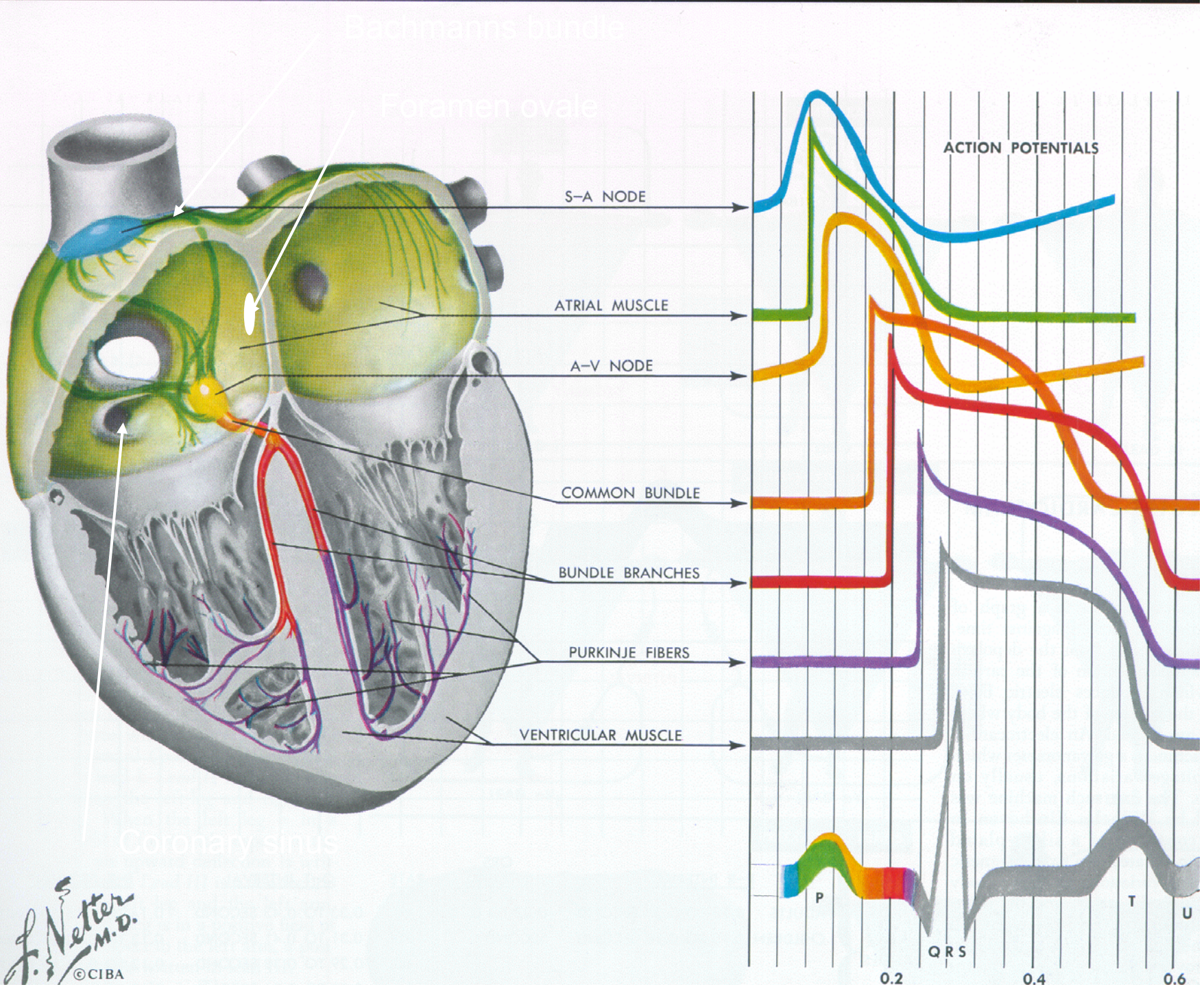
קורס מתמחים
נובמבר 2010

ד"ר מוטי חיים
מנהל שירות אלקטרופיזיולוגיה
קמפוס בילינסון
מ.ר. רבין

בדיקה אלקטרופיזיולוגית
ELECTROPHYSIOLOGY STUDY-EPS

מטרות

- הערכה לבראדיאריתמיות
- הערכה לטאכיאריתמיות
- בירור התעלפויות
- הערכת סיכון ל VT/VF
- אבלאצייה – צריבה של הפרעות קצב


Bachmanns bundle
Foramen ovale
S–A NODE
ATRIAL MUSCLE
A–V NODE
COMMON BUNDLE
BUNDLE BRANCHES
PURKINJE FIBERS
VENTRICULAR MUSCLE
Coronary sinus
ACTION POTENTIALS
P
Q R S
T
U
0.2
0.4
0.6
F. Netter M.D.
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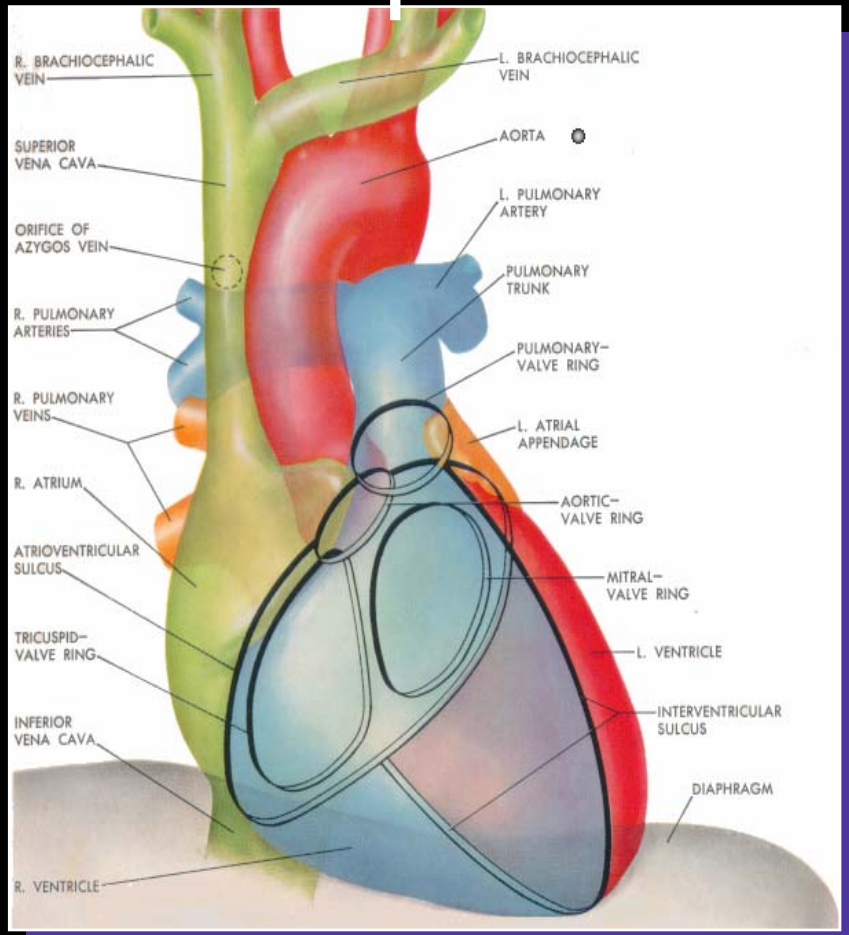
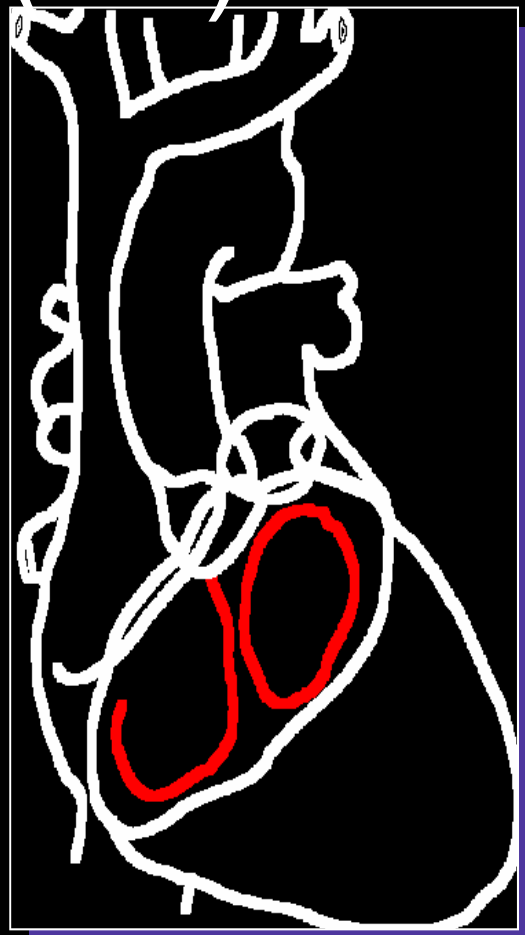
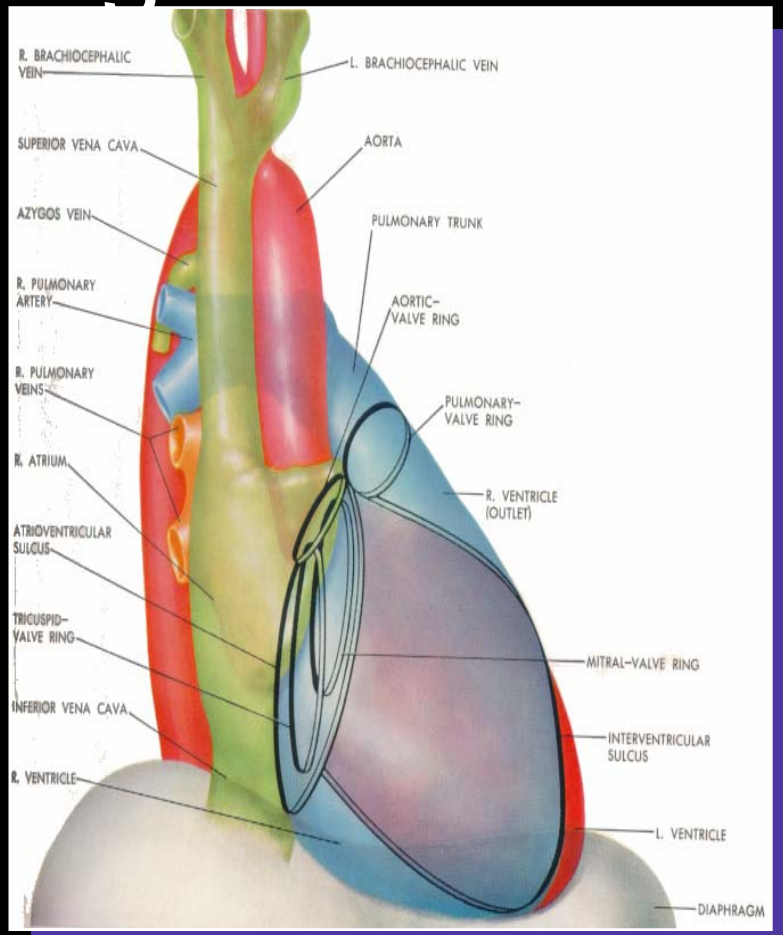
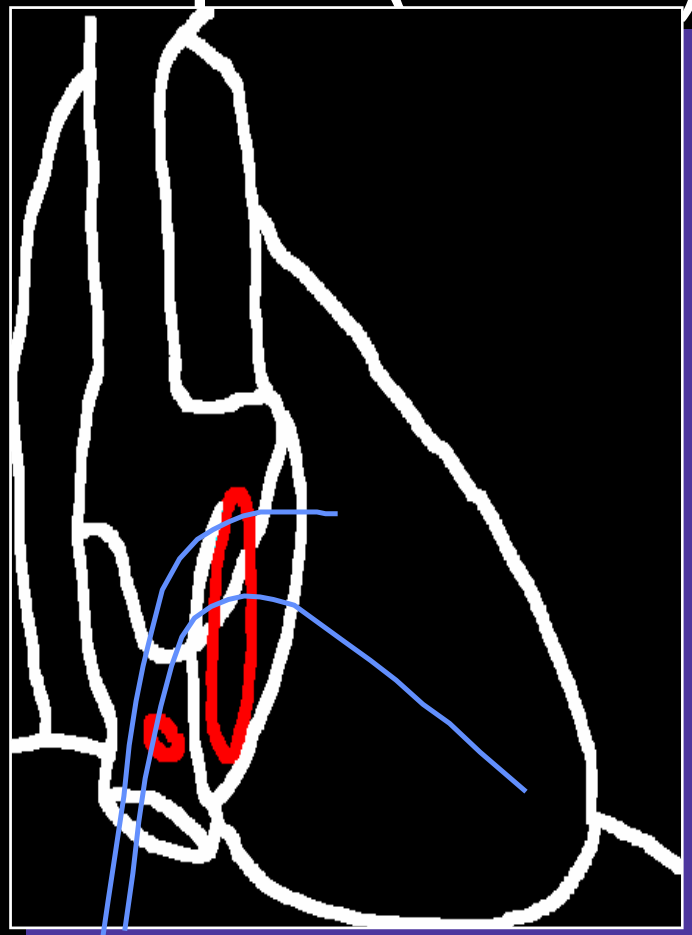
Anteroposterior (AP) view

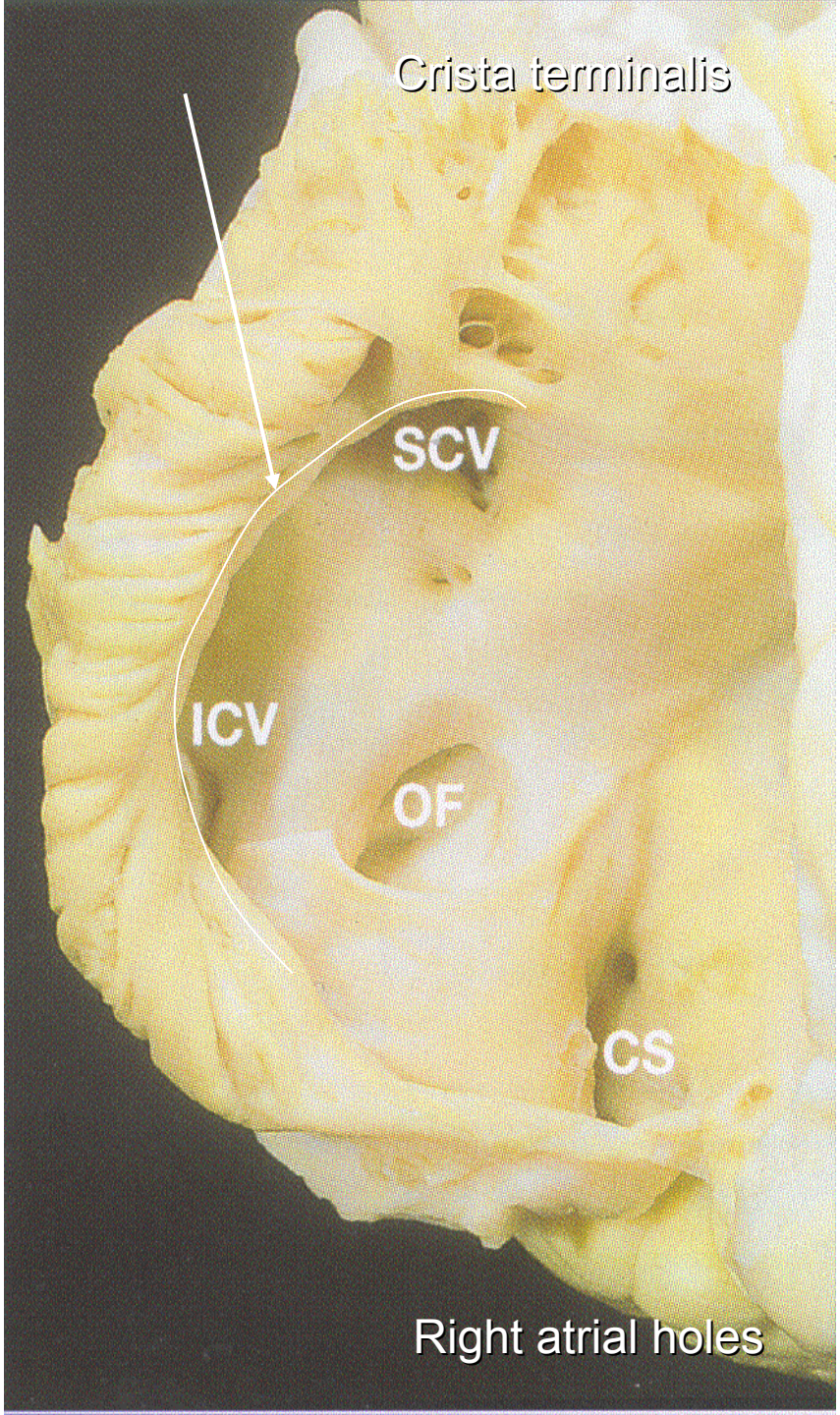




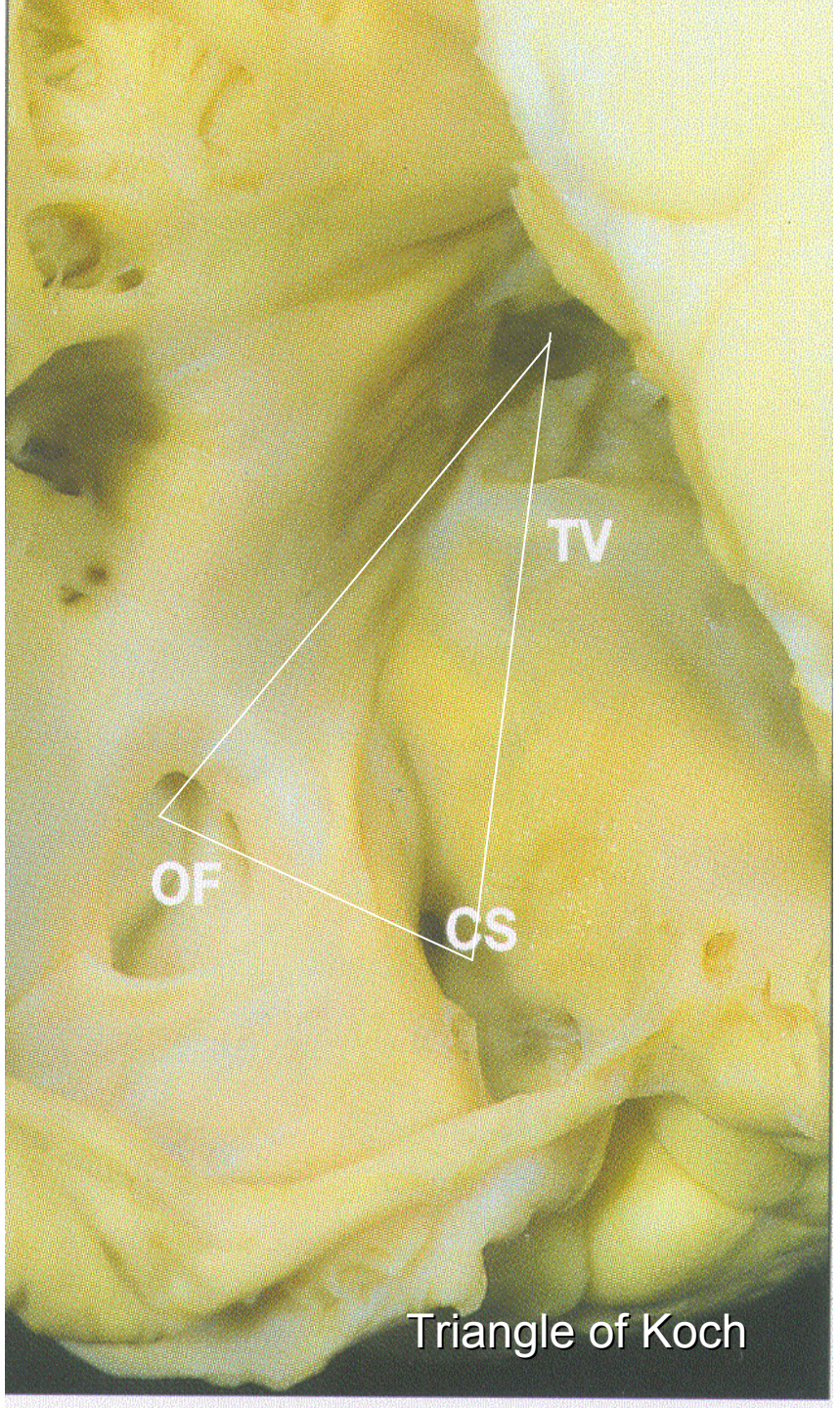
Right Anterior Oblique (RAO)





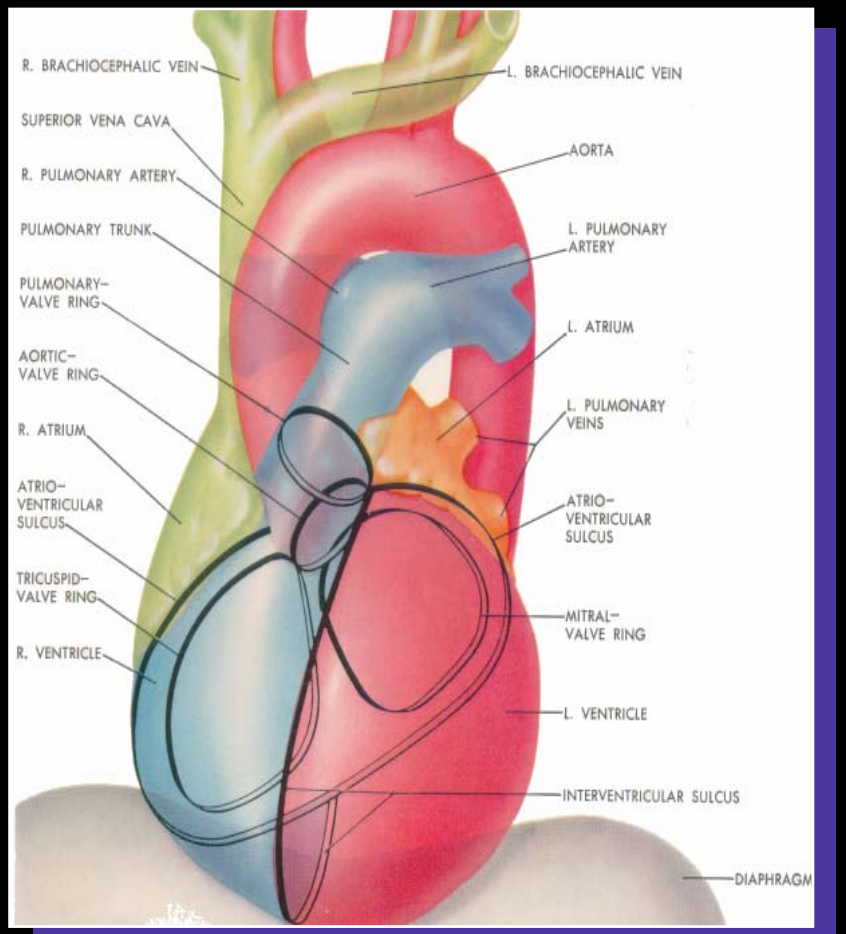


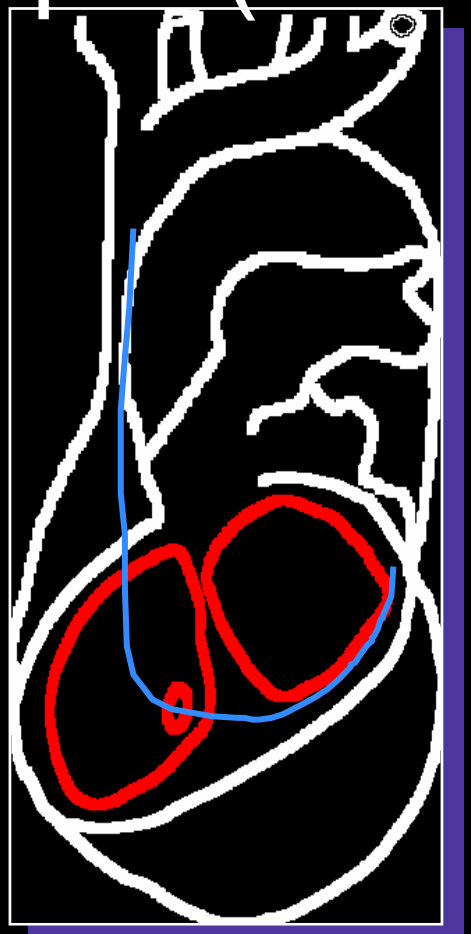
Right atrial holes

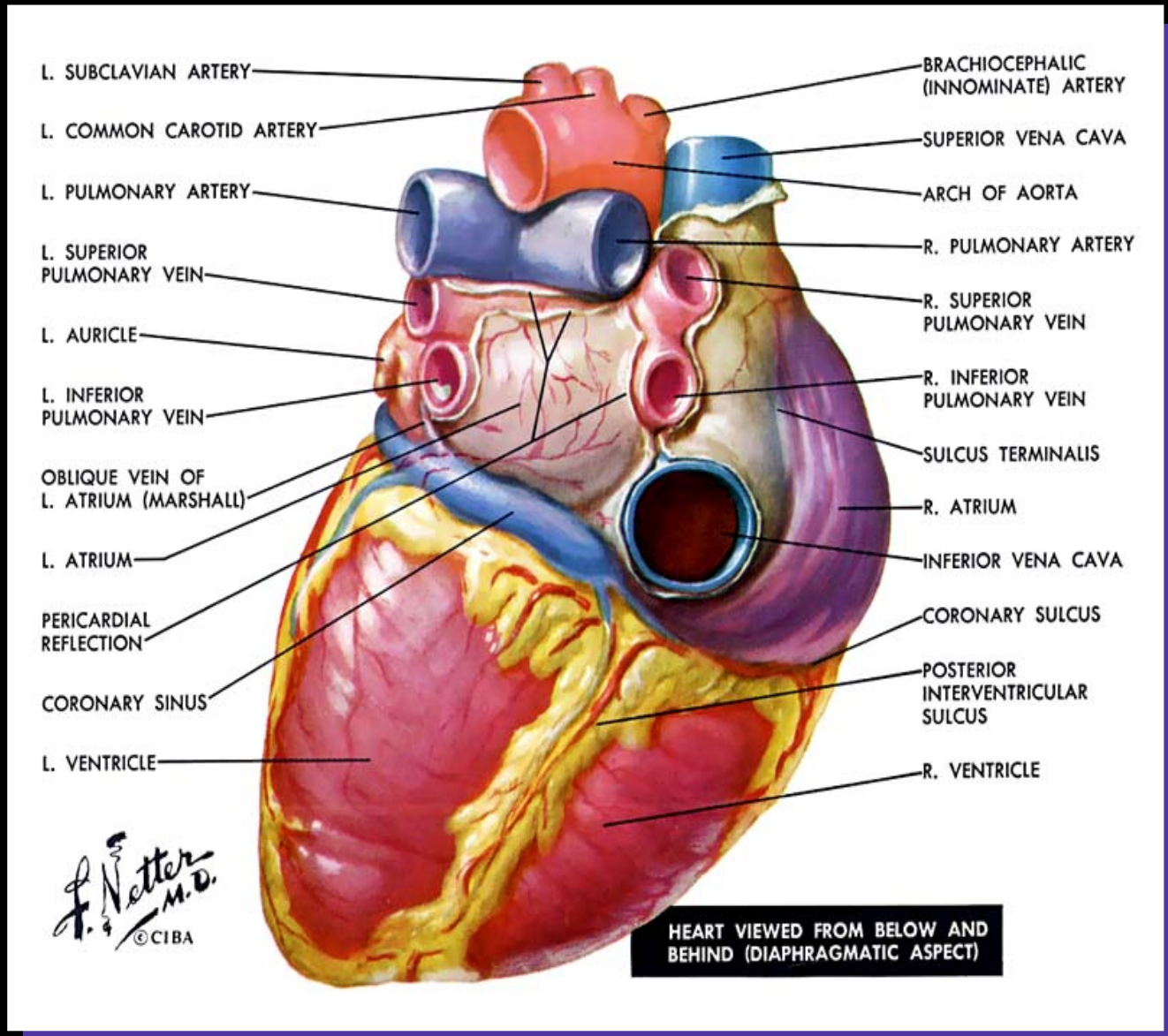


Triangle of Koch

Left Anterior Oblique (LAO)






L. SUBCLAVIAN ARTERY
L. COMMON CAROTID ARTERY
L. PULMONARY ARTERY
L. SUPERIOR PULMONARY VEIN
L. AURICLE
L. INFERIOR PULMONARY VEIN
OBLIQUE VEIN OF L. ATRIUM (MARSHALL)
L. ATRIUM
PERICARDIAL REFLECTION
CORONARY SINUS
L. VENTRICLE
BRACHIOCEPHALIC (INNOMINATE) ARTERY
SUPERIOR VENA CAVA
ARCH OF AORTA
R. PULMONARY ARTERY
R. SUPERIOR PULMONARY VEIN
R. INFERIOR PULMONARY VEIN
SULCUS TERMINALIS
R. ATRIUM
INFERIOR VENA CAVA
CORONARY SULCUS
POSTERIOR INTERVENTRICULAR SULCUS
R. VENTRICLE
F. Netter M.D.
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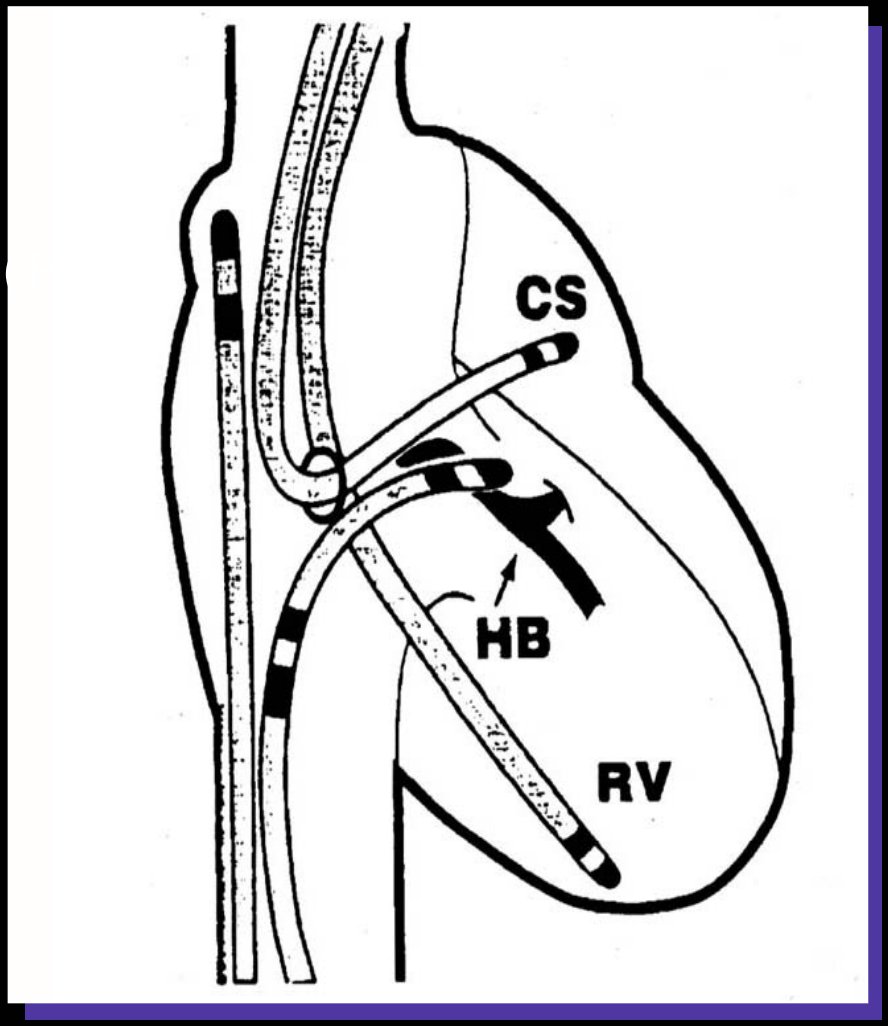
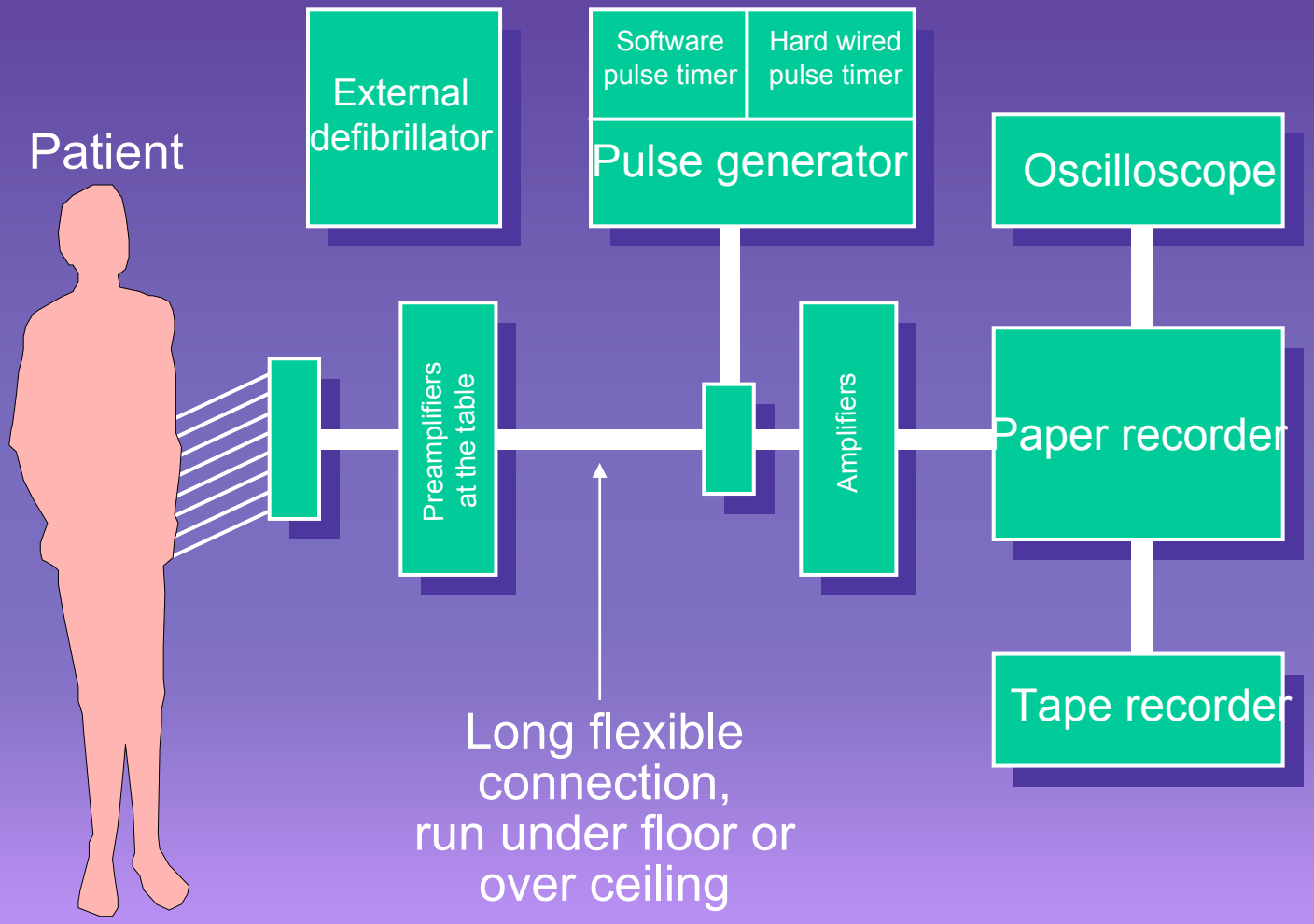
HEART VIEWED FROM BELOW AND BEHIND (DIAPHRAGMATIC ASPECT)

