Hong Kong Core Cardiology Certificate Course (Module 2)
Cardiac Arrhythmia Management in Daily Practice

Pacemaker: What a Cardiology Fellow must know?

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14:45-15:10 (25 min)
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"We provide cure"

MIMS DOCTOR

Pacemaker: What a Cardiology Fellow must know?

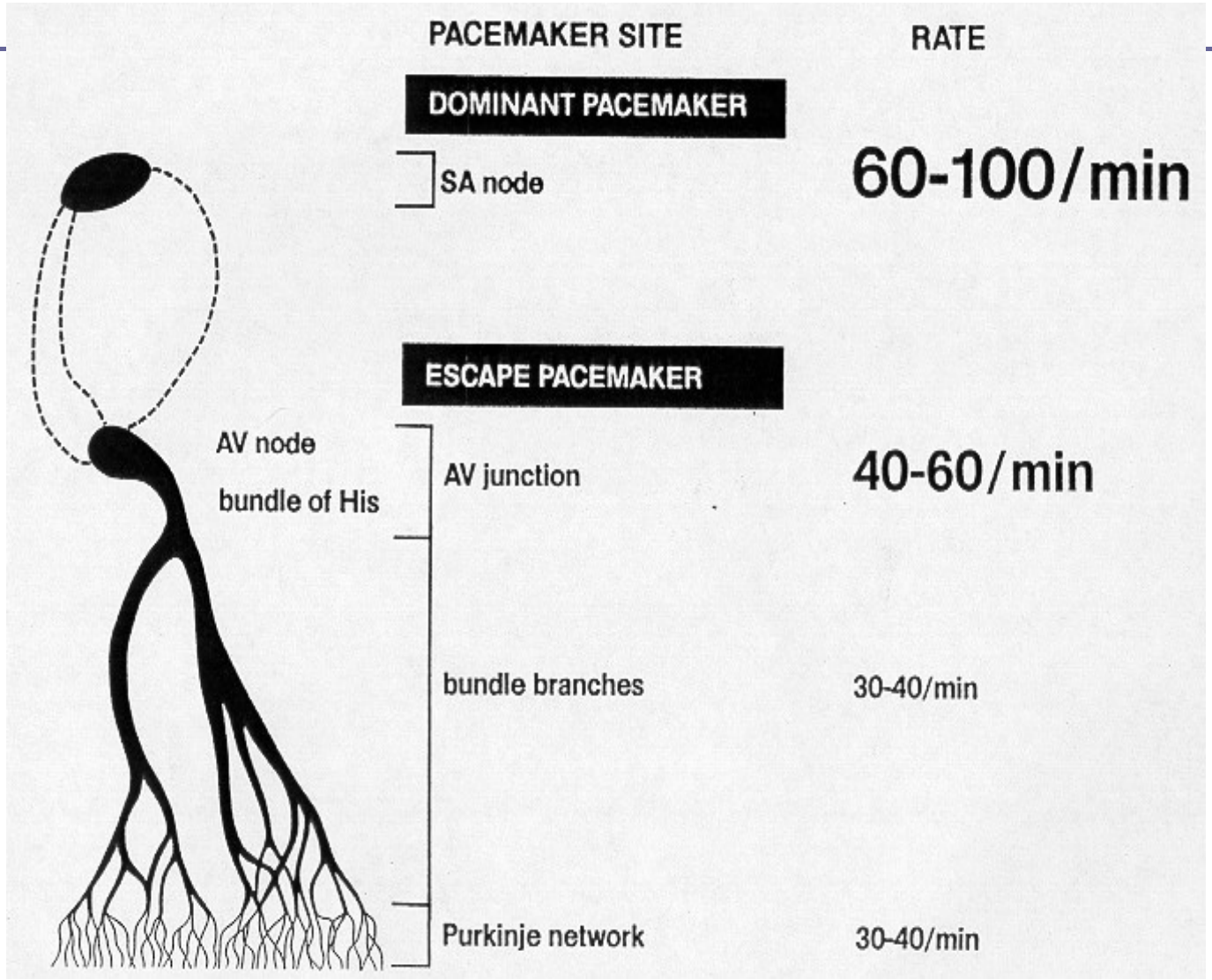
1. Bradyarrhythmias
2. Pacing concepts
3. Pacemaker and Lead technology
4. Types of pacemaker - Transvenous, Leadless, Permanent, Temporary
5. Pacemaker indications
6. Implantation technique and complication management
7. Pacemaker programming
8. Pacemaker follow-up and trouble-shooting
9. Future development


“耳邊蜂”

Pacemaker: What a Cardiology Fellow must know?

