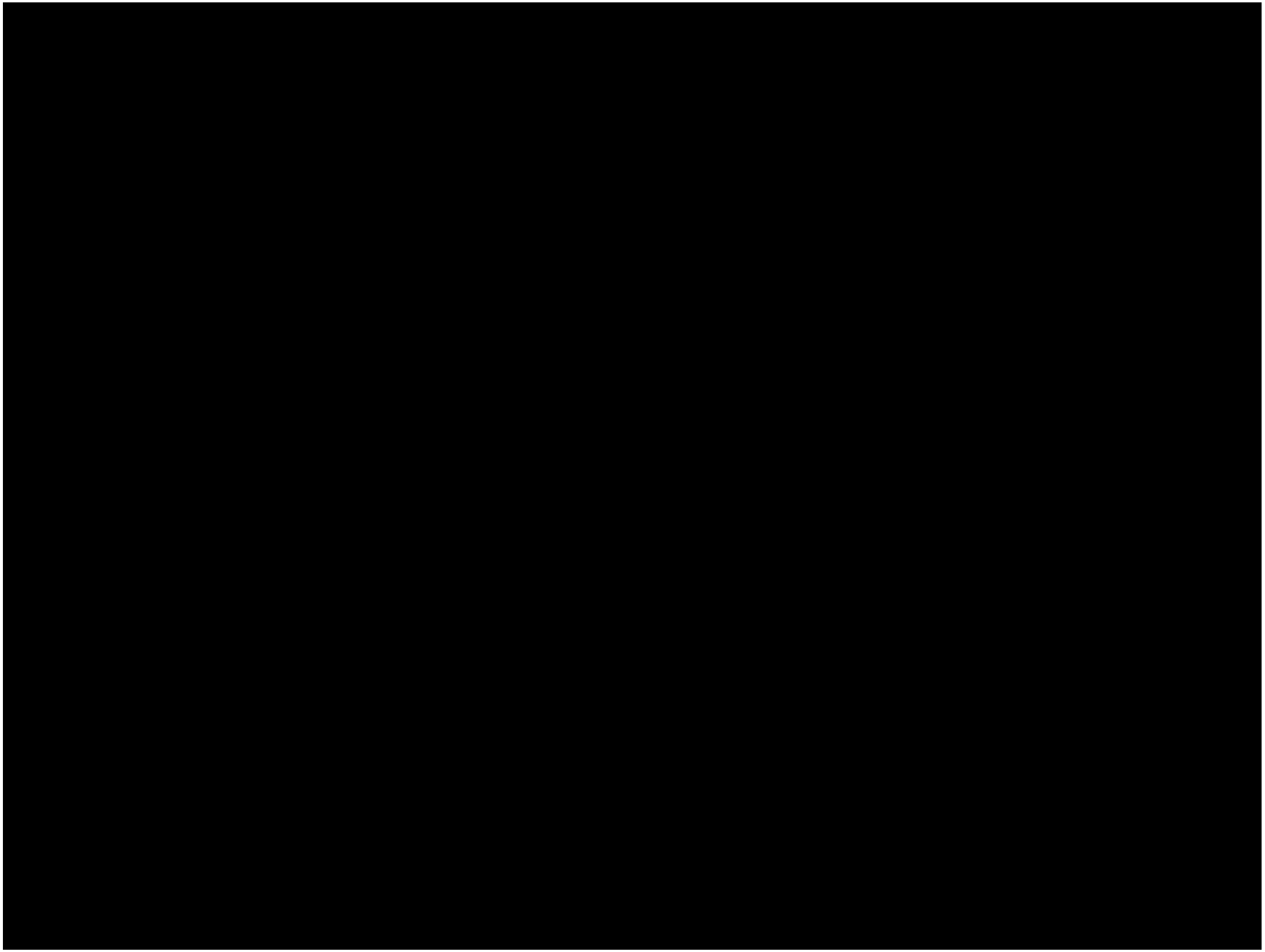
Chronic therapy:

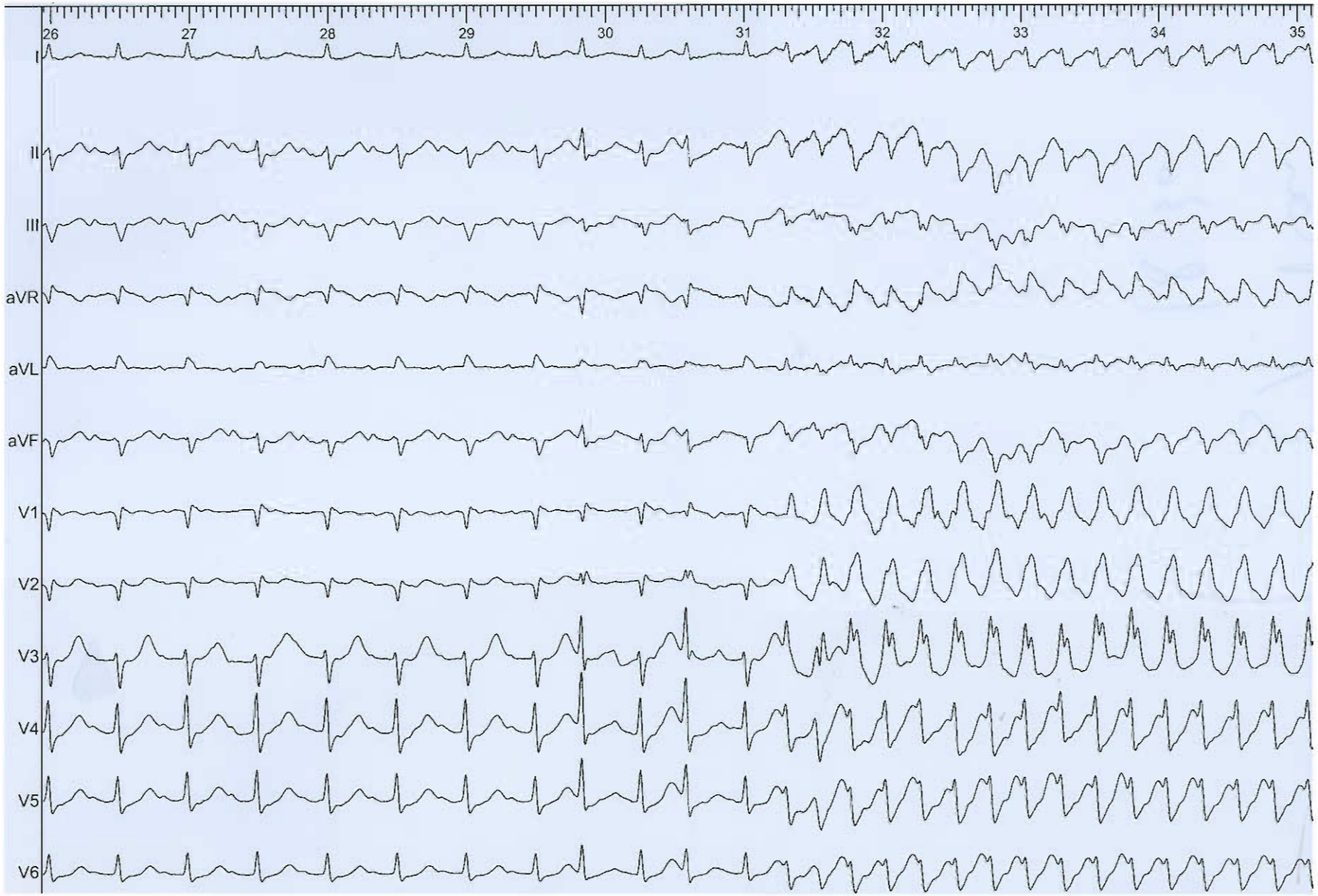
- **Catheter ablation (success > 95%)**



44 year-old man presents with palpitations

Intermittent palpitations for 10 years

What is the likely diagnosis ?


26
27
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32
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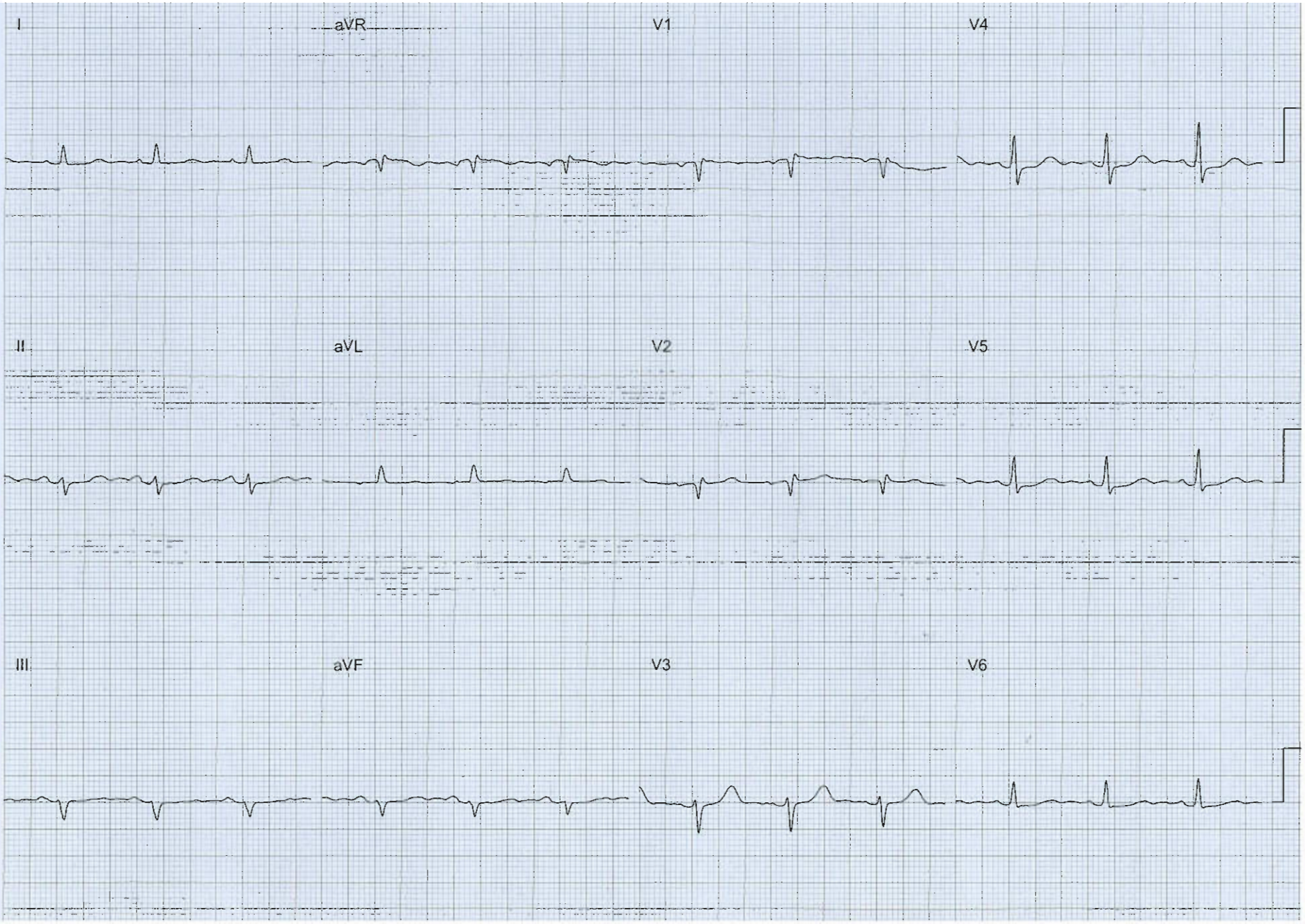
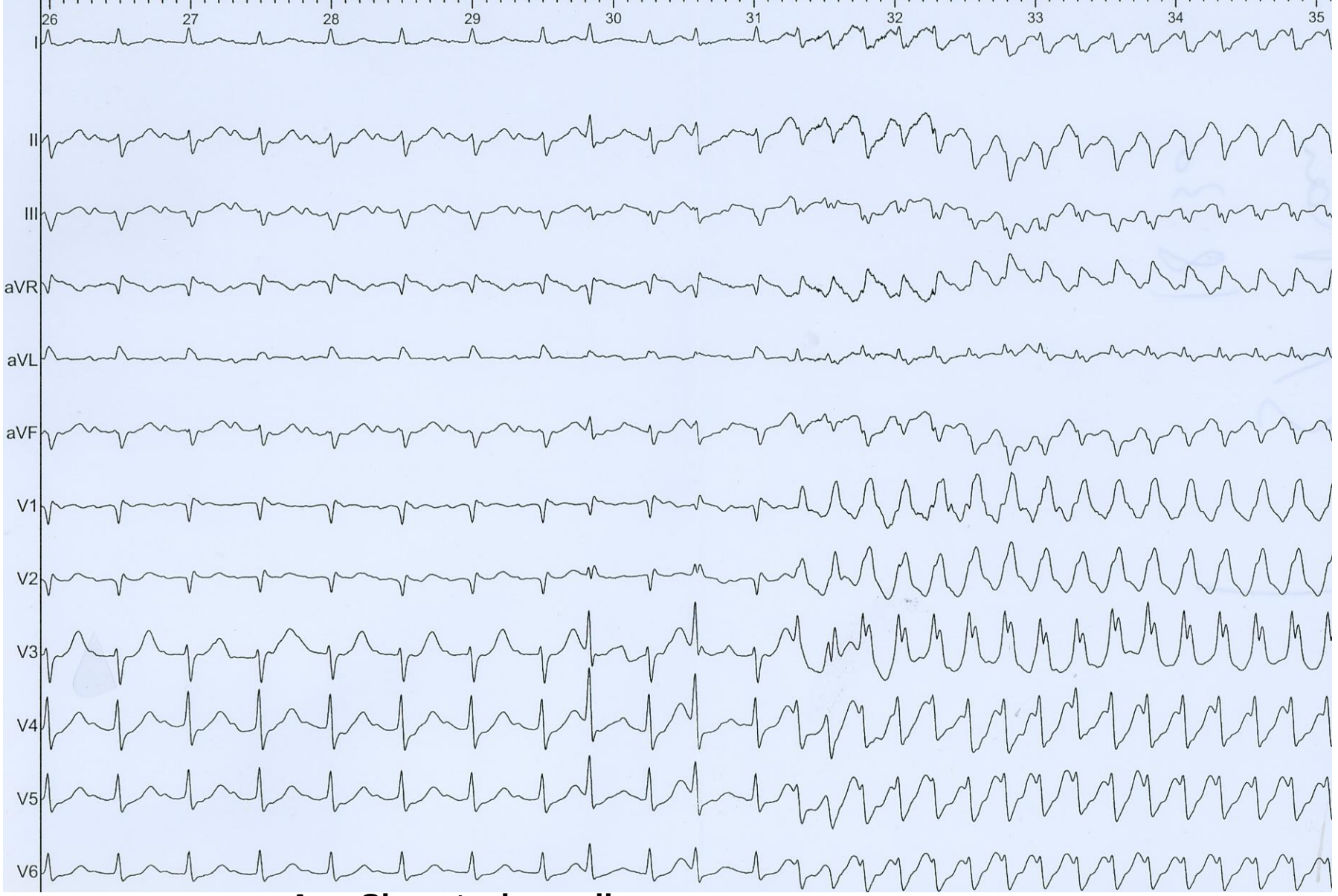
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

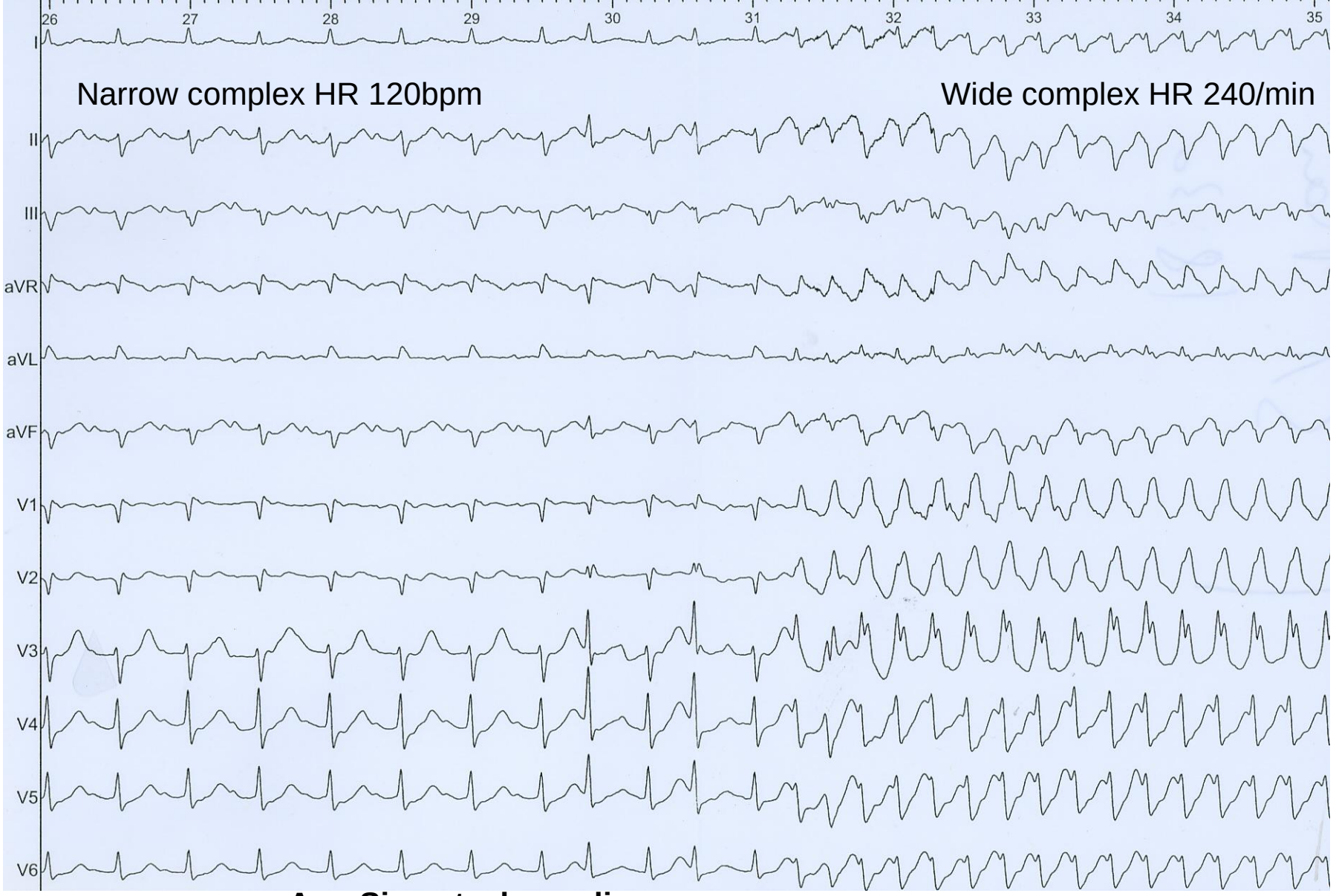

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

What is the likely diagnosis ?

A. **Sinus tachycardia**
B. **Atrial tachycardia**
C. **AV nodal reentrant tachycardia**
D. **AV reentry tachycardia (accessory pathway)**
E. **Atrial flutter**
F. **Ventricular tachycardia**



A. Sinus tachycardia
B. Atrial tachycardia
C. AV nodal reentrant tachycardia
D. AV reentry tachycardia (accessory pathway)
E. Atrial flutter
F. Ventricular tachycardia



A. Sinus tachycardia
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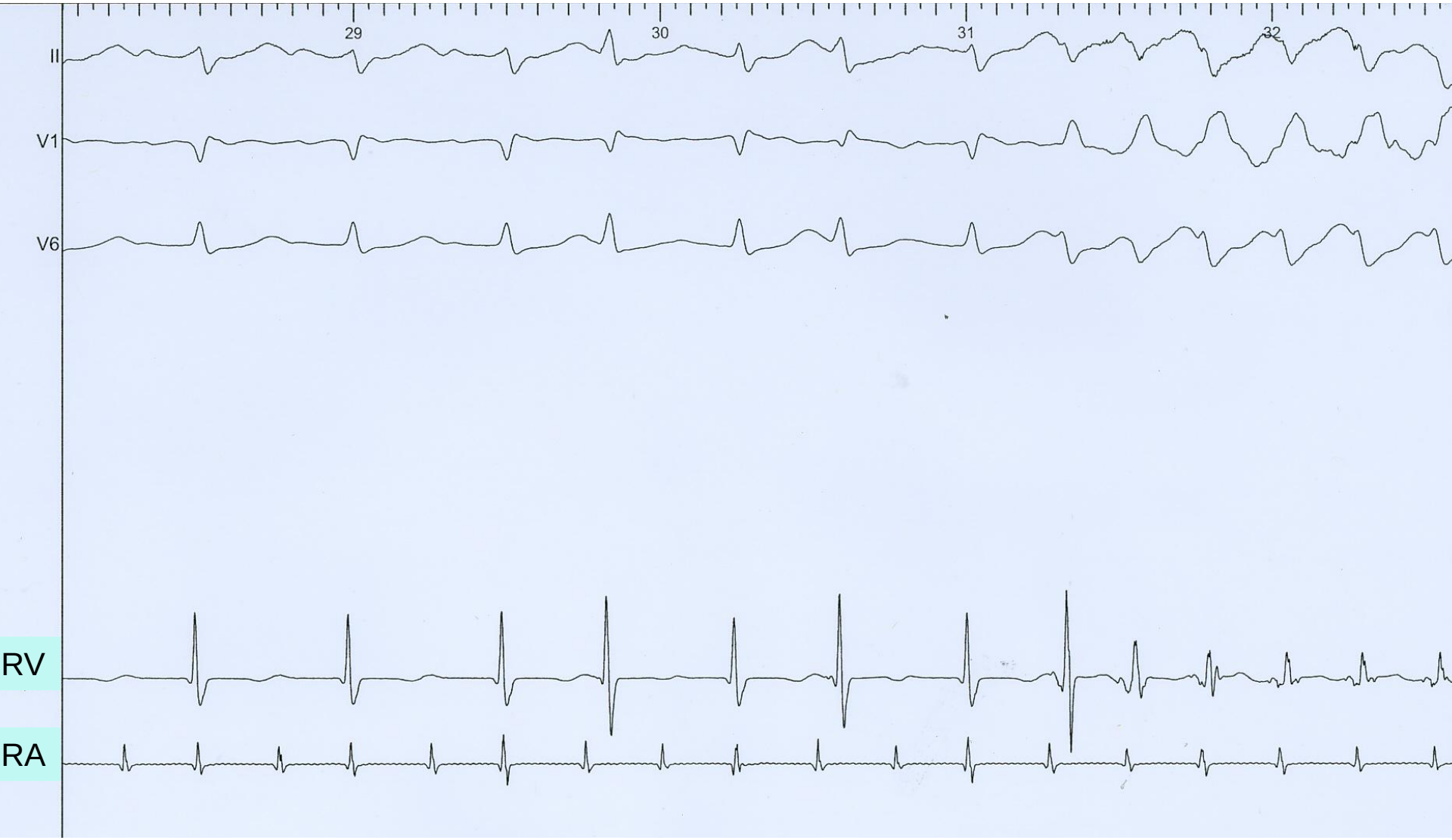
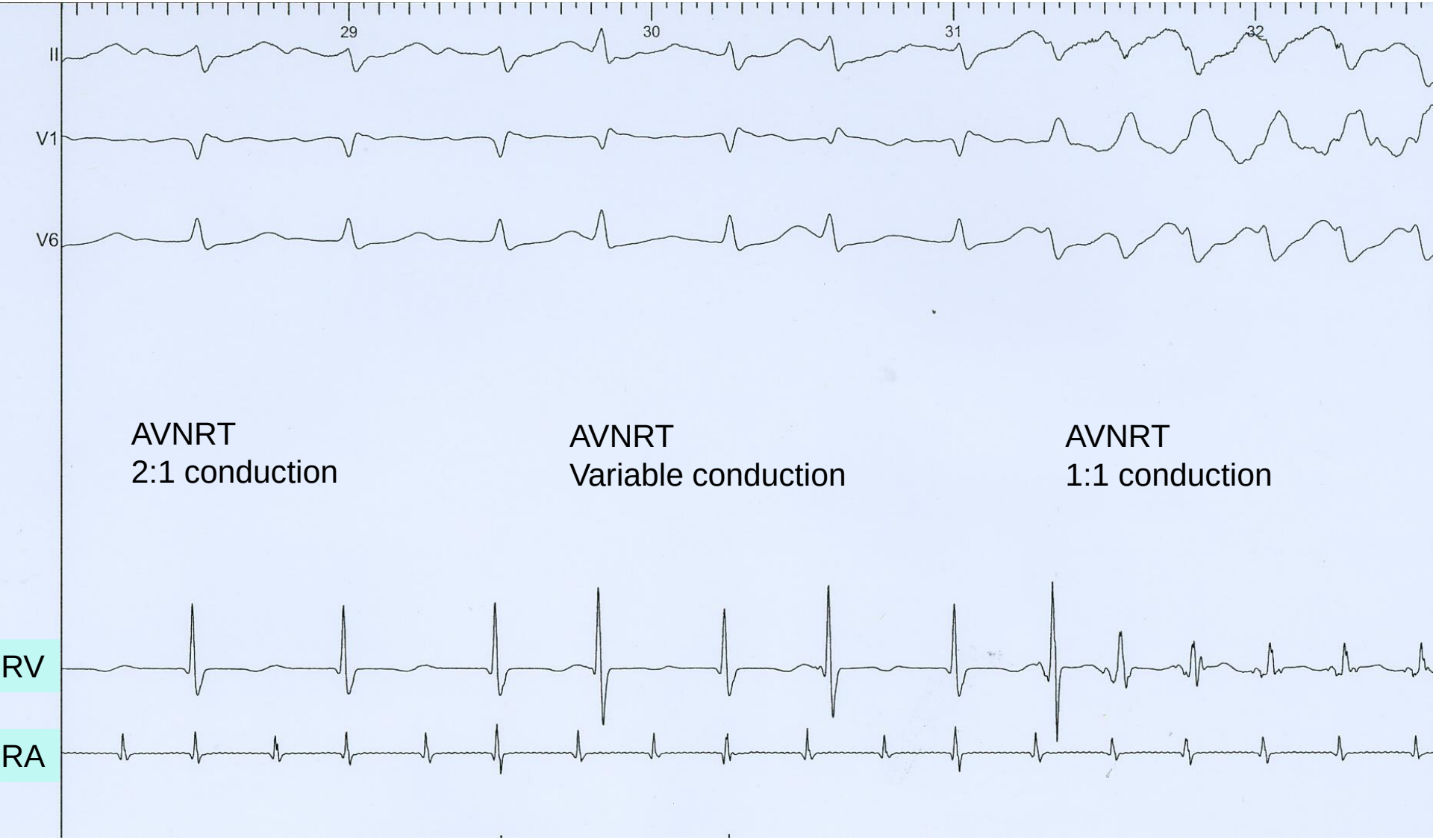
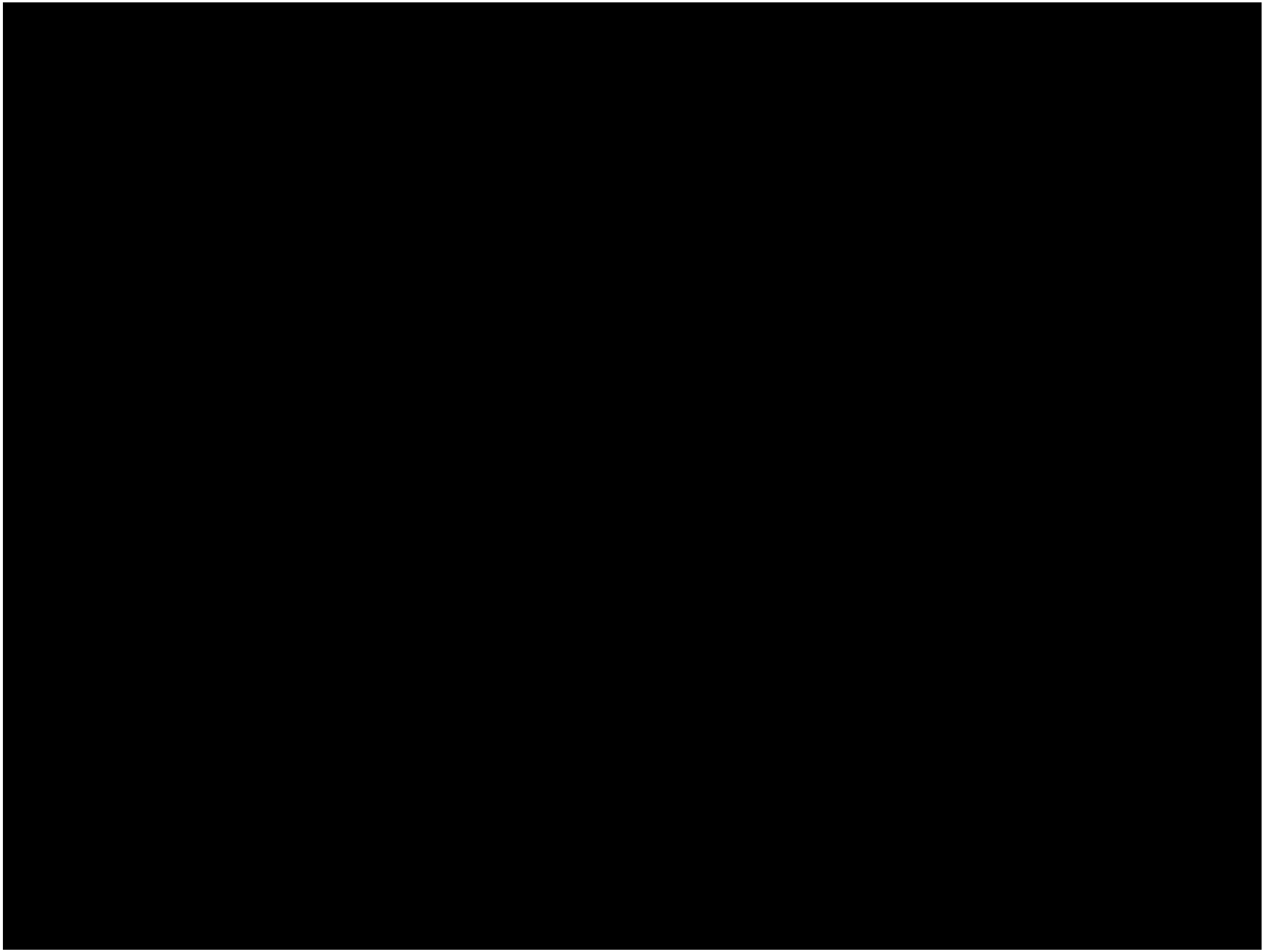
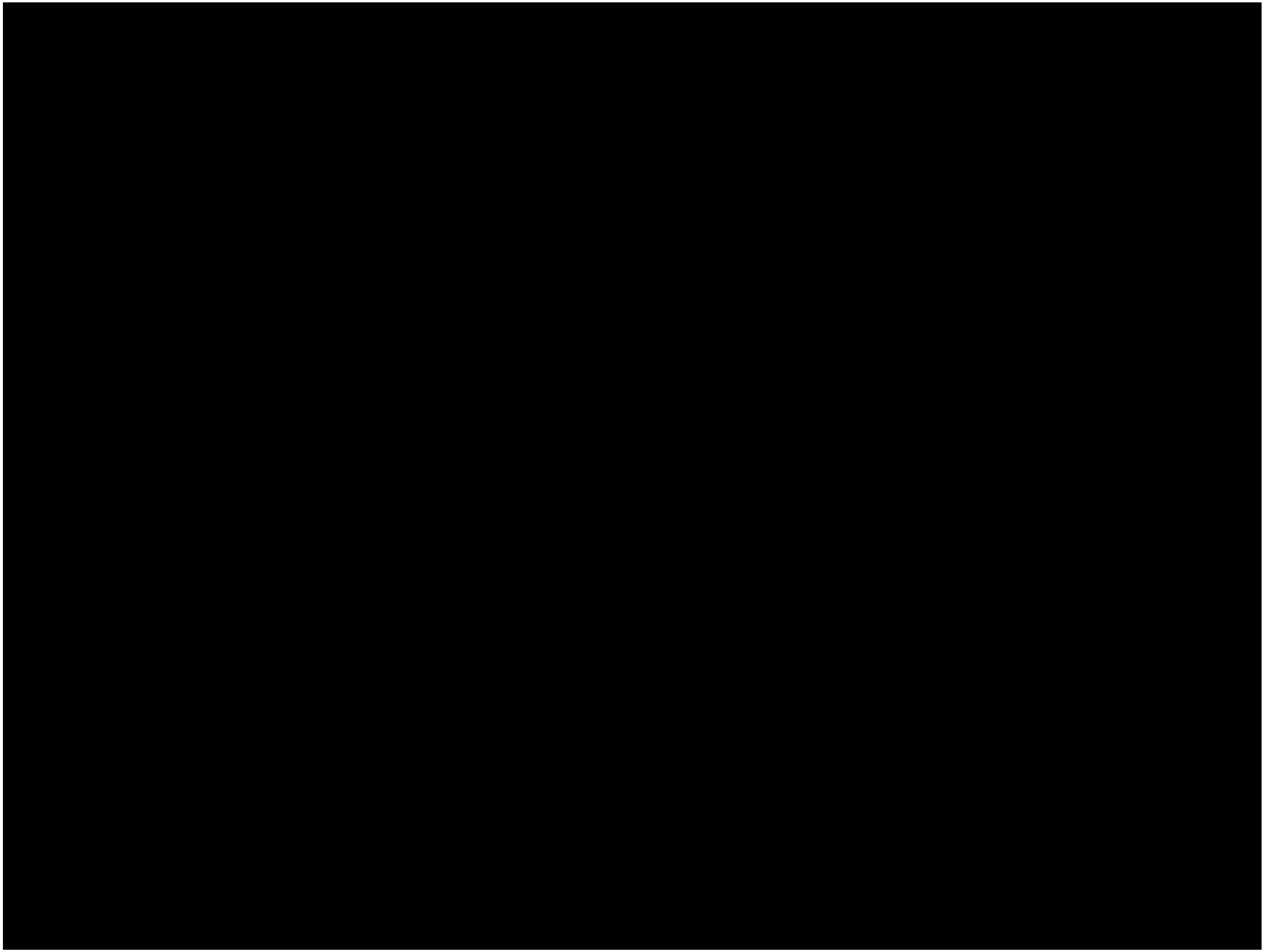