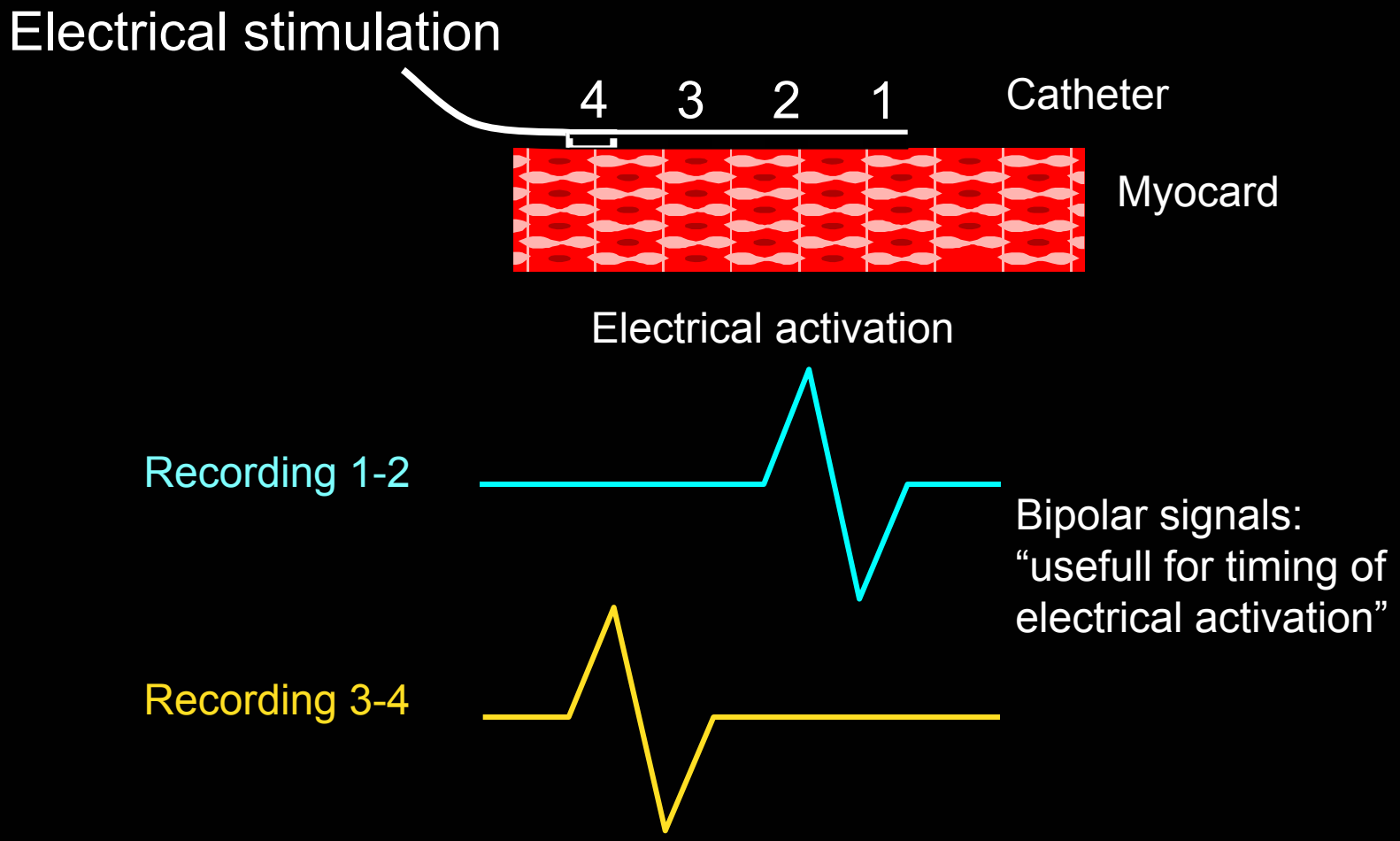
Typical Catheter Placement



Equipment

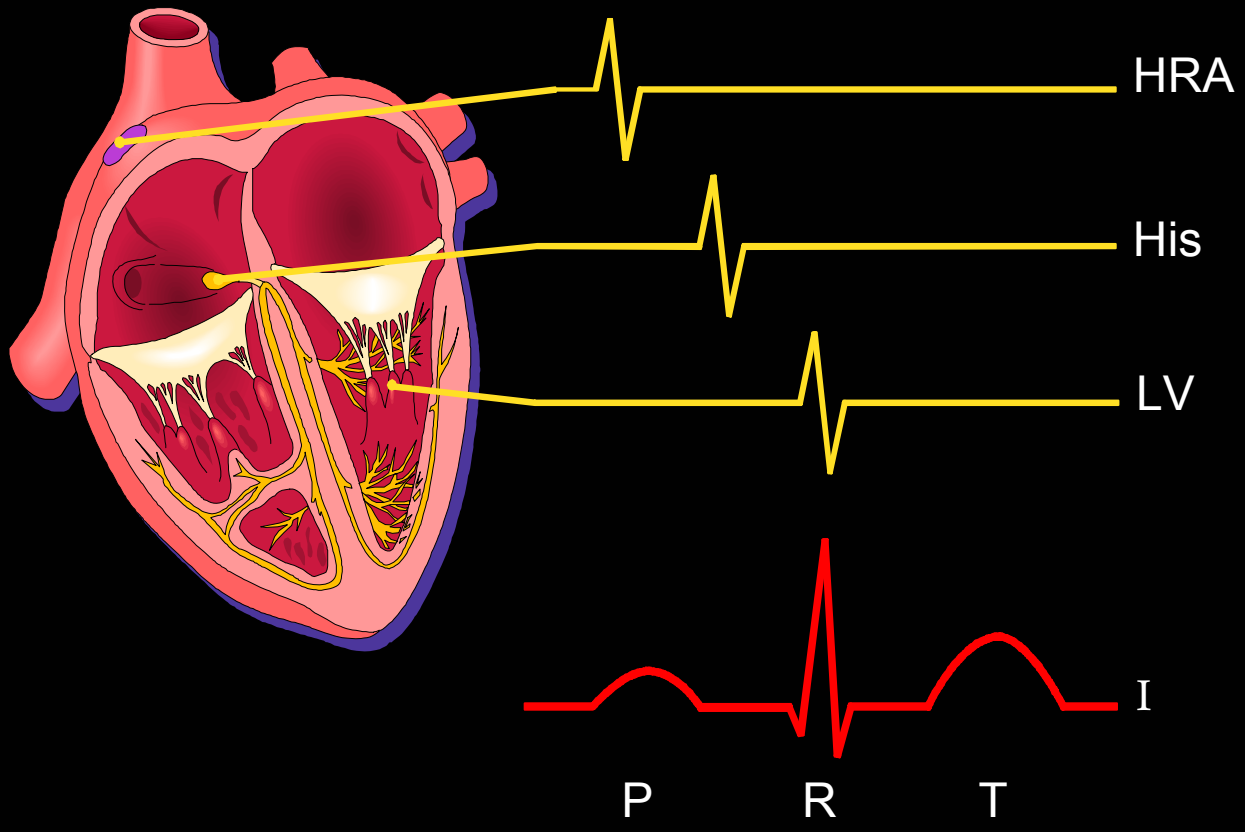

Patient
External defibrillator
Software pulse timer
Hard wired pulse timer
Pulse generator
Oscilloscope
Preamplifiers at the table
Amplifiers
Paper recorder
Tape recorder
Long flexible connection, run under floor or over ceiling

Recordings of electrical activation

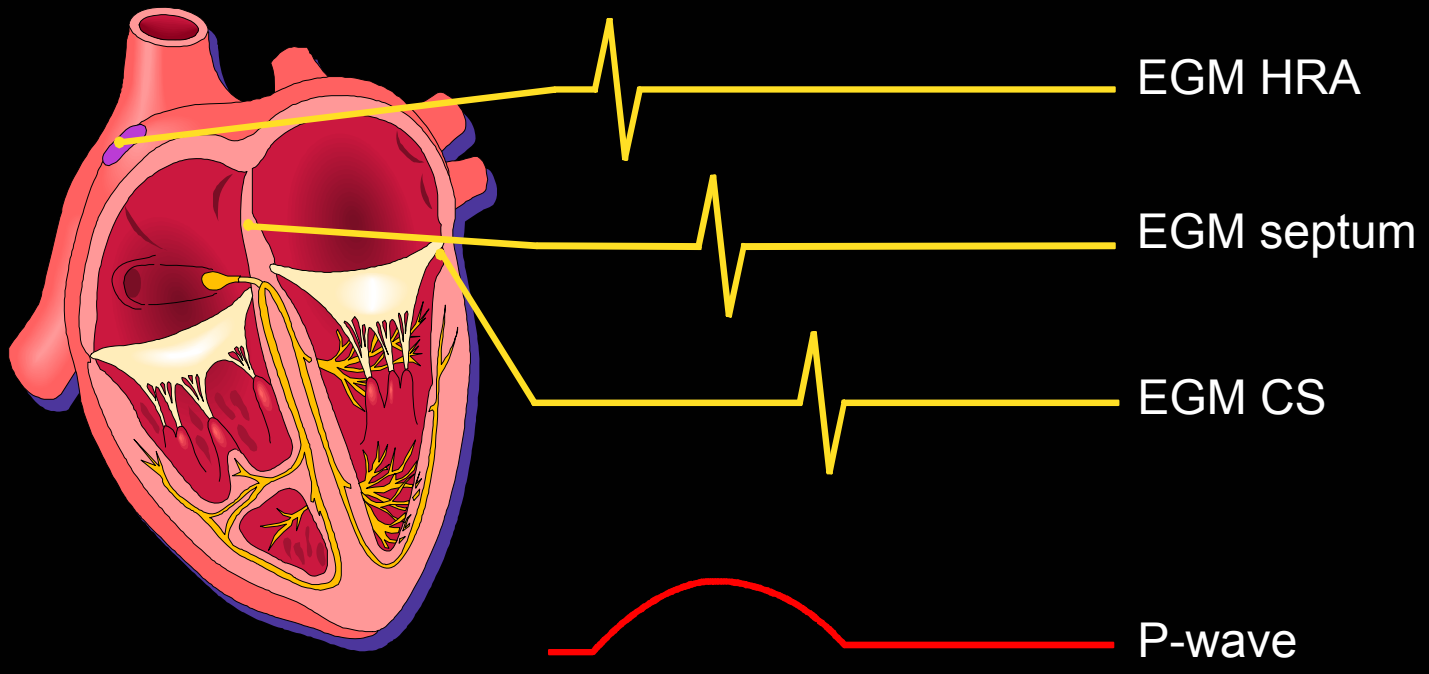


Recordings of electrical activation

Recordings from specific sites



Activitation sequence



Timing relationship of the activation of different sites

BASIC ELECTROPHYSIOLOGICAL STUDY

BASIC INTERVALS

SINUS NODE FUNCTION: SNRT
SACT
SN-EGM

ANTEGRADE PROPERTIES: INCREMENTAL ATRIAL PACING
ATRIAL EXTRASTIMULI TESTING

RETROGRADE PROPERTIES: INCREMENTAL VENT. PACING
VENT. EXTRASTIMULI TESTING

INDUCED TACHYCARDIA MECHANISM AND CHARACTERISTICS

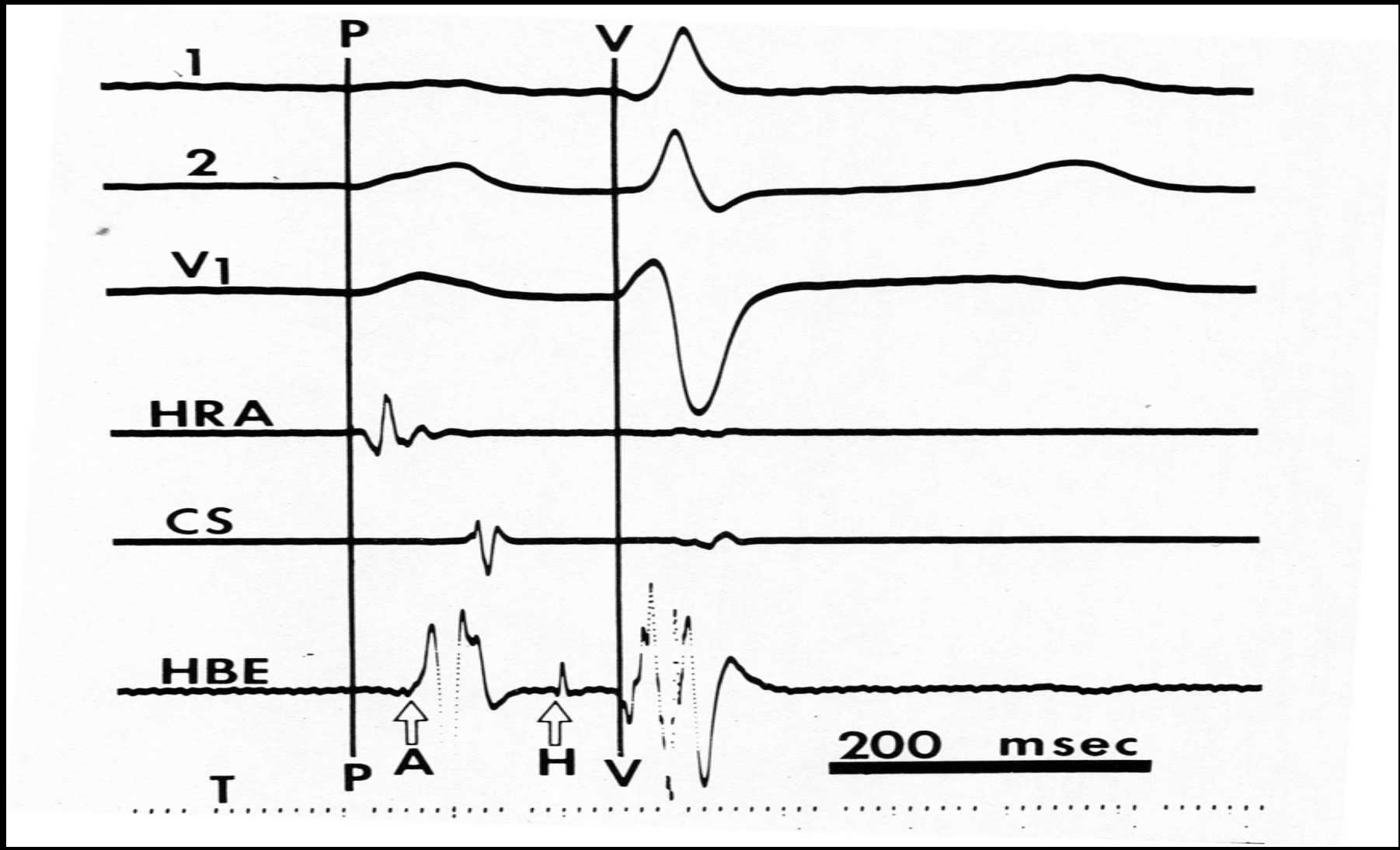

P
V
1
2
V1
HRA
CS
HBE
A
H
P
V
T
200 msec

Table 3–1. *Normal Conduction Intervals in Adults*

Laboratory	*P–A*	*A–H*	*H–V*	*H*
Narula[2,5]	25–60	50–120	35–45	25
Damato[1,3,18,28]	24–45	60–140	30–55	10–15
Castellanos[6]	20–50	50–120	25–55	
Schuilenburg[23,24]		85–150	35–55	
Peuch[4,14]	30–55	45–100	35–55	
Bekheit[25,26]	10–50	50–125	35–45	15–25
Rosen[27]	9–45	54–130	31–55	
Author		60–125	35–55	10–25

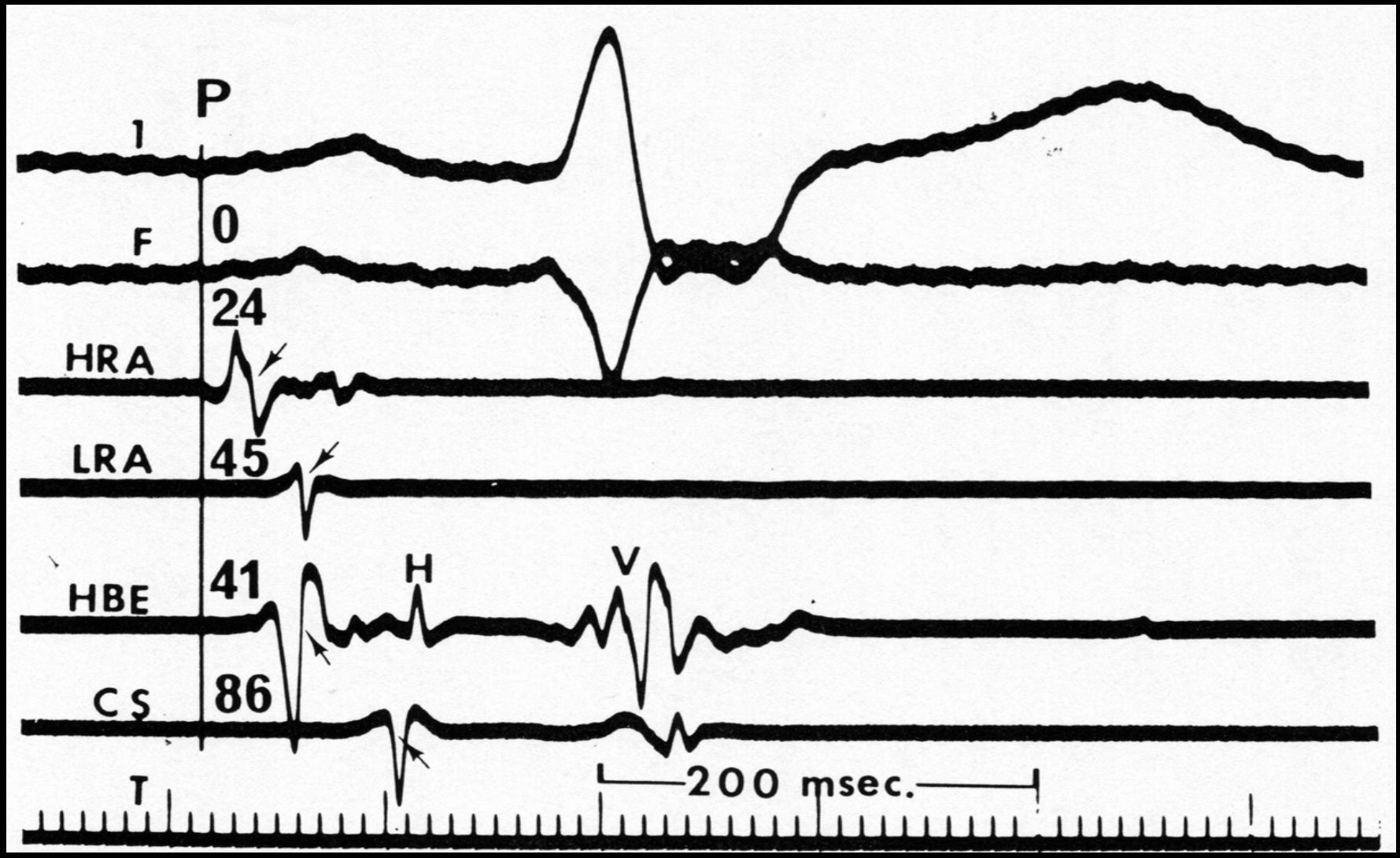
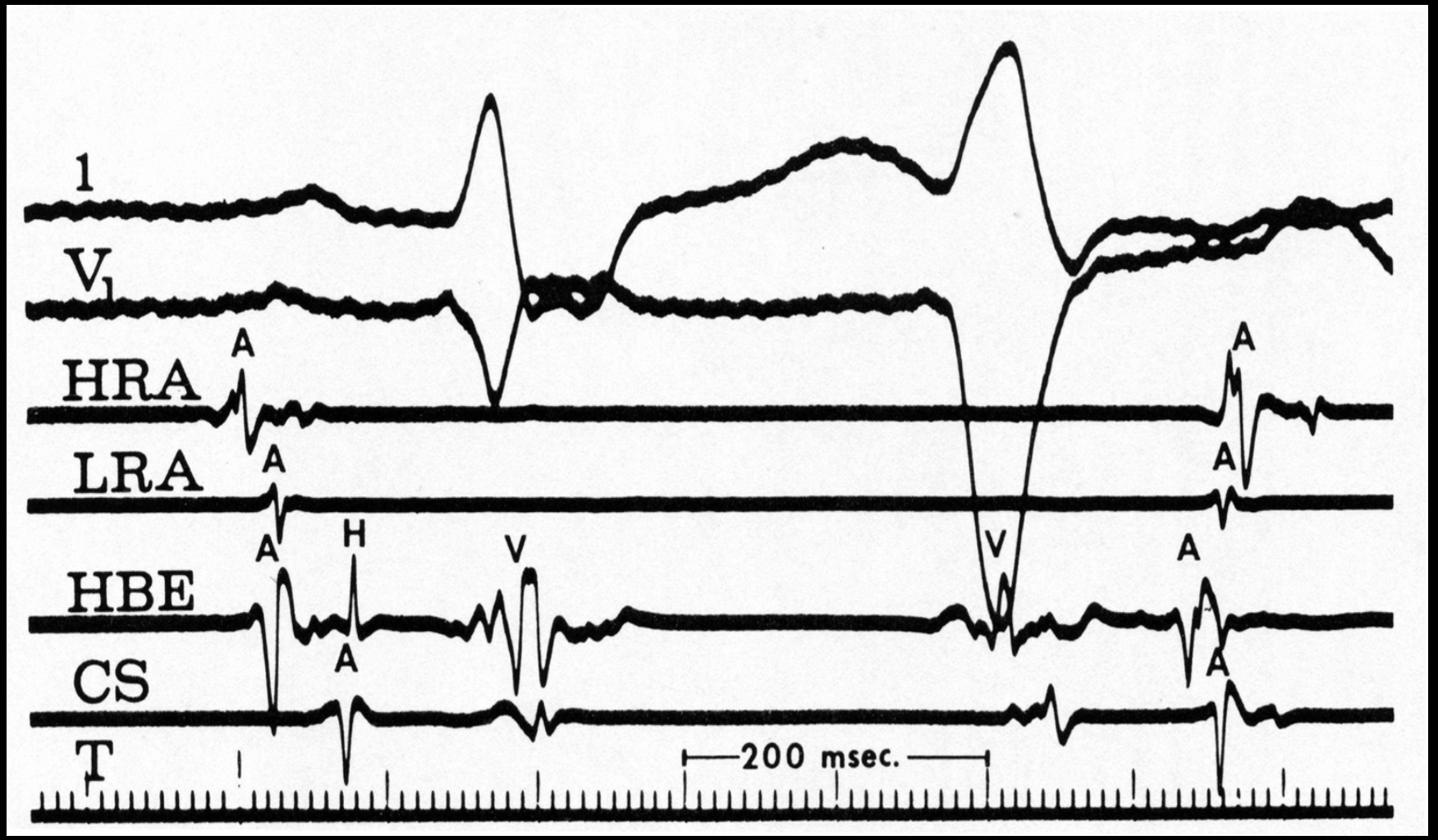
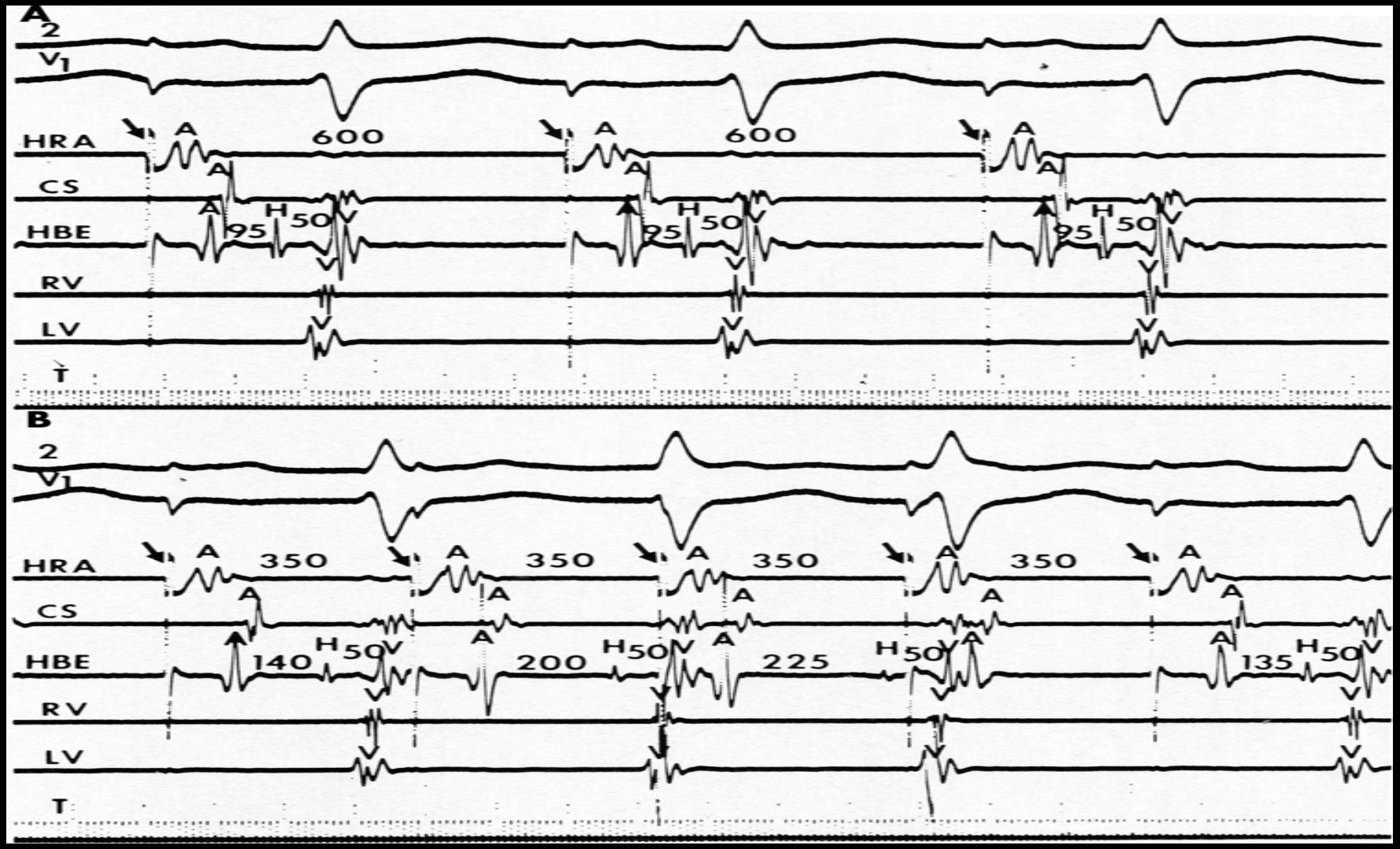
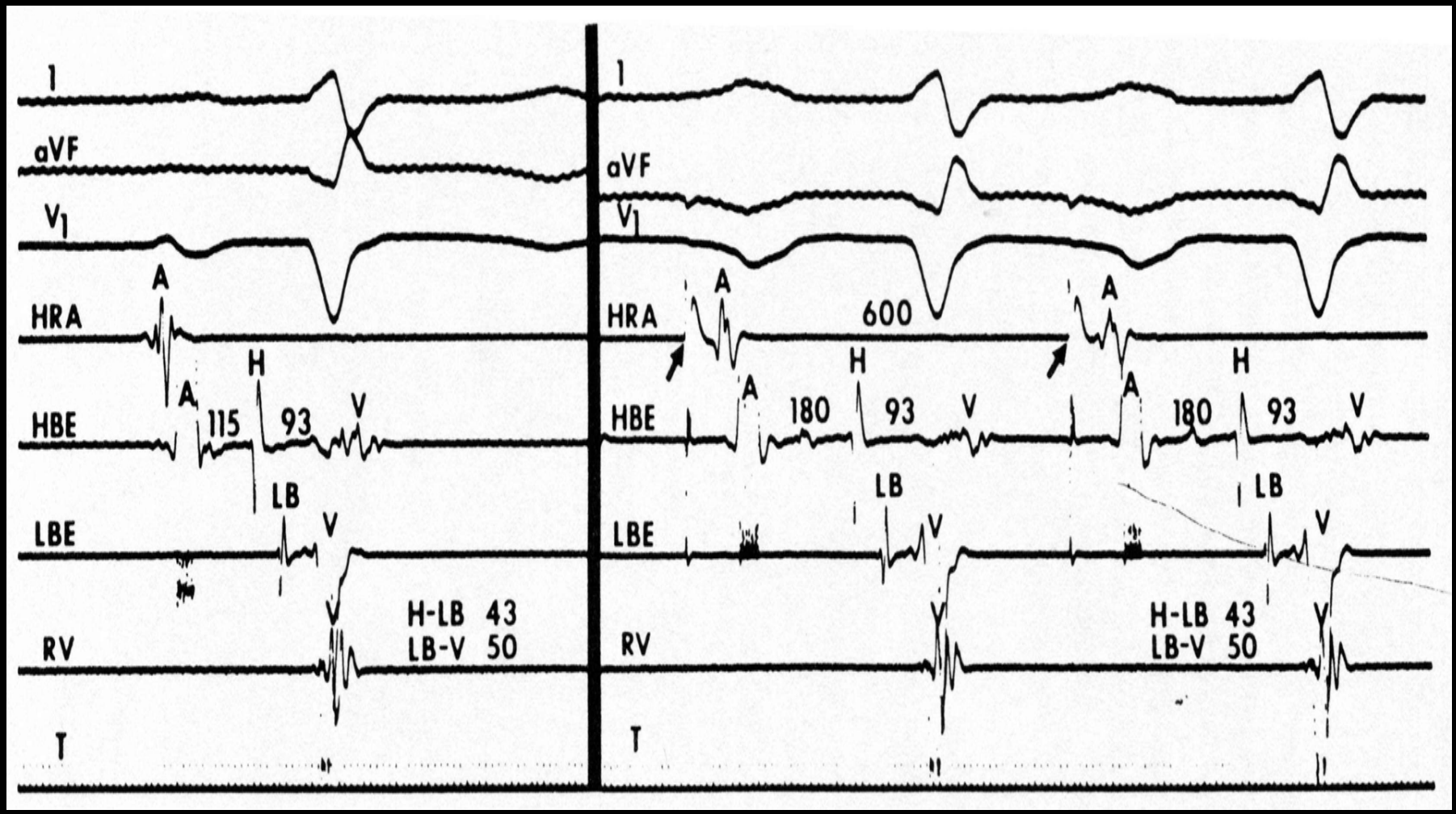

P
I
F
0
24
HRA
LRA
45
41
H
V
HBE
CS
86
T
200 msec.

