



# History of ablation

**Prof. Martin Borggrefe**  
**Universitätsmedizin Mannheim**

**ADVANCES IN CARDIAC  
ARRHYTHMIAS**  
and  
**GREAT INNOVATIONS  
IN CARDIOLOGY**

**Turin**  
**October 13-15, 2016**

# History of Ablation

## Early non-thoracotomy approaches for induction of total av-block

Turina M, Babotai I, Wegmann W.  
Production of chronic atrioventricular block in dogs without thoractomy.  
Cardiovasc Res. **1968**; 2: 389-93

Babotai I, Brownlee R.  
Cardiovasc Res. **1971**; 5: 416-8.  
Experimental atrioventricular block without thoracotomy: a new instrument (injection of formalin)

Fisher VJ, Lee RJ, Christianson LC, Kavalier F. J Appl Physiol. **1966**; 21: 1119-21  
Production of chronic atrioventricular block in dogs without thoracotomy

Steiner C, Kovalik AT. J Appl Physiol. **1968**; 25: 631-2 A simple technique for production of chronic complete heart block in dogs



# History of Ablation

## Production of Chronic Atrioventricular Block in Dogs Without Thoracotomy

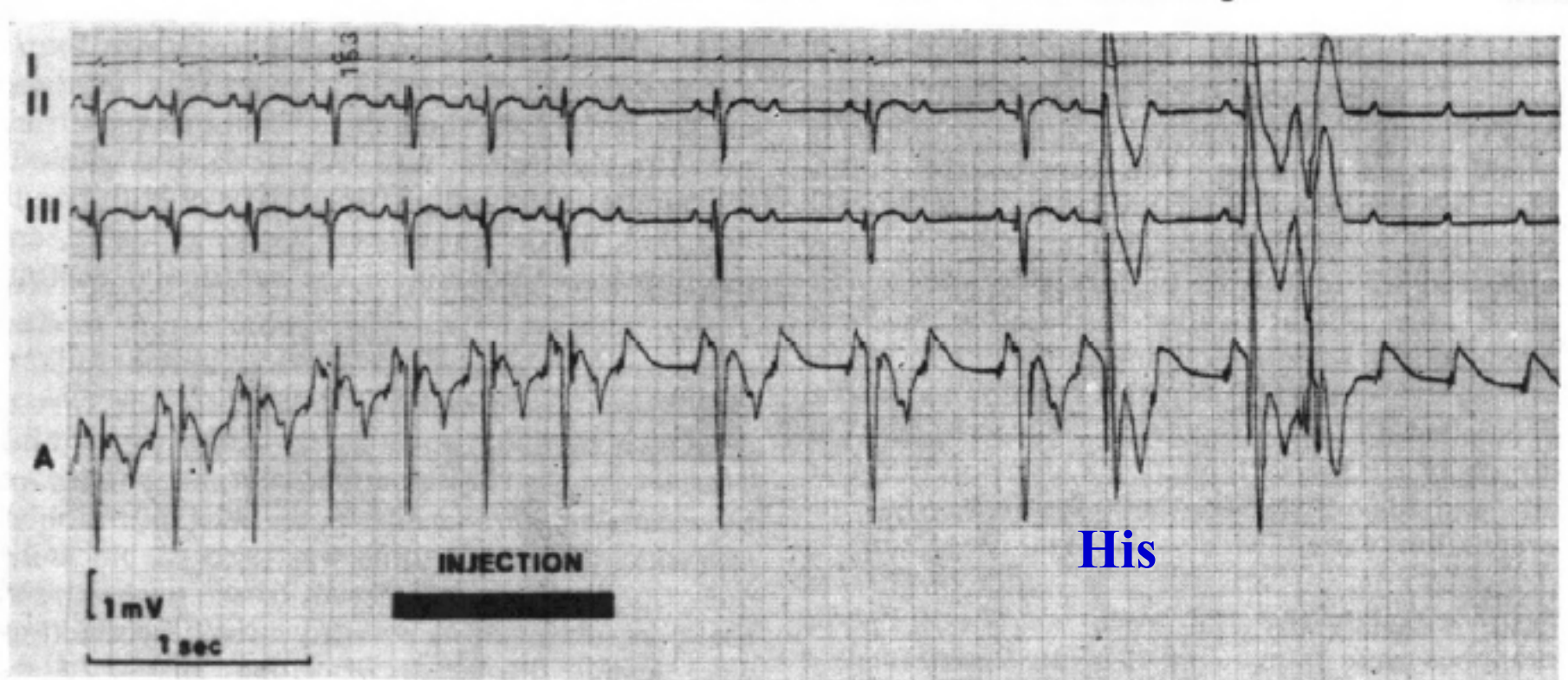


Fig. 3. Percutaneous block production in continuous ECG recording. In first seven P waves atrigrams show bundle spikes; after formaldehyde injection a 2:1 block appears, which after three ventricular extrasystoles progresses to total AV block. Symbols as in Fig. 2.

Arrows denote the depolarization of the bundle of His.  
I, II, III = extremity leads; A = atrigram.

# History of Ablation

## The French experience

From deliberate production of av-  
block in **1967**

.... to un-deliberate His bundle  
ablation in **1979**



# History of Ablation

## Production of Chronic Atrioventricular Block in Dogs Without Thoracotomy

MARKO TURINA\*, ISTVAN BABOTAI, and WERNER WEGMANN

From Surgical Clinic A and the Institute of Pathology, University of Zürich, Switzerland.

*AUTHORS' SYNOPSIS. Total heart block was produced in dogs without thoracotomy by means of a formaldehyde injection into the bundle of His. The method was successful in 22 out of 24 experiments. It is a useful model for haemodynamic studies in the intact animal.*

From: *Cardiovasc Res.* 1968;2: 389-93

## ... deliberate His bundle ablation

Deliberate production of an AV block in humans, followed by a pacemaker implantation, has been reported several times in the last few years (Char-dack, 1964; Gianelli, Ayres, Gomprecht, Conklin, and Kennedy, 1967; Slama, Blondeau, Aigueperse, Cachera, Degorges, and Abbou, 1967). It was used as a last, admittedly heroic, measure to control an otherwise refractory supraventricular tachycardia. In all these operations open-heart surgery had to be done, and percutaneous block production could have achieved the same effect in a much simpler way. If a local anaesthetic agent

Slama, R., Blondeau, Ph., Aigueperse, J., Cachera, J., Degorges, M., and Abbou, E. (1967). Création chirurgicale d'un bloc auriculoventriculaire et implanta-tion d'un stimulateur dans deux cas de troubles du rythme irréductibles. *Arch. Mal. Cœur*, 60, 406.

# History of Ablation

## ... un-deliberate His bundle ablation

Bloc auriculo-ventriculaire intra-hisien définitif induit au cours d'une exploration endoventriculaire droite

par J. VEDEL, R. FRANK, G. FONTAINE, J.F. FOURNIAL et Y. GROSGOGÉAT

*Une exploration électrophysiologique endocavitaire est effectuée chez un malade de 47 ans en raison d'épisodes syncopaux survenus 3 ans après un infarctus myocardique antérieur inaugural.*

*Au cours de l'examen, alors qu'une sonde bipolaire est au contact du tronc du faisceau de His, une tachycardie ventriculaire rapidement syncopale est induite nécessitant pour sa réduction plusieurs chocs électriques externes.*

*Au décours de la cardioversion est mis en évidence un bloc auriculo-ventriculaire complet intra-hisien qui restera définitif alors même que les intervalles de conduction étaient au préalable normaux.*

*Le mécanisme de cet accident exceptionnel de la défibrillation paraît relever d'un phénomène d'induction.*

**MOTS CLÉS : tachycardie ventriculaire, faisceau de His, choc électrique externe, bloc auriculo-ventriculaire.**



# History of Ablation

BLOC A.V. INDUIT AU COURS D'UNE EXPLORATION ENDOVENTRICULAIRE

111

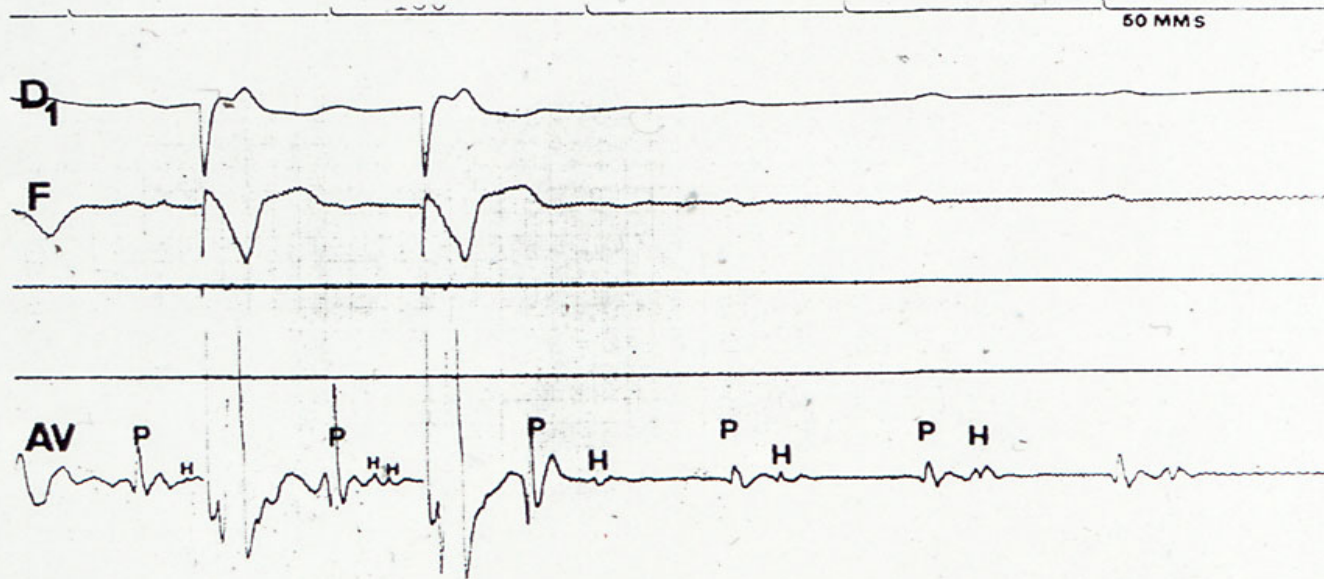


FIG. 5

Inhibition du stimulateur-sentinel. Potentiel H élargi suivant les ondes P bloquées.

From: Vedel J et al., Arch Mal Coeur 72:107 - 112; 1979

# Closed-chest electrode-catheter technique for His bundle ablation in dogs

ROLANDO GONZALEZ, MELVIN SCHEINMAN, WILLIAM MARGARETTEN,  
AND MICHAEL RUBINSTEIN

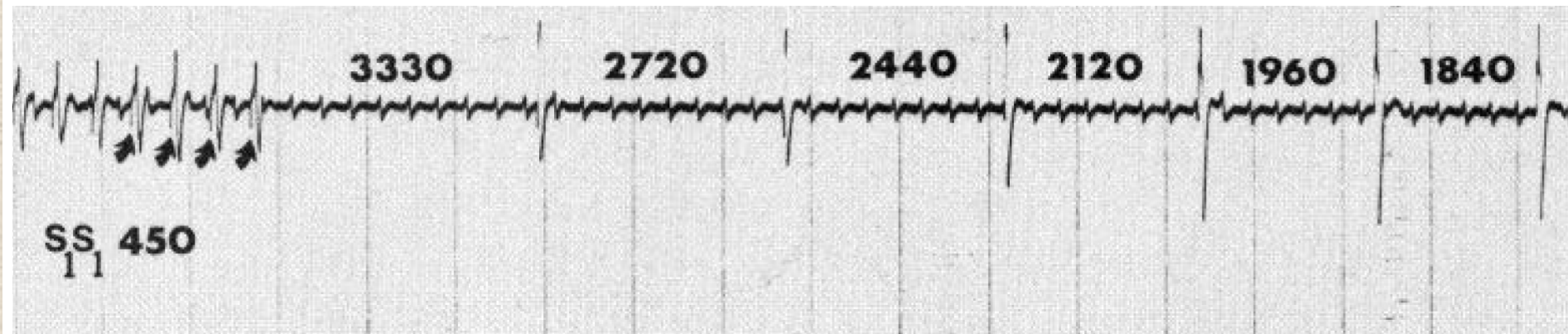
*Departments of Medicine and Pathology, University of California, San Francisco, and  
Medical and Anatomic Pathology Services, San Francisco General Hospital Medical Center,  
San Francisco, California 94143*

GONZALEZ, ROLANDO, MELVIN SCHEINMAN, WILLIAM MARGARETTEN, AND MICHAEL RUBENSTEIN. *Closed-chest electrode-catheter technique for His bundle ablation in dogs*. Am. J. Physiol. 241 (Heart Circ. Physiol. 10): H283-H287, 1981.—A modified quadripolar electrode catheter that had two-thirds of the distal surface insulated with high-voltage plastic was inserted in 10 dogs. After a His bundle potential had been recorded, a synchronized direct-current electrical discharge was delivered between the electrodes showing the largest His bundle deflection using a standard direct-current defibrillator, and a metallic plate was positioned over the dog's back. Complete atrioventricular (AV) block was induced in 9 of 10 dogs, which were followed for 3 mo before being killed. During AV block, the QRS complex was broad and not preceded by a His bundle deflection. The mean control cycle length during AV block was  $1,441 \pm 223$  ms and decreased to  $1,151 \pm 181$  ms after exercise, a response that was usually abolished by  $\beta$ -blockade. Overdrive pacing resulted in pacemaker suppression with gradual rate stabilization after 10–20 beats. There was no evidence of myocardial or valvular damage. This technique provides for a stable model of complete AV block and is suitable for experiments in which heart rate control is required. In addition, this technique may be of value for patients with tachycardia requiring His bundle section.

or valvular damage resulting from these techniques. The purpose of this report is to describe a technique of closed-chest His bundle ablation in dogs and to characterize both the hemodynamic profile and the electrophysiology of the emerging pacemaker.