A. Sinus tachycardia
B. Atrial tachycardia
C. AV nodal reentrant tachycardia
D. AV reentry tachycardia (accessory pathway)
E. Atrial flutter
F. Ventricular tachycardia


29
30
31
32
II
V1
V6
AVNRT
2:1 conduction
AVNRT
Variable conduction
AVNRT
1:1 conduction
RV
RA





SVT-VT Differential Diagnosis

- AV-Dissociation?
  - yes → VT
  - ↓ no
- no “RS” in precordial leads?
  - yes → VT
  - ↓ no
- R-S >100 ms in one precordial lead?
  - yes → VT
  - ↓ no
- morphology criteria for V1 and V6 are met?
  - yes → VT
  - ↓ no

SVT with Aberration

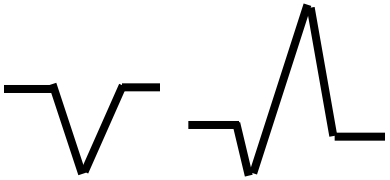
RSB

V1

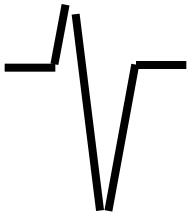
monophasic

L > R

V6



Q



R/S < 1

LSB

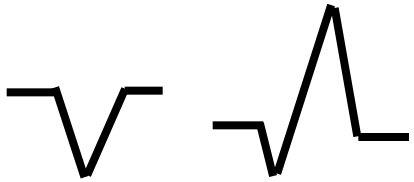
V1

R >30 ms

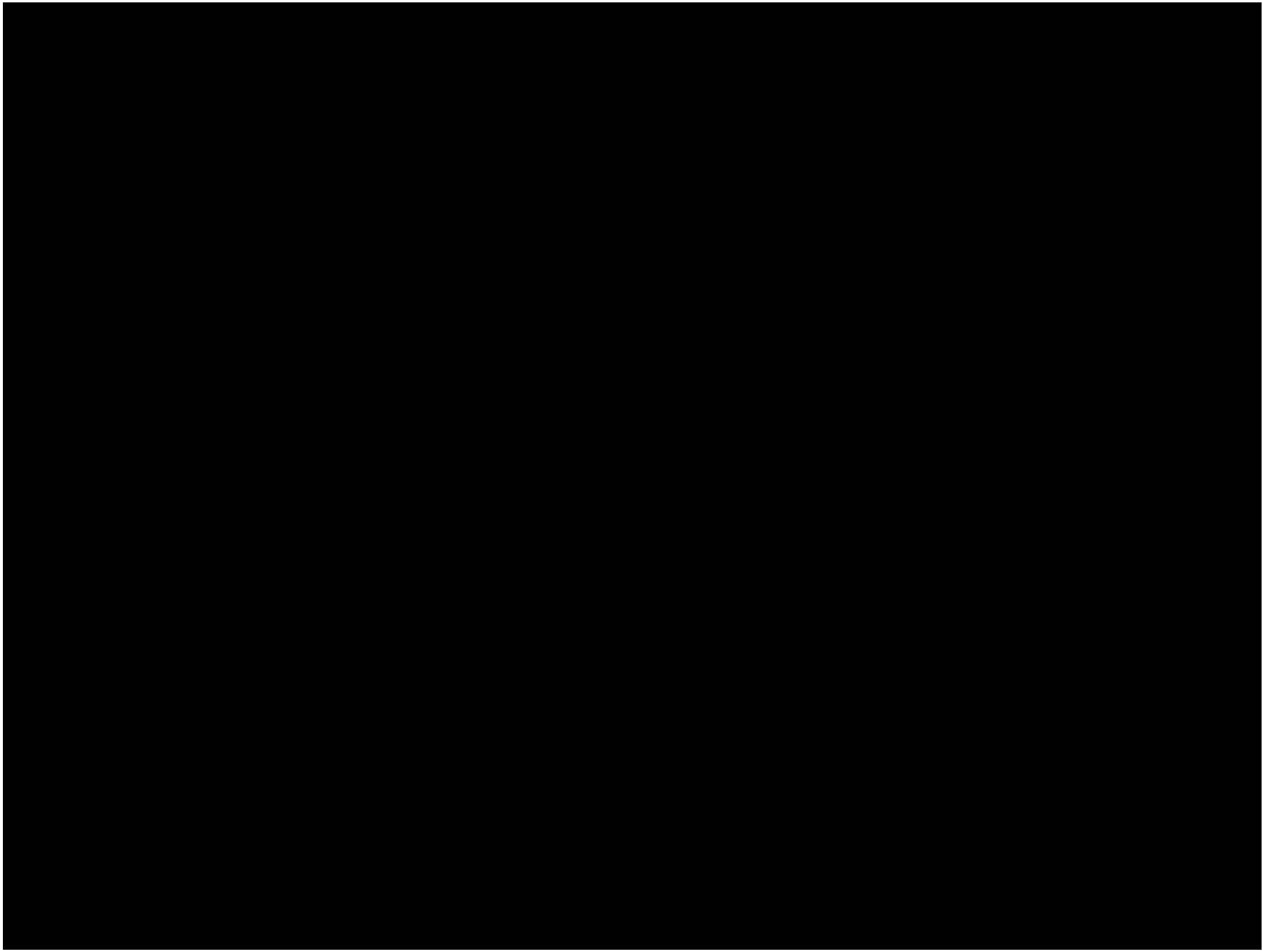
R-S >60 ms

“notched” S

V6



Q

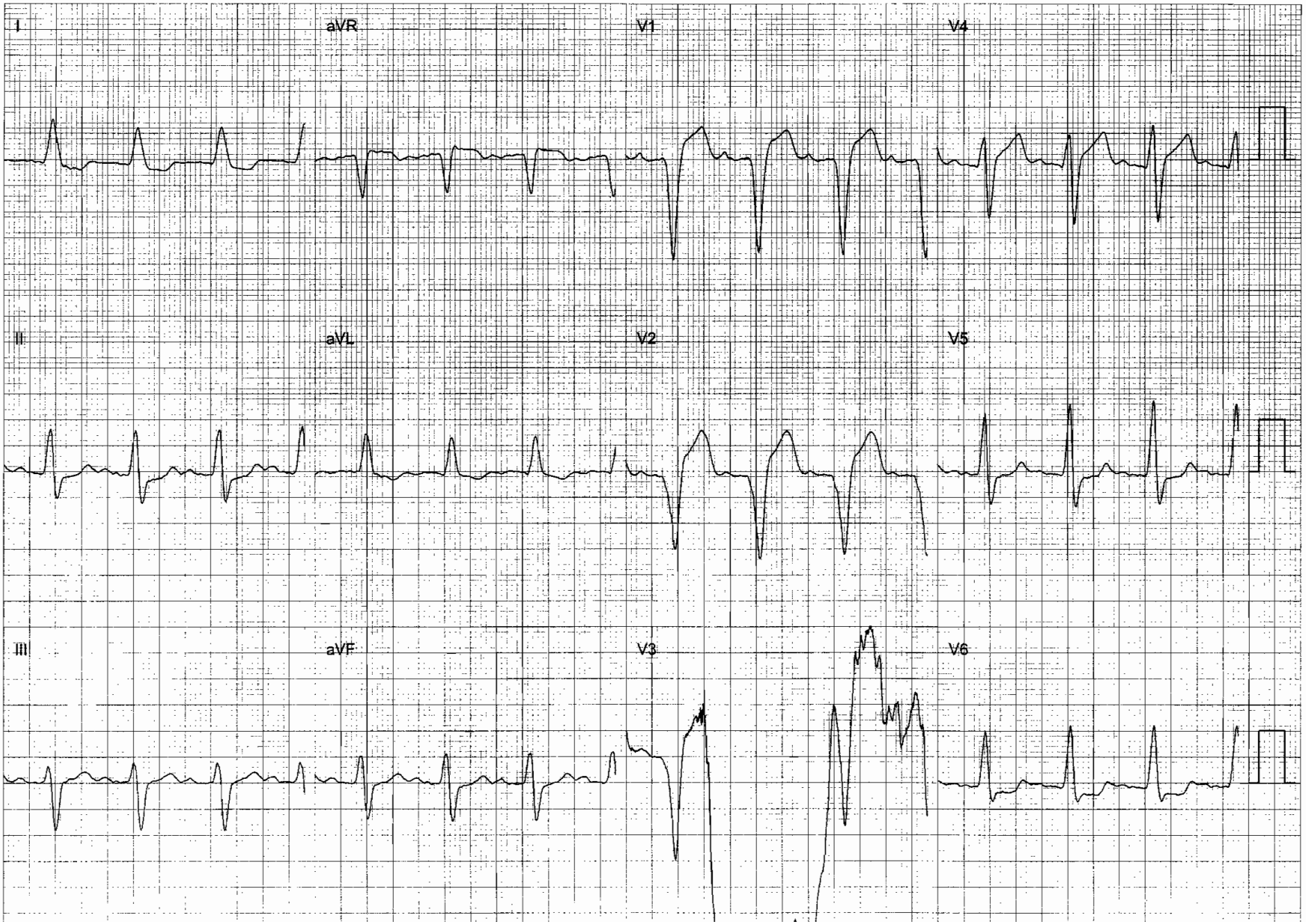


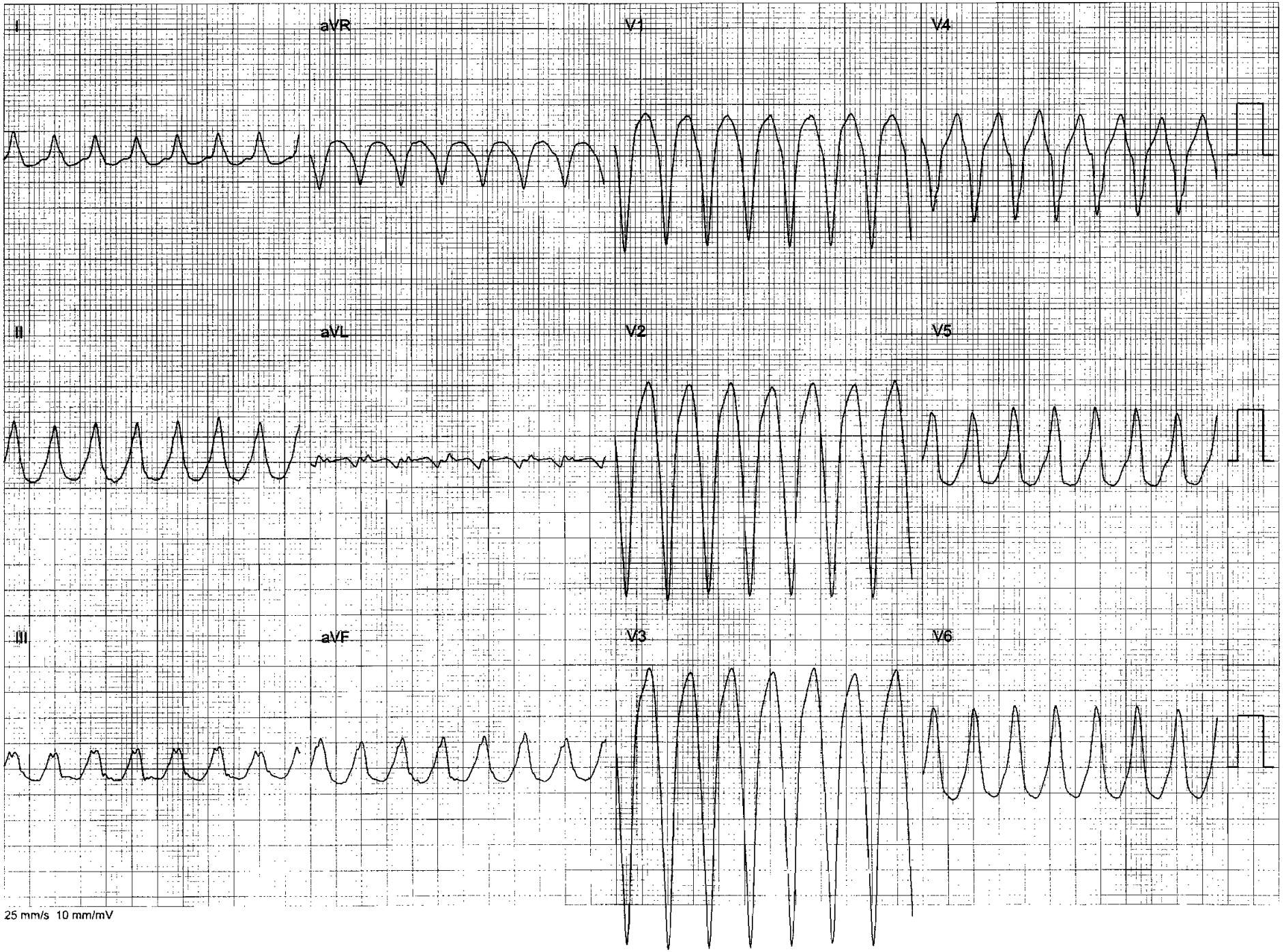
42-year-old male patient with dilated CMP

- Left ventricular EF 25%
- History of paroxysmal atrial fibrillation / atrial flutter

Main complaints

- Exercise intolerance
- Dyspnea on exertion
- Occasional palpitations with presyncope

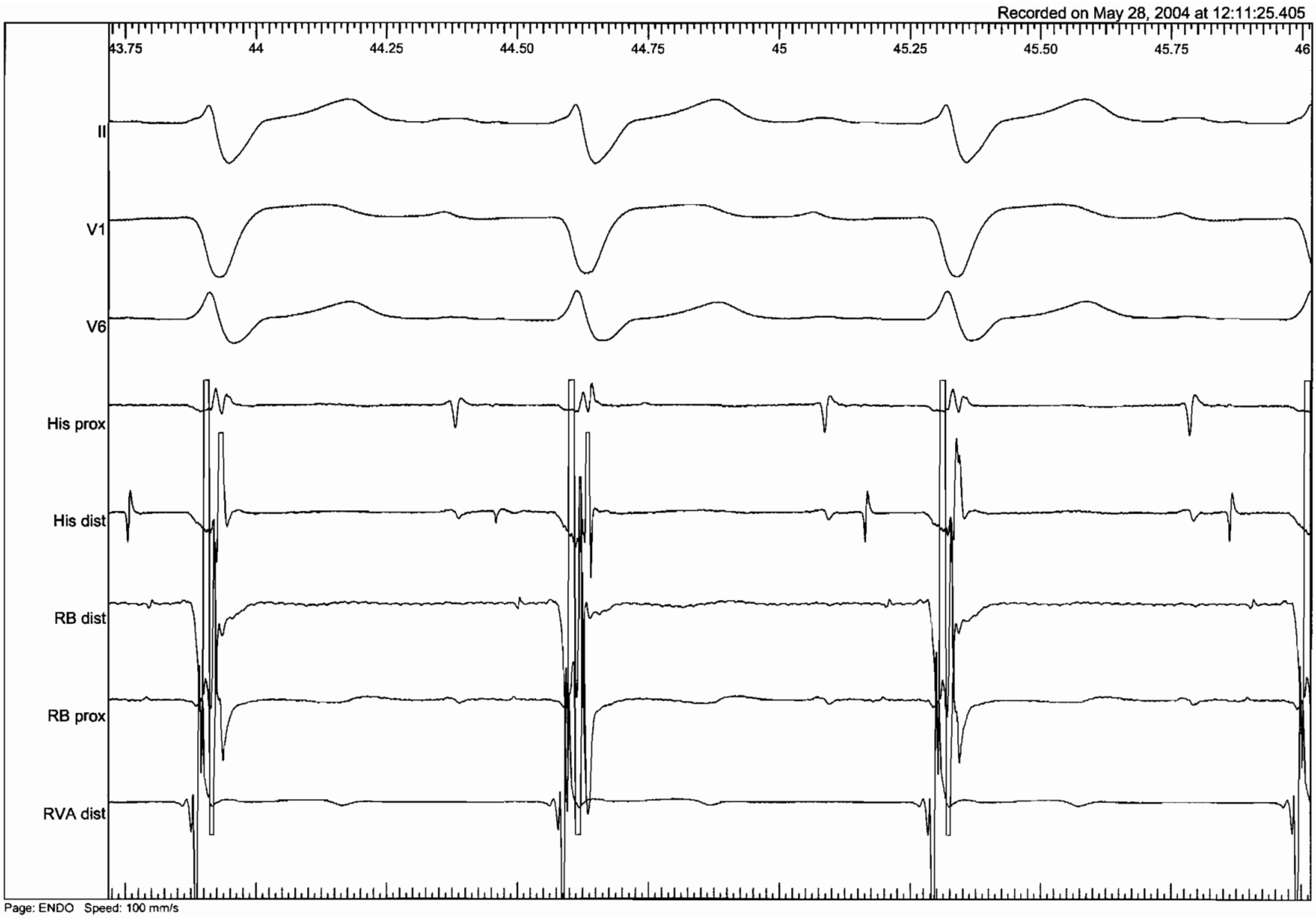

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

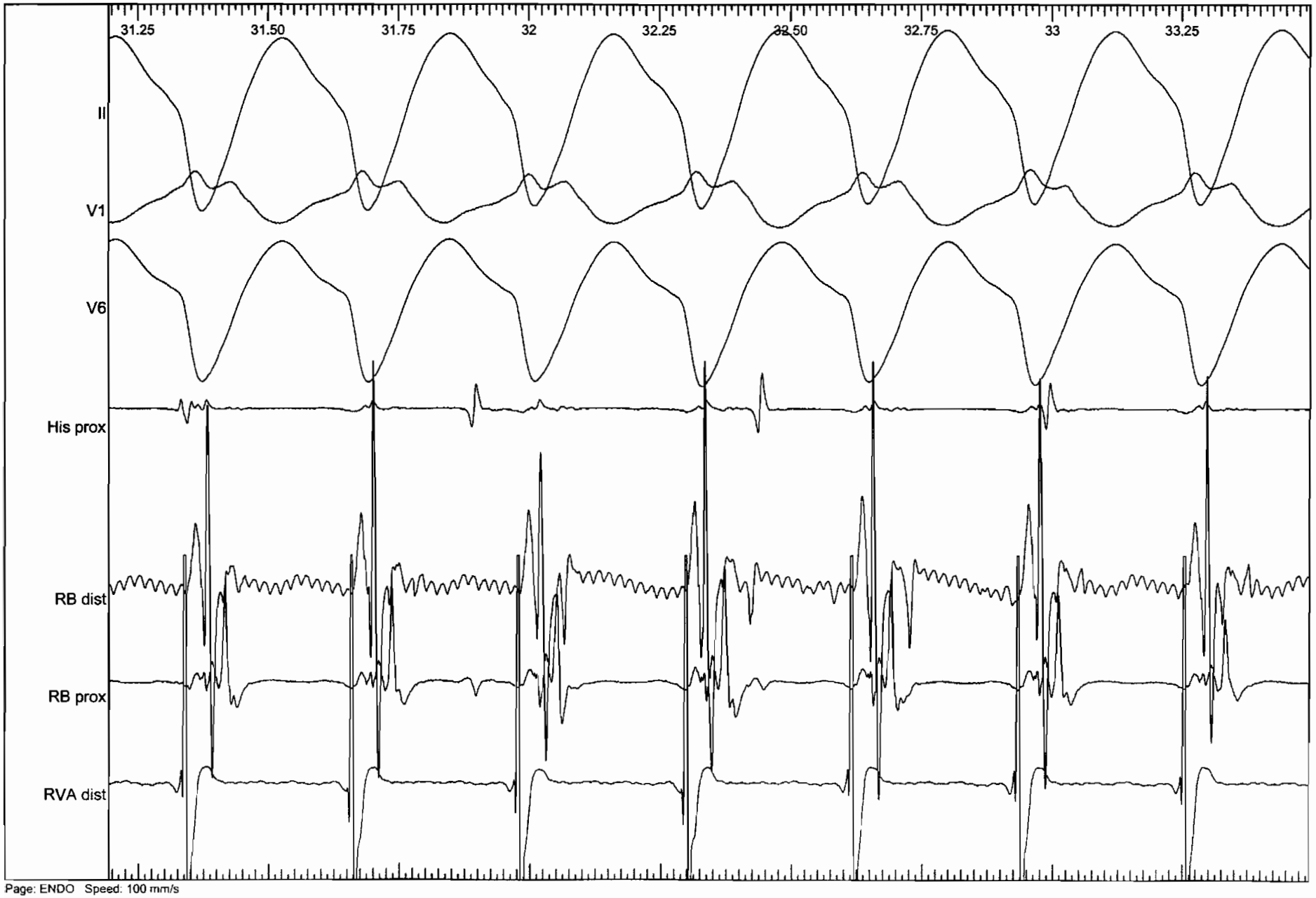

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
25 mm/s 10 mm/mV


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
25 mm/s 10 mm/mV

What is the arrhythmia diagnosis?

A. Atrial flutter
B. Atrial tachycardia with aberration
C. AVNRT with aberration
D. AVRT (accessory pathway)
E. Ventricular tachycardia

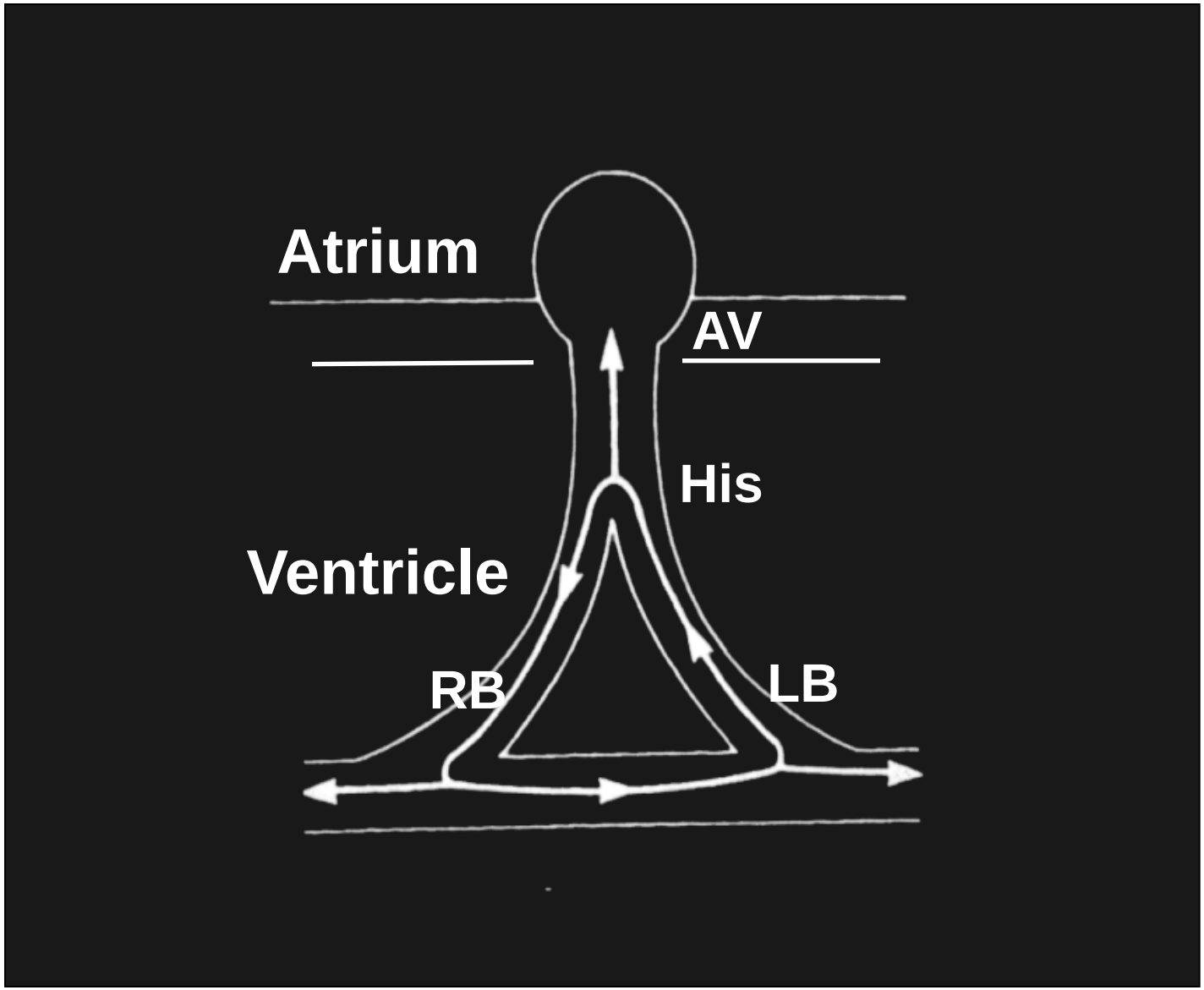

Recorded on May 28, 2004 at 12:11:25.405
43.75
44
44.25
44.50
44.75
45
45.25
45.50
45.75
46
II
V1
V6
His prox
His dist
RB dist
RB prox
RVA dist
Page: ENDO Speed: 100 mm/s


31.25
31.50
31.75
32
32.25
32.50
32.75
33
33.25
II
V1
V6
His prox
RB dist
RB prox
RVA dist
Page: ENDO Speed: 100 mm/s

Bundle Branch Reentrant VT

- Macroreentrant circuit involving the His-Purkinje system, usually with antegrade conduction over the right bundle and retrograde conduction over the left bundle

Bundle Branch Reentry



Bundle Branch Reentrant VT

- The most characteristic VT in patients with dilated cardiomyopathy
- 40% of VTs in patients with dilated cardiomyopathy
- Mechanism responsible for VT in 5-6% of patients with ischemic cardiomyopathy

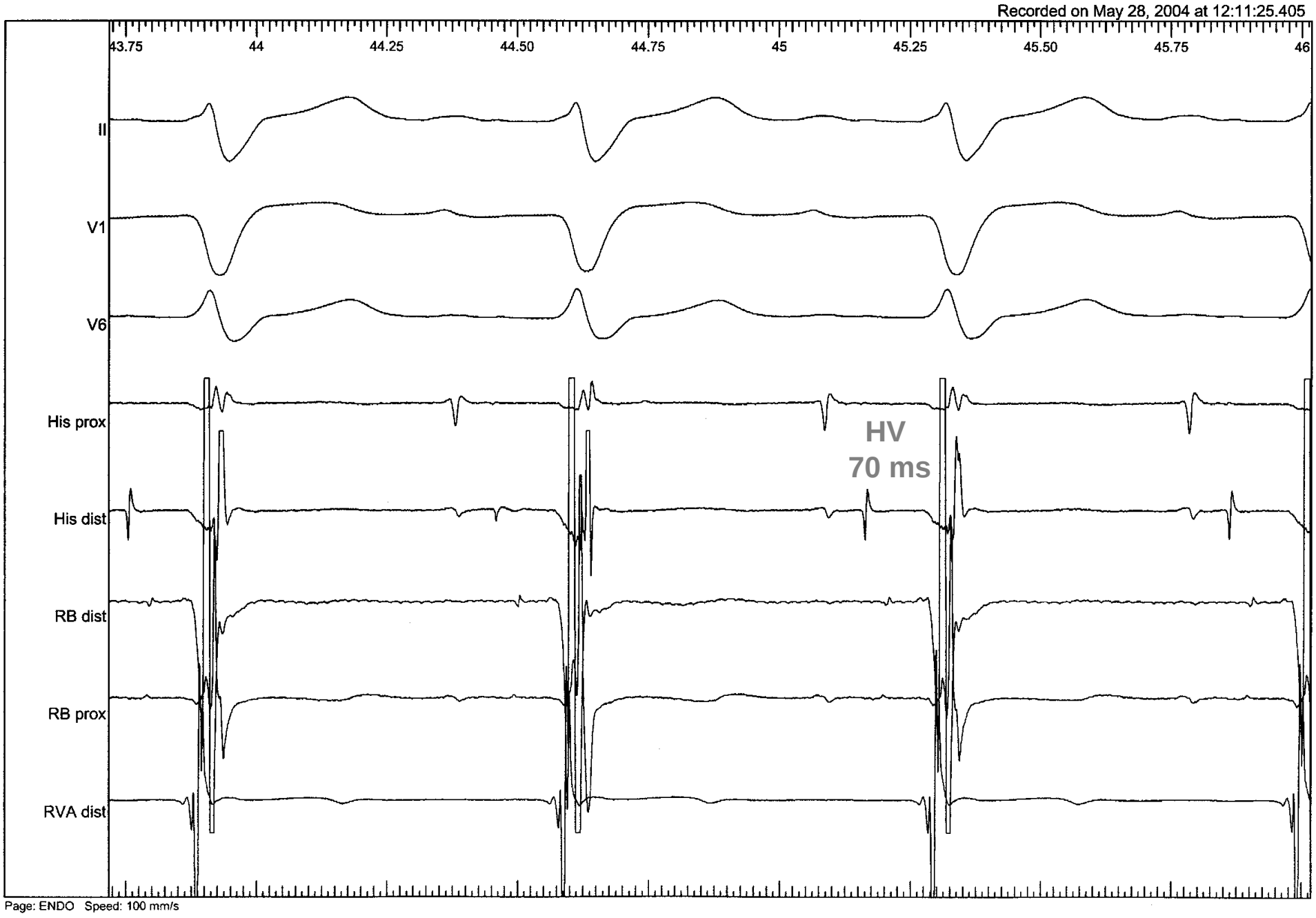
Bundle Branch Reentrant VT

- Usually rapid with a mean CL of 280-300ms
- Syncope occurs in the majority of patients
- Degeneration to VF can occur
- Baseline ECG shows typically a nonspecific IVCD or LBBB.