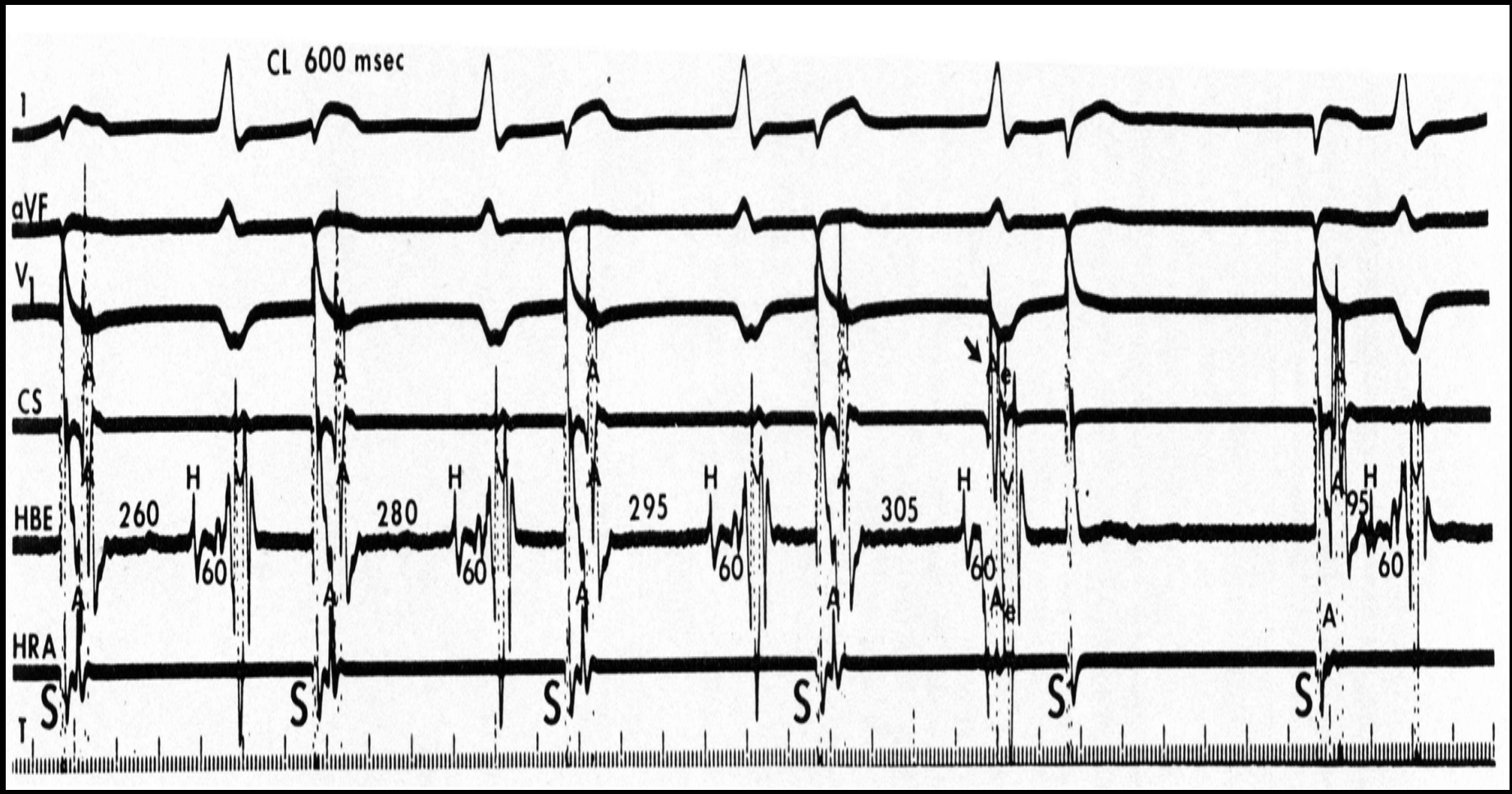
Table 3–1. *Normal Conduction Intervals in Adults*

Laboratory	*P–A*	*A–H*	*H–V*	*H*
Narula[2,5]	25–60	50–120	35–45	25
Damato[1,3,18,28]	24–45	60–140	30–55	10–15
Castellanos[6]	20–50	50–120	25–55	
Schuilenburg[23,24]		85–150	35–55	
Peuch[4,14]	30–55	45–100	35–55	
Bekheit[25,26]	10–50	50–125	35–45	15–25
Rosen[27]	9–45	54–130	31–55	
Author		60–125	35–55	10–25

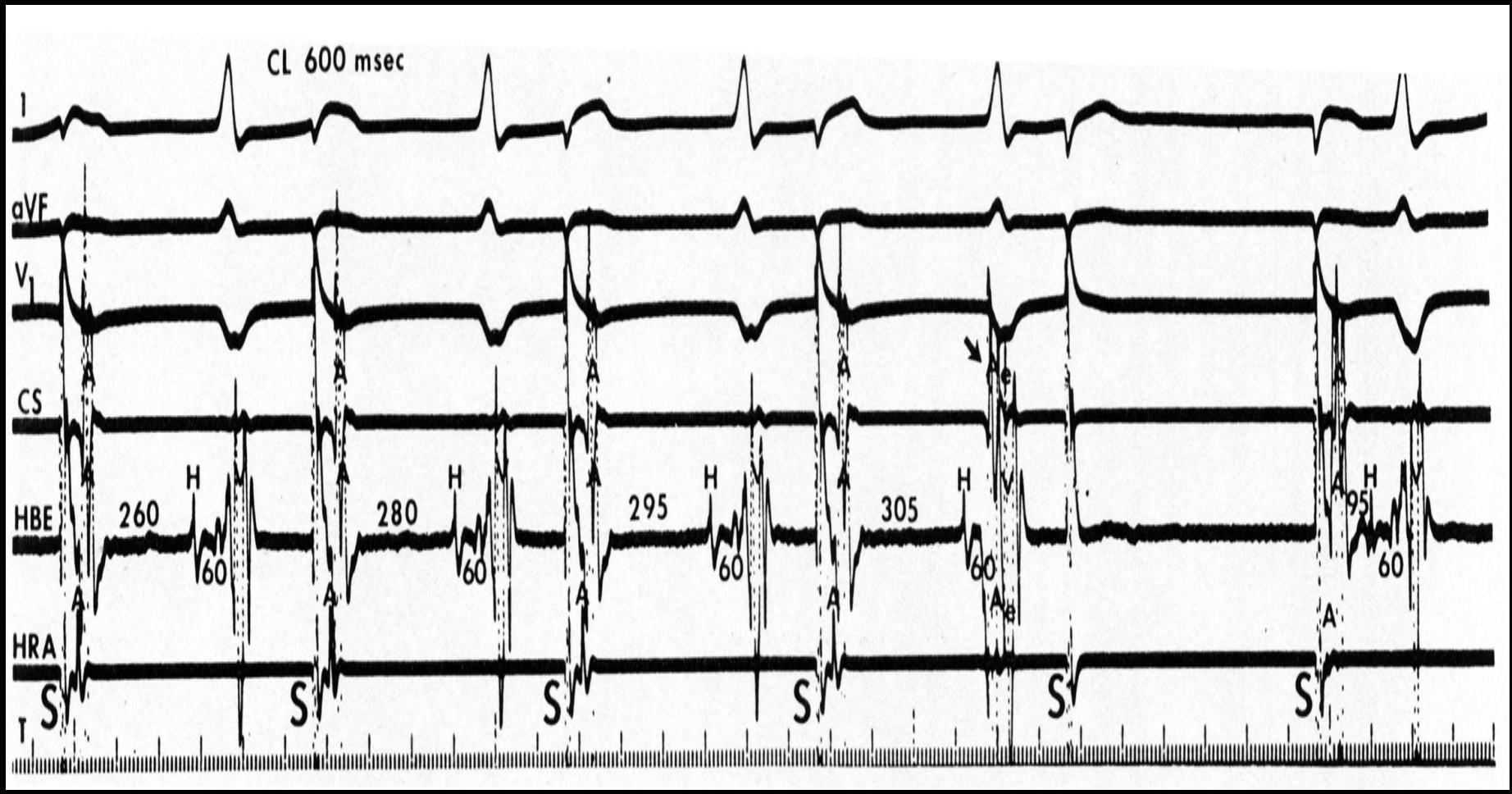

1
V1
HRA
LRA
HBE
CS
T
A
A
A
A
H
A
V
V
A
A
200 msec.

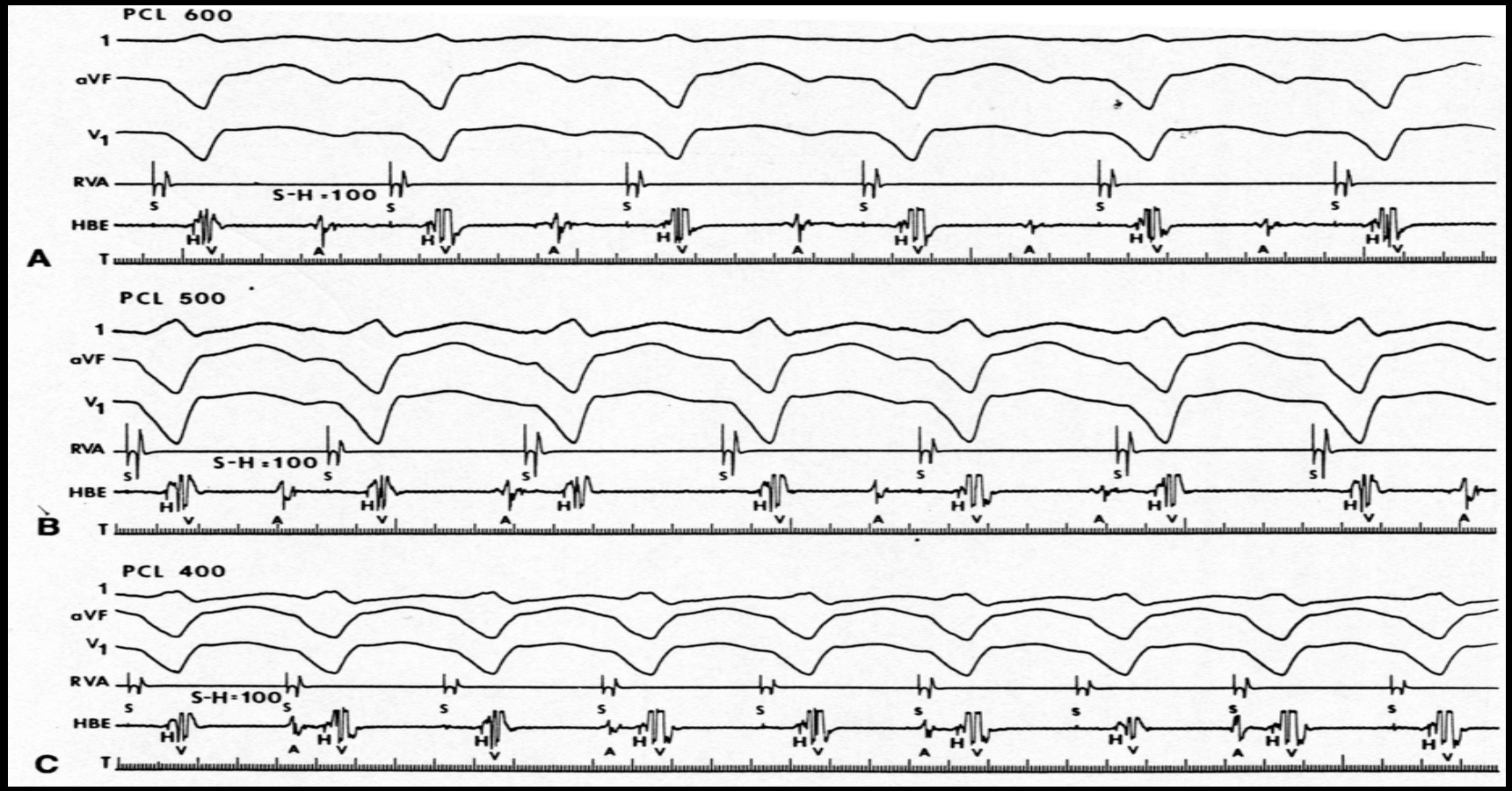

A
2
V1
HRA
CS
HBE
RV
LV
T
A
600
A
600
A
A
A
A
A
H
95
50
H
95
50
H
95
50
V
V
V
V
V
V
B
2
V1
HRA
CS
HBE
RV
LV
T
A
350
A
350
A
350
A
350
A
A
A
A
A
A
A
A
A
H
140
50
H
200
50
H
225
50
H
135
50
V
V
V
V
V
V

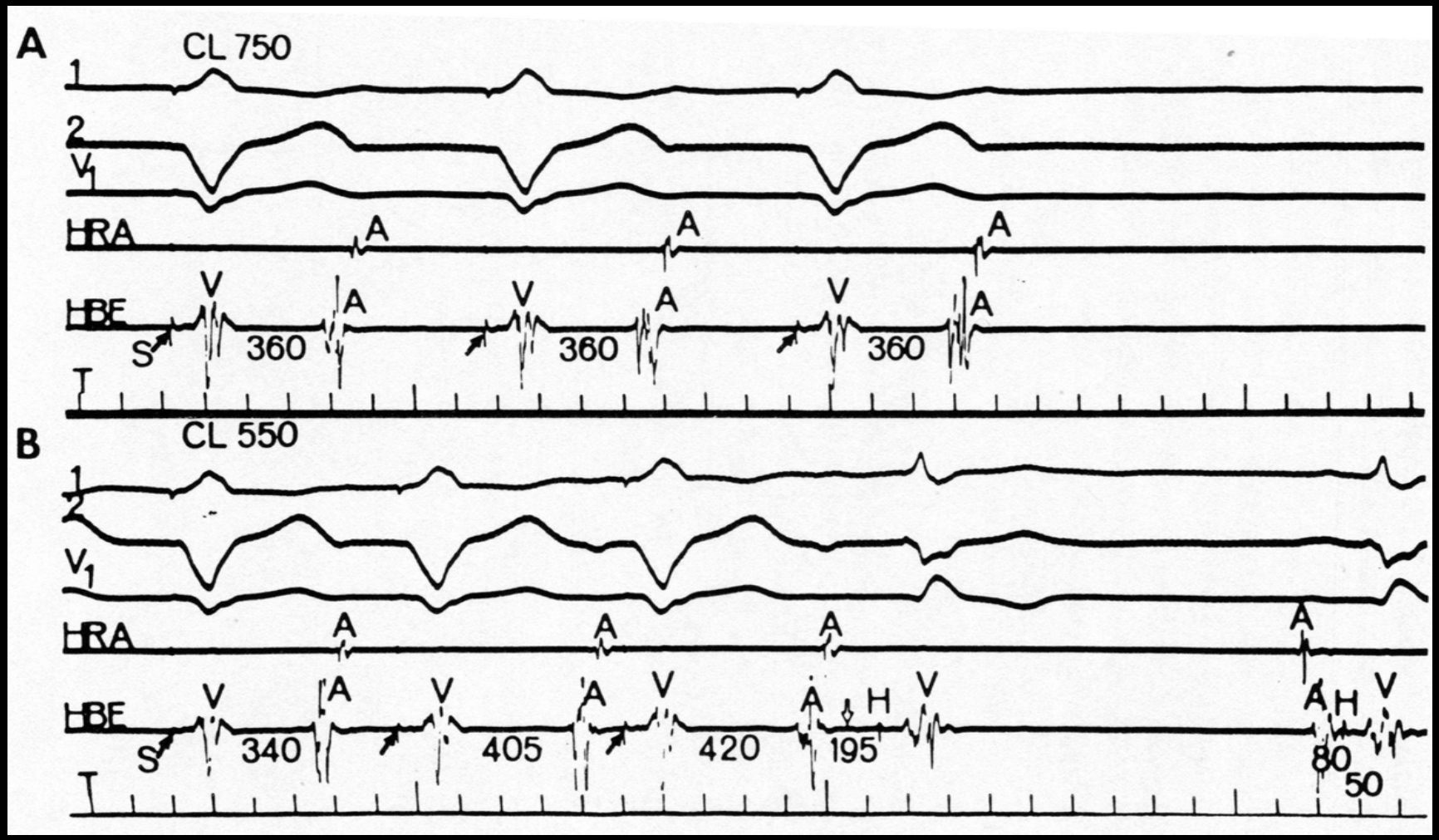

I
aVF
V1
HRA
A
H
A
HBE
115
93
V
LB
LBE
V
H-LB 43
LB-V 50
RV
T
600
180


CL 600 msec
I
aVF
V1
CS
HBE
HRA
T
260
280
295
305
95
60
H
A
V
S

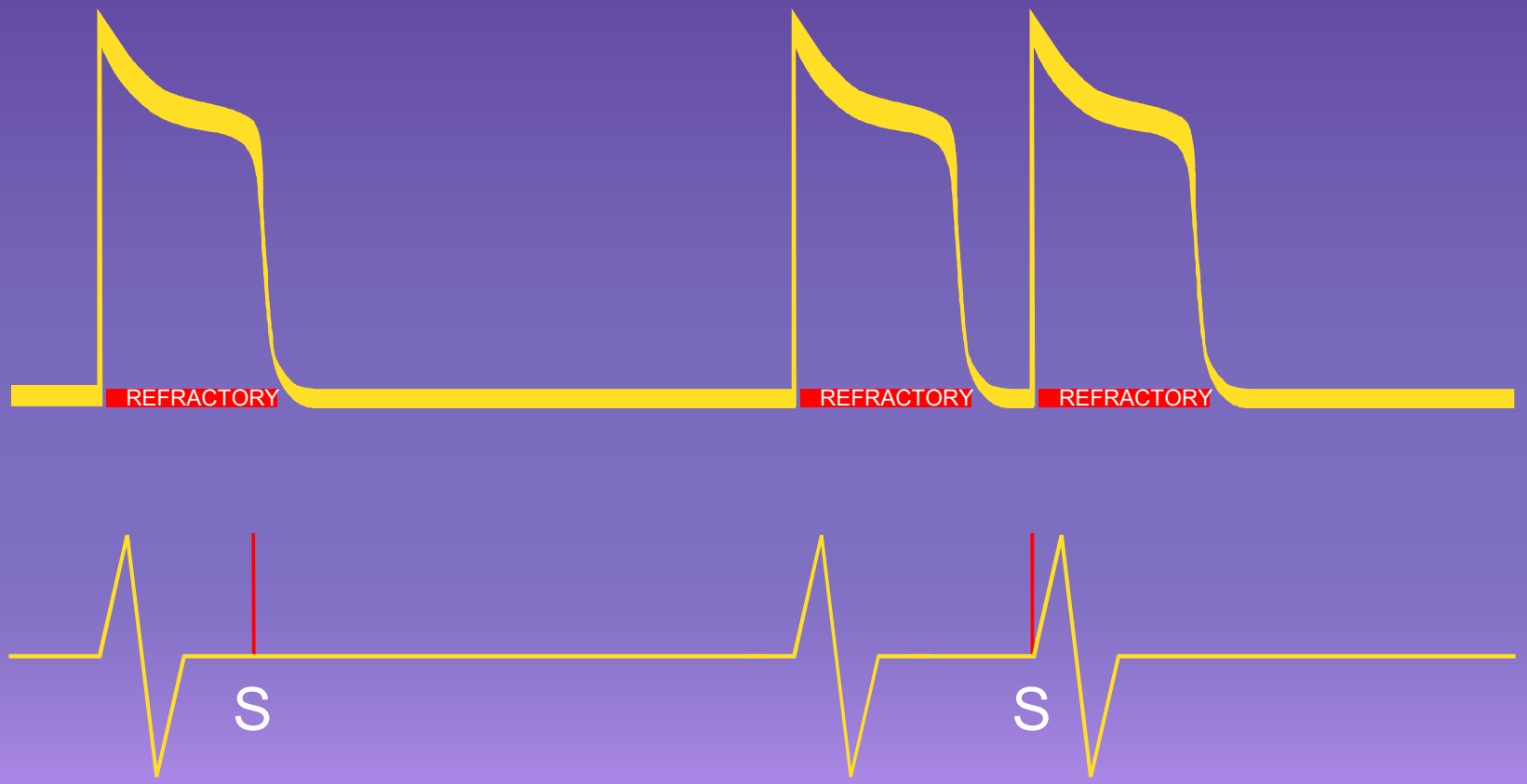

CL 290
1
2
3
V1
HRA
HBE
T
A
V
H
130


CL 600 msec
I
aVF
V1
CS
HBE
HRA
T
260
280
295
305
95
60
H
A
V
S


PCL 600
1
aVF
V1
RVA
S-H=100
HBE
T
A
PCL 500
1
aVF
V1
RVA
S-H=100
HBE
T
B
PCL 400
1
aVF
V1
RVA
S-H=100
HBE
T
C

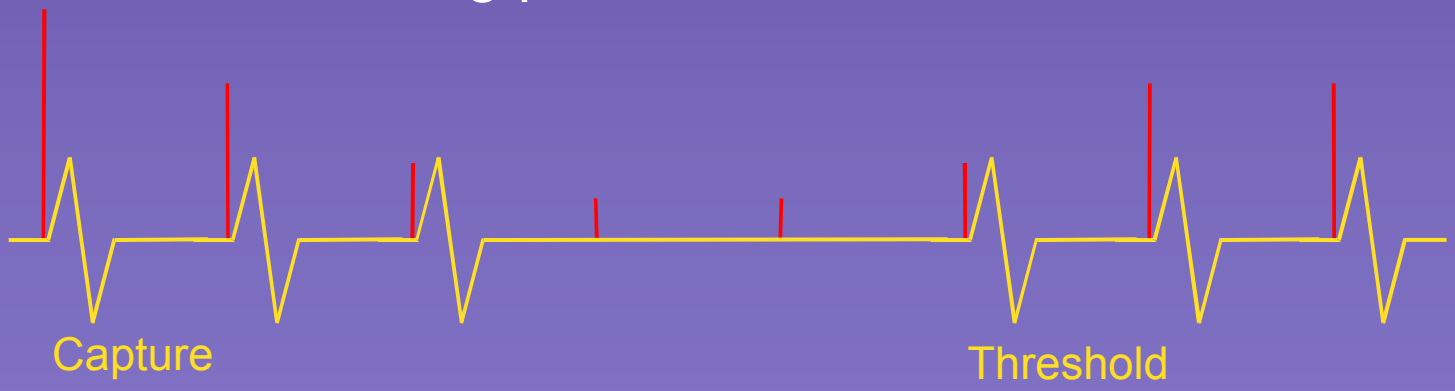

A
CL 750
1
2
V1
HRA
A
A
A
HBE
V
A
V
A
V
A
S
360
360
360
B
CL 550
1
2
V1
HRA
A
A
A
A
HBE
V
A
V
A
V
A
H
V
A
H
V
S
340
405
420
195
80
50

Refractoriness

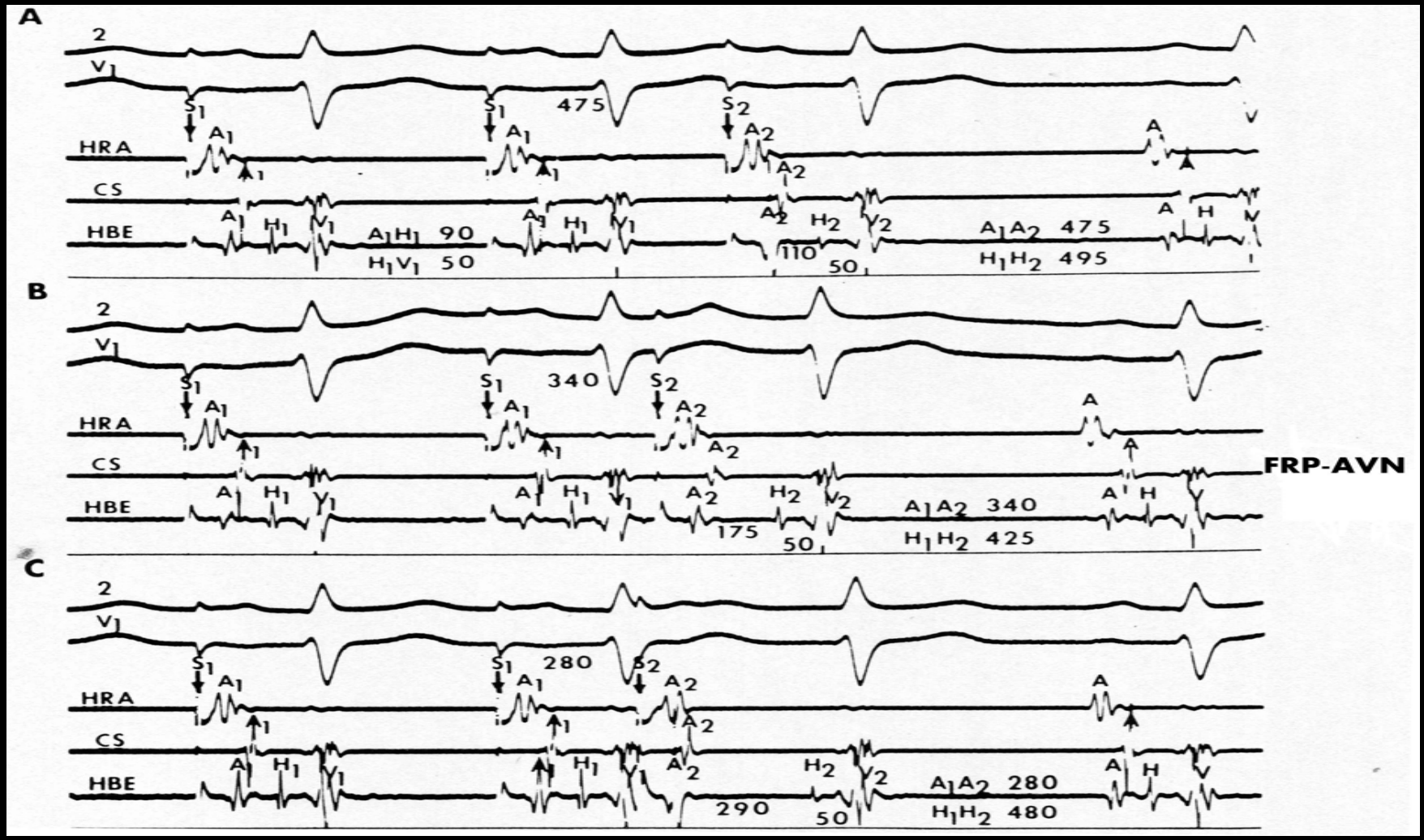


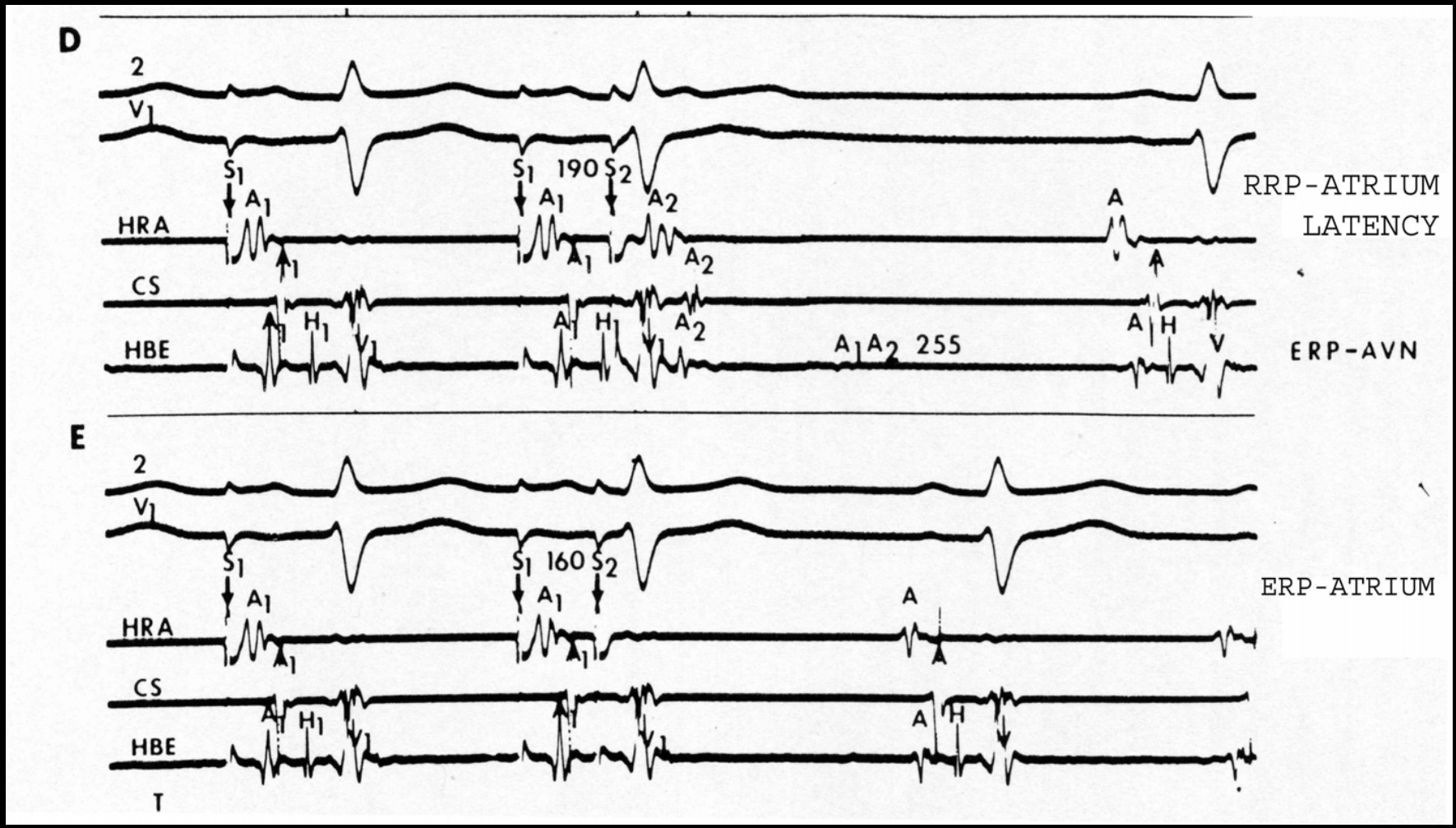
Stimulation threshold

- Stimulation threshold (minimum energy to “activate” the cells in close contact with the electrode)
- An all or nothing phenomenon



- Decrease the stimulation output until capture is lost, increase the output until capture is regained
- Multiply the output at threshold with 2 to set the output

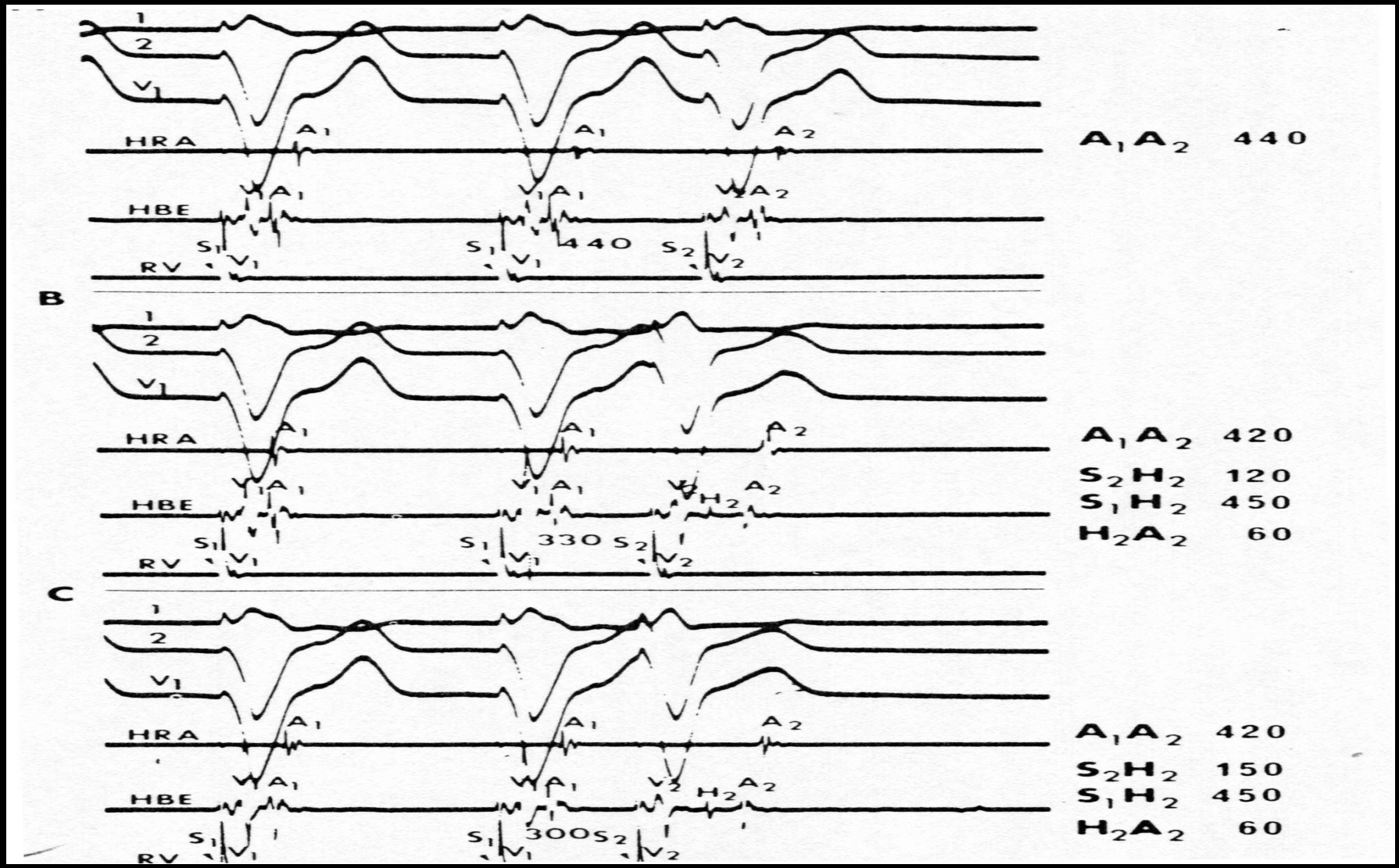

A
2
V1
S1
S1
475
S2
A1
A1
A2
HRA
A
CS
HBE
A1
H1
V1
A1H1 90
H1V1 50
A1
H1
V1
A2
H2
V2
110
50
A1A2 475
H1H2 495
A
H
V
B
2
V1
S1
S1
340
S2
A1
A1
A2
HRA
A
CS
HBE
A1
H1
V1
A1
H1
V1
A2
H2
V2
175
50
A1A2 340
H1H2 425
A
H
V
FRP-AVN
C
2
V1
S1
S1
280
S2
A1
A1
A2
HRA
A
CS
HBE
A1
H1
V1
A2
H2
V2
290
50
A1A2 280
H1H2 480
A
H
V

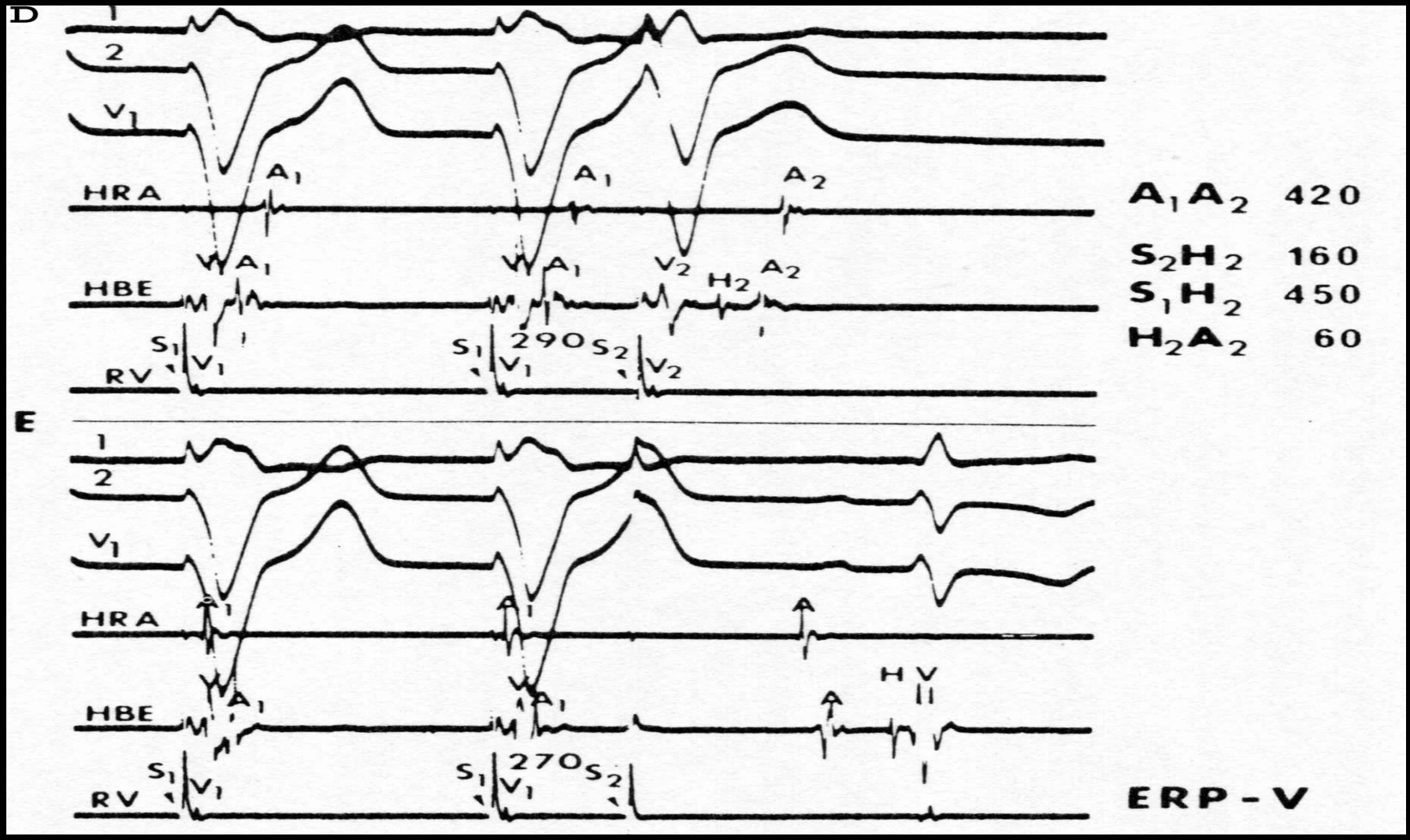

D
2
V1
S1
A1
S1
190
S2
A1
A2
A
HRA
A1
A2
CS
H1
A
H1
A2
A
H
HBE
V1
V1
A1A2 255
V
RRP-ATRIUM
LATENCY
ERP-AVN
E
2
V1
S1
A1
S1
160
S2
A1
A
HRA
A1
A1
CS
A
H1
A
H
HBE
T
ERP-ATRIUM

Atrial refractory period

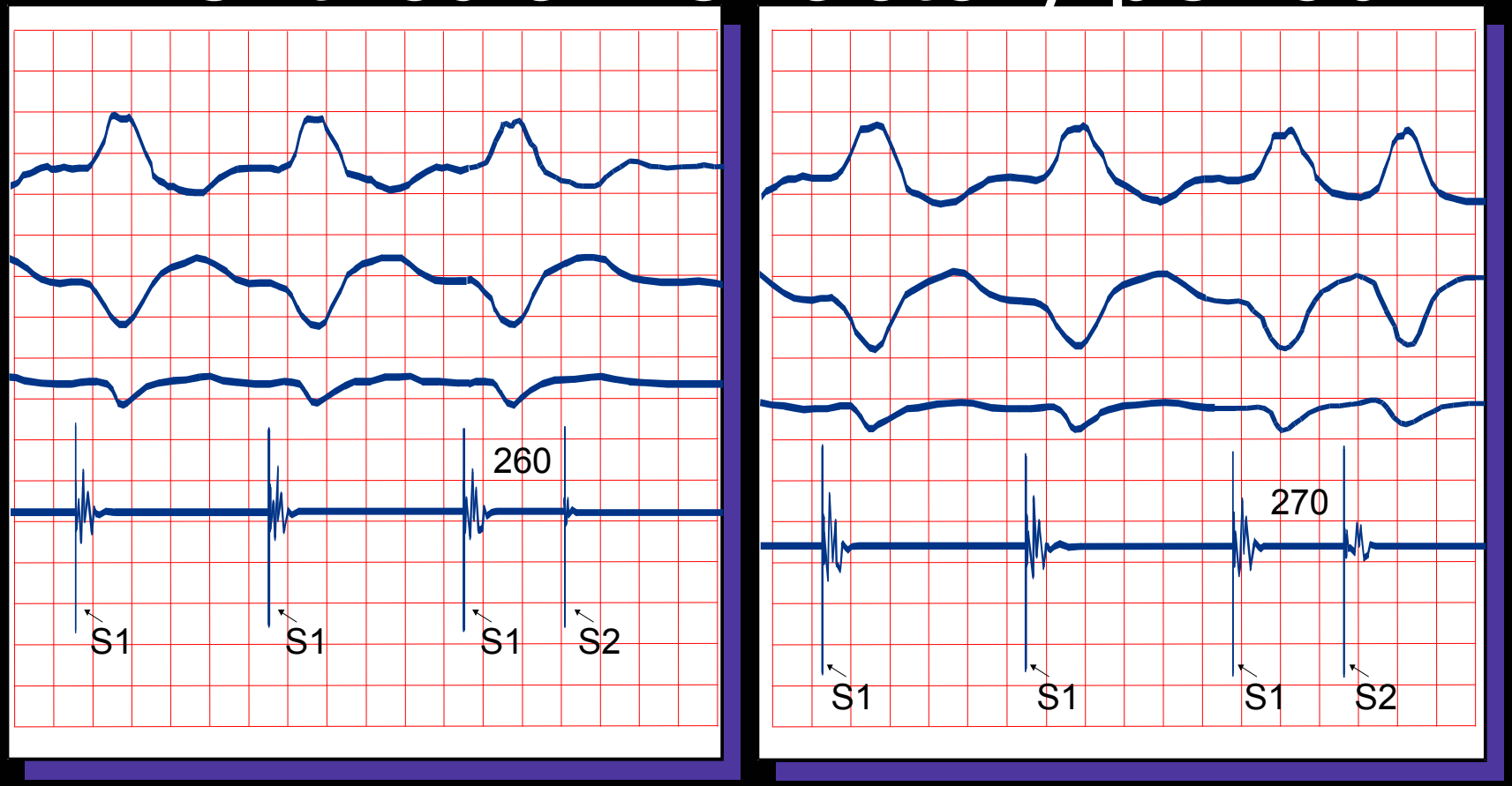
Table 3–5. *Normal Refractory Periods in Adults*

