



Bortom tranvenösa elektroder

Icke-konventionell pacemaker- och ICD-system

Amar Taha

MD, PhD, FESC

Överläkare i Kardiologi

Sahlgrenska universitetssjukhuset

Patientfall 1

- 61 år, man
- Känd bicuspid aortaklaff med kombinerat vitium
- 6 månader tidigare: endokardit med aortarotabcess-> mekanisk komposit graft
- Nu inkommit med hjärtstillestånd. Deff VF x 10 till ROSC
- EKO med fungerande protes, EF 55-65%
- EKG sinus rytm, normal PQ-tid, smala QRS

Open Menti to edit 

Replace this slide 

Add Menti slides 

Patientfall 2

- 90 år, man
- DDD sedan 2010 pga Takybrady. Nu permanent FF med totalblock (Paceberoende).
- Dosbyte 2020
- Dosfickeinfektion 2025 -> Extraktion
- Typ av device:

Open Menti to edit



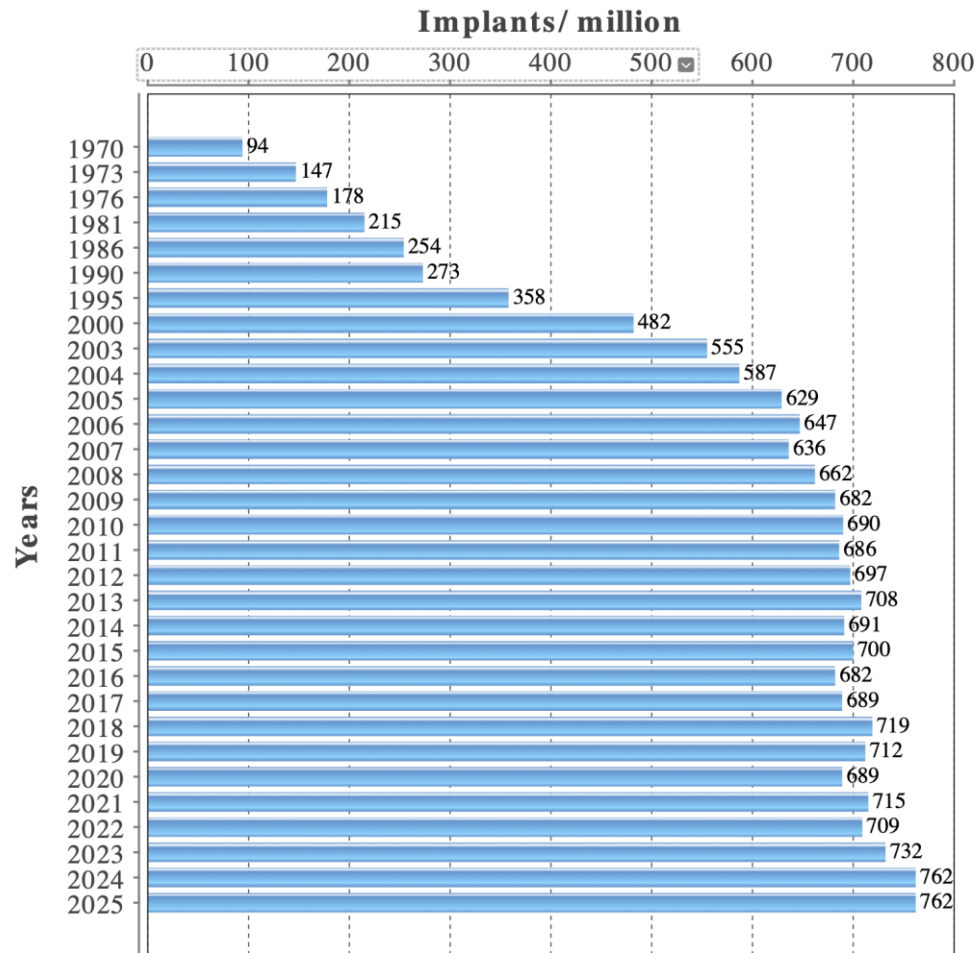
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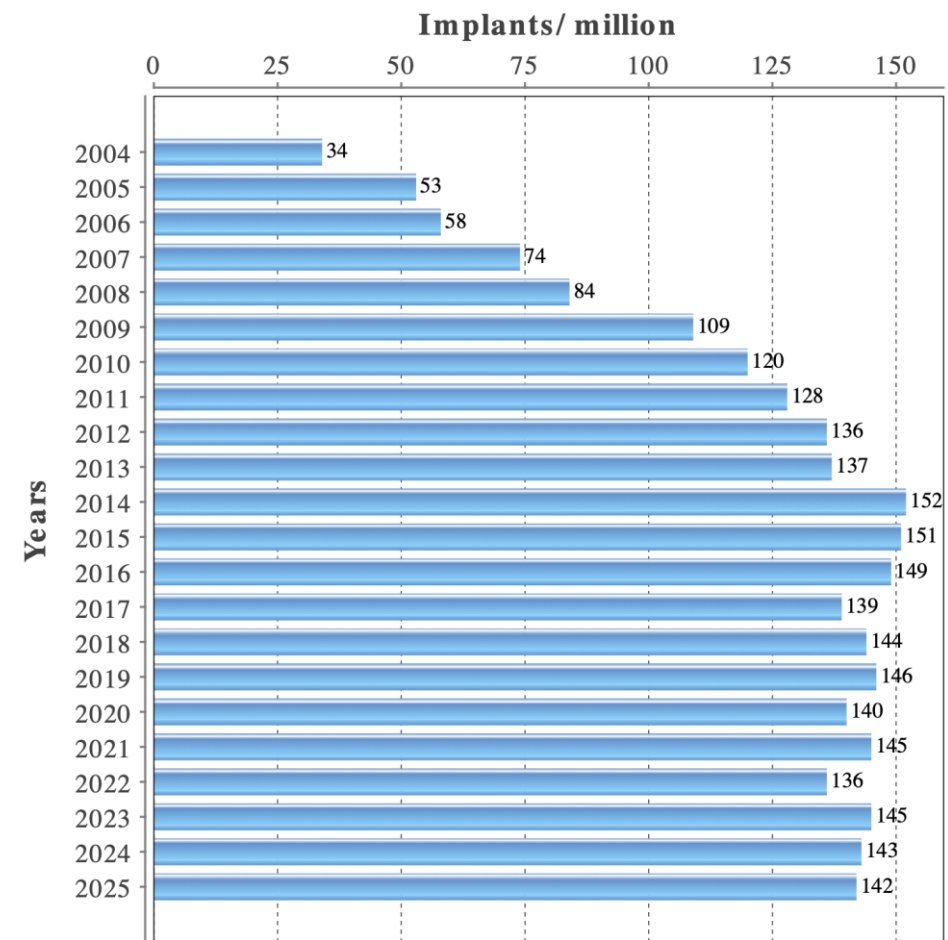
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Pacemaker



ICD



Sverige 2025

- ca 71000 aktiva PM patienter
- ca 19000 aktiva ICD patienter

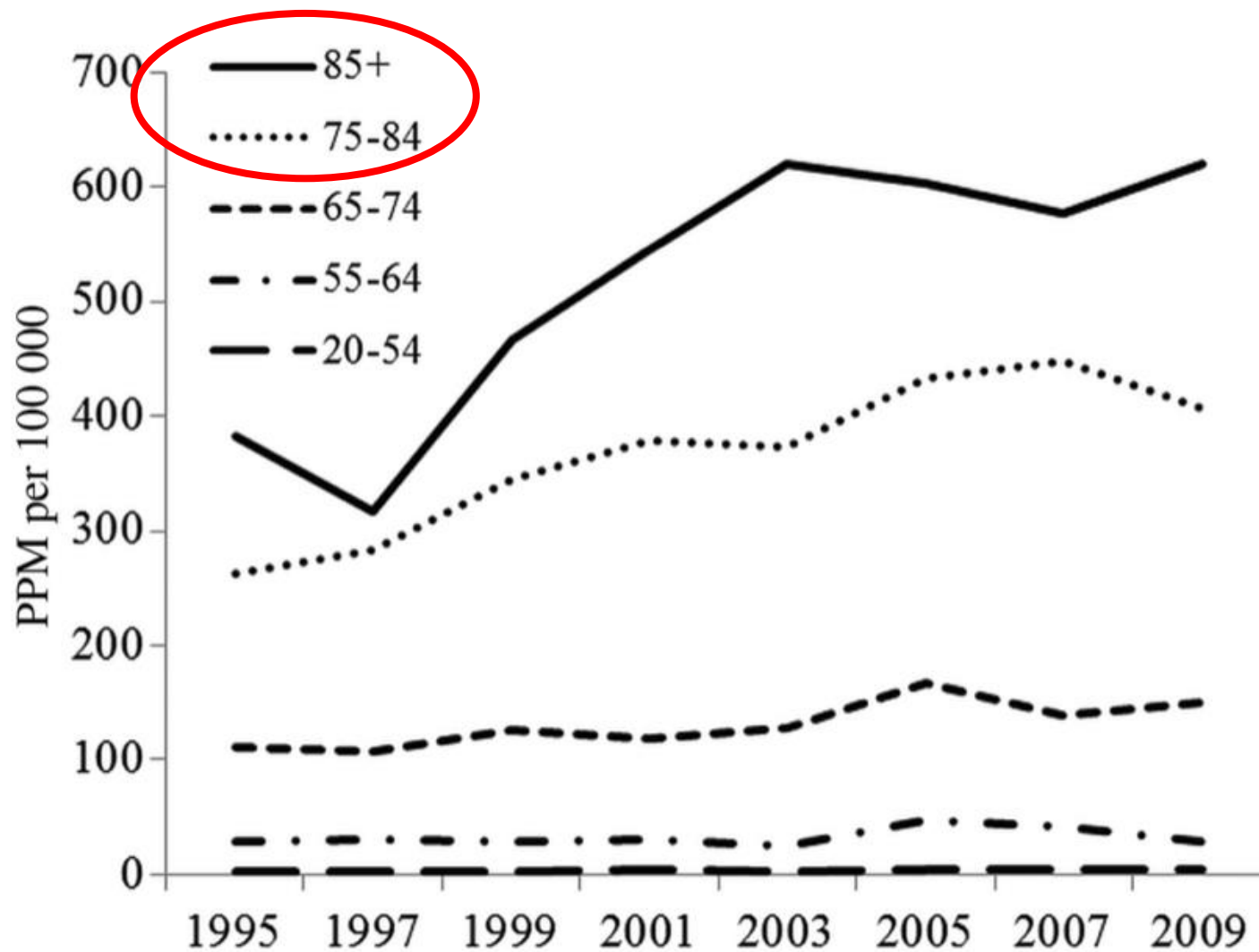


Figure 1 Trends in prevalence-adjusted incidence of permanent pacemaker insertion (per 100 000) by age group, 1995–2009.

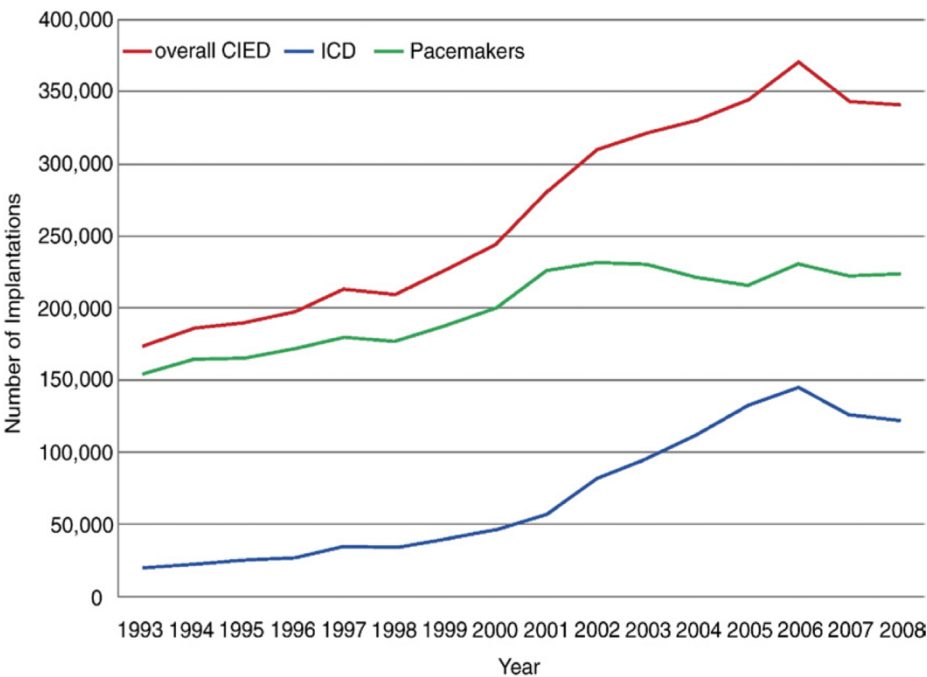


Figure 1 Annual Number of PM and ICD Implantations: 1993 to 2008

Between 1993 and 2008, overall cardiac implantable electrophysiological device (CIED) implantation increased by 96% (an average of 4.7%/year). Pacemaker (PM) implantation increased by 45%, whereas implantable cardioverter-defibrillator (ICD) implantation increased by 504%.

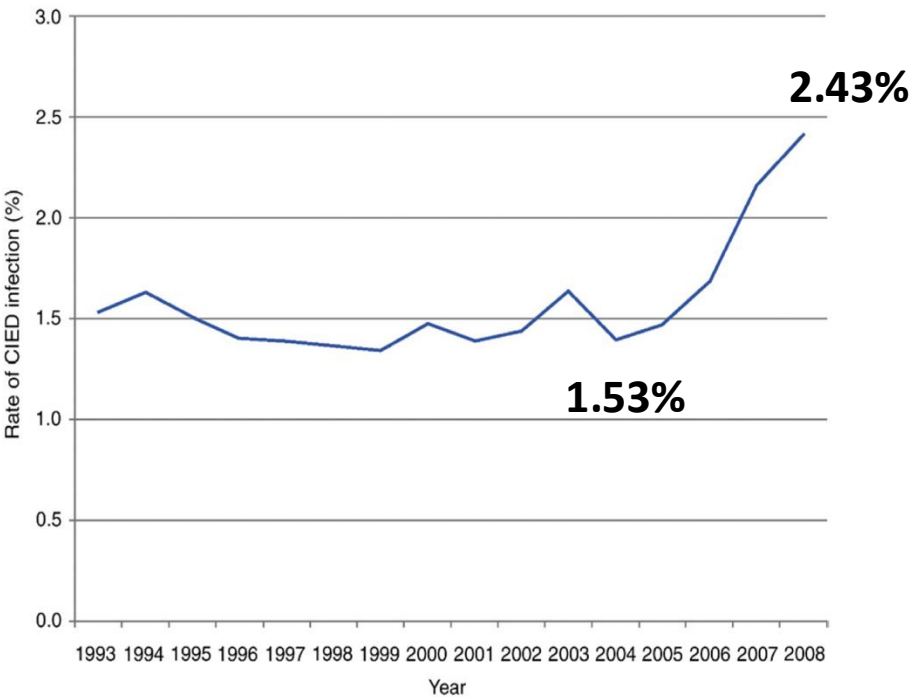
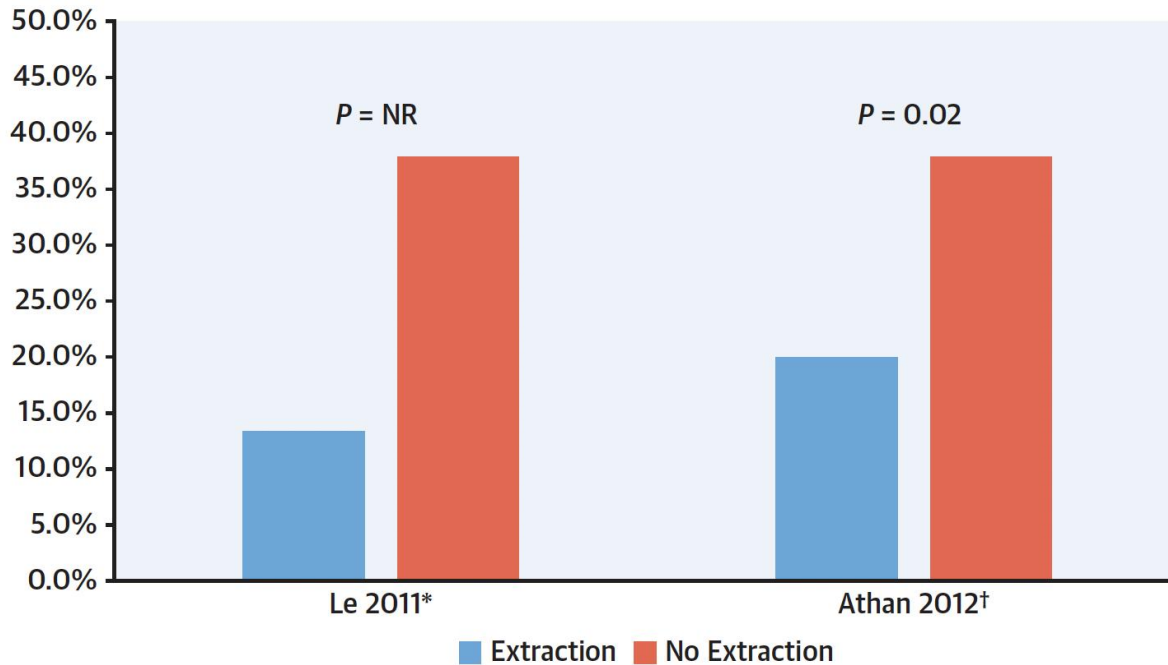


Figure 3 Rate of CIED Infection

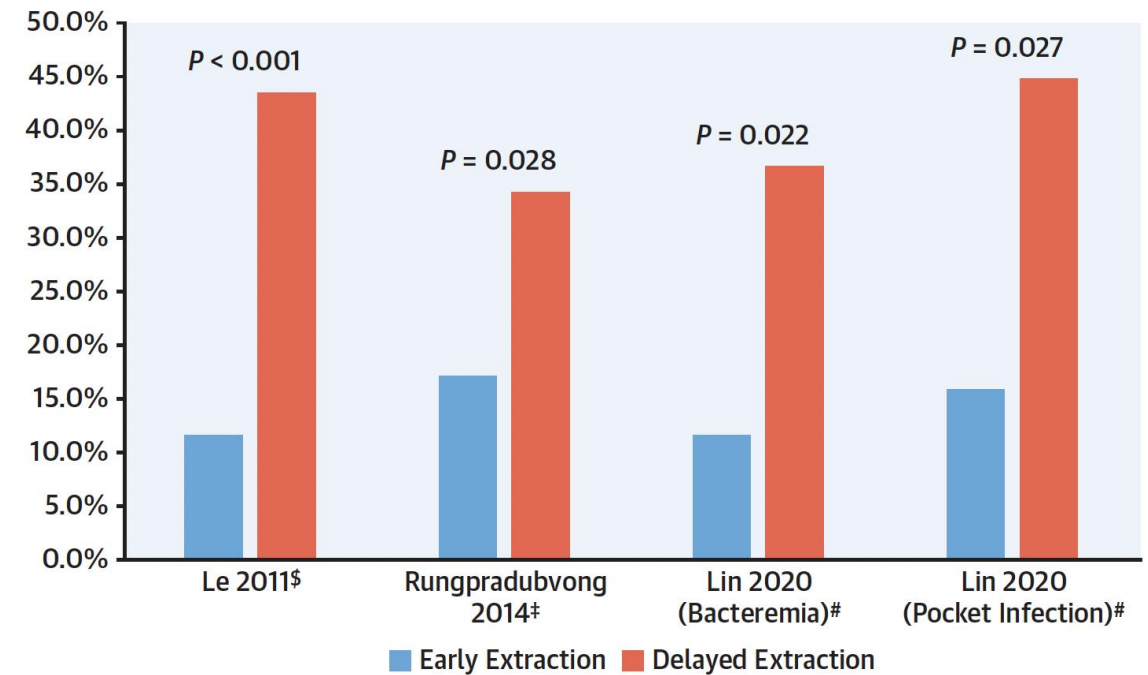
The annual rate of cardiac implantable electrophysiological device (CIED) infection remained fairly constant until 2004 when there was a marked increase. The infection rate increased from 1.53% in 2004 to 2.41% in 2008 ($p < 0.001$).