Bundle Branch Reentrant VT

Electrophysiologic properties:

- HV intervals recorded during sinus rhythm are characteristically prolonged.
- His deflection preceeds each QRS
- Spontaneous tachycardia CL variations are preceeded by similar H-H variations


Recorded on May 28, 2004 at 12:11:25.405
43.75
44
44.25
44.50
44.75
45
45.25
45.50
45.75
46
II
V1
V6
His prox
His dist
RB dist
RB prox
RVA dist
HV
70 ms
Page: ENDO Speed: 100 mm/s

Therapy?

A. Medication?
B. Ablation?
C. ICD?
D. (1)+(2)
E. (1)+(3)
F. all of the above?

Therapy

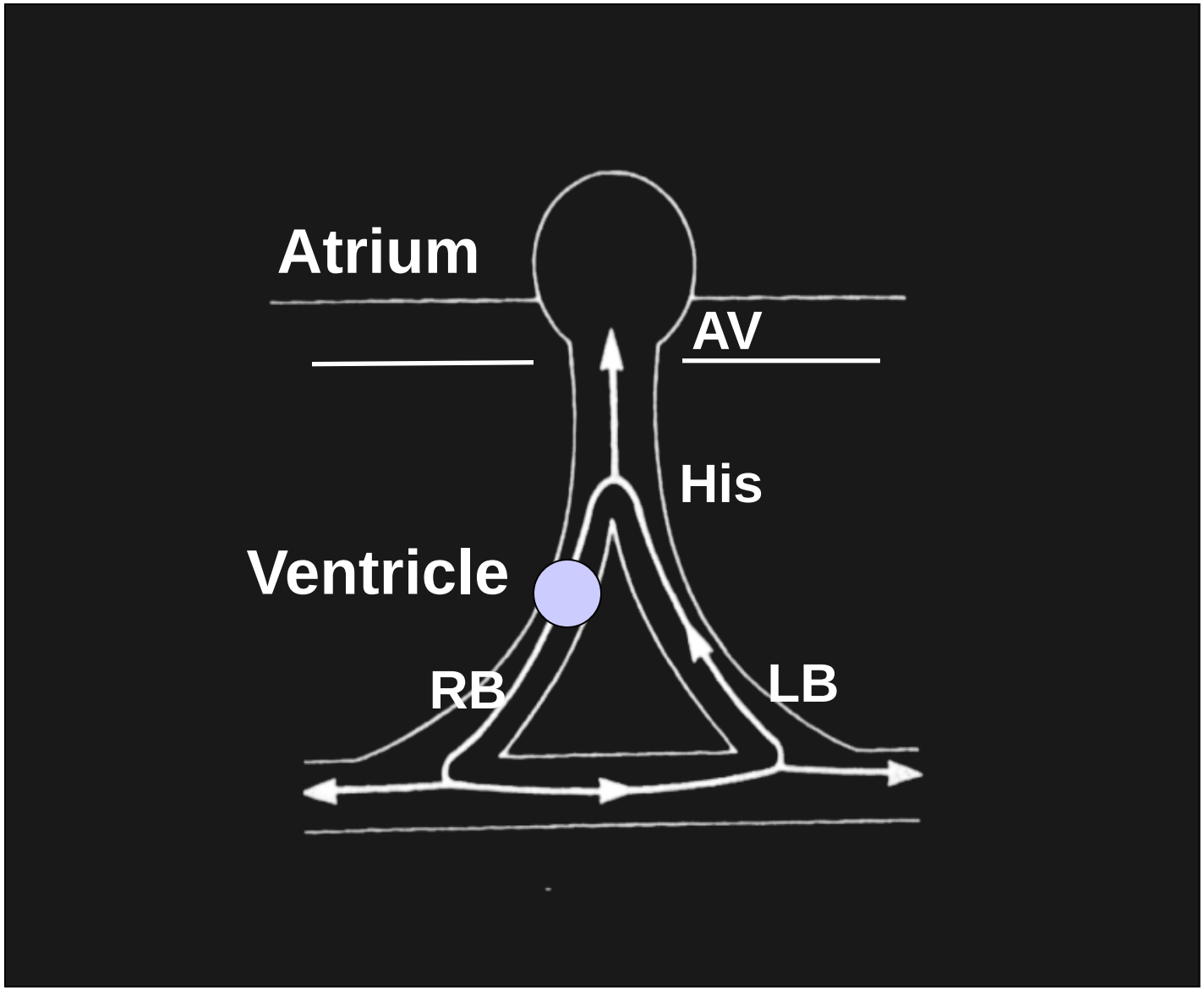
- Catheter ablation of the RBB
  – Success: 95%

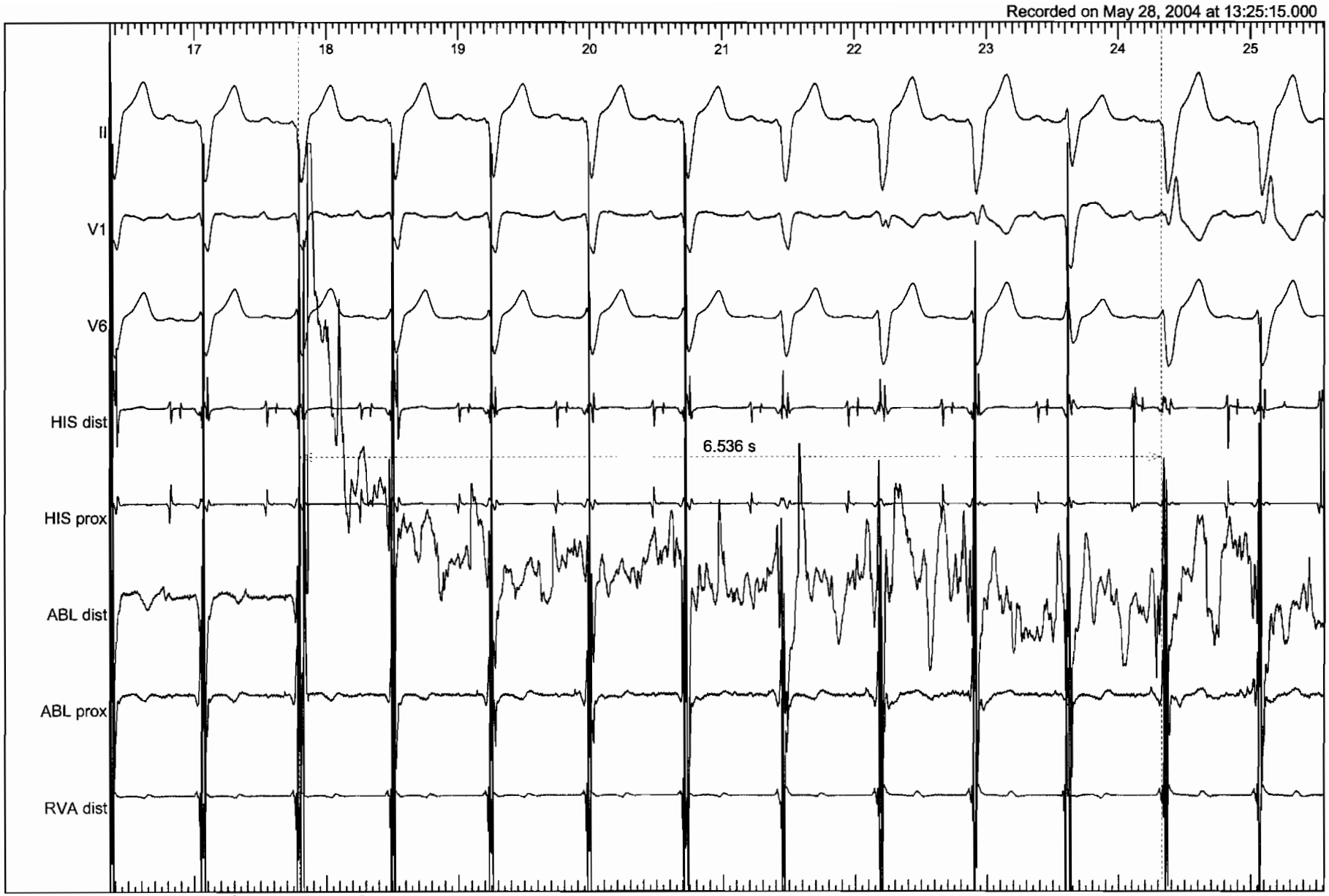
Bundle Branch Reentrant VT

Electrophysiologic properties:

- Important arrhythmia to recognize because ablation of the right bundle is curative
- Some patients may require a PM, particularly those with a preceeding LBBB

Bundle Branch Reentry





Page: ABLATION Speed: 25 mm/s Current Event: Ablation Start
Current Event Info: Time = 13:25:16, , Energy Source = EpShuttle;

Bundle Branch Reentrant VT

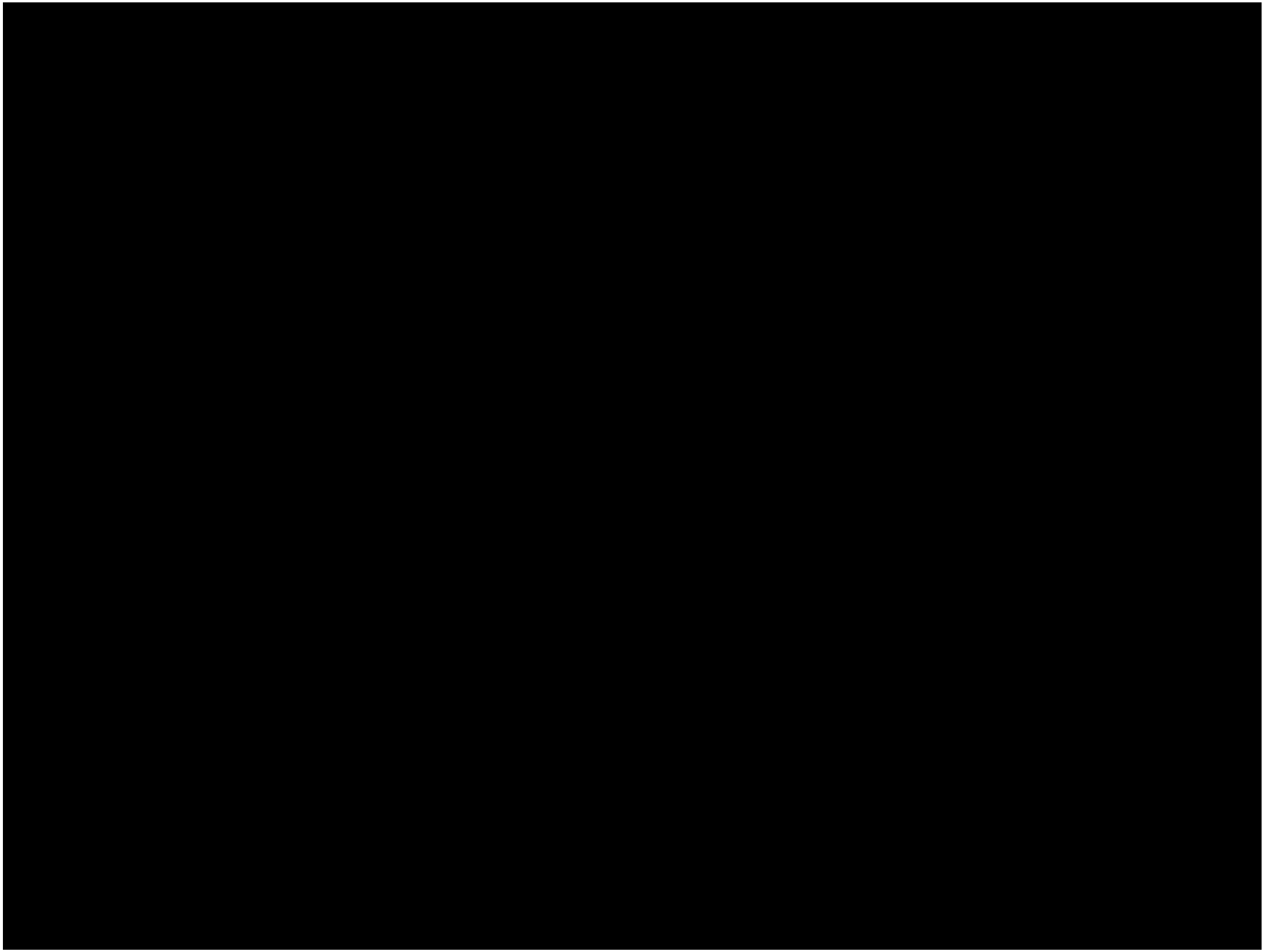
- The RBB has been most commonly targeted for ablation because it is easily accesible.
- ECG pattern of LV conduction delay is common, suggesting that antegrade conduction through the RB might be more stable
- Therefore, ablation of the LB might have a lower risk of AV block.

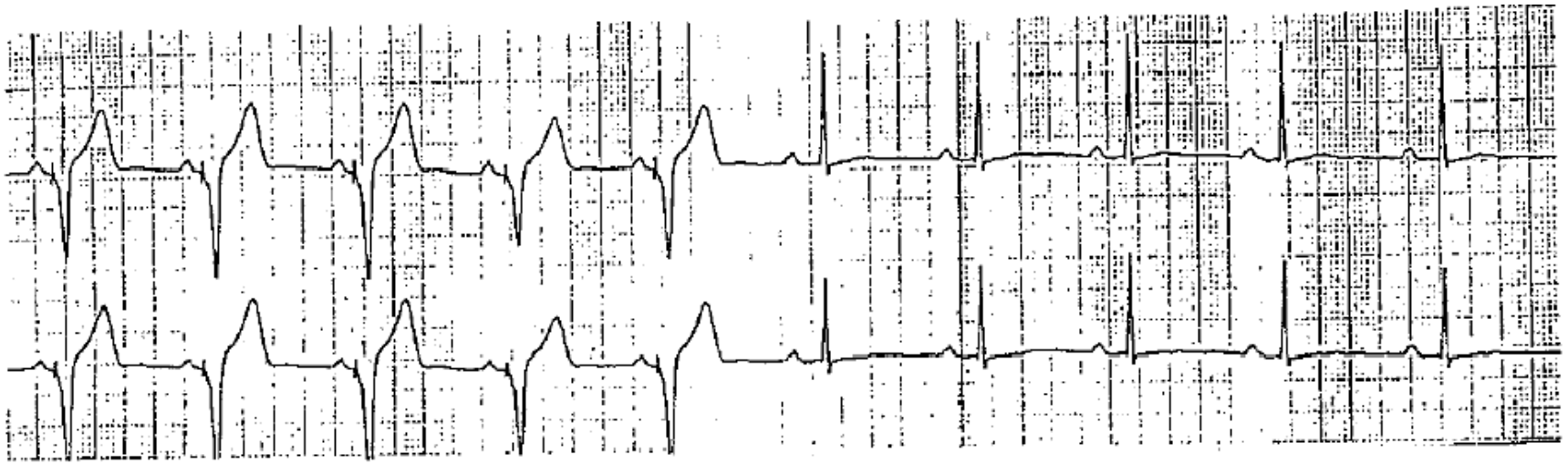
Bundle Branch Reentrant VT

- On the other hand, there is concern that LBBB may have adverse hemodynamic effects in patients with impaired ventricular function.
- Therefore, RB ablation remains the favored approach for the present.

Follow-up

- symptomatic improvement
- LVEF
  - after 6 weeks: 25% -> 45%
  - after 3 months 55%
- no adequate ICD discharges so far





Which is a likely explanation for this pacemaker ECG?

A. Positive AV – Hysterese

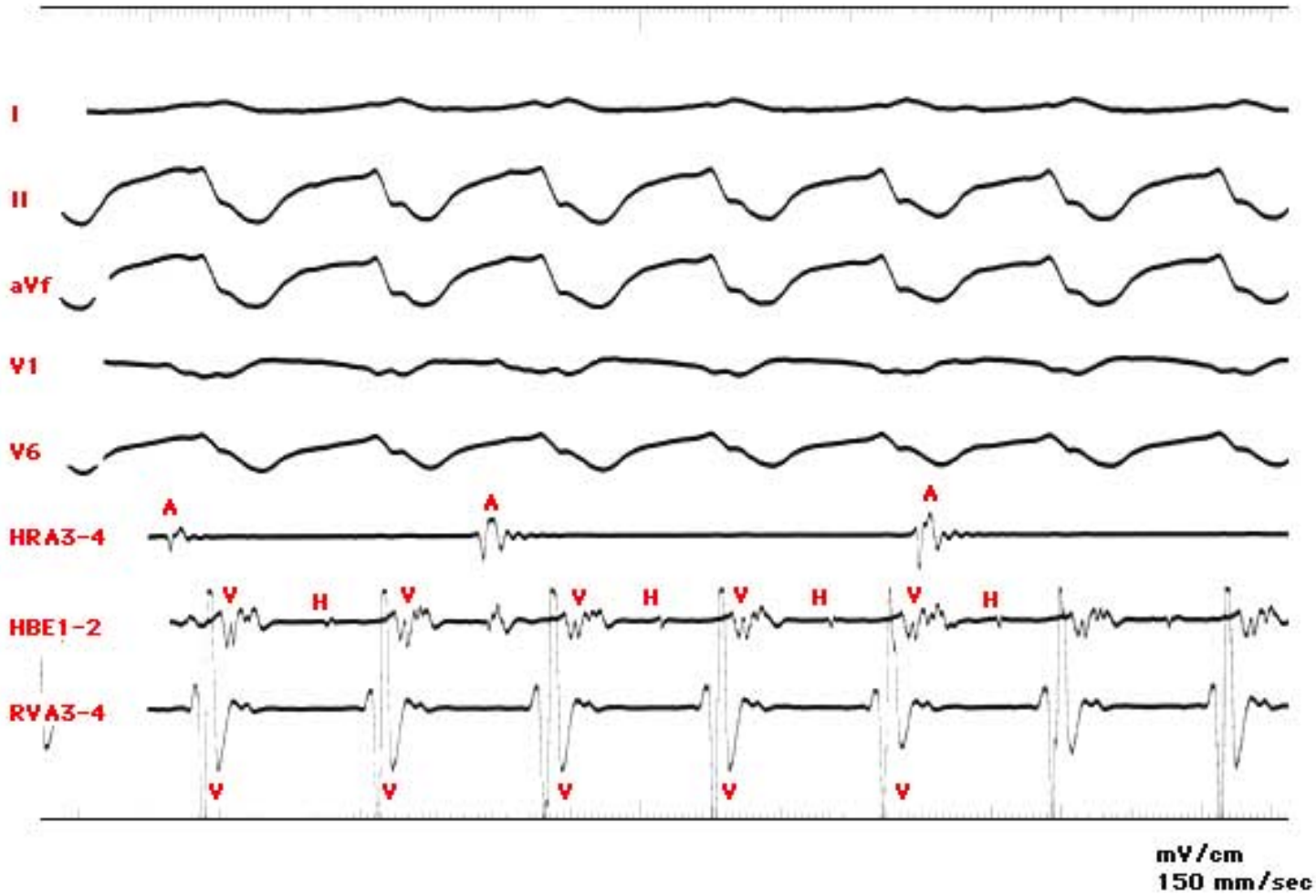
B. A undersensing

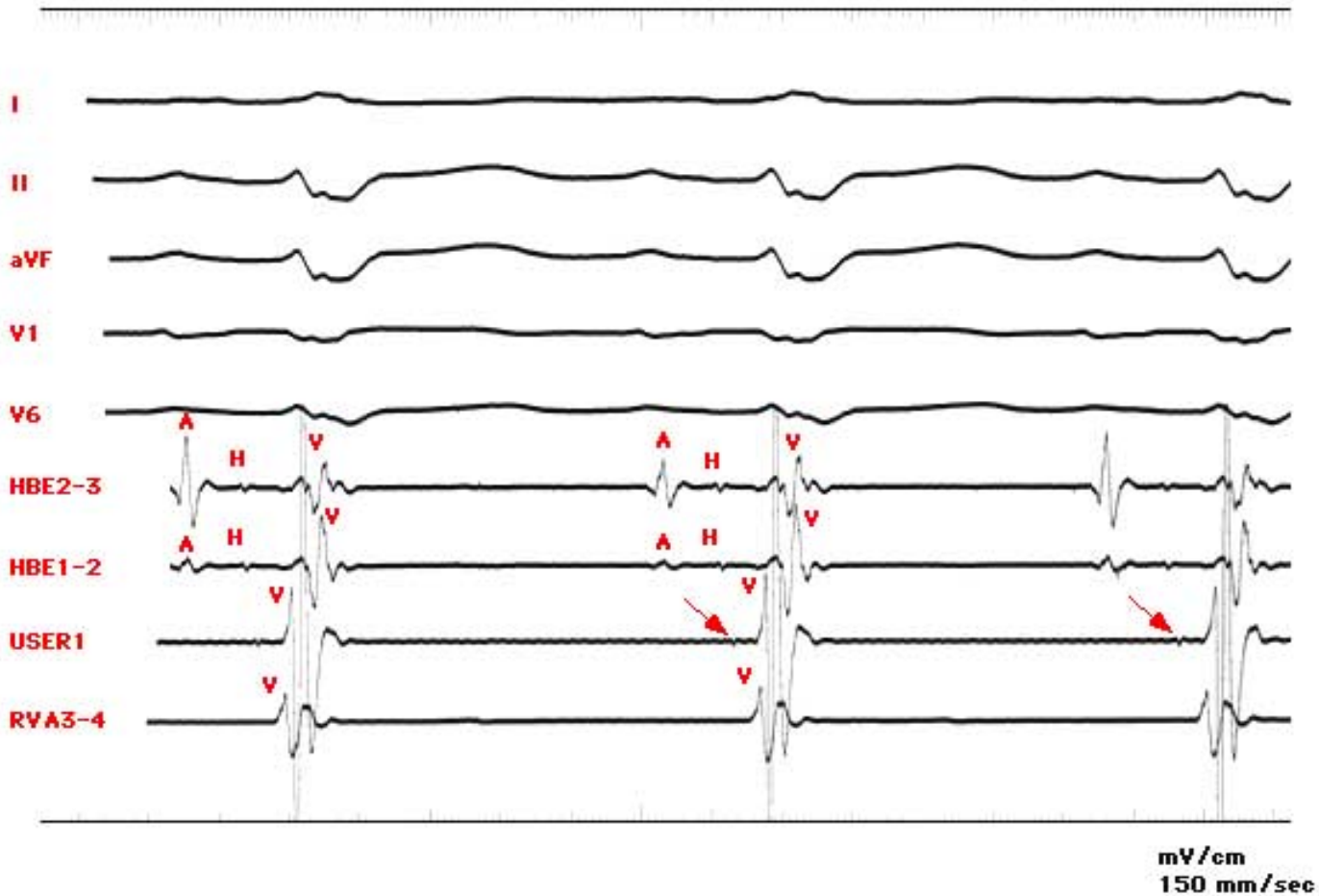
C. V oersensing (in AV-Intervall)

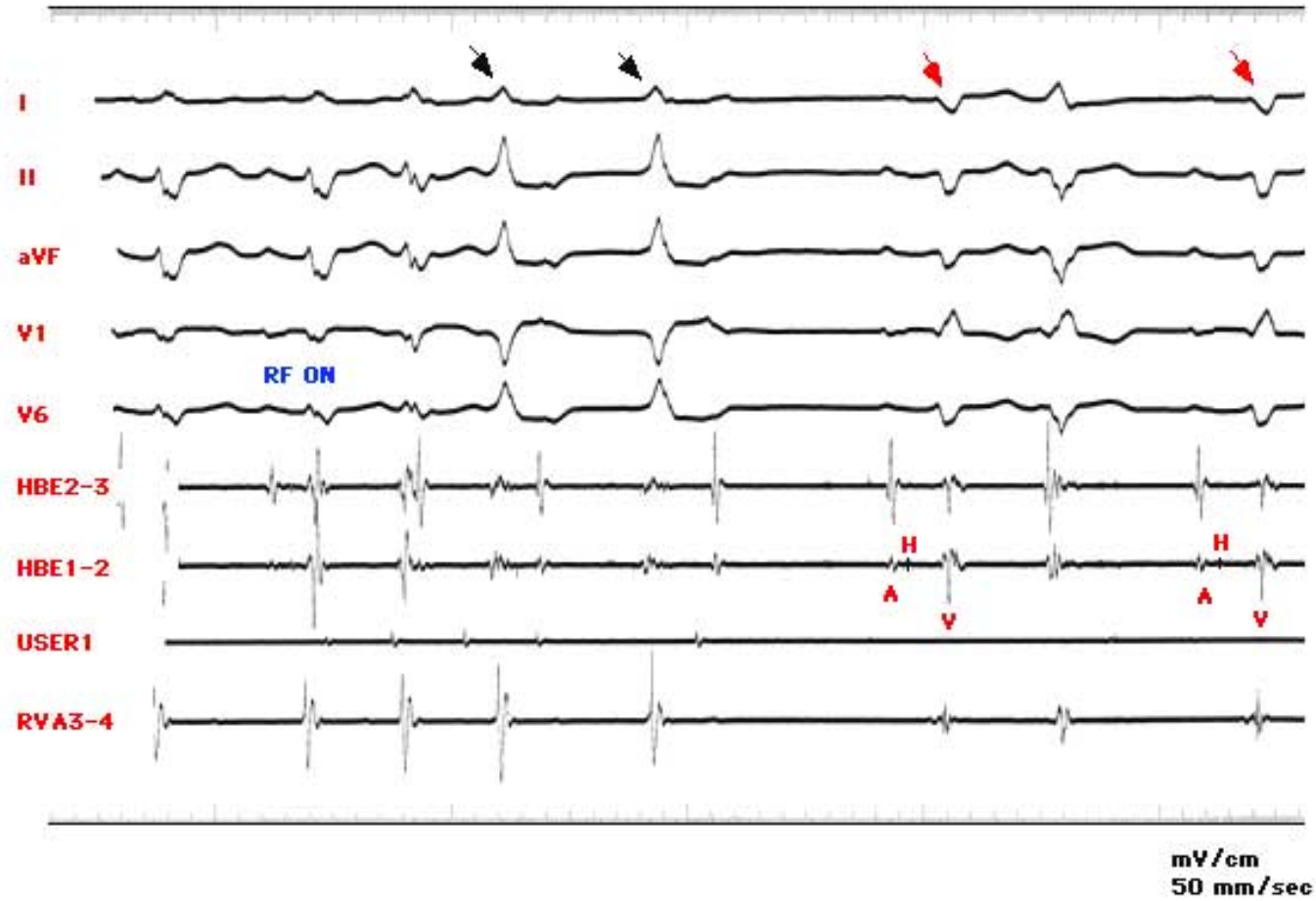
D. V oversensing (vor P-Welle)

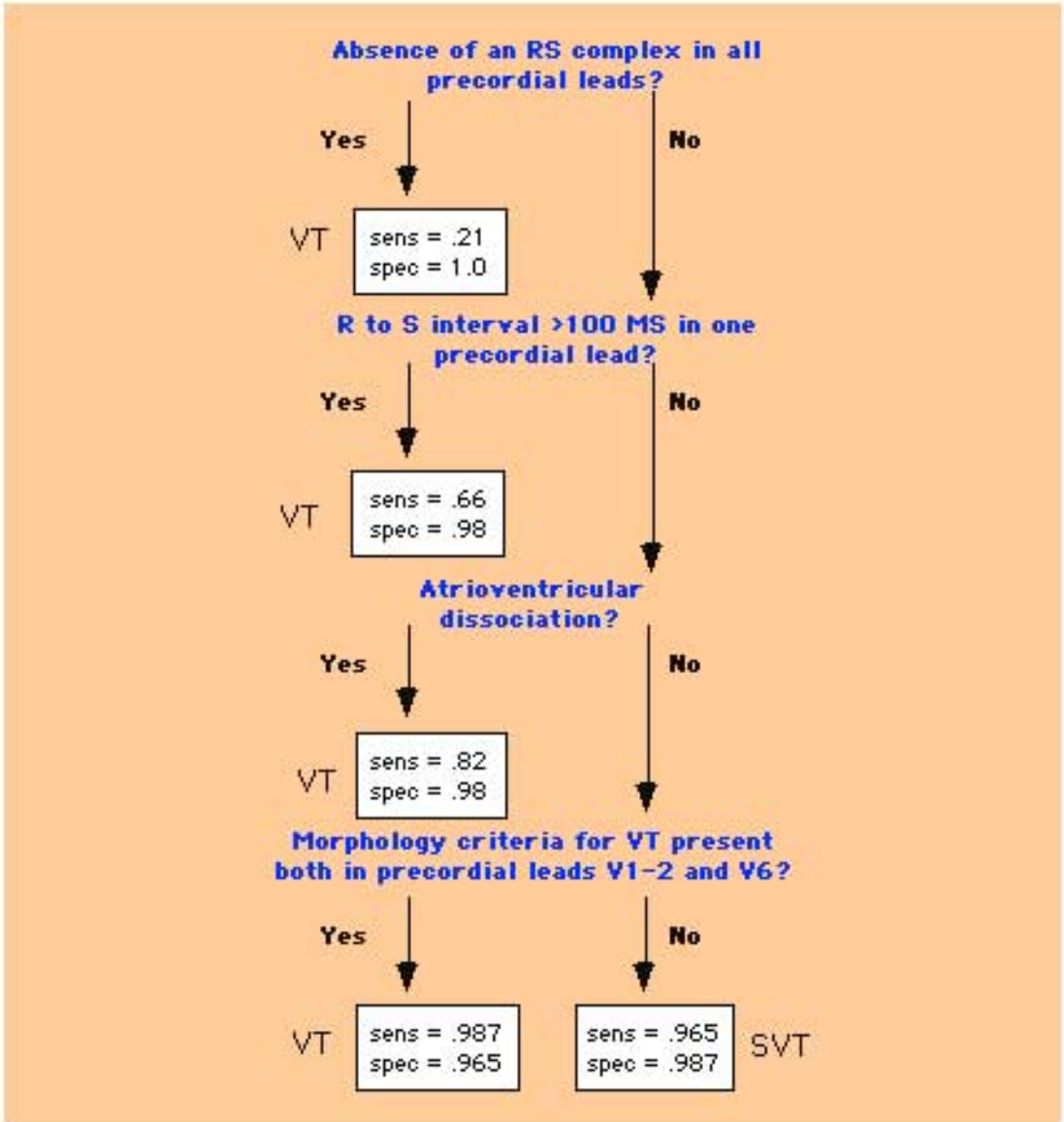
E. T-wave oversensing

F. All of the above


I
II
aVf
V1
V6
HRA3-4
A
A
A
HBE1-2
V
H
V
V
H
V
H
V
H
RVA3-4
V
V
V
V
V
mV/cm
150 mm/sec