1. Bradyarrhythmias
2. Pacemaker Indications
   - 2013 ESC guidelines on cardiac pacing and CRT-P
   - 2018 ACC/AHA/HRS guidelines on the evaluation and management of patients with bradycardia and cardiac conduction delay
3. Leadless pacemaker
4. Future development

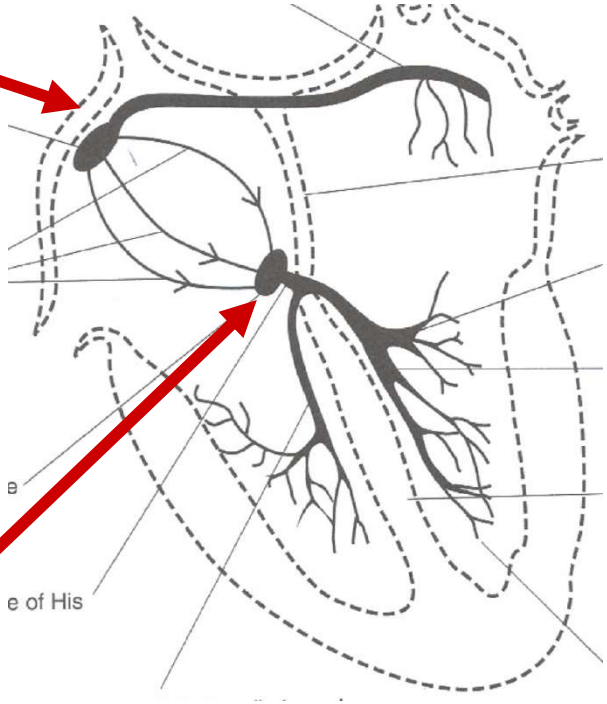
Dominant and Escape Pacemakers



Classification of Bradyarrhythmias

- There are two types of bradyarrhythmias

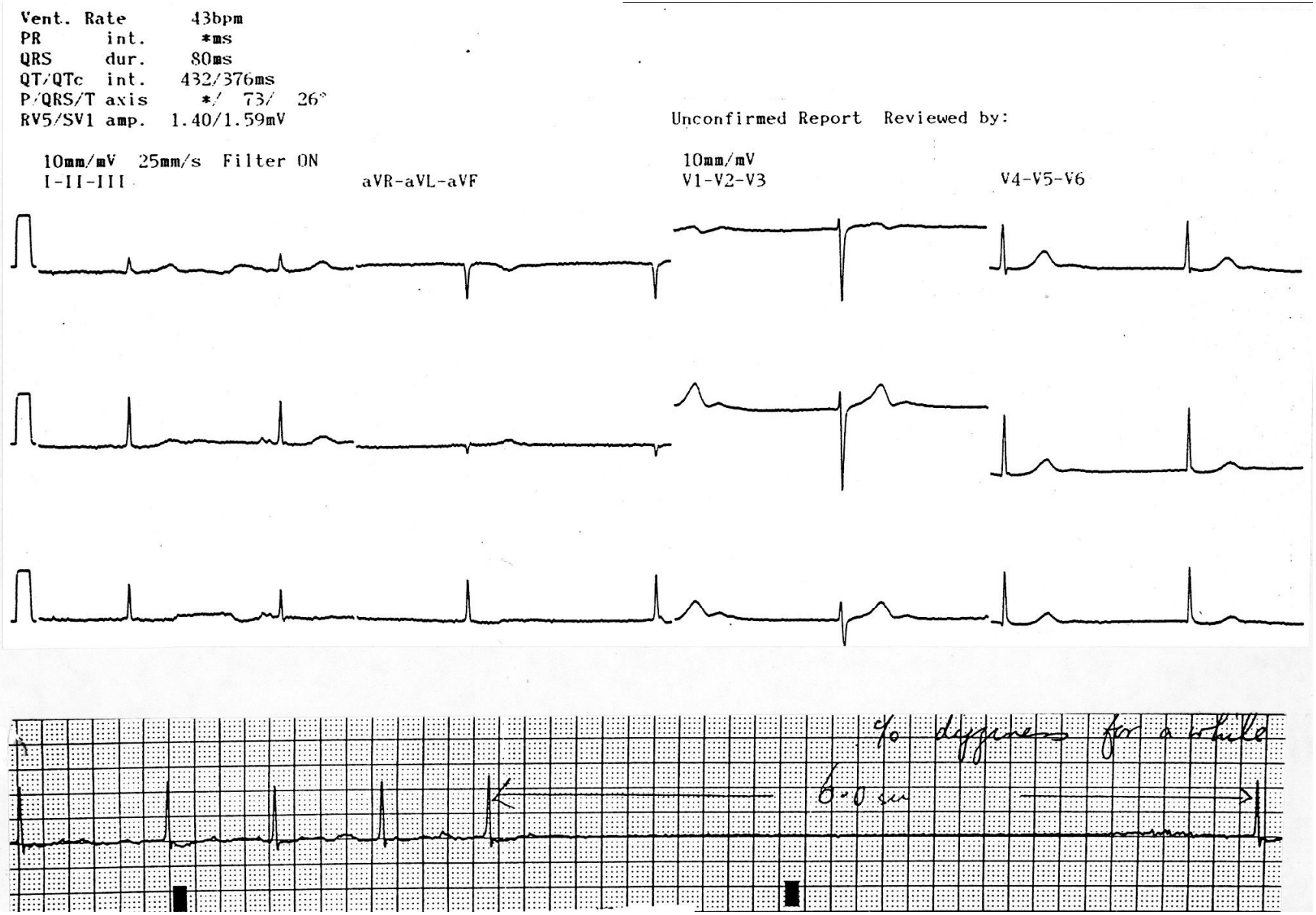
Sinus node (problem with Impulse formation)