# History of Ablation



# History of Ablation

## Catheter-Induced Ablation of the Atrioventricular Junction to Control Refractory Supraventricular Arrhythmias

Melvin M. Scheinman, MD; Fred Morady, MD; David S. Hess, MD; Rolando Gonzalez, MD

• Five patients with recurrent bouts of supraventricular tachycardia proved resistant or became intolerant of both conventional and experimental drugs. These patients were subjected to a new procedure involving delivery of DC shocks to an electrode catheter positioned adjacent to the His bundle. Complete atrioventricular (AV) block was produced in all, one patient died suddenly six weeks after shock therapy, and the remainder had complete AV block with follow-up intervals ranging from four to 12 months. Shock therapy was associated with mild elevations of creatine phosphokinase MB ( $31 \pm 18$  units), but there was no hemodynamic evidence of tricuspid insufficiency. If this new technique proves safe and effective, it should supplant the need for open heart surgical procedures for His-bundle ablation.

(*JAMA* 1982;248:851-855)

rhythm was amiodarone, but administration had to be discontinued because of ocular toxic reactions in two patients, severe tremor in one, and an acute respiratory tract distress syndrome in one. One patient (No. 5) failed trials of verapamil and propafenone and declined a trial of amiodarone therapy.

All patients underwent standard electrophysiological studies with electrode catheters positioned in the high right atrium, across the tricuspid valve, in the coronary sinus, and against the right ventricular apex. None of the patients showed evidence of anterograde preexcita-

# History of Ablation

## CATHETER TECHNIQUE FOR CLOSED-CHEST ABLATION OF THE ATRIOVENTRICULAR CONDUCTION SYSTEM

### A Therapeutic Alternative for the Treatment of Refractory Supraventricular Tachycardia

JOHN J. GALLAGHER, M.D., ROBERT H. SVENSON, M.D., JACK H. KASELL, LAWRENCE D. GERMAN, M.D.,  
GUST H. BARDY, M.D., ARCHER BROUGHTON, M.B.B.S., AND GIUSEPPE CRITELLI, M.D.

**Abstract** This report describes a catheter technique for ablating the His bundle and its application in nine patients with recurrent supraventricular tachycardia that was unresponsive to medical management. A tri-polar electrode catheter was positioned in the region of the His bundle, and the electrode recording a large unipolar His-bundle potential was identified. In the first patient, two shocks of 25 and 50 J, respectively, were delivered by a standard cardioversion unit to the catheter electrode, resulting in an intra-His-bundle conduction defect. Subsequent delivery of 300 J resulted in complete heart block. In the next eight

patients, an initial shock of 200 J was used. The His bundle was ablated by this single shock in six of these patients and by an additional shock of 300 J in one. In the remaining patient, conduction in the atrioventricular node was modified, resulting in alternating first and second-degree atrioventricular block. A stable escape rhythm was preserved in all patients. The procedure was well tolerated, without complications, and all patients have remained free of arrhythmia, without medication, for follow-up periods of two to six months. (N Engl J Med. 1982; 306:194-200.)



# History of Ablation

**Other energy sources –  
the solution to the disadvantages of direct  
current ablation?**



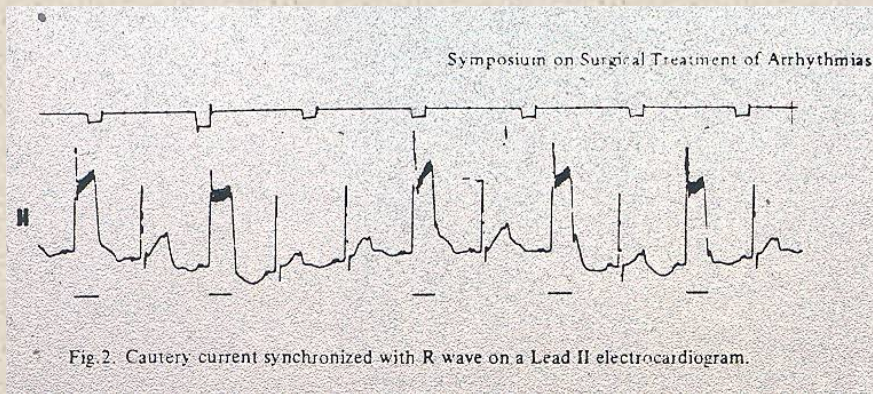
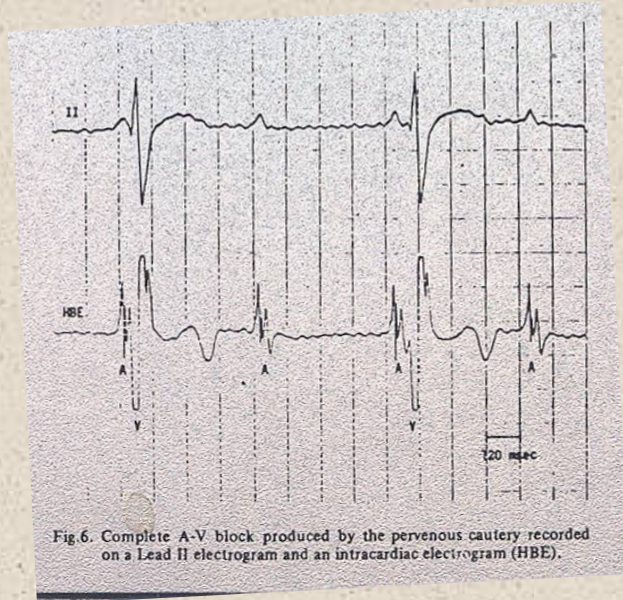
# History of Ablation

Symposium on surgical treatment of  
arrhythmias,  
Tokyo 1977

Transvenous Electrocautery of  
Atrioventricular Connection Guided  
by the His Electrogram

Toshio **Mitsui**, M.D.,  
Hiroshi **Ijima**, M.D.,  
Kenji **Okamura**, M.D.,  
Motokazu **Hori**, M.D.

Jpn Circ J. 1978; 42: 313-8



# History of Ablation

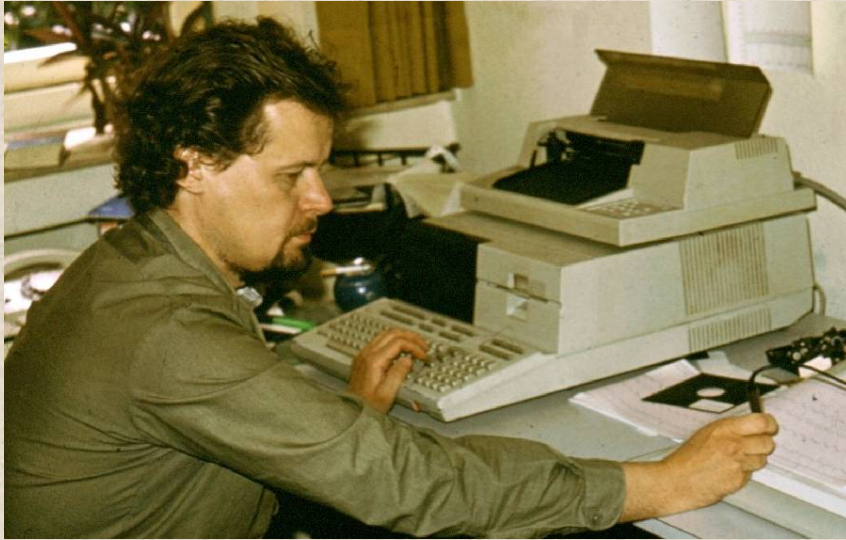
**Narula OS, Bharati S, Chan MC, Embi AA, Lev M.**

**Am J Cardiol 1984; 54: 186-92**

**Microtransection of the His bundle with laser radiation through a pervenous catheter: correlation of histologic and electrophysiologic data**

*microtransection of the His bundle with a pervenous laser catheter in a live dog*

# History of Ablation



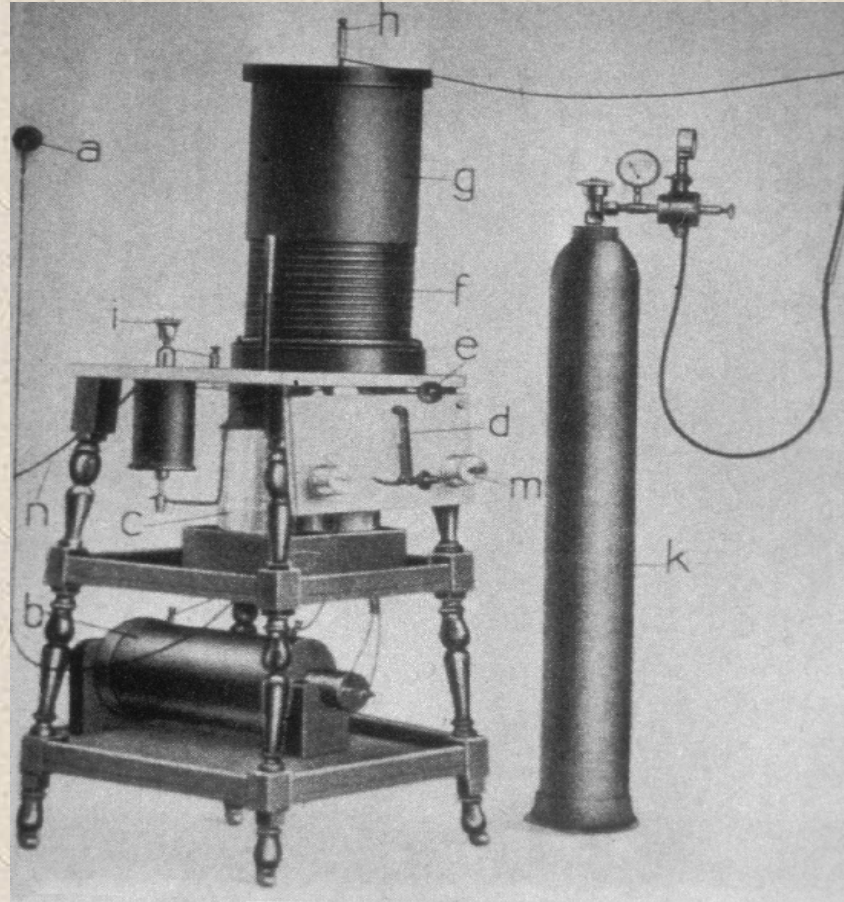
**Düsseldorf, 1983-84**

**Aleksandras Laucevicius,  
Vilnius, Lithuania**

**2006**



# History of Ablation



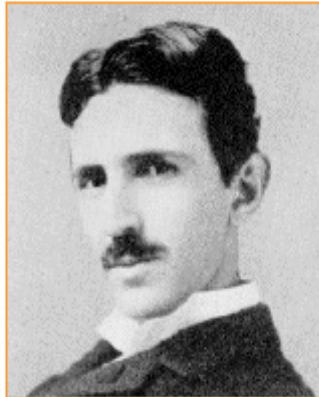


# History of Ablation

## Use of Radiofrequency as Energy Source in Medical Applications

Radiofrequency energy has been used for many decades, mostly surgical applications.

In 1889 engineer **Nikola Tesla** applied a patent in the US for the first radiofrequency device and speculated already in 1891 about potential applications in medicine.



**Nikola Tesla** \* July 10, 1856 in Croatia

studied in Graz, Austria

Prague, Czech Republic

worked in New York (Edison) and Pittsburgh

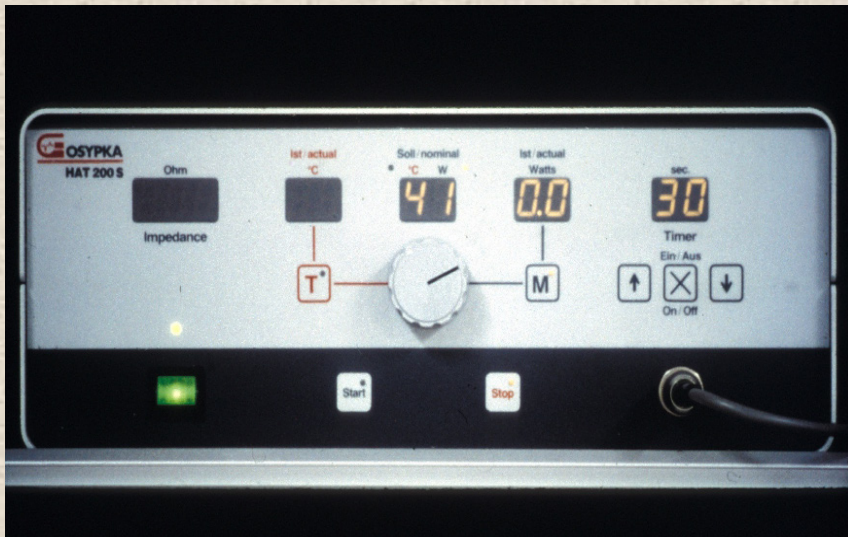
January 7, 1943: Tesla passes away at age 86

Further developments in medical use of radiofrequency energy to treat papillomas, hemorrhoids, scars, its use in neurosurgery and for tissue cutting and other non-cardiac applications were subsequently propelled and developed by **Nernst, Gildemeister, Nagelschmidt, Černý, Heymann, Cushing, Esau, and others\***

\*see also: Borggreffe, M.: Katheterablation tachykarder Herzrhythmusstoerungen mittels Hochfrequenzstrom, Steinkopff, 1994