1-års mortalitet

A

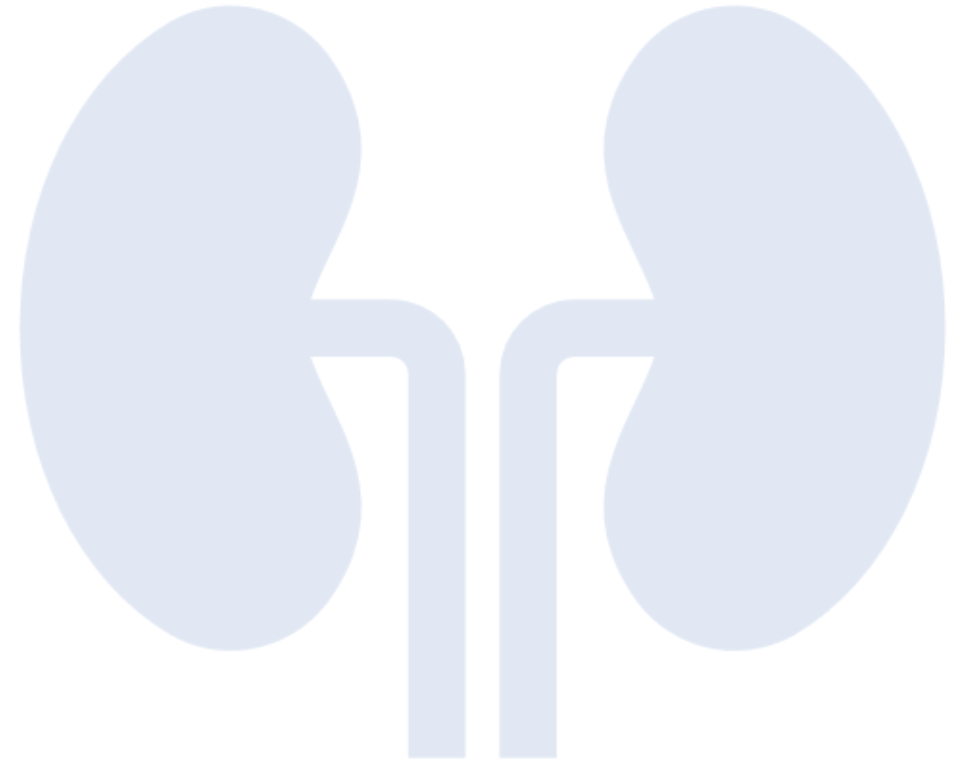


B

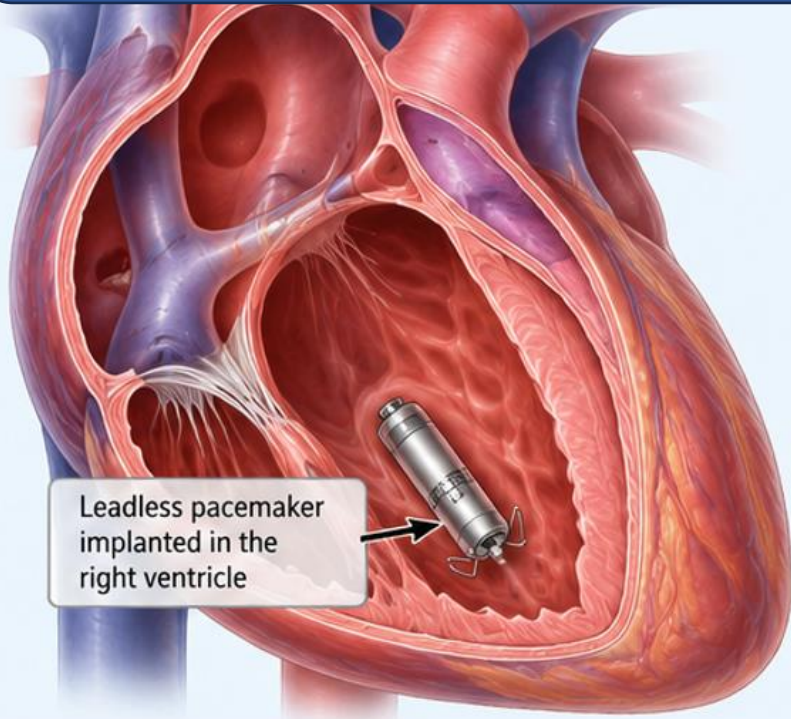


Riskfaktorer för CIED-infektion

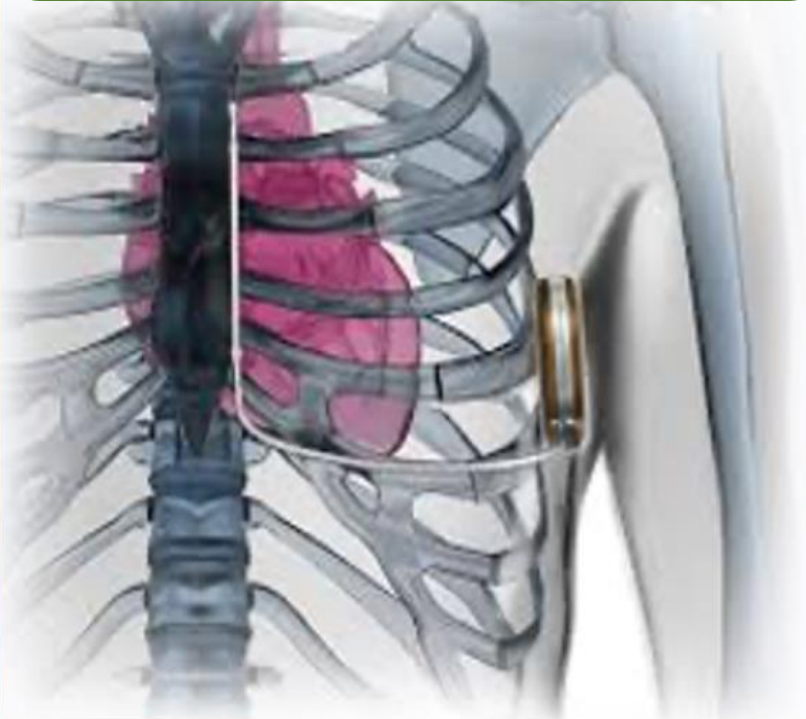
- Dialys
- Kronisk njursvikt
- Immunosuppressive behandling
- Diabetes
- Tidigare CIED-infektion eller endokardit



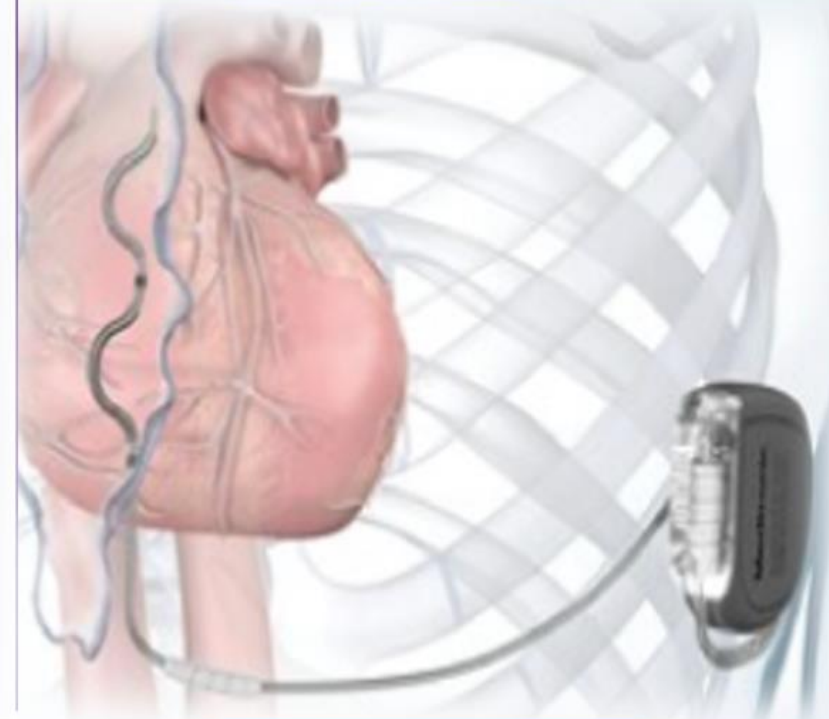
Leadless pacemaker



Subkutan ICD



Extravaskulär ICD



Micra [8, 16, 26-28]



Medtronic

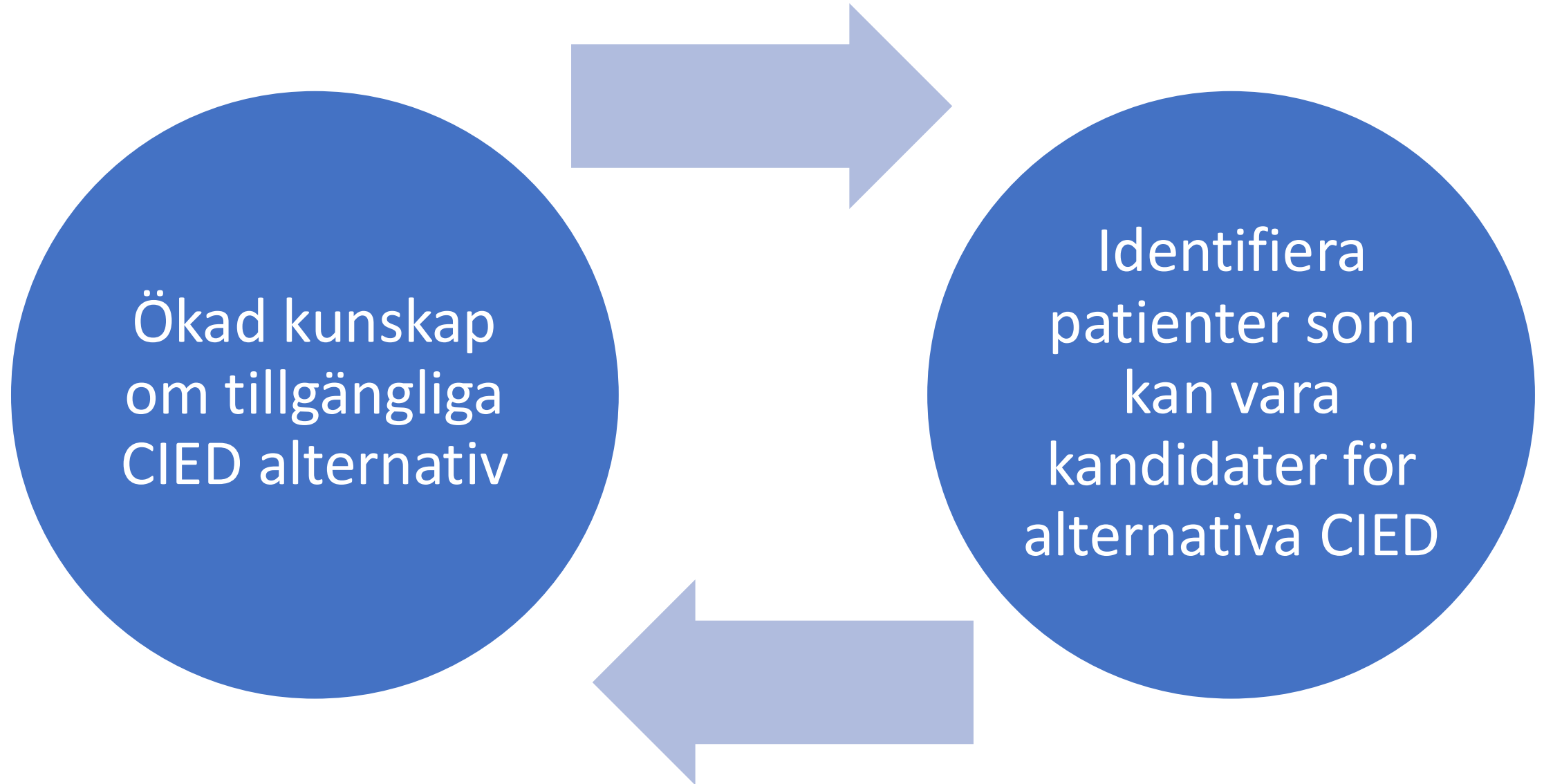
Aveir [33, 34, 36]



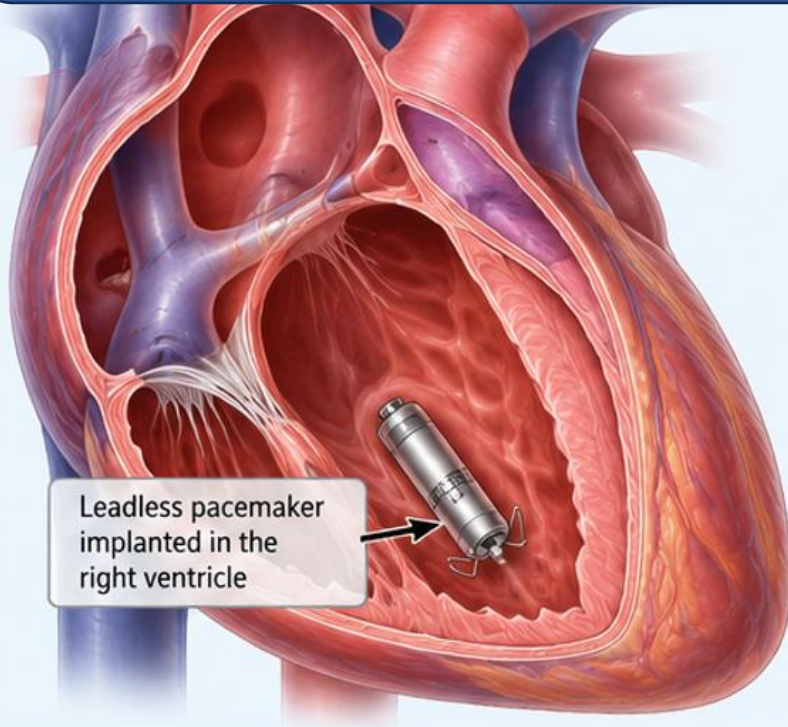
Abbott



Syftet



Leadless pacemaker



Micra [8, 16, 26-28]



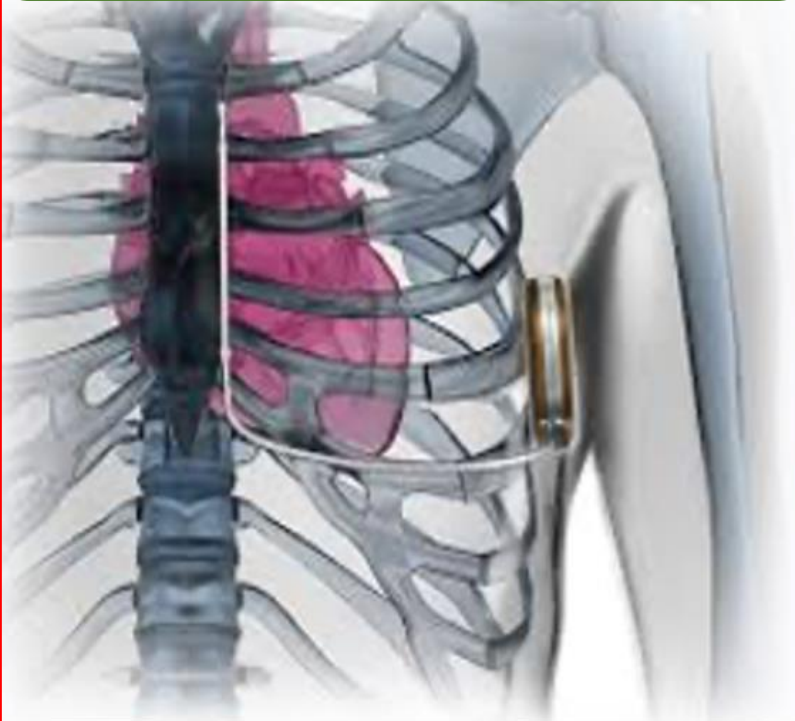
Medtronic

Aveir [33, 34, 36]

