# Dětská kardiostimulace

Roman A. Gebauer

HERZZENTRUM
LEIPZIG

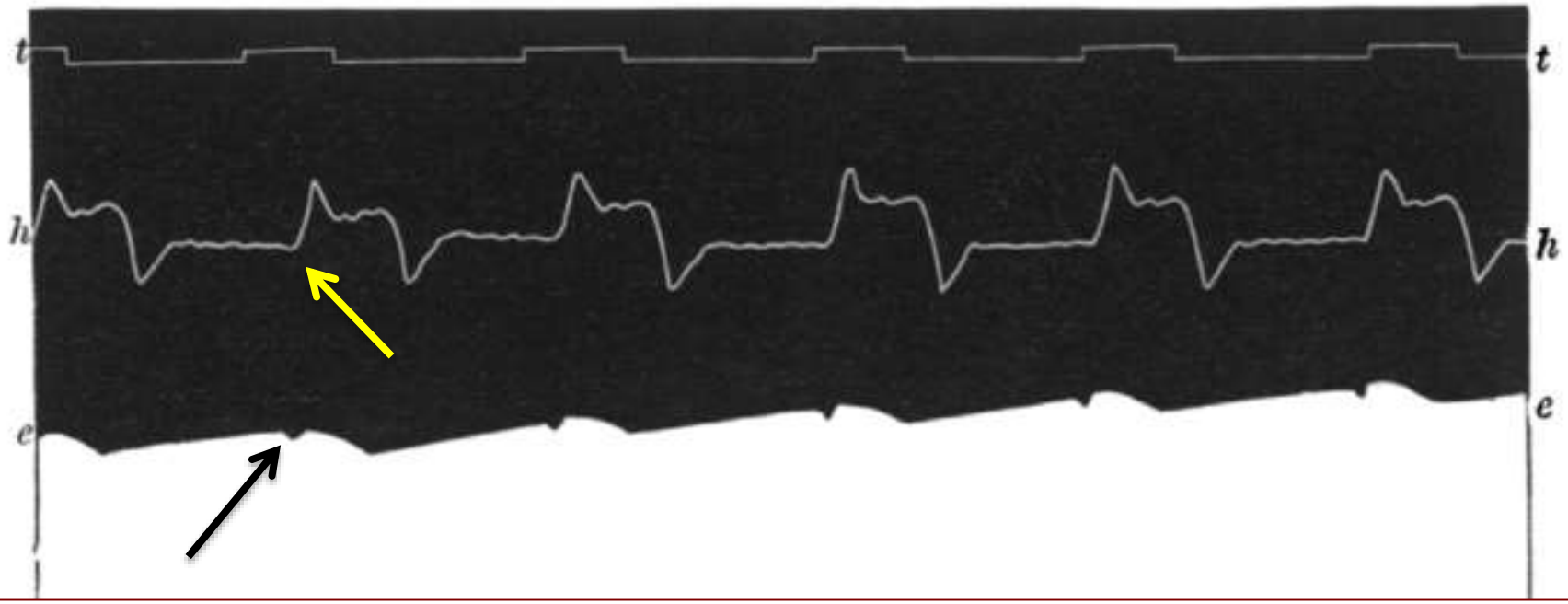
# Once upon a time…

- Hippocrates (460-375 BC)
  - ✓"Those who suffer from frequent and strong faints without any manifest cause die suddenly"
- Aristotle (384-322 BC)
  - ✓"The heart is the source of all movement, since the heart links the soul with the organs of life"

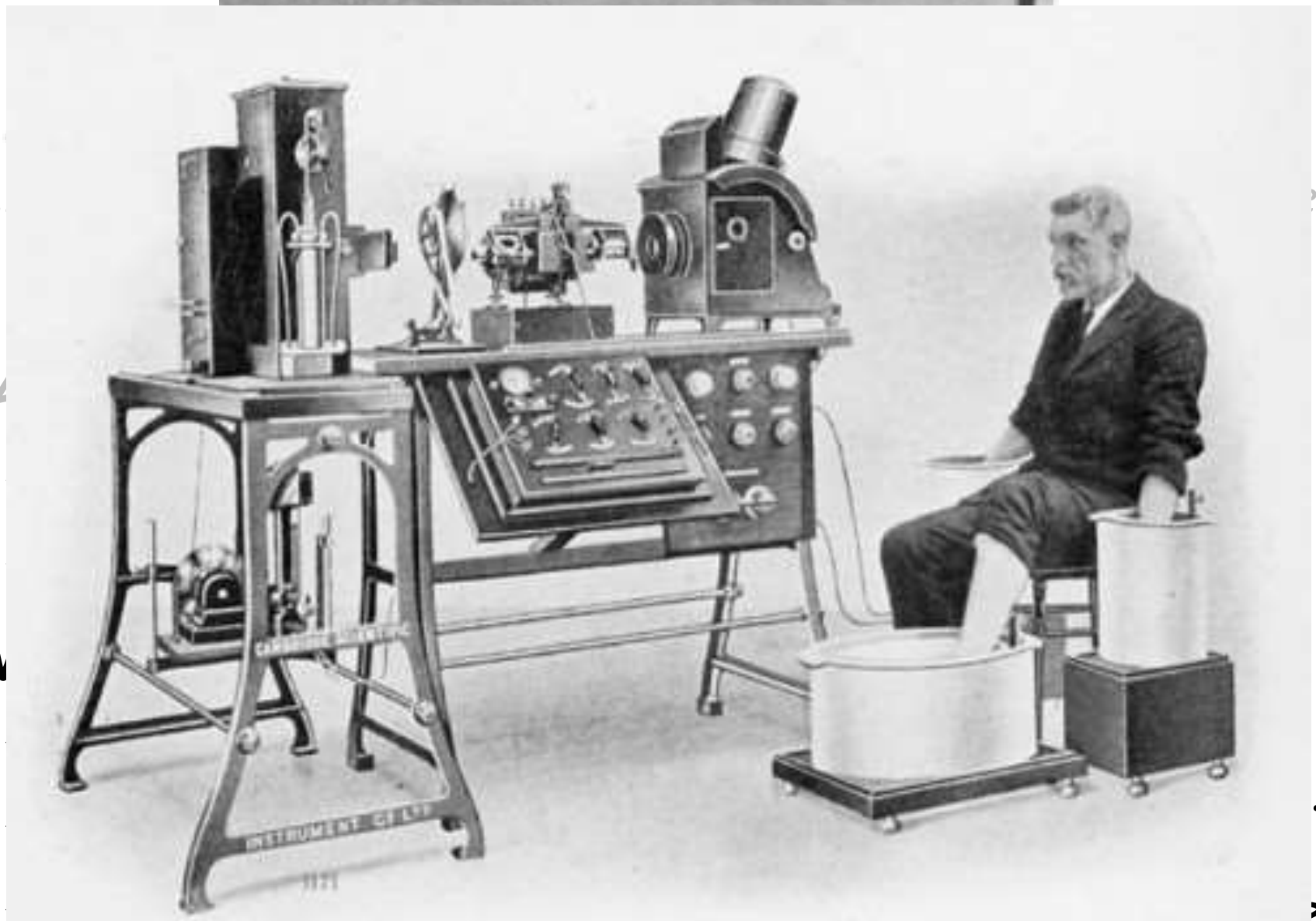
- *… to by bylo na dlouho ☺*

# The first ECG…

*"…Each beat of the heart gives an electric change, beginning at one end of the organ and ending at the other…"*