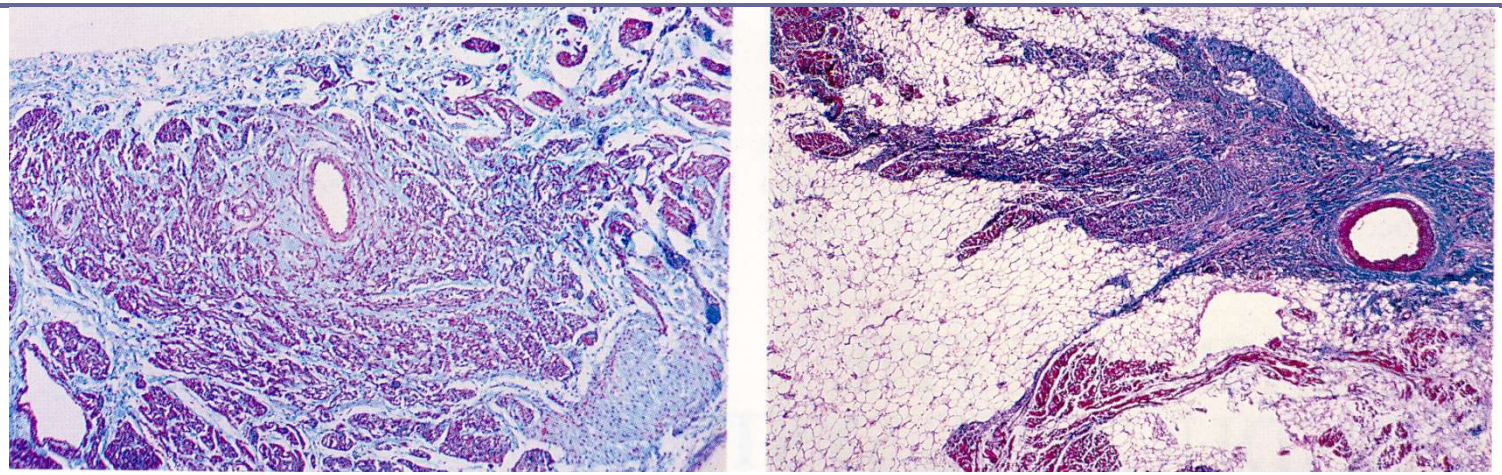
AV node (problem with Impulse conduction)