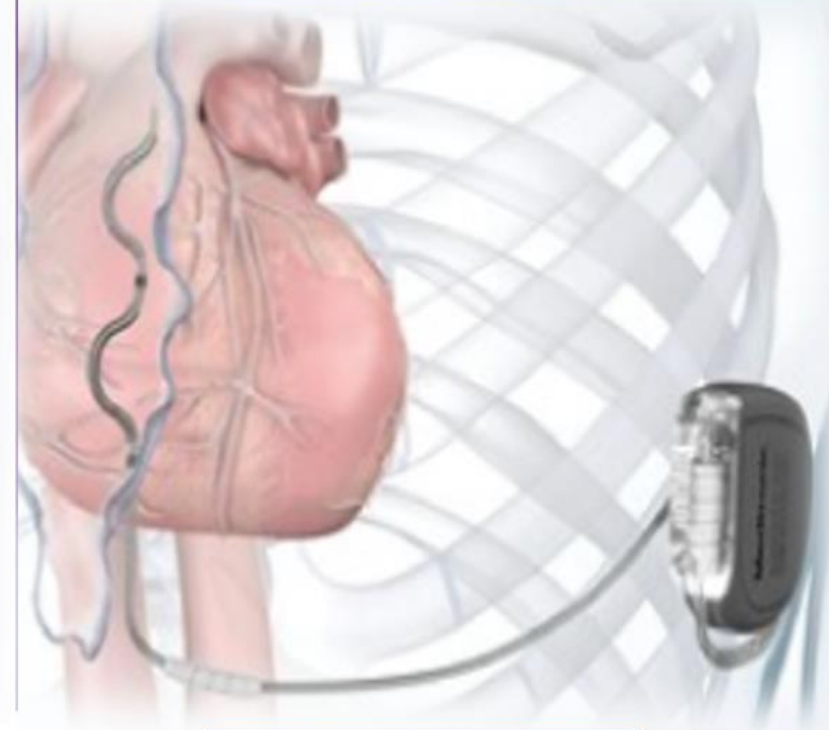


Abbott

Subkutan ICD



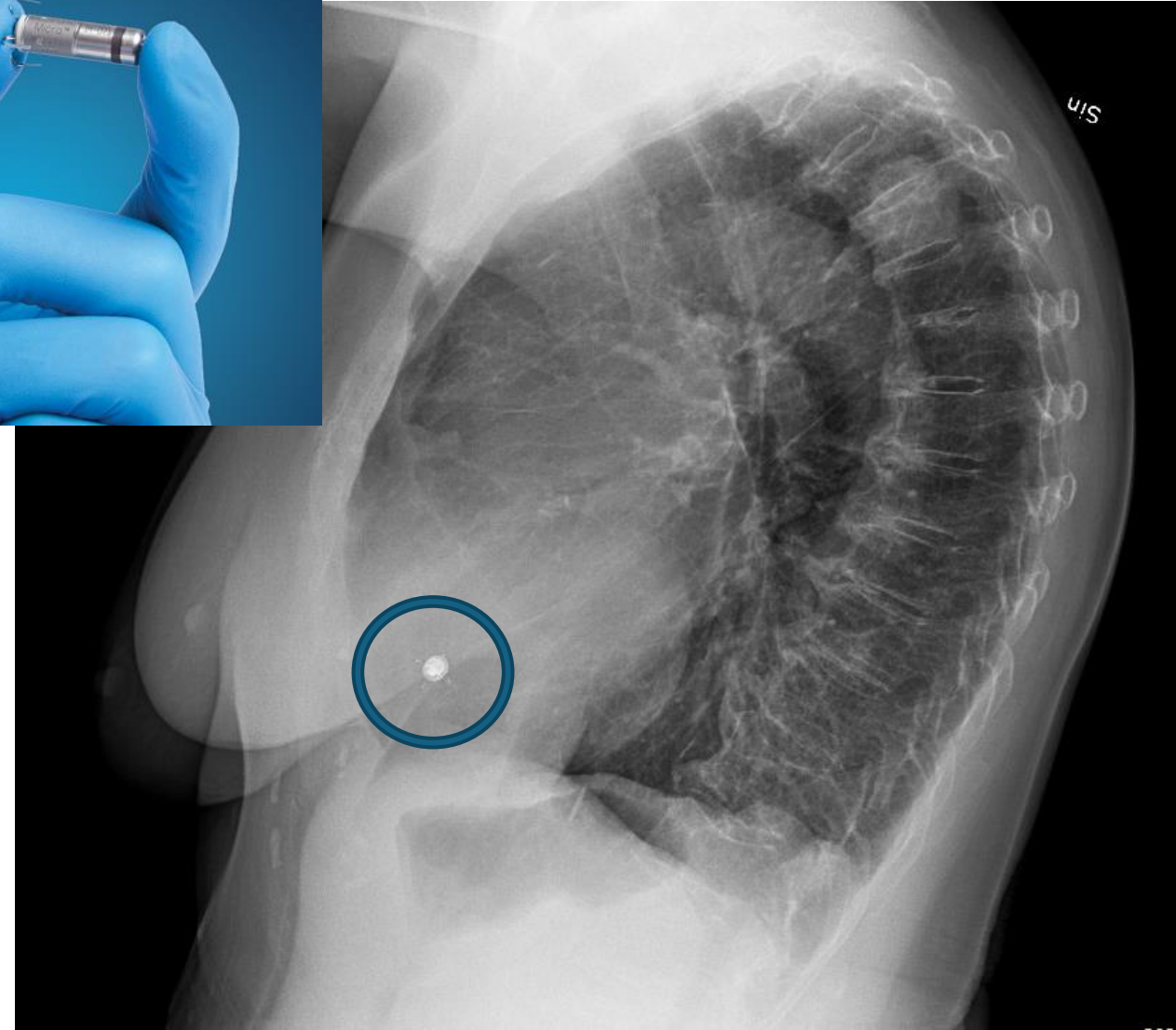
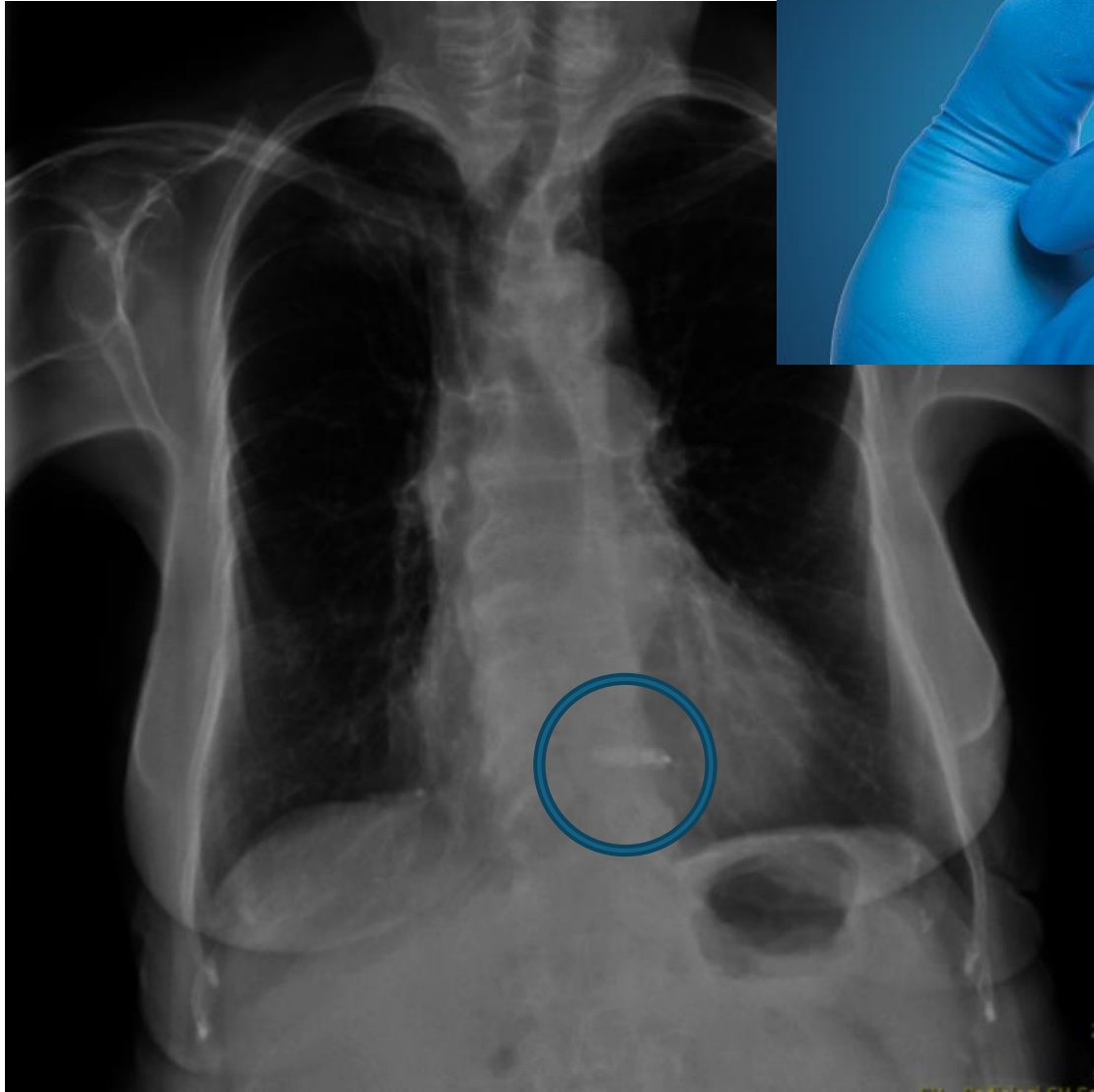
Extravaskulär ICD



Medtronic MICRA

- MICRA VR 2015
- MICRA AV 2020
- MICRA VR2 AV2 2024



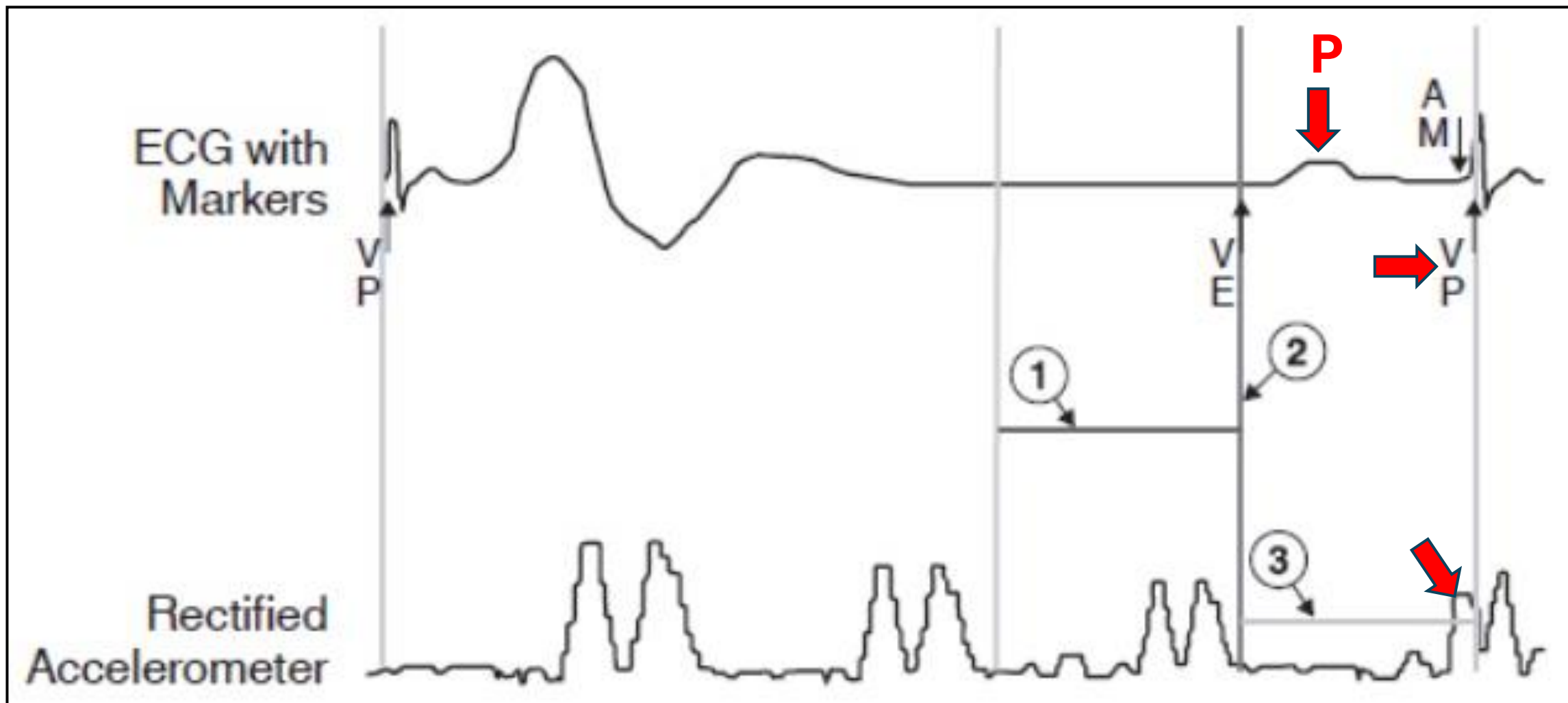


Medtronic - MICRA



MICRA VR (VVI)

Medtronic - MICRA



MICRA AV – *erbjuder AV-synkroni*

Medtronic - MICRA

MICRA AV – erbjuder AV-synkroni (VDD)