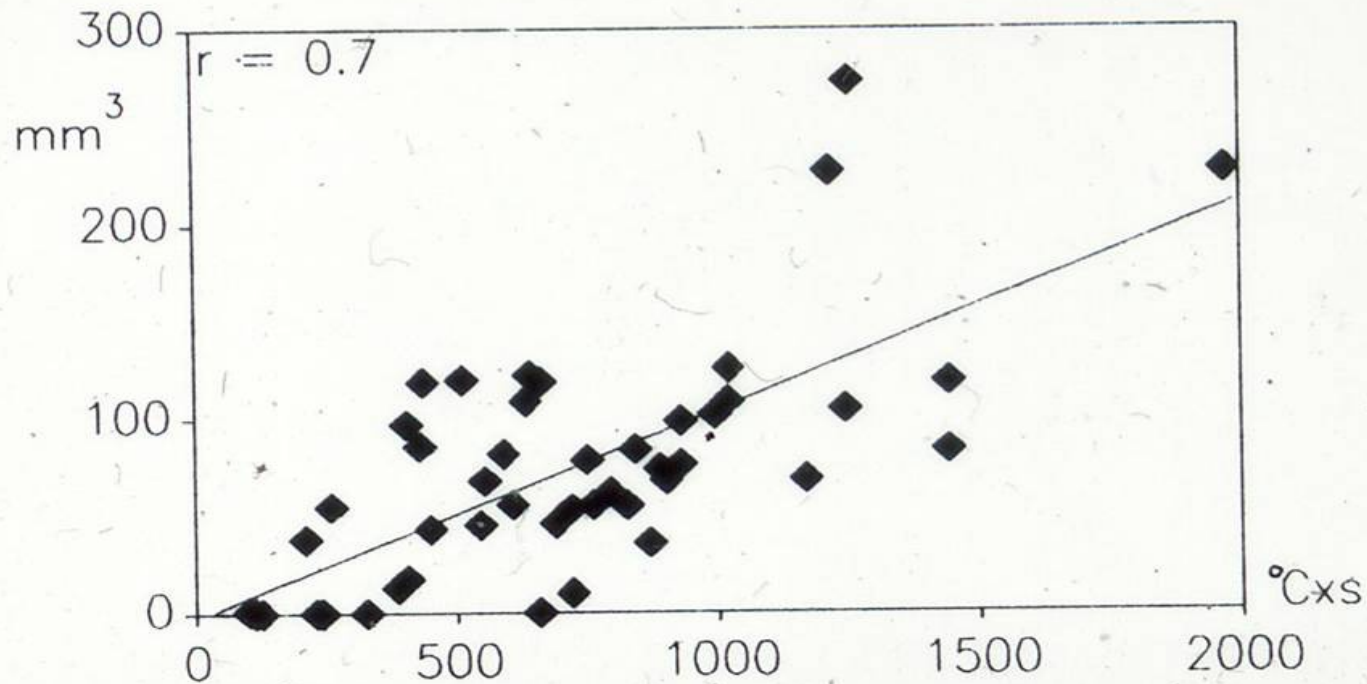


# History of Ablation



# History of Ablation

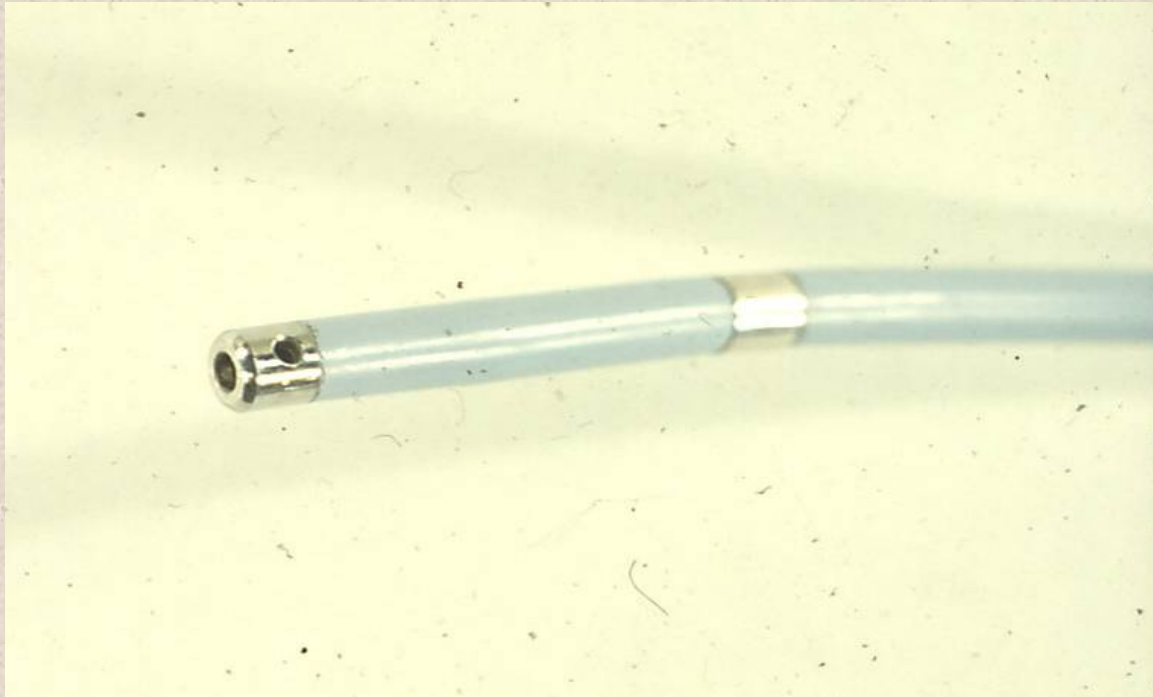
CORRELATION BETWEEN LESIONS VOLUME AND THE INTEGRAL  
OF TEMPERATURE CURVES IN VIVO



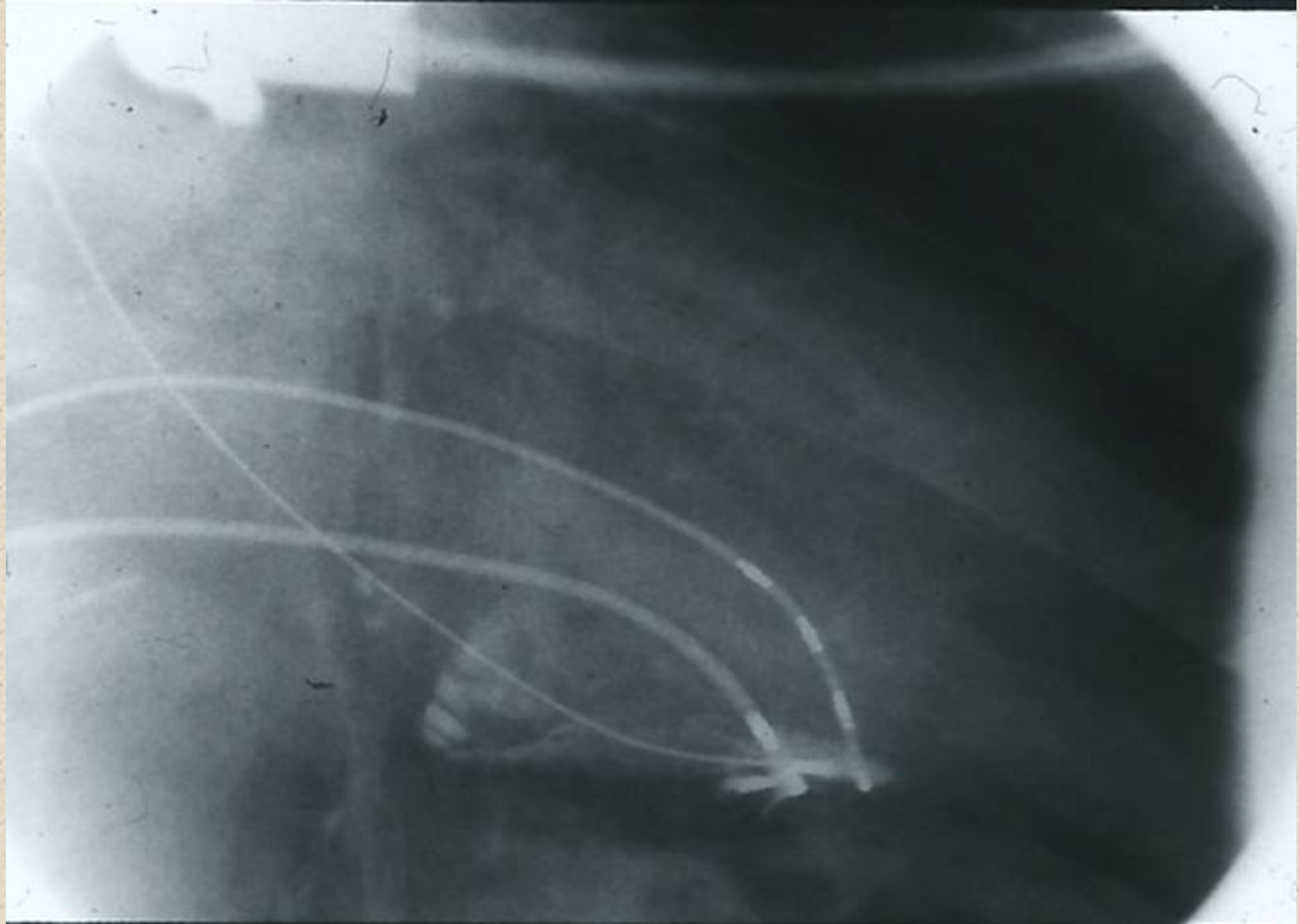
# History of Ablation



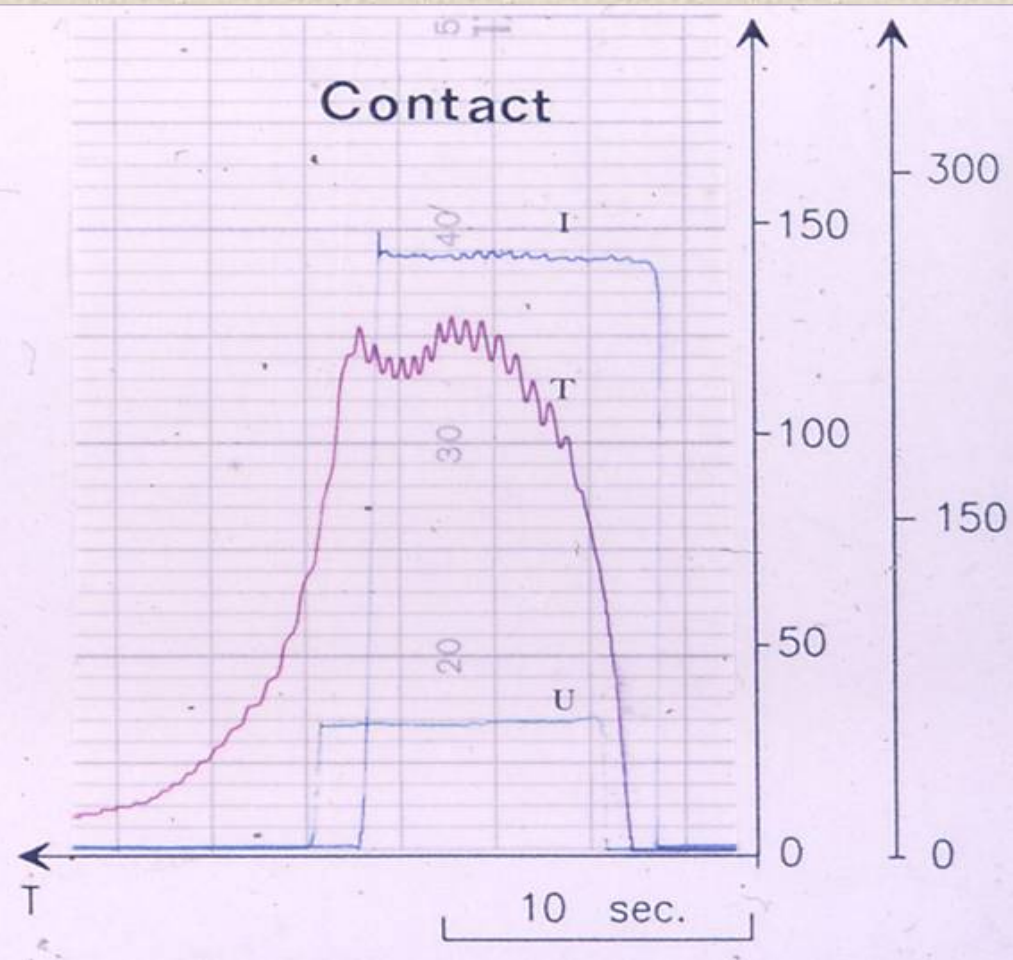
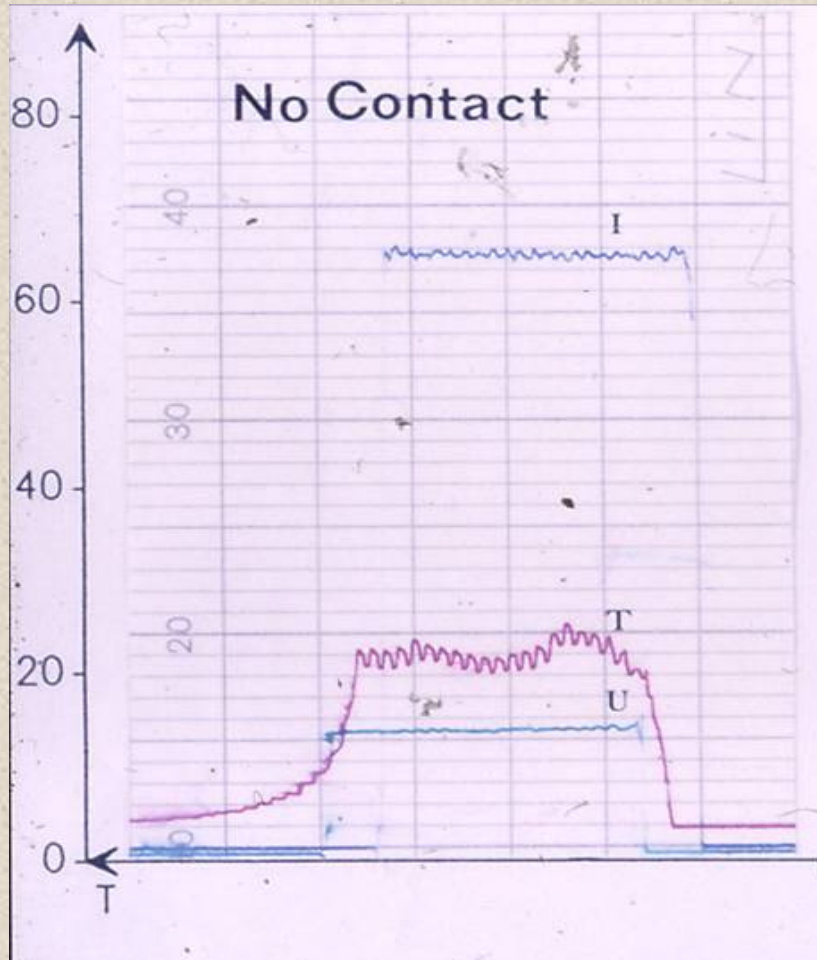
# History of Ablation