Classification of Bradyarrhythmias

- Problems with Impulse Formation (sinus node dysfunction)
  - Sinus Bradycardia
  - Sinus Node Arrest
  - Chronotropic Incompetence
  - Sick Sinus Syndrome


Vent. Rate 43bpm
PR int. *ms
QRS dur. 80ms
QT/QTc int. 432/376ms
P/QRS/T axis */ 73/ 26°
RV5/SV1 amp. 1.40/1.59mV
Unconfirmed Report Reviewed by:
10mm/mV 25mm/s Filter ON
I-II-III
aVR-aVL-aVF
10mm/mV
V1-V2-V3
V4-V5-V6
c/o dyspnea for a while
6.0 cm

Normal and Hypoplastic Sinus Node



Normal sinus node
(~15mm x 5-7mm x 1.5-2mm)

Hypoplastic sinus node in Sick sinus syndrome

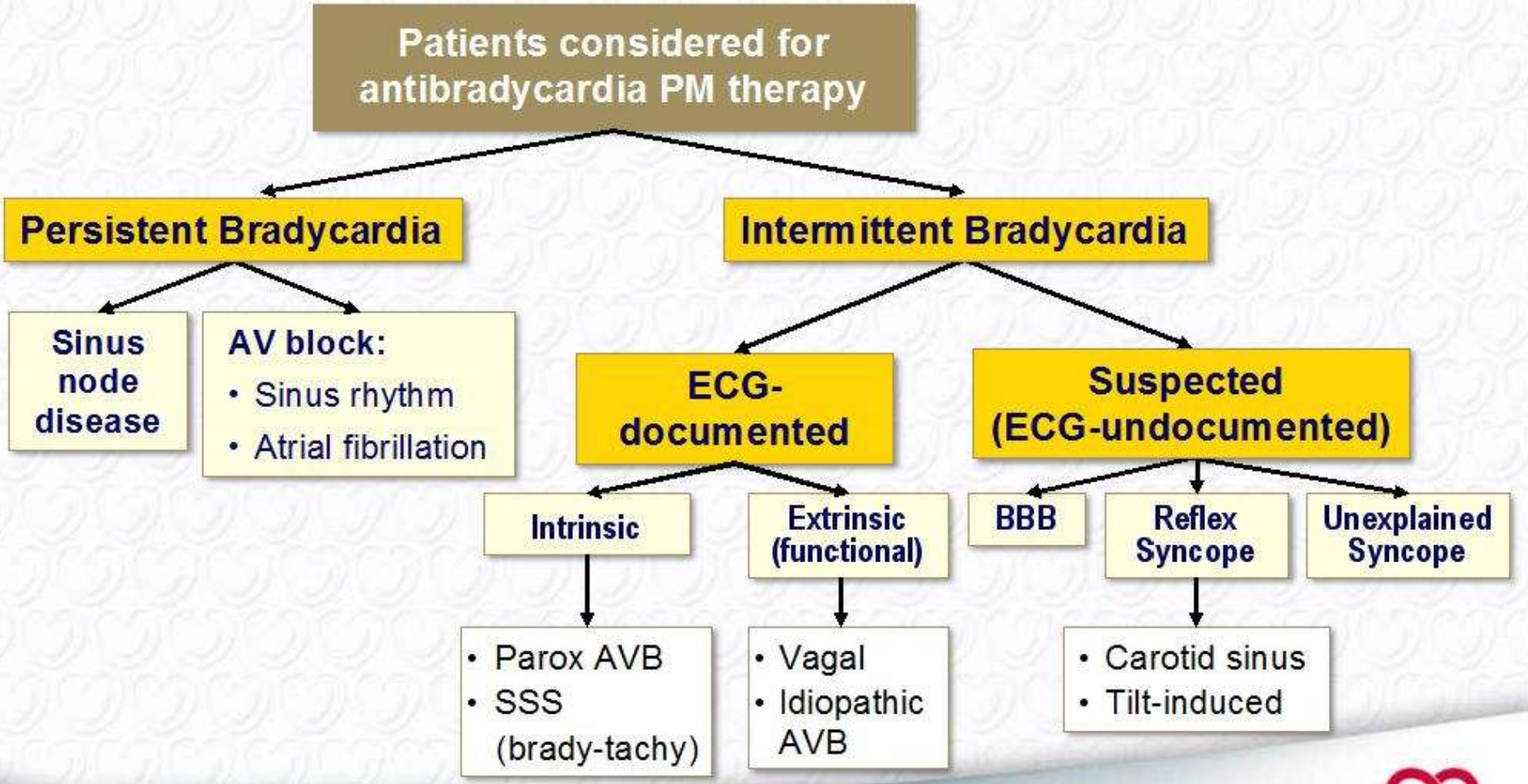
Age-dependent progressive fibrosis of the sinus nodal tissue and surrounding atrial myocardium