I
II
aVF
V1
V6
HBE2-3
HBE1-2
USER1
RVA3-4
A
H
V
mV/cm
150 mm/sec

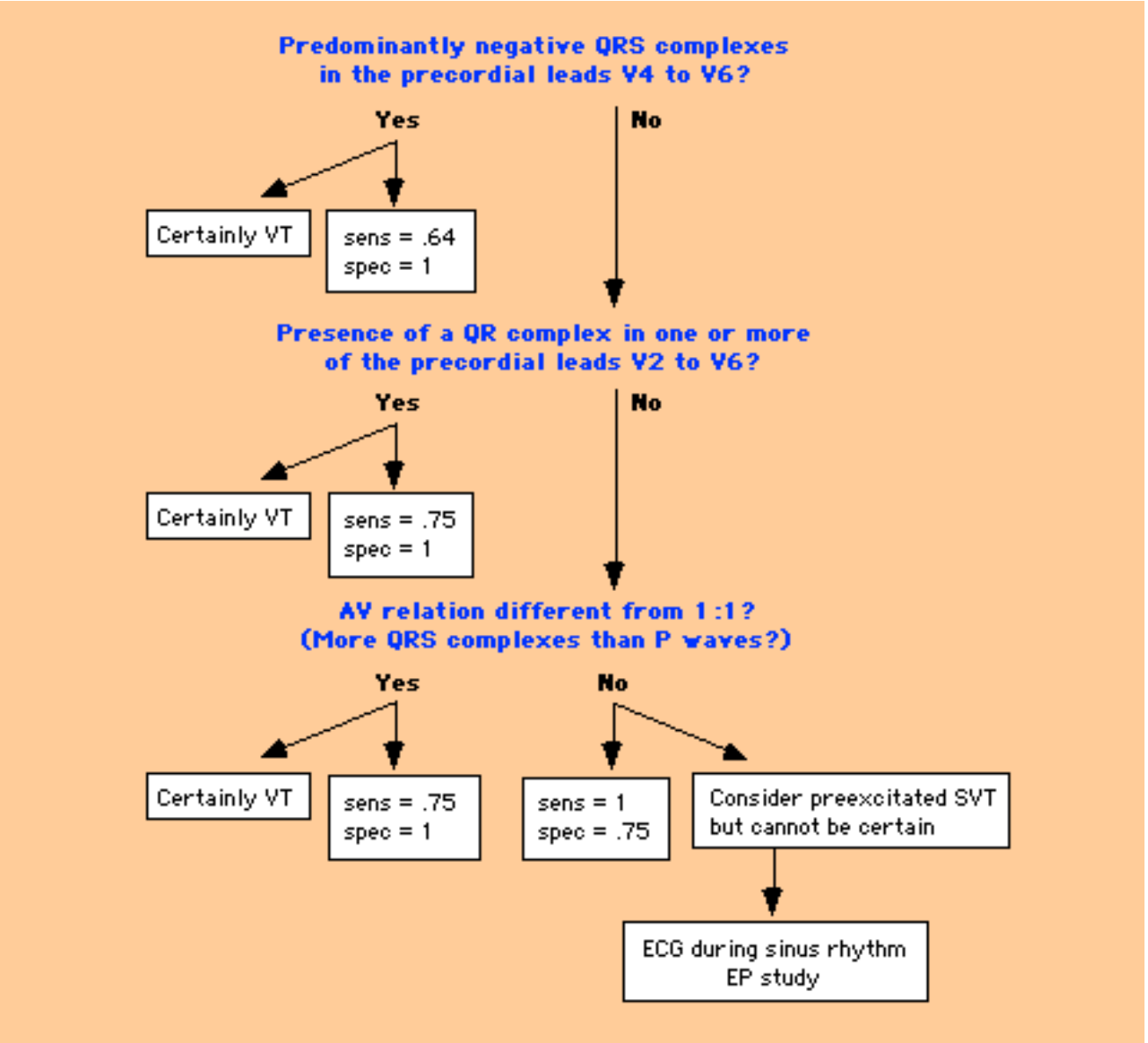

I
II
aVF
V1
V6
RF ON
HBE2-3
HBE1-2
USER1
RVA3-4
H
A
V
H
A
V
mV/cm
50 mm/sec


Absence of an RS complex in all precordial leads?
Yes
No
VT
sens = .21
spec = 1.0
R to S interval >100 MS in one precordial lead?
Yes
No
VT
sens = .66
spec = .98
Atrioventricular dissociation?
Yes
No
VT
sens = .82
spec = .98
Morphology criteria for VT present both in precordial leads V1-2 and V6?
Yes
No
VT
sens = .987
spec = .965
sens = .965
spec = .987
SVT

Bayesian Diagnostic Algorithm for Wide QRS Complex Tachycardia*†

ECG features	Likelihood ratios
QRS width	
≤0.14 second	0.31
>0.14 and ≤0.16 second	0.46
>0.16 second	22.86
QRS axis	
Right superior (-90 to +/- 180 degrees)	7.86
Left (-60 to -90 degrees) with RBBB pattern	8.21
Right (+120 to +/- 180 degrees) with LBBB pattern	3.93
None of the above	0.47
V1 morphology in RBBB pattern	
Taller left "rabbit ear" (double-peaked R wave)	50
Biphasic Rs or qR	4.03
Triphasic RSR'	0.21
None of the above	1..41
V1 or V2 morphology in LBBB pattern	
Any one of: (a) R ≥0.04 second (b) Notched downstroke of S wave (c) Delayed nadir of S wave >0.06 second	50
None of the above	0.13
Interval from QRS onset to peak in V6	
≥0.08 second	19.30
<0.08 second	0.46
V6 morphology	
Monophasic QS	50
Biphasic rS (R smaller than S) with RBBB pattern	50
Triphasic qRs (R larger than S) with RBBB pattern	0.13
None of the above	0.57

Differentiation of WCT in the presence of preexcitation



SVT-VT Differential Diagnosis

- AV-Dissociation?
  - yes → VT
  - ↓ no
- no “RS” in precordial leads?
  - yes → VT
  - ↓ no
- R-S >100 ms in one precordial lead?
  - yes → VT
  - ↓ no
- morphology criteria for V1 and V6 are met?
  - yes → VT
  - ↓ no

SVT with Aberration

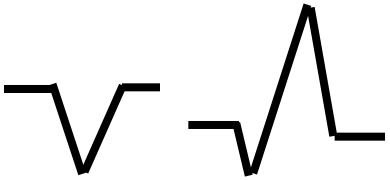
RSB

V1

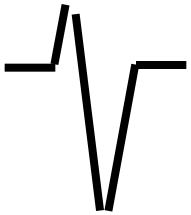
monophasic

L > R

V6



Q



R/S < 1

LSB

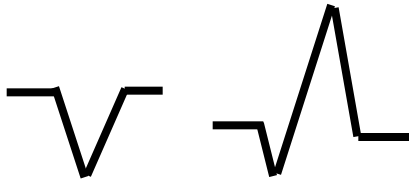
V1

R >30 ms

R-S >60 ms

“notched” S

V6

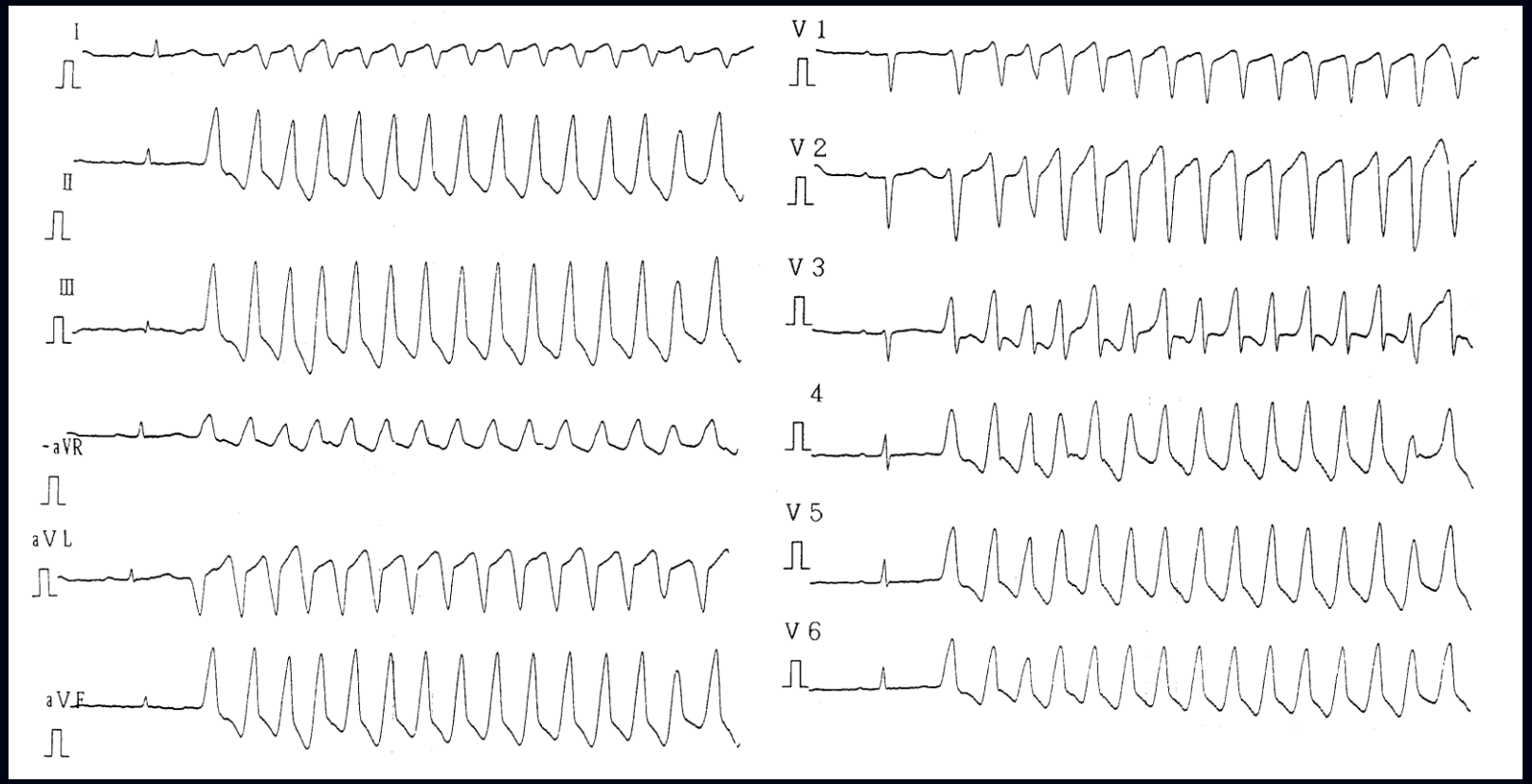


Q

SVT-VT Differential Diagnosis

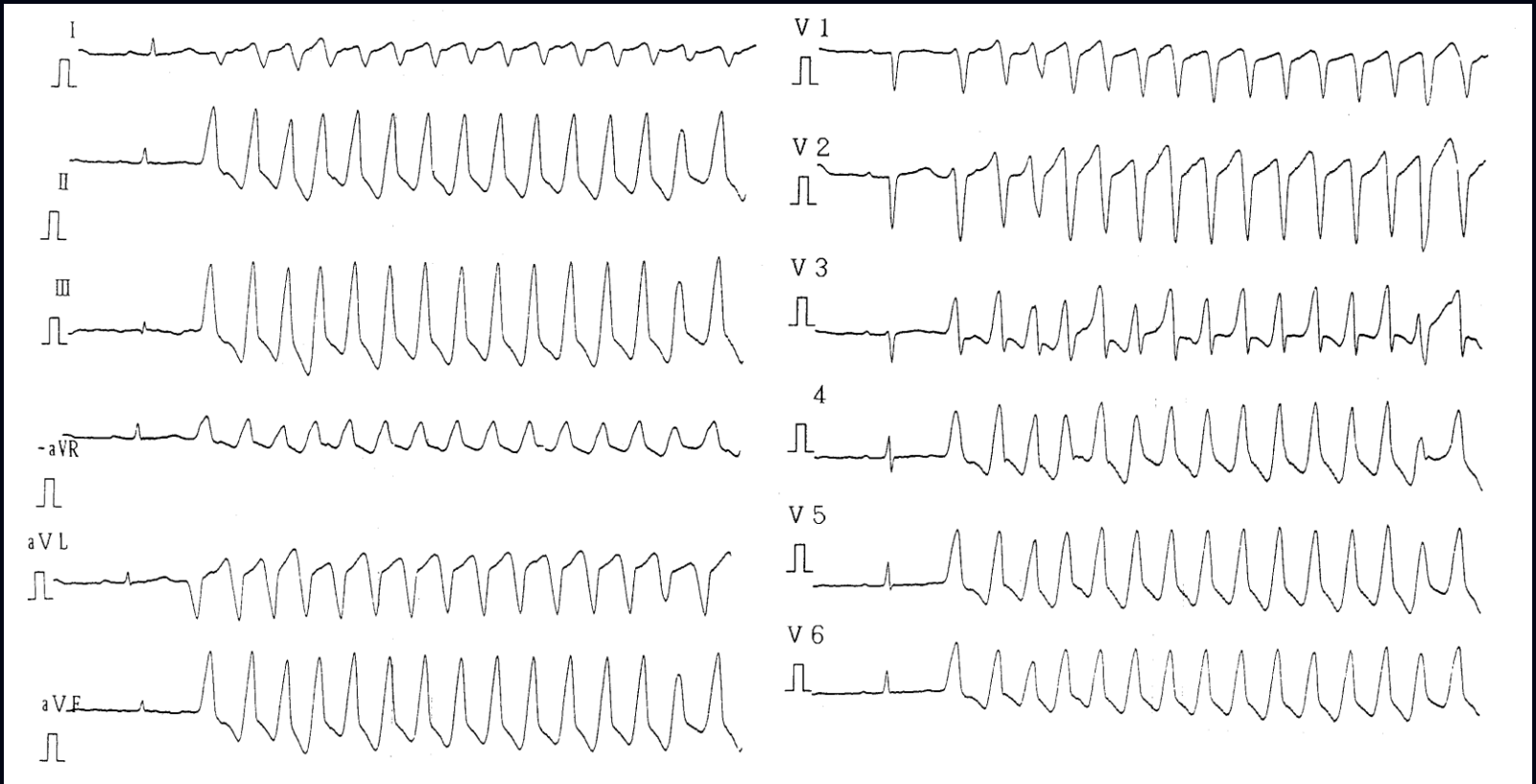
VT:

- Capture beats, Fusion beats
- VT with the same morphology as VES in SR
- QRS axis < - 30º
- LSB with right axis
- LSB with QRS > 160 ms
- RSB with QRS > 140 ms
- St. p. myocardial infarction



Ablation ? ICD ? Ablation and ICD ?

Right Ventricular Outflow Tract VT (RVOT VT)

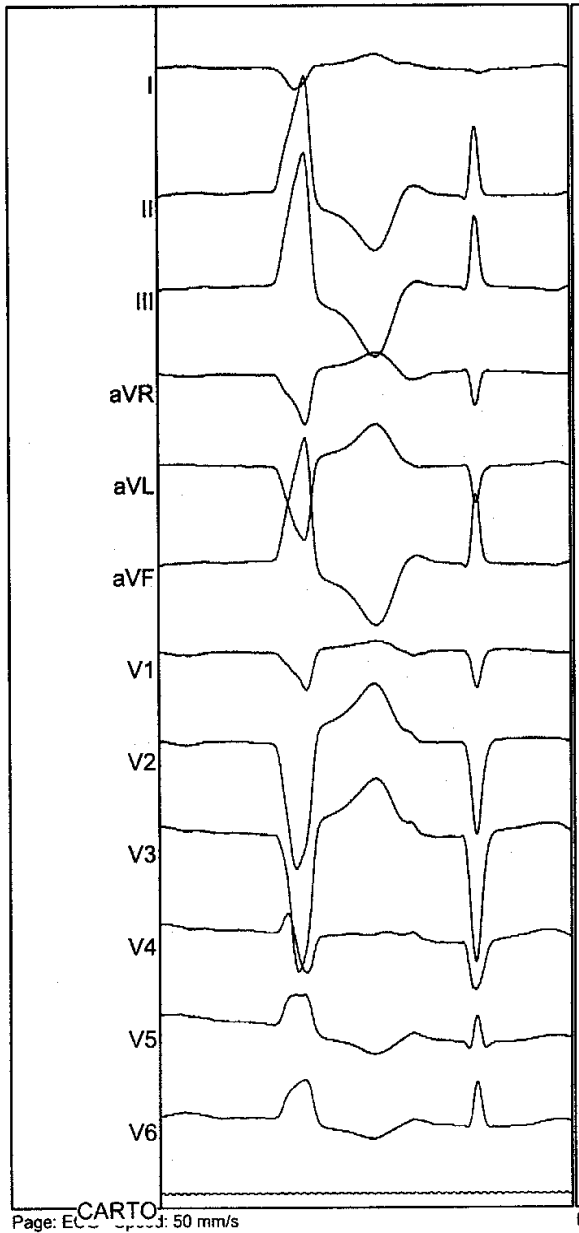


Right Ventricular Outflow Tract VT (RVOT VT)

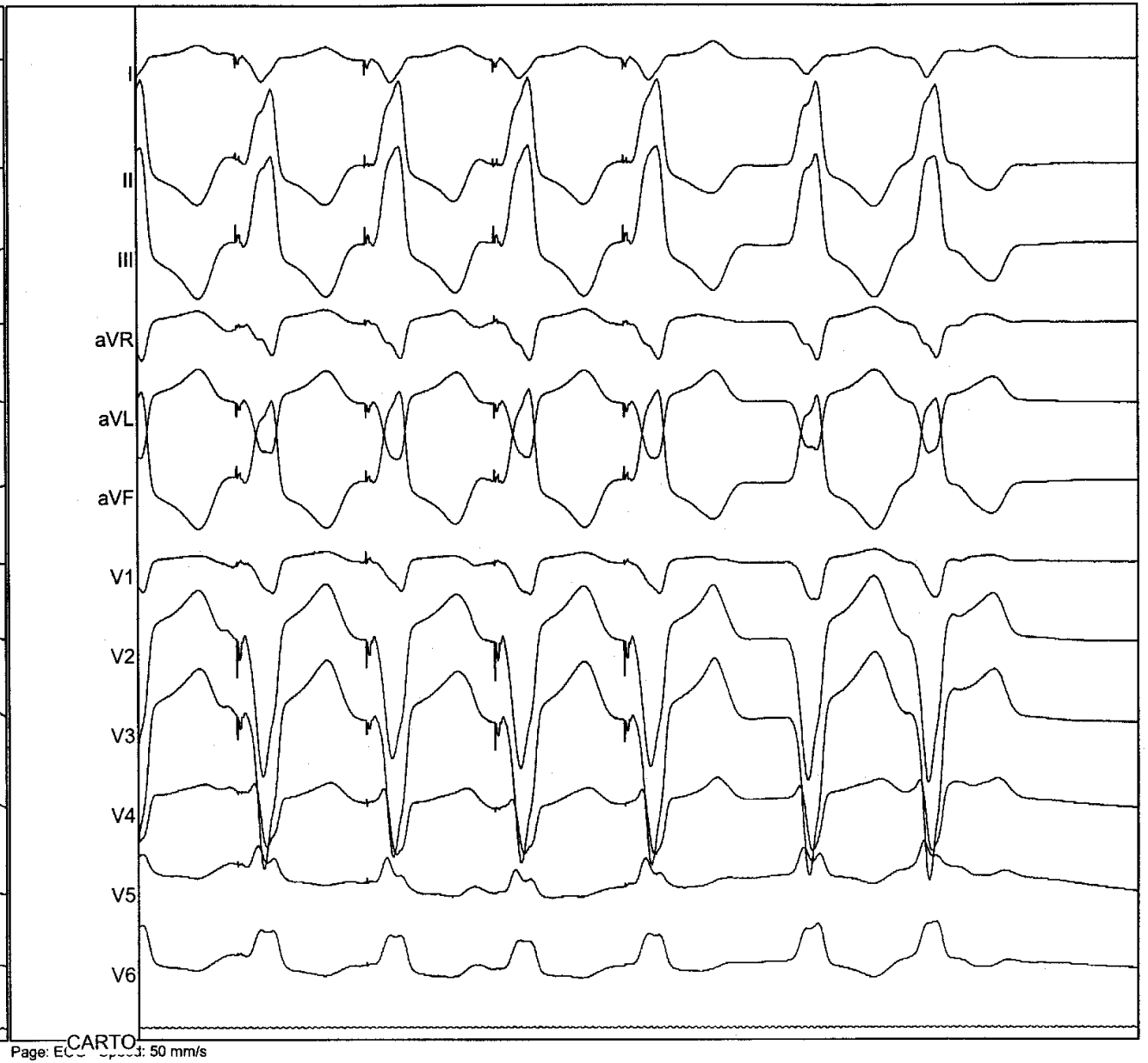
- benign!
- young adults
- structurally normal heart
- LBBB, inferior axis
- often induced with exercise
- mechanism: triggered or automaticity
- therapy: acute: adenosine, vagal manoeuvers
  chronic: beta-Blockers, Ca-antagonists
- success of ablation > 90%