# History of Ablation



# History of Ablation



# History of Ablation

## Nonpharmacological Therapy of Tachyarrhythmias



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Krannert Institute of Cardiology  
Indiana University School of Medicine  
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Indianapolis, Indiana



FUTURA PUBLISHING COMPANY, INC.  
Mount Kisco, New York  
1987

### Part III: Catheter Ablation Techniques

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*Frank I. Marcus*
14. **Radiofrequency Ablation: An Improvement of Ablation Techniques in Comparison to Direct-Current Delivery?**  
*Thomas Budde, Martin Borggreffe, Andrea Podczek, B. Jacob, J. Langwasser, H. Frenzel, and Günter Breithardt*
15. **Catheter Ablation for Control of Cardiac Arrhythmias: A Report of the Percutaneous Cardiac Mapping and Ablation Registry**  
*G. Thomas Evans, Jr., Melvin M. Scheinman, and the Executive Committee of the Percutaneous Cardiac Mapping and Ablation Registry*
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*Günter Breithardt, Martin Borggreffe, Andrea Podczek, Detlev Rohner, and Thomas Budde*





# History of Ablation

**Frank I Marcus.**

**The use of radiofrequency energy for intracardiac ablation:  
Historical perspectives and results of experiments in animals,  
pp. 213-9.**

**In: Nonpharmacological Therapy of Tachyarrhythmias,  
eds. G.Breithardt, M. Borggrefe, D.P. Zipes, 1987. Futura  
Publishing Company, in., Mount Kisco, N.Y.**



# History of Ablation

**Huang SK, Bharati S, Graham AR, Lev M, Marcus FI, Odell RC.  
JACC 1987;9: 349-58**

**Closed chest catheter desiccation of the atrioventricular  
junction using radiofrequency energy –  
a new method of catheter ablation**



# History of Ablation



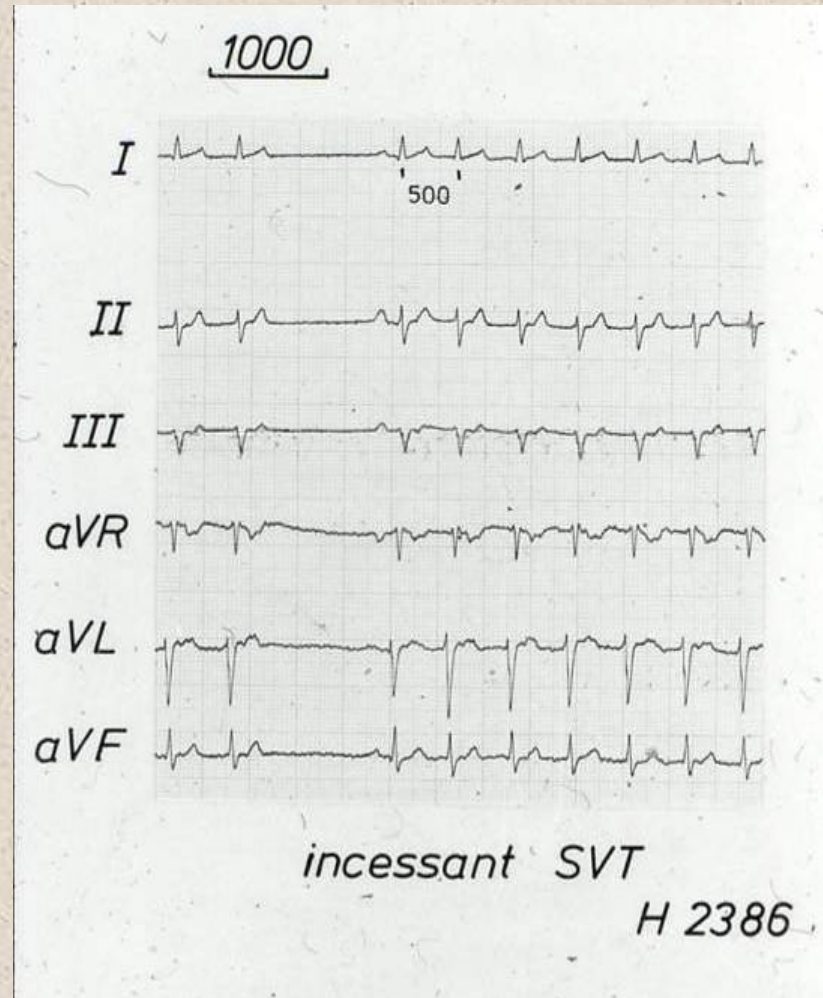
# History of Ablation

Lavergne T, Guize L, Le Heuzey JY, Carcone P, Geslin J,  
Cousin MT.

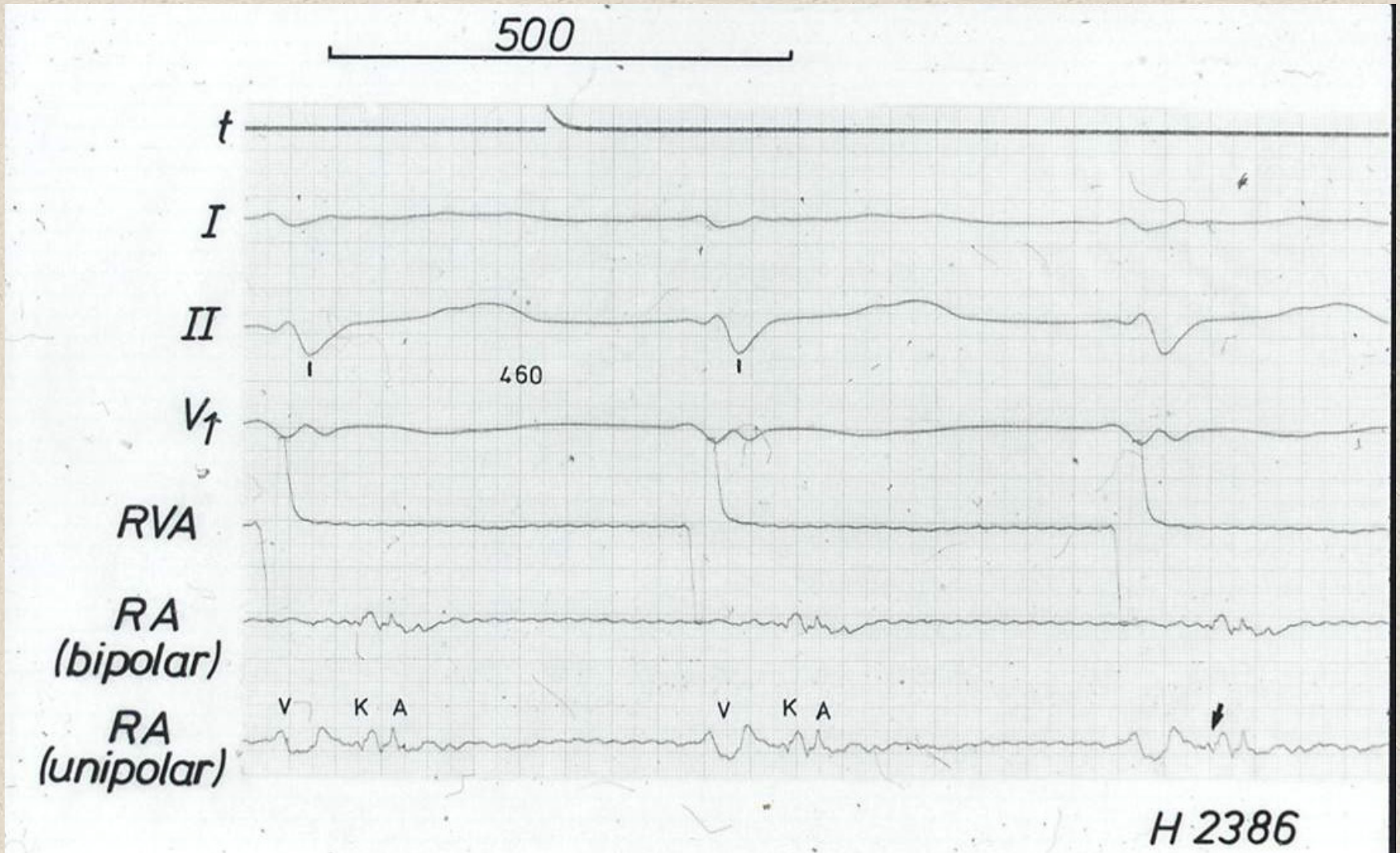
**Closed-chest atrioventricular junction ablation by high-frequency  
energy transcatheter desiccation.**

**Lancet 1986; 2(8511): 858-859**

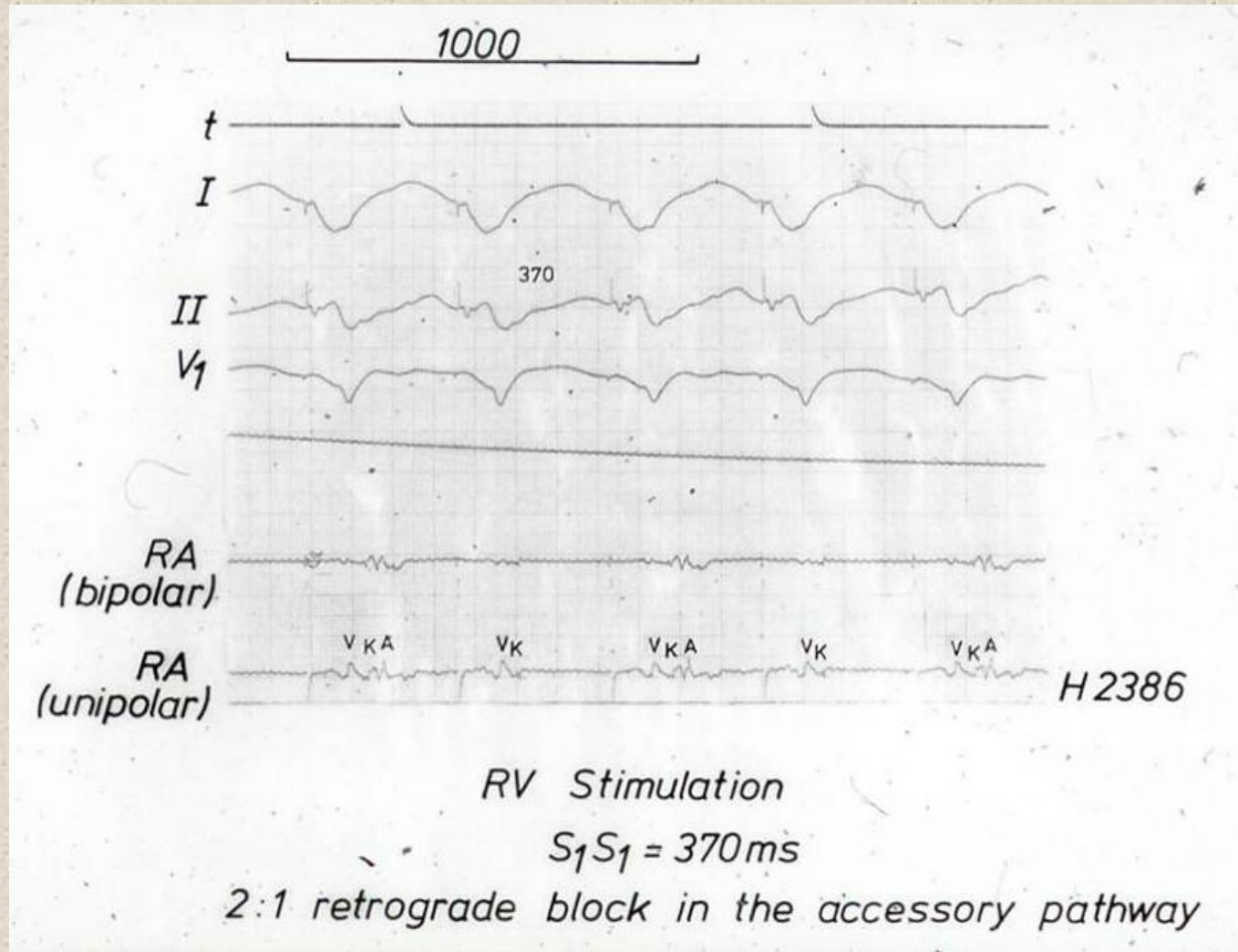
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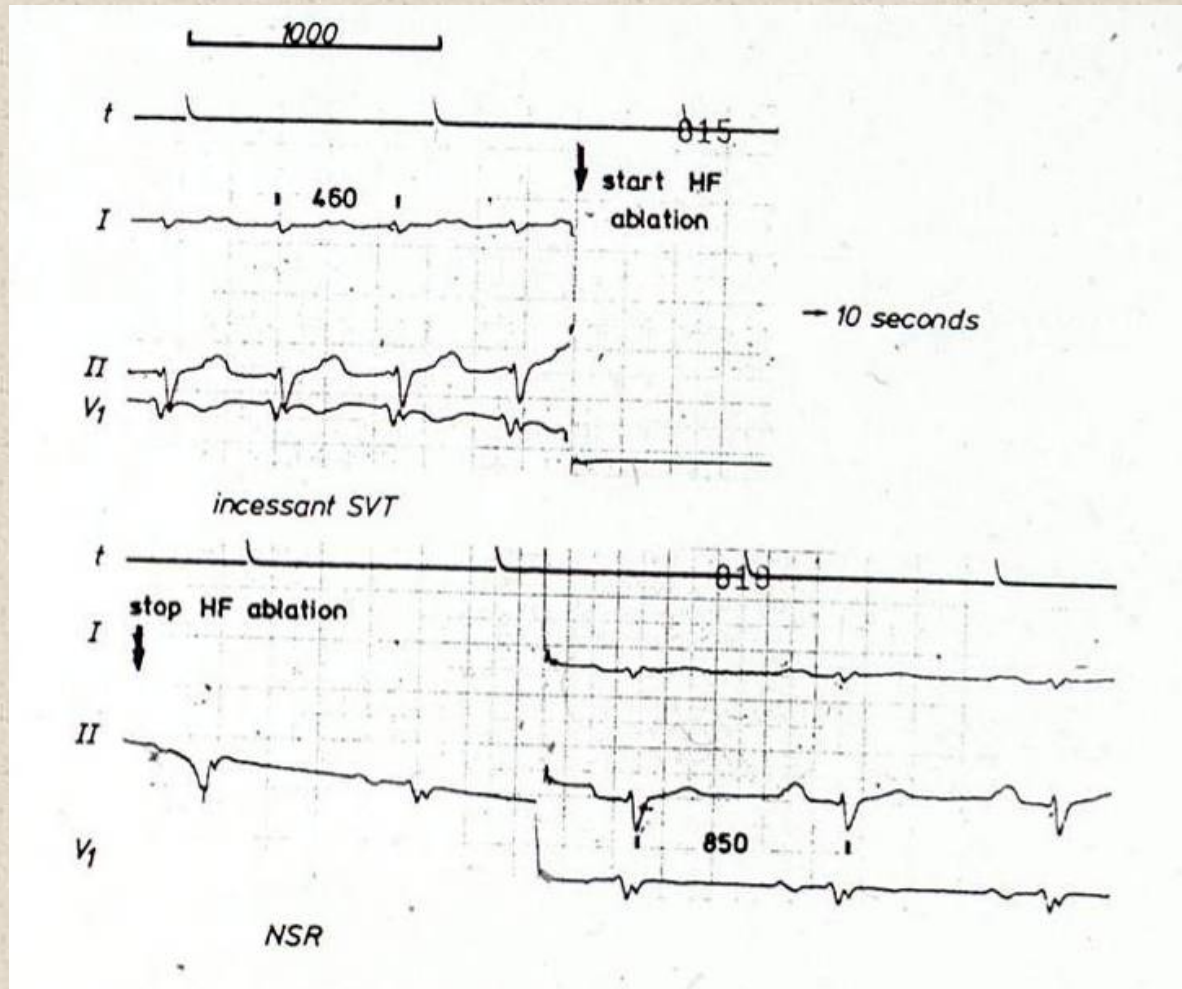
# History of Ablation