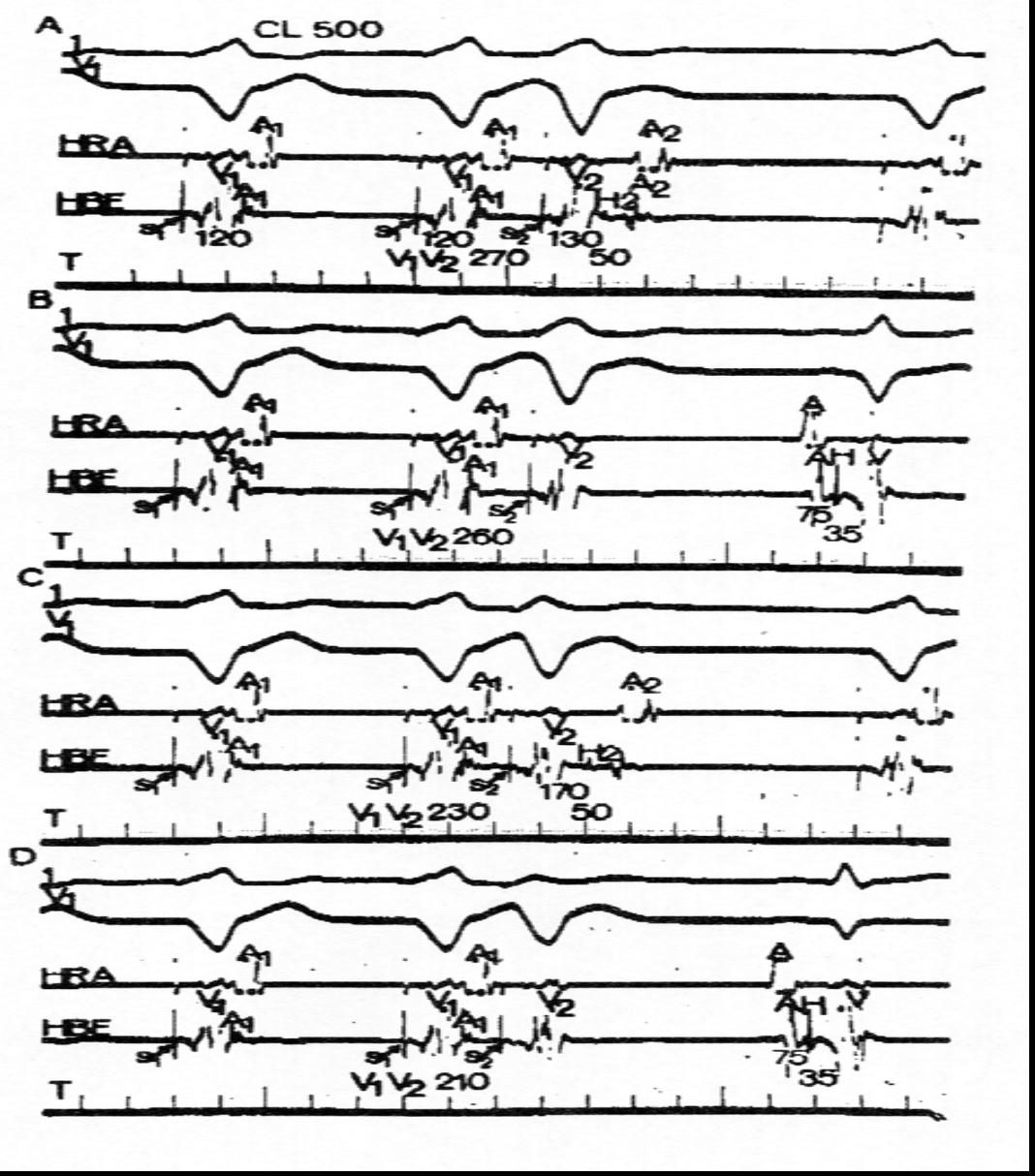
Laboratory	*ERP Atrium*	*ERP AVN*	*FRP AVN*	*ERP HPS*	*ERP V*
Denes[78]	150–360	250–365	350–495	—	—
Akhtar[66*]	230–330	280–430	320–680	340–430	190–290
Schuilenburg[23]	—	230–390	330–500	—	—
Author	170–300	230–425	330–525	330–450	170–290

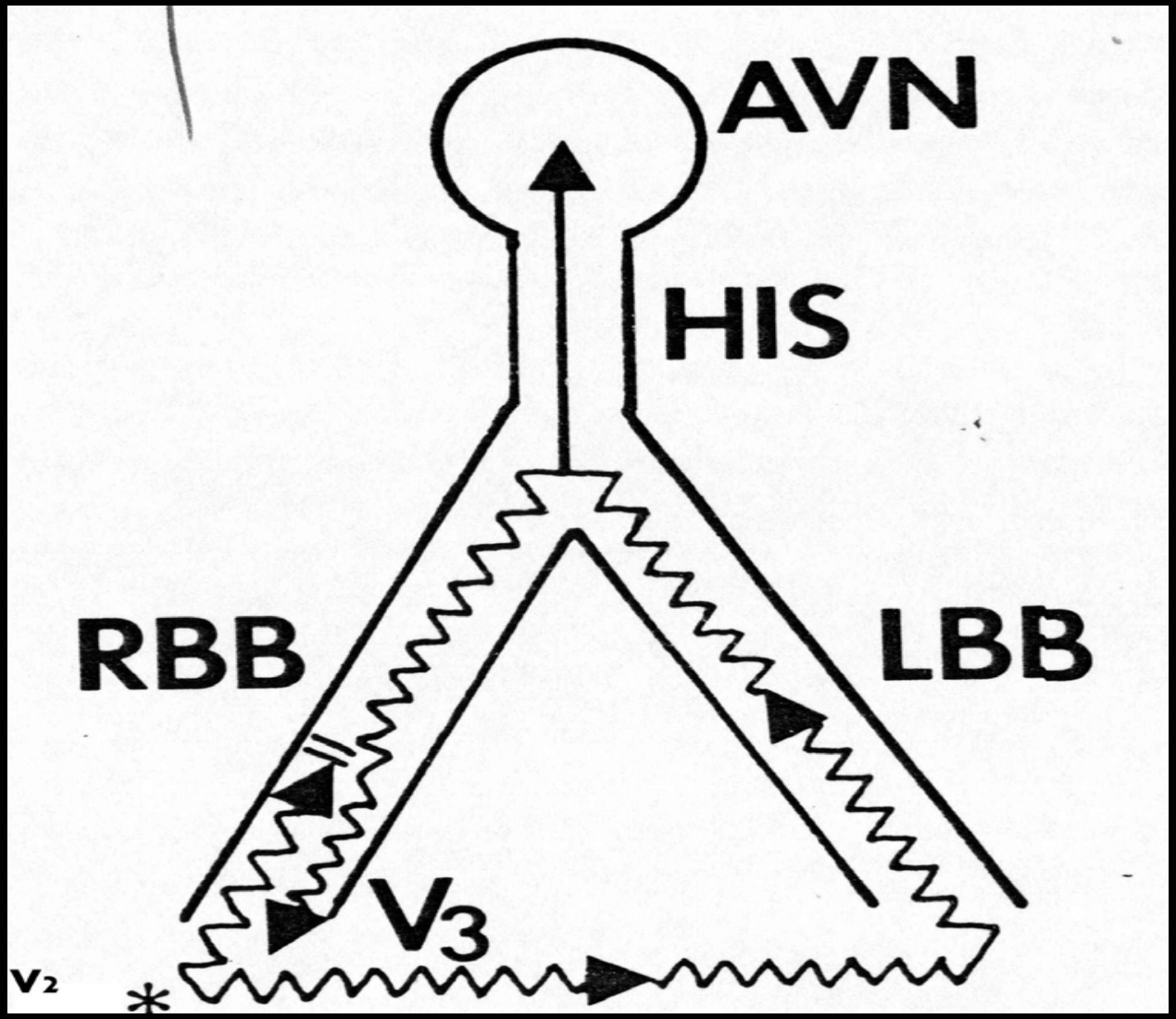

1
2
V1
HRA
A1
A1
A2
HBE
V1
A1
V1
A1
V2
A2
S1
S1
440
S2
RV
V1
V1
V2
A1A2 440
B
1
2
V1
HRA
A1
A1
A2
HBE
V1
A1
V1
A1
V2
H2
A2
S1
S1
330
S2
RV
V1
V2
A1A2 420
S2H2 120
S1H2 450
H2A2 60
C
1
2
V1
HRA
A1
A1
A2
HBE
V1
A1
V2
H2
A2
S1
S1
300
S2
RV
V1
V2
A1A2 420
S2H2 150
S1H2 450
H2A2 60


D
1
2
V1
HRA
A1
A1
A2
HBE
A1
V2
H2
A2
S1
V1
RV
S1
290
S2
V1
V2
A1A2 420
S2H2 160
S1H2 450
H2A2 60
E
1
2
V1
HRA
A1
HBE
A1
H
V
S1
V1
RV
S1
270
S2
V1
ERP-V

Ventricular refractory period




A
CL 500
I
V1
HRA
HBE
A1
A2
H2
S1
S2
120
120
130
V1V2 270
50
T
B
A
AH
V
75
35
V1V2 260
C
170
V1V2 230
50
D
210


AVN
HIS
RBB
LBB
V3
V2

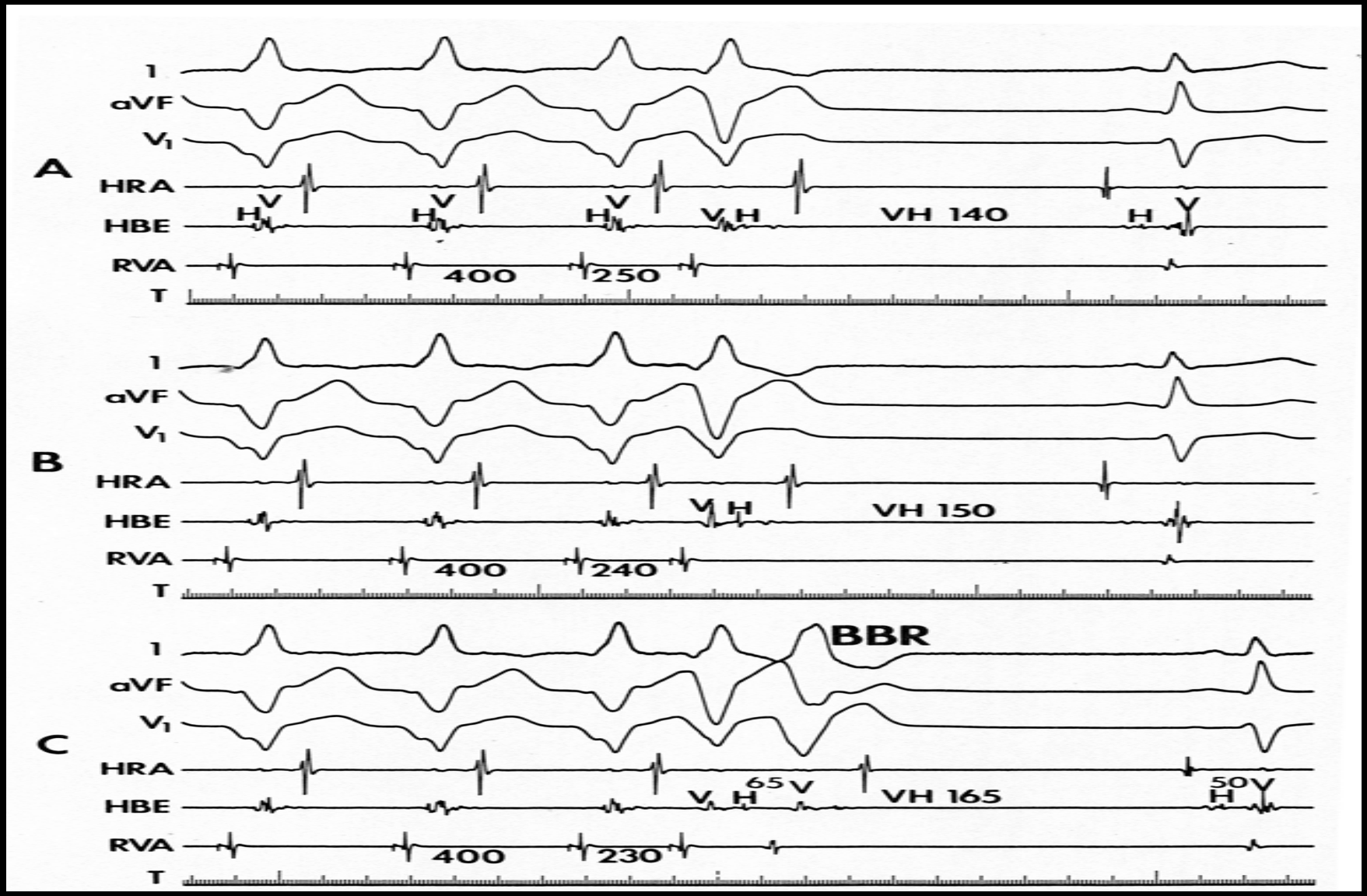
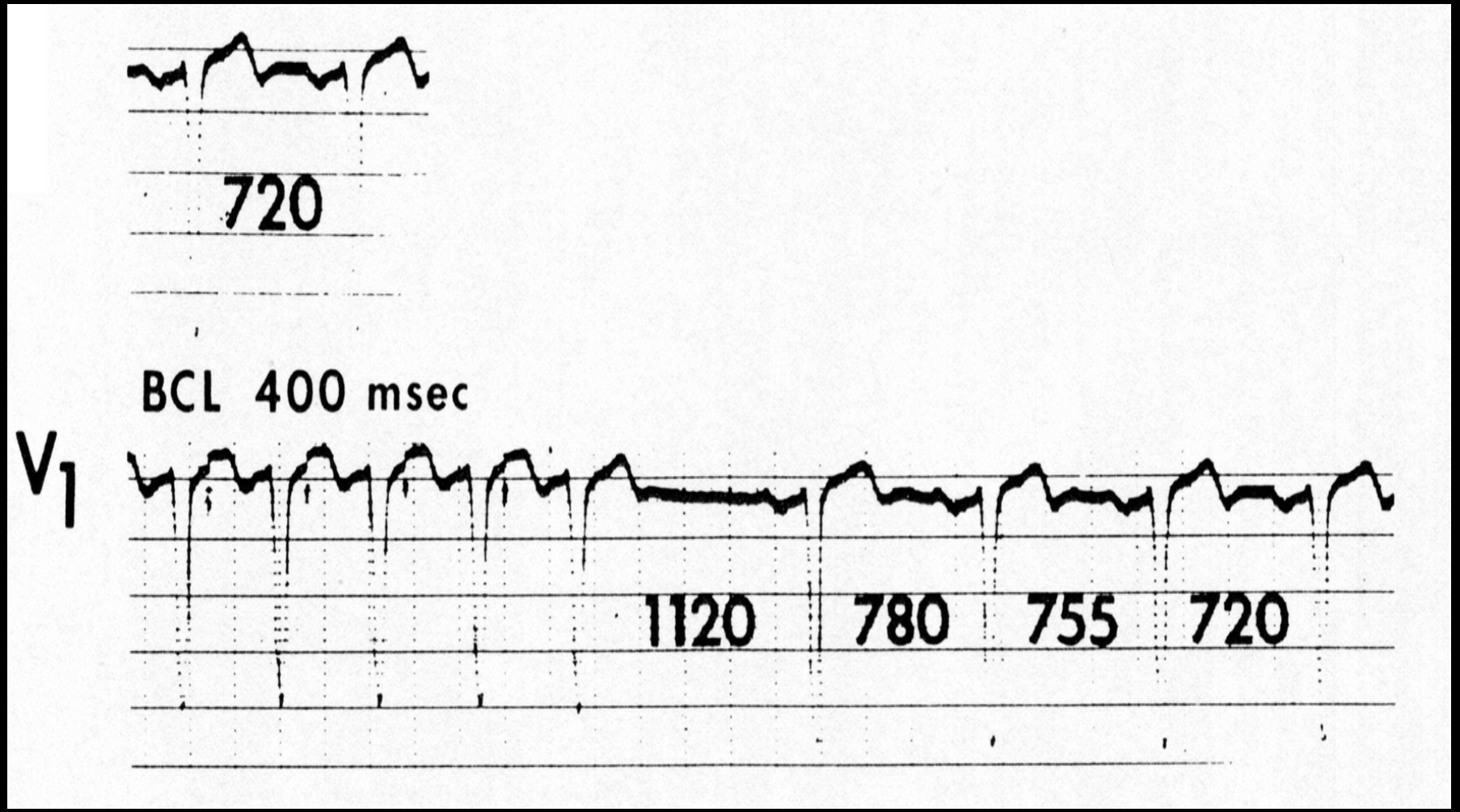
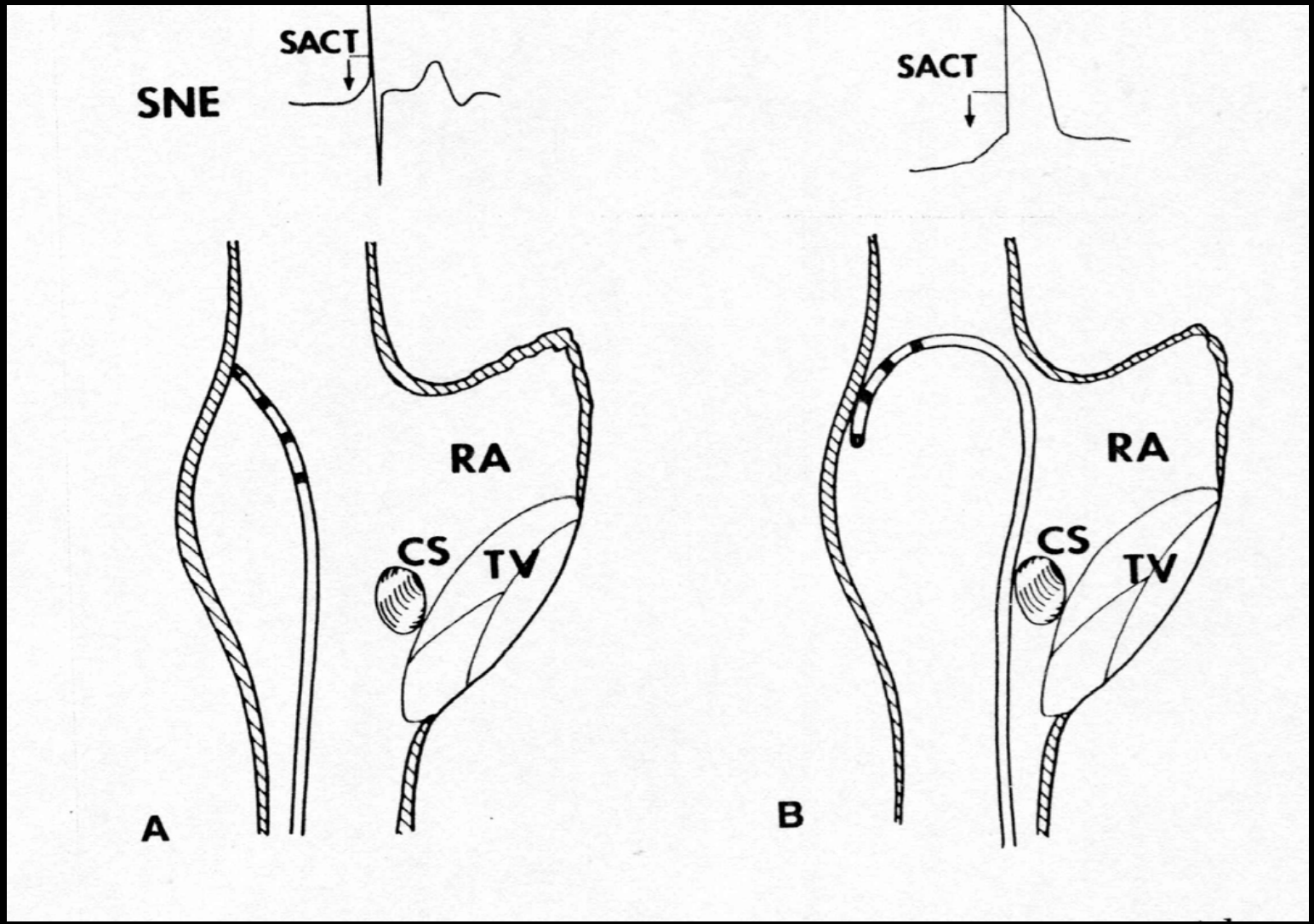

A
1
aVF
V1
HRA
HBE
RVA
T
H V
H V
H V
V H
VH 140
H V
400
250
B
1
aVF
V1
HRA
HBE
RVA
T
V H
VH 150
400
240
C
BBR
1
aVF
V1
HRA
HBE
RVA
T
65
V H V
VH 165
50
H V
400
230

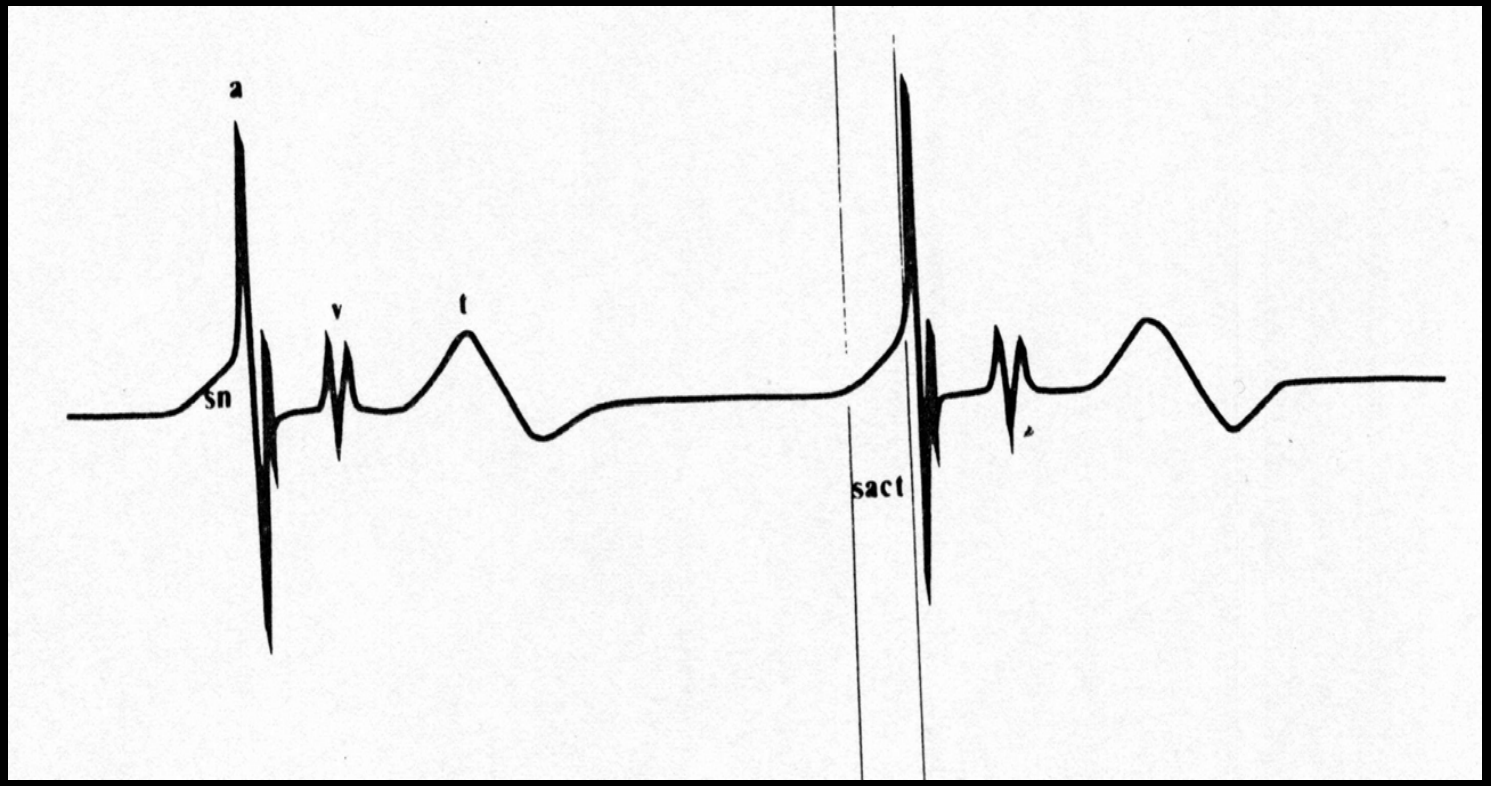
Table 4–2. *Measurements of Sinus Recovery Time (SRT) Following Overdrive Suppression*

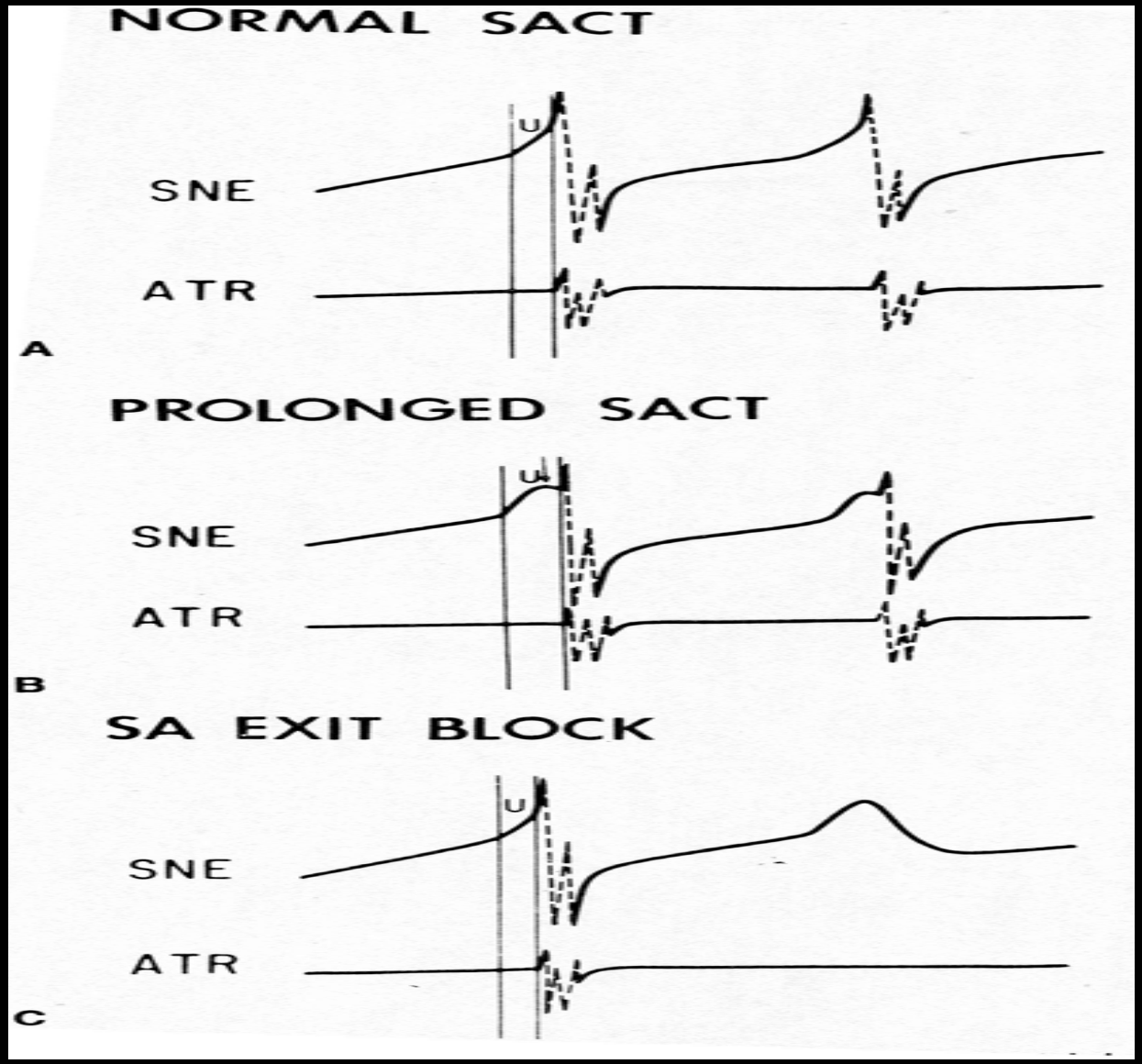
Laboratory	*SRT (msec)*	*CSRT (msec)*	*SRT / SCL%*	*TRT*
Narula[70]		<525		5 or 6 beats
Kulbertus[71]	<1600	<680		
Mandel[7]	<1.3 (SCL) + 101		<130%	
Rosen[10]	<1400			
Delius[72]	<1400	<525		3.8 sec
Breithardt[30]	<1400	<508		
Alboni[40,41]		<354		
Author		<550	<150%	<5 sec, 4 to 6 beats

CSRT = corrected sinus node recovery time; SCL = sinus cycle length; SRT = sinus node recovery time; TRT = total recovery time.