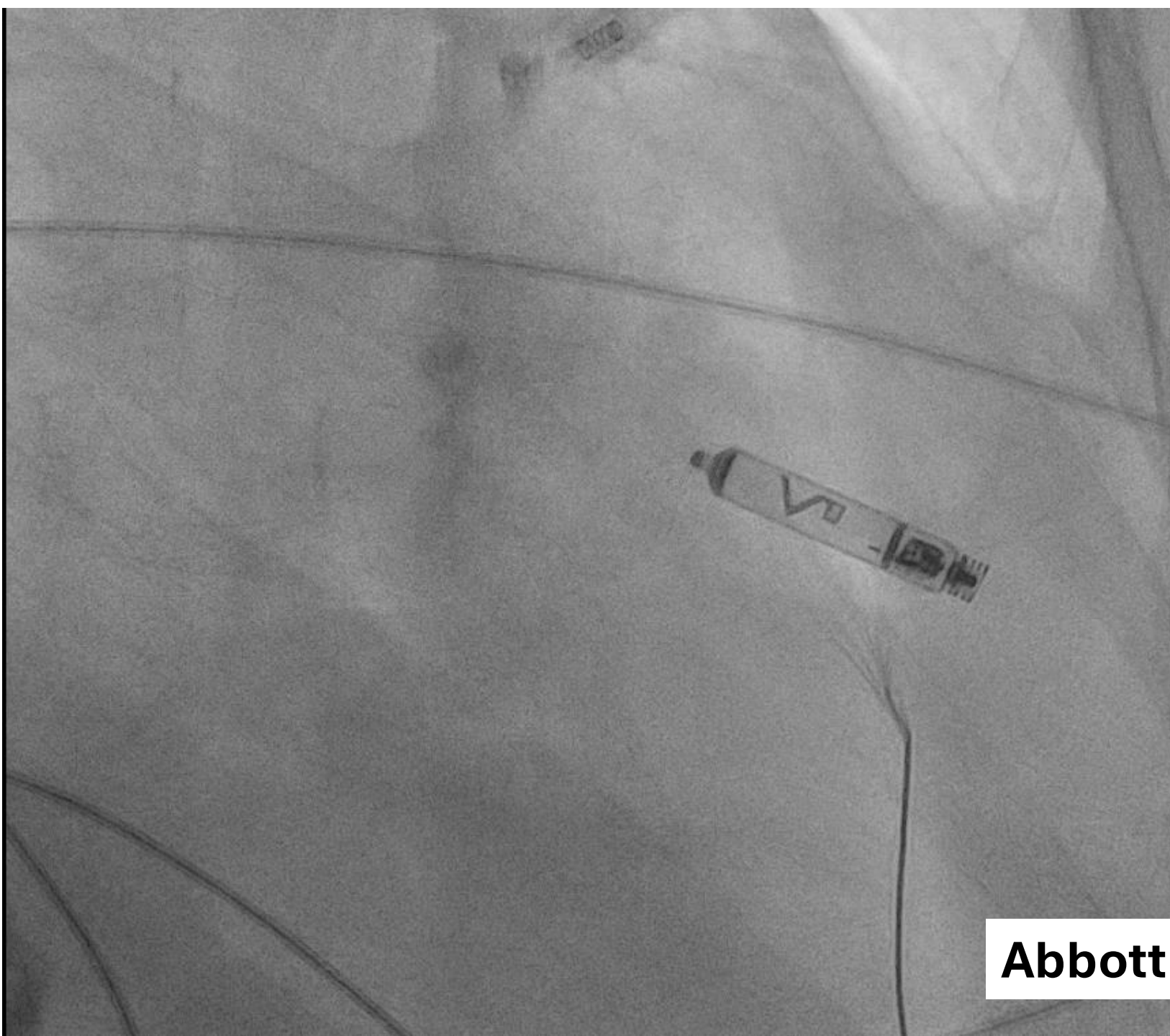


Medtronic - MICRA

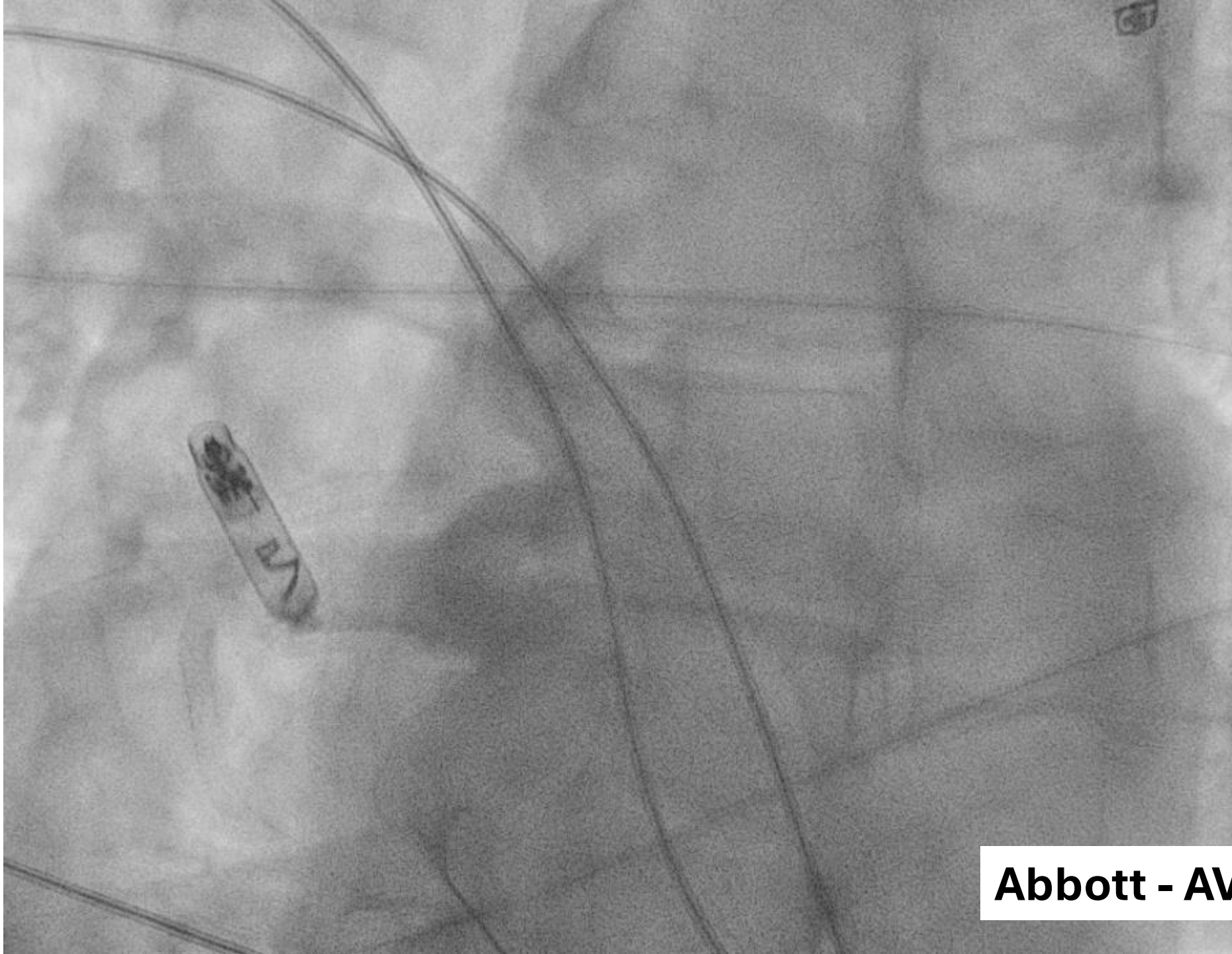


Abbotts leadless Pacemaker - AVEIR

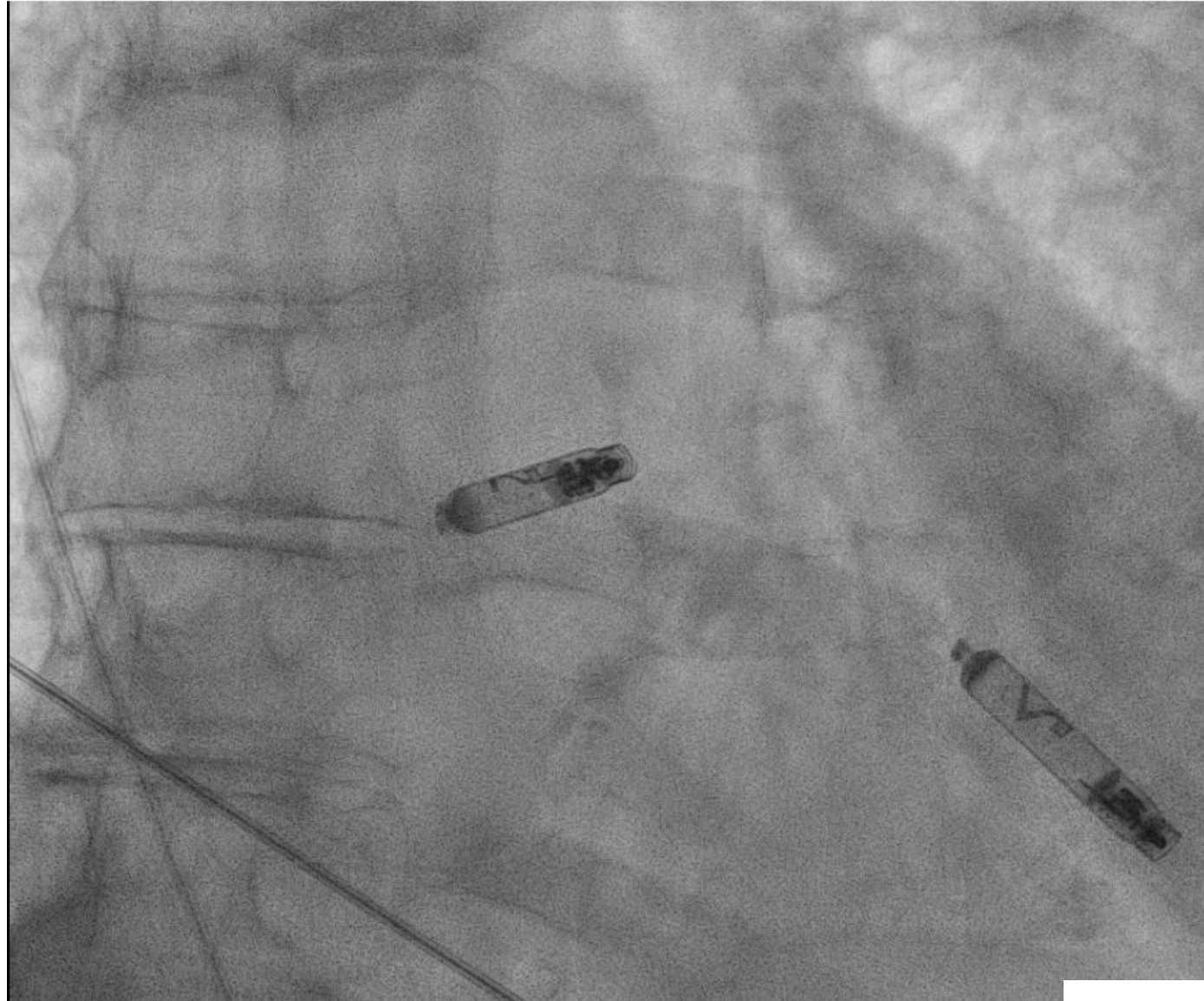
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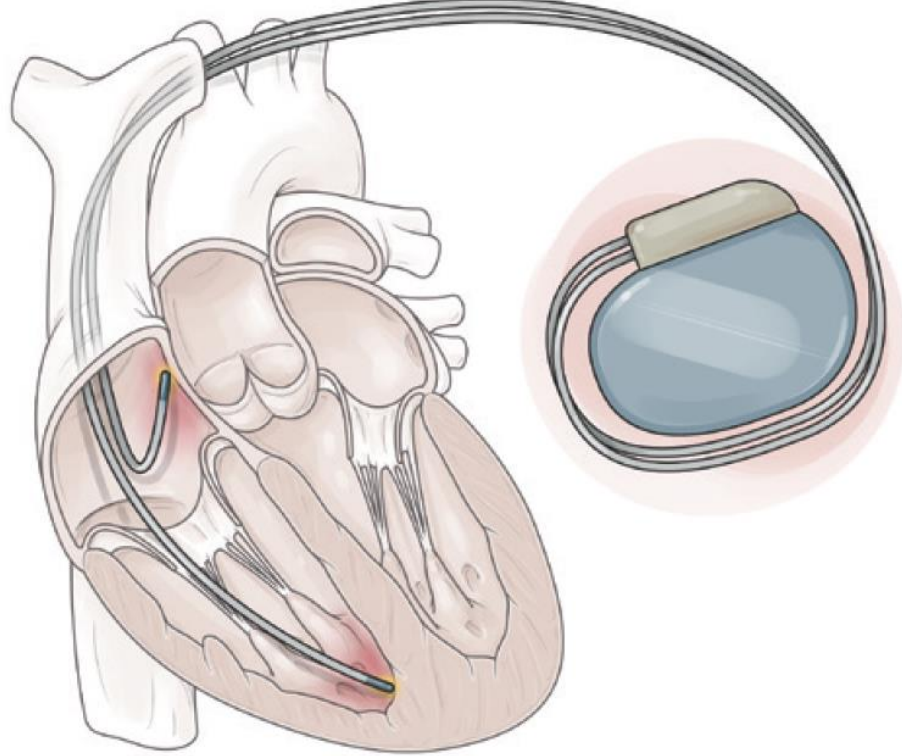
Abbott - AVEIR VR



Abbott - AVEIR AR



Abbott - AVEIR DR



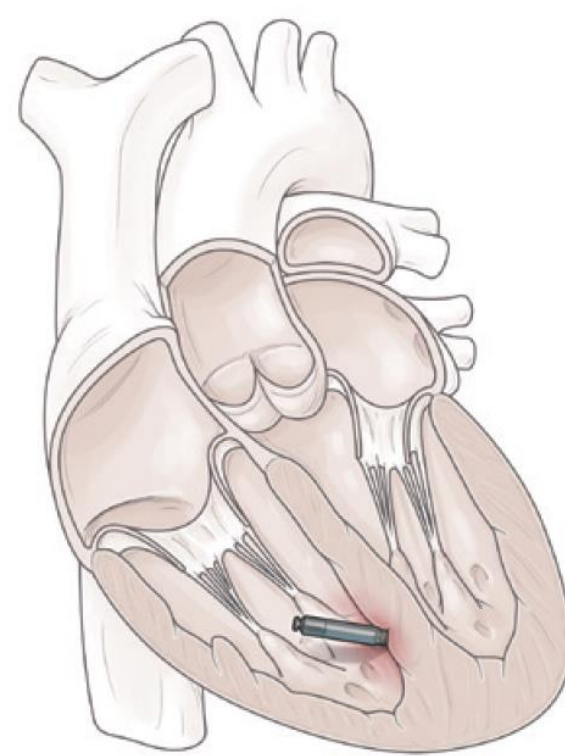
Conventional Transvenous Pacemaker

Pros:

- Longer duration of use
- Better at ensuring atrioventricular synchrony
- Ability to achieve conduction system pacing

Cons:

- Higher risk of infection
- Higher risk of lead-related complications



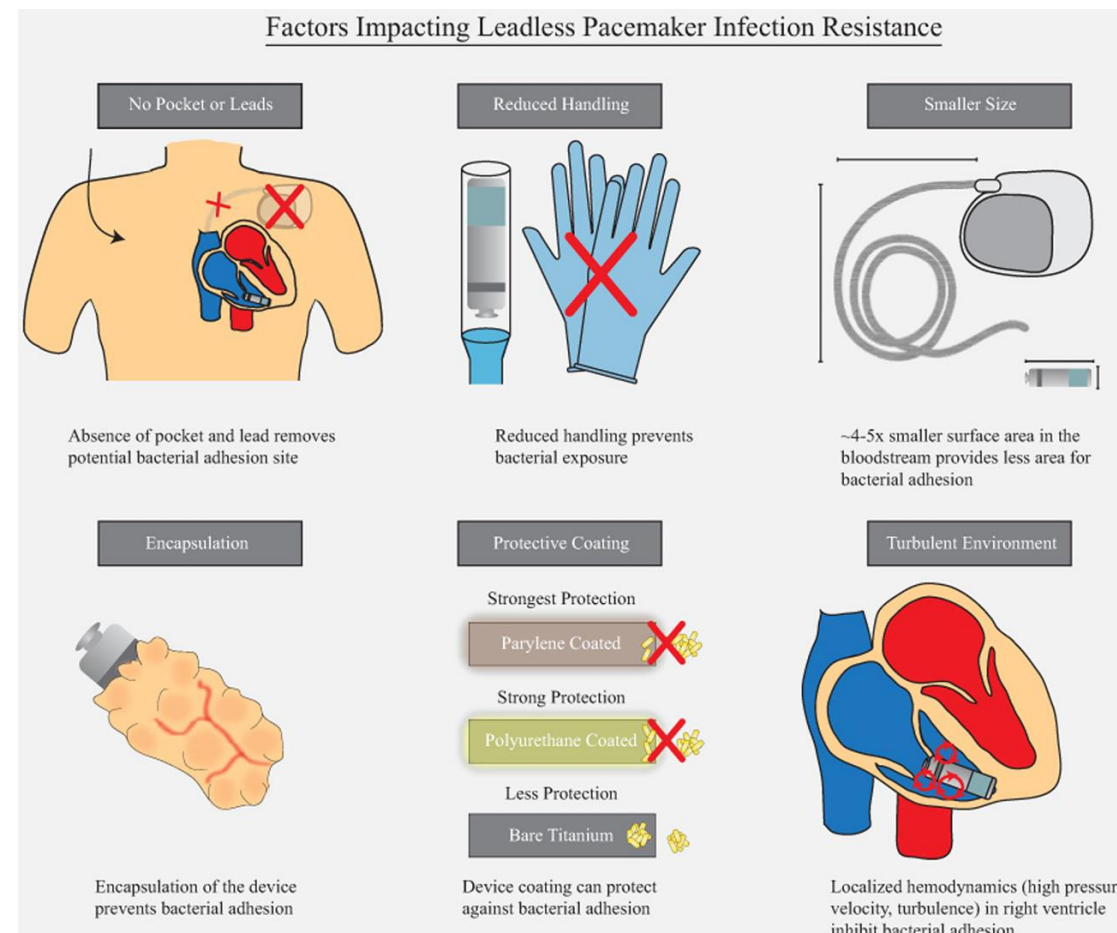
Leadless Pacemaker

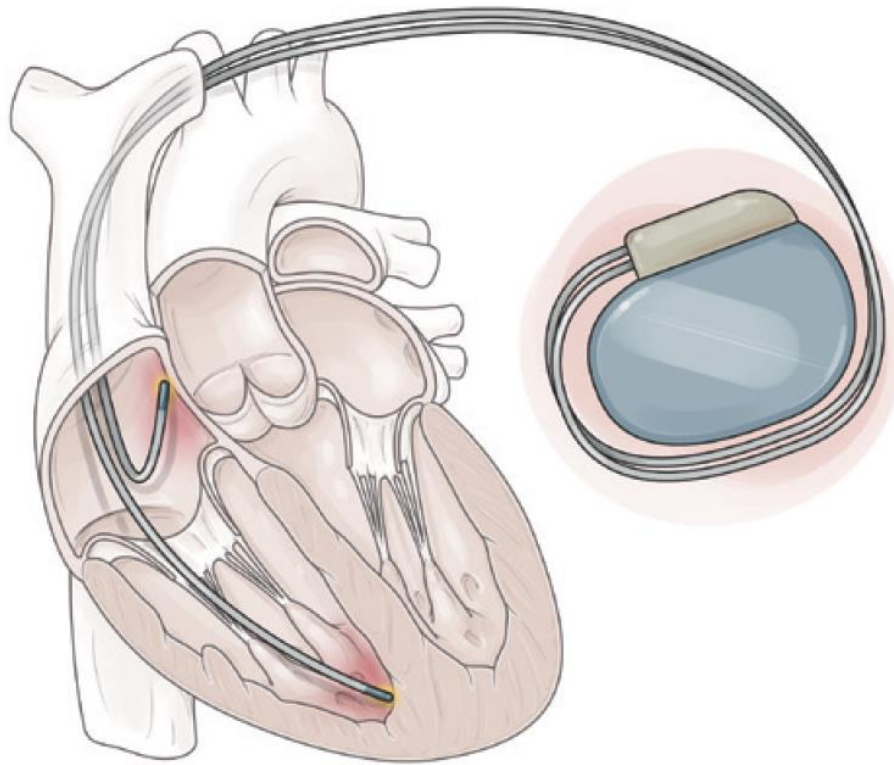
Pros:

- Lower risk of infection
- No lead-related complications
- Lower need for device-related reintervention

Cons:

- Suboptimal degree of atrioventricular synchrony in many patients
- Higher risk of cardiac perforation
- Inability to achieve conduction system pacing
- Lack of experience with long-term device extraction





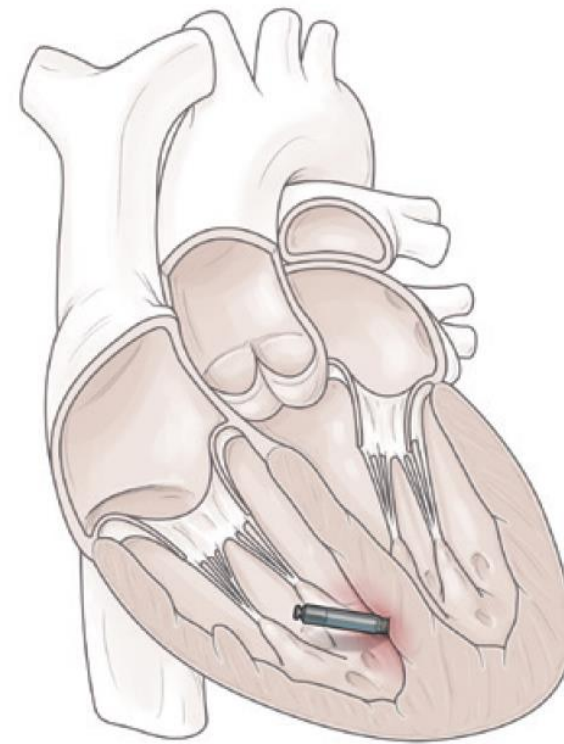
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ICD-behandling

The Evolution of Implantable Cardioverter-Defibrillators

1980

First ICD Implanted



1990s

Smaller & Advanced ICDs



2000s

ICD with Cardiac Resynchronization Therapy (CRT)



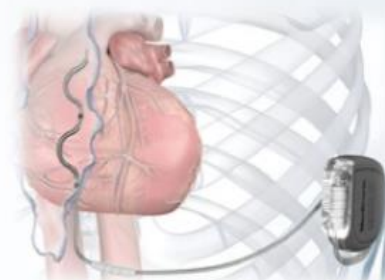
2009

Introduction of the S-ICD



2023

Introduction of the EV-ICD



Complications at 6 months

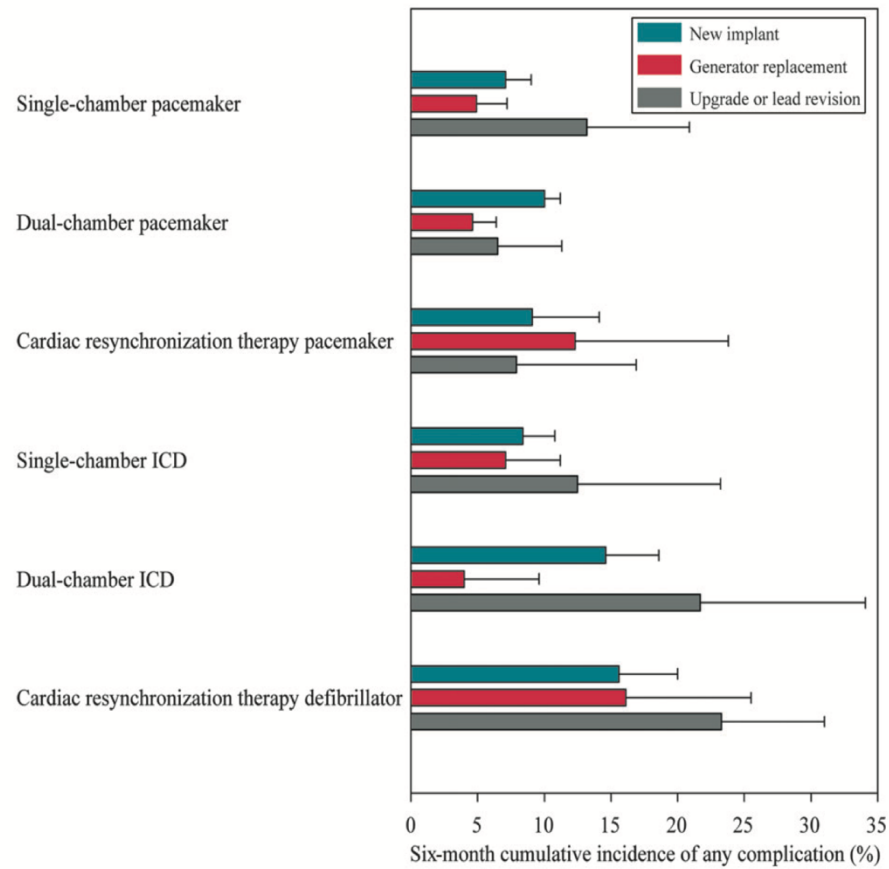


Figure 1 Risk of any complication according to procedure and CIED type (with 95% CI).