# History of Ablation



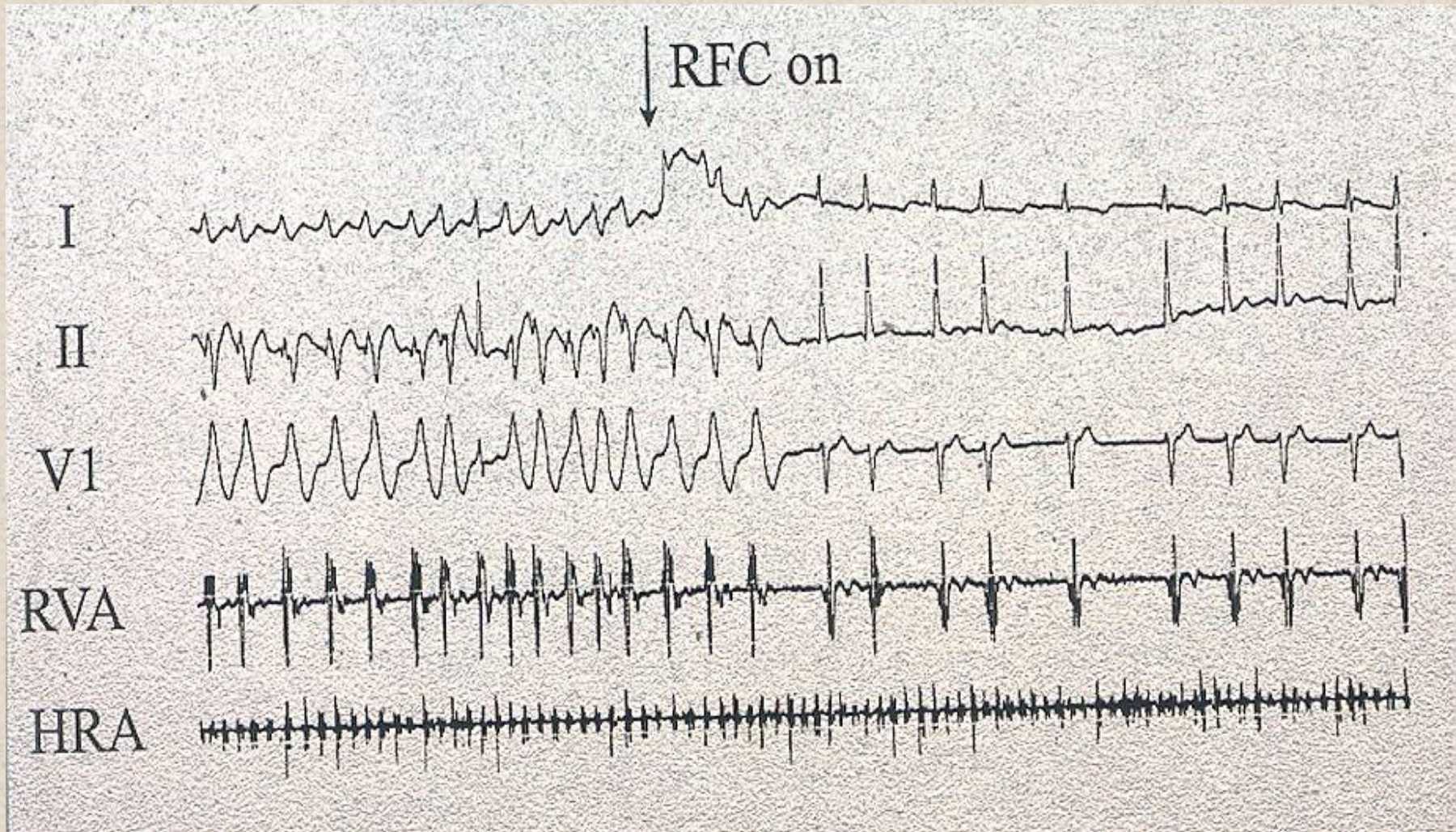
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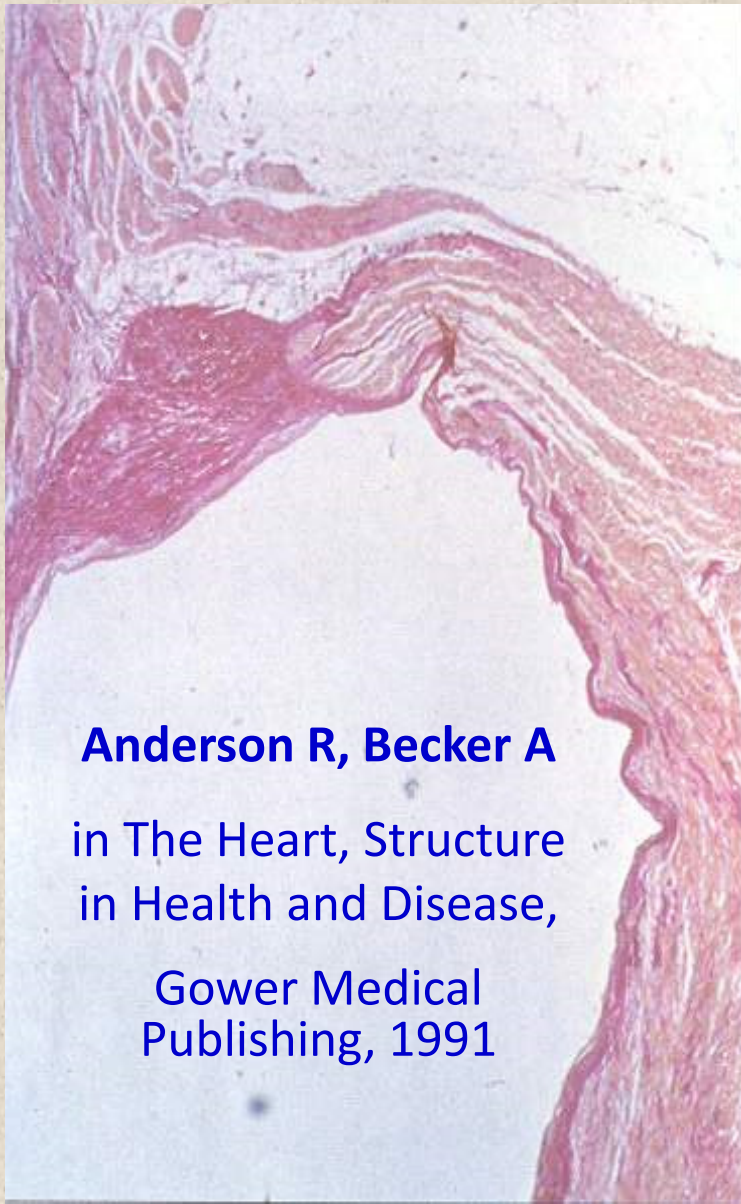
# History of Ablation

## RF ablation of accessory pathways



# History of Ablation

## RF ablation of accessory pathways



### High Frequency Alternating Current Ablation of an Accessory Pathway in Humans

MARTIN BORGGREFE, MD, THOMAS BUDDE, MD, ANDREA PODCZECK, MD,  
GÜNTER BREITHARDT, MD

Düsseldorf, West Germany

High frequency alternating current ablation of an accessory pathway was performed in a patient with incessant circus movement tachycardia using a right-sided, free wall accessory pathway. Antiarrhythmic drugs, anti-tachycardia pacing and transvenous catheter ablation using high energy direct current shocks could not control the supraventricular tachycardia. A 7F bipolar electrode catheter with an interelectrode distance of 1.2 cm was positioned at the site of earliest retrograde activation during circus movement tachycardia. At this area, two alternating current high frequency impulses were delivered with an energy output of 50 W through the distal tip of the bipolar catheter, while the patient was awake. After the first shock supraventricular tachycardia ter-

minated and accessory pathway conduction was absent without altering anterograde conduction in the normal atrioventricular (AV) conduction system. No reports of pain or other complications were noted. In short-term follow-up of 5 months, the patient had been free of arrhythmias without antiarrhythmic medication.

Thus, high frequency alternating current ablation was performed for the first time in the treatment of an arrhythmia incorporating an accessory pathway in a human. This technique may be an attractive alternative to the available transcatheter ablation techniques and to anti-tachycardia surgery.

(*J Am Coll Cardiol* 1987;10:576-82)

*European Heart Journal* (1988) 9, 927-932

### Modification of a left-sided accessory atrioventricular pathway by radiofrequency current using a bipolar epicardial-endocardial electrode configuration

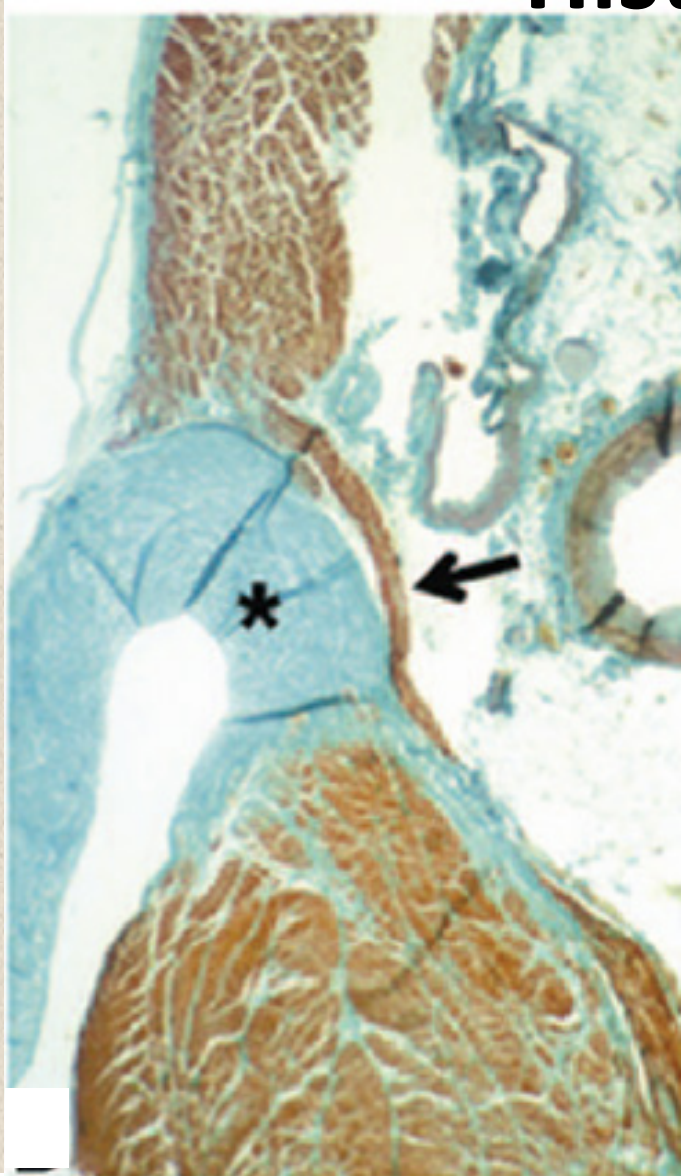
K.-H. KUCK, K.-P. KUNZE, M. SCHLÜTER M. GEIGER, W. M. JACKMAN\* AND G. V. NACCARELLI§  
Department of Cardiology, University Hospital Eppendorf, Hamburg, F.R.G., \*University of Oklahoma, Oklahoma City, OK, and §University of Texas, Houston, TX, U.S.A.

KEY WORDS: Wolff-Parkinson-White syndrome, transcatheter ablation.