RVOT VT

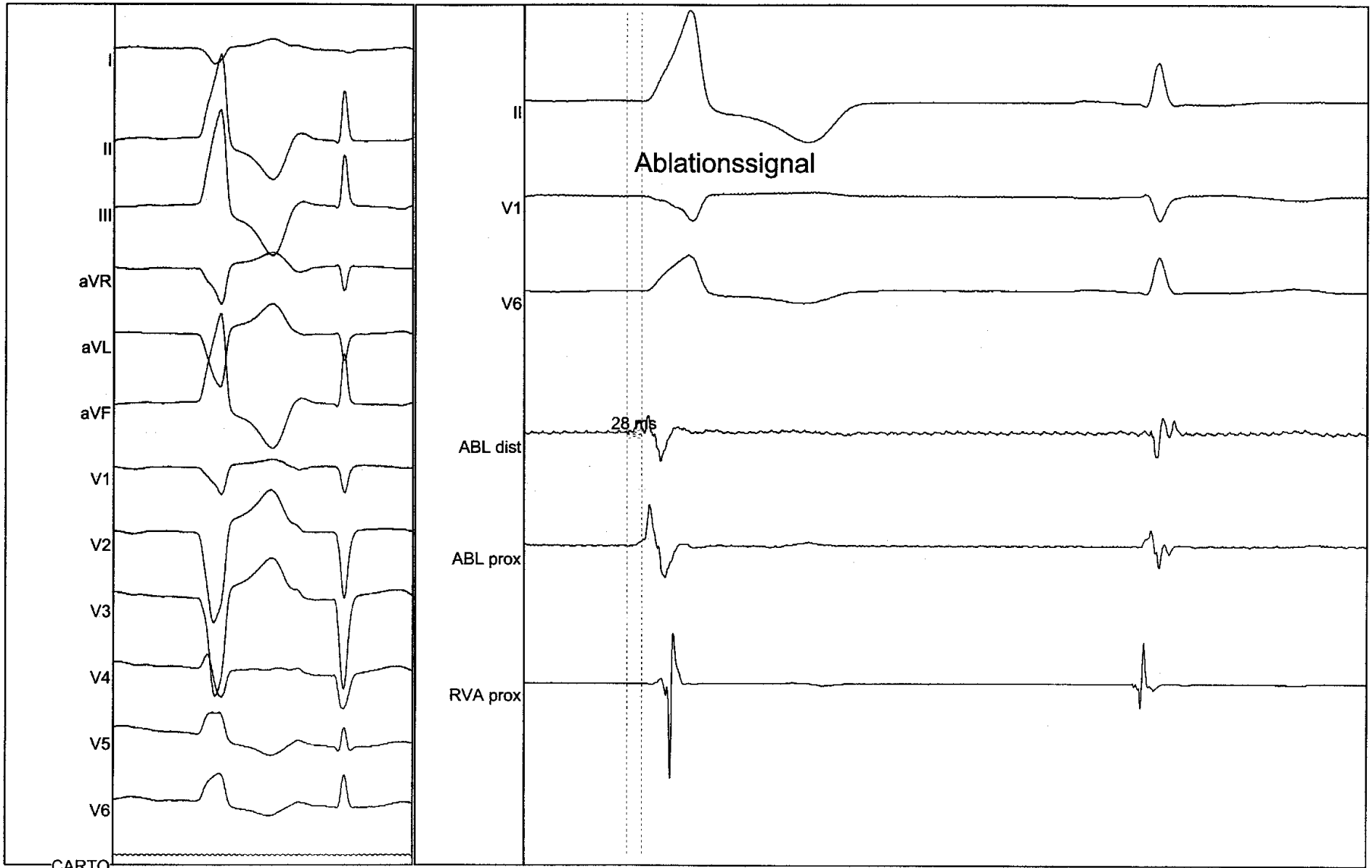
VT EKG

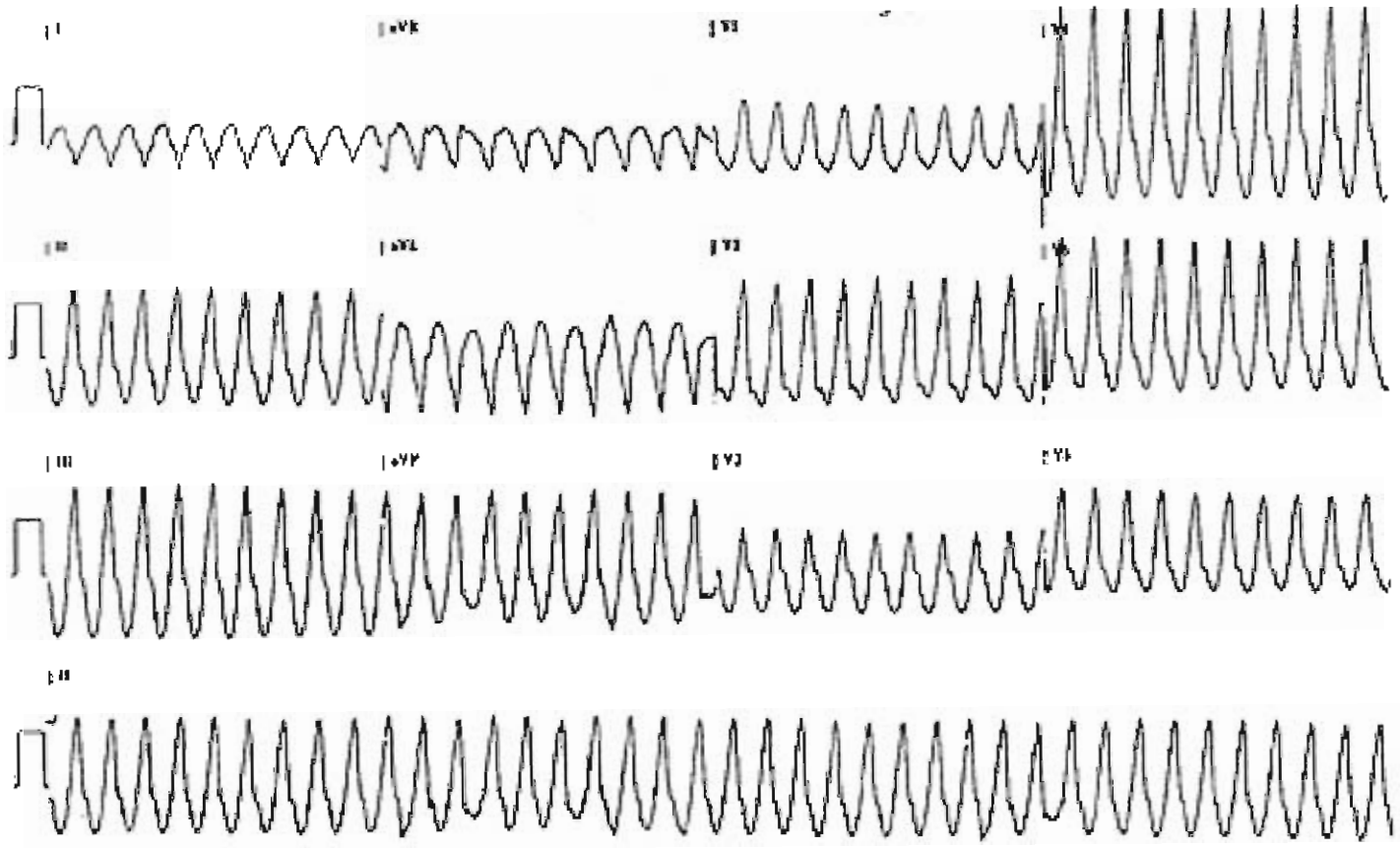


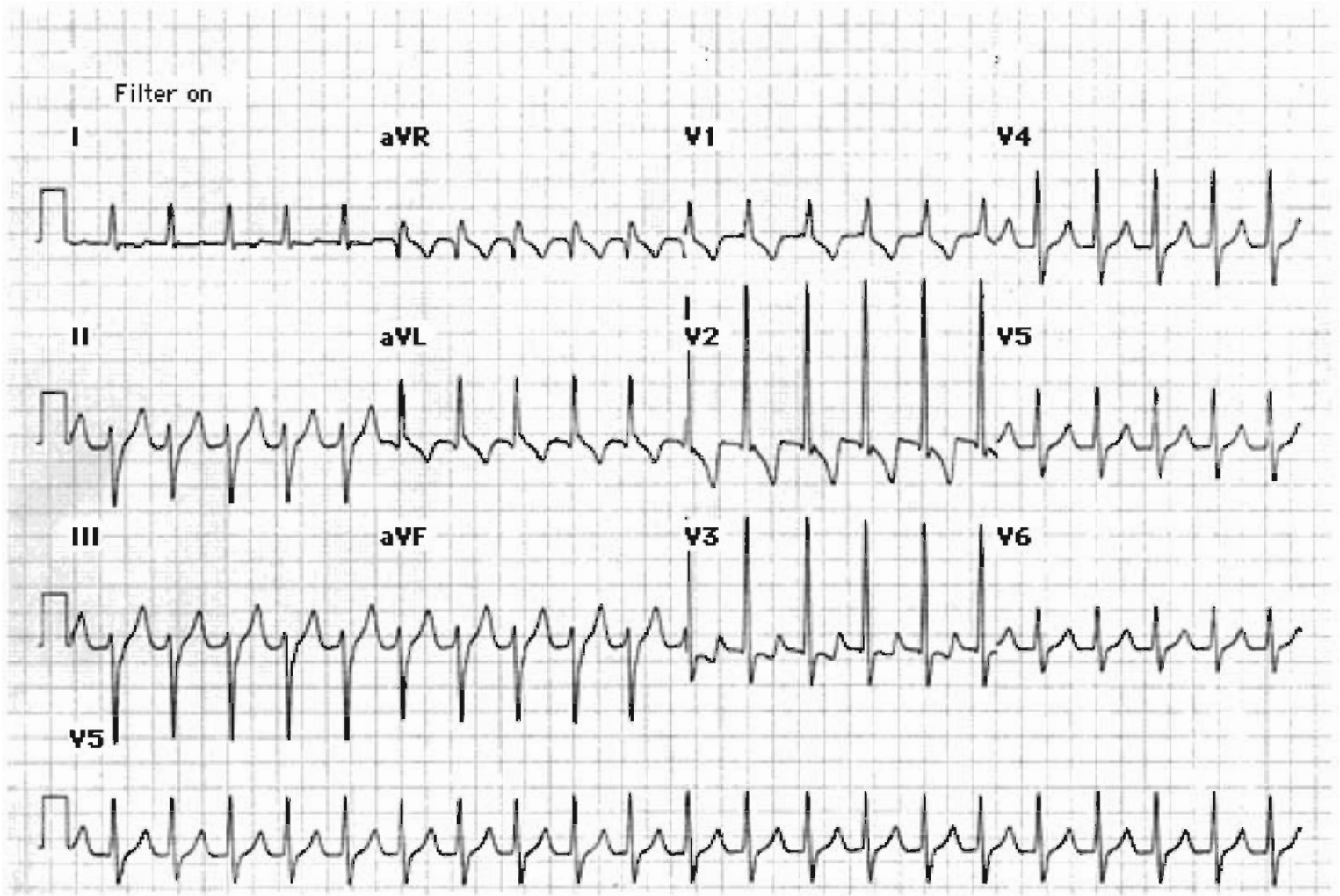
Pace Map



RVOT VT:
Activation Mapping

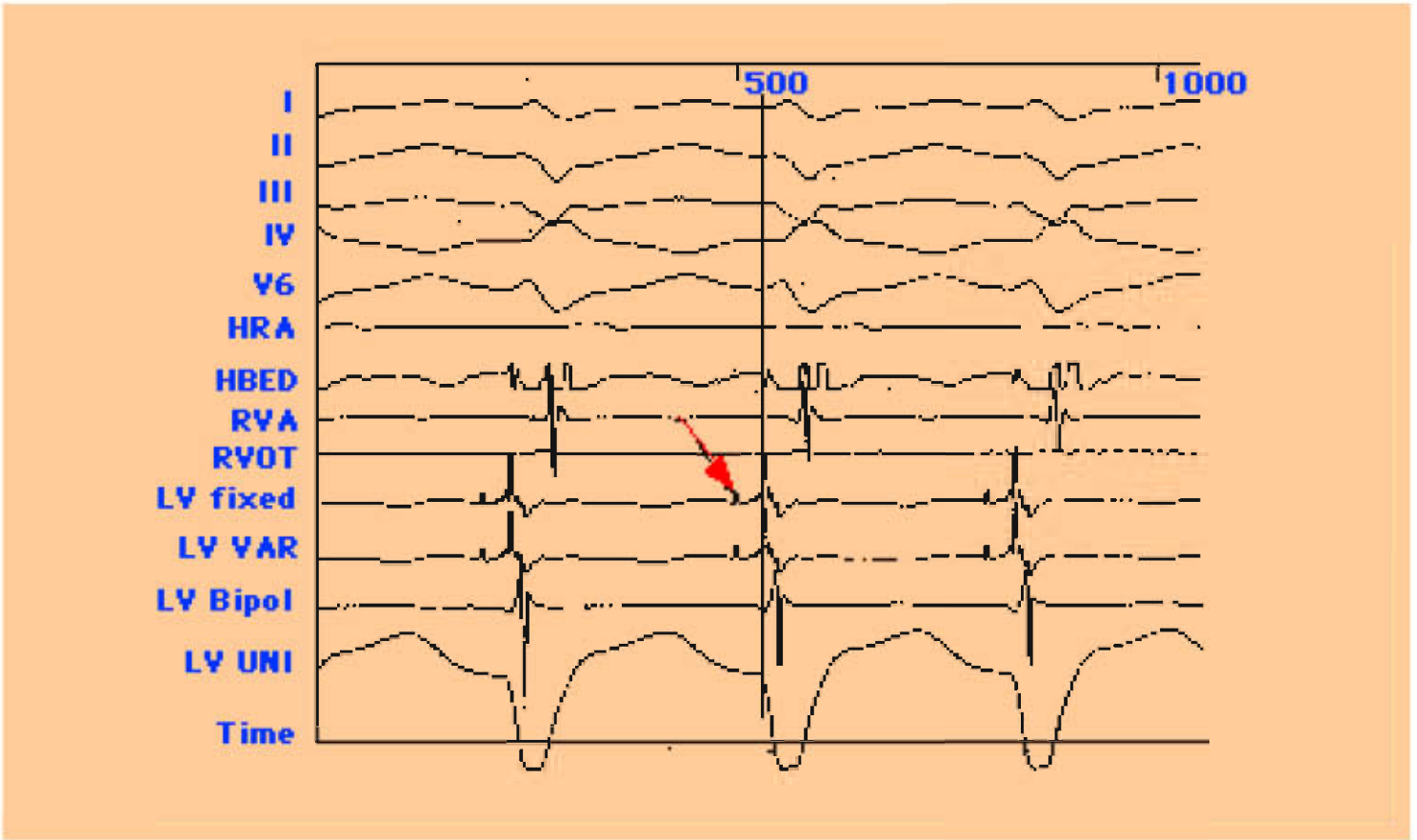


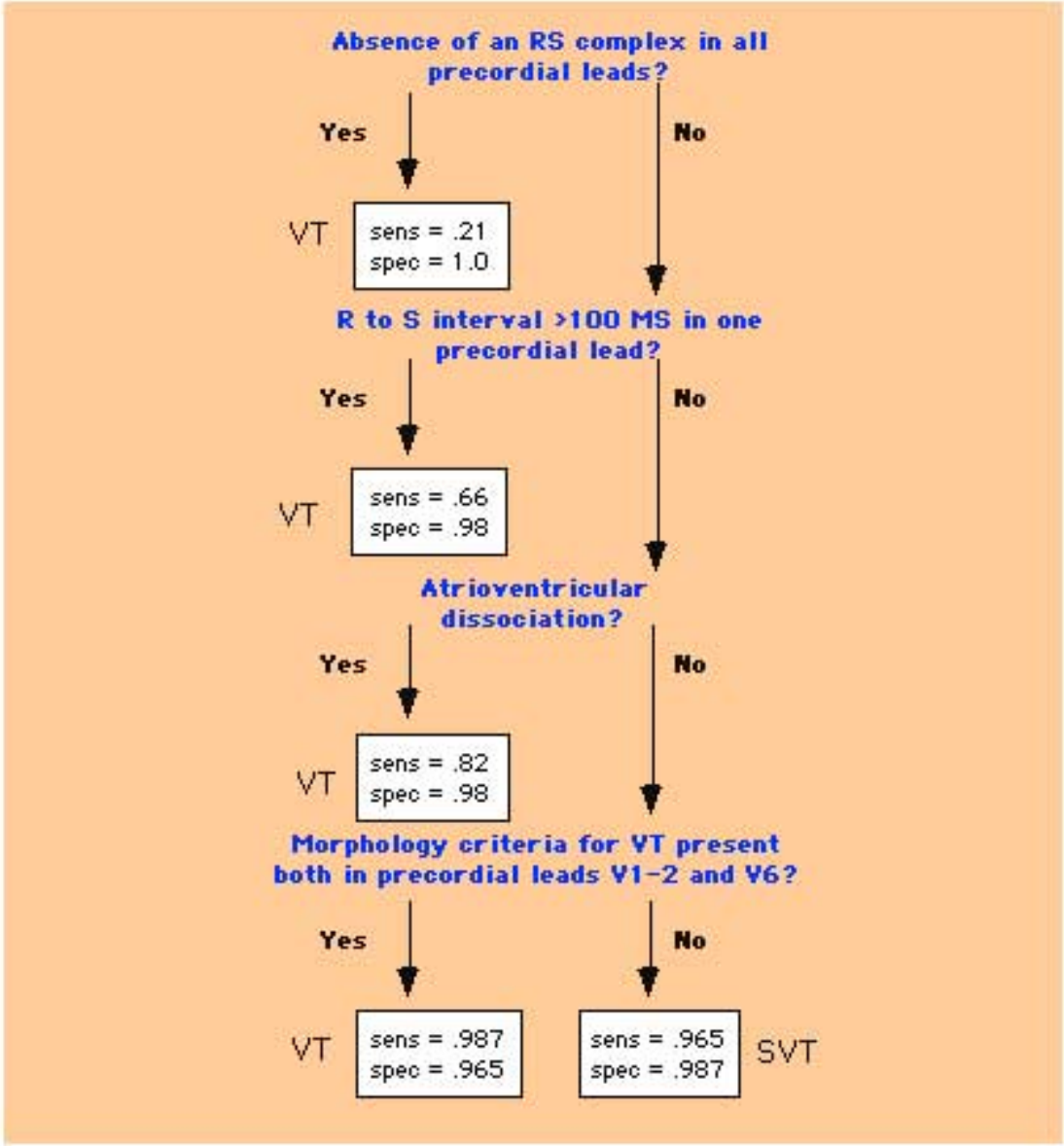


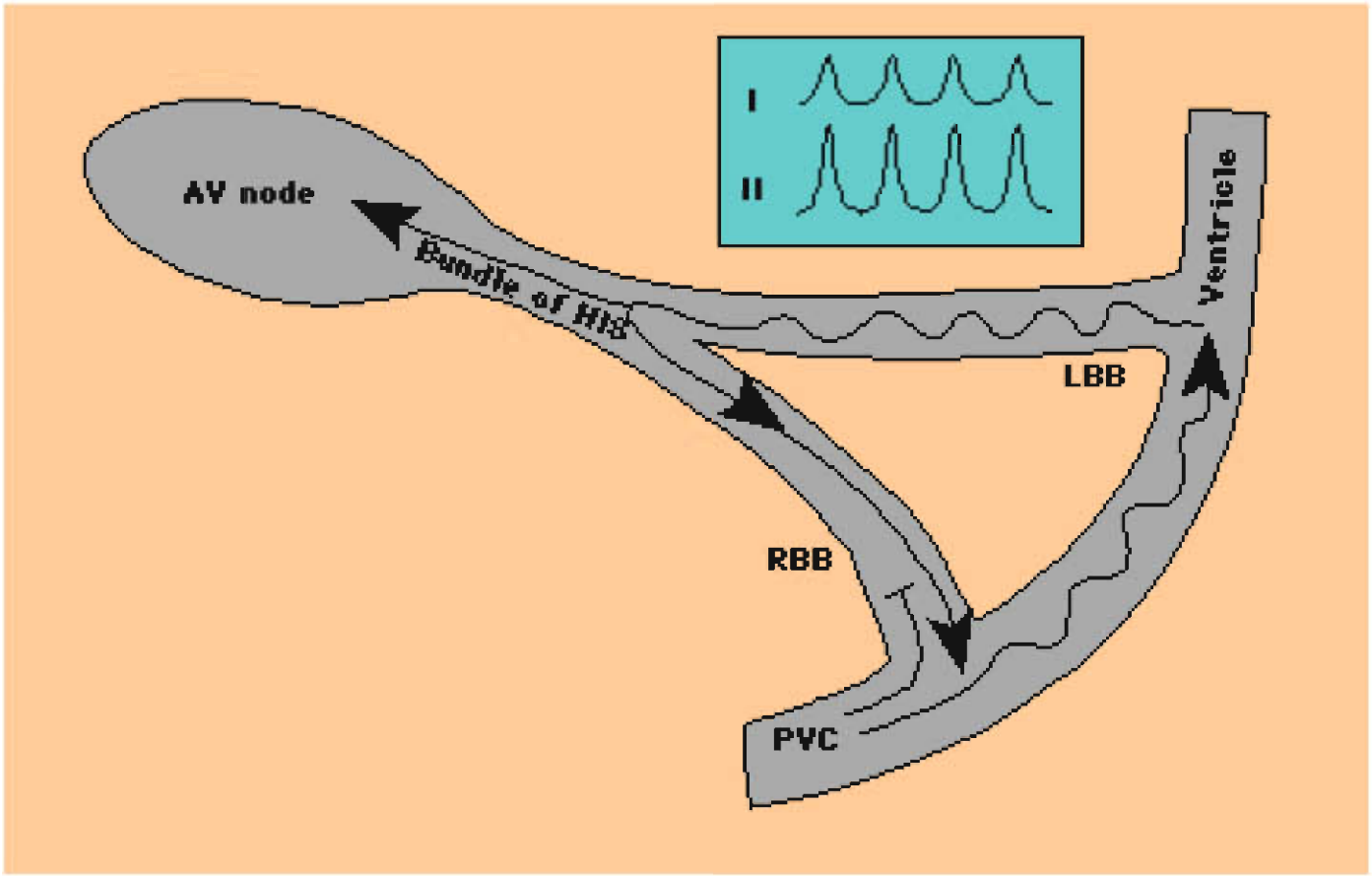

Filter on
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V5

Left Ventricular Fascicular VT

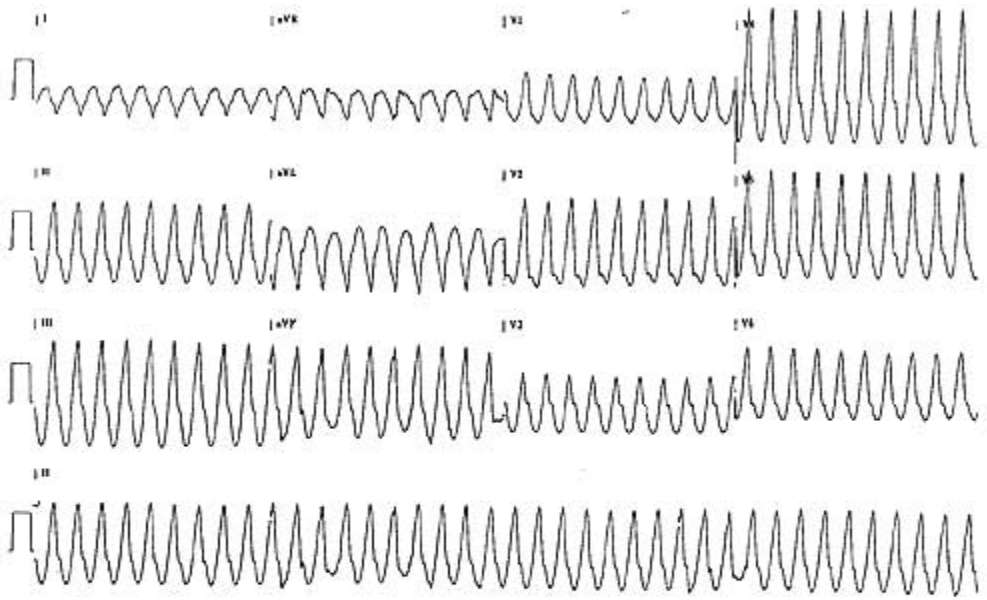
- **benign!**
- **young men (80%)**
- **structurally normal heart**
- **RBBB, left axis deviation**
- **At rest, sometimes induced with exercise**
- **Purkinje-reentry**
- **induction with atrial pacing**
- **verapamil sensitive**
- **success of ablation: 85-90%**


500
1000
I
II
III
IV
V6
HRA
HBED
RVA
RVOT
LV fixed
LV VAR
LV Bipol
LV UNI
Time

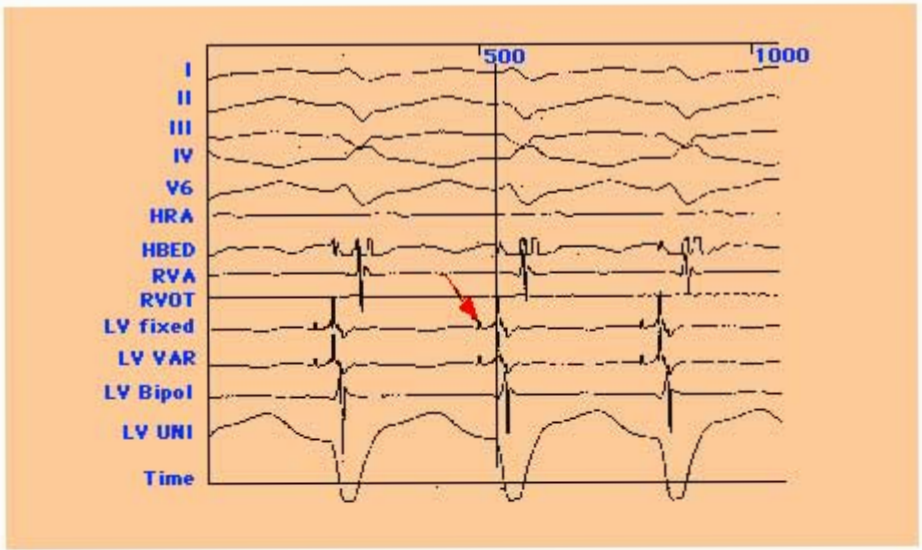

Absence of an RS complex in all precordial leads?
Yes
No
VT
sens = .21
spec = 1.0
R to S interval >100 MS in one precordial lead?
Yes
No
VT
sens = .66
spec = .98
Atrioventricular dissociation?
Yes
No
VT
sens = .82
spec = .98
Morphology criteria for VT present both in precordial leads V1-2 and V6?
Yes
No
VT
sens = .987
spec = .965
sens = .965
spec = .987
SVT


I
II
AV node
Bundle of His
Ventricle
LBB
RBB
PVC

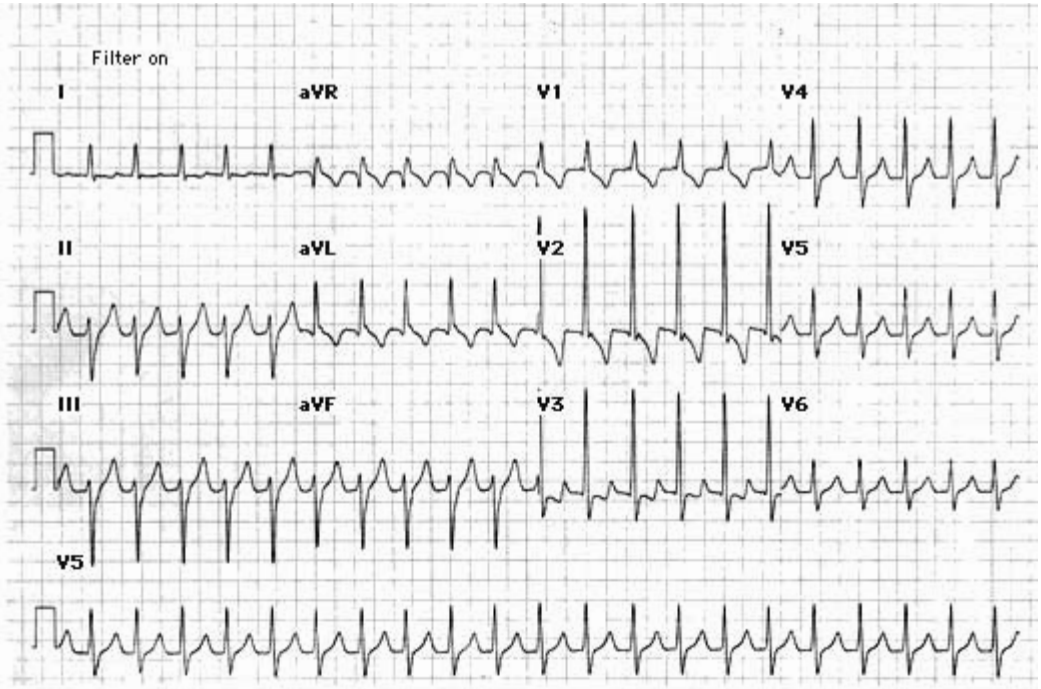
VT in the absence of structural heart disease



Twelve lead ECG recorded in a patient with RMVT from the LVOT This electrocardiogram (ECG) illustrates repetitive monomorphic ventricular tachycardia (RMVT) with a right bundle, inferior axis morphology signifying its left ventricular site of origin. This VT was localized to the area of the aorto-mitral continuity in the left ventricular outflow tract (LVOT).



Idiopathic left ventricular tachycardia ILVT originates from the inferior portion of the ventricular septum. Surface leads (I, II, III, V1, and V6), and intracardiac recordings from the high right atrium (HRA), His bundle region (HBE), right ventricular apex (RVA), right ventricular outflow tract (RVOT), and several recordings from the left ventricle at the site of successful ablation (LV fixed, LV var, LV bipol, LV uni) are shown. The presence of a sharp potential in the LV recordings (arrow) is consistent with local activation of the Purkinje system. This potential precedes the onset of the QRS during VT by 40 msec. (Reprinted with permission of Futura Publishing Company.)

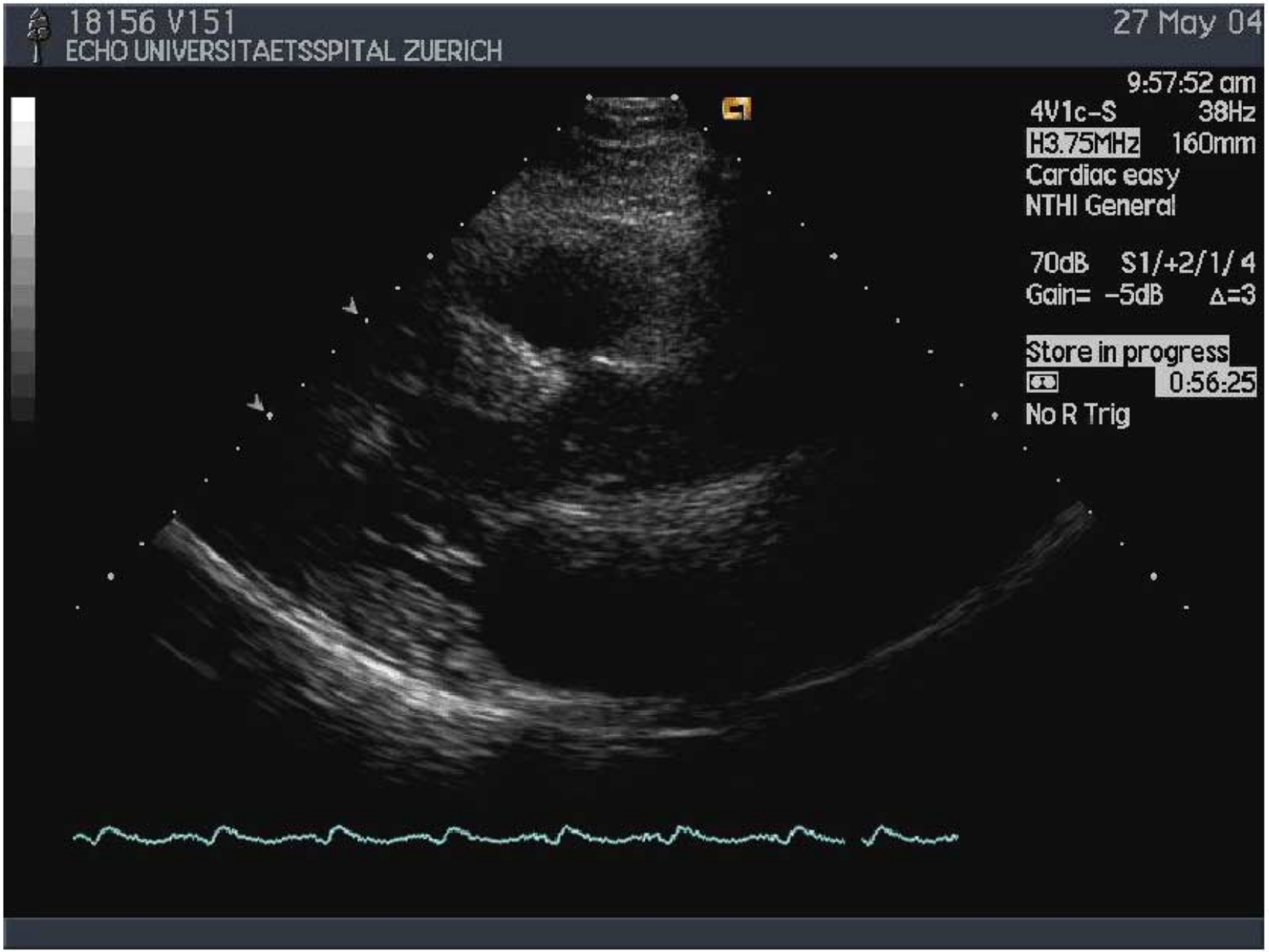


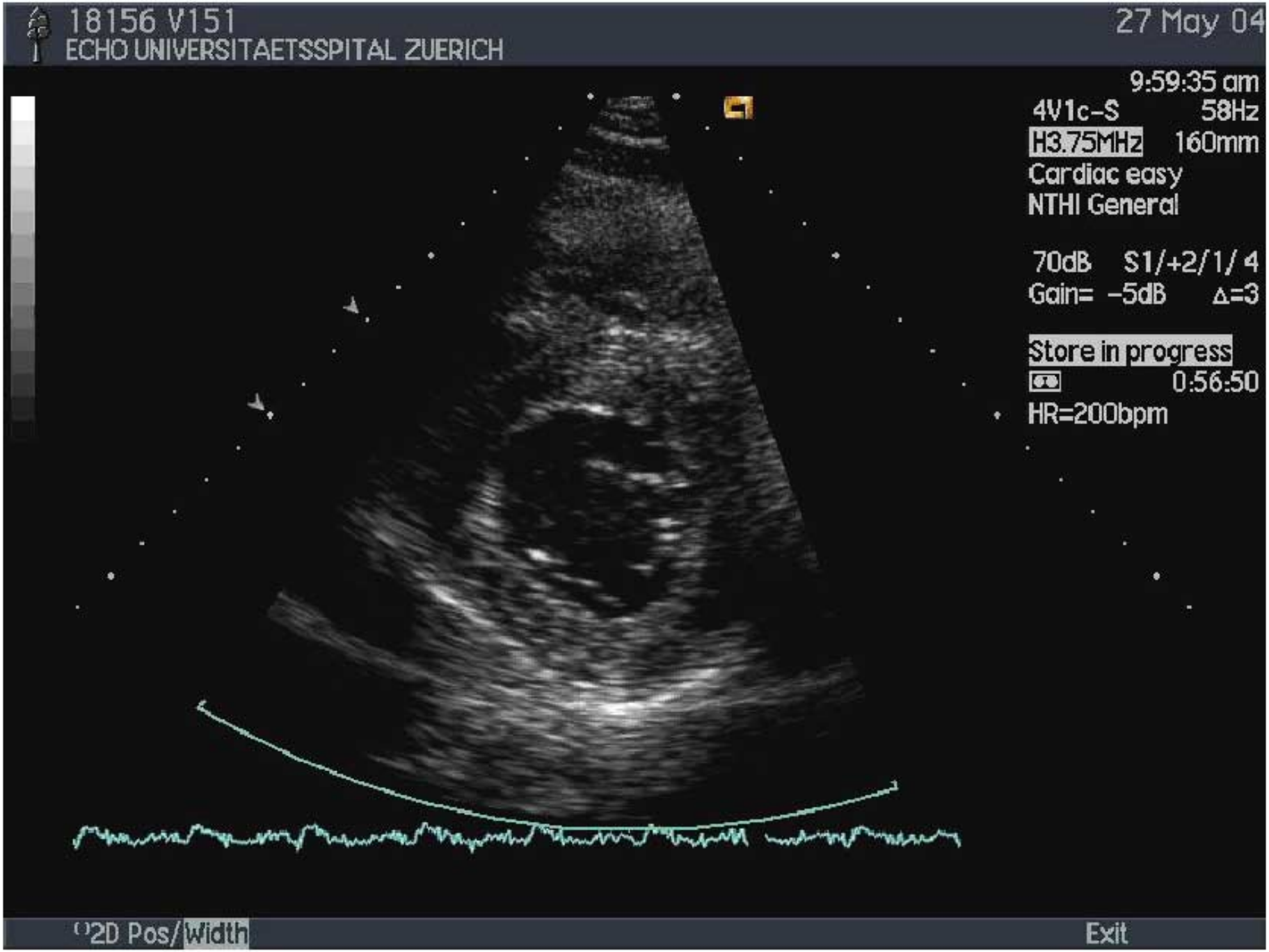
Electrocardiogram of an idiopathic left ventricular tachycardia The typical ECG features of an idiopathic left ventricular tachycardia are QRS complexes that are relatively narrow (0.12 sec) and have a right bundle branch morphology (tall R waves in V1 and V2 and a terminal S wave in V5 and V6); the frontal plane axis is extremely leftward (negative QRS complexes in leads II, III and aVF), suggesting a left anterior fascicular block. The tachycardia was localized to the inferior apical left ventricular septum, accounting for the extreme leftward axis.

Criteria for diagnosing LBBB

- **Patients with a QRS duration ≥ 0.10 second without criteria for either LBBB or RBBB are classified as having intraventricular conduction disease (IVCD)**

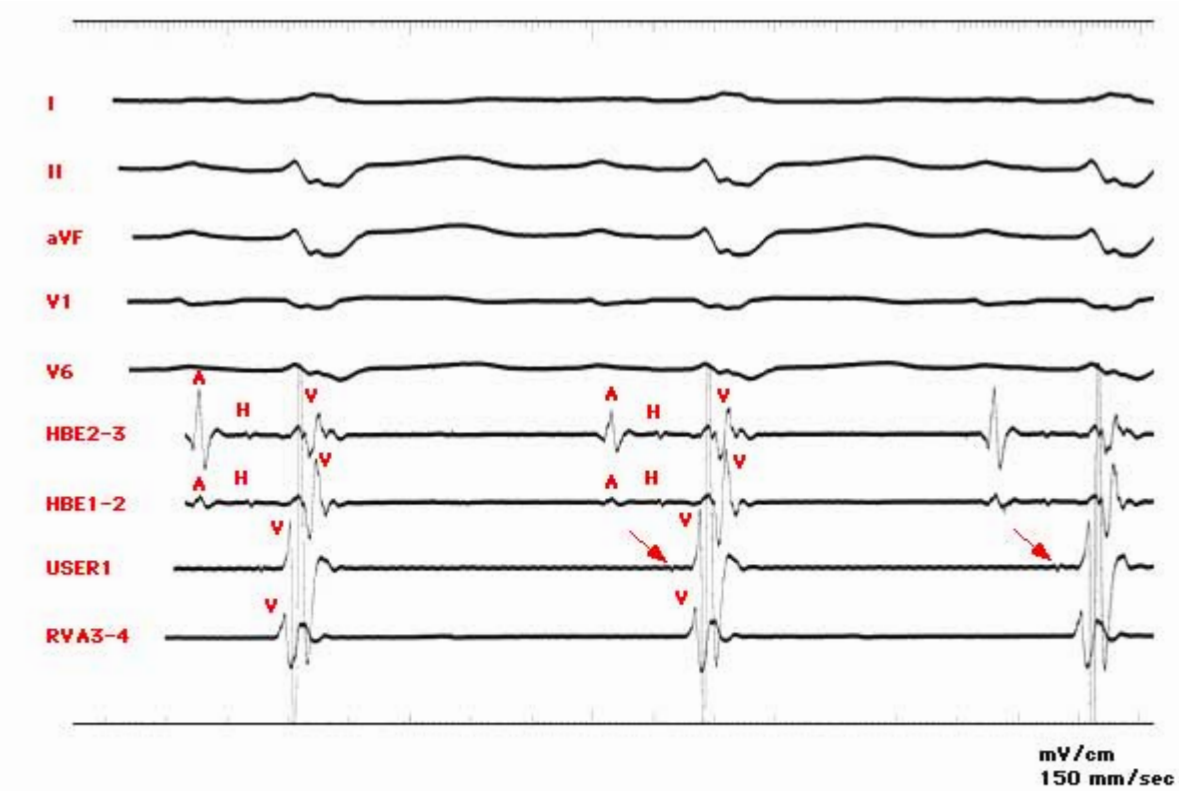
Freedman HH. Ventricular conduction defects. In: Freedman HH, ed. Diagnostic Electrocardiography and Vectorcardiography. New York: McGraw Hill, 1971:163–92
Willems JL, et al. Criteria for intraventricular conduction disturbances and pre-excitation. *JACC* 1985;5:1261–2


18156 V151
ECHO UNIVERSITAETSSPITAL ZUERICH
27 May 04
9:57:52 am
4V1c-S
38Hz
H3.75MHz
160mm
Cardiac easy
NTHI General
70dB
S1/+2/1/4
Gain= -5dB
Δ=3
Store in progress
0:56:25
No R Trig