- Reoperation
- Pneumothorax
- Perforation
- Systemisk infektion/endokardit

1990s

Smaller & Advanced ICDs



2000s

ICD with Cardiac
Resynchronization
Therapy (CRT)



Andra problem:

- Venös ocklussion
- Tricuspidalisklaff

2009

Introduction of
the S-ICD

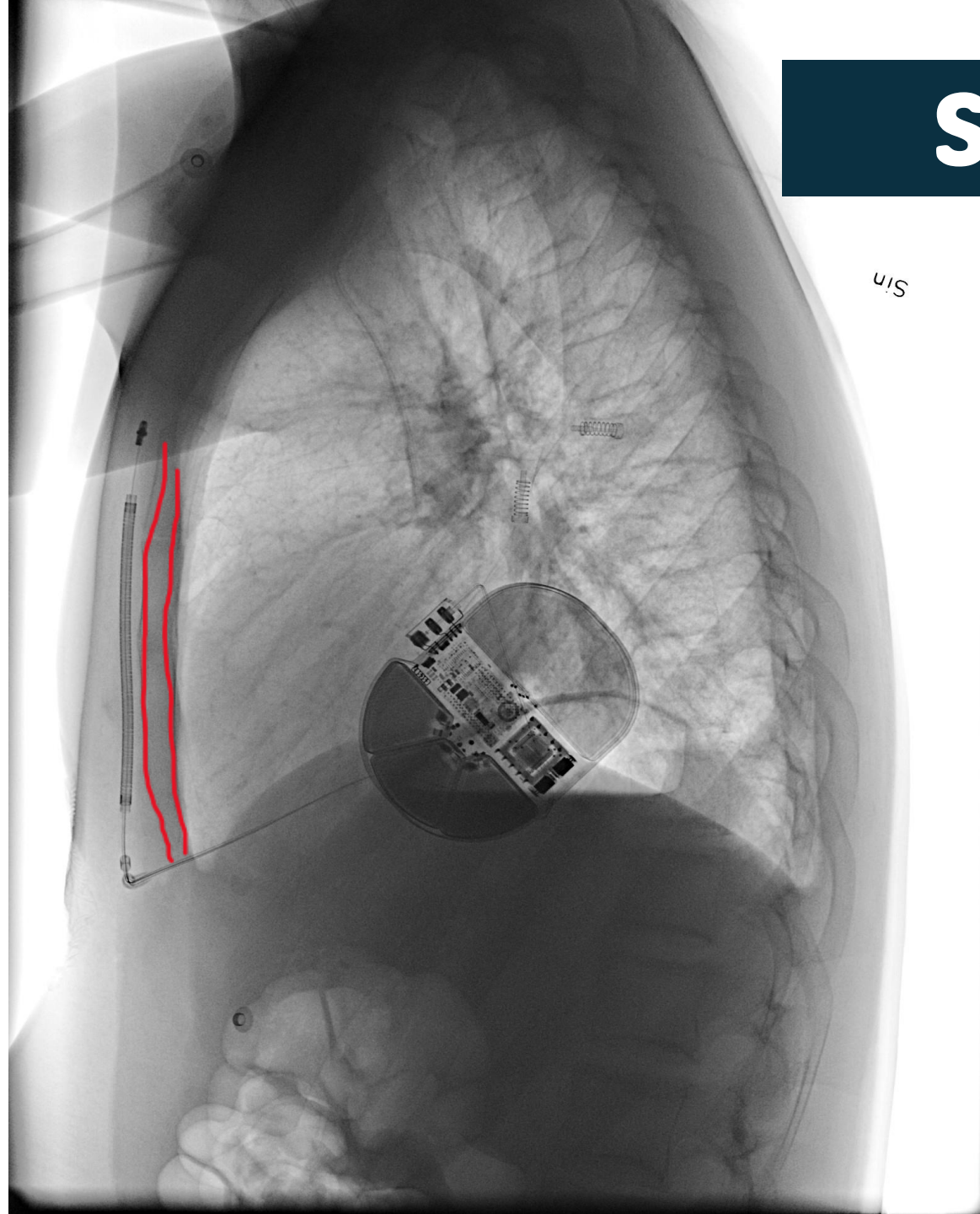


ORIGINAL ARTICLE

An Entirely Subcutaneous Implantable Cardioverter–Defibrillator

Gust H. Bardy, M.D., Warren M. Smith, M.B., Margaret A. Hood, M.B., Ian G. Crozier, M.B., Iain C. Melton, M.B., Luc Jordaens, M.D., Ph.D., Dominic Theuns, Ph.D., Robert E. Park, M.B., David J. Wright, M.D., Derek T. Connelly, M.D., Simon P. Fynn, M.D., Francis D. Murgatroyd, M.D., Johannes Sperzel, M.D., Jörg Neuzner, M.D., Stefan G. Spitzer, M.D., Andrey V. Ardashev, M.D., Ph.D., Amo Oduro, M.B., B.S., Lucas Boersma, M.D., Ph.D., Alexander H. Maass, M.D., Isabelle C. Van Gelder, M.D., Ph.D., Arthur A. Wilde, M.D., Ph.D., Pascal F. van Dessel, M.D., Reinoud E. Knops, M.D., Craig S. Barr, M.B., Pierpaolo Lupo, M.D., Riccardo Cappato, M.D., and Andrew A. Grace, M.B., Ph.D.

S-ICD



2009

Introduction of
the S-ICD



ORIGINAL ARTICLE

Subcutaneous or Transvenous Defibrillator Therapy

R.E. Knops, L.R.A. Olde Nordkamp, P.-P.H.M. Delnoy, L.V.A. Boersma, J. Kuschyk, M.F. El-Chami, H. Bonnemeier, E.R. Behr, T.F. Brouwer, S. Käb, S. Mittel, A. F. P. F. Oost, L. Smeeding, W. van der Stuijt, A. de Weger

Circulation

Volume 152, Issue 3, 22 July 2025; Pages 172-182
<https://doi.org/10.1161/CIRCULATIONAHA.125.074576>



ORIGINAL RESEARCH ARTICLE

Device-Related Complications in Transvenous Versus Subcutaneous Defibrillator Therapy During Long-Term Follow-Up: The PRAETORIAN-XL Trial

ORIGINAL RESEARCH

Annals of Internal Medicine

Perioperative Safety and Early Patient and Device Outcomes Among Subcutaneous Versus Transvenous Implantable Cardioverter Defibrillator Implantations

A Randomized, Multicenter Trial

2009

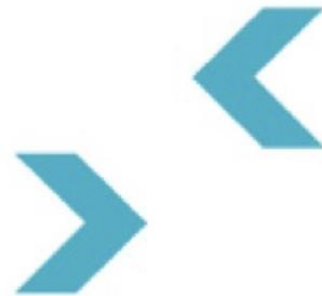
Introduction of
the S-ICD

Int
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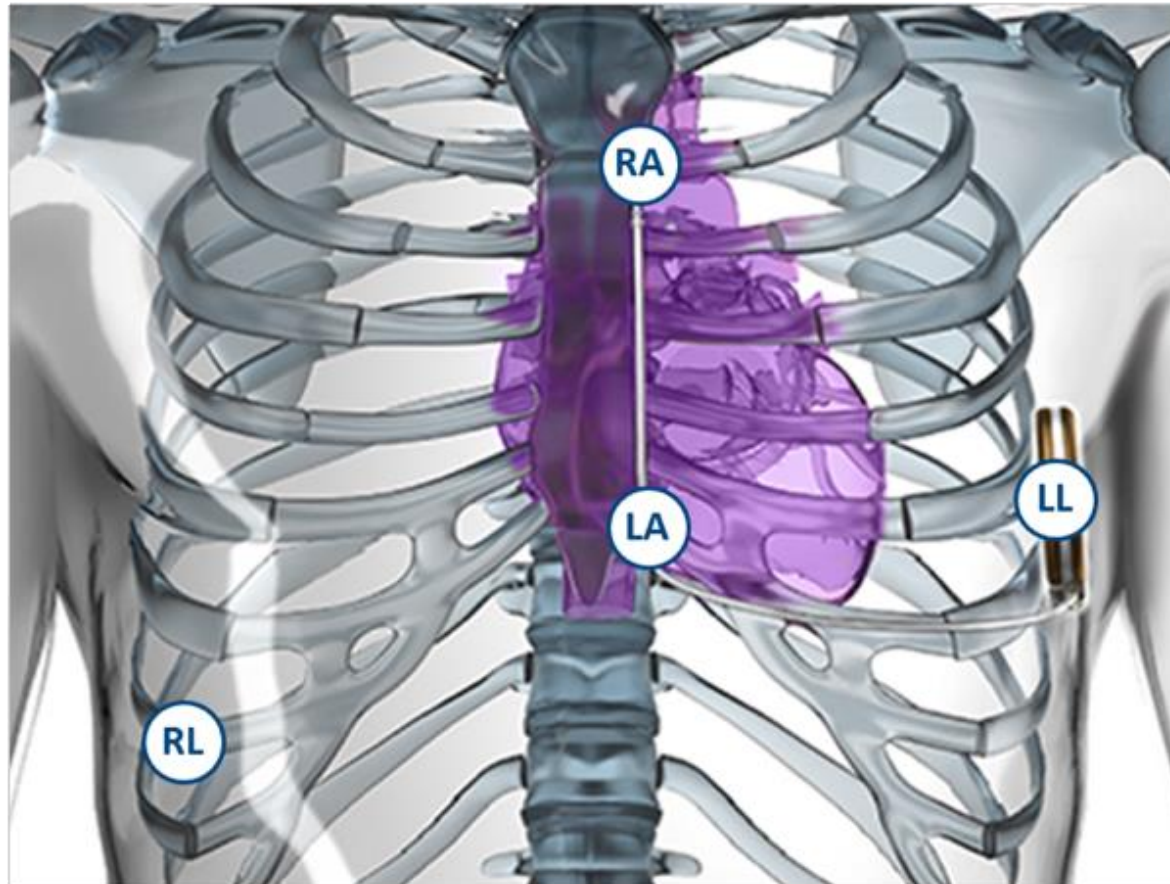
- **Erbjuder endast chock**
- **Ingen ATP eller Pacing**
- **Screening**



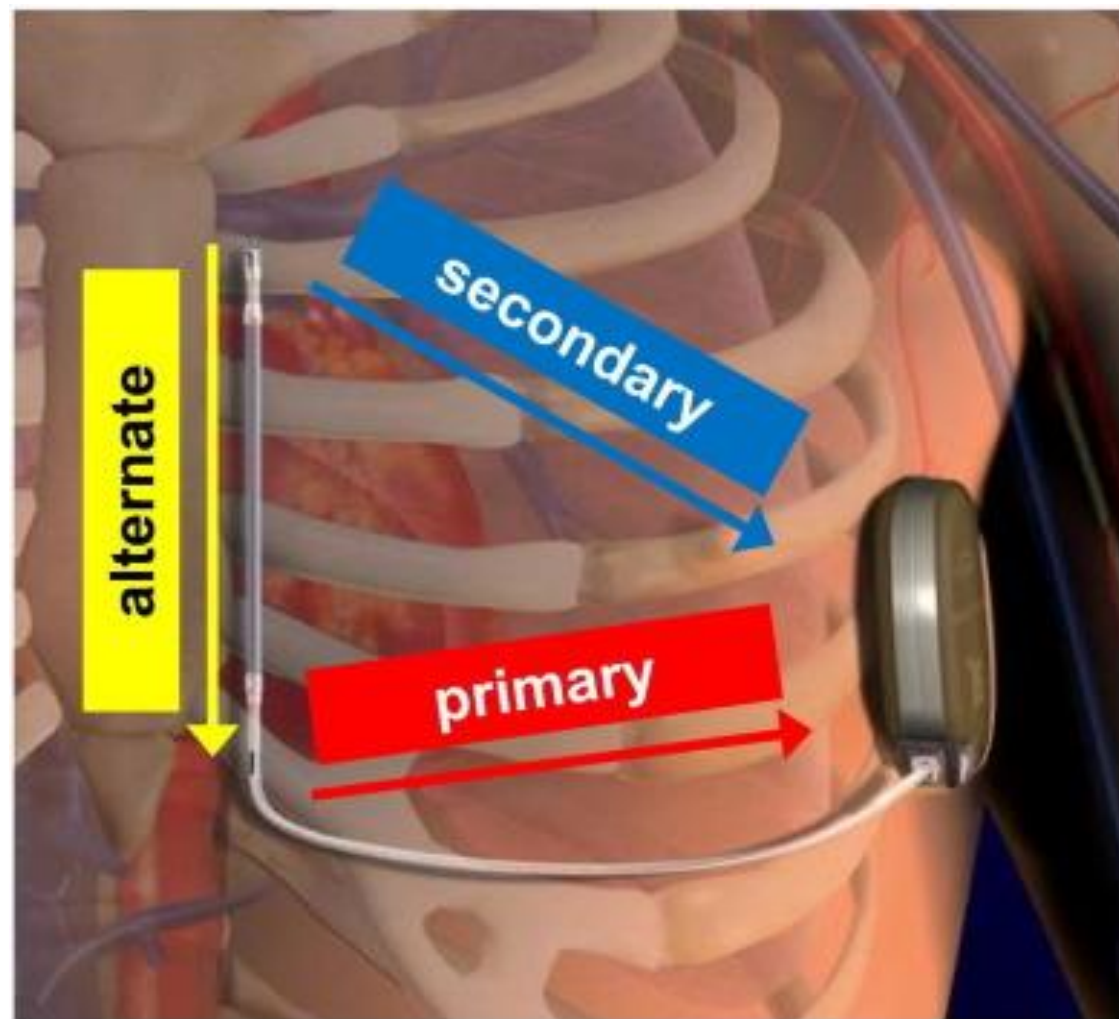
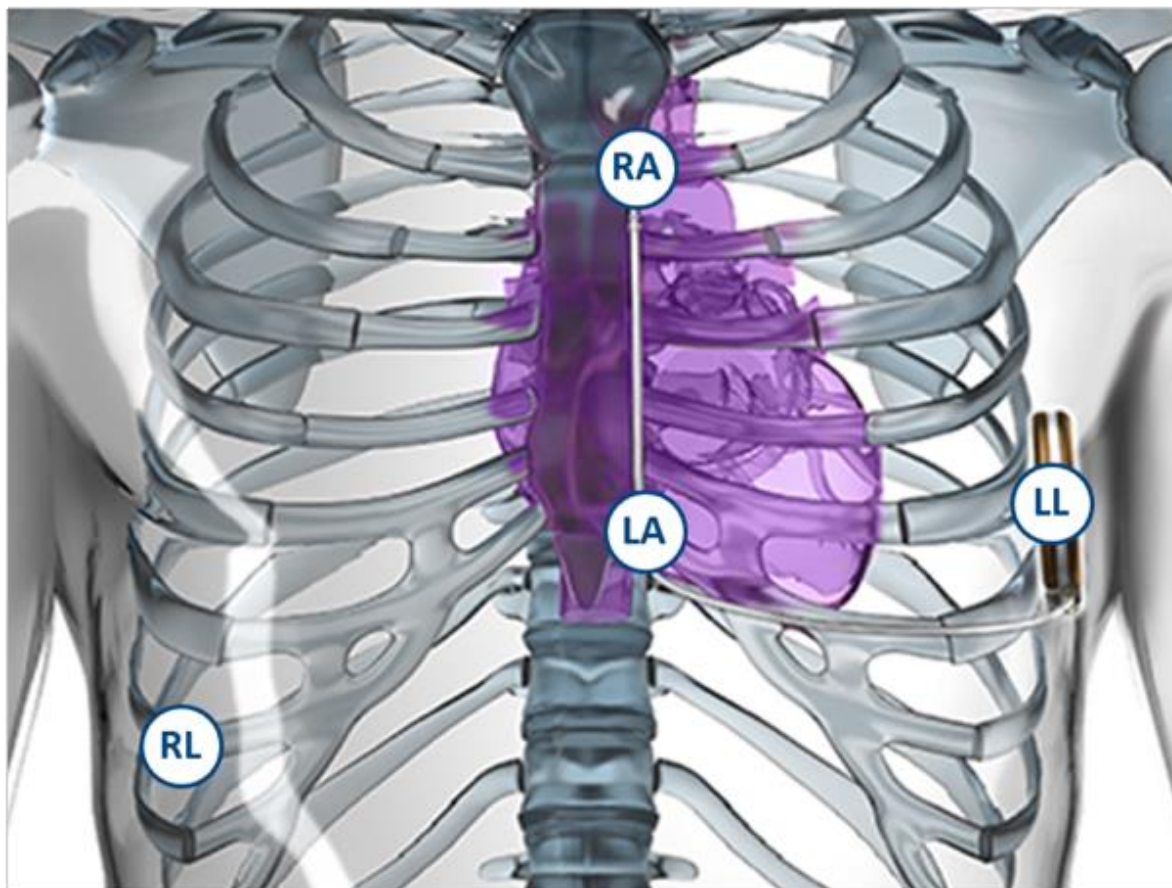
S-ICD screening