Classification of Bradyarrhythmias

- Problems with Impulse Conduction
  - First Degree AV block
  - Second Degree AV block
    - Mobitz Type 1 – Wenckebach
    - Mobitz Type 2
  - Advanced, high grade AV block
  - Third Degree AV block – Complete heart block
  - Bundle branch block
  - Bifasicular/Trifasicular block

International Guidelines
It depends on the interpretation …

Classification of bradyarrhythmias based on the patient's clinical presentation



www.escardio.org/guidelines

European Heart Journal 2013;34:2281-2329
Europace 2013;15:1070–1118

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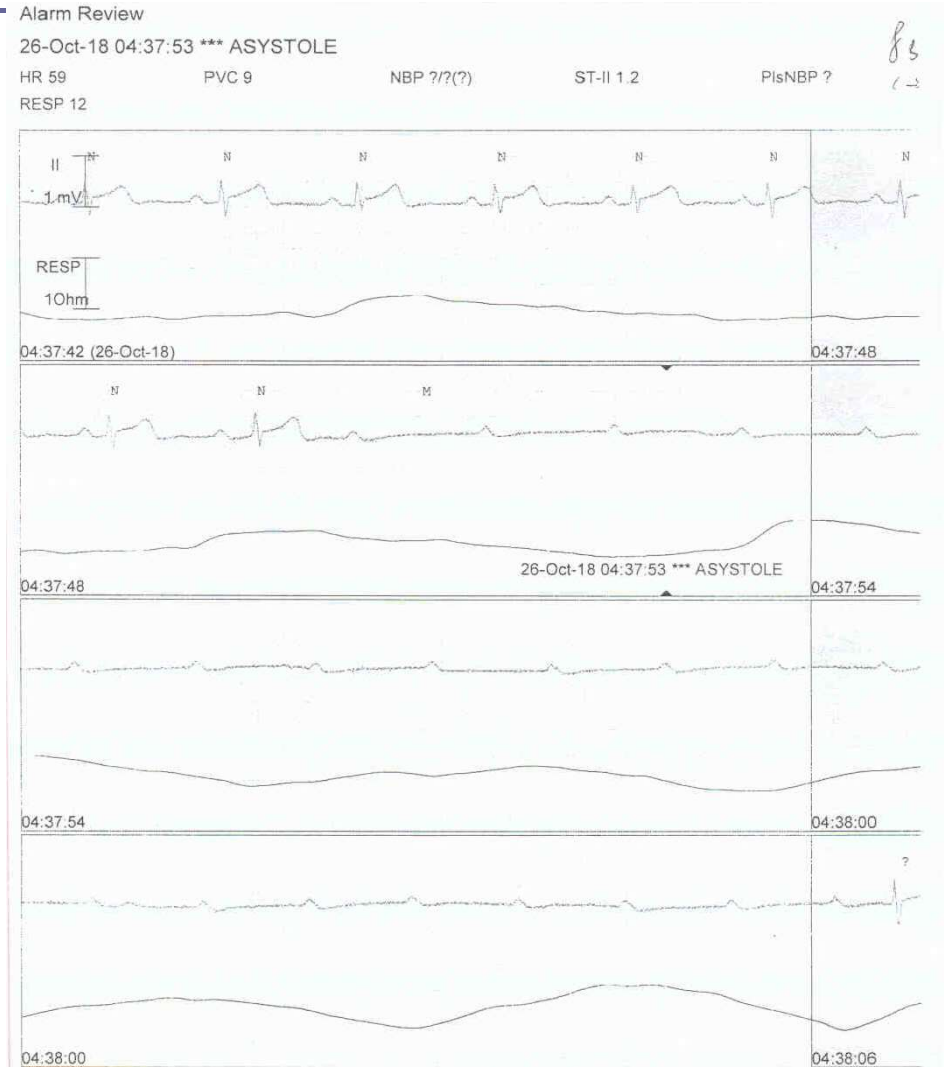
Indication for pacing in patients with persistent bradycardia