720
BCL 400 msec
V1
1120
780
755
720


SACT
SNE
SACT
RA
CS
TV
A
RA
CS
TV
B


a
v
t
sn
sact


NORMAL SACT
SNE
ATR
A
PROLONGED SACT
SNE
ATR
B
SA EXIT BLOCK
SNE
ATR
C

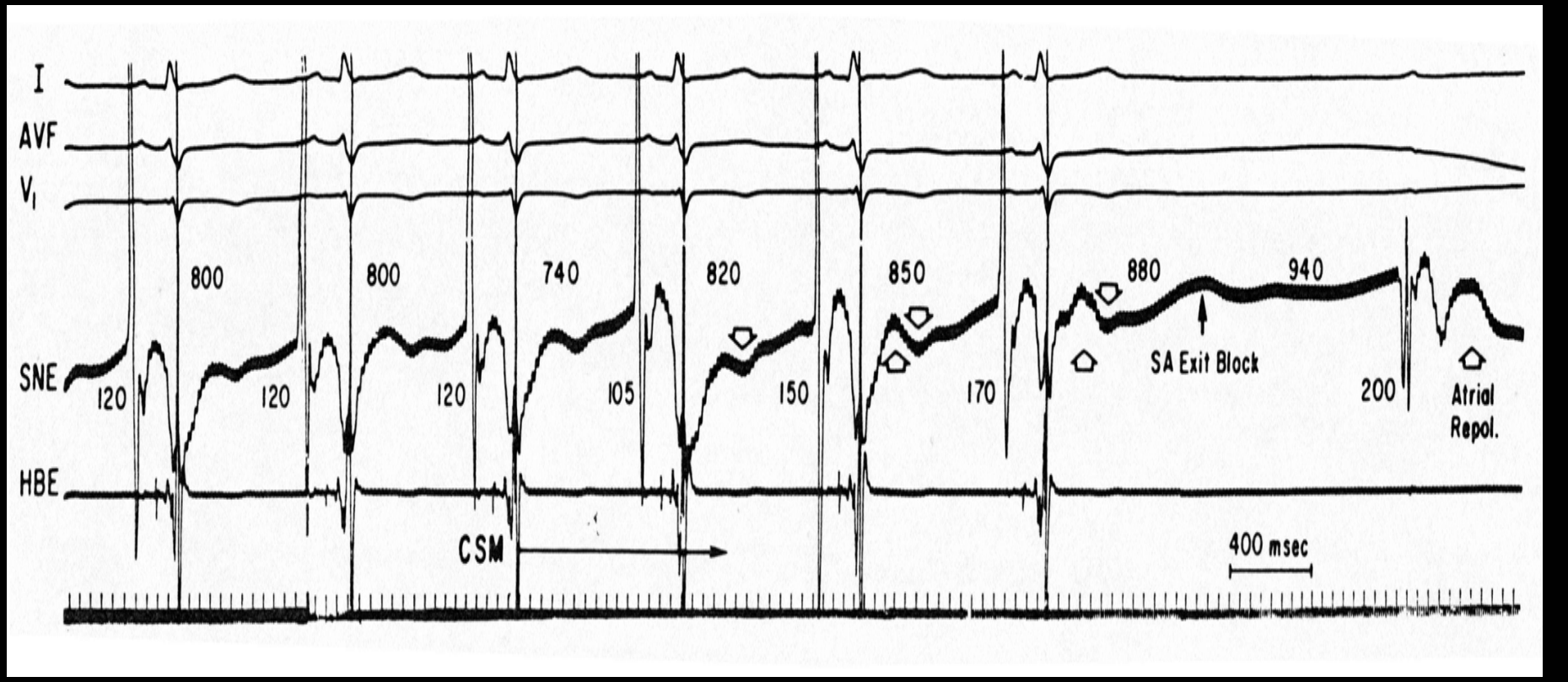
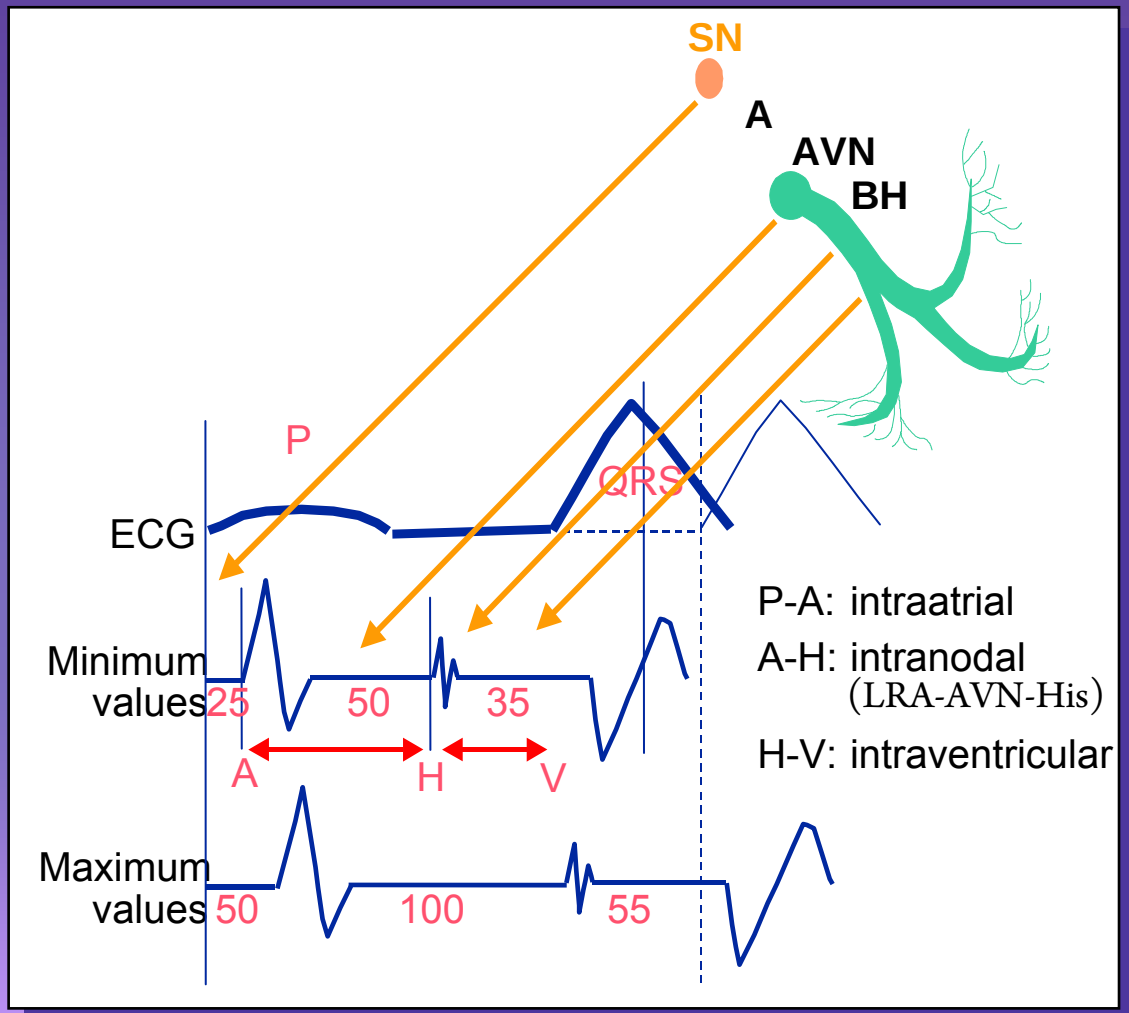
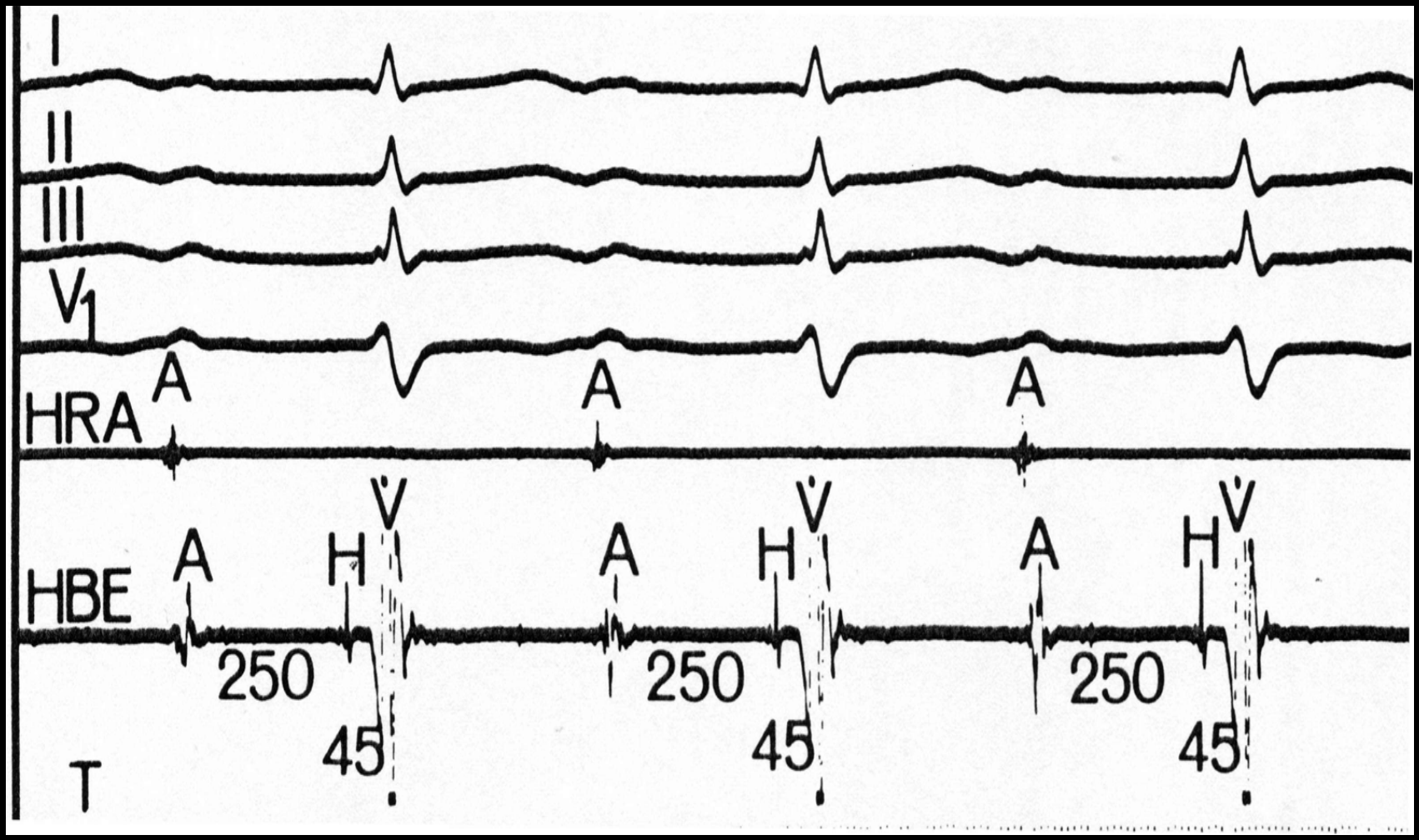

I
AVF
V1
SNE
HBE
800
800
740
820
850
880
940
120
120
120
105
150
170
200
SA Exit Block
Atrial Repol.
CSM
400 msec

Table 4–1. *Sinoatrial Conduction Time (SACT)*

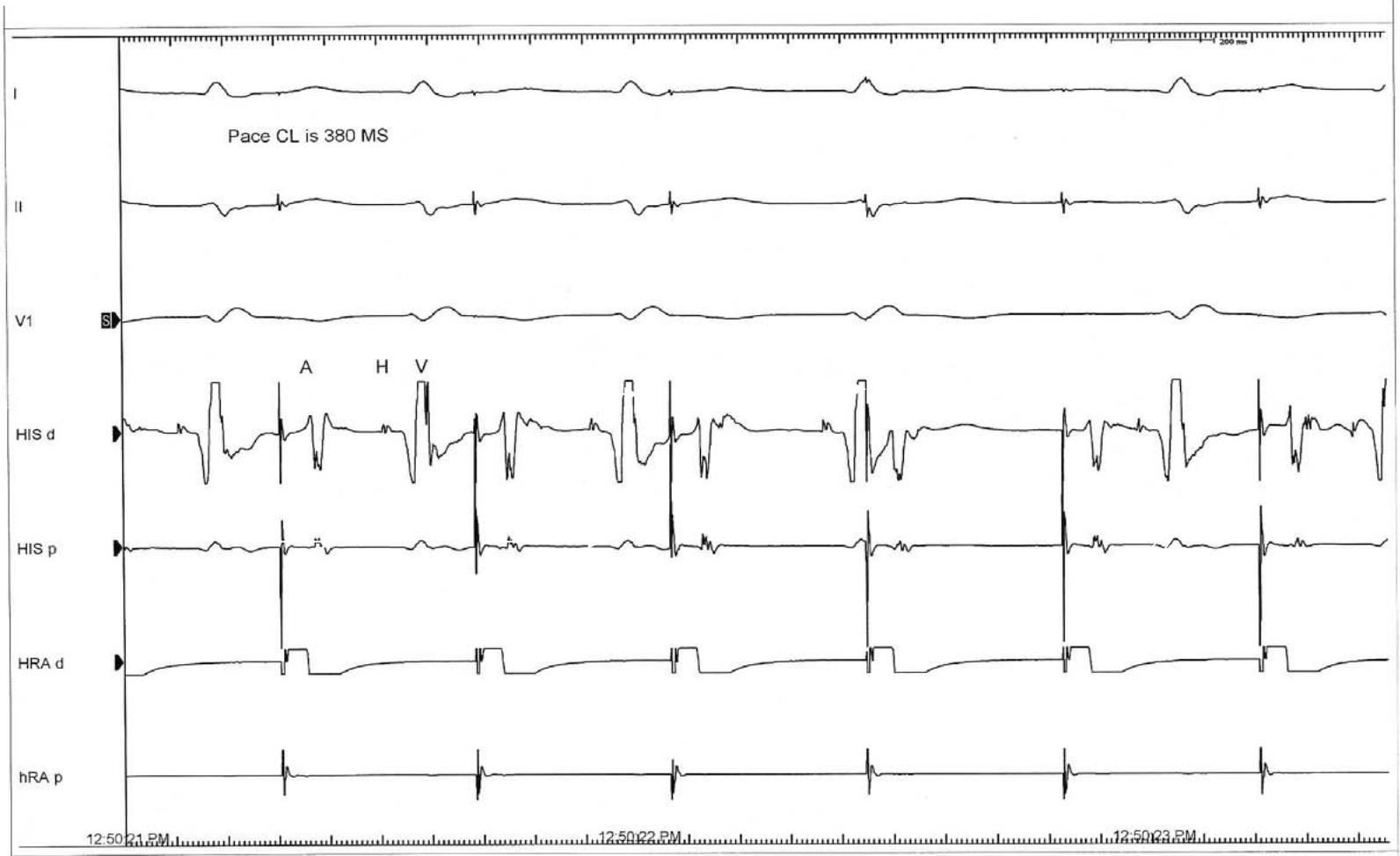
Laboratory	*SACT (msec)*
Strauss[25]	68–156
Masini[27]	40–94
Mandel[9,38]	41–107
Breithardt[28,30]	48–112
Dhingra[26]	40–153
Steinbeck[39]	40–70
Alboni[40,41]	46–96
Gomes[42]	59–111
Authors	45–125

Normal Conduction Intervals




I
II
III
V1
HRA
A
A
A
HBE
A
H
V
A
H
V
A
H
V
250
250
250
45
45
45
T

Belinson



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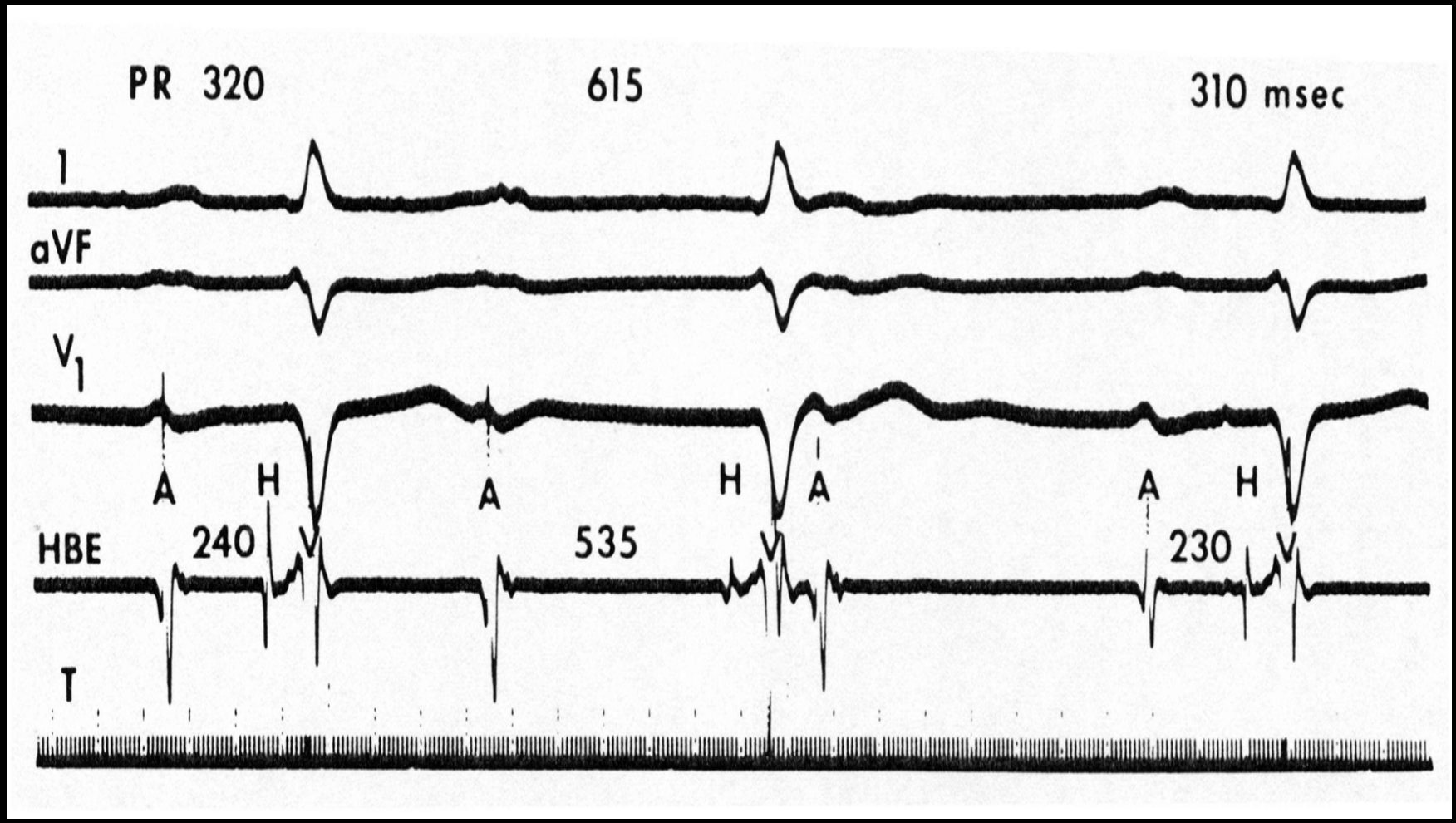
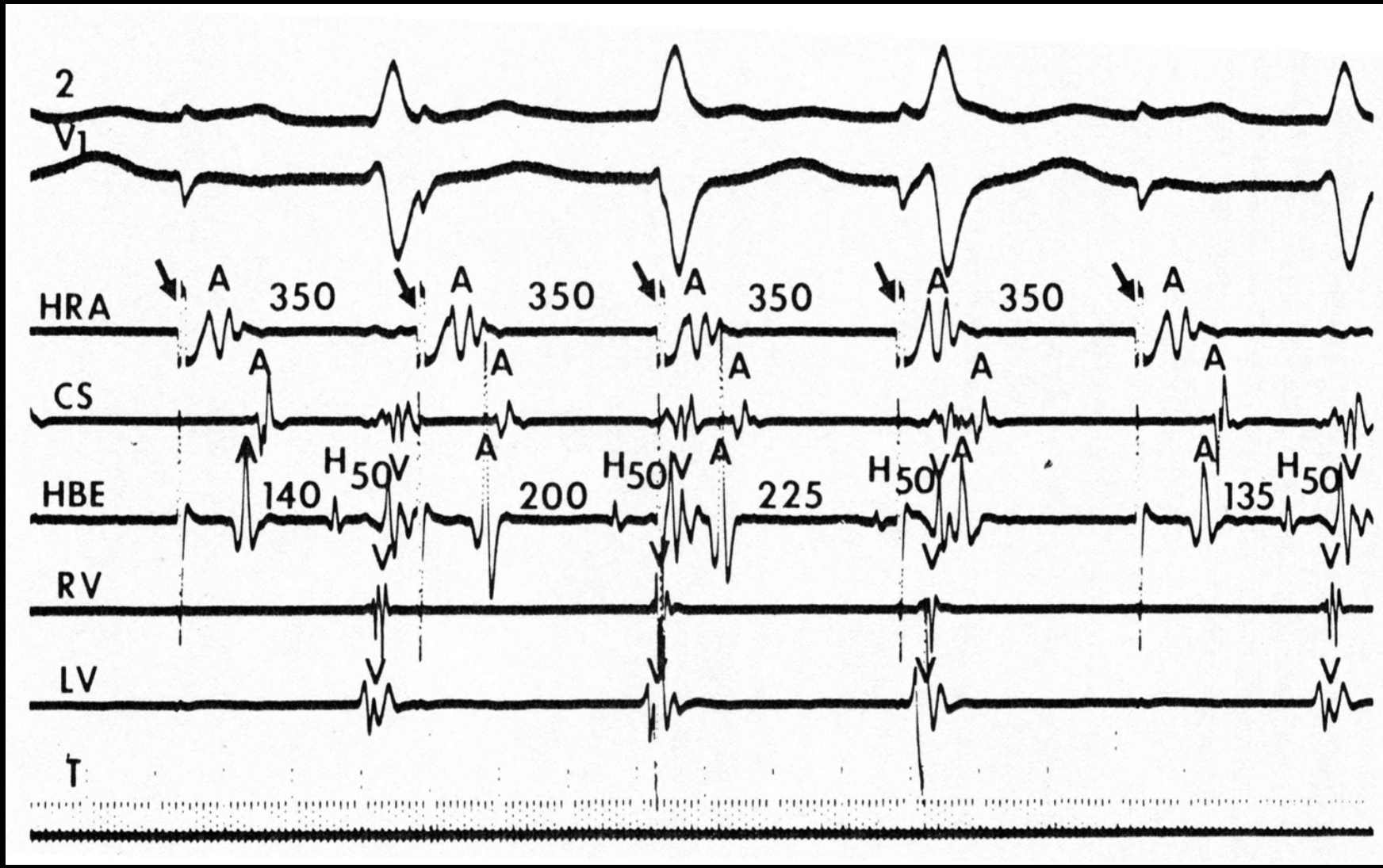
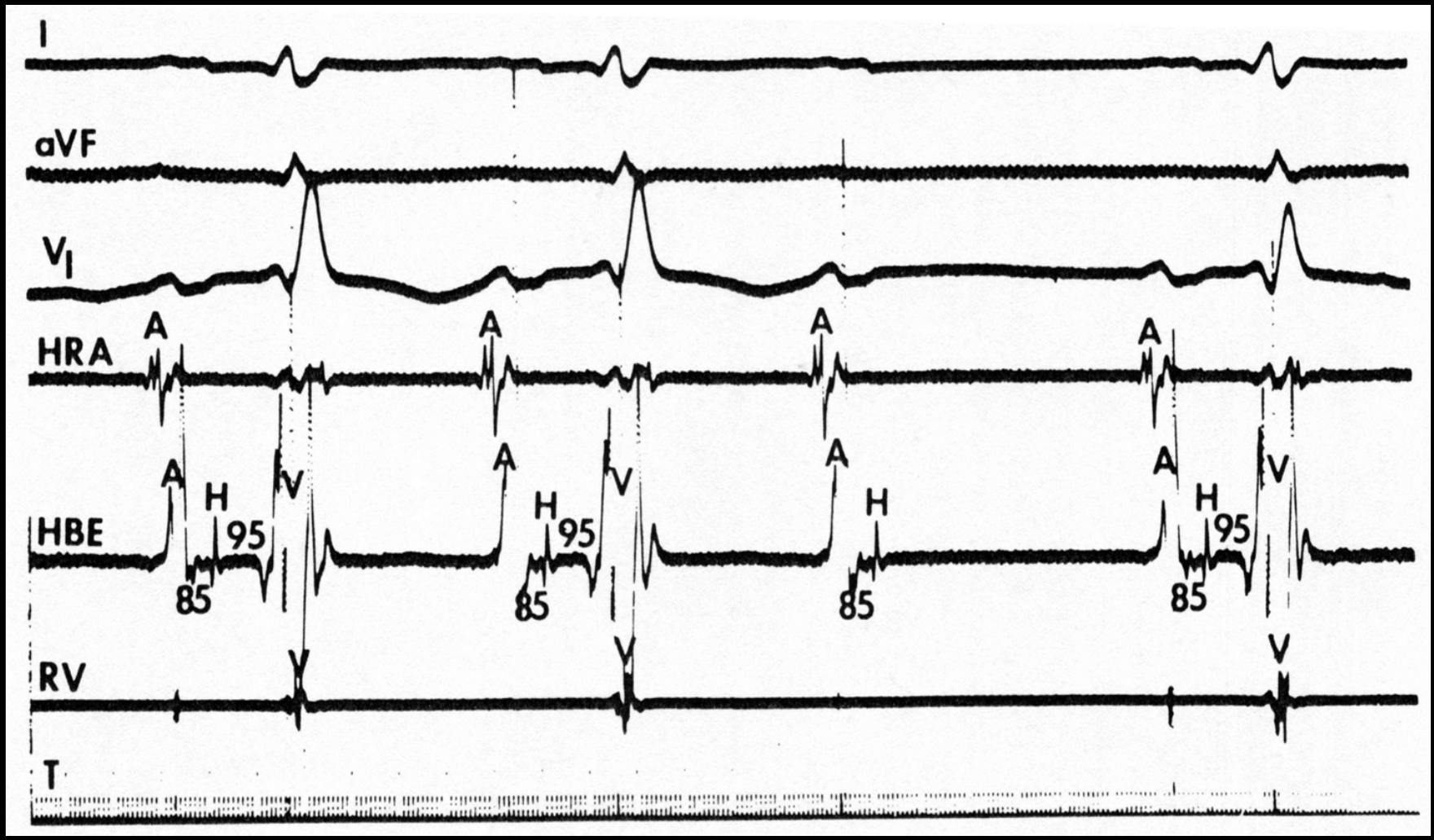
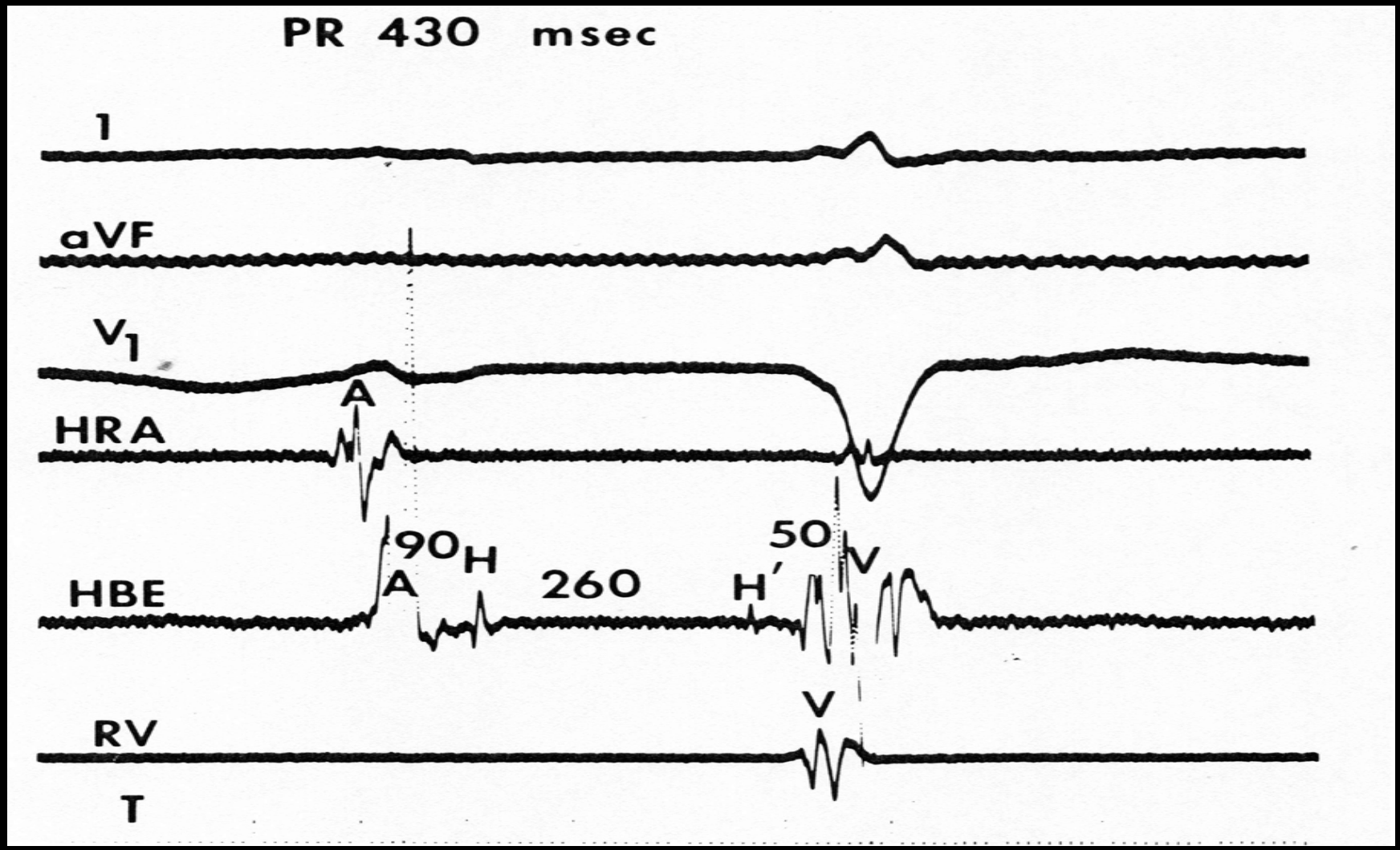