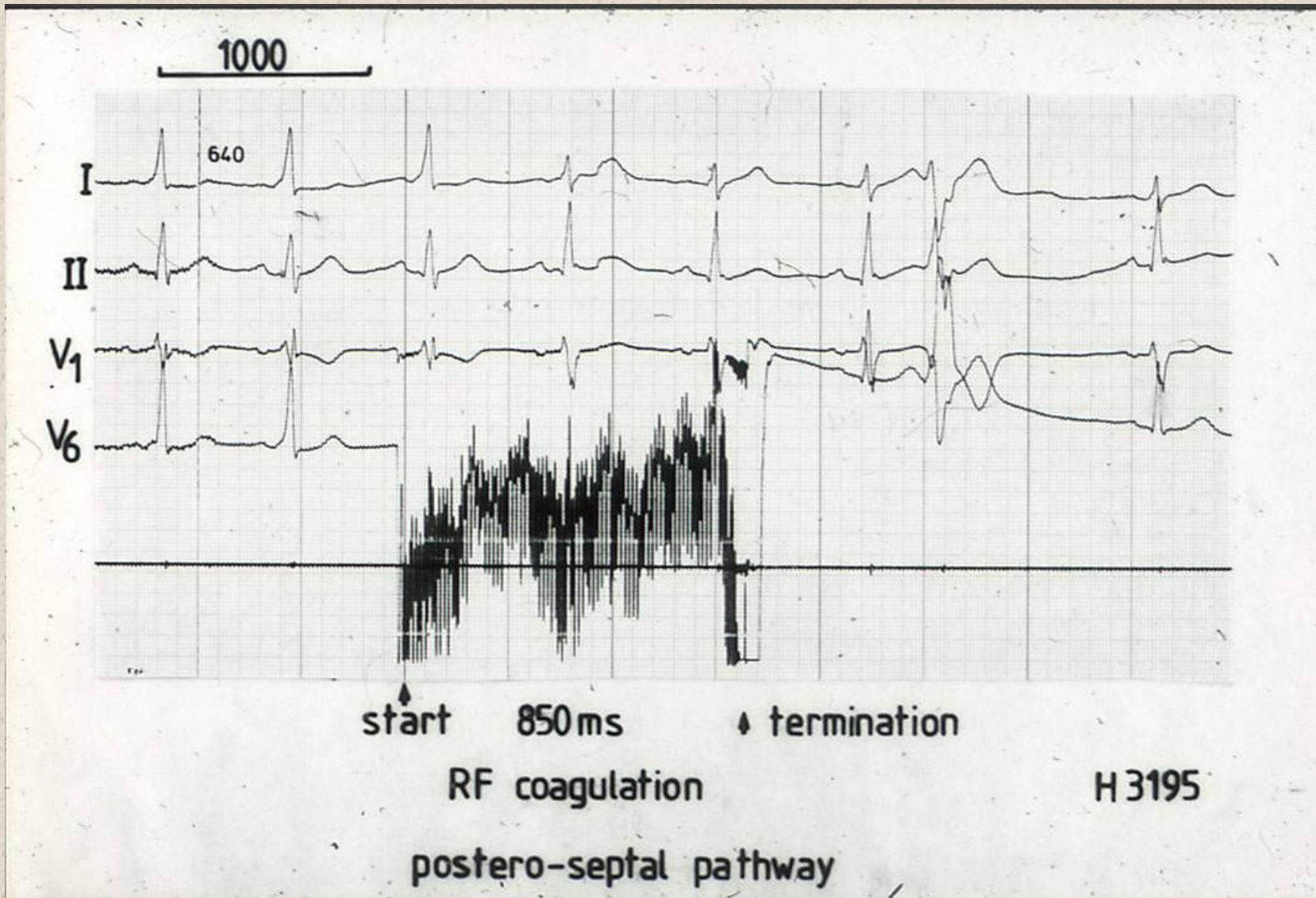
Transcatheter ablation of a left posterolateral free wall accessory atrioventricular pathway using radiofrequency current and a bipolar epicardial-endocardial electrode configuration was attempted in a 19-year-old woman. The patient had suffered from recurrent syncope due to atrial fibrillation with rapid conduction to the ventricles. Following applications of radiofrequency current between one electrode in the coronary sinus and another in the left ventricle placed high against the mitral annulus, the anterograde effective refractory period was increased from less than 205 ms to a lasting value of 460 ms. Radiofrequency application could be performed without general anaesthesia and caused no side-effects.

Anderson R, Becker A  
in *The Heart, Structure  
in Health and Disease,*  
Gower Medical  
Publishing, 1991

# History of Ablation



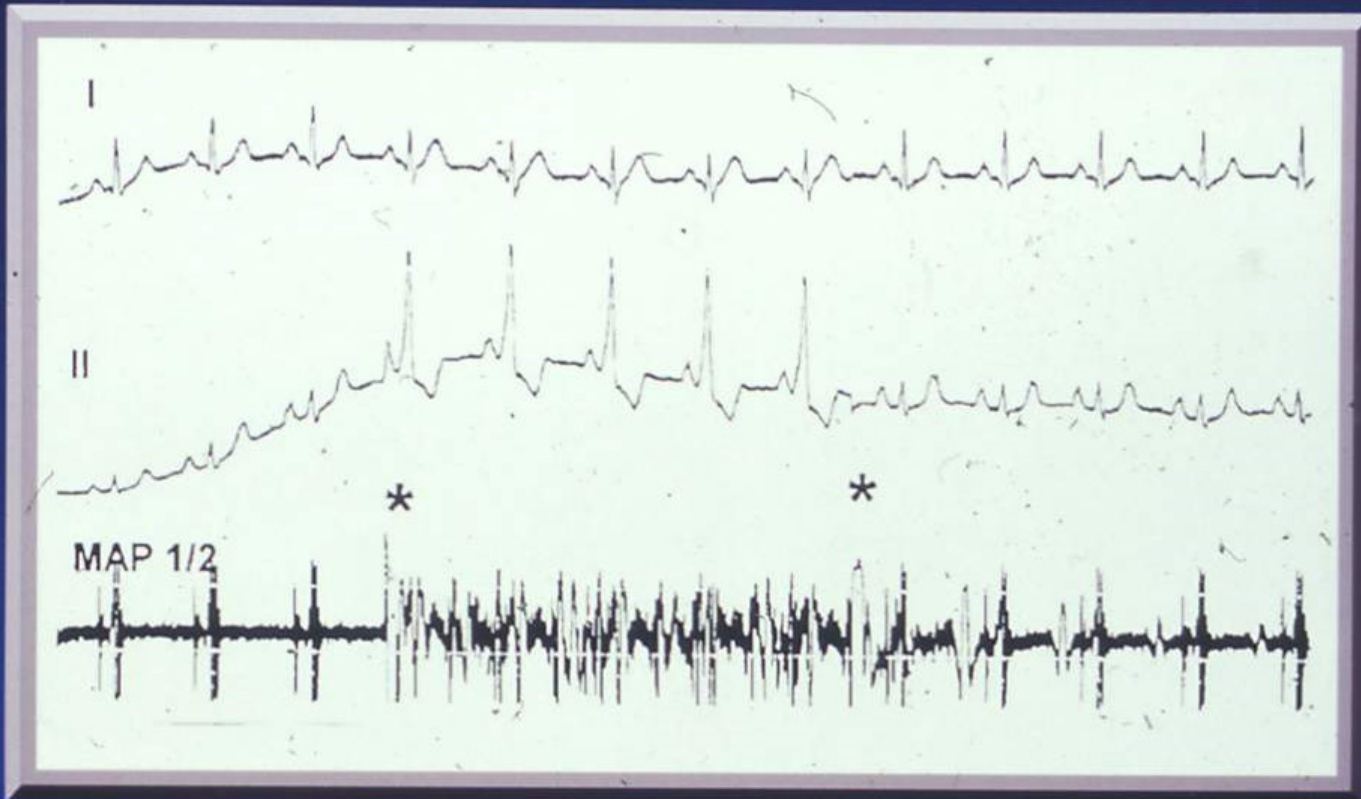
**Histological section stained  
with Masson's trichrome  
tissue**



# History of Ablation

## Subthreshold stimulation

### Emergence of preexcitation during STS

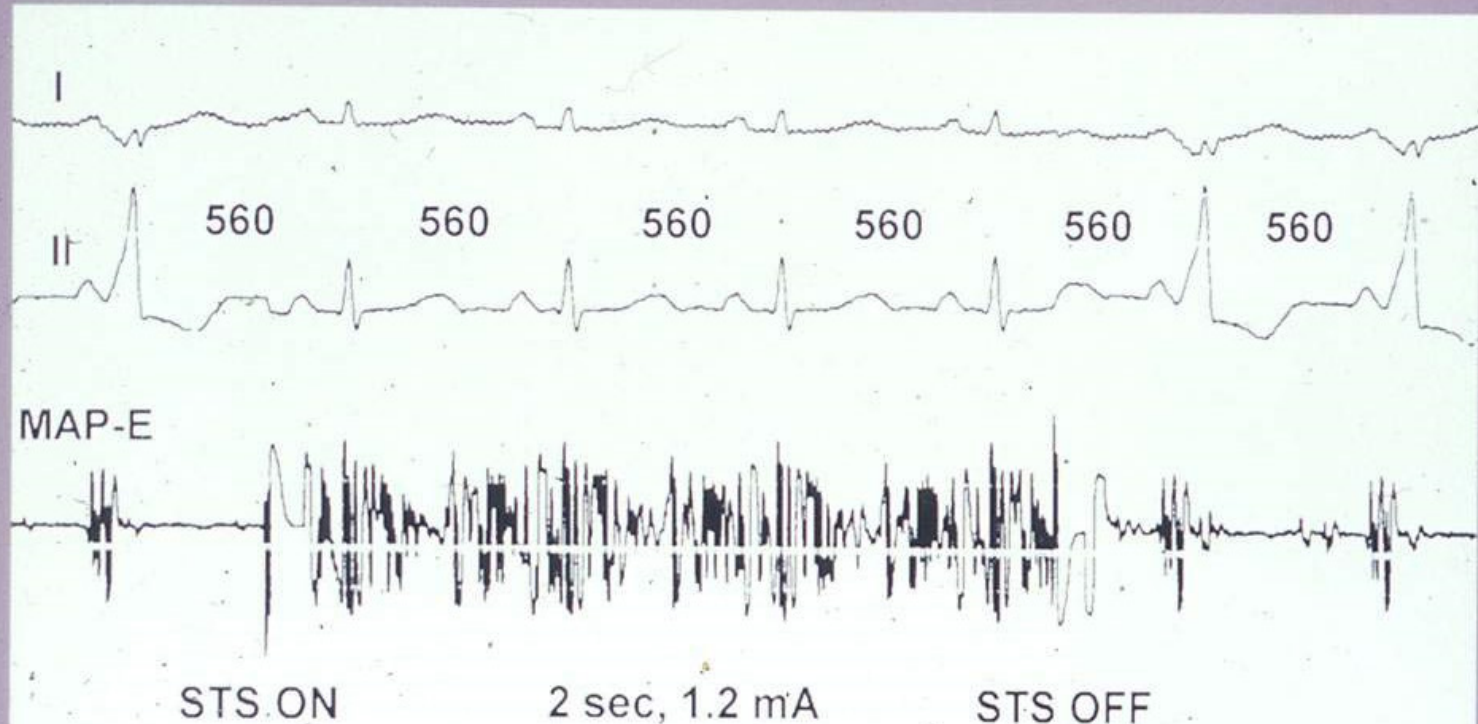


(GH30693, H-5596)