*"I do not imagine that electrocardiography is likely to find any very extensive use in the hospital. It can at most be of rare and occasional use to afford a record of some rare anomaly of cardiac action."*



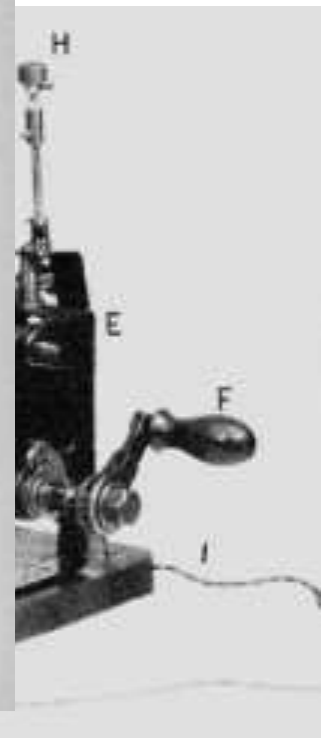
PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF SALT SOLUTION

# The first pacing machines


PHYSICIAN INFENTS

SELF-STARTER for
Dead Man's Heart

spac



# The ines

- Early 19
  - ✓P. Zoll
    pacem ock

al electrodes
t over the

. at 2ms / 50-

l!)

# The first pacing machines – cont.

- Late 1950's – early 1960's

***"Golden Years of pacing"***

✓1957 - first battery operated wearable pacemaker

✓1958 - first totally implantable pacemaker

✓1960 - first long-term correction of AV block, with a implantable pacemaker

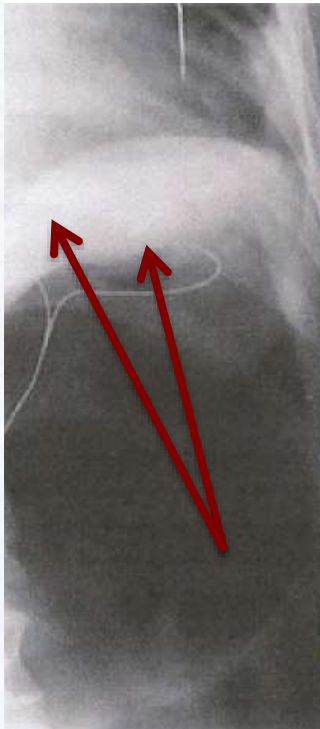
✓…

# The first pacing machines

- 1957 – first battery operated wearable


# The first pacing machines

- 1958 - first totally implantable pacemaker
  - ✓in Sweden by surgeon Ake Senning & engineer Rur
  - ✓Pat
    - ○ 2



# Further evolution

## Paradigm Shifts in Cardiac Pacemakers

**1950s**
AC-powered pacemakers tethered to an extension cord (Furman)

**1950s**
Battery-powered transistorized "wearable" pacemakers (Lillehei/Bakken)

**1958**
First fully implantable pacemaker (Elmqvist/ Senning)

**2015**
Implantable pacemaker—basic system had not evolved significantly

Mulpuru, S.K. et al. J Am Coll Cardiol. 2017;69(2):189-210.

# Future directions of cardiac pacing

## Improve cardiac resynchronization and cardiac efficiency

- Position of the pacing lead
- Cardiac resynchronization therapy (CRT)
- Reduction of unnecessary ventricular pacing
- Recruit His-Purkinje conduction

# 1990 - 2010

## "Pacing induced cardiomyopathy"

Dyssynchrony

Regional heterogeneity of function and loading

Structural and cellular remodeling

Dyssynchronous cardiomyopathy

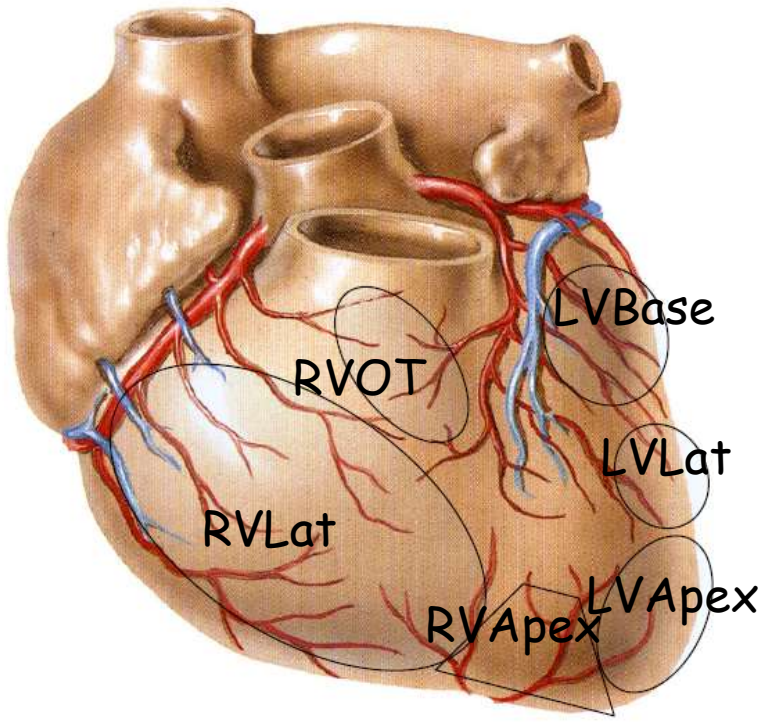
How ny?

Gu CHD

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION
American Heart Association.