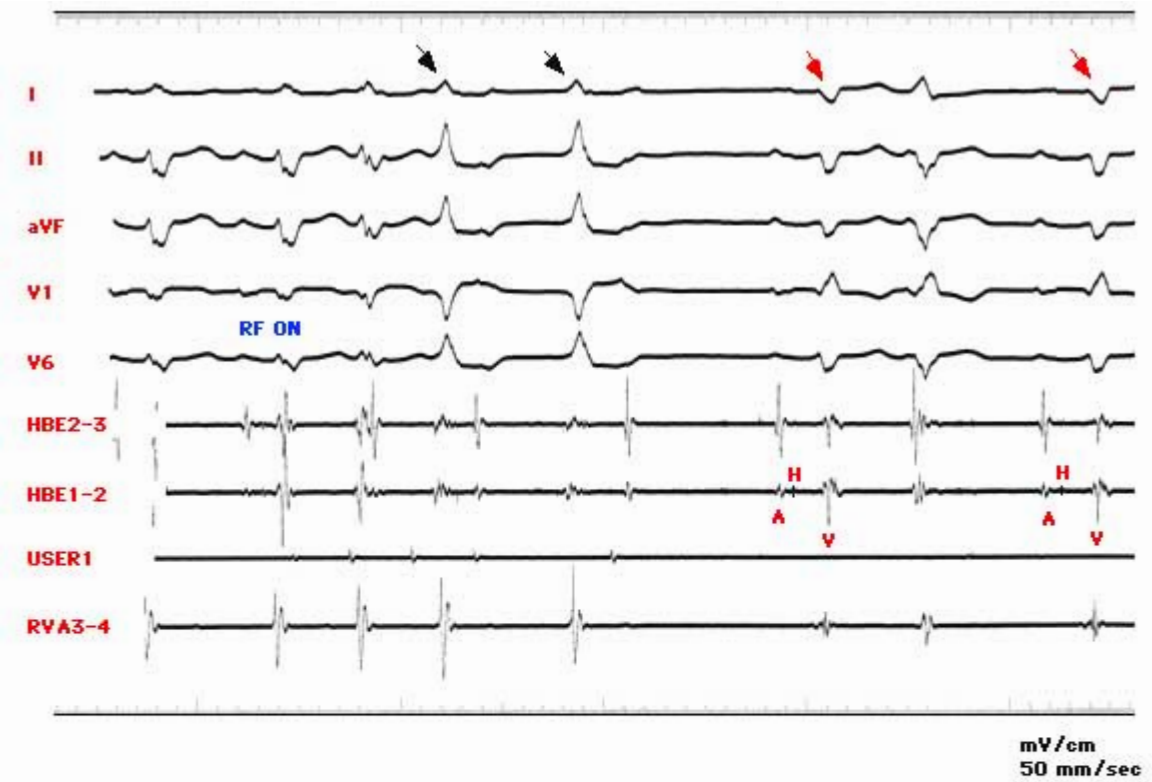

18156 V151
ECHO UNIVERSITAETSSPITAL ZUERICH
27 May 04
9:59:35 am
4V1c-S
58Hz
H3.75MHz
160mm
Cardiac easy
NTHI General
70dB
S1/+2/1/ 4
Gain= -5dB
Δ=3
Store in progress
0:56:50
HR=200bpm
2D Pos/Width
Exit

Medications

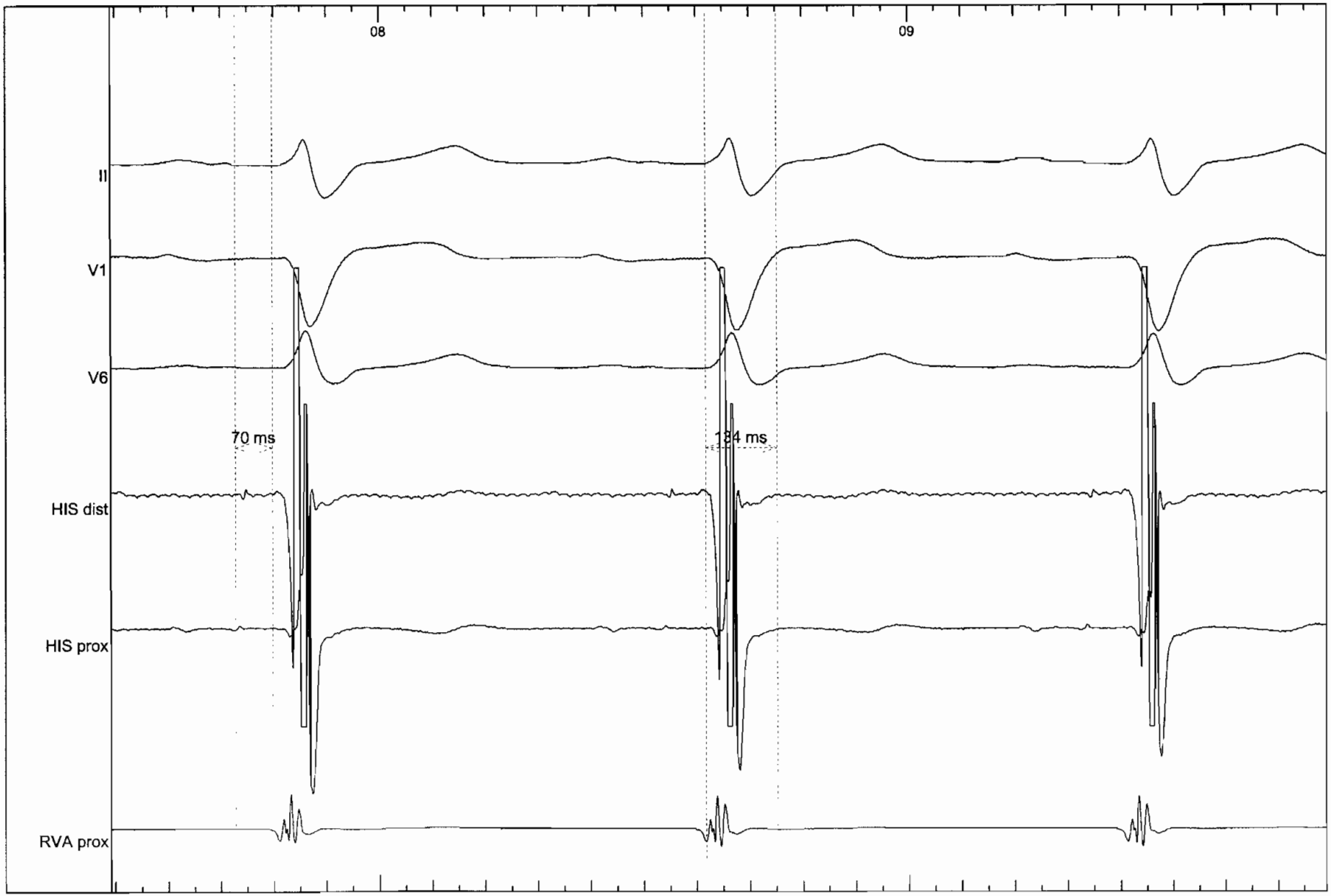
- Bisoprolol 5 mg
- Enalapril 5mg
- Hydrochlorothiazid 25 mg

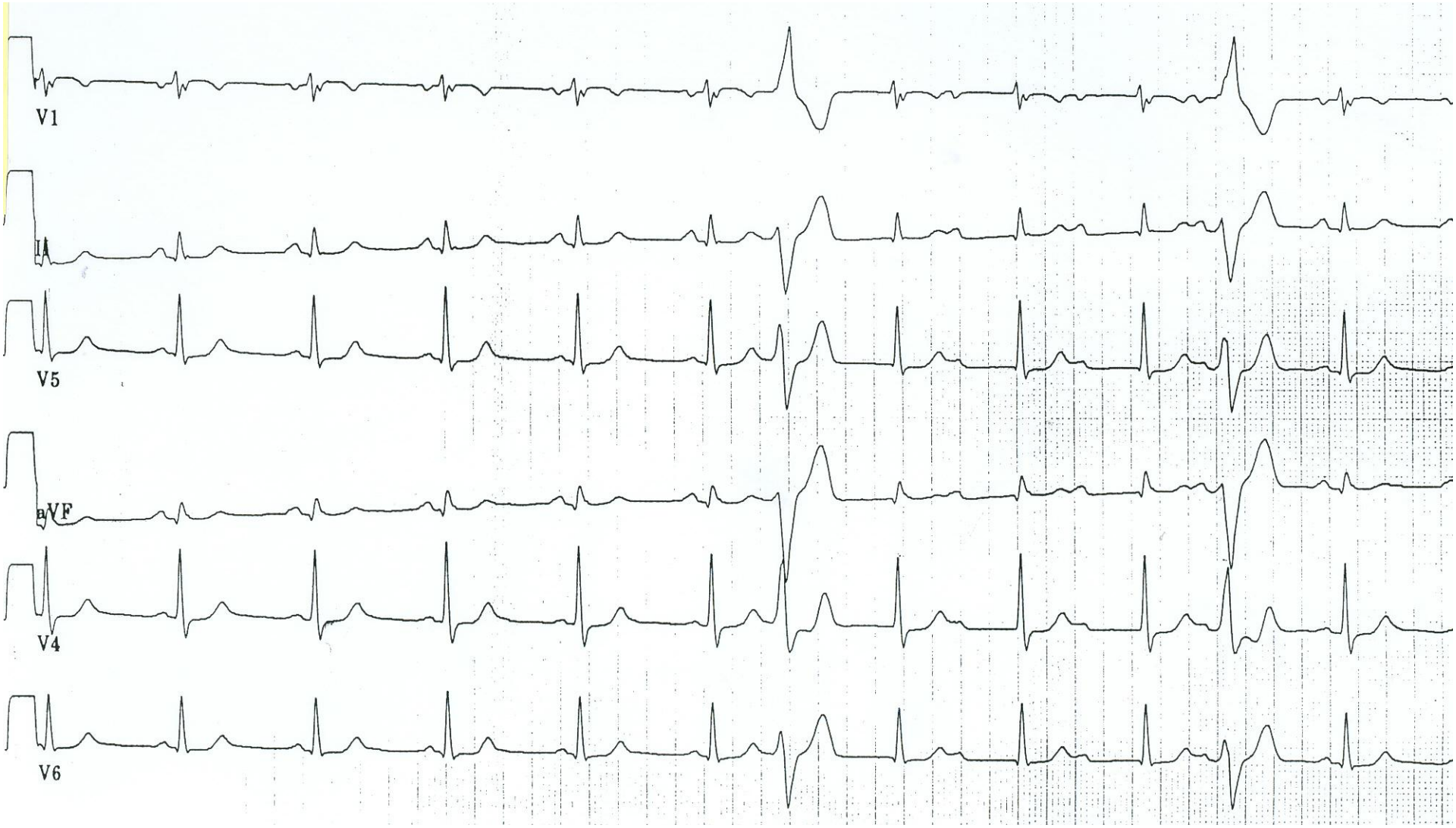


Intracardiac recordings in a patient with bundle branch reentrant ventricular tachcyardia Shown are five surface ECG leads (I, II, aVF, V1, V6) and intracardiac recordings from the His bundle region (HBE2-3,1-2), the right ventricular apex (RVA3-4), and a mapping catheter (USER1) positioned distal to the His catheter along the RV septum to record a right bundle potential (arrow). The right bundle potential was recorded 30 ms after the His potential (H). A=atrial electrogram, V=ventricular electrogram.

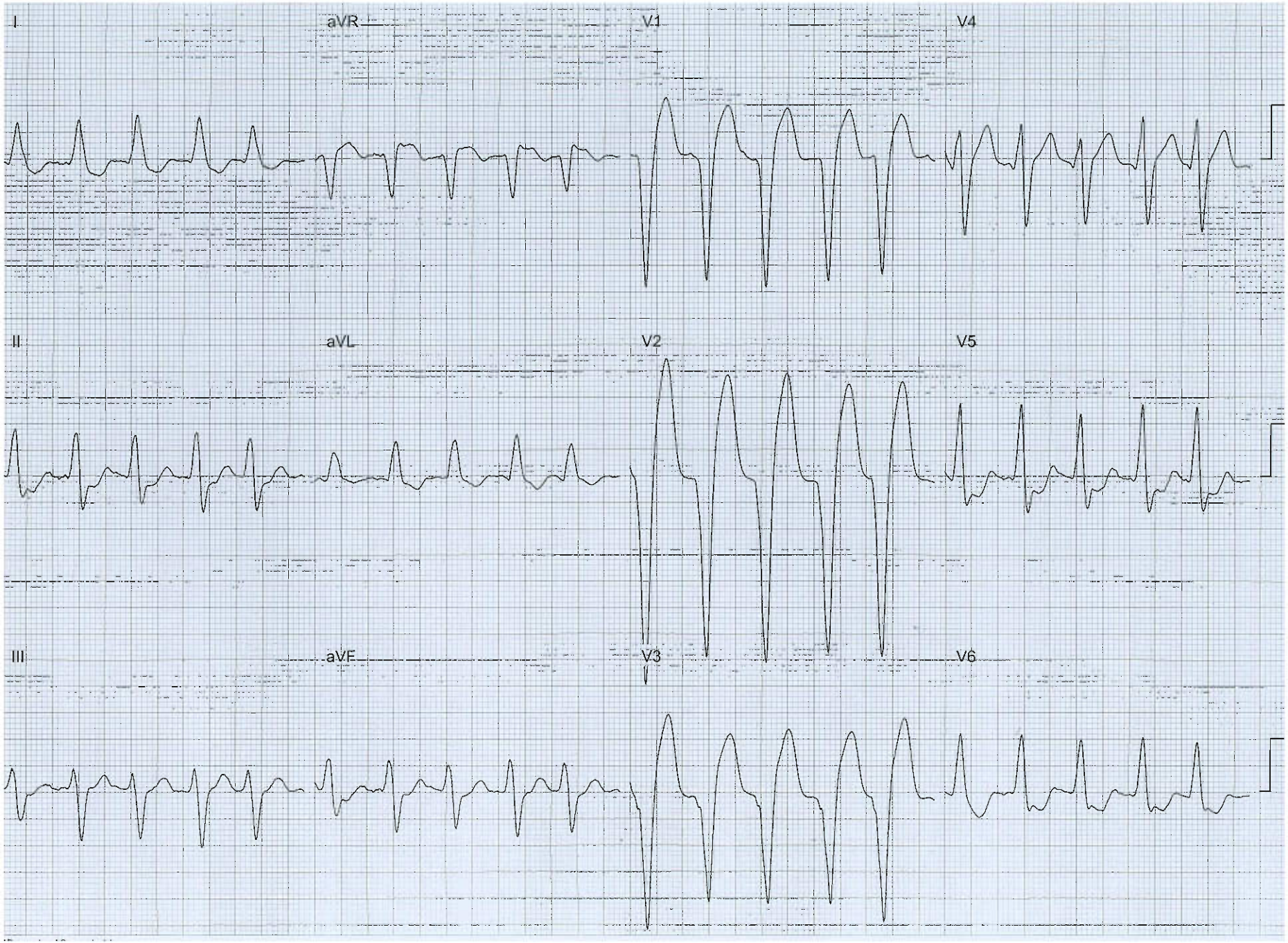


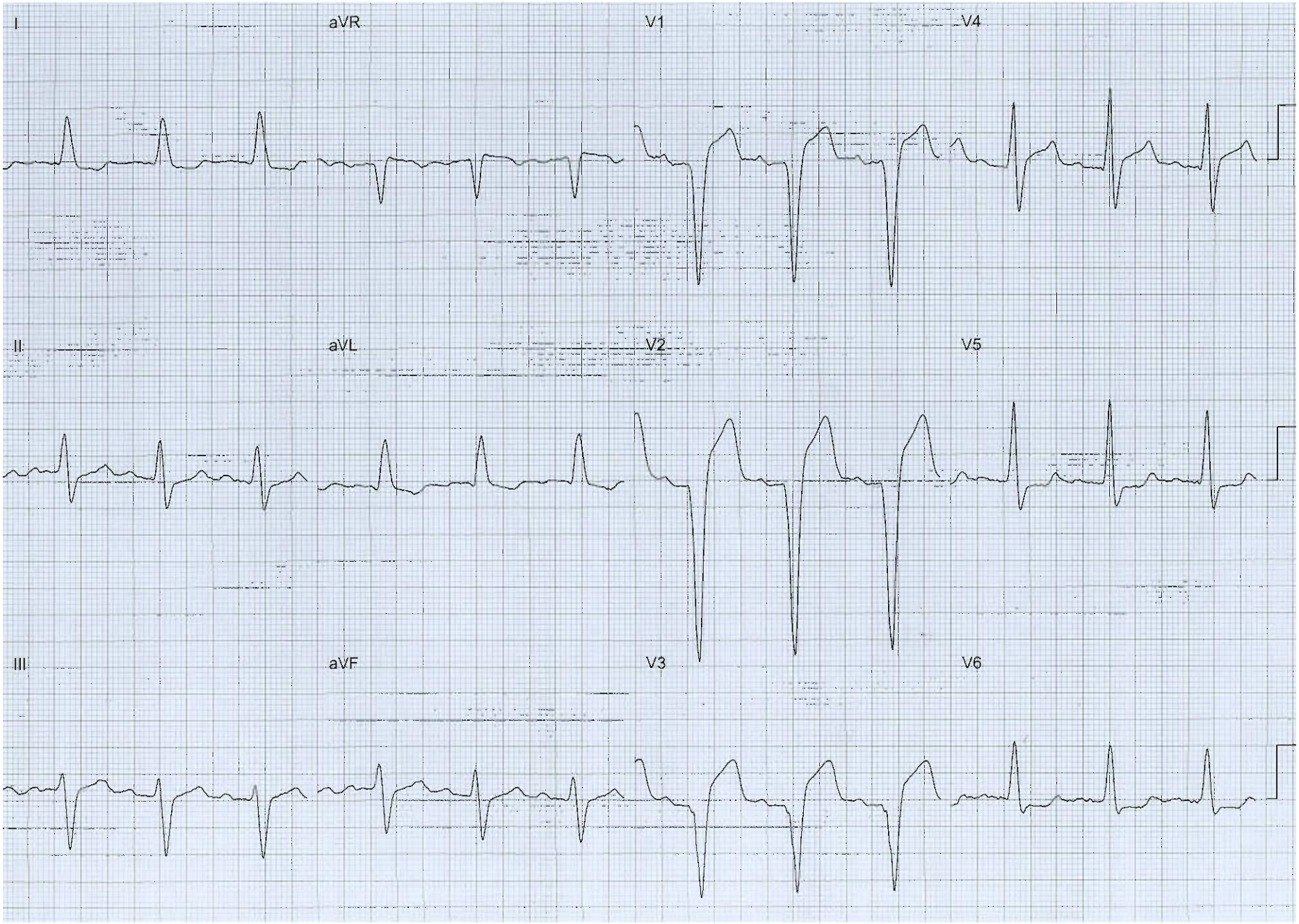
Radiofrequency catheter ablation of the right bundle branch Shown are five surface ECG leads (I, II, aVF, V1, V6) and intracardiac recordings from the His bundle region (HBE2-3,1-2), the right ventricular apex (RVA3-4), and a mapping catheter (USER1) positioned distal to the His catheter along the RV septum. Application of radiofrequency (RF) energy to the tip of the mapping catheter causes two accelerated beats with a typical left bundle branch block (LBBB) morphology (black arrow), likely from heating and activating the right bundle branch. After these beats, complete right bundle branch block (RBBB) is present (red arrow), as evidenced by the change in QRS morphology, particularly in lead V1. Following right bundle branch ablation, the HV interval increased to 105 ms, though no infranodal A-V block was noted. Right bundle branch reentrant tachycardia was no longer inducible. A permanent pacemaker was placed becaued of the markedly prolonged HV interval. H=His bundle electrogram. A=atrial electrogram. V=ventricular electrogram.


08
09
II
V1
V6
70 ms
184 ms
HIS dist
HIS prox
RVA prox
Page: ABLATION Speed: 100 mm/s



Junger Mann mit interm. Herzrasen im Notfall
Seine Tachykardie hat sich spontan terminiert


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

44 jähriger Mann mit intermittierenden Palpitationen

Breitkomplex Tachykardie mit spontaner Terminierung

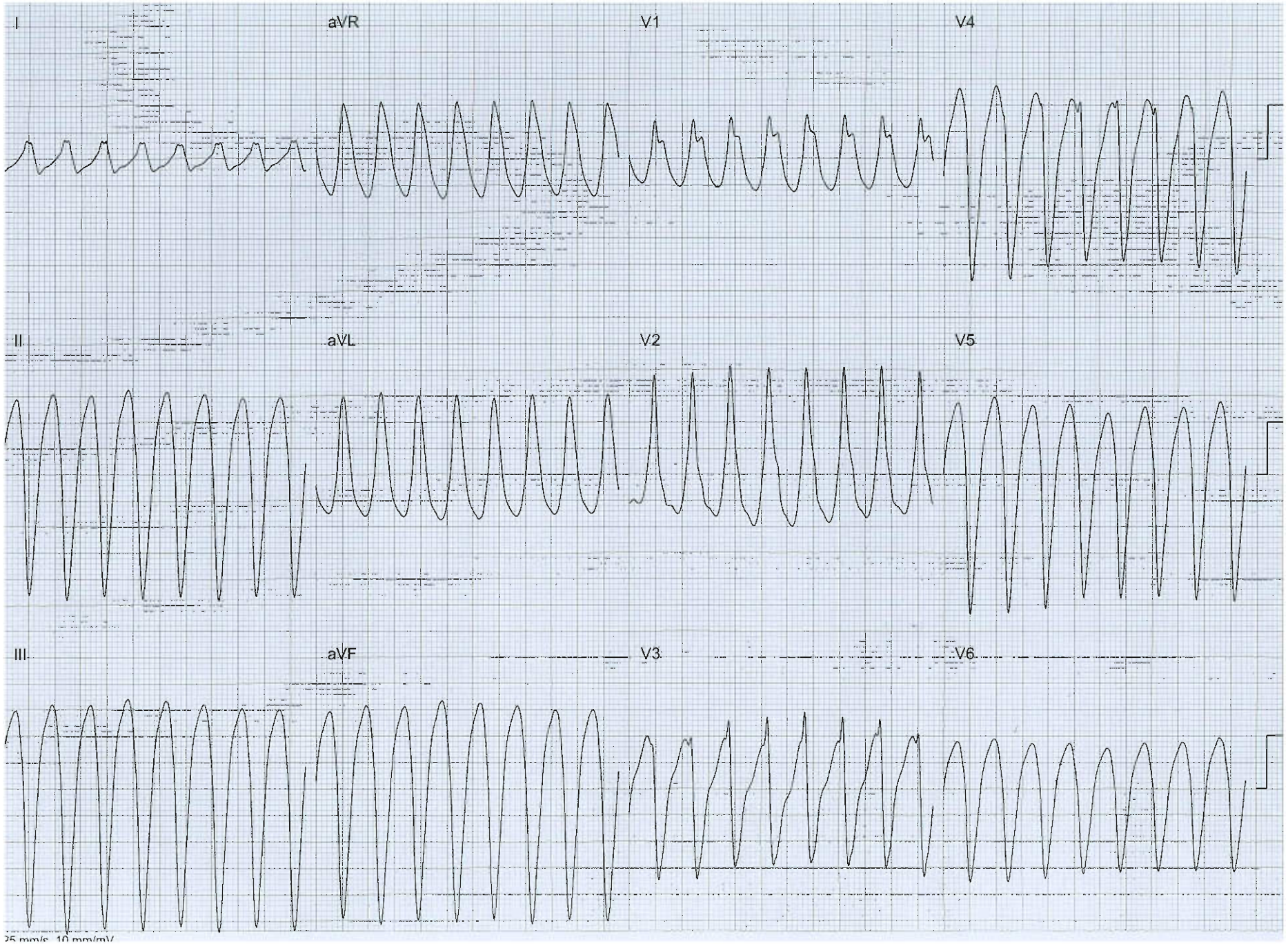
Normale Koronarien; EF 25%, globale Hypokinesie

Was ist hier die Diagnose ?

A. **Atriale Tachykardie**
B. **AV Knoten Reentry Tachykardie**
C. **AV Reentry Tachykardie**
D. **Vorhofflattern**
E. **Kammertachykardie**

Tachykardie QRS ähnlich wie QRS im SR

LSB-Bild und langer PR Intervall


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
25 mm/s 10 mm/mV

SR → lange PR und LSB

Tachykardie 1 → HF 145/min LSB (ähnlich wie im SR)

Tachykardie 2 → HF 200/min RSB

Dilatative Kardiomyopathie (EF 25%)

Wie würden Sie den Patienten therapieren ?

A) Antiarrhythmische Therapie

B) Katheter Ablation

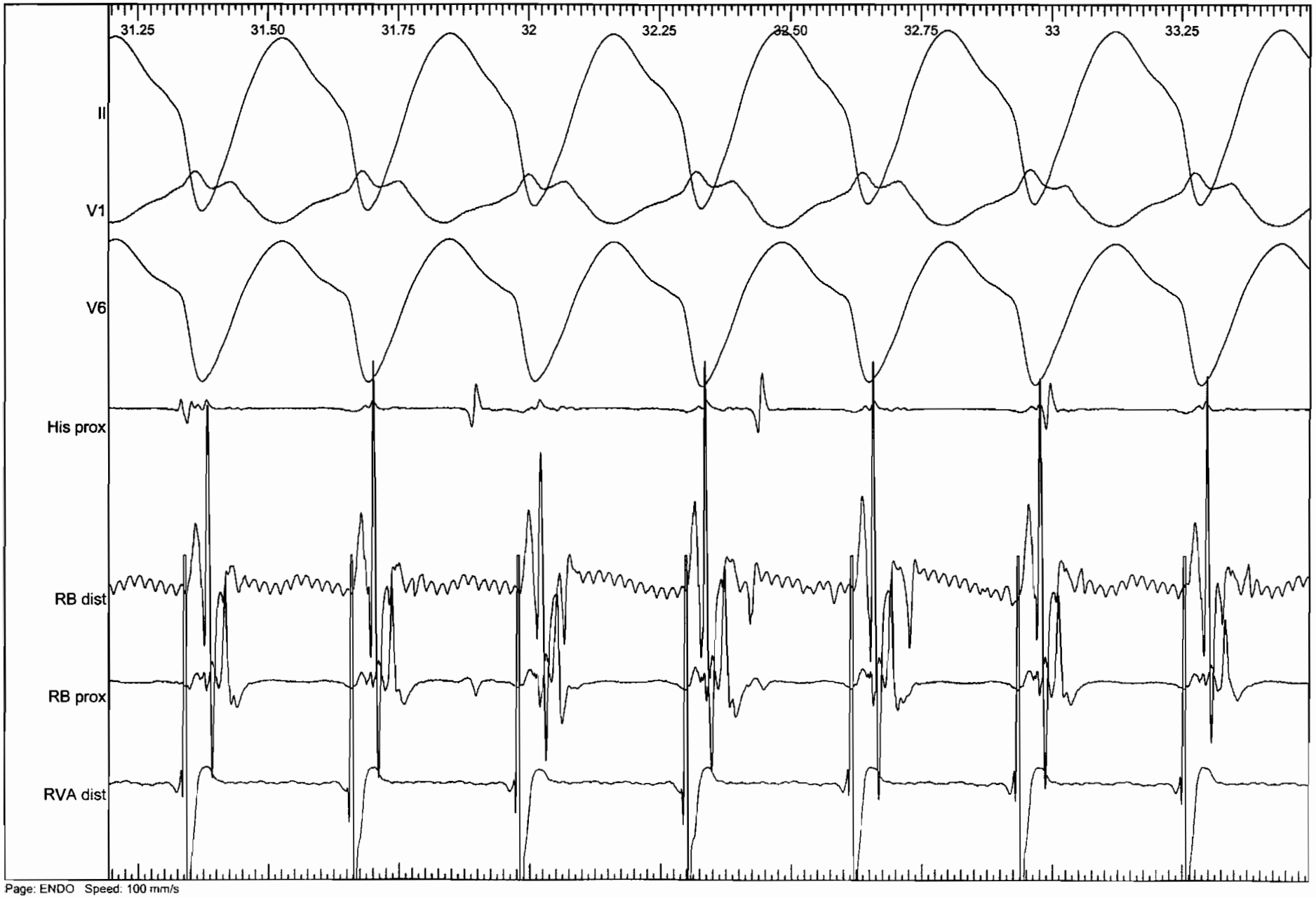
C) ICD

D) [A] und [B]

E) [A] und [C]

F) [B] und [C]

G) [A] und [B] und [C]


31.25
31.50
31.75
32
32.25
32.50
32.75
33
33.25
II
V1
V6
His prox
RB dist
RB prox
RVA dist
Page: ENDO Speed: 100 mm/s

Wie würden Sie den Patienten therapieren ?