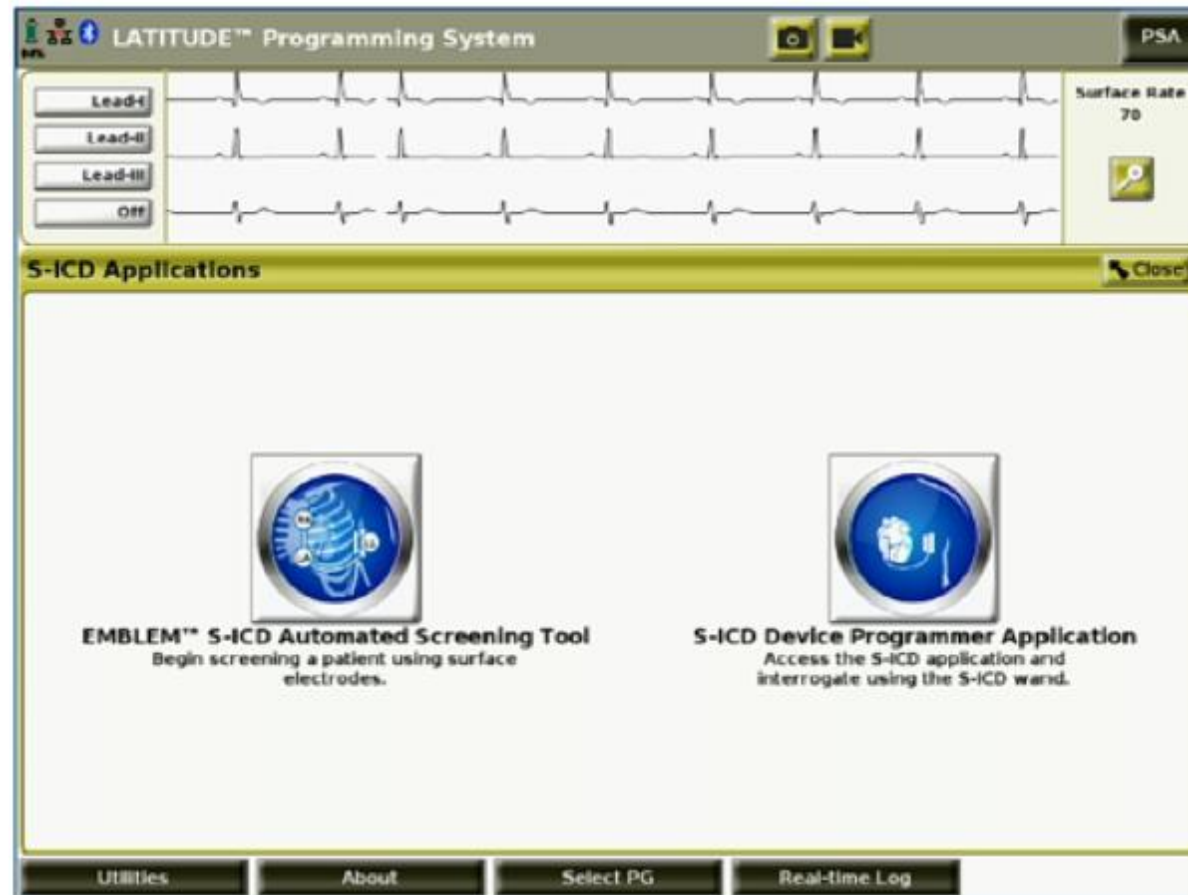
Step 1



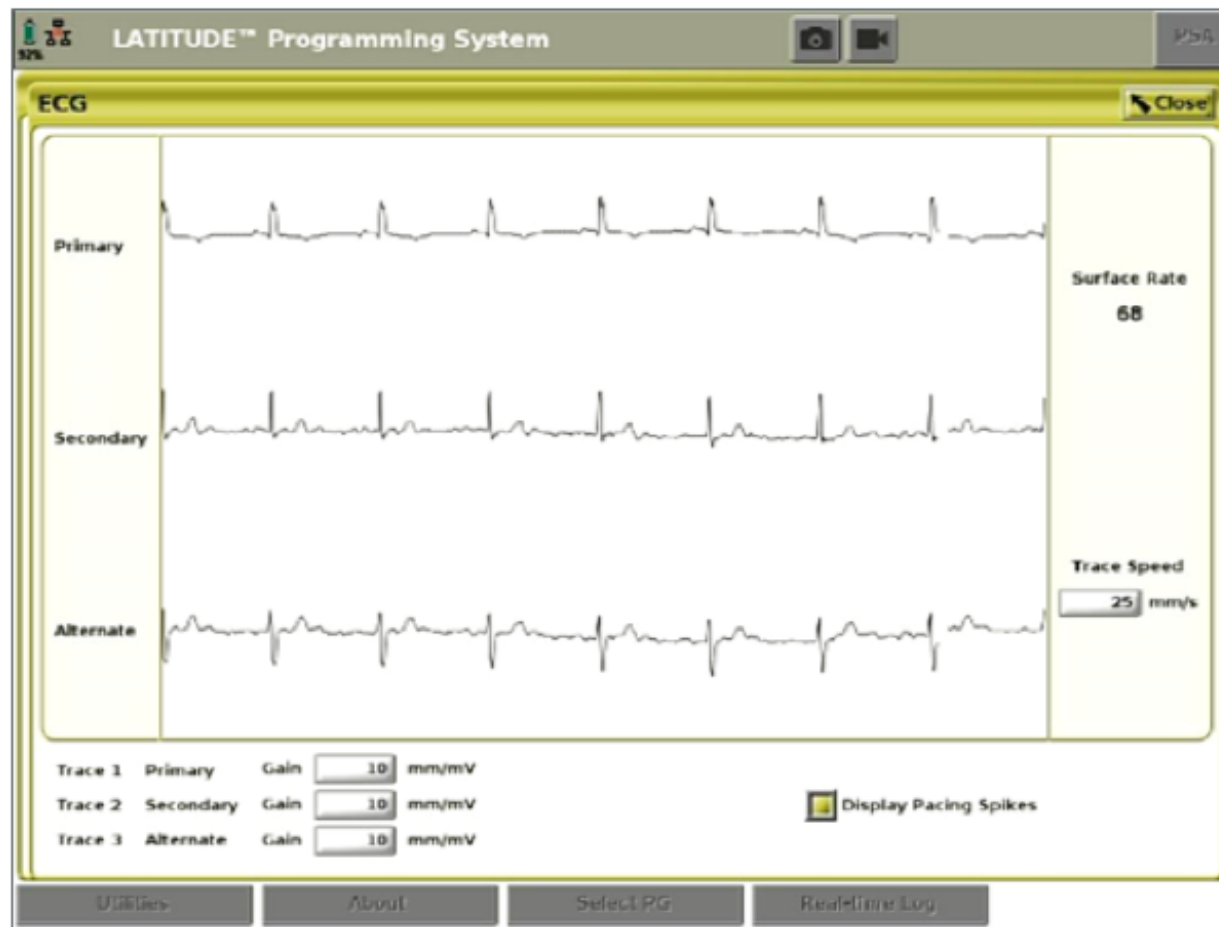
Step 1



Step 2



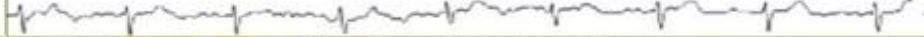
Step 3



Step 4

LATITUDE™ Programming System PSA

EMBLEM™ S-ICD Automated Screening Tool

Primary 
Secondary 
Alternate 

Surface Rate **69** 

Information **Screening** **About** **Instructions**



- Place Leads.
- Run tests with the patient both supine and standing/sitting.
- Consider also testing at elevated heart rate for active patients.
- Minimum screening criteria: One lead must be OK in all tested postures.

Sternal Lead Position
Left Sternal Margin

  **Choose** **Choose** **Choose** **Choose**

Supine Standing /Sitting Optional Posture Optional Posture Optional Posture Optional Posture

Primary	OK	OK				
Secondary	OK	FAIL				
Alternate	FAIL	FAIL				
Notes						

 See the posture detail view for possible failure reasons.

 Save Report  Print Report  Add Filtered Electrograms to Report **End Screening Session**

Utilities **About** **Select ICG** **Realtime Log**

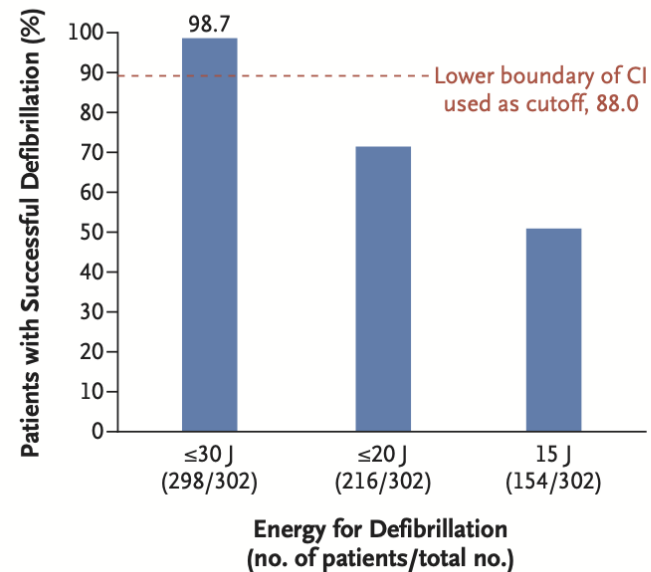
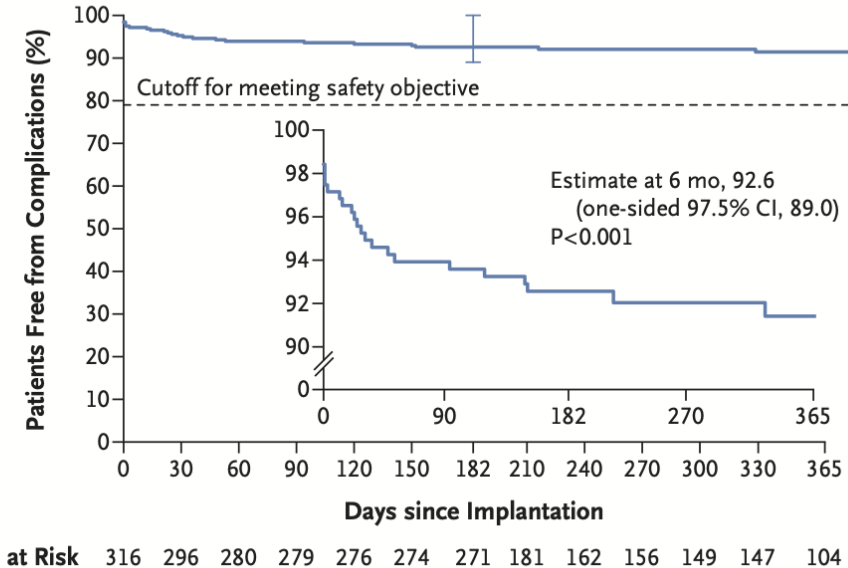
2023

Introduction of
the EV-ICD

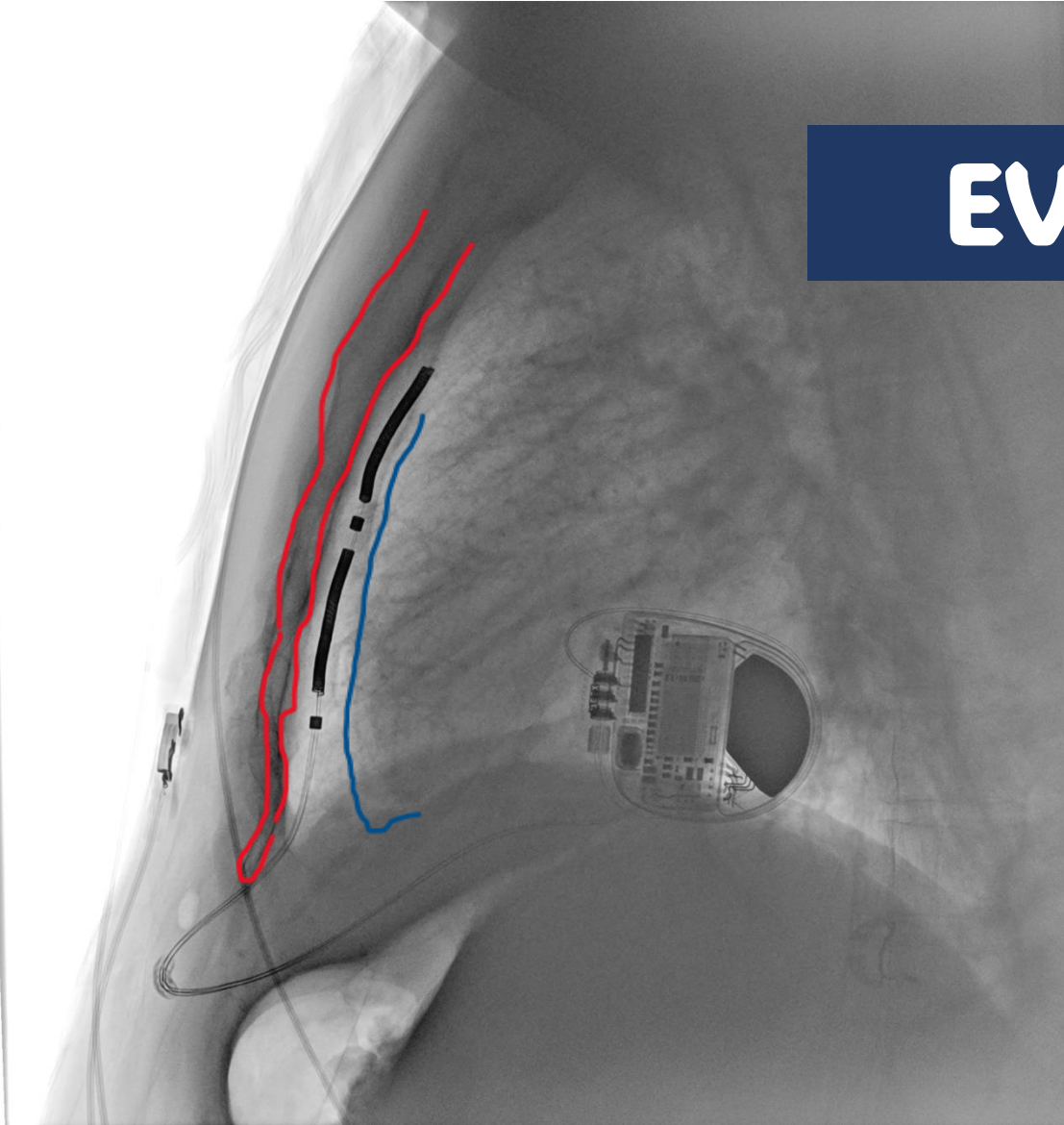
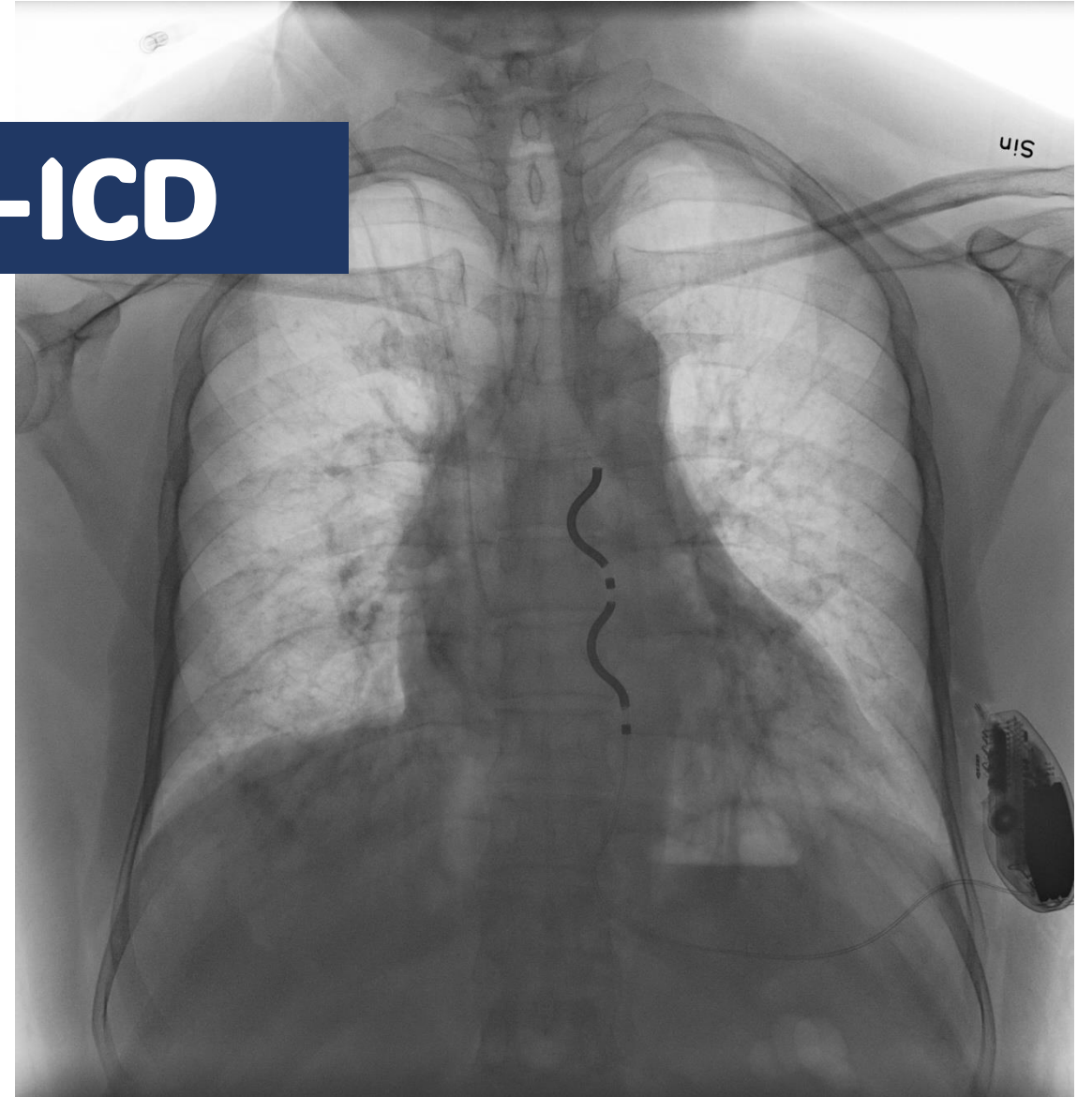
ORIGINAL ARTICLE