# Permanent Cardiac Pacing in Children - Choosing the Optimal Pacing Site: A Multi-Center Study

- Cross-sectional study (N=178, 21 centers)
  - ✓CAVB, structurally normal heart
  - ✓Initially normal LVEF
  - ✓Pacing sites (pts)
    - ✓RV
      - RVOT (8), RV lat (44)
      - RVA (61), RV Septum (29)
    - ✓LV
      - LVA (12), LV lat (17)
      - LV Base (7)
  - ✓ Pacing duration 5.4 yrs




Janoušek et al. Circulation 2013

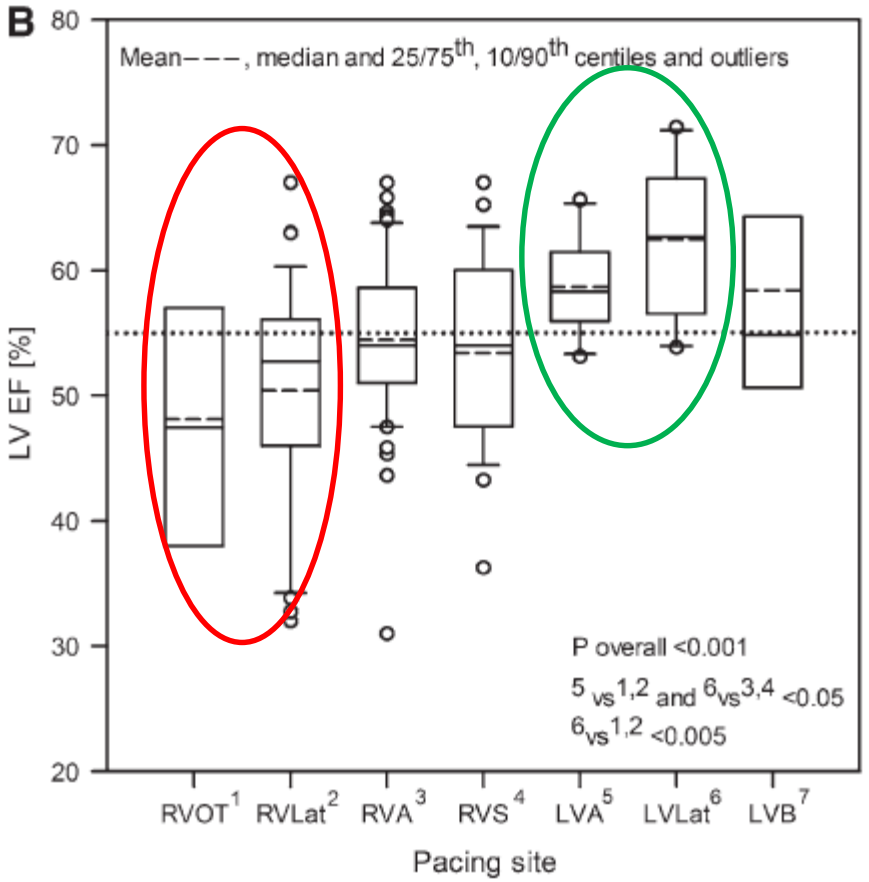
Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association

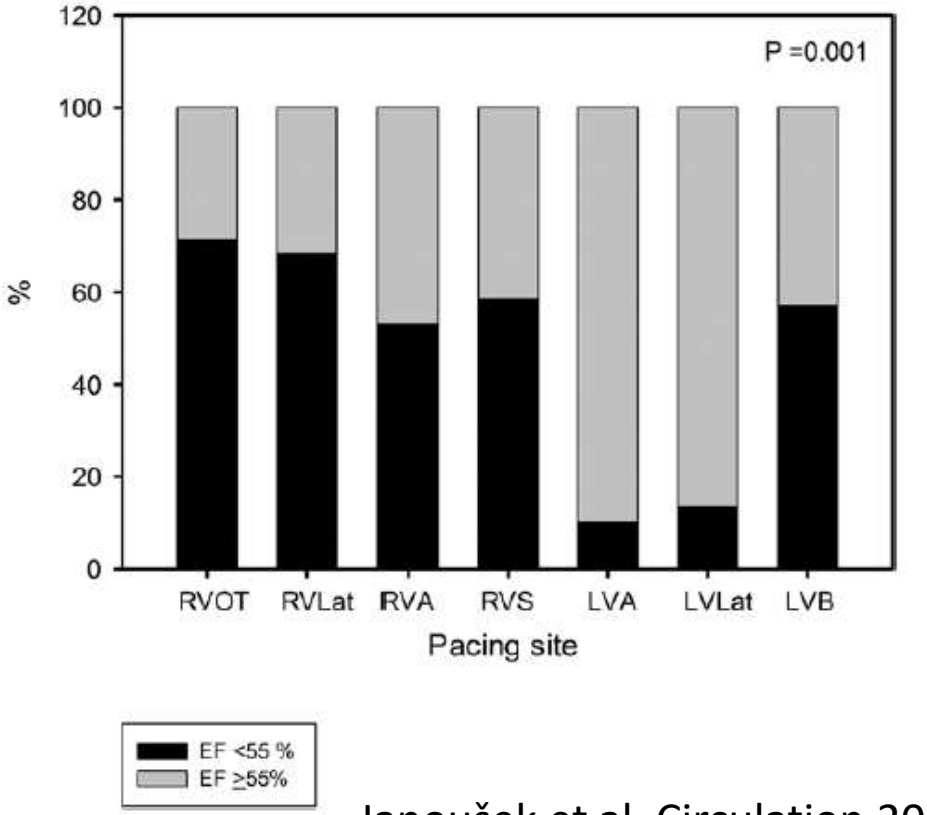
**Permanent Cardiac Pacing in Children - Choosing the Optimal Pacing Site: A Multi-Center Study**