A) Antiarrhythmische Therapie

B) Katheter Ablation

C) ICD

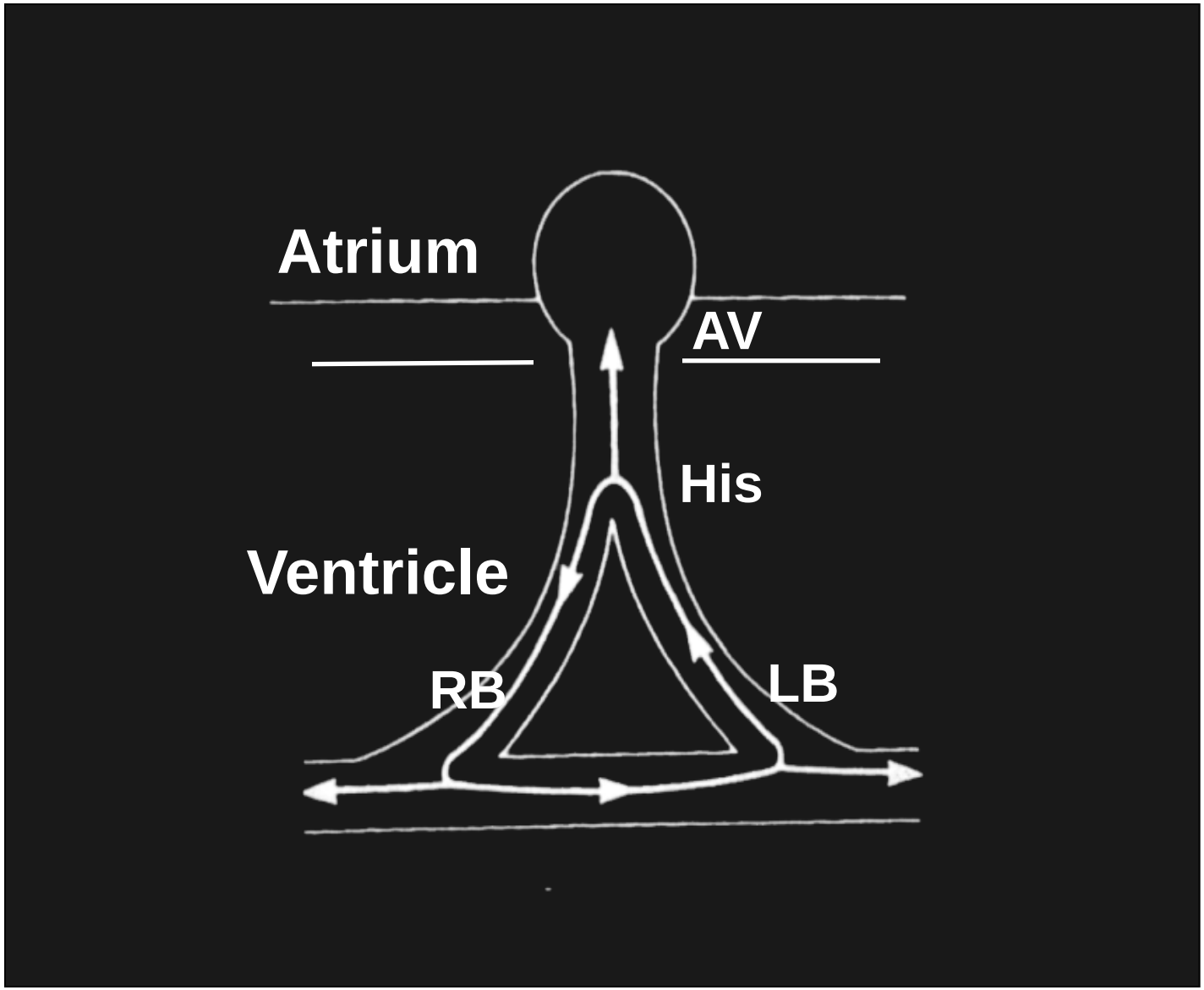
D) [A] und [B]

E) [A] und [C]

F) [B] und [C]

G) [A] und [B] und [C]

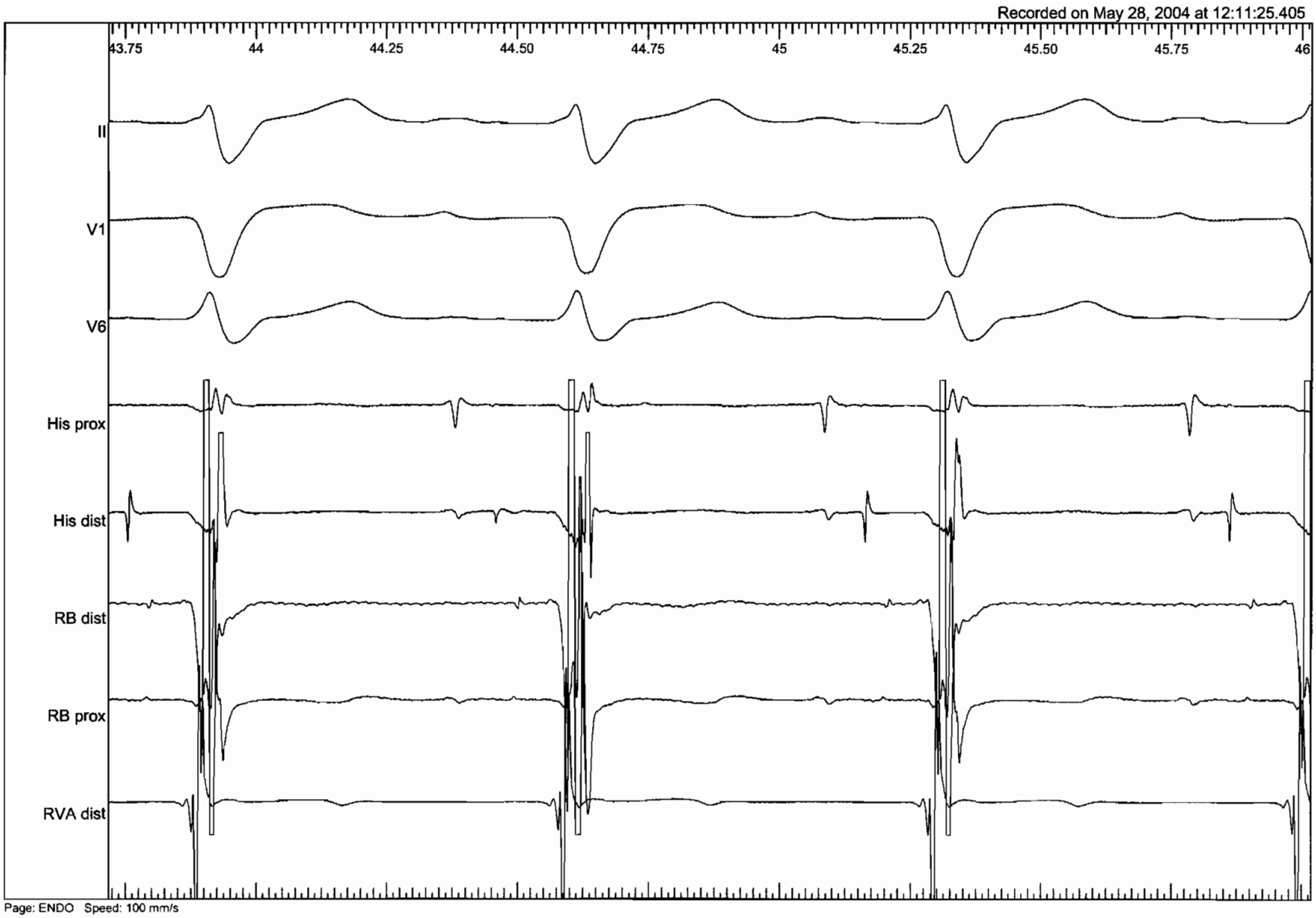
Bundle Branch Reentry

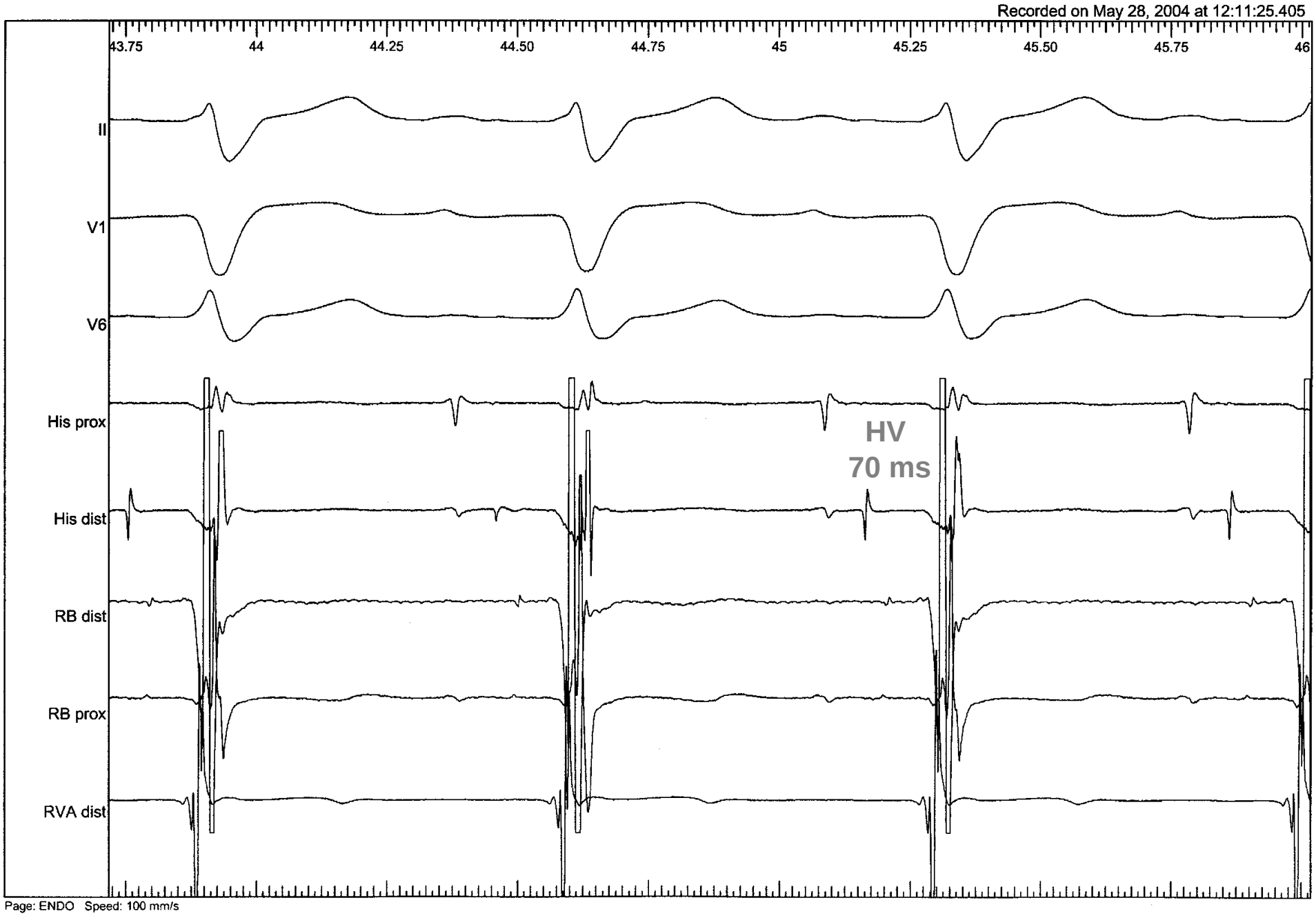


Bundle Branch Reentrant VT

- Macroreentry im His-Purkinje System
- 30% der VTs in dilatativer KMP
- Selten in ischämischer KMP (ca. 5%)
- Rasche Tachykardien (häufig >200/min) $\rightarrow$ Synkope
- Leitungsstörungen bereits im SR

  typischerweise LSB oder nicht-spezifischer IVCD.

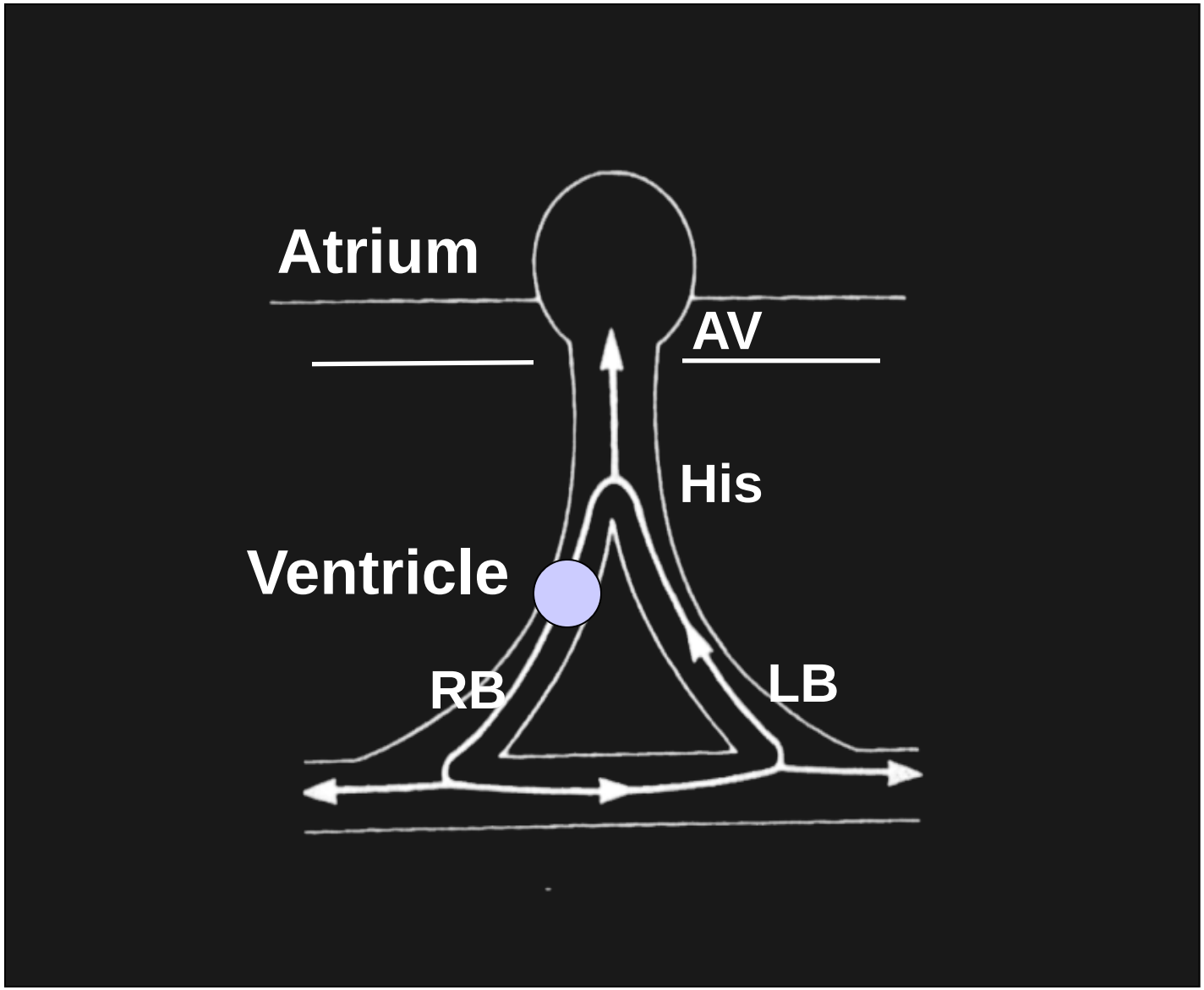

Recorded on May 28, 2004 at 12:11:25.405
43.75
44
44.25
44.50
44.75
45
45.25
45.50
45.75
46
II
V1
V6
His prox
His dist
RB dist
RB prox
RVA dist
Page: ENDO Speed: 100 mm/s

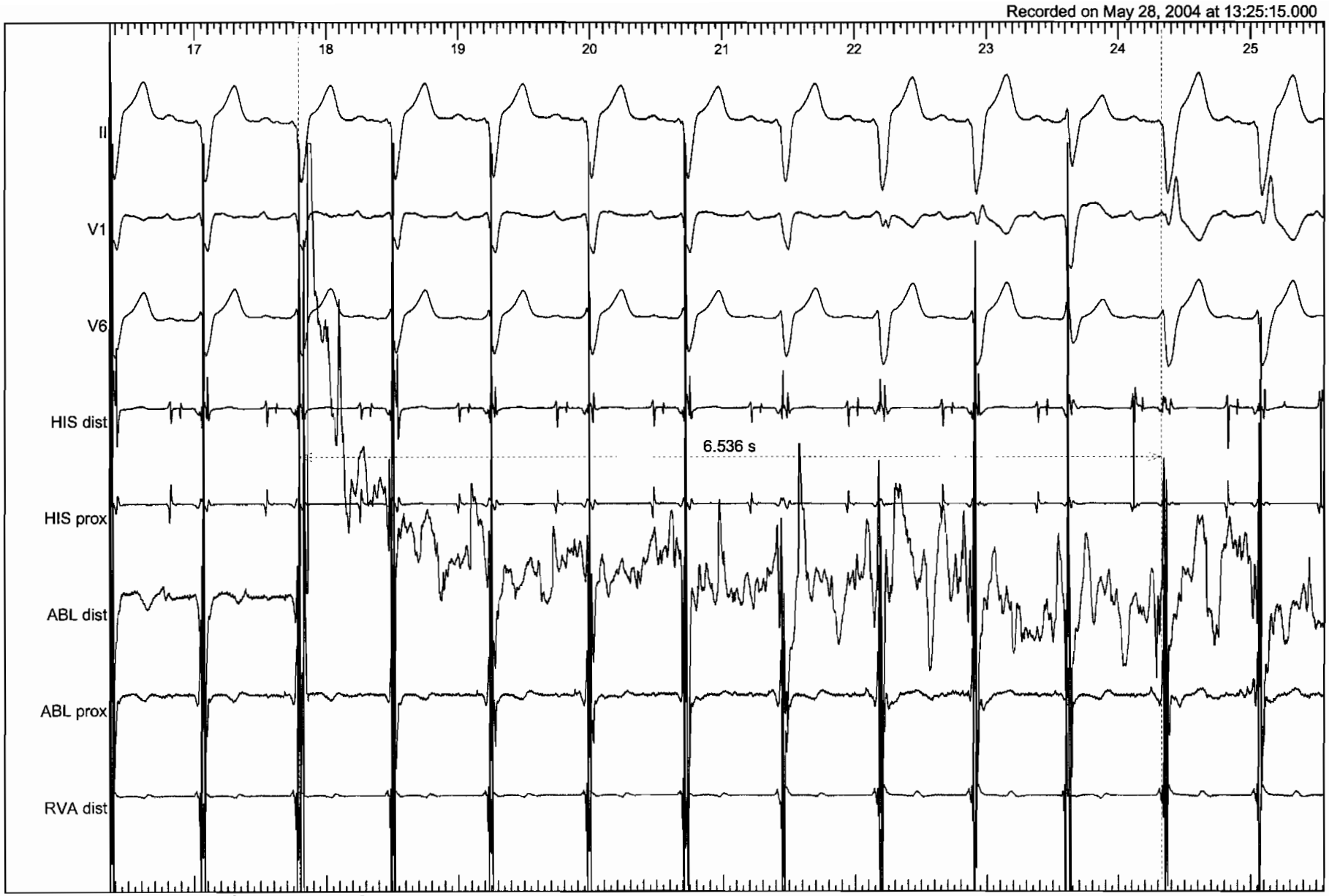

Recorded on May 28, 2004 at 12:11:25.405
43.75
44
44.25
44.50
44.75
45
45.25
45.50
45.75
46
II
V1
V6
His prox
His dist
RB dist
RB prox
RVA dist
HV
70 ms
Page: ENDO Speed: 100 mm/s

Bundle Branch Reentrant VT

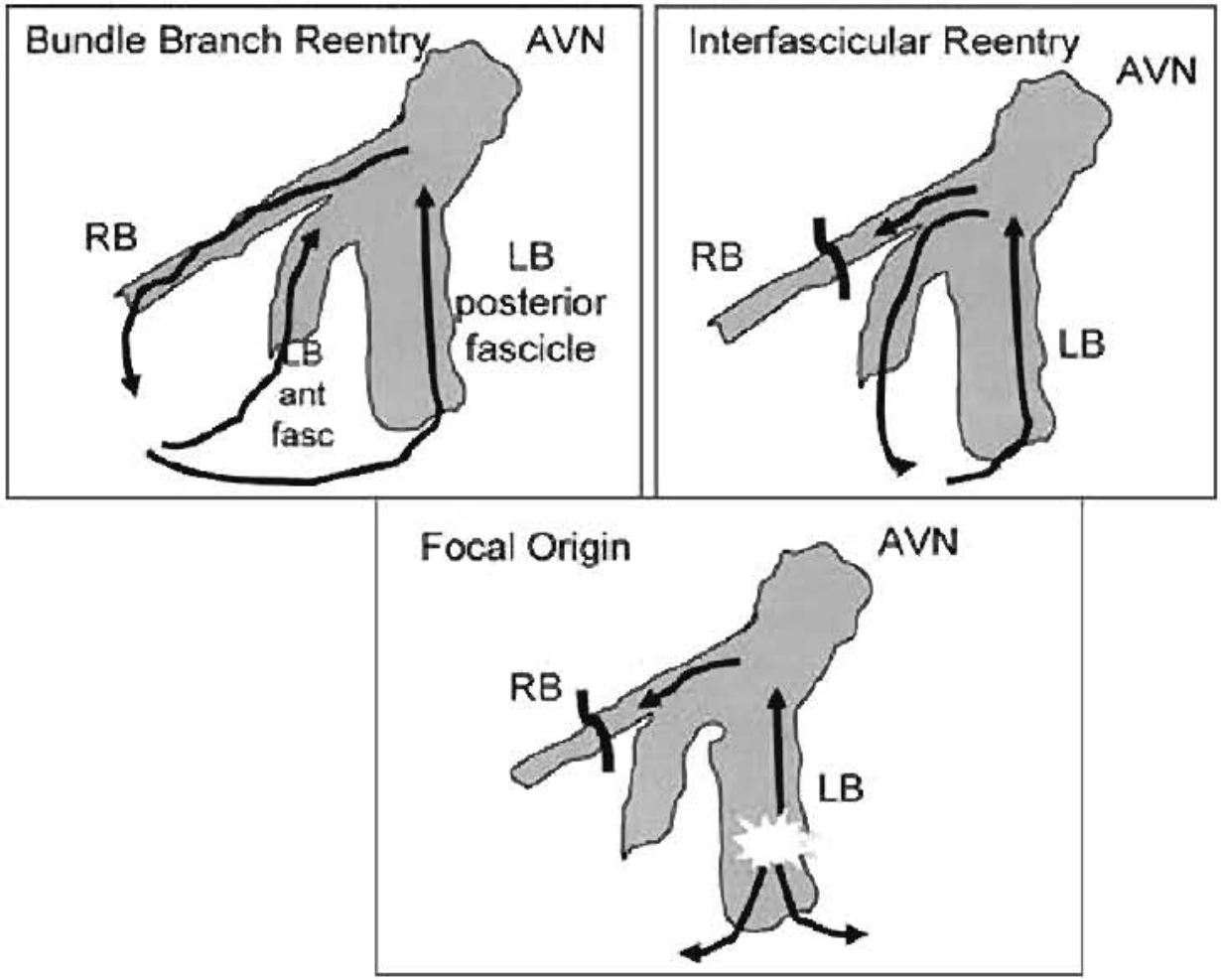
- Tachykardie meistens mit LSB Morphology
- Auslösbare, monomorphe, terminierbare VT (Reentry)
- VA-Dissoziation
- RF Ablation ist 95% kurativ.

Bundle Branch Reentry





Page: ABLATION Speed: 25 mm/s Current Event: Ablation Start
Current Event Info: Time = 13:25:16, , Energy Source = EpShuttle;

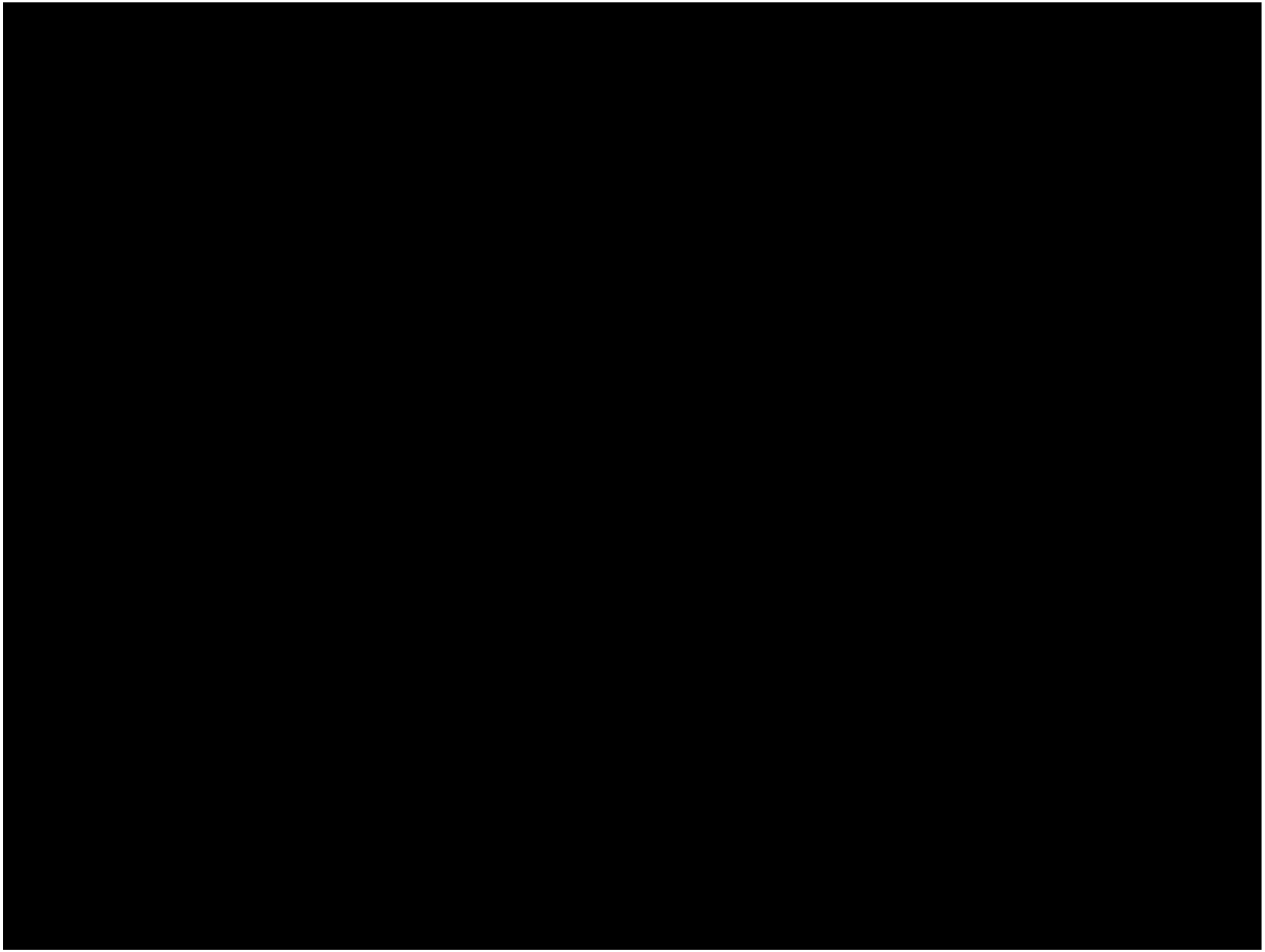

Bundle Branch Reentry
AVN
RB
LB
posterior
fascicle
LB
ant
fasc
Interfascicular Reentry
AVN
RB
LB
Focal Origin
AVN
RB
LB

Follow-up

- Symptomatische Verbesserung
- LVEF

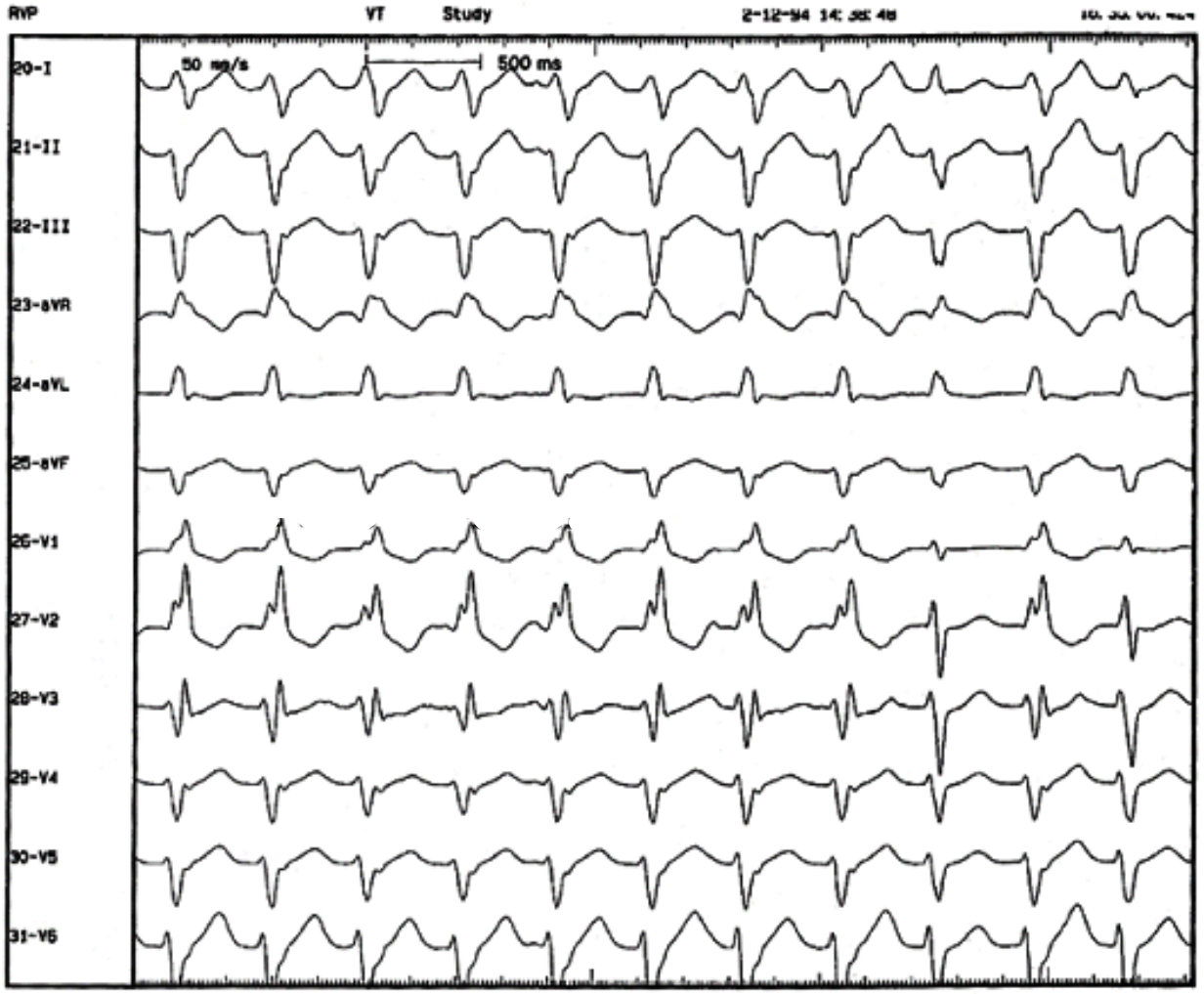
  nach 6 Wochen: 25% -> 45%

  nach 3 Monaten 55%
- Keine adäquate ICD Schocks bisher

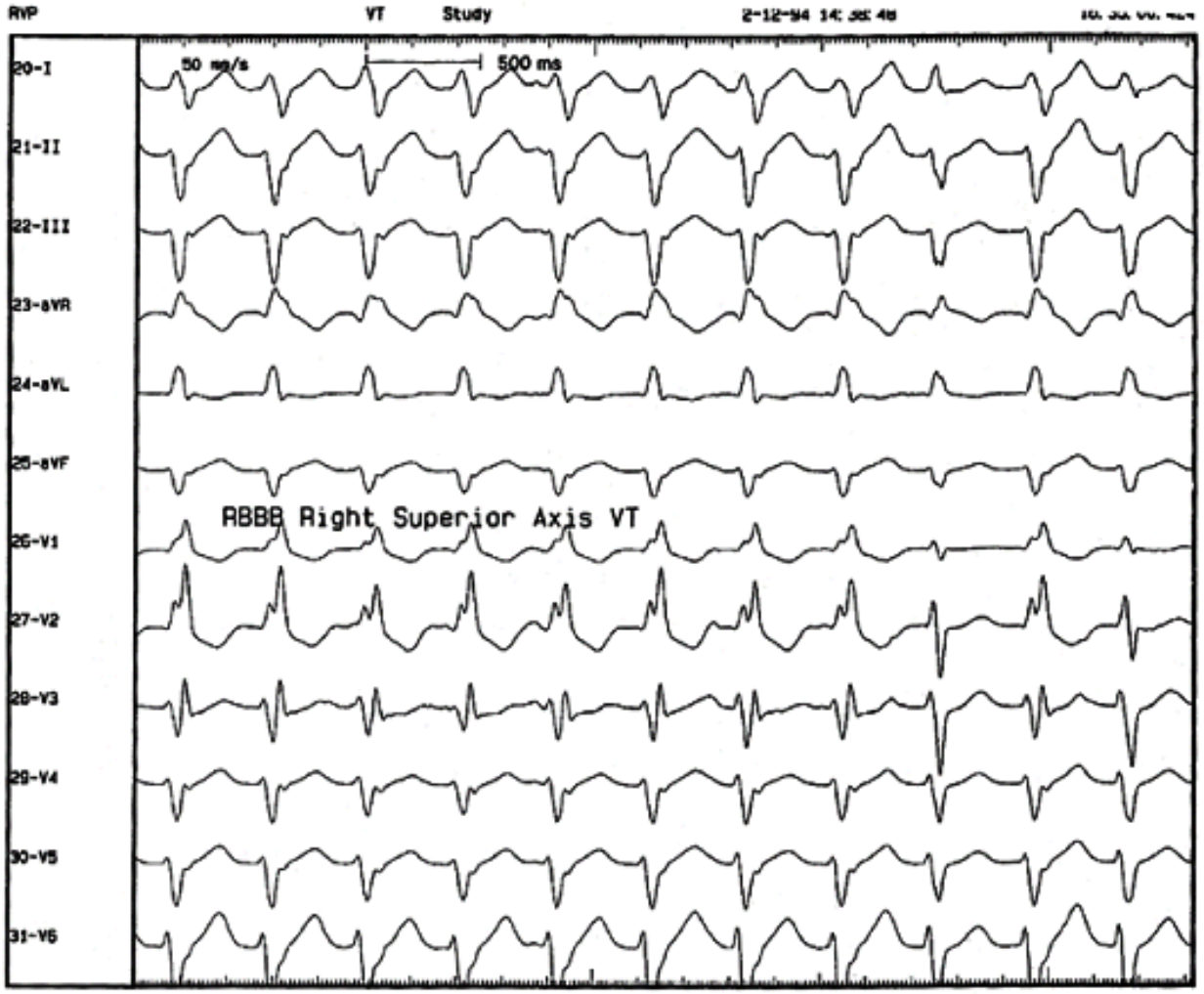


38 j. Patient mit interm. Präsynkope

Patient ist sonst kardial gesund



Idiopathische linksventrikuläre VT



Idiopathische linksventrikuläre VT

- strukturell normales Herz
- junge Männer
- RSB, superiore oder rechtsseitige Achse
- benigne!
- getriggert
- Therapie: akut und chronisch: Verapamil
- Ablationserfolg: 85-90%

Ventrikuläre Tachykardien die abladierbar sind:

- Bundle Branch Reentry VT
- Rechts Ventrikuläre Ausflusstrakt VT (RVOT VT)
- Idiopathische Links Ventrikuläre VT

Bundle Branch Reentrant VT

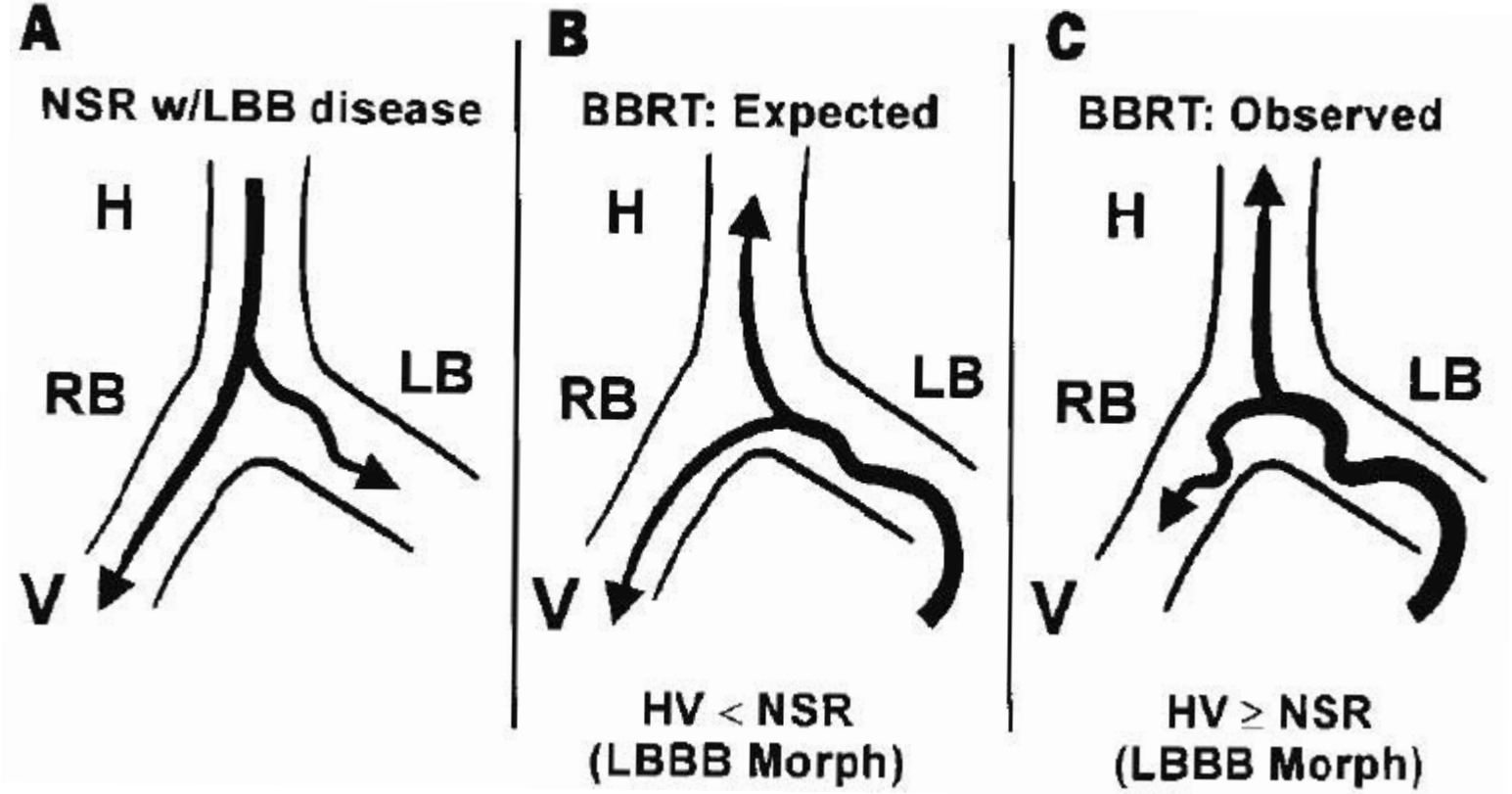
- The RBB has been most commonly targeted for ablation because it is easily accesible.
- ECG pattern of LV conduction delay is common, suggesting that antegrade conduction through the RB might be more stable
- Therefore, ablation of the LB might have a lower risk of AV block.

