History of ablation

Prof. Martin Borggrefe
Universitätsmedizin Mannheim
History of Ablation

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


Babotai I, Brownlee R. Experimental atrioventricular block without thoracotomy: a new instrument (injection of formalin)


Production of chronic atrioventricular block in dogs without thoracotomy

History of Ablation

Fig. 3. Percutaneous block production in continuous ECG recording. In first seven P waves atriograms 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 = atriogram.
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

... deliberate His bundle ablation

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

Deliberate production of an AV block in humans, followed by a pacemaker implantation, has been reported several times in the last few years (Chardack, 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

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

par J. Vedel, R. Frank, G. Fontaine, J.F. Founial et Y. Grosgogeat

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

Fig. 5
Inhibition du stimulateur sentinelle. 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 RUBINSTEIN. 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 ± 223 ms and decreased to 1,151 ± 181 ms after exercise, a response that was usually abolished by β-blockade. Overdrive pacing resulted in pacemaker suppression with gradual rate stabilization after 10–20 beats. There was no evidence of myocardial 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 atroventricular (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 ± 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-
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 tripolar 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

Fig.1. Complete A-V block produced by the percutaneous cautery recorded on a Lead II electrocardiogram and an intracardiac electrogram.

Fig.2. Cautery current synchronized with R wave on a Lead II electrocardiogram.
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
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: Borggreve, M.: Katheterablation tachykardier Herzrhythmusstörungen mittels Hochfrequenzstrom, Steinkopff, 1994
History of Ablation
History of Ablation

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

![Graph showing correlation between lesion volume and temperature integral.](image-url)
History of Ablation
History of Ablation
History of Ablation
History of Ablation
History of Ablation

Nonpharmacological Therapy of Tachyarrhythmias

Part III: Catheter Ablation Techniques

10. Laser Ablation of Tachycardias: Experimental Basis and Preliminary Clinical Application
   Sanjeev Saksena

11. Neodymium: YAG Laser Photocoagulation of Ventricular Tachycardia: Rationale, Method of Application, and Results in 17 Patients

12. Experimental Studies on Electrical Catheter Ablation
   Richard N.W. Hauer, Willem Straat, Michel T. de Zwart, Michel P. Freericks, Cornelius Borst, and Etienne O. Robles de Medinaceli

13. The Use of Radiofrequency Energy for Intracardiac Ablation: Historical Perspectives and Results of Experiments in Animals
   Frank I. Marcus

14. Radiofrequency Ablation: An Improvement of Ablation Techniques in Comparison to Direct-Current Delivery?
   Thomas Budde, Martin Borggrefe, 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

16. Catheter Ablation of Abnormal Junctional Pathways
   A. John Camm, D. Wyn Davies, and David E. Ward

17. Treatment of Resistant Ventricular Tachycardia by Endocavitary Fulguration and Antiarrhythmic Therapy in 111 Consecutive Patients Followed for 18 Months
   Guy Fontaine, R. Frank, J.L. Tonet, Y. Gallais, I. Touzet, M. Todorova, M. Baraka, and Yves Grosgeot

18. Catheter Ablation for Patients with Ventricular Tachycardia
   Helmut Klein, H.J. Trappe, C.A. Hartwig, and P.R. Lichtlen

19. Clinical Experience with Catheter Ablation of Ventricular Tachycardia Using Defibrillator Pulses
   Günter Breithardt, Martin Borggrefe, 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.

History of Ablation


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
History of Ablation
History of Ablation

Borggreffe et al, J Am Coll Cardiol 1987; 10:576-582
History of Ablation

Borggrefe et al, J Am Coll Cardiol 1987; 10:576-582
History of Ablation

Borggrefe et al, J Am Coll Cardiol 1987; 10:576-582
History of Ablation

RF ablation of accessory pathways

Hindricks et al, J Am Coll Cardiol 1995; 25: 444-451
History of Ablation

RF ablation of accessory pathways

High Frequency Alternating Current Ablation of an Accessory Pathway in Humans

MARTIN BORSTERE, M.D., THOMAS BODDE, M.D., ANDREA PODCZECK, M.D.,
GÜNTER BREITHARDT, M.D.
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, antitachycardio pacing and transvenous catheter ablation using high energy direct current shocks could not control the supraventricular tachycardia. A 17 bipolar electrode catheter with an interelectrode distance of 1.2 cm was positioned at the site of earliest retrograde activation during cisco 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 terminated and accessory pathway conduction was absent without altering antegrade 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 technique and to antitachycardia surgery.

(From Circulation 1982;65:778-80)

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

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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 application of radiofrequency current between one electrode on the coronary sinus and another in the left ventricle placed high against the mitral annulus, the retrograde effective refractory period increased from less than 203 ms to a lasting value of 416 ms. Radiofrequency application could be performed without general anesthesia and caused no side-effect.
History of Ablation

Histological section stained with Masson’s trichrome tissue
RF coagulation
postero-septal pathway
History of Ablation

Subthreshold stimulation

Emergence of preexcitation during STS
History of Ablation

Subthreshold stimulation

Anterograde AP-block during STS

MAP-E

560 560 560 560 560 560

STS.ON  2 sec, 1.2 mA  STS OFF

GH3084.H-6409
History of Ablation
RF ablation of accessory pathways

Through the middle of lesion

Toward atrial appendage

→ = remnant of acc. pathway

M. Borggrefe and Yen Ho, in preparation
- Patient 5
  - M/31
  - Aborted SCD
  - No FH of syncope/SCD
  - WPW syndrome

Eckardt et al, Pace 2001;224: 1423ff
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*

- AF/Afla: 13
- AVNRT: 8
- WPW: 2
- EAT: 3

$n = 115$

$n = 26 \ (23\%)$
History of Ablation

Catheter ablation
History of Ablation

Ablation of AVNRT
History of Ablation

Ablation of atrial fibrillation

<table>
<thead>
<tr>
<th>History</th>
<th>Acute success rate</th>
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<tbody>
<tr>
<td>Right atrial lesions</td>
<td>60%</td>
</tr>
<tr>
<td>(Schwartz, Haïssaguerre, Gaita)</td>
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<tr>
<td>Complete right/ left atrial lesions</td>
<td>0–20%</td>
</tr>
<tr>
<td>(Kuck)</td>
<td></td>
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<tr>
<td>Pulmonary vein isolation</td>
<td>60-70%*</td>
</tr>
<tr>
<td>(Haïssaguerre)</td>
<td></td>
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<tr>
<td>Ablation of left posterior wall</td>
<td>60-85%</td>
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<tr>
<td>(Pappone)</td>
<td></td>
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*40% Re-Ablation
History of Ablation

Ablation of ventricular tachyarrhythmias

Hartzler 1983
Fontaine 1984 „Fulguration“
Borggrefe 1996 Radiofrequency energy

Ablation of multiple VT‘s
Ablation of unstable VT‘s

Ablation of VF Haïssaguerre 2002
History of Ablation
Mapping and Ablation of idiopathic VF

Haïssaguerre et al, Circulation, 2002; 106: 962-967
How To Better Catch Arrhythmias