# Prevent conventional pacing associated cardiomyopathy by proper placement of the ventricular leads

LV ejection fraction at follow-up

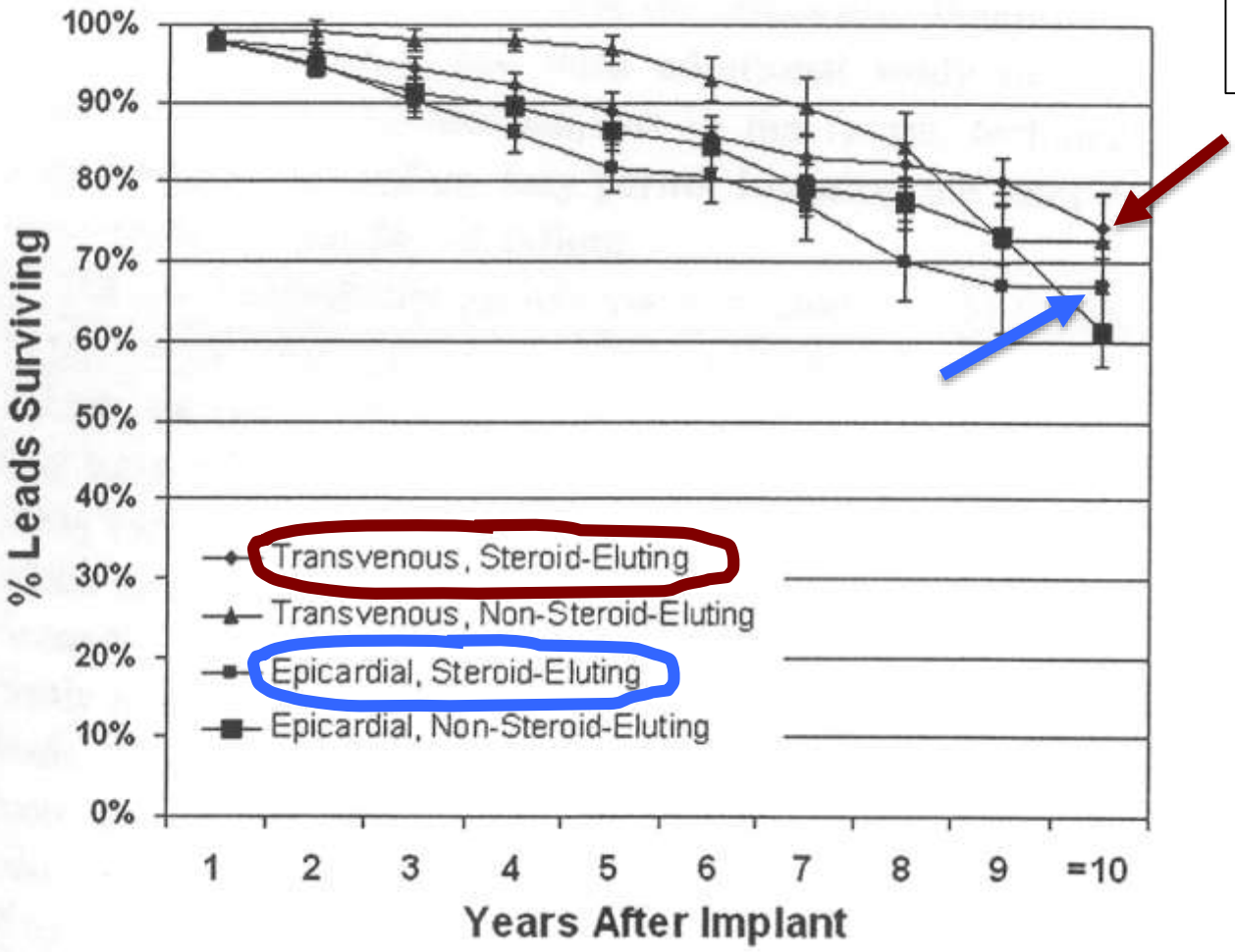



Proportion of pts with LVEF<55 %




Janoušek et al. Circulation 2013

# The lead -
## "Achilles" heel of the pacing system

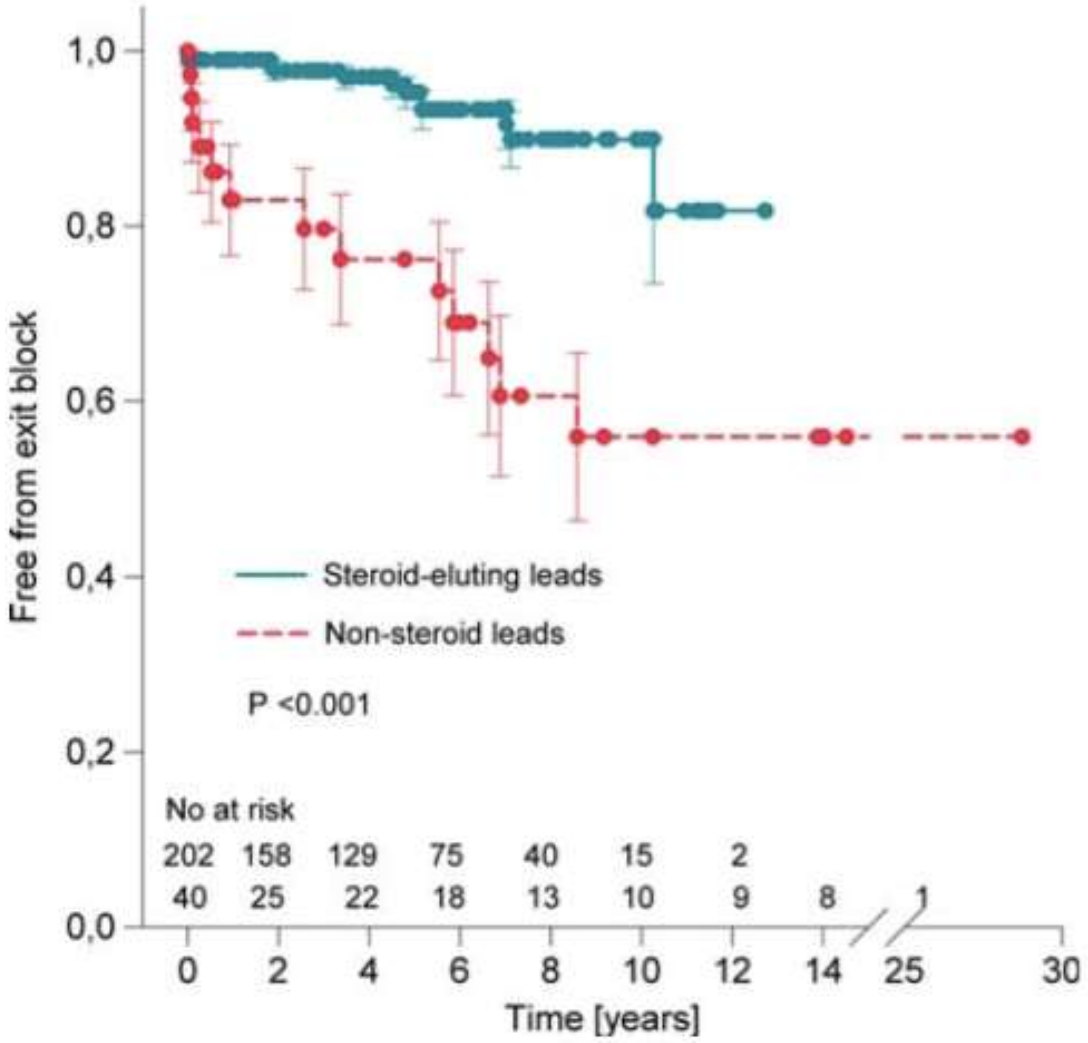



***Risk factors for lead failure***

- ✓ **Age <12 years** (HR=2,7, p<0,001)
- ✓ **CHD** (HR=1,8, p=0,001)
- ✓ **Epicardial lead** (HR=1,6, p=0,007)