Efficacy and Safety of an Extravascular Implantable Cardioverter–Defibrillator

P. Friedman, F. Murgatroyd, L.V.A. Boersma, J. Manlucu, D. O'Donnell, B.P. Knight, N. Clémenty, C. Leclercq, A. Amin, B.P. Merkely, U.M. Birgersdotter-Green, J.Y.S. Chan, M. Biffi, R.E. Knops, G. Engel, I. Muñoz Carvajal, L.M. Epstein, V. Sagi, J.B. Johansen, M. Sterliński, C. Steinwender, T. Hounshell, R. Abben, A.E. Thompson, C. Wiggenhorn, S. Willey, and I. Crozier, for the Extravascular ICD Pivotal Study Investigators

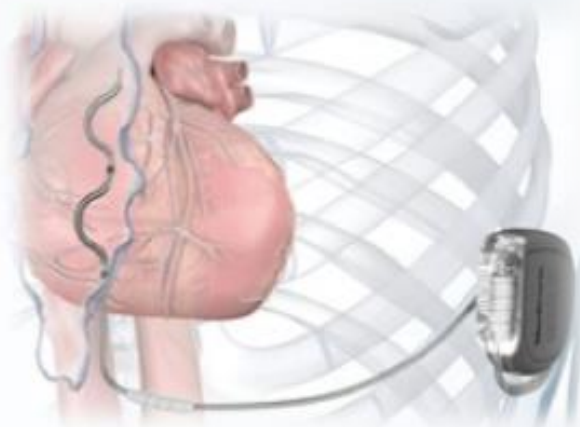
**A Defibrillation Efficacy at Implantation****B Freedom from Major System- or Procedure-Related Complications**

EV-ICD



2023

Introduction of
the EV-ICD

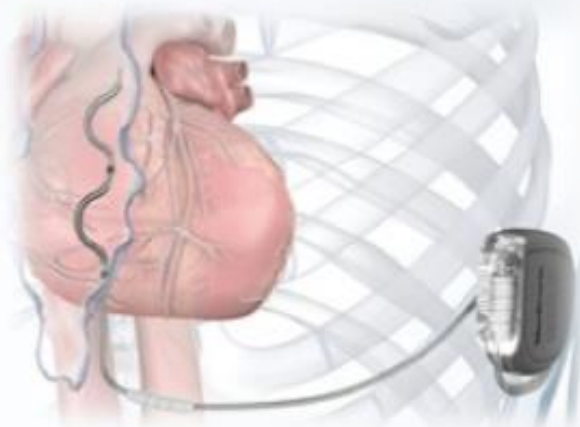


EV-ICD erbjuder:

- **ATP**
- **Pausprevention**
- **Bättre batterilivslängd än S-ICD**
- **Bättre diagnostik**
- **Inget behov av screening**

2023

Introduction of
the EV-ICD



EV-ICD erbjuder:

- ATP
- Pausprevention
- Bättre batterilivslängd än S-ICD
- Bättre diagnostik
- Inget behov av screening

Däremot:

- Inga RCT
- Tidigare sternotomi är en kontraindikation

Guidelines

Guidelines

Recommendations	Class ^a	Level ^b
Subcutaneous defibrillator should be considered as an alternative to transvenous defibrillator in patients with an indication for an ICD when pacing therapy for bradycardia, cardiac resynchronization, or ATP is not needed. ³⁶⁶	Ila	B

Consensus - USA

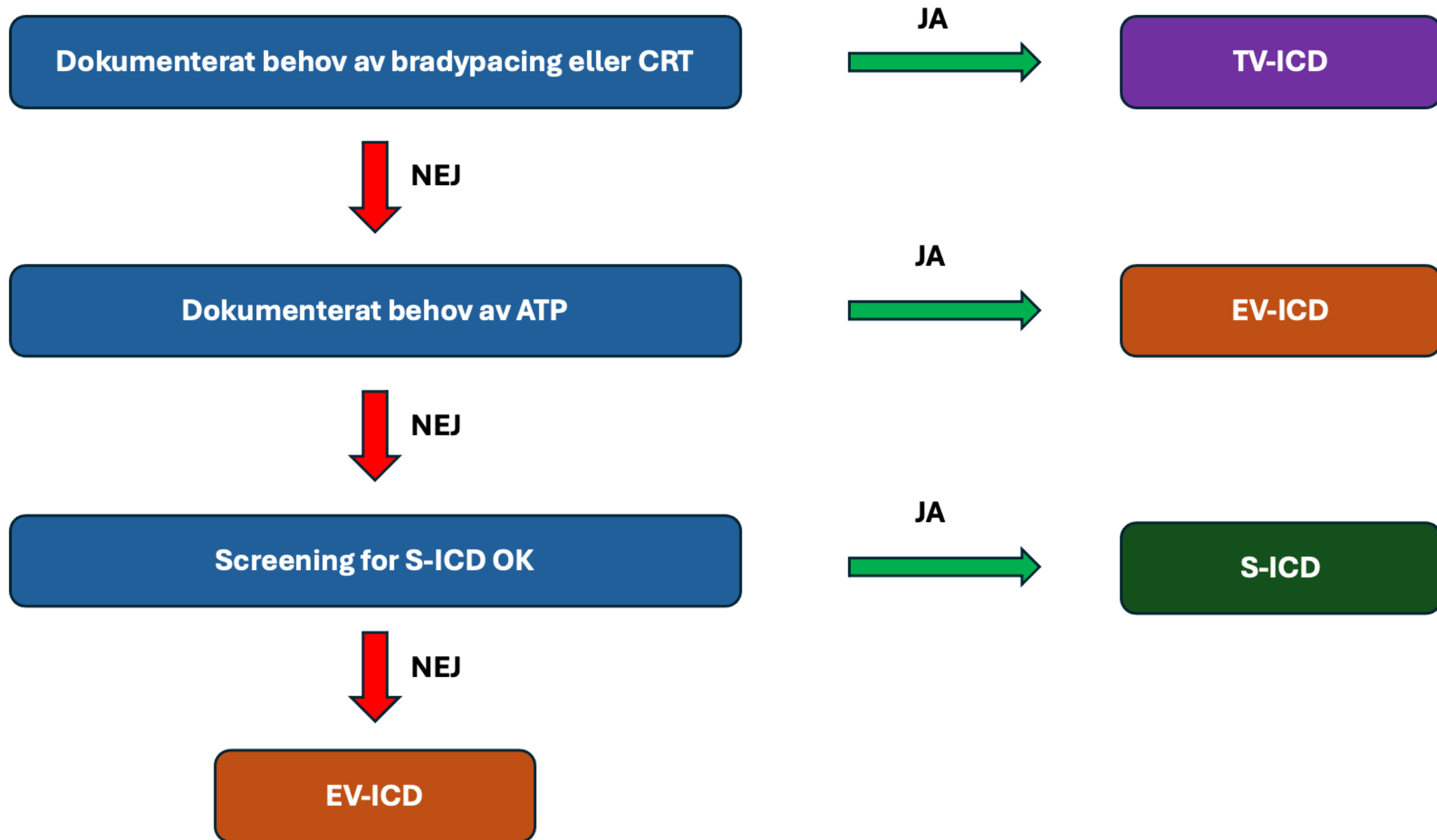
Recommendations for nonvascular ICD therapies

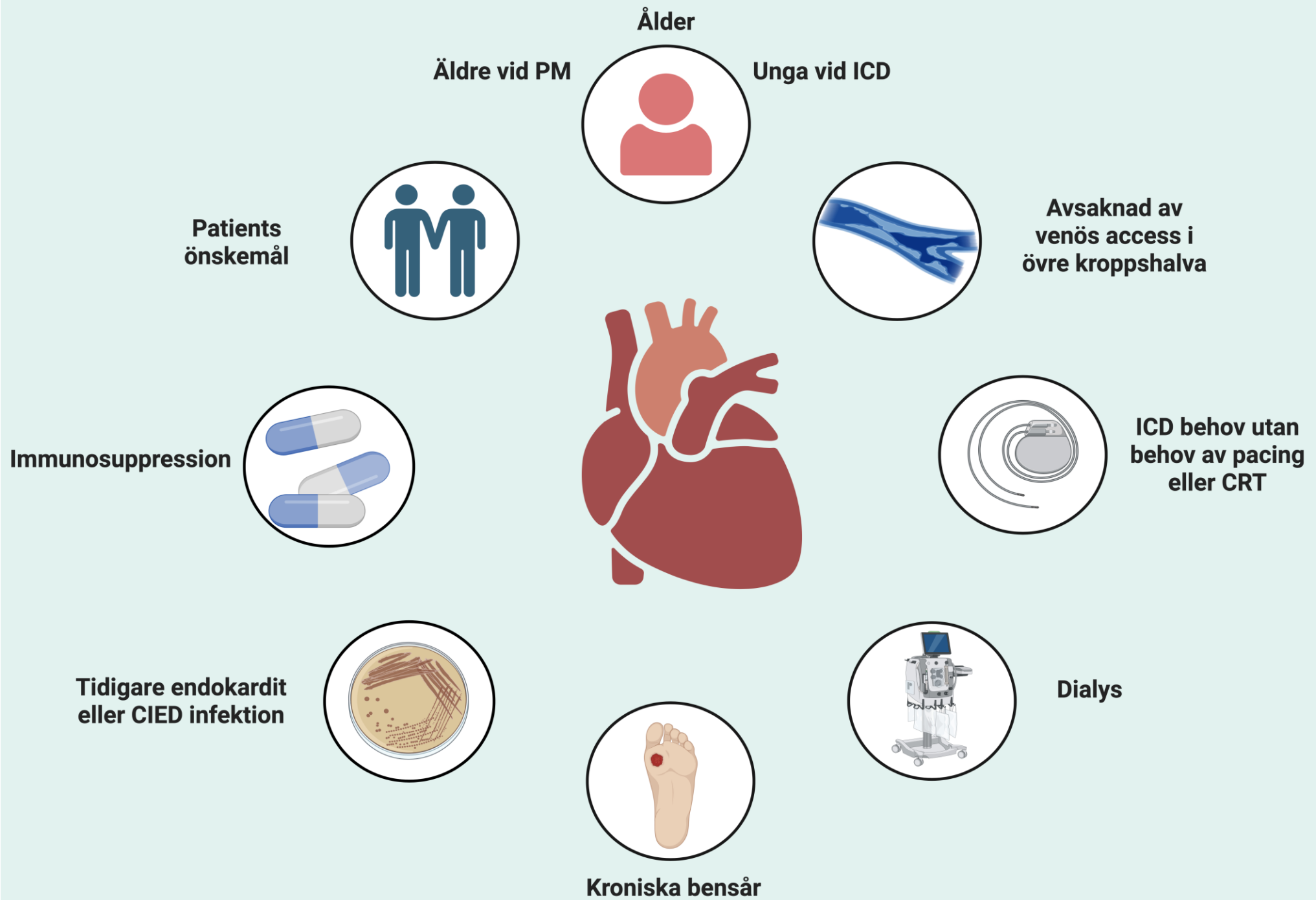
COR	LOE	Recommendations
1	C-EO	1. In patients who meet indications for primary or secondary prevention ICD therapy and without an indication for bradycardia pacing or cardiac resynchronization therapy (CRT), shared decision making is recommended to choose the type of ICD (transvenous vs nonvascular) based on a patient-centered approach.
1	B-R	2. In patients who meet indications for primary or secondary prevention ICD therapy and without an indication for bradycardia pacing or CRT, who have inadequate vascular access, a mechanical tricuspid valve, high risk of infection, or a history of CIED infection, an S-ICD is recommended. ¹⁵⁻¹⁸
2a	C-LD	3. In patients who meet indications for primary or secondary prevention ICD therapy and without an indication for bradycardia pacing or CRT or a history of sternotomy, who have inadequate vascular access, high risk of infection, or a history of CIED infection, an EV-ICD is reasonable. ¹⁹⁻²²
1	B-NR	4. In patients who meet indications for primary or secondary prevention ICD therapy, and without an indication for bradycardia pacing and CRT, where avoiding a transvenous lead might be beneficial (eg, younger patients), an S-ICD is recommended. ^{23,24}
2a	C-LD	5. In patients who meet indications for primary or secondary prevention ICD therapy, and without an indication for bradycardia pacing and CRT or a history of sternotomy, where avoiding a transvenous lead might be beneficial (eg, younger patients), an EV-ICD is reasonable. ^{19,23}



Förslag för val av ICD:

- Nyimplantationer
 - Elektrodrevision*
 - Efter extraktion för infektion**
-





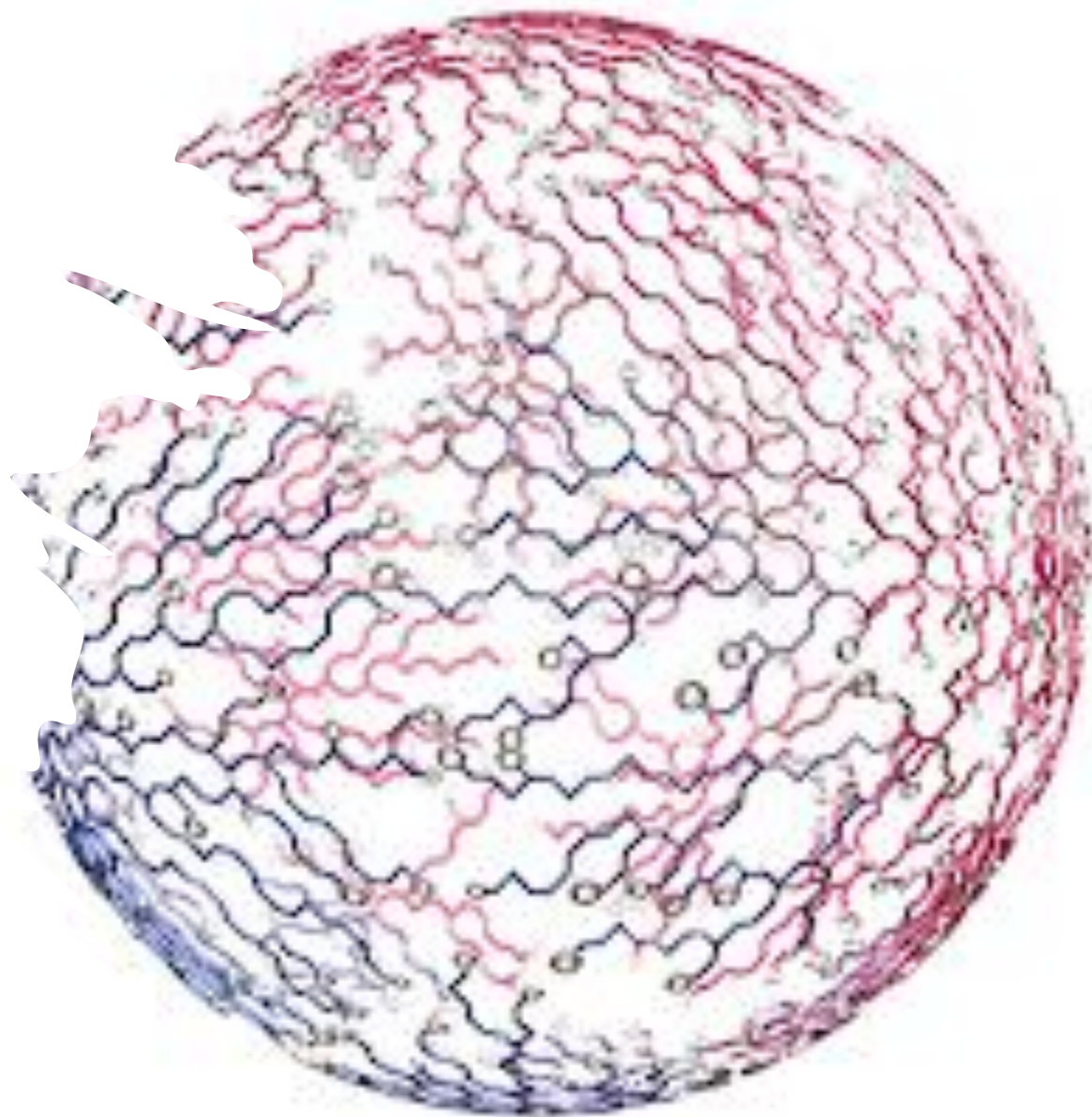
Patientfall 1

- 61 år, man
- HTN
- Känd bicuspid aortaklaff med kombinerat vitium
- 6 månader tidigare och i väntan på operation: Endokardit med aortarotabcess-> mekanisk komposit graft
- Nu inkommit med hjärtstillestånd. Deff VF x 10 till ROSC
- EKO med fungerande protes, EF 55-65%
- EKG sinus rytm, normal PQ-tid, smala QRS

Patientfall 2

- 90 år, man
- DDD sedan 2010 pga Takybrady. Nu permanent FF med totalblock (Paceberoende).
- Dosbyte 2020
- Dosfickeinfektion 2025 -> Extraktion
- Typ av device:

Tack för
uppmärksamheten

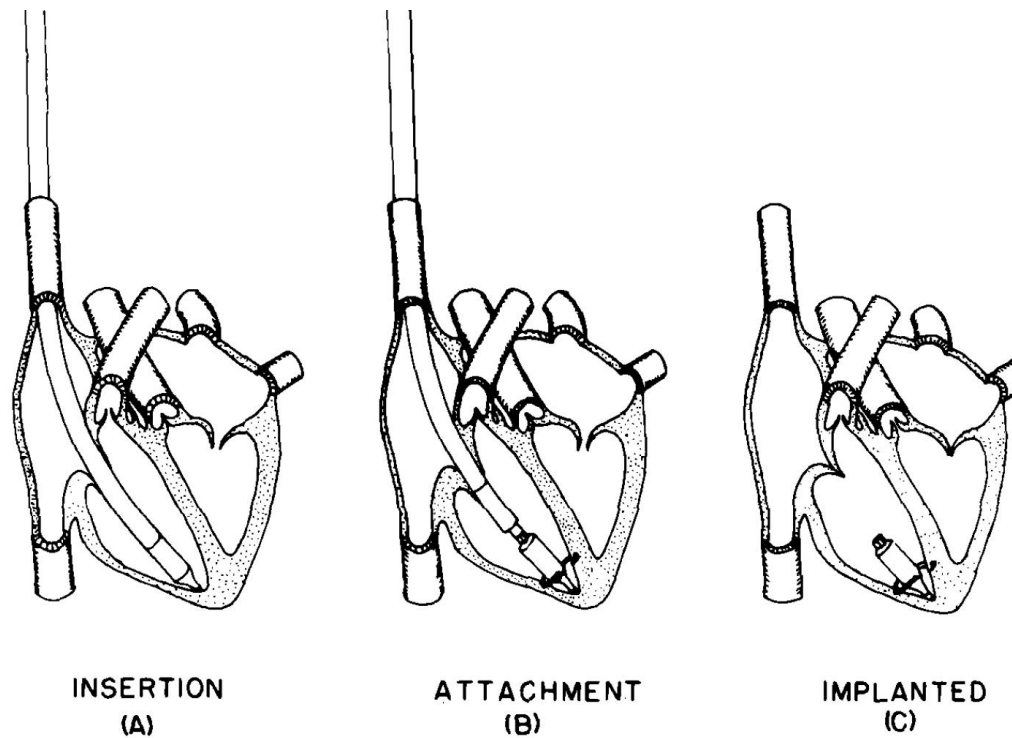


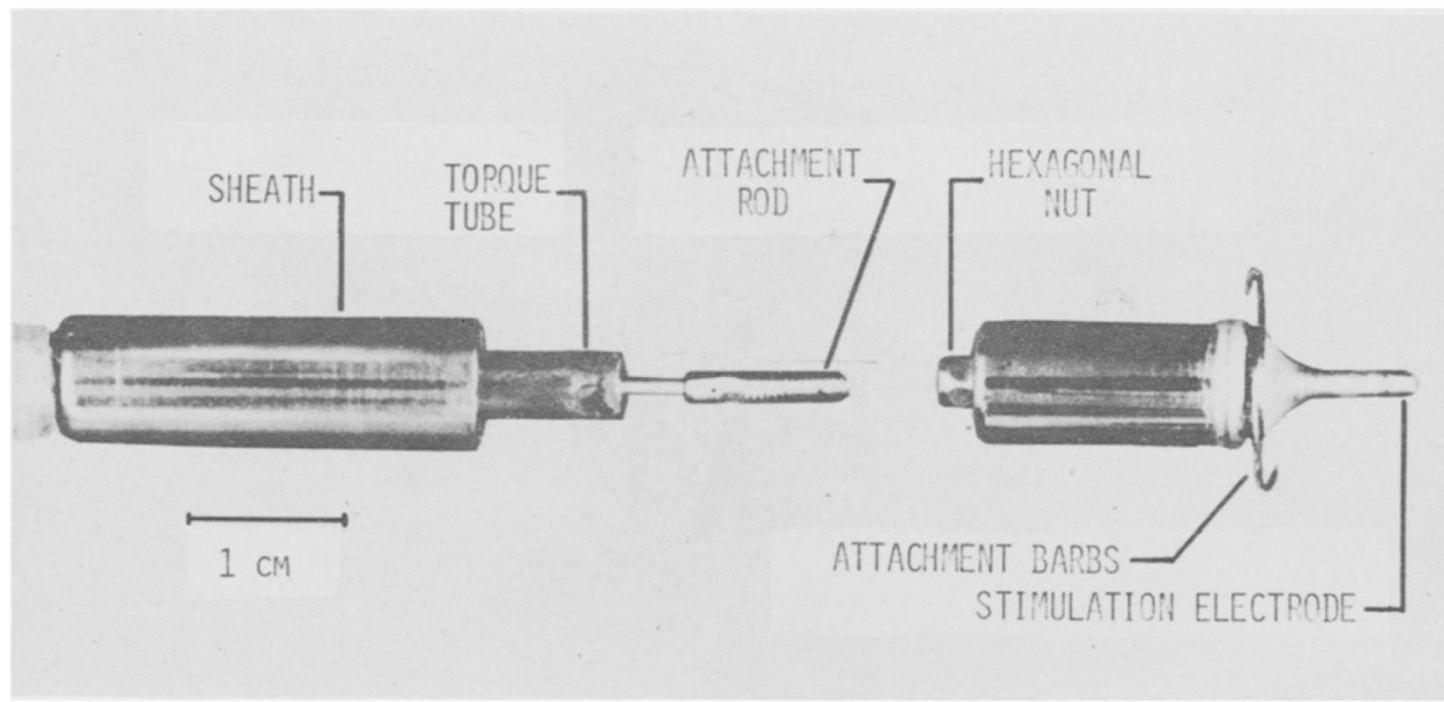
Extra material

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.







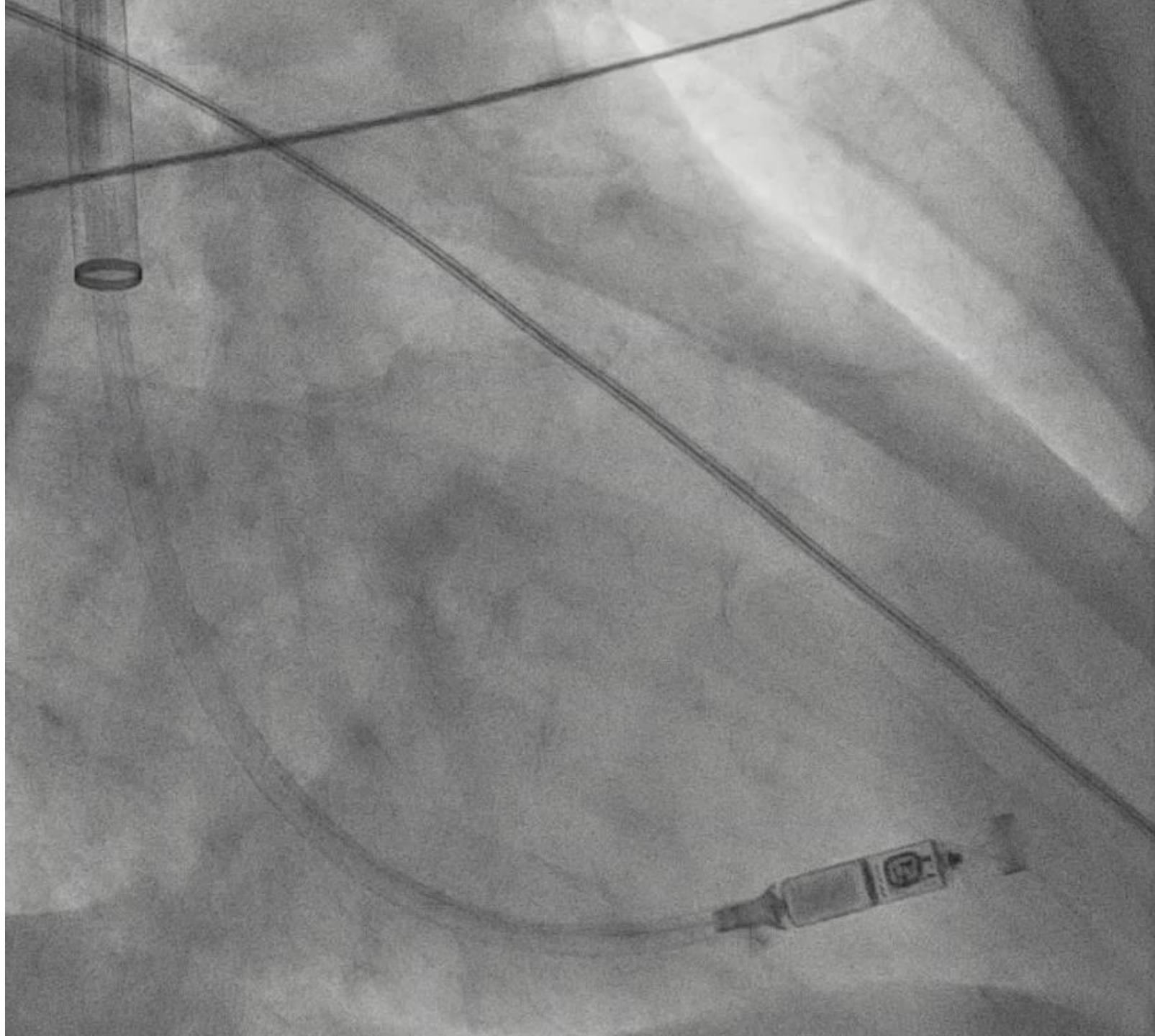
MICRA



AVEIR VR



AVEIR AR



Aidentifiziert namn
Pacemaker 3,75 b/s 3,75 b/s
Serie 6
Bild 1 / 27
2020-09-15, 13:51

SID 101 cm
FD 30 cm
LAO 32°
CRAN 1°

Medtronic - MICRA

Complications at 6 months

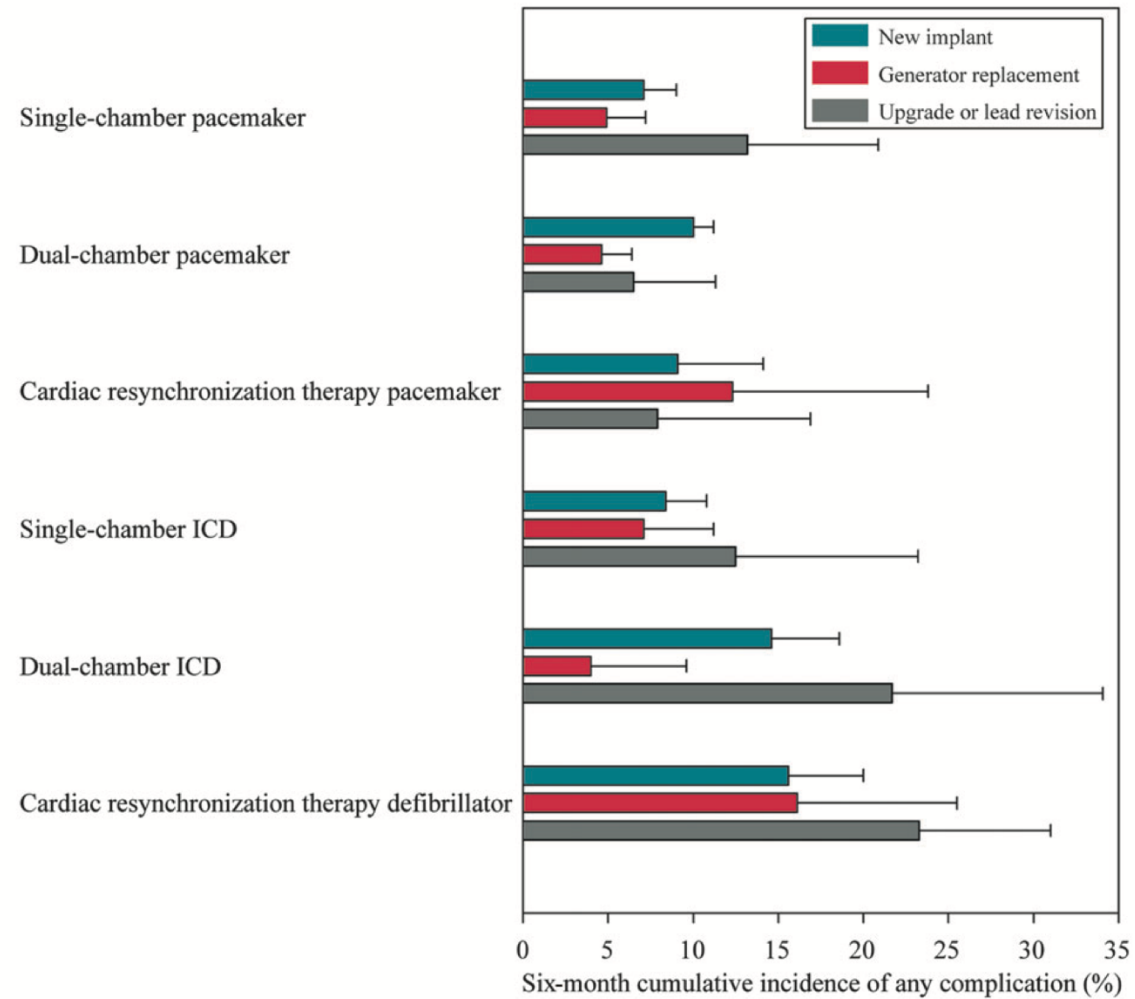


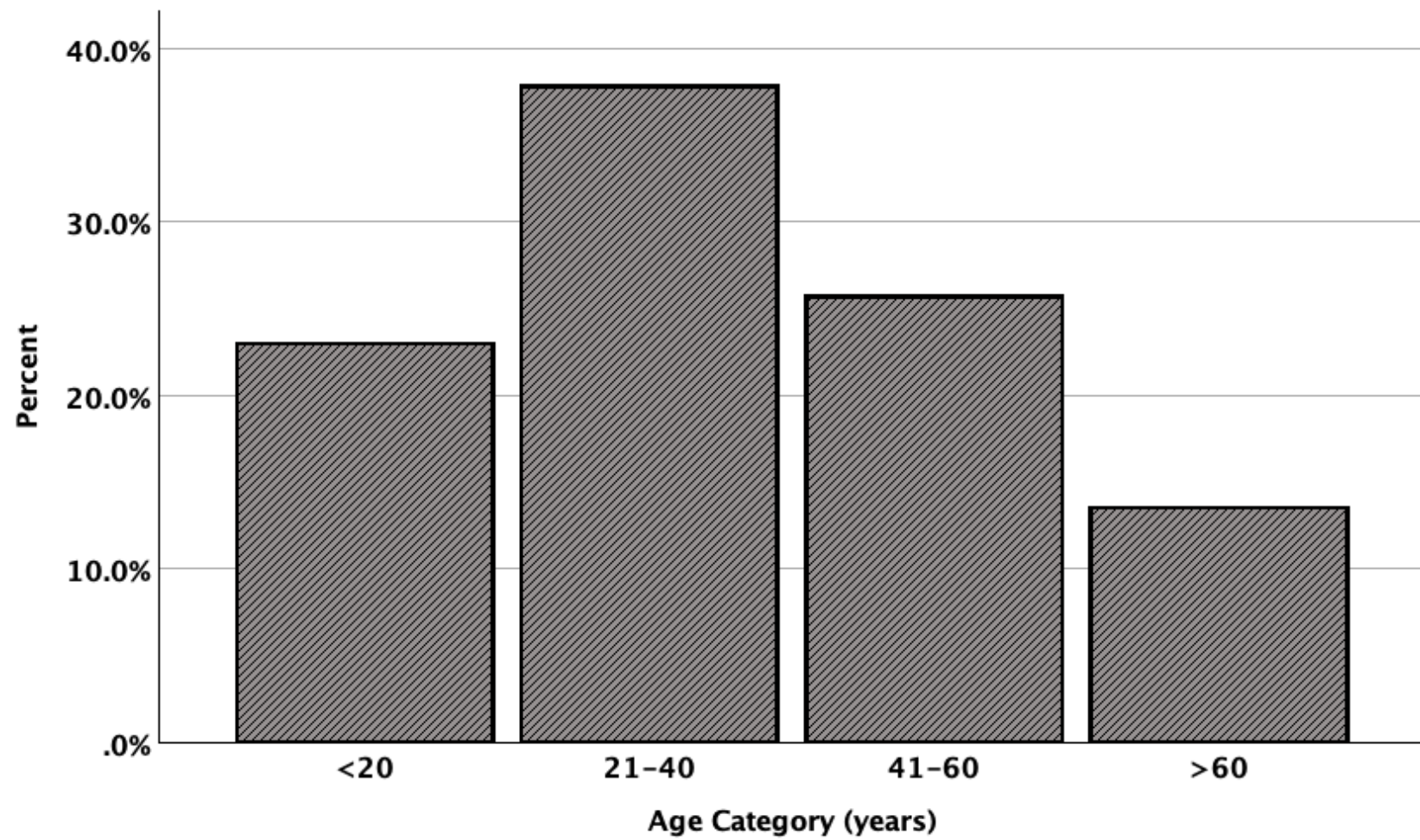
Figure 1 Risk of any complication according to procedure and CIED type (with 95% CI).

Guidelines - USA

COR	LOE	RECOMMENDATIONS
I	B-NR	1. In patients who meet criteria for an ICD who have <u>inadequate vascular access or are at high risk for infection</u> , and in whom pacing for bradycardia or VT termination or as part of CRT is neither needed nor anticipated, a subcutaneous implantable cardioverter-defibrillator is recommended (S11.1-1–S11.1-5).
IIa	B-NR	2. In patients who meet indication for an ICD, implantation of a subcutaneous implantable cardioverter-defibrillator is reasonable if pacing for bradycardia or VT termination or as part of CRT is neither needed nor anticipated (S11.1-1–S11.1-4).
III: Harm	B-NR	3. In patients with an indication for bradycardia pacing or CRT, or for whom antitachycardia pacing for VT termination is required, a subcutaneous implantable cardioverter-defibrillator should not be implanted (S11.1-1–S11.1-4,S11.1-6–S11.1-8).

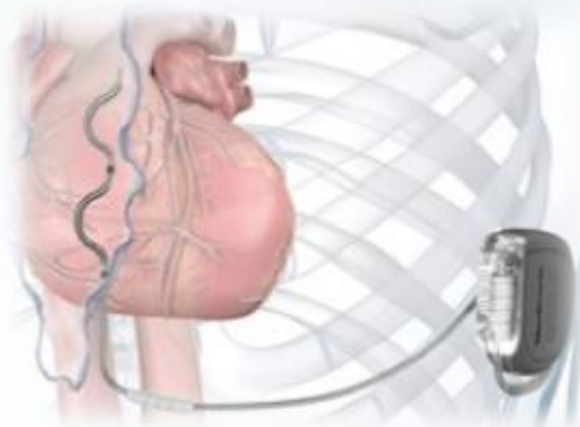
	Transvenous ICD ^a	Subcutaneous ICD ^b	Extravascular ICD ^c
Lead location	Endovascular/endocardial	Parasternal (subcutaneous)	Anterior mediastinum (substernal)
Potential for cardiac injury/ perforation	Present	Absent	Present
ICD generator location	Pectoral	Left midaxillary region	Left midaxillary region
Maximum delivered energy	40 J	80 J	40 J
ATP	Available	Not available	Available
Chronic pacing therapy	Available as chronic pacing therapy	Not available	Available as short-duration pause prevention pacing
Postshock pacing	Available	Available	Available
Generator volume	33 cc	60 cc	33 cc
Generator mass	79 g	130 g	77 g

Thompson et al, J Cardiovasc Electrophysiol. 2022



2023

Introduction of
the EV-ICD



ESC

European Society
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EHRA DOCUMENT



EHRA

European Heart
Rhythm Association

Cardiac implantable electronic device upgrades and downgrades: a *Clinical Consensus Statement* of the European Heart Rhythm Association (EHRA) of the ESC, the Asia Pacific Heart Rhythm Association (APHRS), Canadian Heart Rhythm Society (CHRS), Heart Rhythm Society (HRS), and the Latin American Heart Rhythm Society (LAHRS)

In summary

Non-transvenous ICDs:

- Provide safe and effective therapy for ventricular arrhythmias
- Offer promising long-term durability (particularly for S-ICDs)
- Eliminate complications associated with transvenous lead placement
 - altering the risk/benefit ratio