# History of Ablation

## Subthreshold stimulation

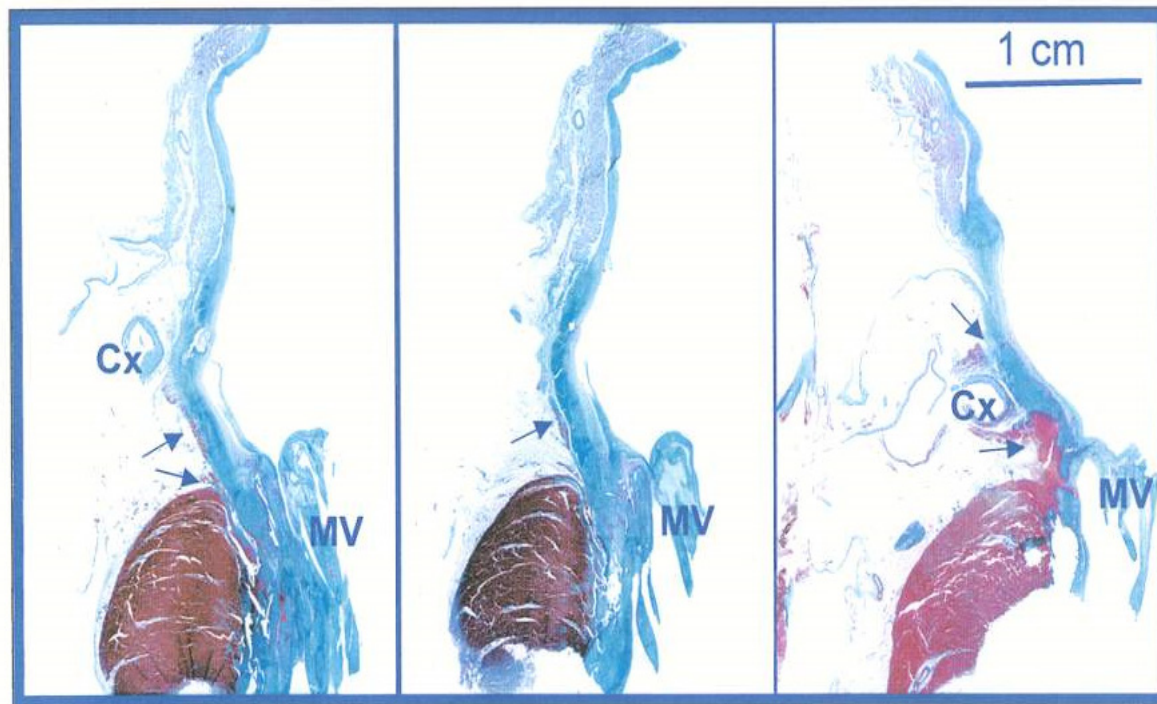
### Anterograde AP-block during STS



GH3064.H-6409

# History of Ablation

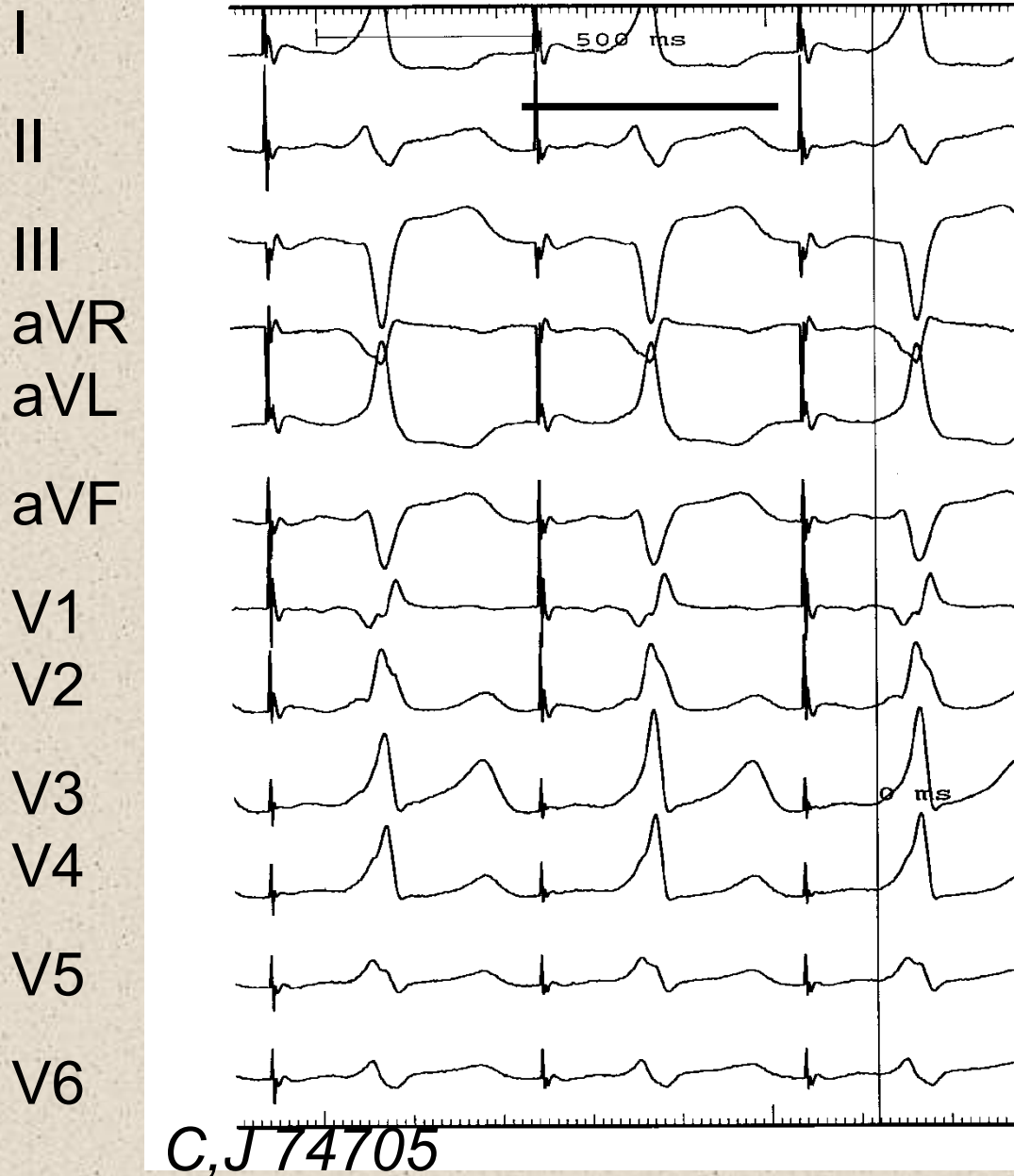
## RF ablation of accessory pathways



Through  
the middle  
of lesion

Toward  
atrial  
appendage

→ = remnant of acc. pathway

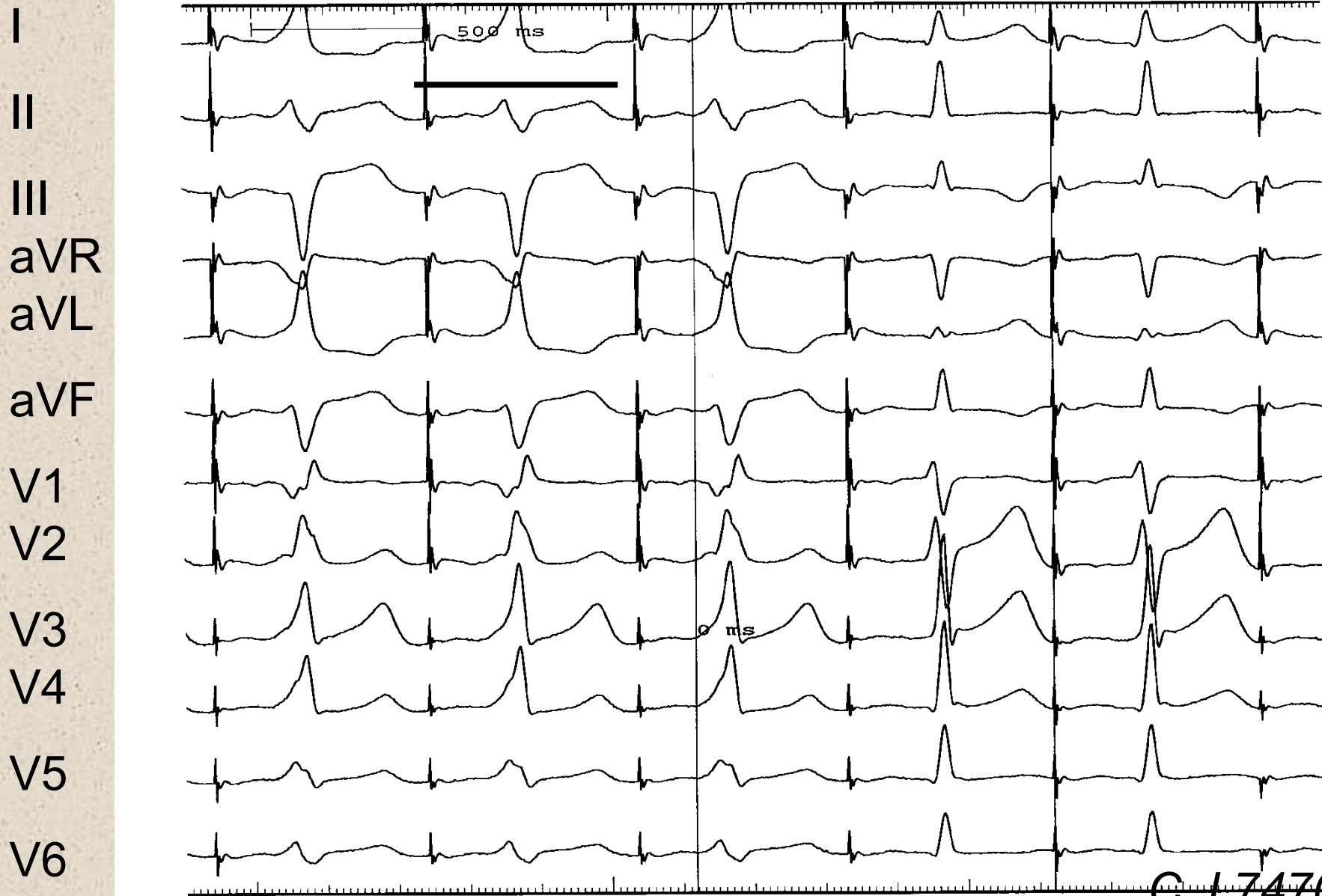


- Patient 5
- M/31
- Aborted SCD
- No FH of syncope/SCD
- WPW syndrome

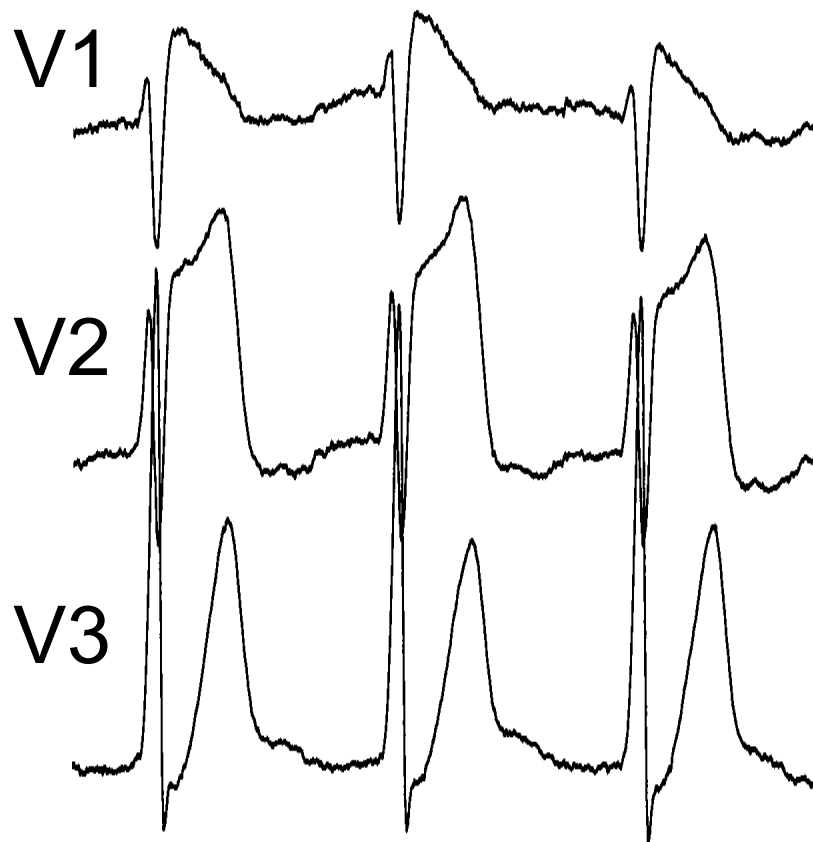
Eckardt et al, Pace 2001;224: 1423ff



590ms



C, J 74705



60mg ajmaline

C,J 74705

■ **Patient 5**

■ M/31

■ Aborted SCD

■ No FH of  
syncpe/SCD

■ WPW syndrome

■ Transient Brug. sign

■ Inducible VF

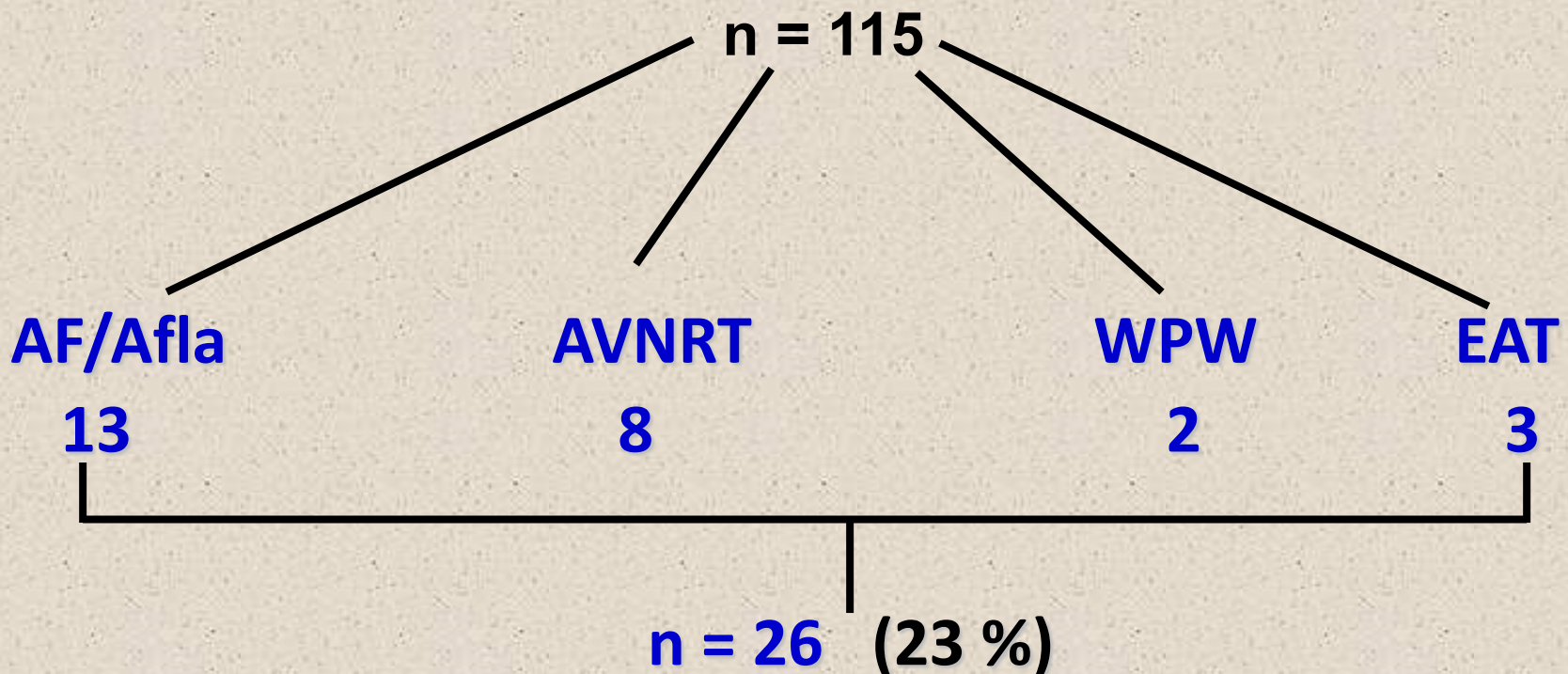
■ ICD

Eckardt et al, Pace 2001;224: 1423ff

# History of Ablation

**Mannheim-Münster-Turino**

*Supraventricular Tachycardias in BBS*



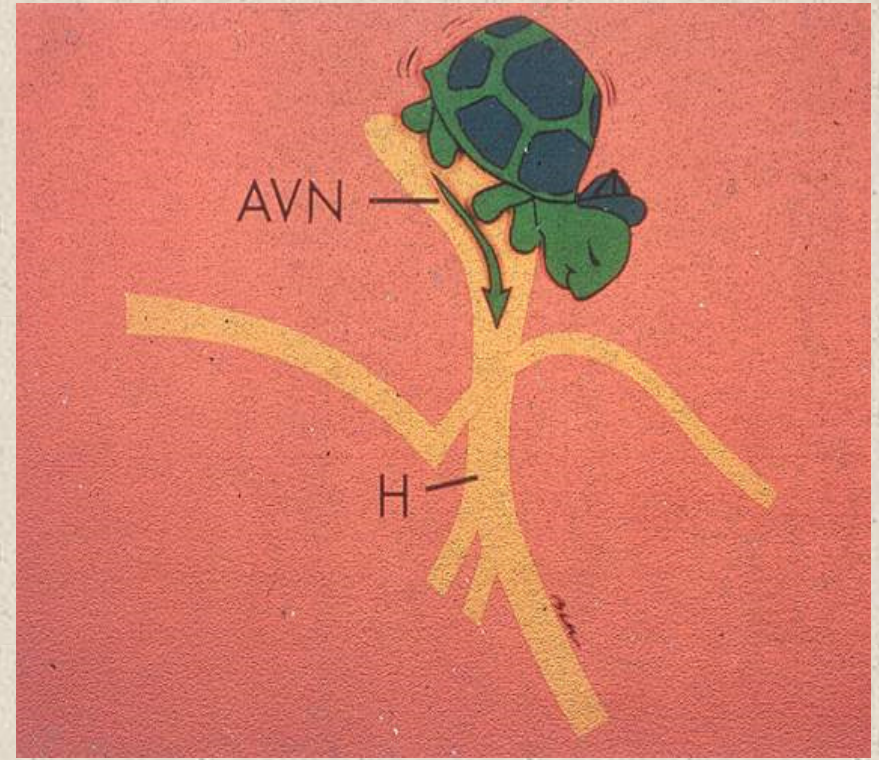
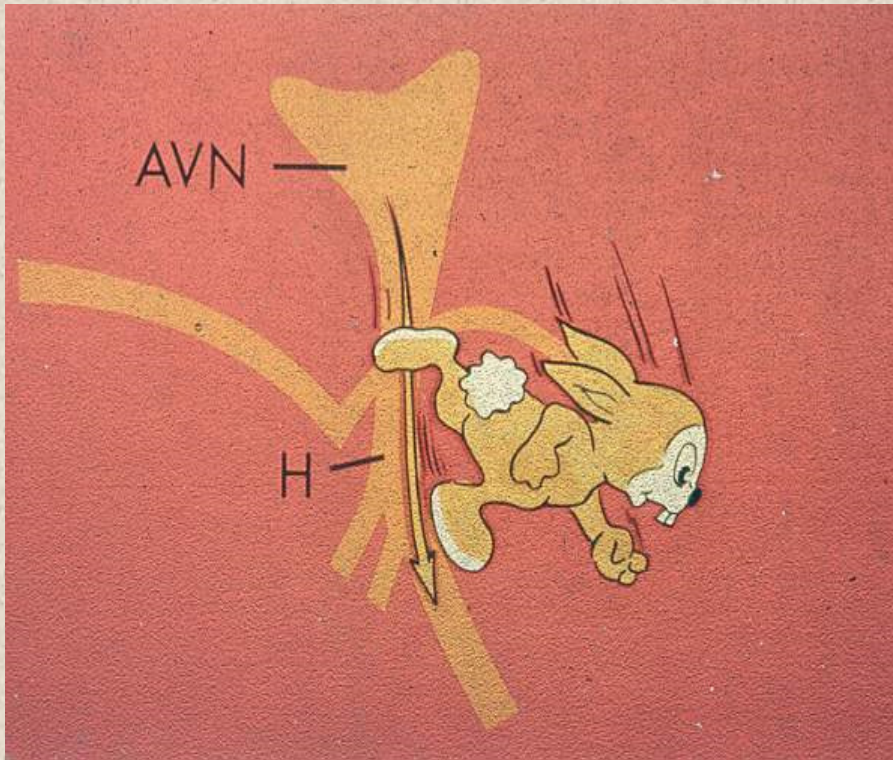