PR 320
615
310 msec
I
aVF
V1
A
H
A
H
A
A
H
HBE
240
535
230
V
V
V
T

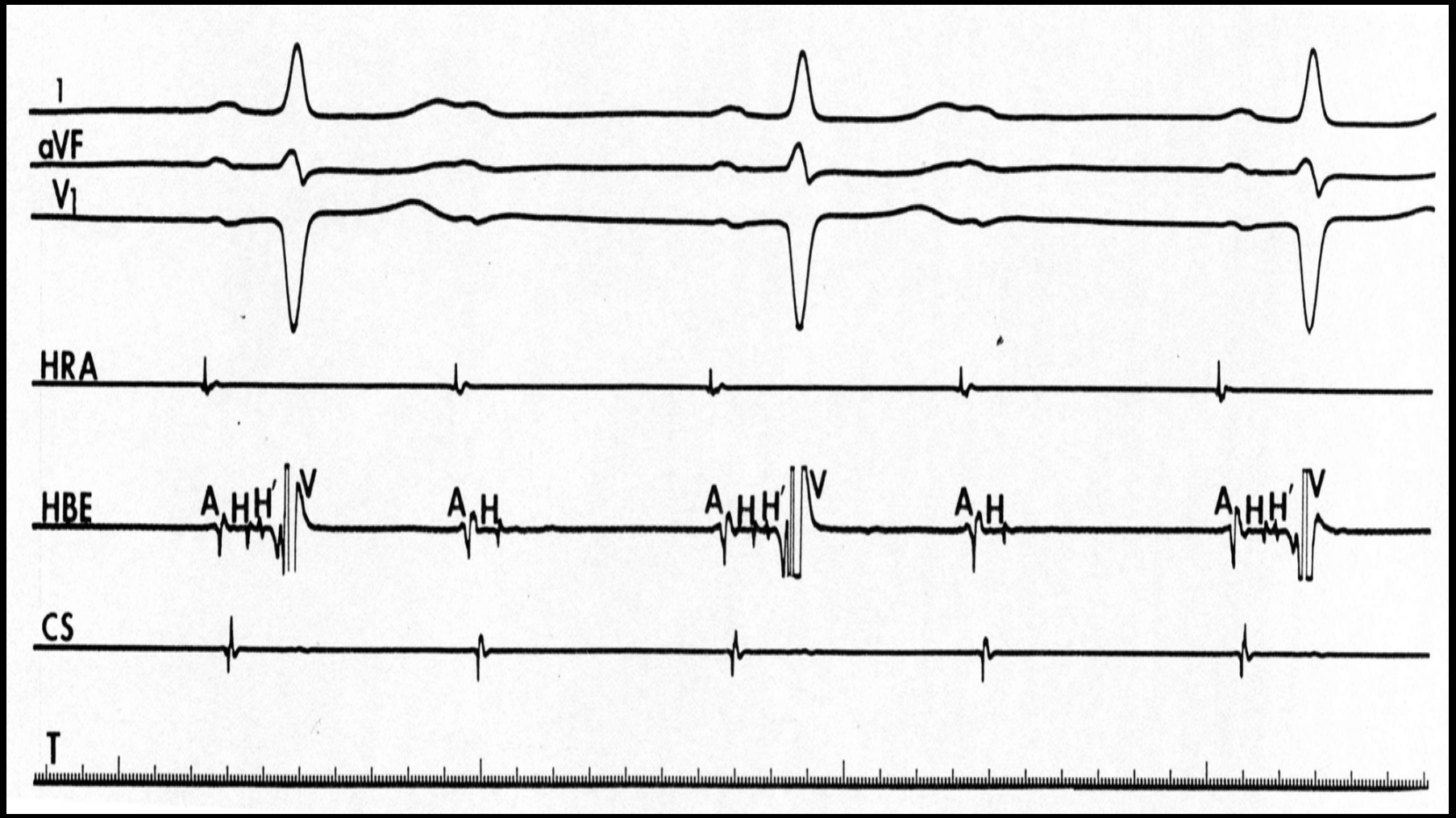

2
V1
HRA
CS
HBE
RV
LV
T
A
350
140
200
225
135
H50
V

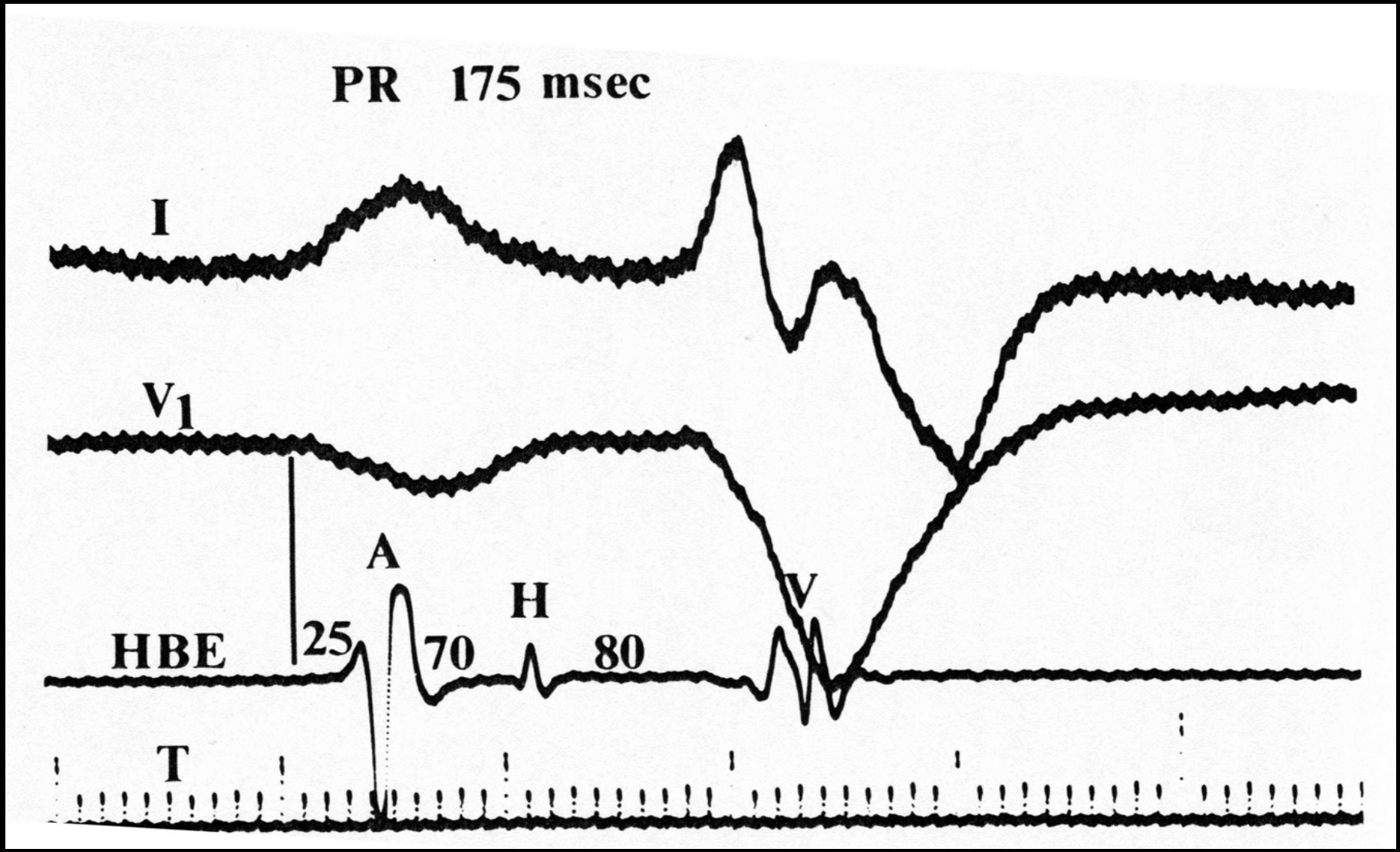

I
aVF
V1
HRA
A
A
A
A
HBE
A
H
V
95
85
A
H
V
95
85
A
H
85
A
H
V
95
85
RV
V
V
V
T

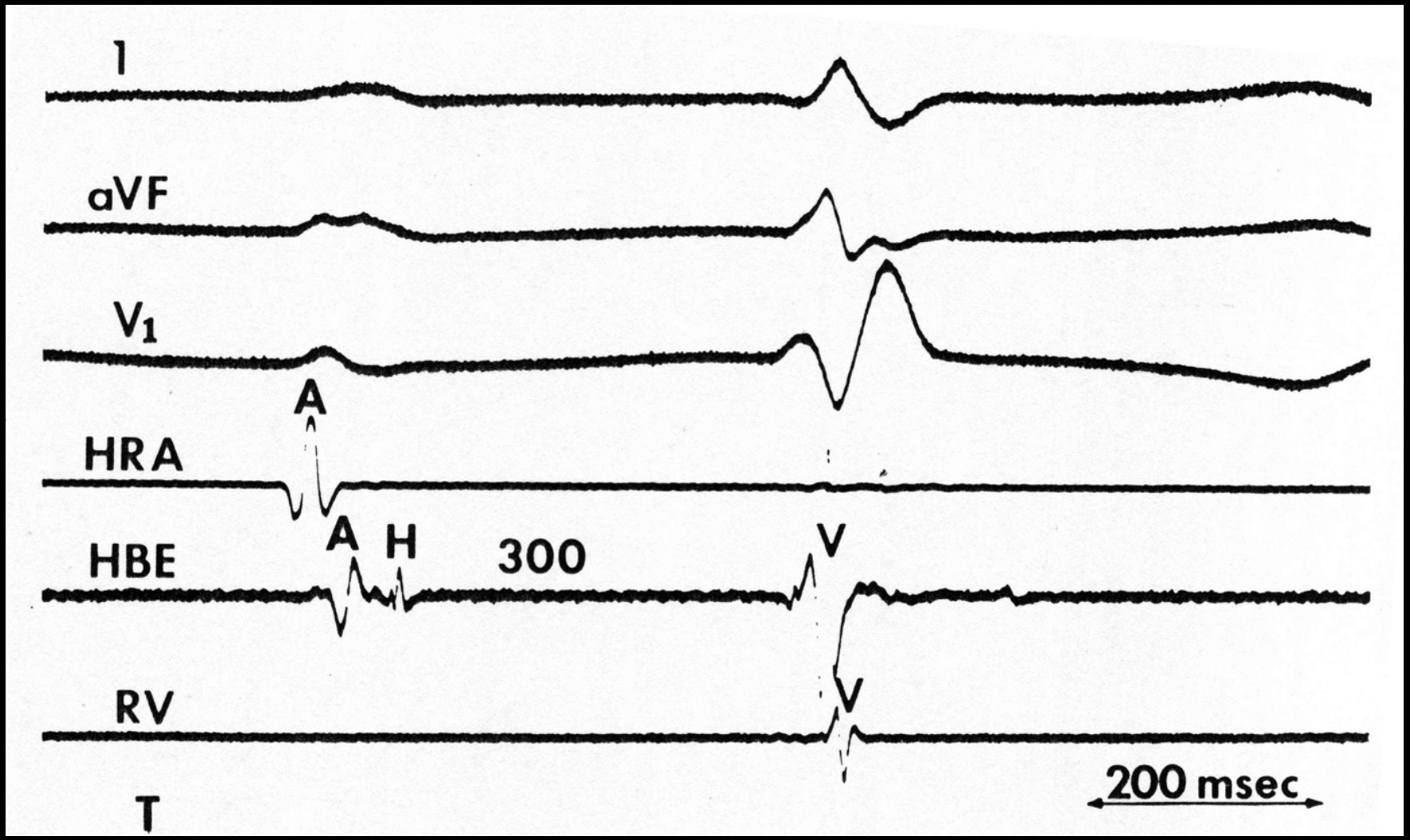

PR 160msec
I
II
III
V1
HRA
CS
HBE
T
A
H
H'
V
80
40
70
40

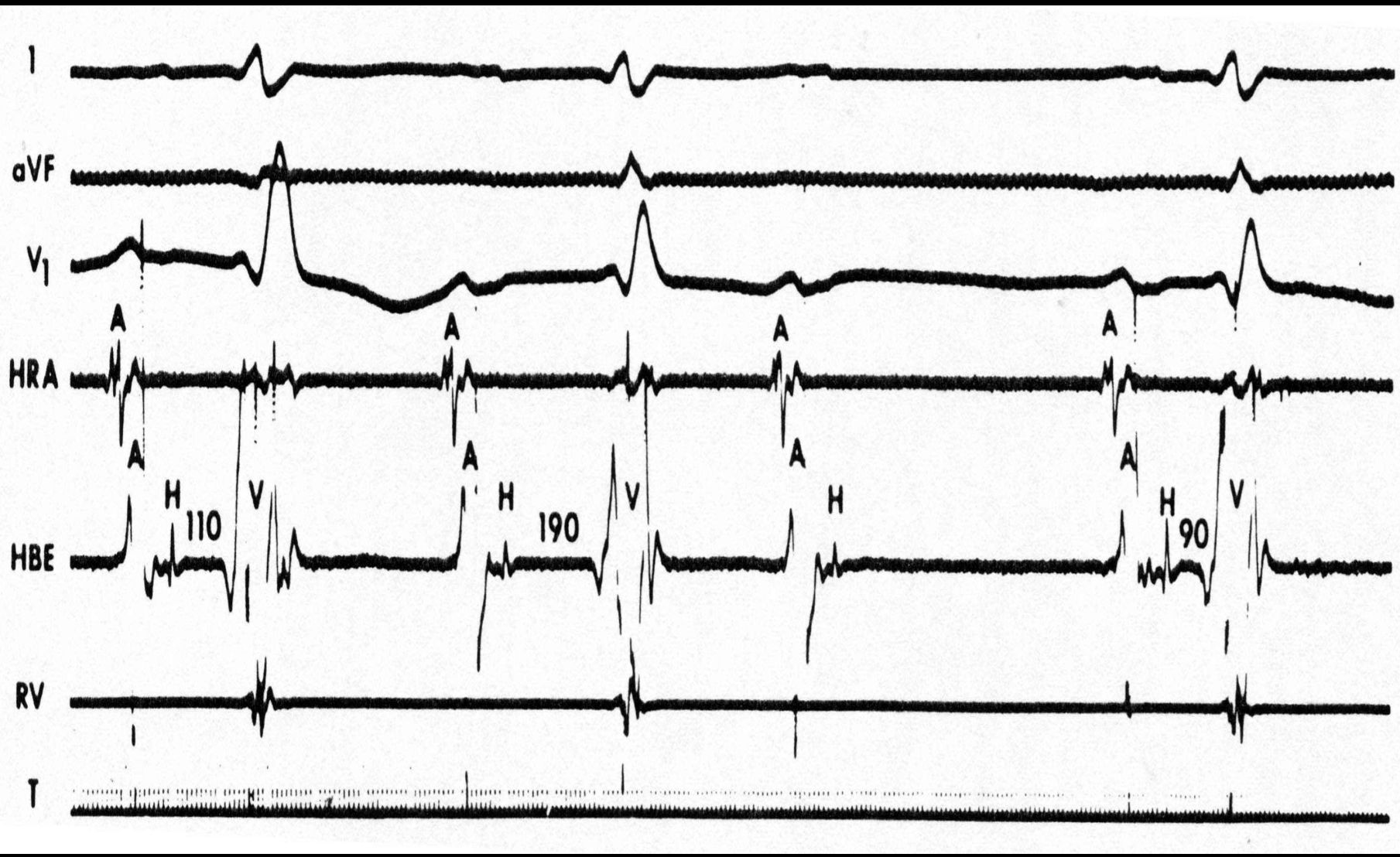

PR 430 msec
I
aVF
V1
A
HRA
90
H
50
V
HBE
A
260
H'
V
RV
T

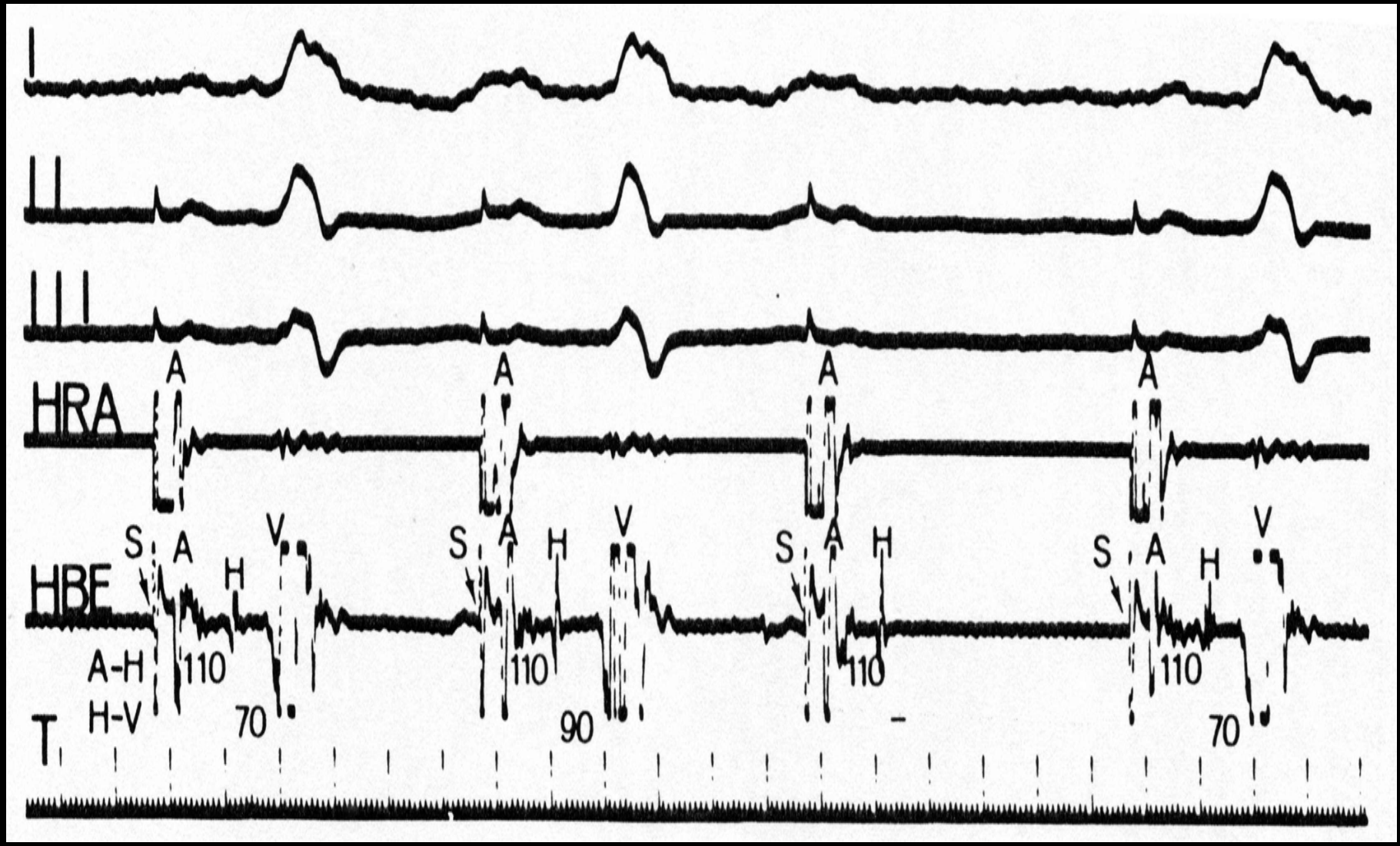

I
II
III
V1
A
A
A
A
HRA
A
A
A
A
CS
A
A
A
A
H
H'
H
H
H'
H
HBE
T

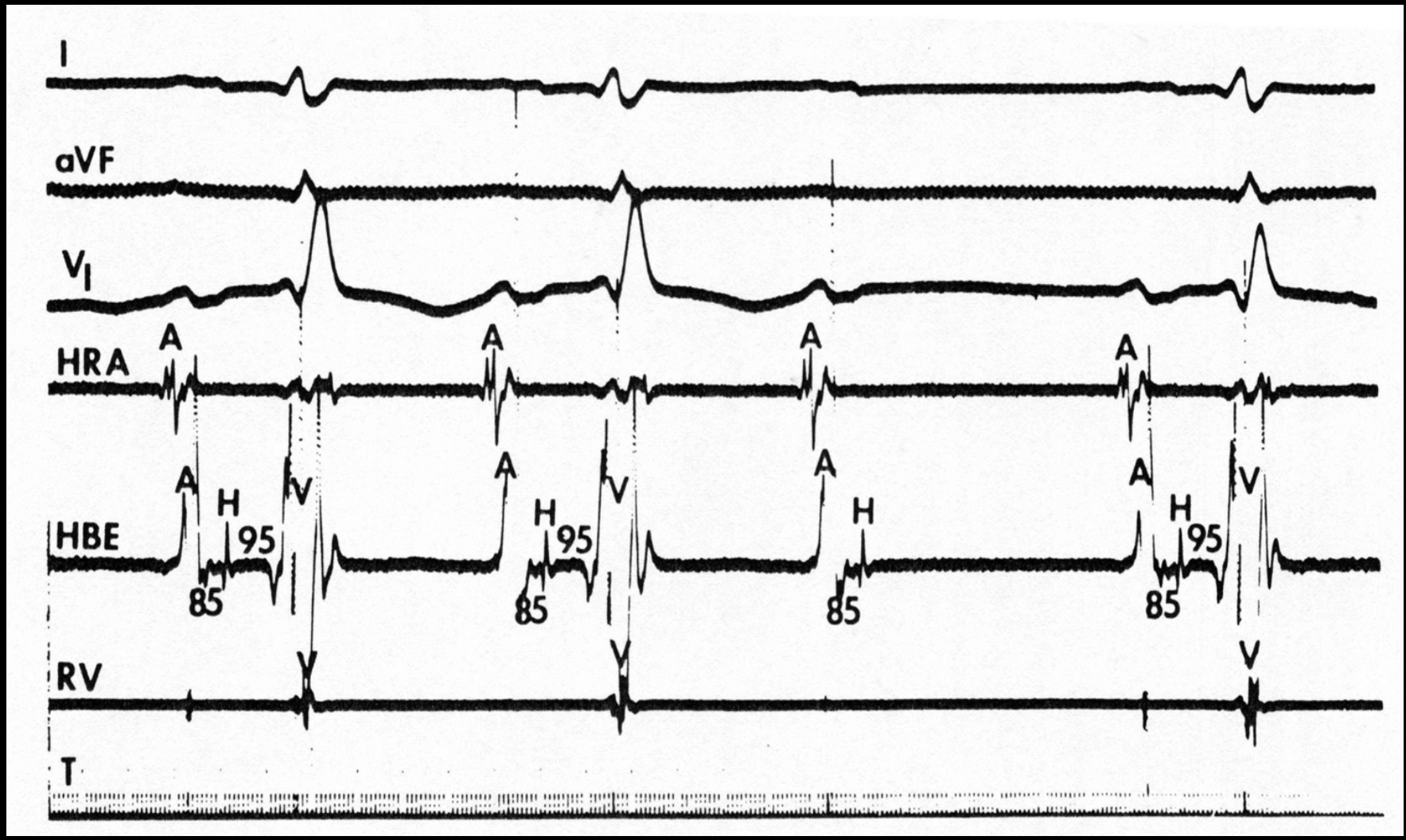

I
aVF
V1
HRA
HBE
A H H' V
A H
A H H' V
A H
A H H' V
CS
T

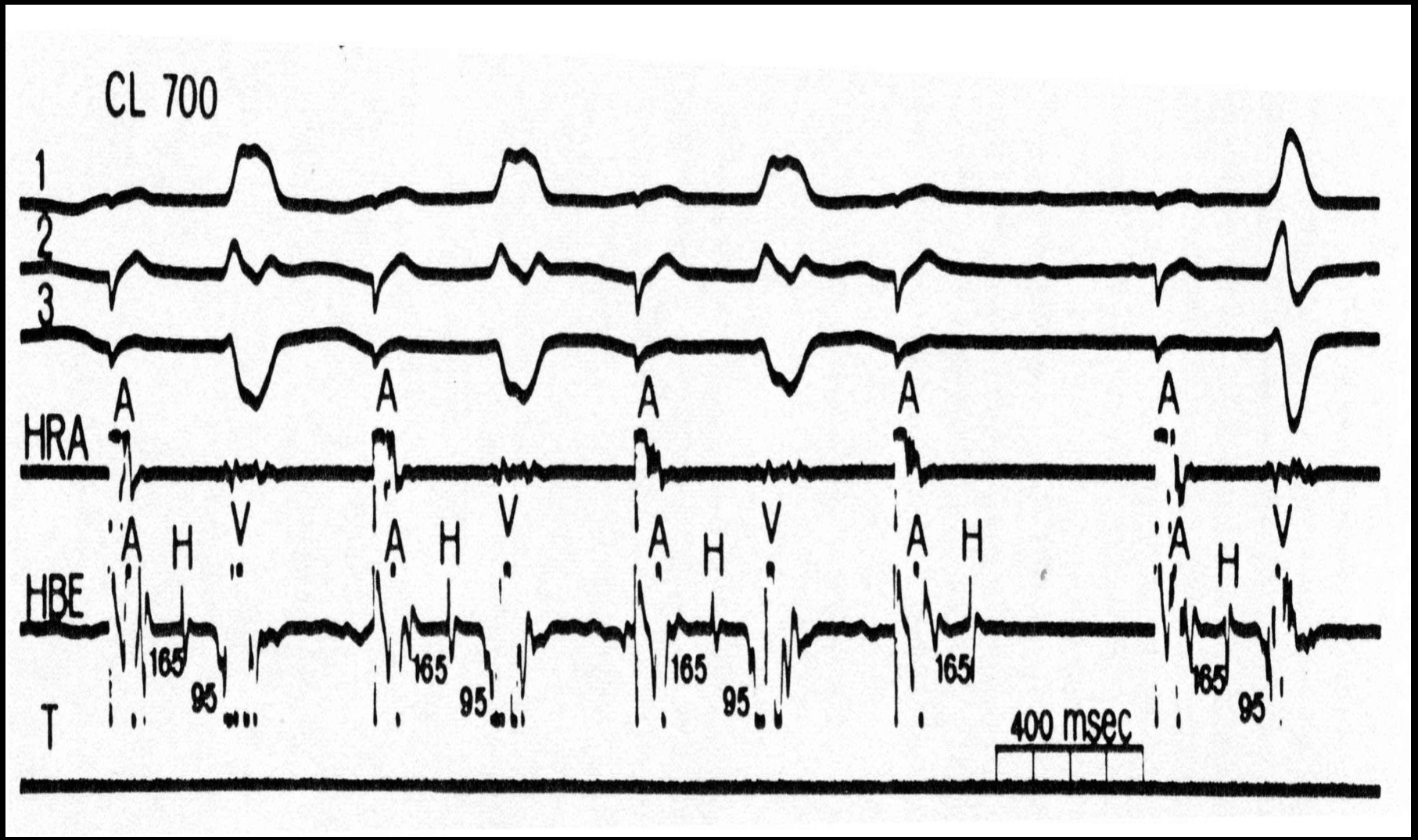

PR 175 msec
I
V1
A
H
V
HBE
25
70
80
T

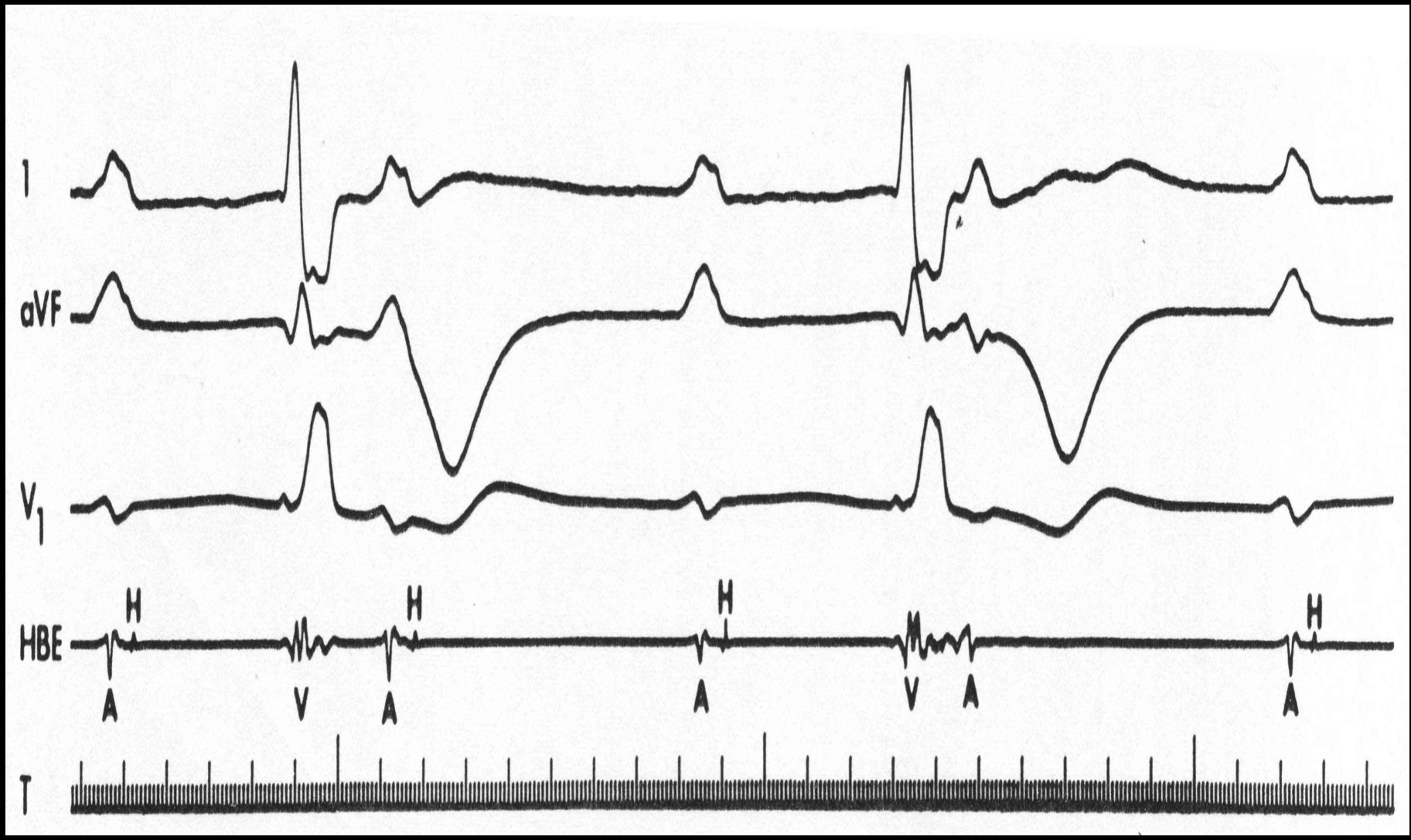

I
aVF
V1
A
HRA
A
H
300
HBE
V
V
RV
T
200 msec

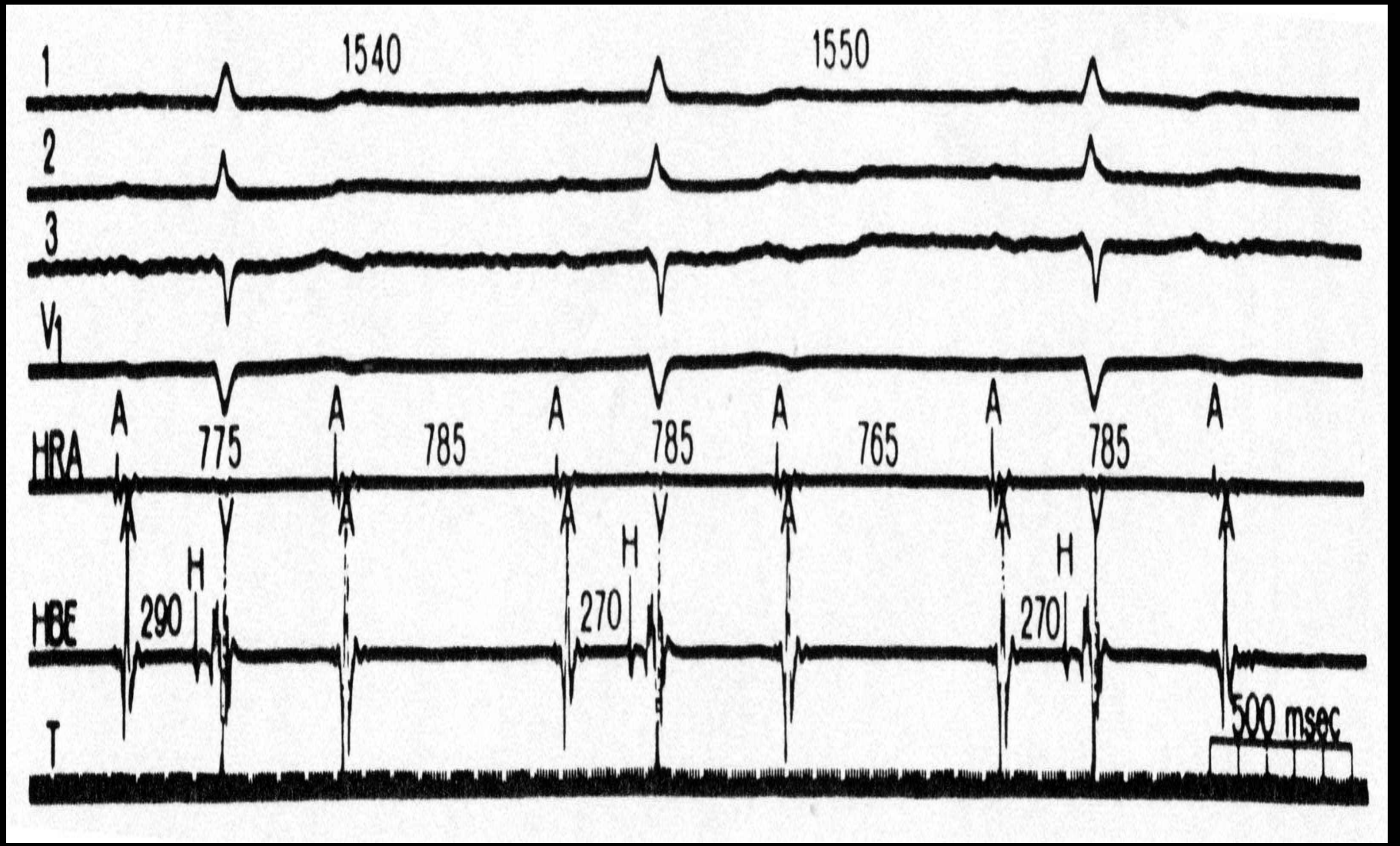

I
aVF
V1
A
A
A
A
HRA
A
A
A
A
H
110
V
H
190
V
H
H
90
V
HBE
RV
T

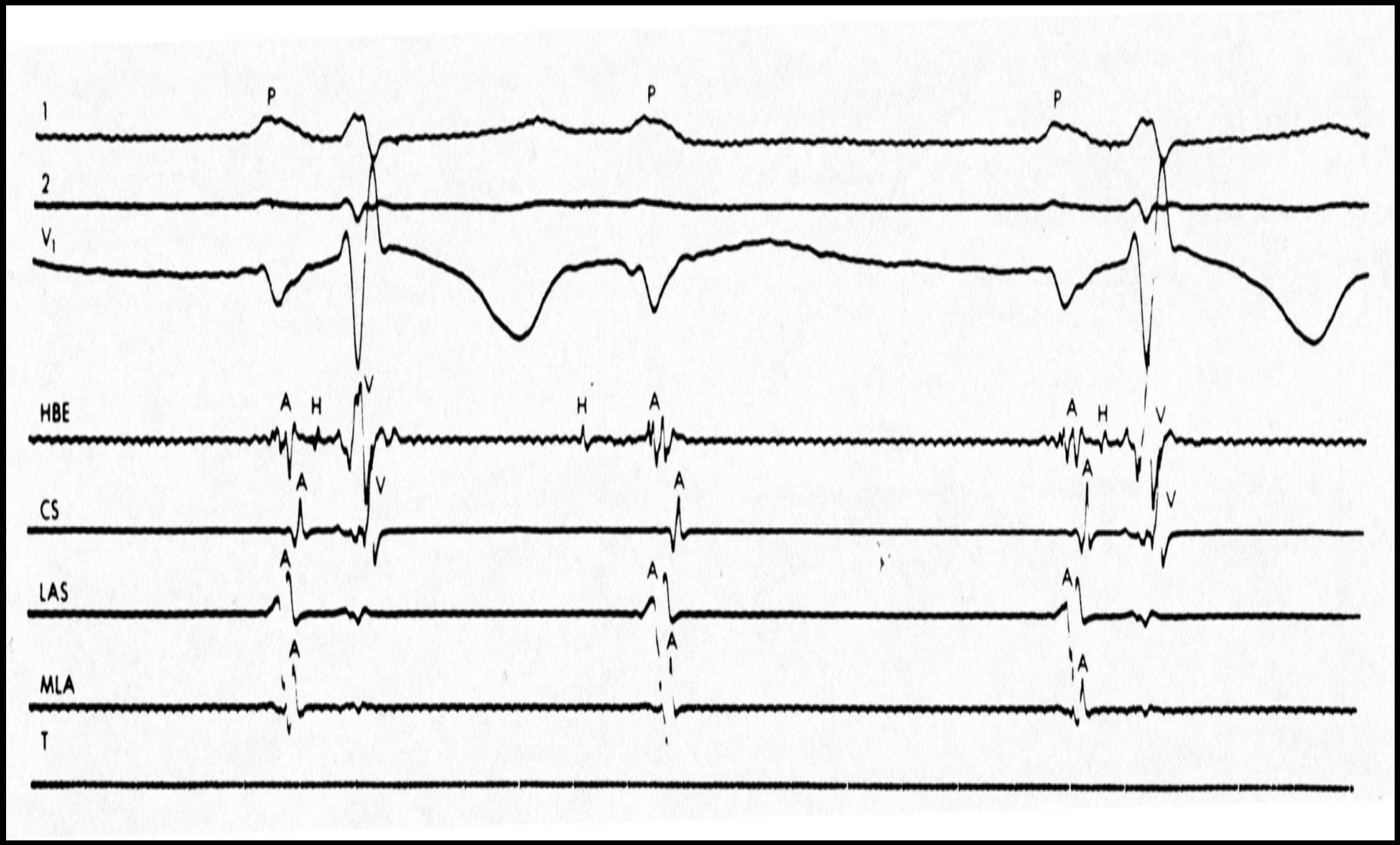

I
II
III
HRA
HBE
A
S
A
H
V
A-H
H-V
110
70
110
90
110
110
70
T

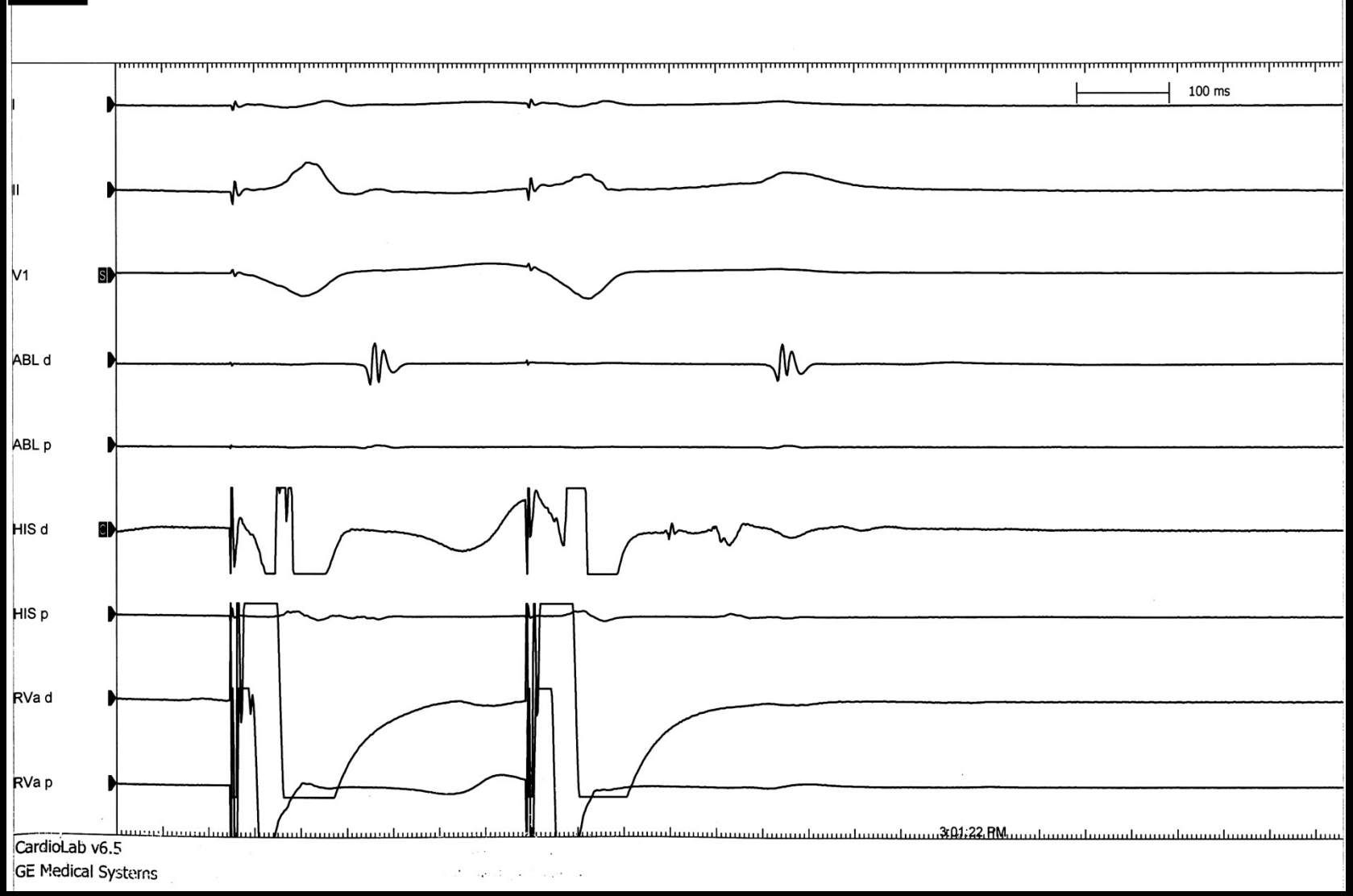

I
aVF
V1
HRA
A
A
A
A
HBE
A
H
V
95
85
A
H
V
95
85
A
H
95
85
A
H
V
95
85
RV
V
V
V
T


CL 700
1
2
3
HRA
HBE
T
A
H
V
165
95
400 msec


I
aVF
V1
HBE
H
H
H
H
A
V
A
A
V
A
A
T


1
2
3
V1
HRA
HBE
T
1540
1550
A
775
785
785
765
785
H
V
290
270
270
500 msec


1
2
V1
P
P
P
HBE
CS
LAS
MLA
T
A
H
V


100 ms
I
II
V1
ABL d
ABL p
HIS d
HIS p
RVa d
RVa p
3:01:22 PM
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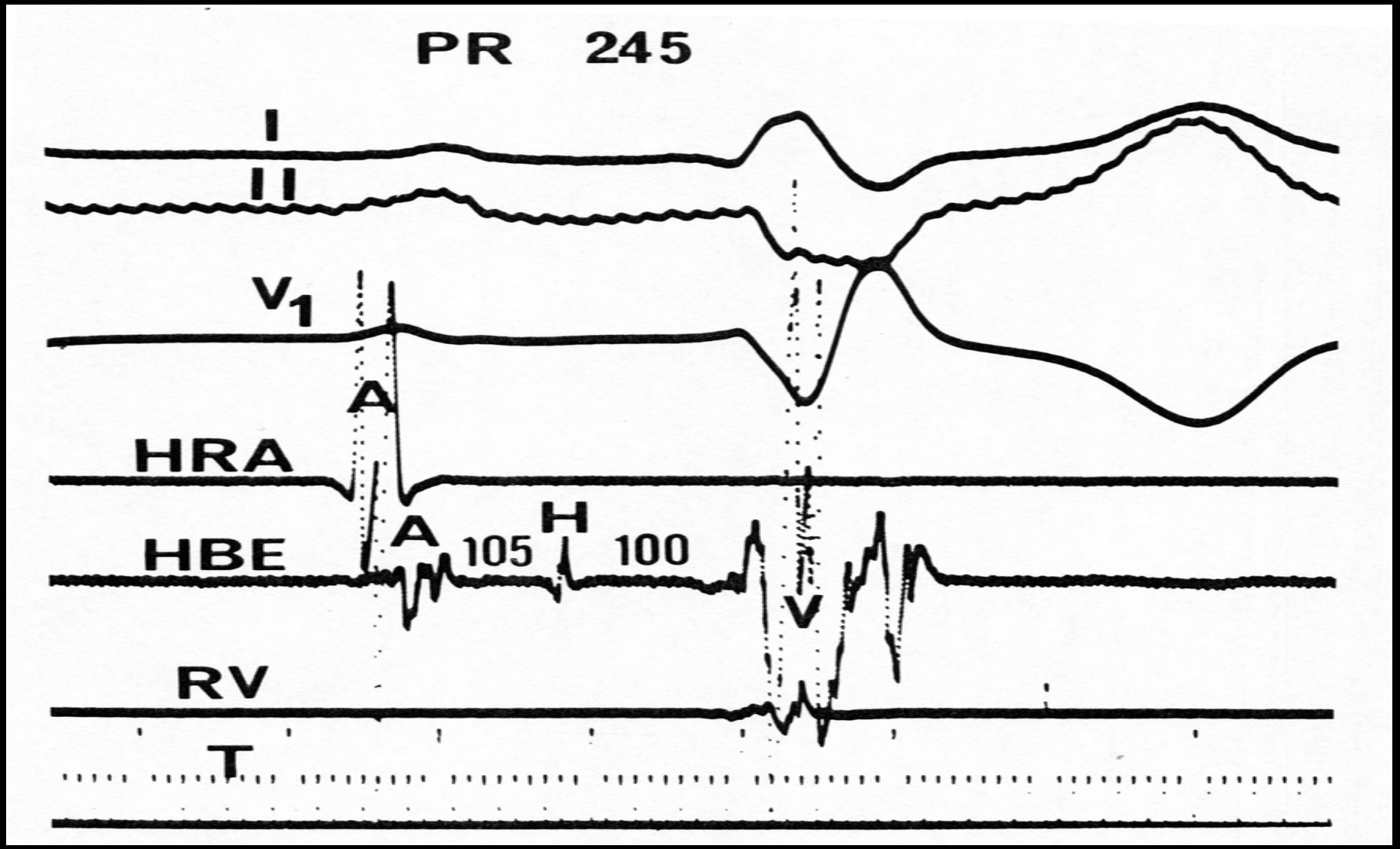
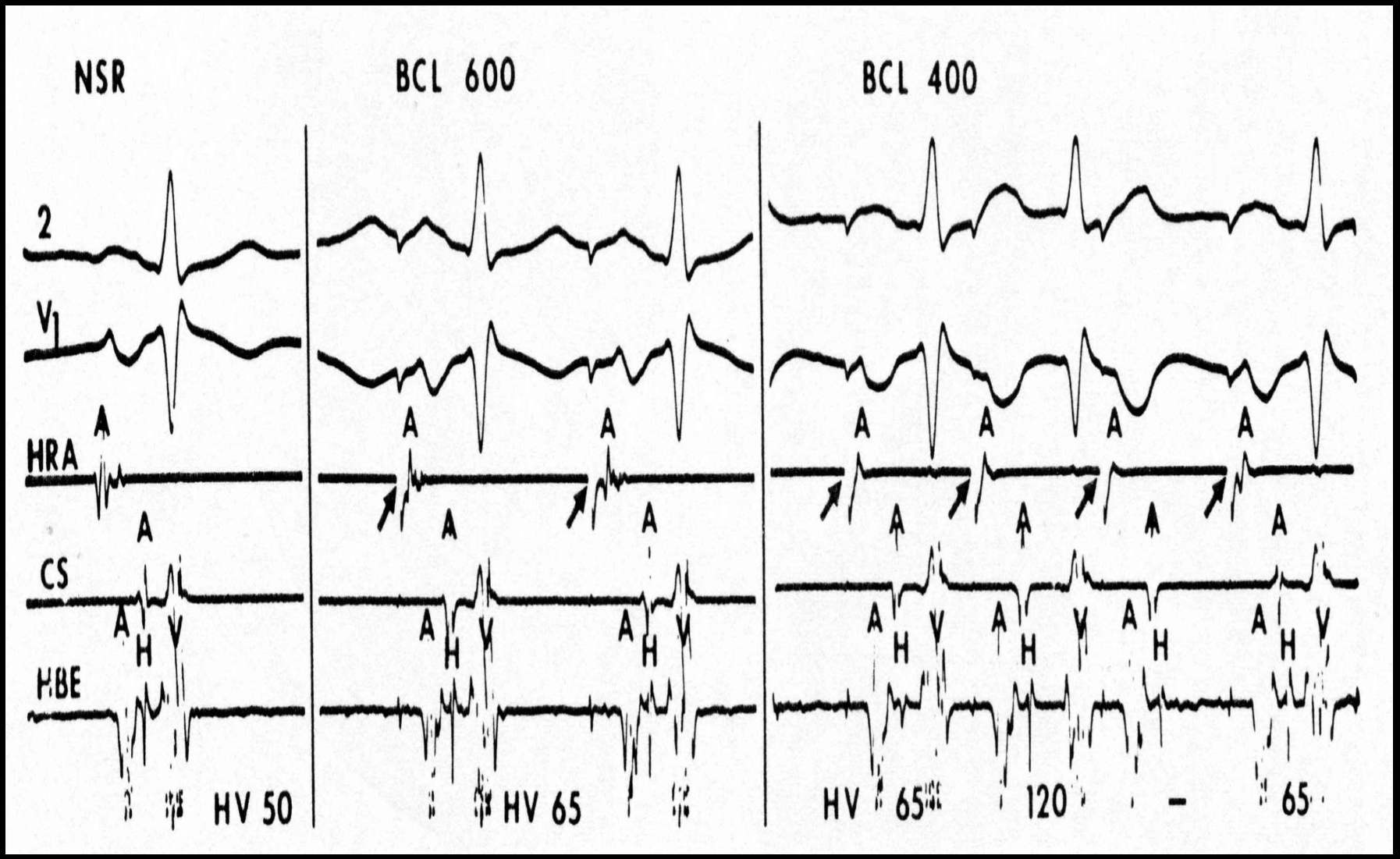
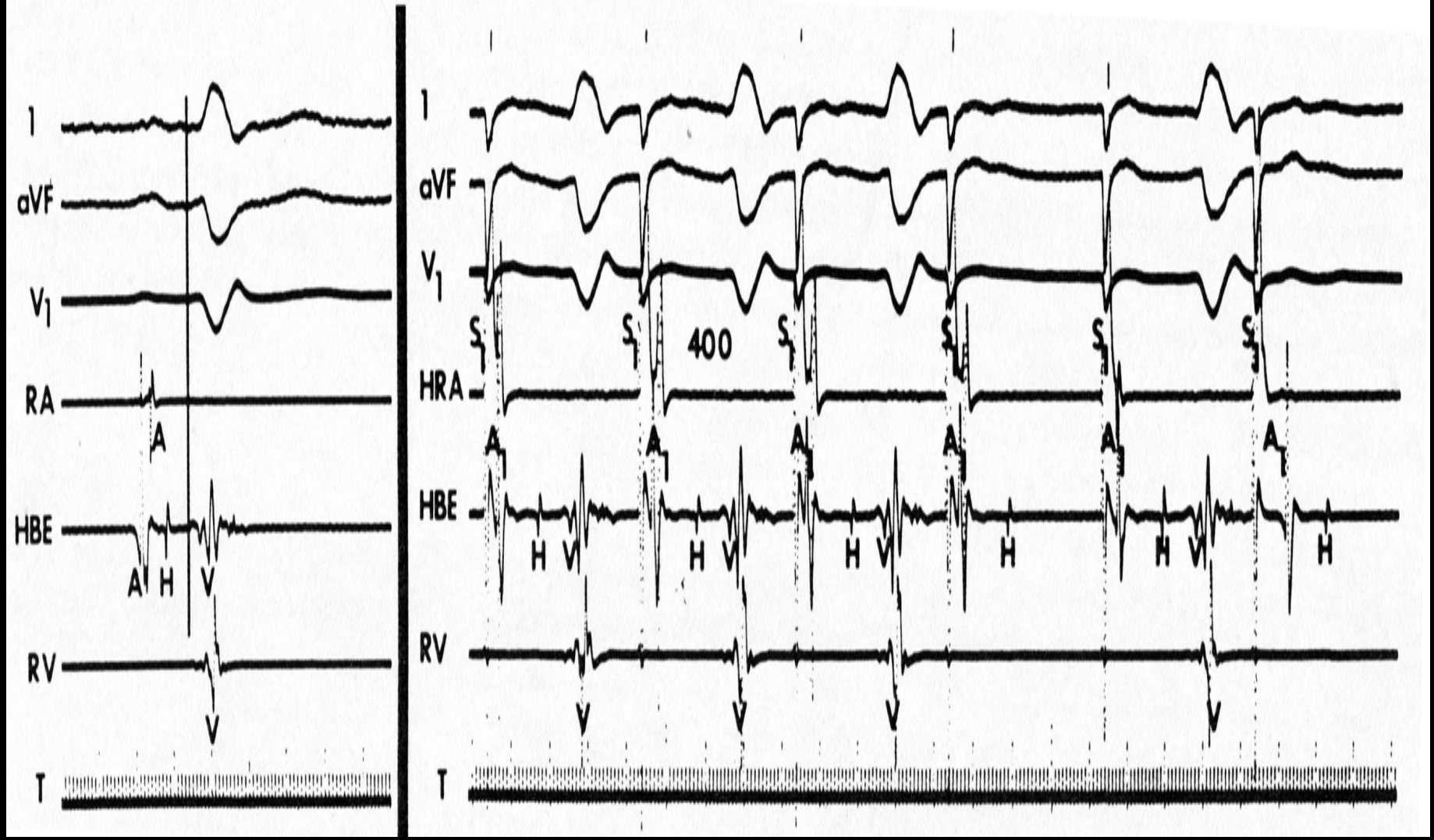
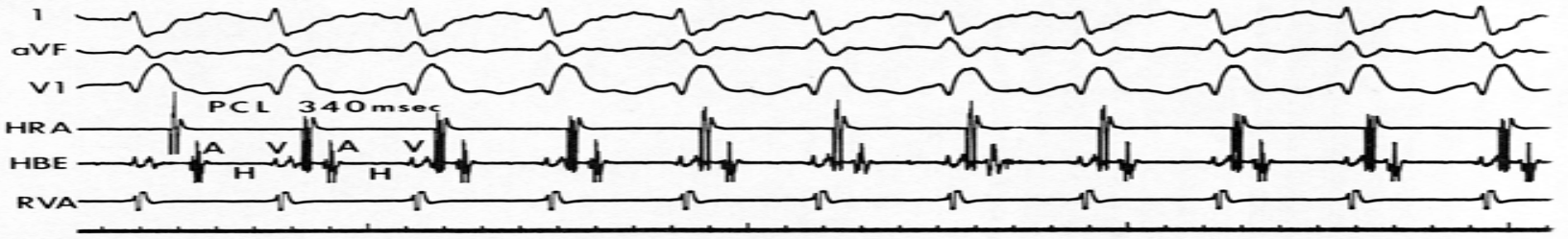
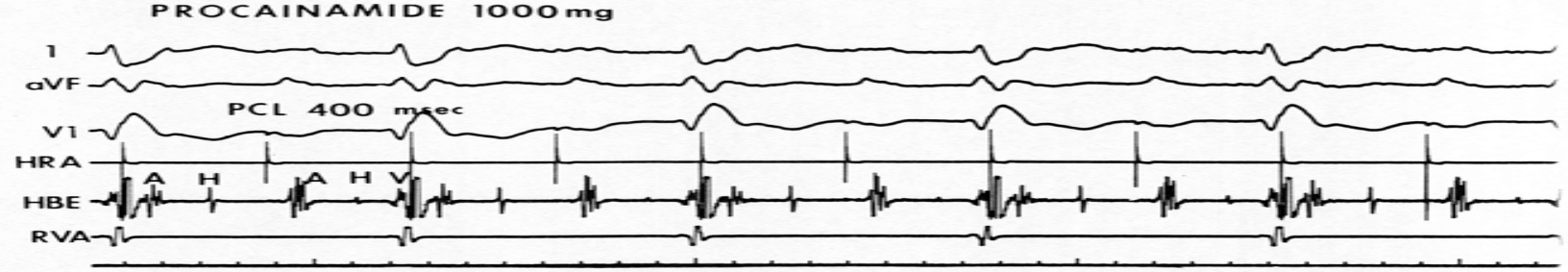
SYNCOPE •