Fortescue EB et al. HeartRhythm 2004

# The lead -
## "Achilles heel" of the pacing system




***Risk factors for lead failure***

- ✓ **Unipolar lead** (HR=2,7, p<0,001)
- ✓ **Height at the time of implantation** (HR 0.81, P=0.028 per each 10 cm increment)

Kubuš P et al. Europace 2011

# Future directions of cardiac pacing

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- Position of the pacing lead
- Cardiac resynchronization therapy (CRT)
- Reduction of unnecessary ventricular pacing
- Recruit His-Purkinje conduction

## Reduce hardware to reduce lead failure, valve injury, device infection

- leadless pacemakers

J. ELECTROCARDIOLOGY, 3 (3-4) 325-331, 1970

## Special Article

# Totally Self-Contained Intracardiac Pacemaker*

J. WILLIAM SPICKLER, PH.D., NED S. RASOR, PH.D.†, PAUL KEZDI, M.D.
S. N. MISRA, M.D., K. E. ROBINS, P.E., AND CHARLES LeBOEUF, P.E.

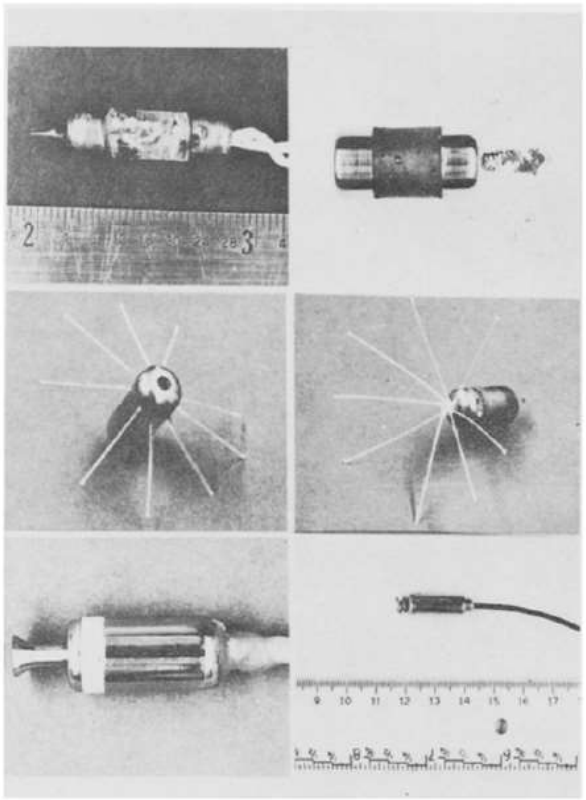

Fig. 2. Some early unsatisfactory dummy capsules used to explore attachment technique.

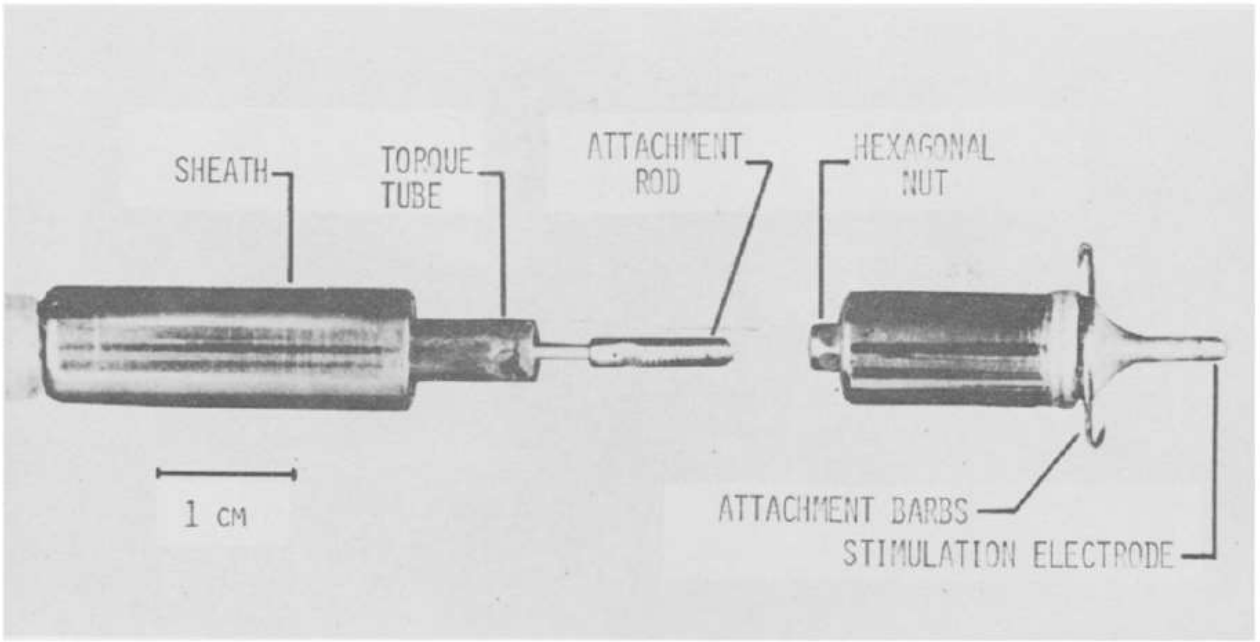


Fig. 4. Intracardiac pacemaker with catheter for transvenous insertion.