# History of Ablation

## Catheter ablation



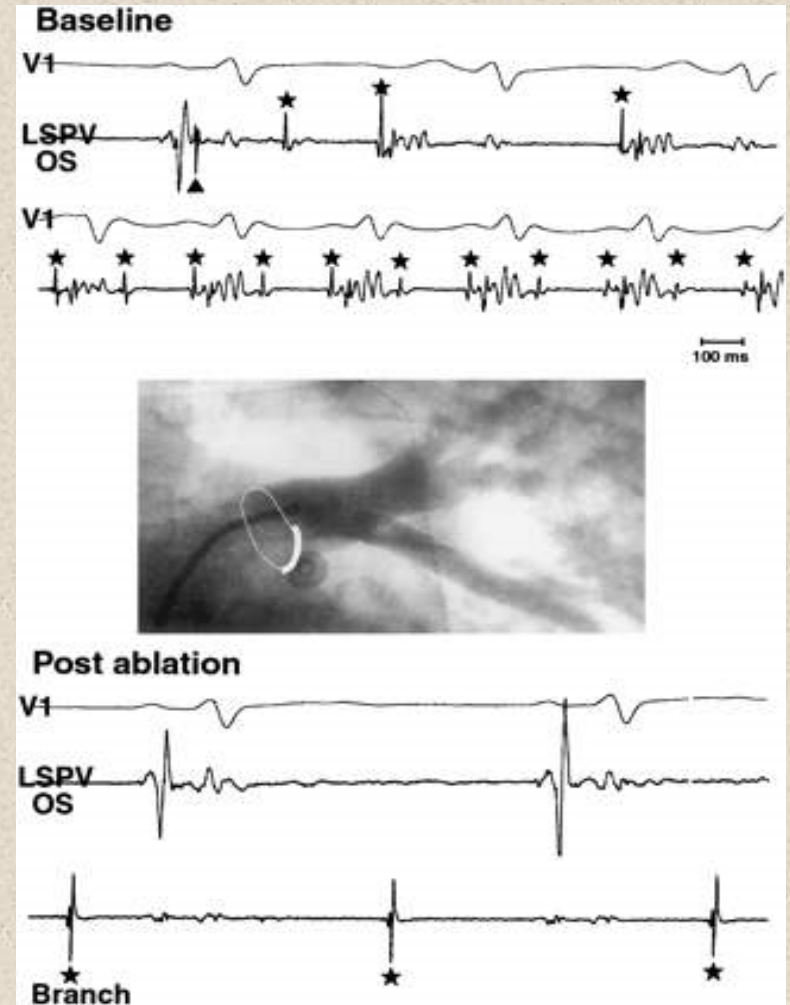
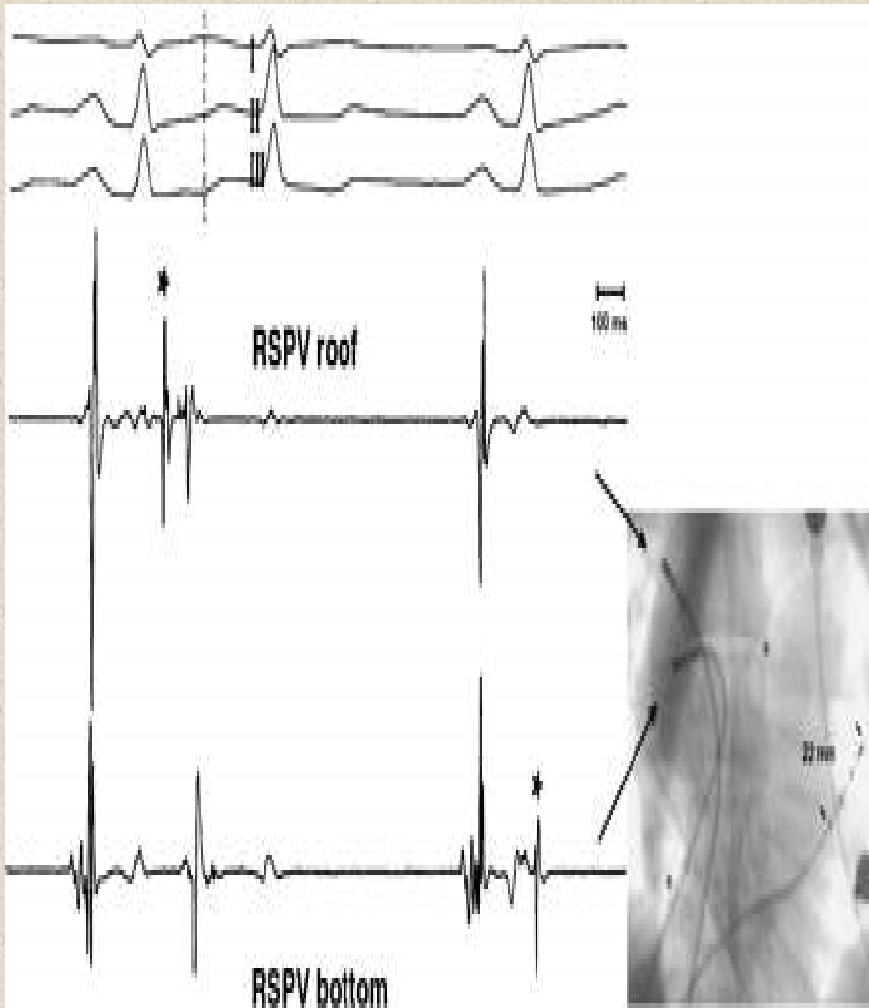
# History of Ablation

## Ablation of AVNRT



# History of Ablation

## Ablation of atrial fibrillation



# History of Ablation

## Ablation of AF

History	Acute success rate
➤ <b>Right atrial lesions</b> (Schwartz, Haïssaguerre, Gaita)	60%
➤ <b>Complete right/ left atrial lesions</b> (Kuck)	0–20%
➤ <b>Pulmonary vein isolation</b> (Haïssaguerre)	60-70%*
➤ <b>Ablation of left posterior wall</b> (Pappone)	60-85%

\*40% Re-Ablation

# History of Ablation

## Ablation of ventricular tachyarrhythmias

Hartzler	1983	
Fontaine	1984	„Fulguration“
Borggrefe	1996	Radiofrequency energy



Ablation of **multiple** VT's  
**unstable** VT's

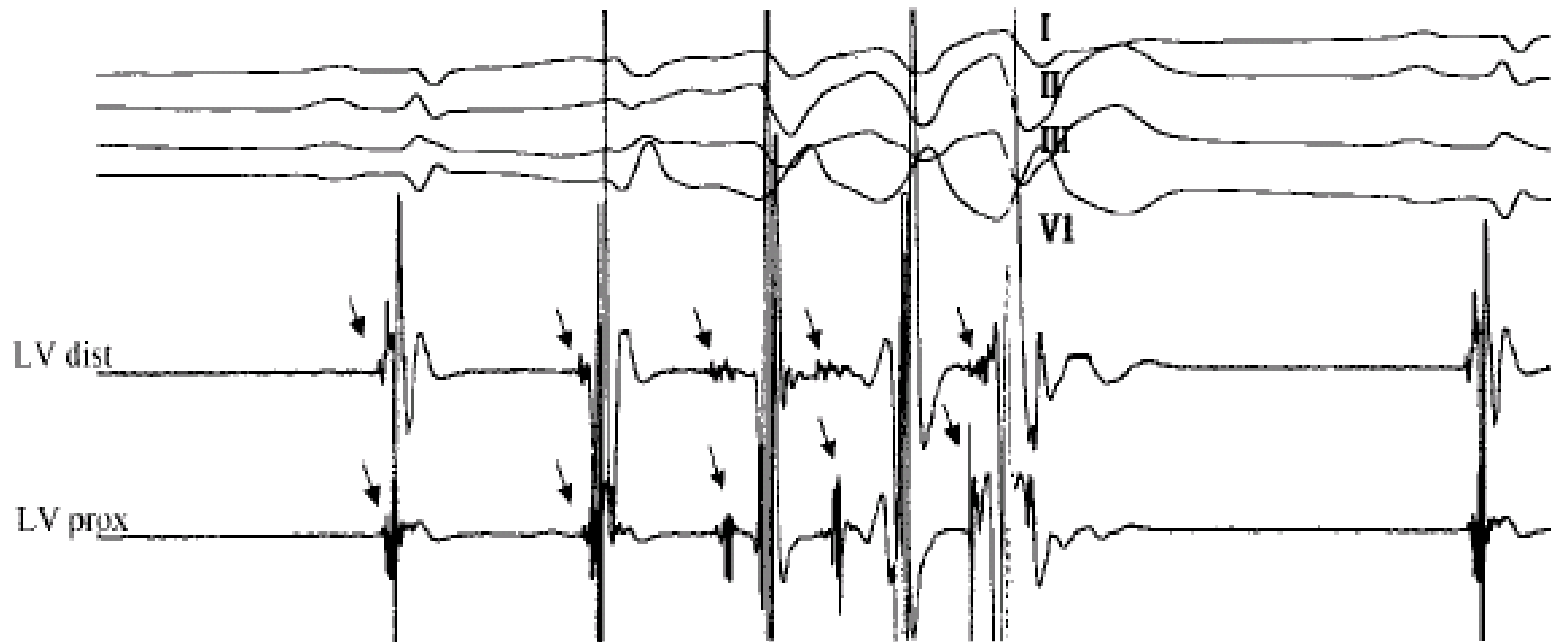
Ablation of VF  Haïssaguerre 2002





# History of Ablation

## Mapping and Ablation of idiopathic VF



# How To Better Catch Arrhythmias