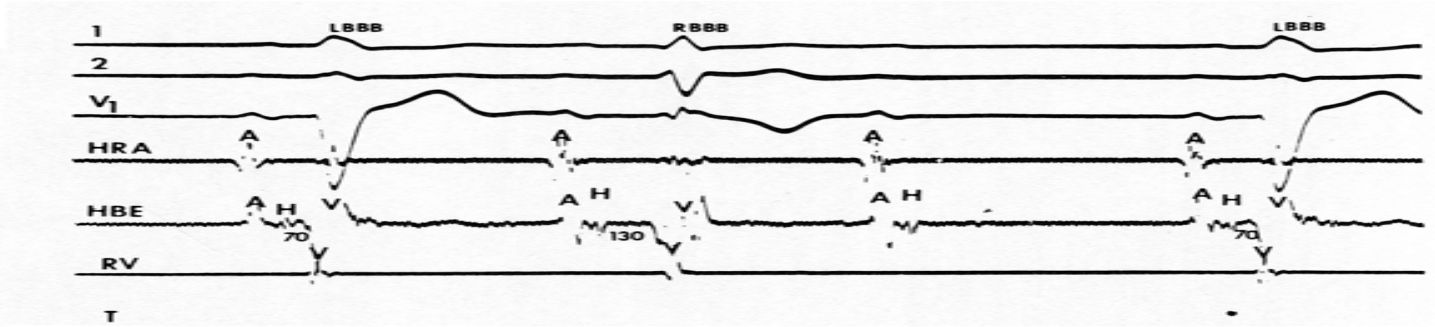

PR 245
I
II
V1
A
HRA
A
105
H
100
HBE
V
RV
T

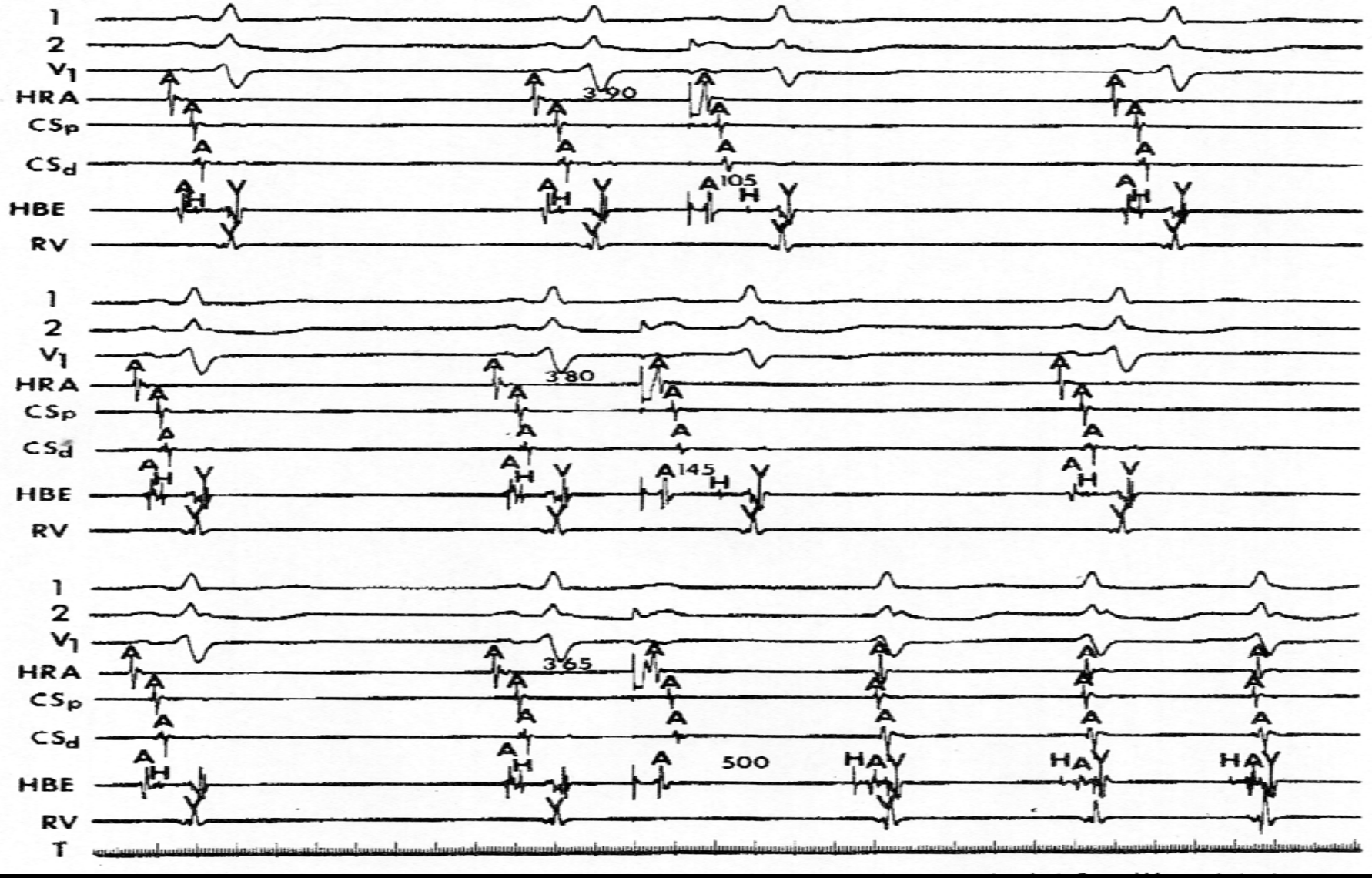

NSR
BCL 600
BCL 400
2
V1
HRA
CS
HBE
A
H
V
HV 50
HV 65
HV 65
120
65

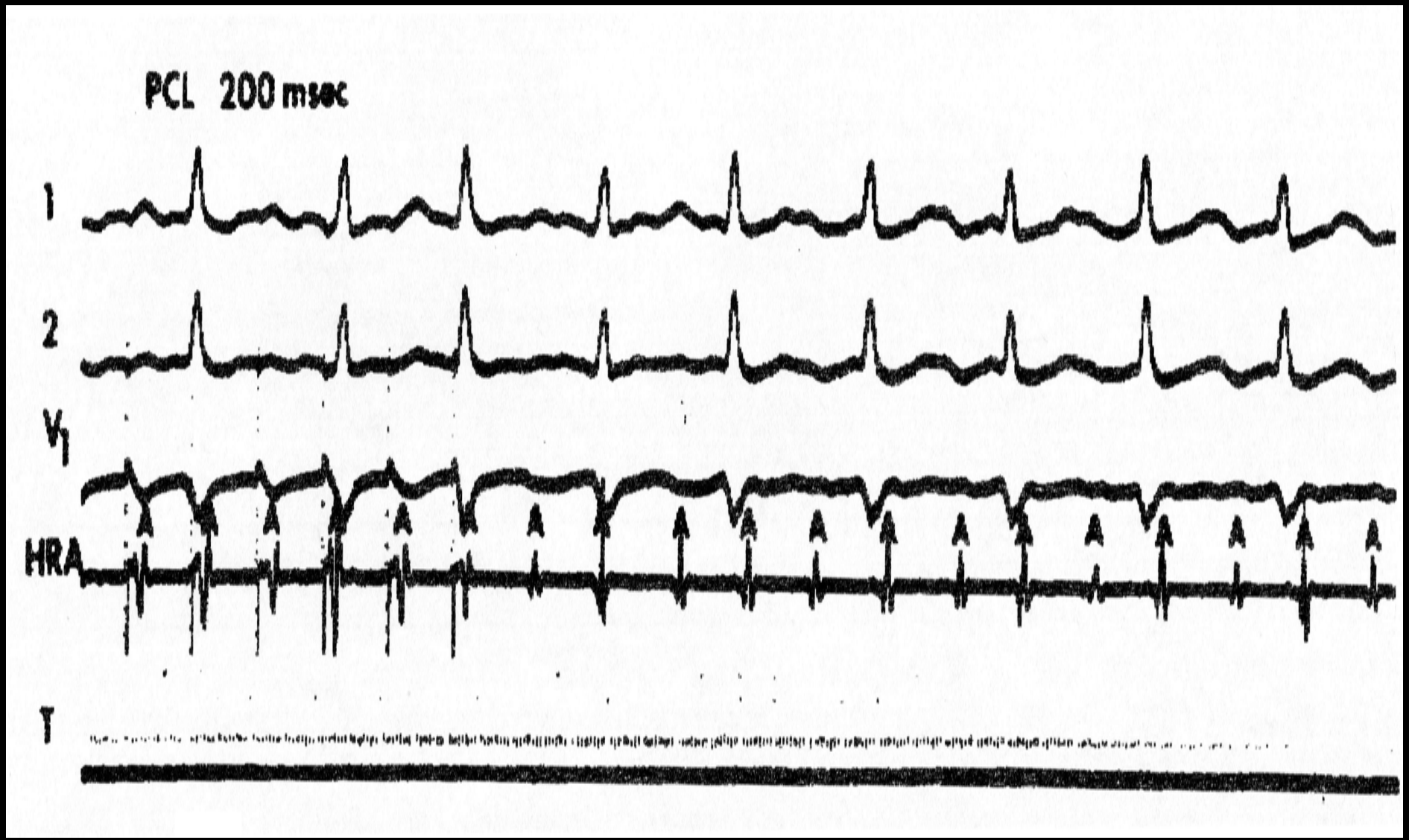

I
aVF
V1
RA
A
HBE
A H V
RV
V
T
I
aVF
V1
S1 S1 400 S1 S1 S1
HRA
A A A A A A
HBE
H V H V H V H H V H
RV
V V V V
T

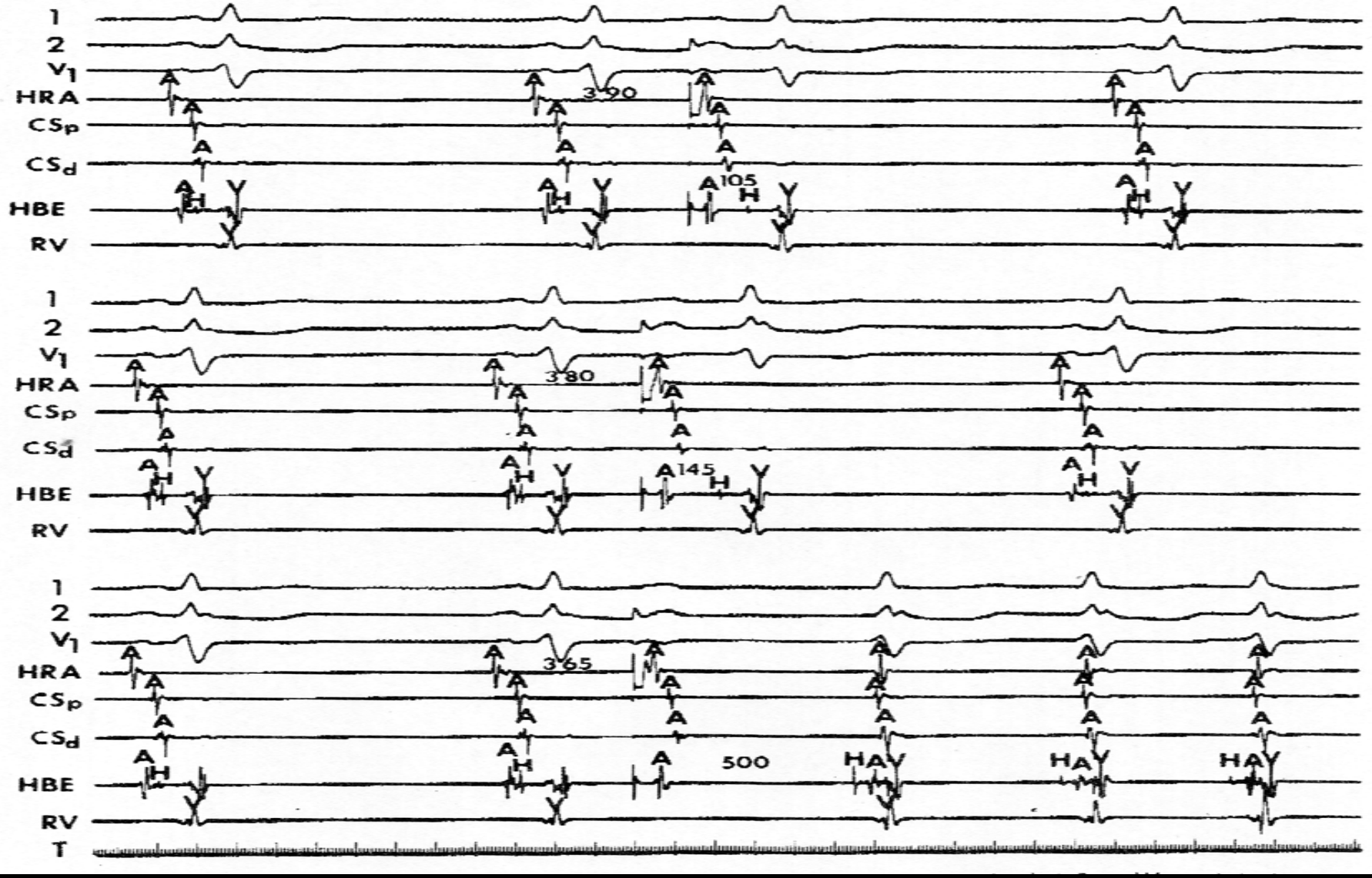

1
aVF
V1
PCL 340msec
HRA
HBE
RVA
A V A V
H H

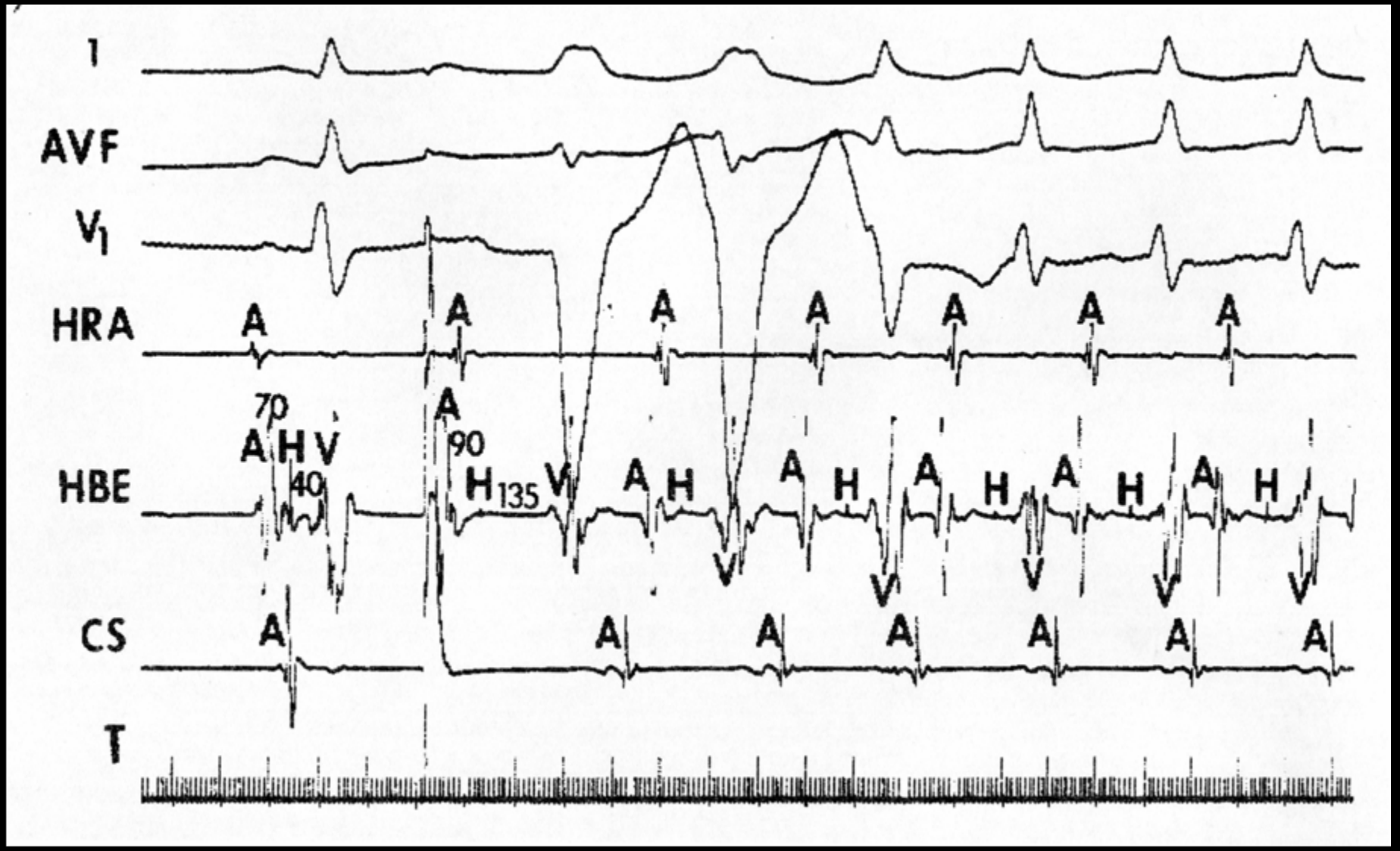

PROCAINAMIDE 1000mg
1
aVF
PCL 400 msec
V1
HRA
HBE
RVA
A H A H V

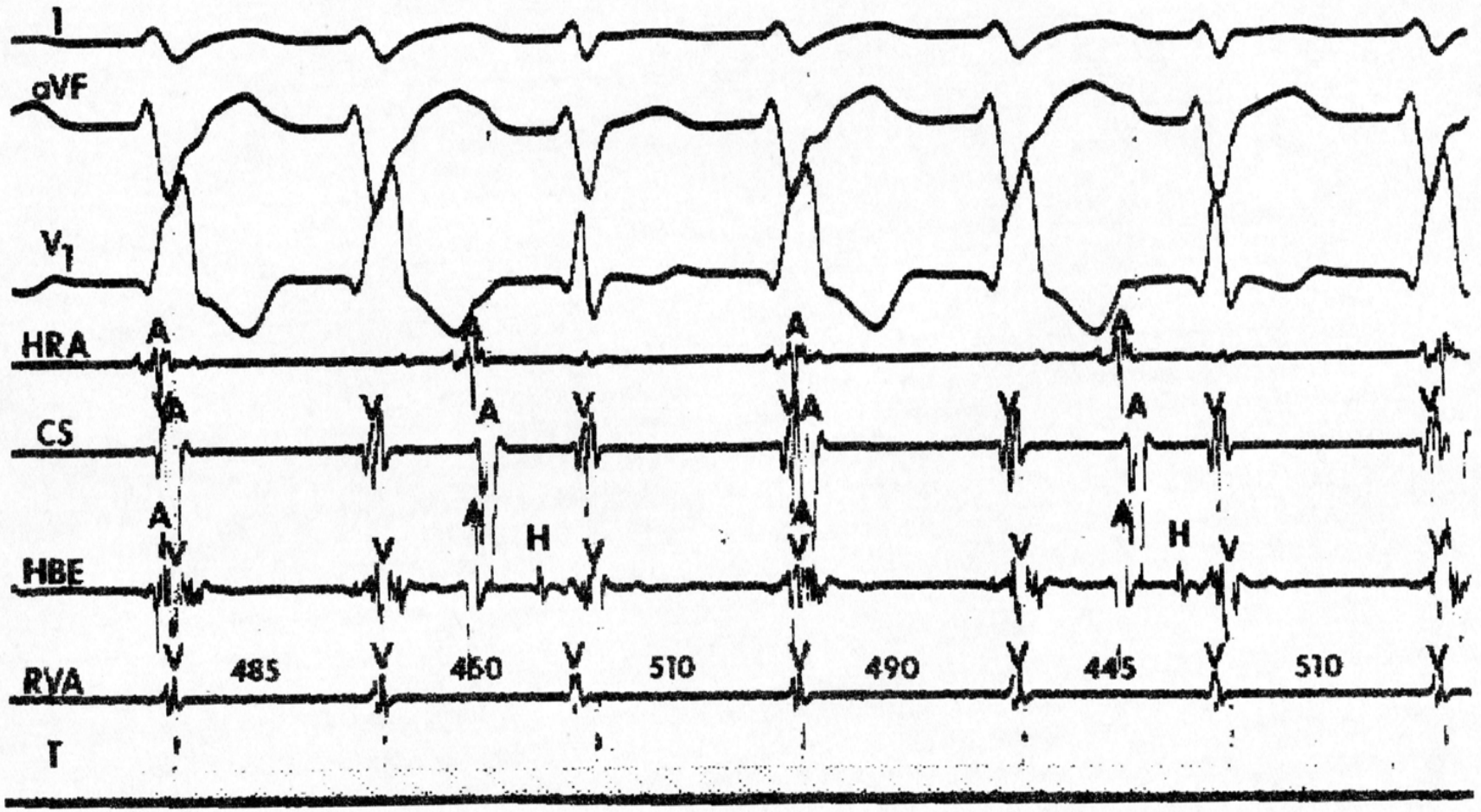

1
2
V1
HRA
HBE
RV
T
LBBB
RBBB
LBBB
A H V
70
130

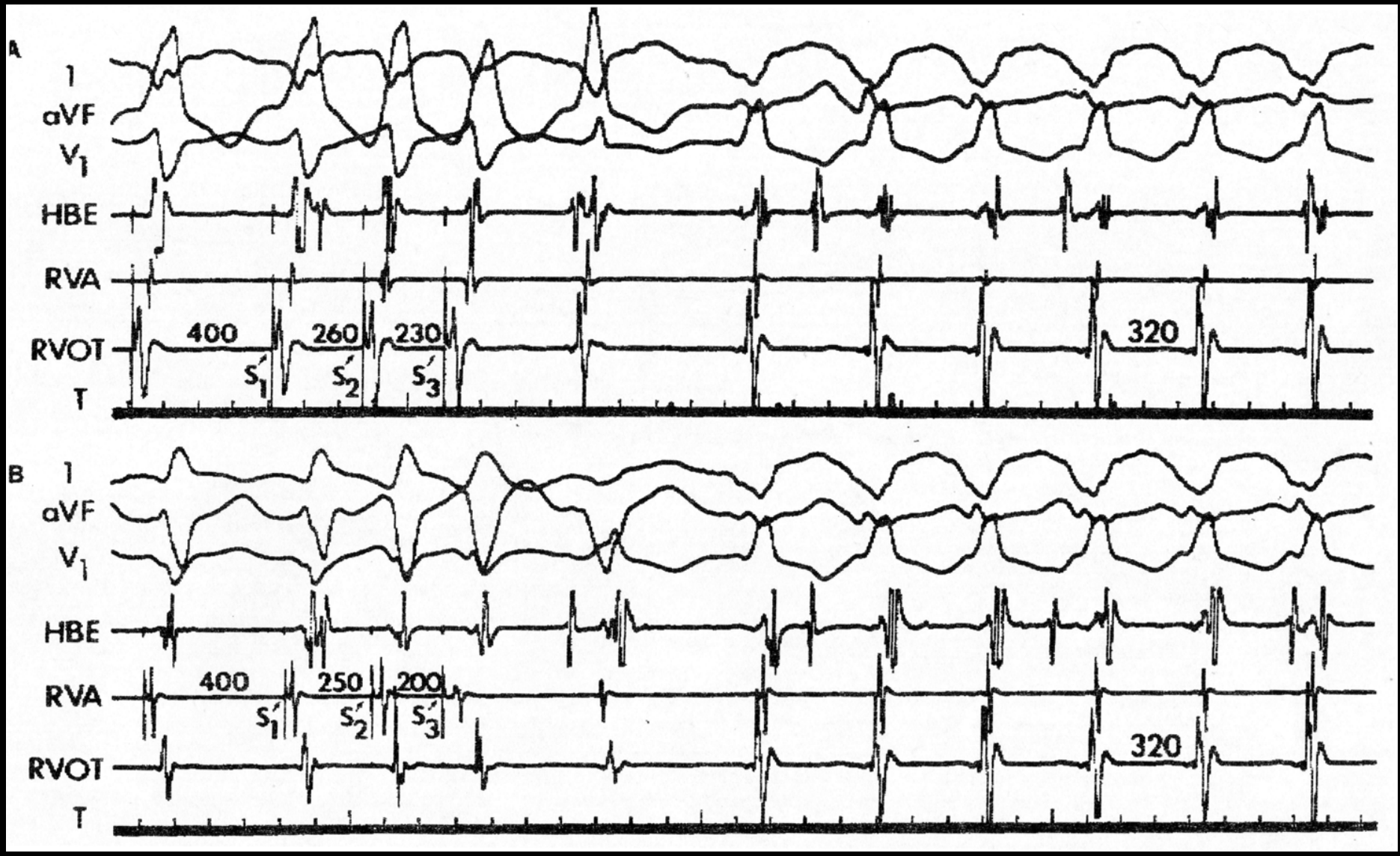

1
2
V1
HRA
CSp
CSd
HBE
RV
390
105
380
145
365
500
T


PCL 200 msec
I
2
V1
HRA
T


1
2
V1
HRA
CSp
CSd
HBE
RV
390
105
380
145
365
500
T


I
AVF
V1
HRA
HBE
CS
T
A
70
A H V
40
A
90
H135
V
A H
A
H
A
H
A
H
A
H
A
A
A
A
A
A
A

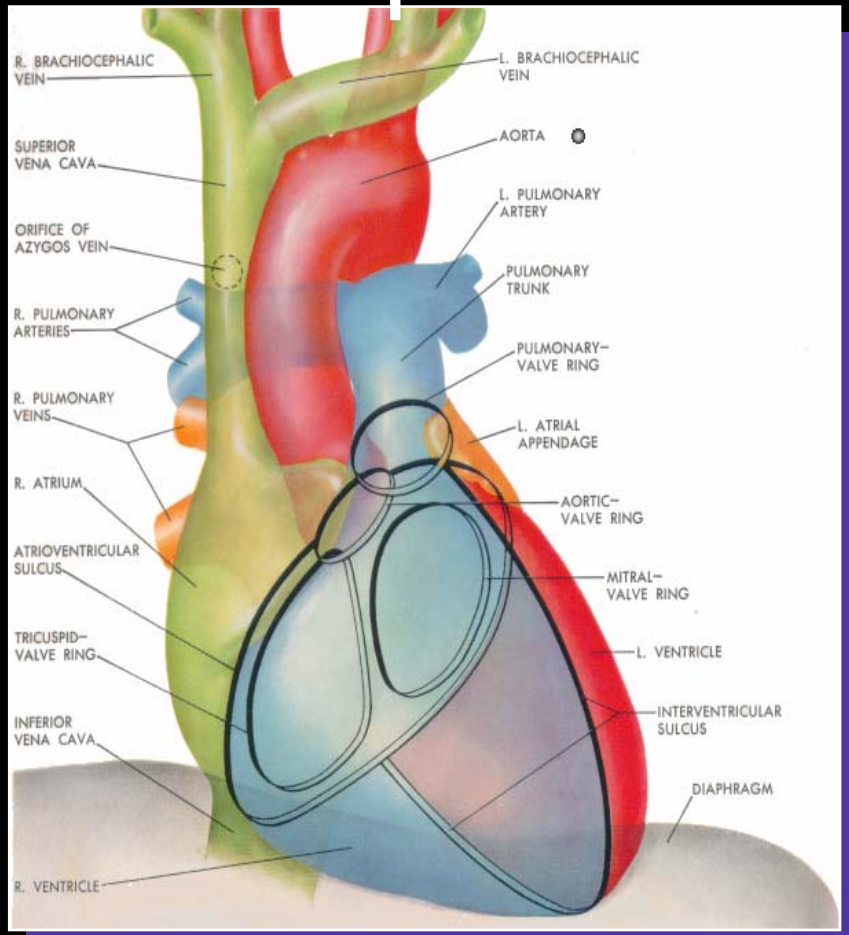

I
aVF
V1
HRA
CS
HBE
RVA
T
A
V
H
485
460
510
490
445
510

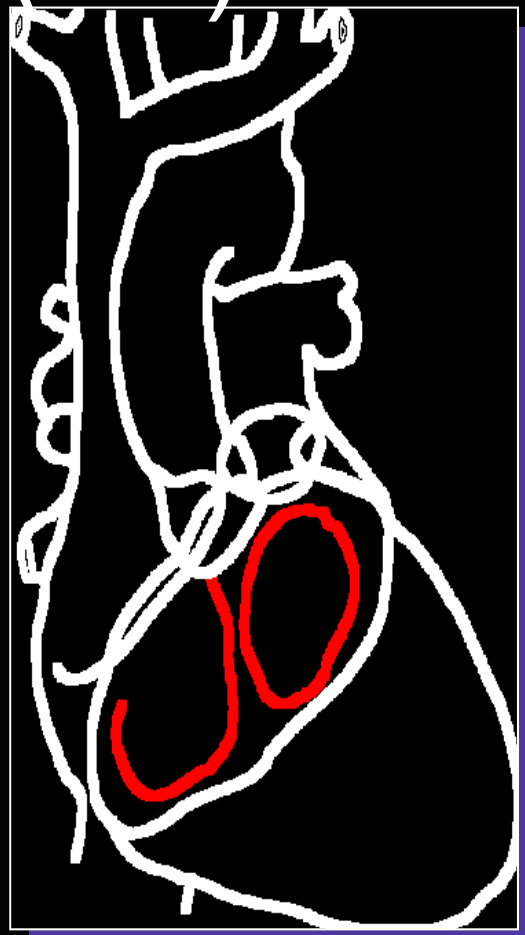

A
I
aVF
V1
HBE
RVA
RVOT
T
400
260
230
320
S'1
S'2
S'3
B
I
aVF
V1
HBE
RVA
RVOT
T
400
250
200
320
S'1
S'2
S'3

Goals of EPS in sudden cardiac arrest

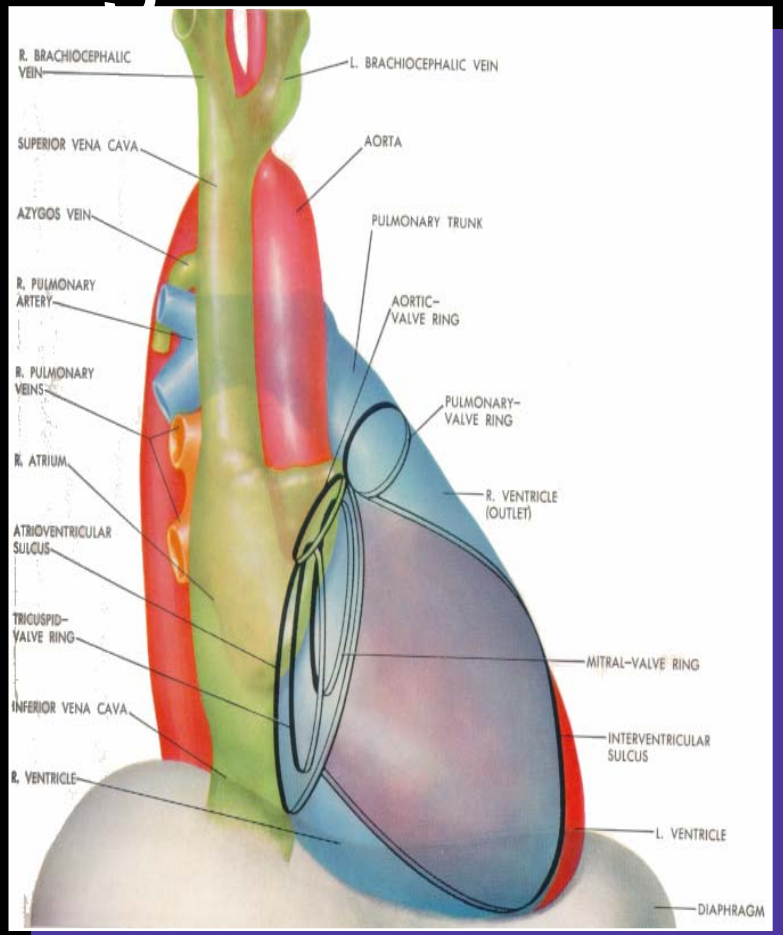
- Define susceptibility to inducible Arrhythmias
- Define drug therapy
- Identify sites of Arrhythmia origin
- Identify candidates for implantable Cardioverter/Defribillator
- Indentify candidates for Ablation
- Confirm efficacy of therapy

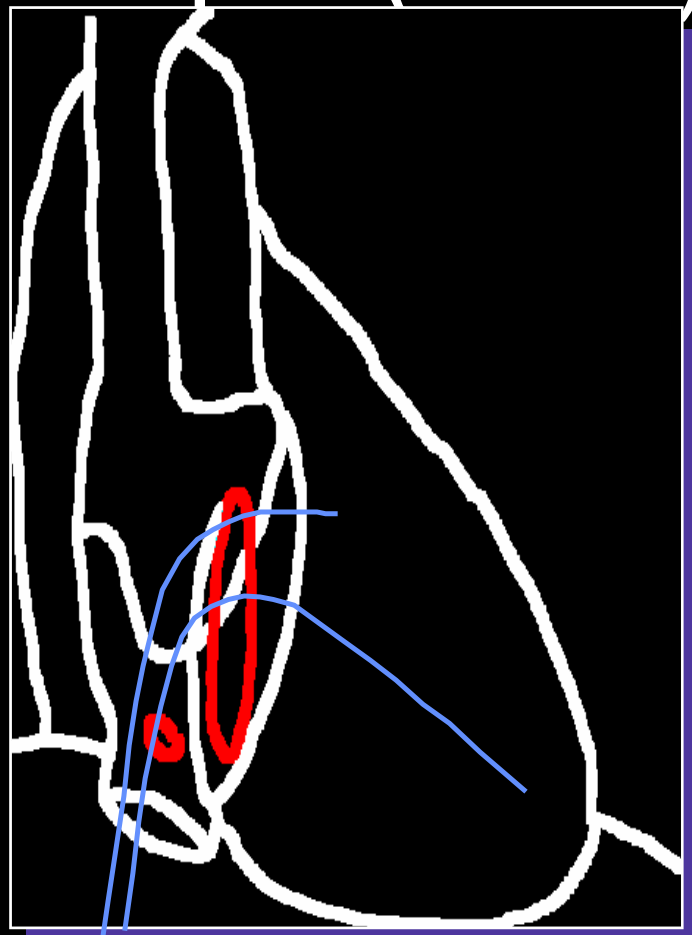
Anteroposterior (AP) view



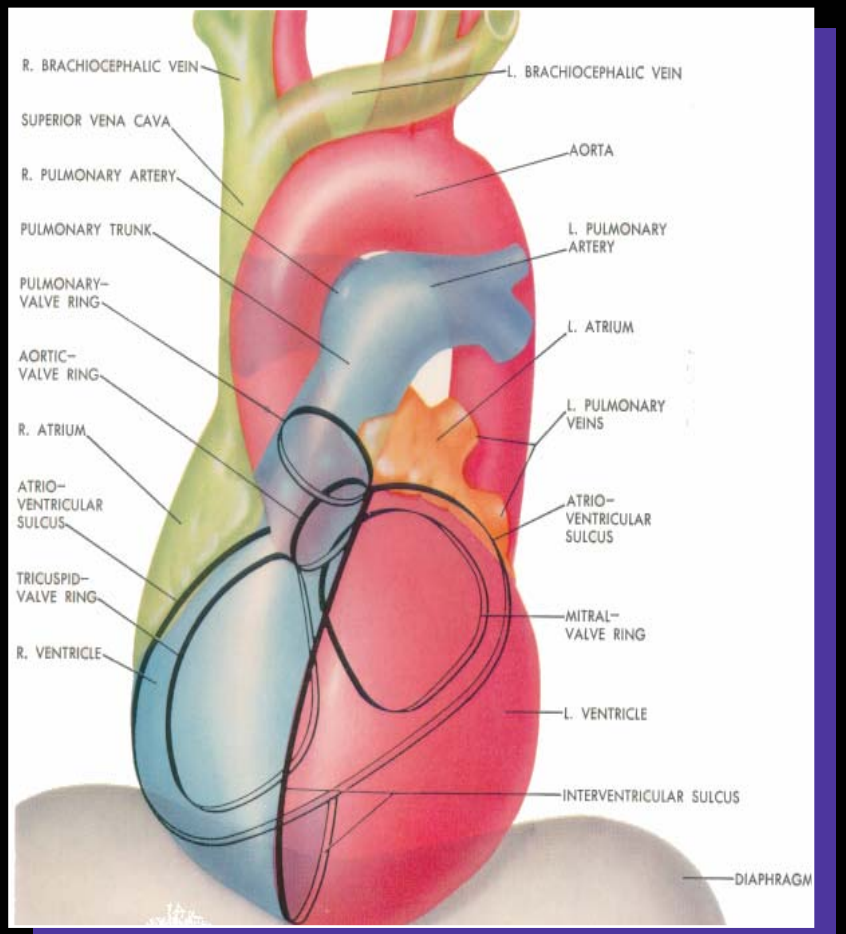


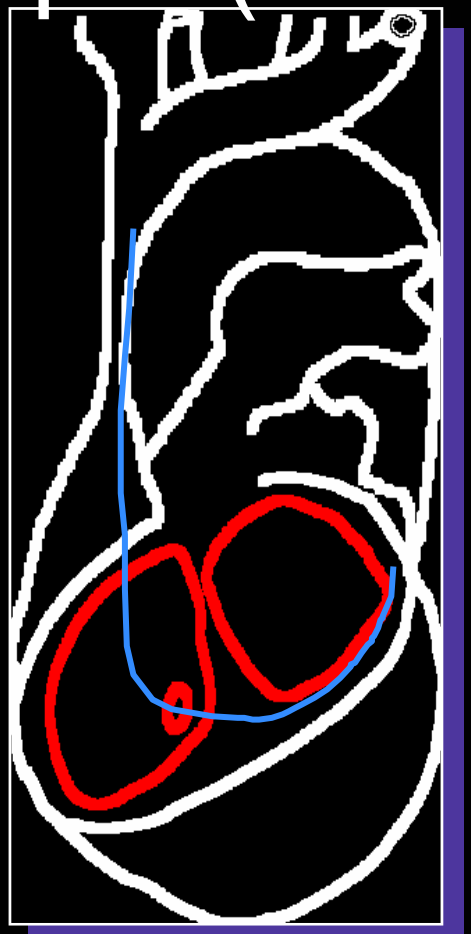
Right Anterior Oblique (RAO)