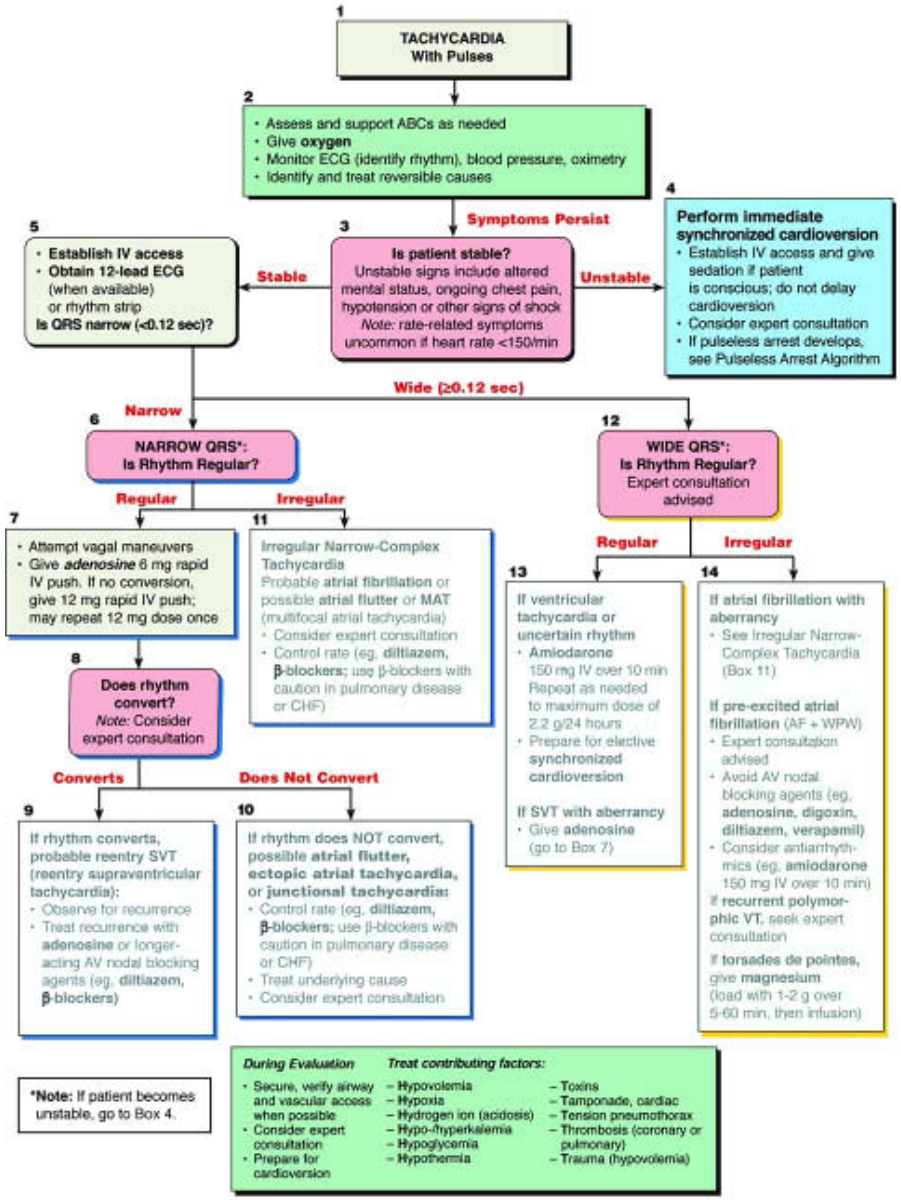
Bundle Branch Reentrant VT

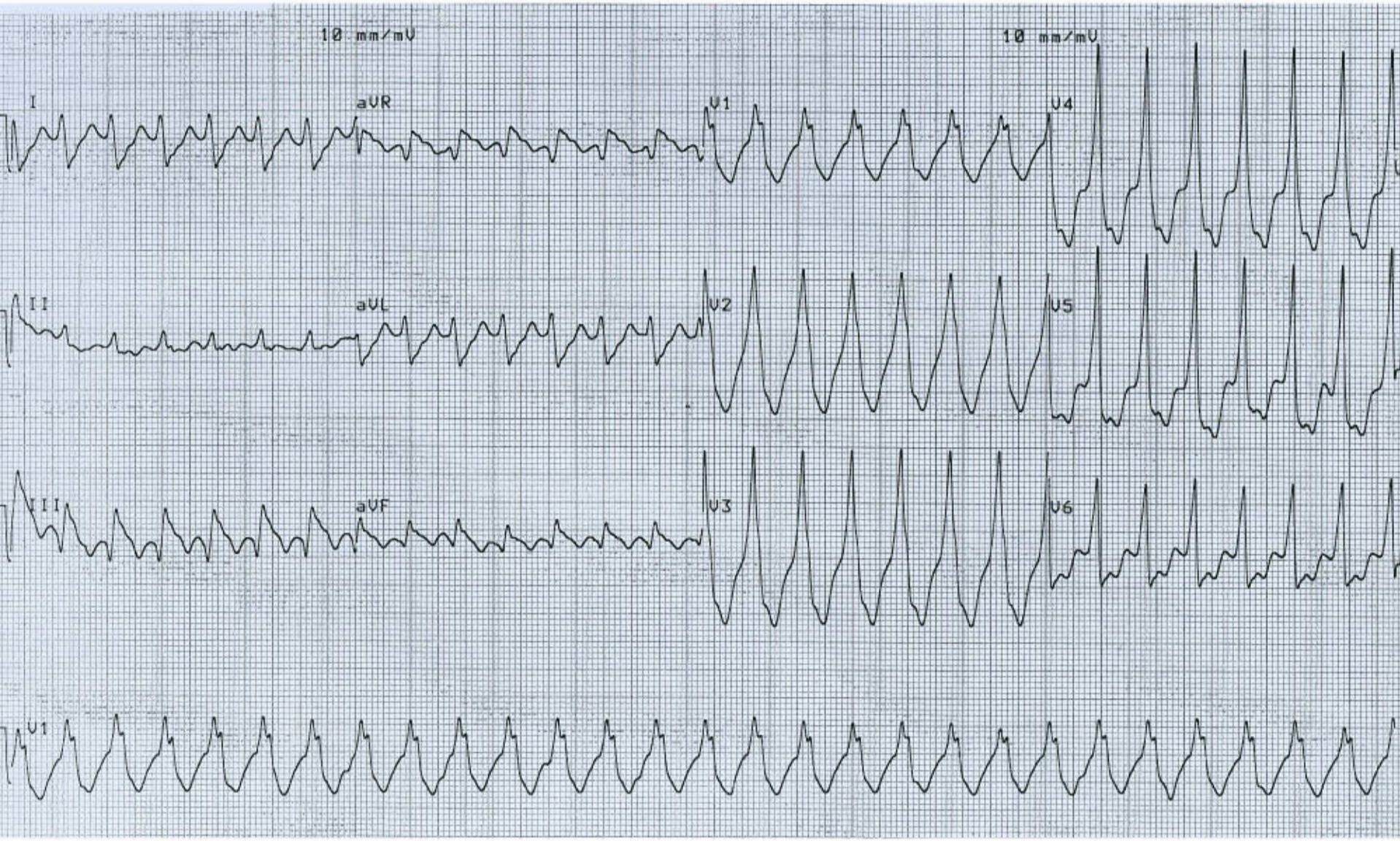
- On the other hand, there is concern that LBBB may have adverse hemodynamic effects in patients with impaired ventricular function.
- Therefore, RB ablation remains the favored approach for the present.

Bundle Branch Reentrant VT

- In patients with interfascicular VT and focal VT involving the Purkinje system, ablation of the RB is unlikely to be effective.


A
NSR w/LBB disease
H
RB
LB
V
B
BBRT: Expected
H
RB
LB
V
HV < NSR
(LBBB Morph)
C
BBRT: Observed
H
RB
LB
V
HV ≥ NSR
(LBBB Morph)


1
TACHYCARDIA
With Pulses
2
• Assess and support ABCs as needed
• Give oxygen
• Monitor ECG (identify rhythm), blood pressure, oximetry
• Identify and treat reversible causes
Symptoms Persist
3
Is patient stable?
Unstable signs include altered mental status, ongoing chest pain, hypotension or other signs of shock
Note: rate-related symptoms uncommon if heart rate <150/min
Stable
Unstable
4
Perform immediate synchronized cardioversion
• Establish IV access and give sedation if patient is conscious; do not delay cardioversion
• Consider expert consultation
• If pulseless arrest develops, see Pulseless Arrest Algorithm
5
• Establish IV access
• Obtain 12-lead ECG (when available) or rhythm strip
Is QRS narrow (<0.12 sec)?
Narrow
Wide (≥0.12 sec)
6
NARROW QRS*:
Is Rhythm Regular?
Regular
Irregular
7
• Attempt vagal maneuvers
• Give adenosine 6 mg rapid IV push. If no conversion, give 12 mg rapid IV push; may repeat 12 mg dose once
8
Does rhythm convert?
Note: Consider expert consultation
Converts
Does Not Convert
9
If rhythm converts, probable reentry SVT (reentry supraventricular tachycardia):
• Observe for recurrence
• Treat recurrence with adenosine or longer-acting AV nodal blocking agents (eg, diltiazem, β-blockers)
10
If rhythm does NOT convert, possible atrial flutter, ectopic atrial tachycardia, or junctional tachycardia:
• Control rate (eg, diltiazem, β-blockers; use β-blockers with caution in pulmonary disease or CHF)
• Treat underlying cause
• Consider expert consultation
11
Irregular Narrow-Complex Tachycardia
Probable atrial fibrillation or possible atrial flutter or MAT (multifocal atrial tachycardia)
• Consider expert consultation
• Control rate (eg, diltiazem, β-blockers; use β-blockers with caution in pulmonary disease or CHF)
12
WIDE QRS*:
Is Rhythm Regular?
Expert consultation advised
Regular
Irregular
13
If ventricular tachycardia or uncertain rhythm
• Amiodarone 150 mg IV over 10 min. Repeat as needed to maximum dose of 2.2 g/24 hours
• Prepare for elective synchronized cardioversion
If SVT with aberrancy
• Give adenosine (go to Box 7)
14
If atrial fibrillation with aberrancy
• See Irregular Narrow-Complex Tachycardia (Box 11)
If pre-excited atrial fibrillation (AF + WPW)
• Expert consultation advised
• Avoid AV nodal blocking agents (eg, adenosine, digoxin, diltiazem, verapamil)
• Consider antiarrhythmics (eg, amiodarone 150 mg IV over 10 min)
If recurrent polymorphic VT, seek expert consultation
If torsades de pointes, give magnesium (load with 1-2 g over 5-60 min, then infusion)
*Note: If patient becomes unstable, go to Box 4.
During Evaluation
• Secure, verify airway and vascular access when possible
• Consider expert consultation
• Prepare for cardioversion
Treat contributing factors:
– Hypovolemia
– Hypoxia
– Hydrogen ion (acidosis)
– Hypo-/hyperkalemia
– Hypoglycemia
– Hypothermia
– Toxins
– Tamponade, cardiac
– Tension pneumothorax
– Thrombosis (coronary or pulmonary)
– Trauma (hypovolemia)


10 mm/mV
10 mm/mV
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1


5 mm/mV
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

Supraventricular Arrhythmias/Atrial Fibrillation

Class I

1. Sustained atrial fibrillation and atrial flutter in patients with hemodynamic compromise or ongoing ischemia should be treated with one or more of the following:
a. Synchronized cardioversion with an initial monophasic shock of 200 J for atrial fibrillation and 50 J for flutter, preceded by brief general anesthesia or conscious sedation whenever possible. (Level of Evidence: C)

b. For episodes of atrial fibrillation that do not respond to electrical cardioversion or recur after a brief period of sinus rhythm, the use of antiarrhythmic therapy aimed at slowing the ventricular response is indicated. One or more of these pharmacological agents may be used:
i. Intravenous amiodarone. (Level of Evidence: C)

ii. Intravenous digoxin for rate control principally for patients with severe LV dysfunction and heart failure. (Level of Evidence: C)

Supraventricular Arrhythmias/Atrial Fibrillation

Class I

Sustained atrial fibrillation and atrial flutter in patients with ongoing ischemia but without hemodynamic compromise should be treated with one or more of the following:
a. Beta-adrenergic blockade is preferred, unless contraindicated. (Level of Evidence: C)

b. Intravenous diltiazem or verapamil. (Level of Evidence: C)

c. Synchronized cardioversion with an initial monophasic shock of 200 J for atrial fibrillation and 50 J for flutter, preceded by brief general anesthesia or conscious sedation whenever possible. (Level of Evidence: C)

For episodes of sustained atrial fibrillation or flutter without hemodynamic compromise or ischemia, rate control is indicated. In addition, patients with sustained atrial fibrillation or flutter should be given anticoagulant therapy. Consideration should be given to cardioversion to sinus rhythm in patients with a history of atrial fibrillation or flutter prior to STEMI. (Level of Evidence: C)

Supraventricular Arrhythmias/Atrial Fibrillation

Class I

Reentrant paroxysmal supraventricular tachycardia, because of its rapid rate, should be treated with the following in the sequence shown:
a. Carotid sinus massage. (Level of Evidence: C)

b. Intravenous adenosine (6 mg 1 over 1 to 2 seconds; if no response, 12 mg IV after 1 to 2 minutes may be given; repeat 12 mg dose if needed. (Level of Evidence: C)

c. Intravenous beta-adrenergic blockade with metoprolol (2.5 to 5.0 mg every 2 to 5 minutes to a total of 15 mg over 10 to 15 minutes) or atenolol (2.5 to 5.0 mg over 2 minutes to a total of 10 mg in 10 to 15 minutes). (Level of Evidence: C)

d. Intravenous diltiazem (20 mg [0.25 mg/kg]) over 2 minutes followed by an infusion of 10 mg/h). (Level of Evidence: C)

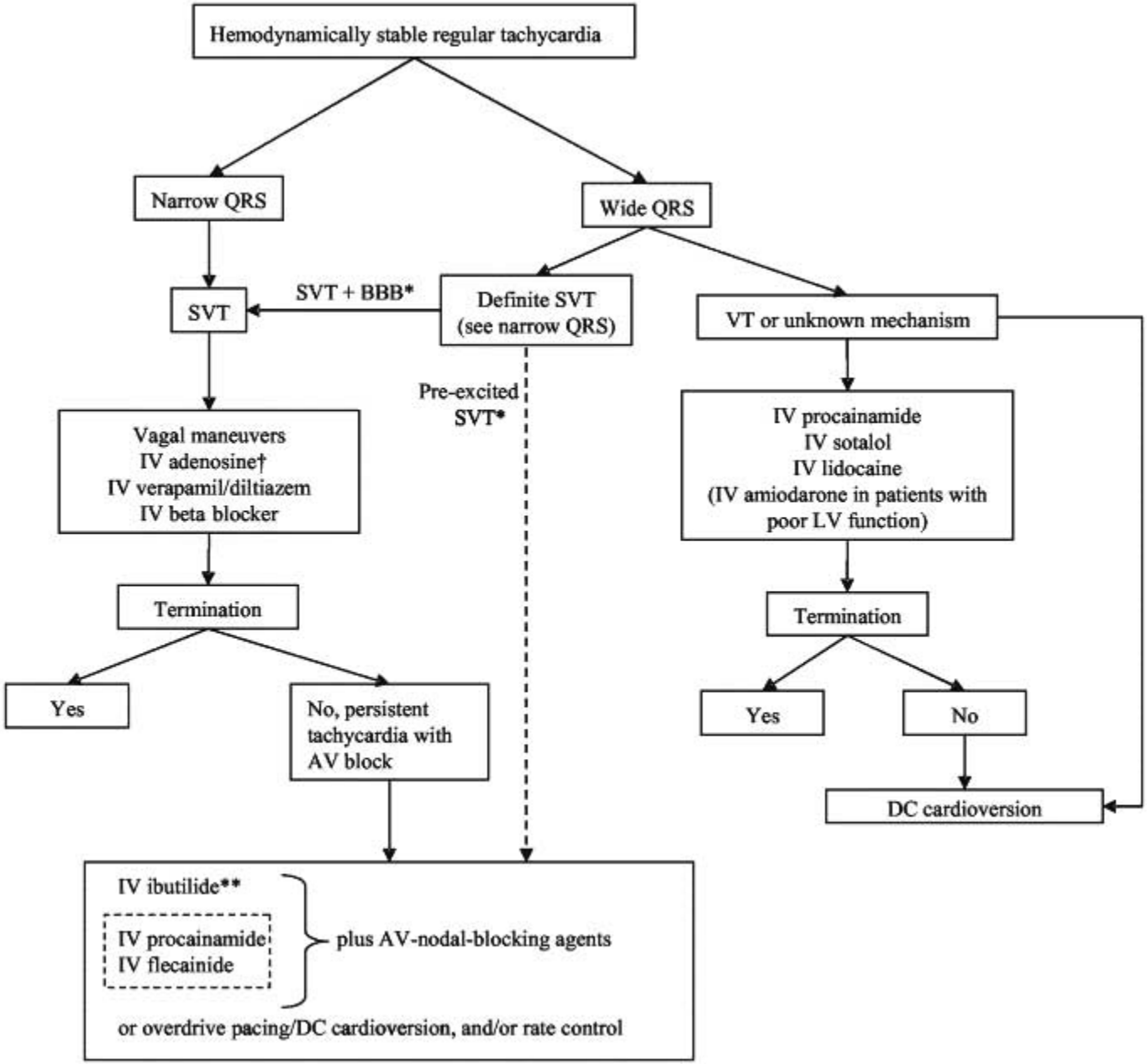
e. Intravenous digoxin, recognizing that there may be a delay of at least 1 hour before pharmacological effects appear (8 to 15 mcg/kg [0.6 to 1.0 mg in a person weighing 70 kg]). (Level of Evidence: C)

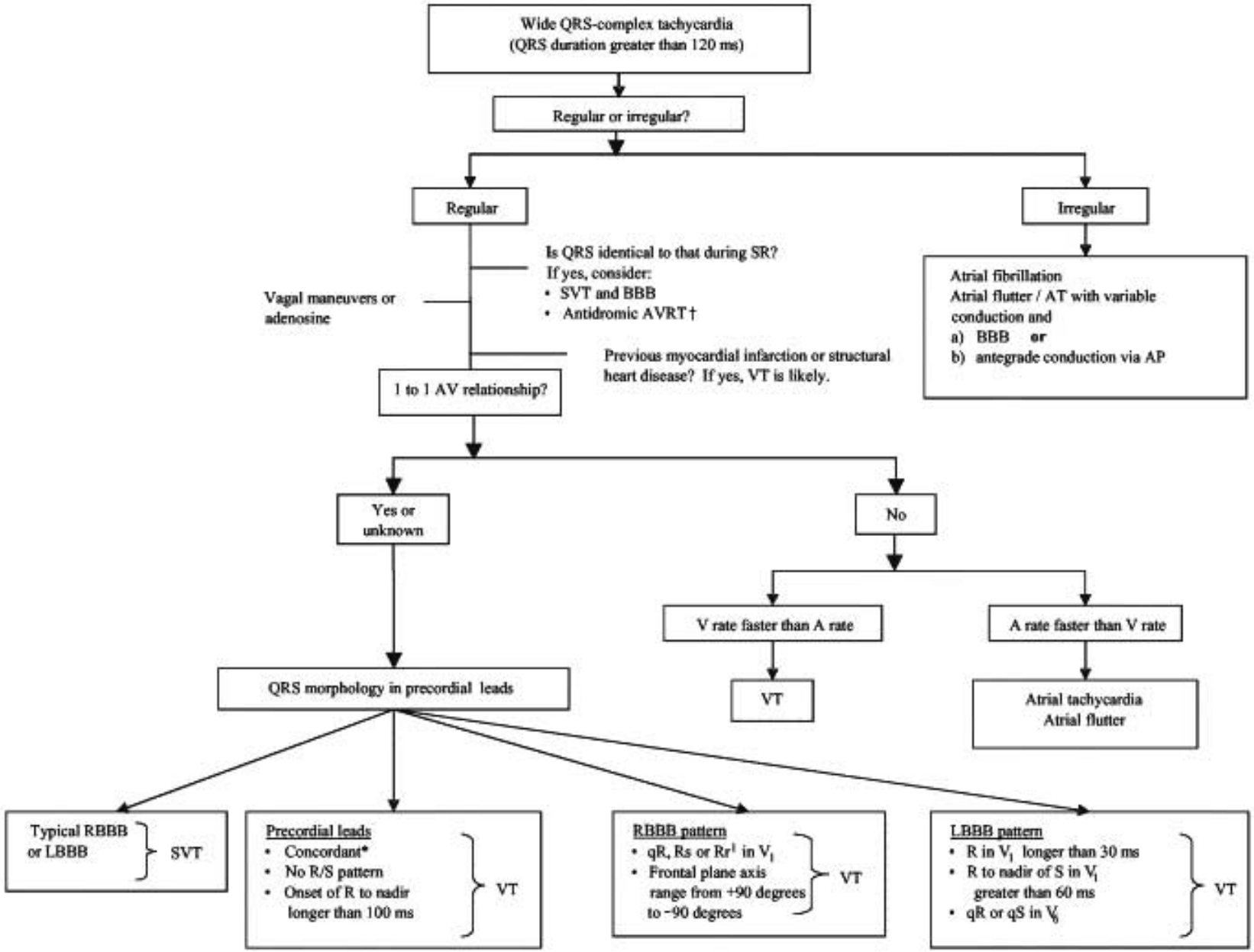
ECG	Recommendation*	Classification	Level of Evidence	References
Narrow QRS-complex tachycardia (SVT)	Vagal maneuvers	I	B	
	Adenosine	I	A	15,17,18
	Verapamil, diltiazem	I	A	19
	Beta blockers	IIb	C	20,21
	Amiodarone	IIb	C	22
	Digoxin	IIb	C	
Wide QRS-complex tachycardia				
•SVT + BBB	See above			
•Pre-excited SVT/AF†	Flecainide‡	I	B	23
	Ibutilide‡	I	B	24
	Procainamide‡	I	B	
	DC cardioversion	I	C	
•Wide QRS-complex tachycardia of unknown origin	Procainamide‡	I	B	25,26
	Sotalol‡	I	B	27
	Amiodarone	I	B	29,30
	DC cardioversion	I	B	28
	Lidocaine	IIb	B	26,27
	Adenosine§	IIb	C	31
	Beta blockers¶	III	C	28
	Verapamil**	III	B	32
Wide QRS-complex tachycardia of unknown origin in patients with poor LV function	Amiodarone	I	B	29,30
	DC cardioversion, lidocaine	I	B	28

Clinical Presentation	Recommendation	Class	Level of Evidence	References
Poorly tolerated AVNRT with hemodynamic intolerance	Catheter ablation	I	B	58
	Verapamil, diltiazem, beta blockers, sotalol, amiodarone	IIa	C	58
	Flecainide,*; propafenone*	IIa	C	
Recurrent symptomatic AVNRT	Catheter ablation	I	B	58
	Verapamil	I	B	59
	Diltiazem, beta blockers	I	C	60
	Digoxin†	IIb	C	
Recurrent AVNRT unresponsive to beta blockade or calcium-channel blocker and patient not desiring RF ablation	Flecainide,* propafenone,* sotalol	IIa	B	53,61–65
	Amiodarone	IIb	C	66
AVNRT with infrequent or single episode in patients who desire complete control of arrhythmia	Catheter ablation	I	B	
Documented PSVT with only dual AV-nodal pathways or single echo beats demonstrated during electrophysiological study and no other identified cause of arrhythmia	Verapamil, diltiazem, beta blockers, flecainide,* propafenone*	I	C	
	Catheter ablation‡	I	B	
Infrequent, well-tolerated AVNRT	No therapy	I	C	58
	Vagal maneuvers	I	B	
	Pill-in-the-pocket	I	B	
	Verapamil, diltiazem, beta blockers	I	B	
	Catheter ablation	I	B	67

Arrhythmia	Recommendation	Classification	Level of Evidence	References
WPW syndrome (pre-excitation and symptomatic arrhythmias), well tolerated	Catheter ablation	I	B	55,85–87
	Flecainide, propafenone	IIa	C	64,86,88–99
	Sotalol, amiodarone, beta blockers	IIa	C	100–104
	Verapamil, diltiazem, digoxin	III	C	105
WPW syndrome (with AF and rapid-conduction or poorly tolerated AVRT)	Catheter ablation	I	B	55,57,85,106–111
AVRT, poorly tolerated (no pre-excitation)	Catheter ablation	I	B	55,57,85,106–111
	Flecainide, propafenone	IIa	C	64,86,88–99
	Sotalol, amiodarone	IIa	C	100–104
	Beta blockers	IIb	C	105
	Verapamil, diltiazem, digoxin	III	C	105
Single or infrequent AVRT episode(s) (no pre-excitation)	None	I	C	
	Vagal maneuvers	I	B	
	Pill-in-the-pocket — verapamil, diltiazem, beta blockers	I	B	54,112
	Catheter ablation	IIa	B	55,57,85,106–111
	Sotalol, amiodarone	IIb	B	100–104
	Flecainide, propafenone	IIb	C	64,86,88–99,105
	Digoxin	III	C	
Pre-excitation, asymptomatic	None	I	C	
	Catheter ablation	IIa	B	55,57,85,106–111

Clinical Situation	Recommendation	Classification	Level of Evidence	References
Acute treatment†				
A.Conversion				
Hemodynamically unstable patient	DC cardioversion	I	B	
Hemodynamically stable patient	Adenosine	IIa	C	123,130
	Beta blockers	IIa	C	131,132
	Verapamil, diltiazem	IIa	C	114,133
	Procainamide	IIa	C	
	Flecainide/propafenone	IIa	C	133–136
	Amiodarone, sotalol	IIa	C	116,135,137–140
B.Rate regulation (in absence of digitalis therapy)	Beta blockers	I	C	131,132
	Verapamil, diltiazem	I	C	141
	Digoxin	IIb	C	
Prophylactic therapy				
Recurrent symptomatic AT	Catheter ablation	I	B	124
	Beta blockers, calcium-channel blockers	I	C	
	Disopyramide‡	IIa	C	138
	Flecainide/propafenone‡	IIa	C	133,135,136,142,143
	Sotalol, amiodarone	IIa	C	116,137–139
Asymptomatic or symptomatic incessant Ats	Catheter ablation	I	B	
Nonsustained and asymptomatic	No therapy	I	C	
	Catheter ablation	III	C	


Hemodynamically stable regular tachycardia
Narrow QRS
Wide QRS
SVT
SVT + BBB*
Definite SVT
(see narrow QRS)
VT or unknown mechanism
Pre-excited
SVT*
Vagal maneuvers
IV adenosine†
IV verapamil/diltiazem
IV beta blocker
IV procainamide
IV sotalol
IV lidocaine
(IV amiodarone in patients with
poor LV function)
Termination
Termination
Yes
No, persistent
tachycardia with
AV block
Yes
No
DC cardioversion
IV ibutilide**
IV procainamide
IV flecainide
plus AV-nodal-blocking agents
or overdrive pacing/DC cardioversion, and/or rate control


Wide QRS-complex tachycardia
(QRS duration greater than 120 ms)
Regular or irregular?
Regular
Irregular
Is QRS identical to that during SR?
If yes, consider:
• SVT and BBB
• Antidromic AVRT †
Vagal maneuvers or adenosine
Previous myocardial infarction or structural heart disease? If yes, VT is likely.
Atrial fibrillation
Atrial flutter / AT with variable conduction and
a) BBB or
b) antegrade conduction via AP
1 to 1 AV relationship?
Yes or unknown
No
V rate faster than A rate
A rate faster than V rate
VT
Atrial tachycardia
Atrial flutter
QRS morphology in precordial leads
Typical RBBB or LBBB
SVT
Precordial leads
• Concordant*
• No R/S pattern
• Onset of R to nadir longer than 100 ms
VT
RBBB pattern
• qR, Rs or Rr' in V1
• Frontal plane axis range from +90 degrees to −90 degrees
VT
LBBB pattern
• R in V1 longer than 30 ms
• R to nadir of S in V1 greater than 60 ms
• qR or qS in V6
VT