J. ELECTROCARDIOLOGY, 3 (3-4) 325-331, 1970

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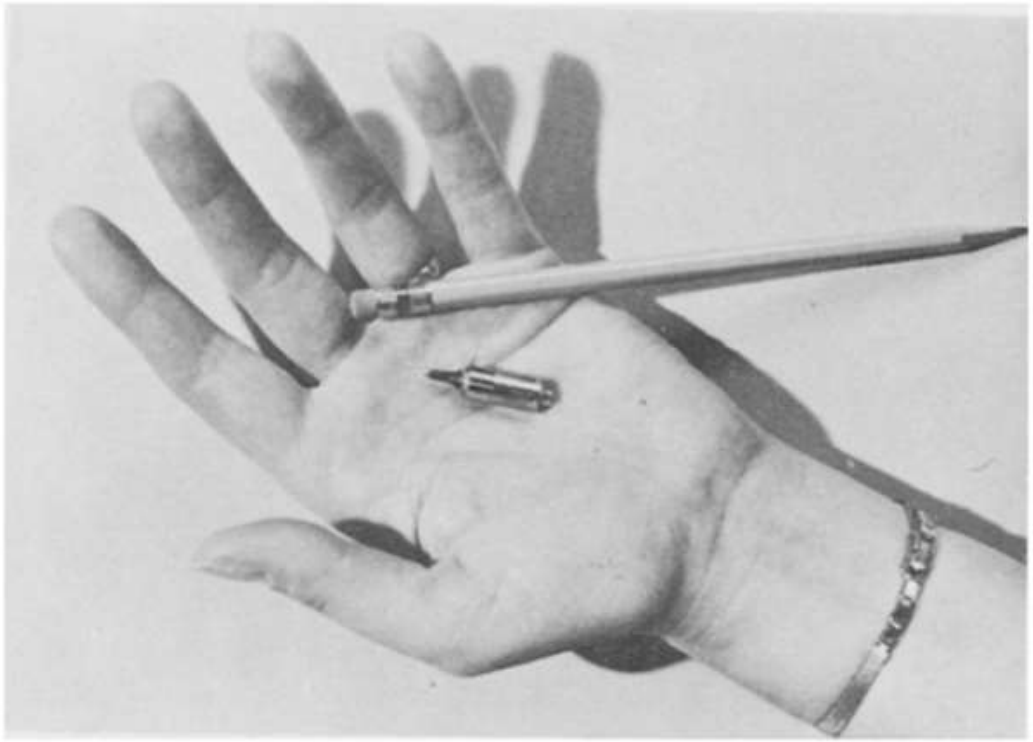
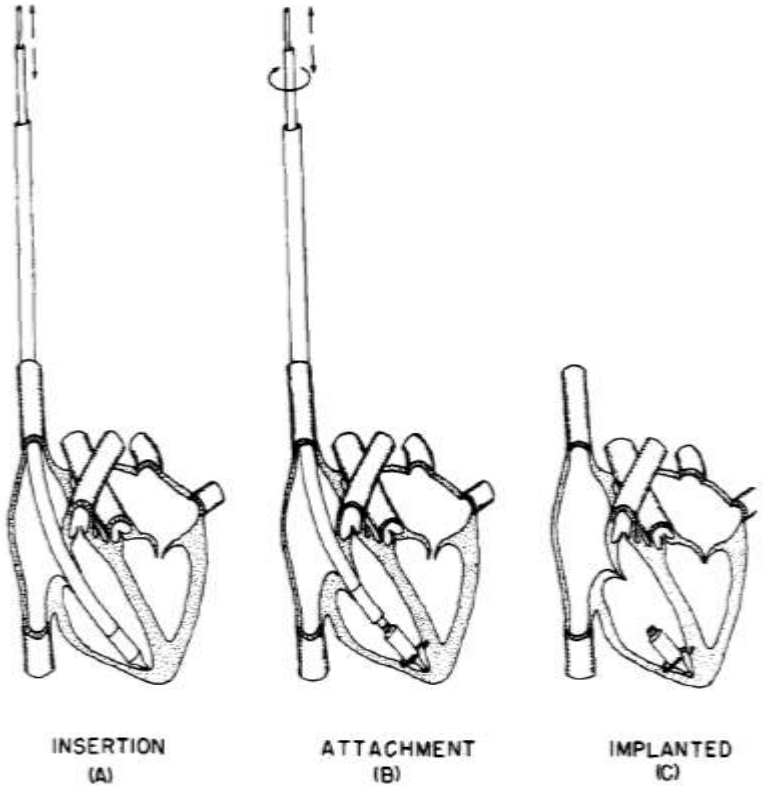


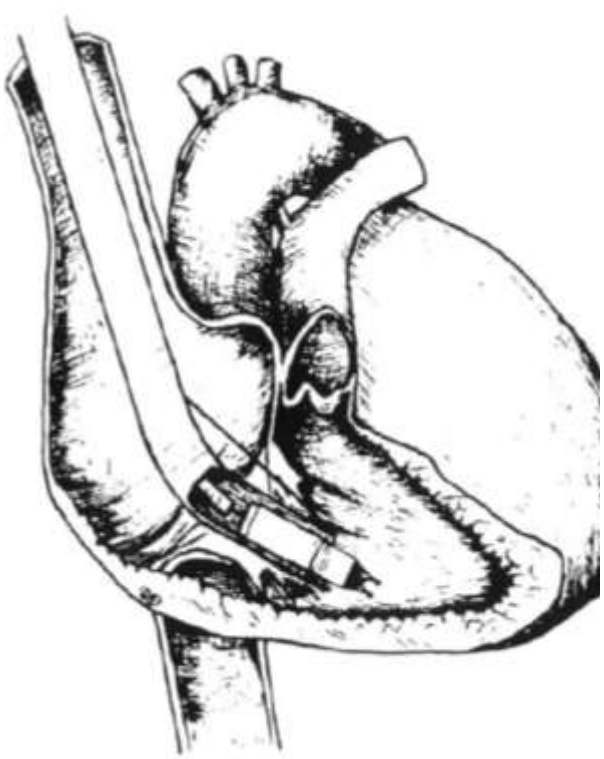


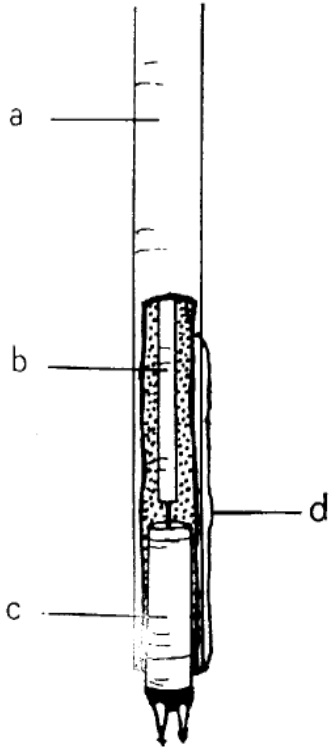
EUR.J.CPE.1991.1:27–30

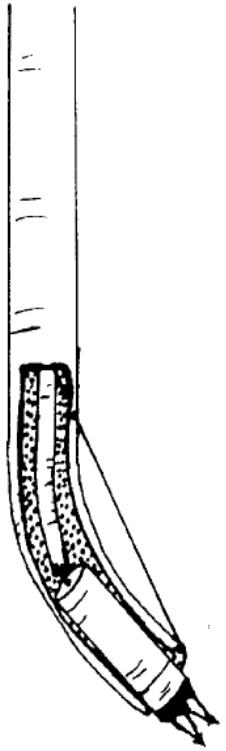
# A Miniature Pacemaker Introduced Intravenously and Implanted Endocardially. Preliminary Findings from an Experimental Study