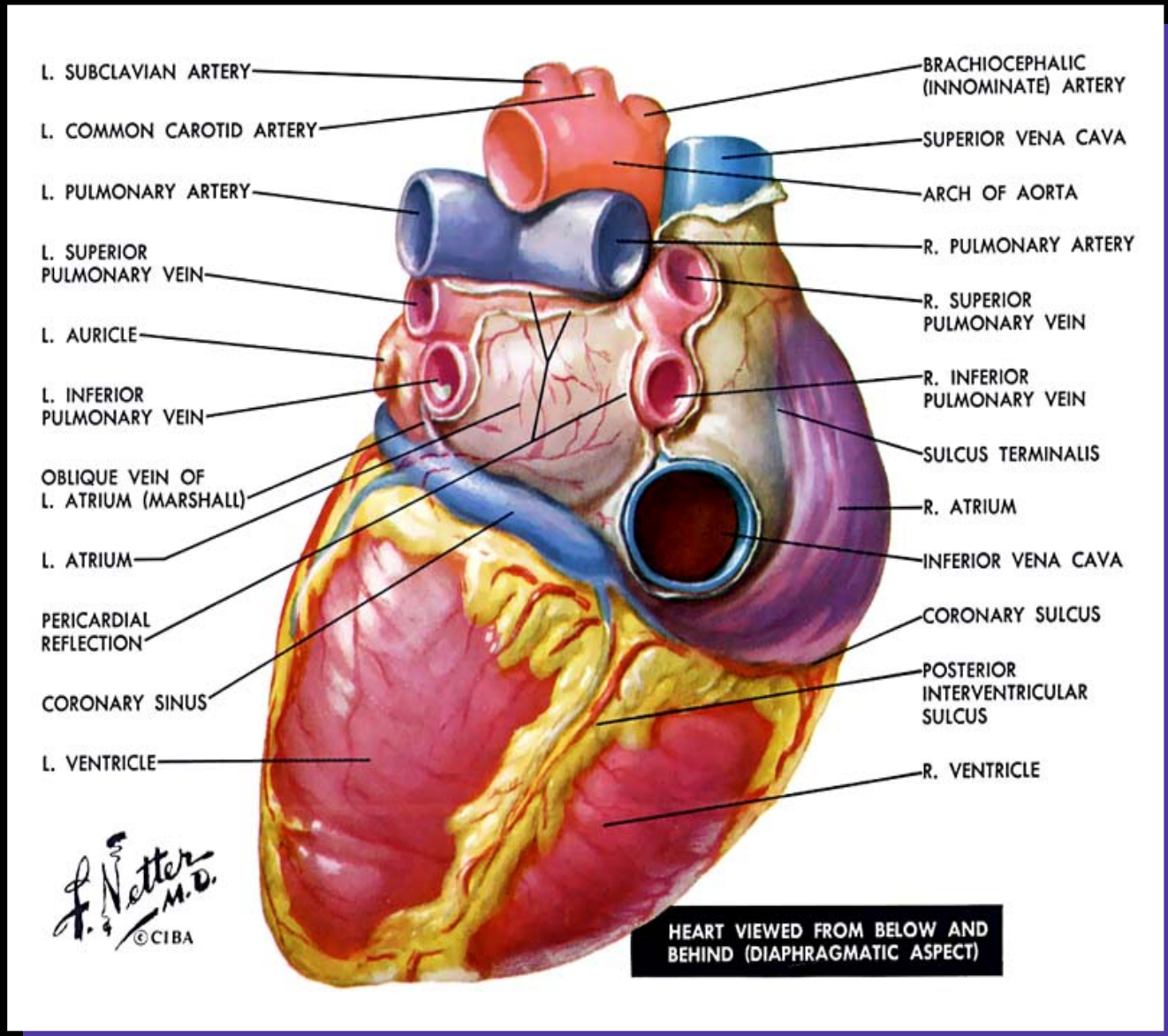


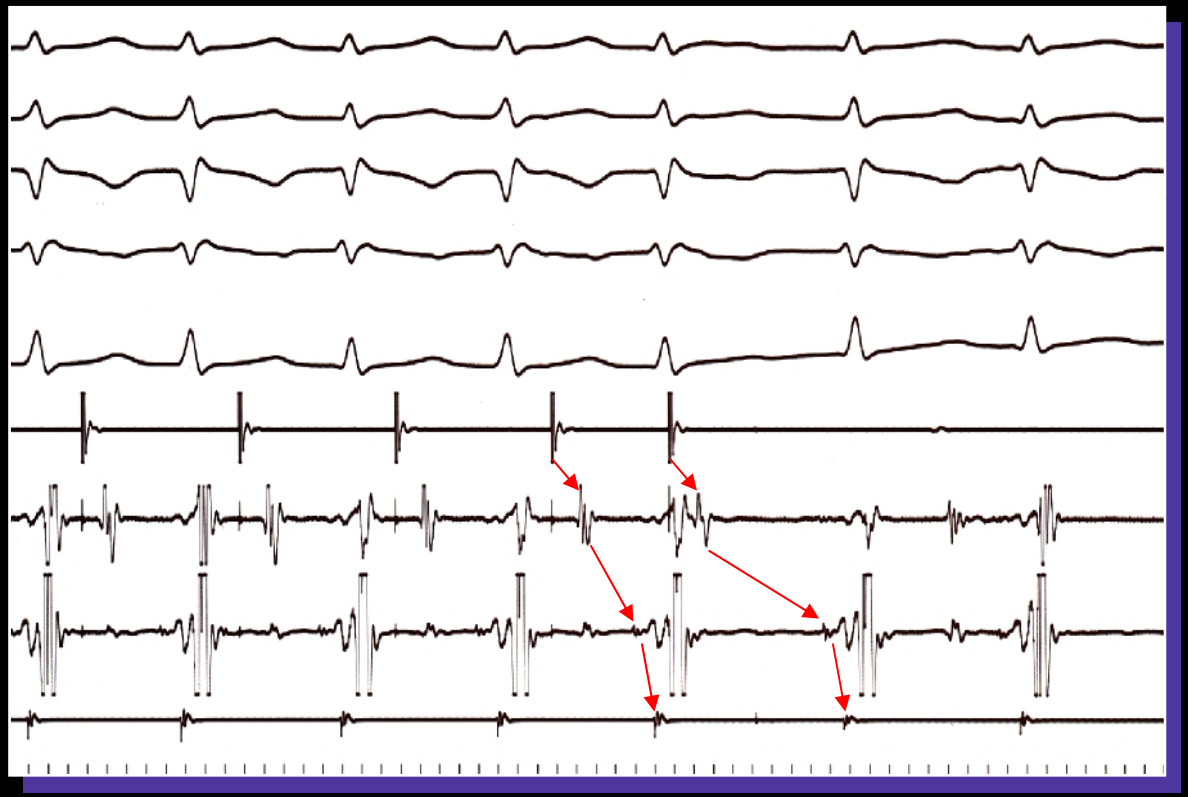


Left Anterior Oblique (LAO)





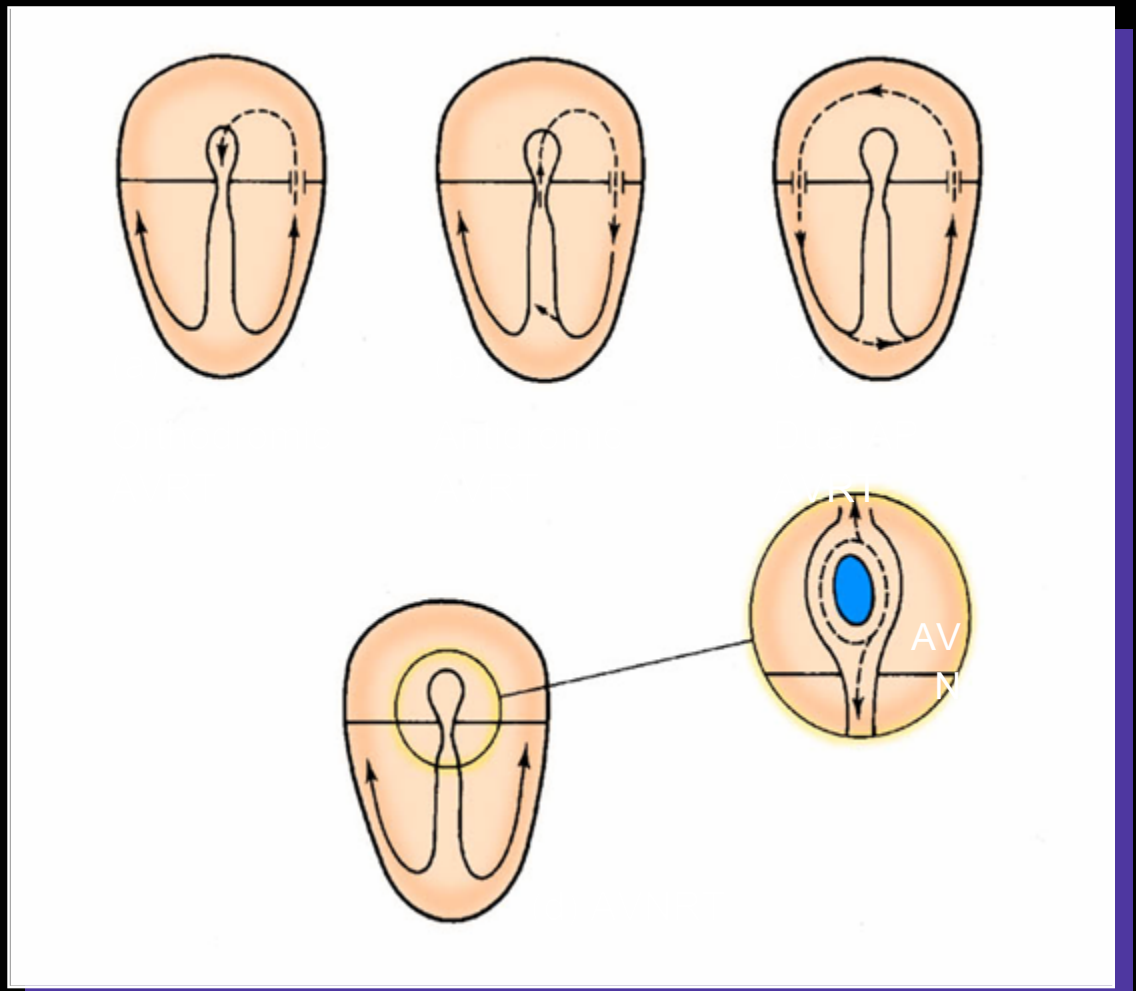

L. SUBCLAVIAN ARTERY
L. COMMON CAROTID ARTERY
L. PULMONARY ARTERY
L. SUPERIOR PULMONARY VEIN
L. AURICLE
L. INFERIOR PULMONARY VEIN
OBLIQUE VEIN OF L. ATRIUM (MARSHALL)
L. ATRIUM
PERICARDIAL REFLECTION
CORONARY SINUS
L. VENTRICLE
BRACHIOCEPHALIC (INNOMINATE) ARTERY
SUPERIOR VENA CAVA
ARCH OF AORTA
R. PULMONARY ARTERY
R. SUPERIOR PULMONARY VEIN
R. INFERIOR PULMONARY VEIN
SULCUS TERMINALIS
R. ATRIUM
INFERIOR VENA CAVA
CORONARY SULCUS
POSTERIOR INTERVENTRICULAR SULCUS
R. VENTRICLE
F. Netter M.D.
©CIBA
HEART VIEWED FROM BELOW AND BEHIND (DIAPHRAGMATIC ASPECT)



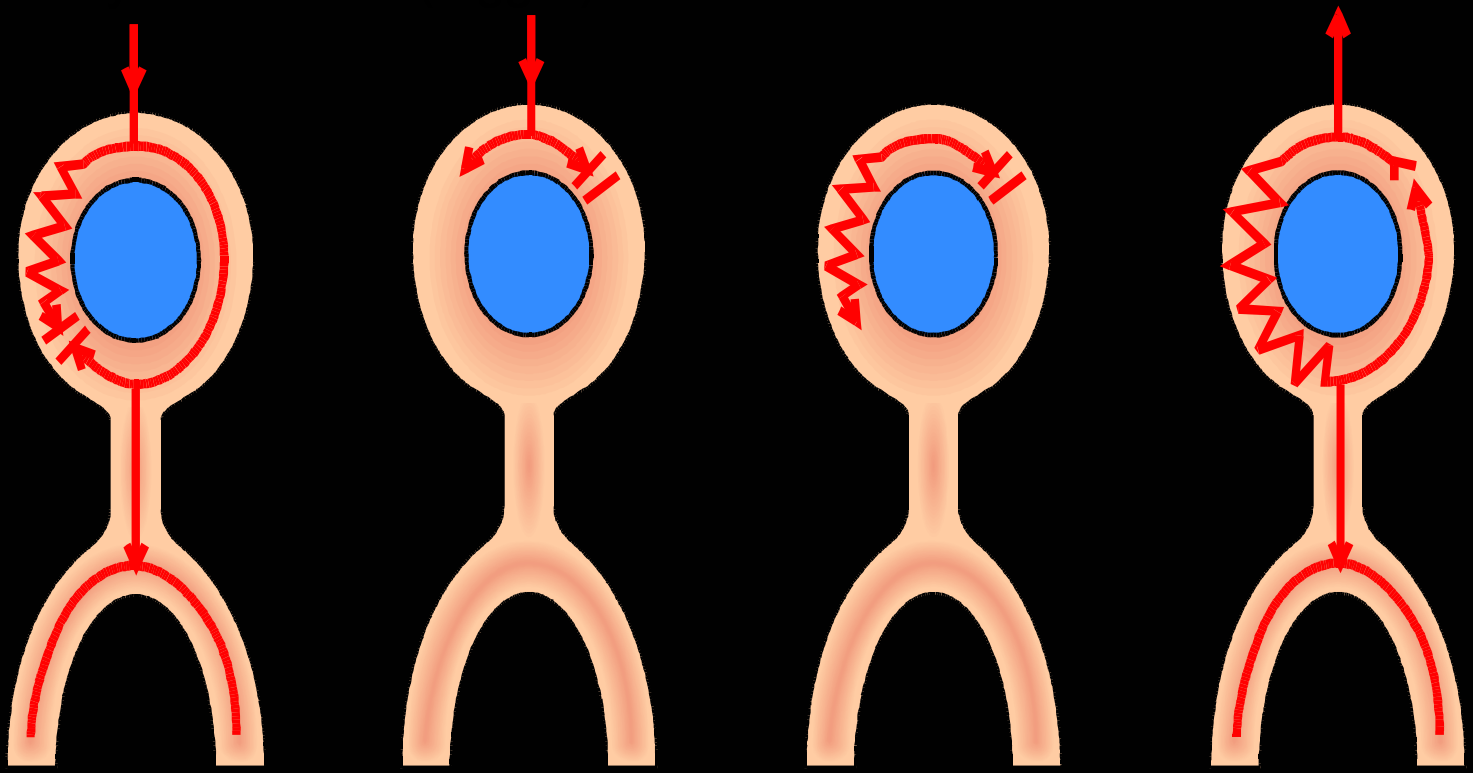
Wolff-Parkinson-White Syndrome via Intersim

- **Substrate consists of•**
- **Slow pathway (AV-node)•**
- **Fast pathway (Kent bundle)•**
- **Delta wave is premature V-depolarisation•**
- **Trigger: •**
- **Extra beat inside the reentry circuit•**
- **For initiation and termination•**

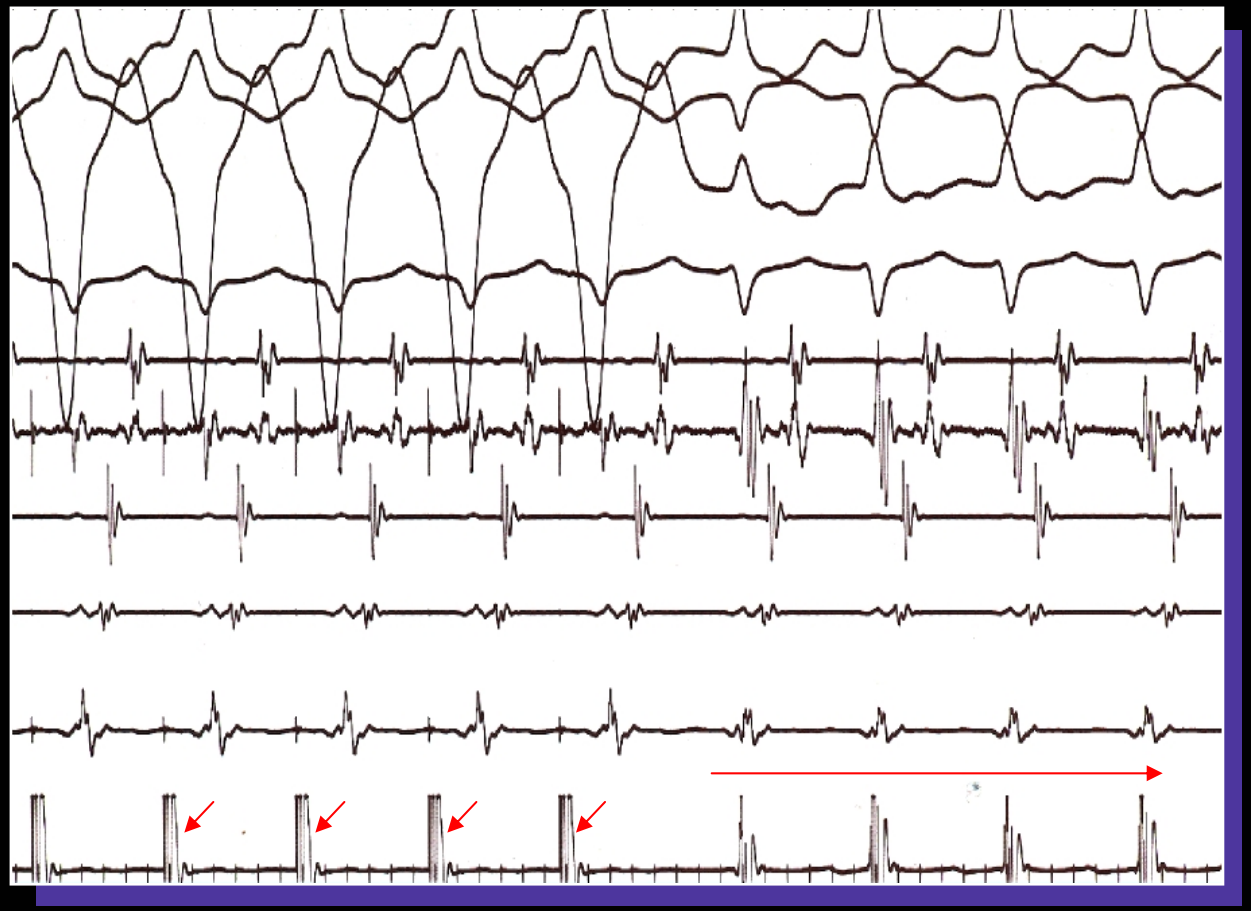
Typical reentry circuits



Initiation of reentry



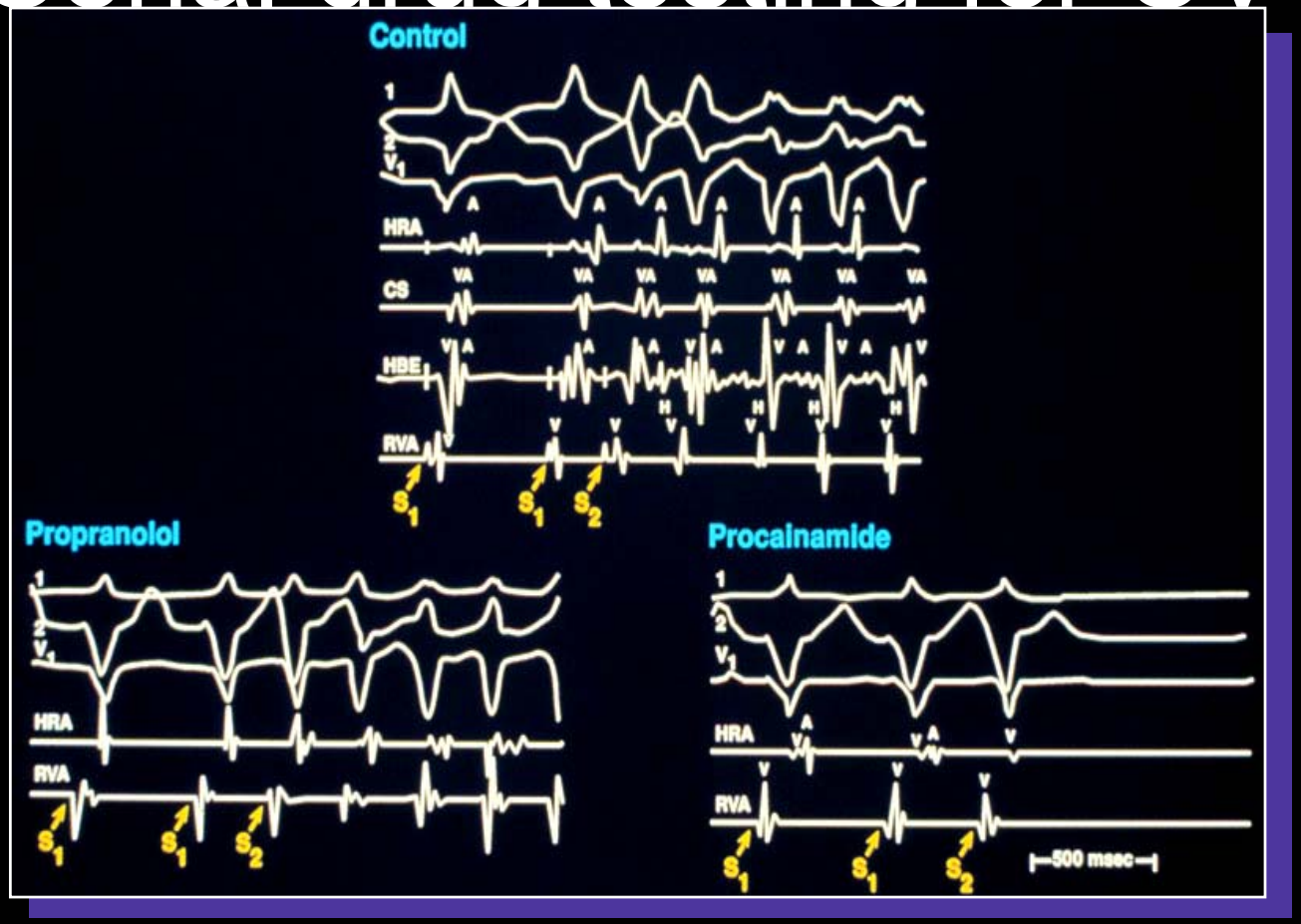
Initiation of SVT



Activation sequence

Termination of SVT with ventricular stimulation

Serial drug testing for SVT



Source: Josephson ME et al. In: *Clinical Cardiac Electrophysiology*. 1979;298

Conclusions II

Conduction properties •

Conduction times:-

- Intra atrial
- Nodal (AH interval)
- HIS-Purkinje (HV interval)
- Intra ventricular (acc. pathway)

Conclusions III

Refractory periods: •

- Atrial
- Nodal
- Ventricular
- Accessory pathways