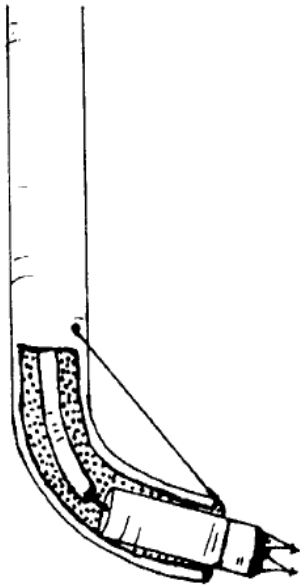
P.E. VARDAS, C. POLITOPOULOS, E. MANIOS, F. PARTHENAKIS, and C. TSAGARAKIS

Cardiology Dept., University of Crete Medical School, Greece







# Leadless pacemaker

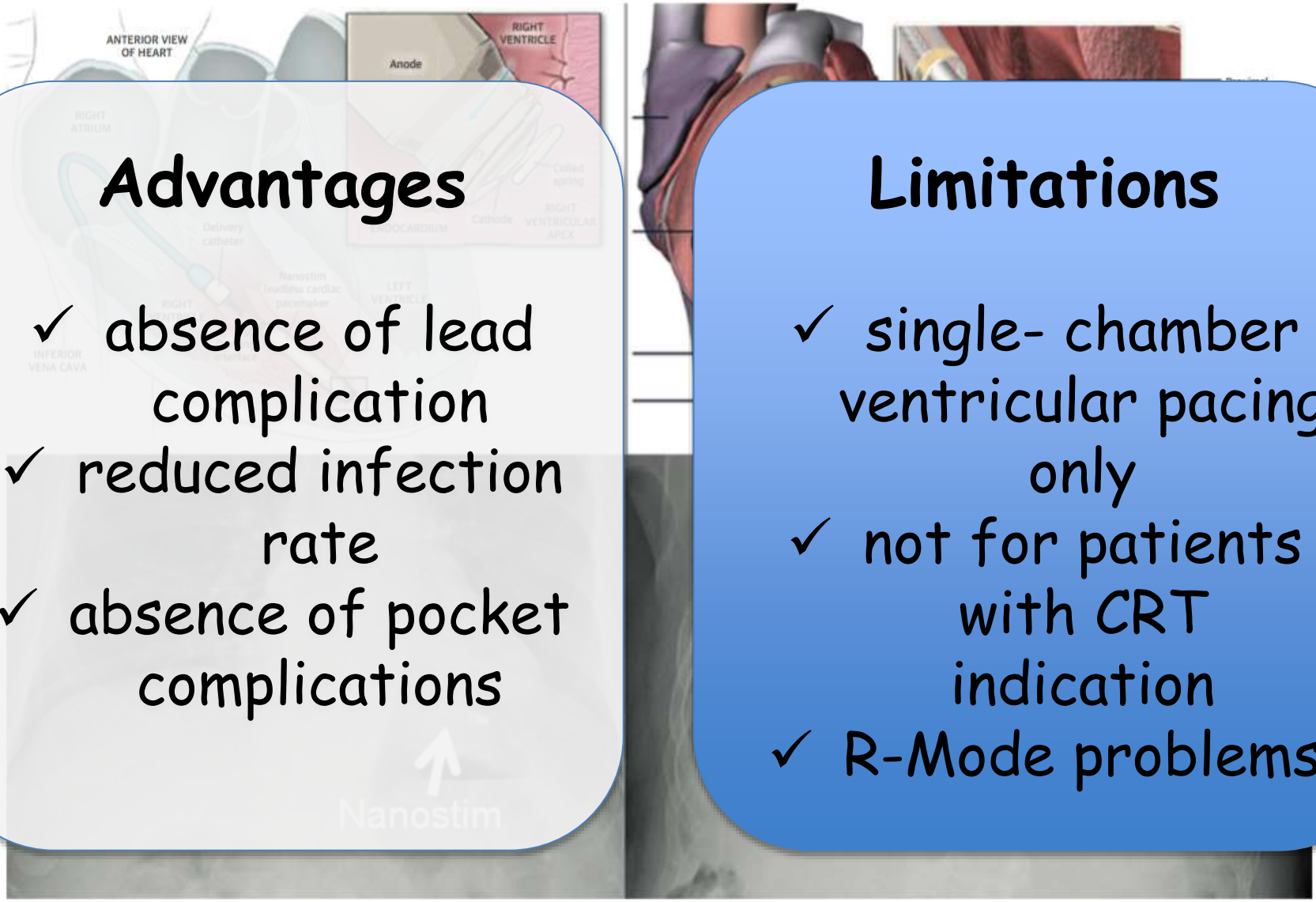
Nanostim, St. Jude Medical


- ✓ **Active fixation**
- ✓ Size 6x42 mm; Weight 2g
- ✓ Battery longevity ≈ 8.4yrs
- ✓ Introducer 18F

Micra, Medtronic


- ✓ **Passive fication**
- ✓ Size 7x26 mm; Weight 2g
- ✓ Battery longevity 7-15 yrs
- ✓ Introducer 24F

# Leadless pacemaker




## Advantages

- ✓ absence of lead complication
- ✓ reduced infection rate
- ✓ absence of pocket complications

## Limitations

- ✓ single- chamber ventricular pacing only
- ✓ not for patients with CRT indication
- ✓ R-Mode problems

Madhavan M. JACC, 2017

# Leadless pacemaker –

## multicomponent system – *WiSE-CRT* system

**N=35 pts.**

Successful implantation in 34 pts.

**Indications**

- ✓ Difficult CS anatomy (n =12)
- ✓ Failure to respond to conventional CRT (n = 10)
- ✓ High CS pacing threshold or phrenic nerve capture (n = 5)

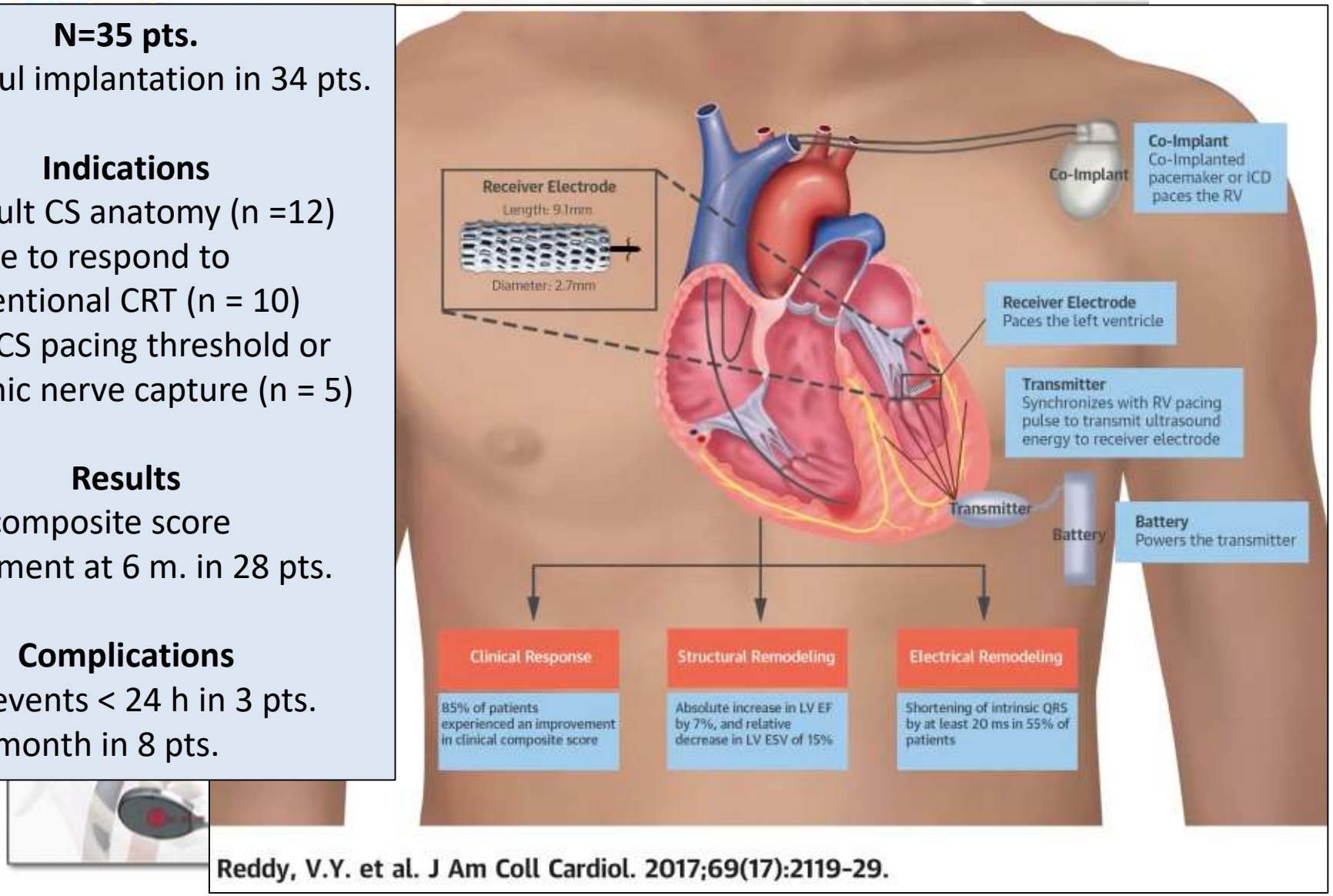
**Results**

Clinical composite score improvement at 6 m. in 28 pts.

**Complications**

Serious events < 24 h in 3 pts.

24 h - 1 month in 8 pts.




Reddy, V.Y. et al. J Am Coll Cardiol. 2017;69(17):2119-29.

Madhavan M. JACC, 2017

# Future directions of cardiac pacing

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- leadless pacemakers

## Eliminate batteries and other hardware

- In development: Batteryless pacemakers that harvest the mechanical energy of cardiac contraction to power the pacemaker
- In development: Biological pacemakers that are gene- or cell-based

# Conformal piezoelectric energy harvesting and storage from motions of the heart, lung, and diaphragm

Canan Dagdeviren[a,1], Byung Duk Yang[a,1], Yewang Su[b,c,1], Phat L. Tran[d], Pauline Joe[a], Eric Anderson[a], Jing Xia[b,c], Vijay Doraiswamy[d], Behrooz Dehdashti[e], Xue Feng[f], Bingwei Lu[b], Robert Poston[e], Zain Khalpey[e], Roozbeh Ghaffari[g], Yonggang Huang[c], Marvin J. Slepian[d,h], and John A. Rogers[a,i,2]

[a]Department of Materials Science and Engineering, Beckman Institute for Advanced Science and Technology, and Frederick Seitz Materials Research Laboratory, and [i]Departments of Chemistry, Mechanical Science and Engineering, and Electrical and Computer Engineering, University of Illinois at Urbana–Champaign, Urbana, IL 61801; [b]Center for Mechanics and Materials and [f]Department of Engineering Mechanics, Tsinghua University, Beijing 100084, China; [c]Department of Civil and Environmental Engineering, Department of Mechanical Engineering, Center for Engineering and Health, and Skin Disease Research Center, Northwestern University, Evanston, IL 60208; [d]Department of Medicine and Sarver Heart Center and Departments of [e]Surgery and [h]Biomedical Engineering, The University of Arizona, Tucson, AZ 85724; and [g]MC10 Inc., Cambridge, MA 02140

- Advanced implantable materials and devices
- high-efficiency mechanical-to-electrical energy conversion from the natural contractile and relaxation motions of the heart, lung, and diaphragm
- several different animal models

PNAS, 2014

# Summary

- From simple anti-bradycardia devices to complex programmable systems
- Prosynchronization strategy
- Lead is still the problem
- Leadless pacing – not for children available
- ~~Maybe~~ batteryless pacemakers are the future !!!

# 9. ročník víkendového EKG/ECHO kurzu pro pediatry a dětské kardiology

Termín: 7.-9. září 2018

***Orea Resort Devět Skal***, Sněžné - Milovy 11, 592 02 Svratka

- Interaktivní EKG a echo kurz
- Intenzivní zábava
- ....

# Thank you for attention!