Recommendations	Class	Level
1) Sinus node disease. Pacing is indicated when symptoms can clearly be attributed to bradycardia.	I	B
2) Sinus node disease. Pacing may be indicated when symptoms are likely to be due to bradycardia, even if the evidence is not conclusive.	IIb	C
3) Sinus node disease. Pacing is not indicated in patients with sinus bradycardia which is asymptomatic or due to reversible causes.	III	C
4) Acquired AV block. Pacing is indicated in patients with third- or second-degree type 2 AV block irrespective of symptoms.	I	C
5) Acquired AV block. Pacing should be considered in patients with second-degree type 1 AV block which causes symptoms or is found to be located at intra- or infra-His levels at EPS.	IIa	C
6) Acquired AV block. Pacing is not indicated in patients with AV block which is due to reversible causes.	III	C

European Heart Journal 2013;34:2281-2329
Europace 2013;15:1070–1118

M/87, presented with syncope and transient complete heart block



2018 ACC/AHA/HRS Guideline on the evaluation and management of patients with bradycardia and cardiac conduction delay

In sinus node dysfunction, there is **no established minimum heart rate or pause duration** where permanent pacing is recommended.

Establishing temporal correlation between symptoms and bradycardia is important when determining whether permanent pacing is needed.

Indication for cardiac pacing in patients with BBB

Recommendations	Class	Level
1) BBB, unexplained,syncope and abnormal EPS. Pacing is indicated in patients with syncope, BBB and positive EPS defined as HV interval of ≥70 ms, or second- or third-degree His-Purkinje block demonstrated during incremental atrial pacing or with pharmacological challenge.	I	B
2) Alternating BBB. Pacing is indicated in patients with alternating BBB with or without symptoms.	I	C
3) BBB, unexplained syncope with non-diagnostic investigations. Pacing may be considered in selected patients with unexplained syncope and BBB.	IIb	B
4) Asymptomatic BBB. Pacing is not indicated for BBB in asymptomatic patients	III	B

www.escardio.org/guidelines

European Heart Journal 2013;34:2281-2329
Europace 2013;15:1070–1118

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Indication for cardiac pacing in patients with undocumented reflex syncope

Recommendations	Class	Level
1) Carotid sinus syncope. Pacing is indicated in patients with dominant cardioinhibitory carotid sinus syndrome and recurrent unpredictable syncope.	I	B
2) Tilt-induced cardioinhibitory syncope. Pacing may be indicated in patients with tilt-induced cardioinhibitory response with recurrent frequent unpredictable syncope and age >40 years after alternative therapy has failed.	IIb	B
3) Tilt-induced non-cardioinhibitory syncope. Cardiac pacing is not indicated in the absence of a documented cardioinhibitory reflex.	III	B

European Heart Journal 2013;34:2281-2329
Europace 2013;15:1070–1118

Dual-chamber versus ventricular pacing

Outcome	Dual-chamber benefit over ventricular pacing
All-cause deaths	No benefit
Stroke, embolism	Benefit (in meta-analysis only, not in single trial)
Atrial fibrillation	Benefit
HF, hospitalization for HF	No benefit
Exercise capacity	Benefit
Pacemaker syndrome	Benefit
Functional status	No benefit
Quality of life	Variable
Complications	More complications with dual-chamber

European Heart Journal 2013;34:2281-2329
Europace 2013;15:1070–1118

2013 ESC Guidelines
Pacing from alternative right ventricular sites

- The Task Force is unable to give definite recommendations until the results of larger trials became available (His region, mid- or high ventricular septum, outflow tract).

2018 ACC/AHA/HRS Guideline on the evaluation and management of patients with bradycardia and cardiac conduction delay

Class IIa recommendation

In patients with atrioventricular block who have an indication for permanent pacing with **a LVEF between 36% and 50%** and are expected to require ventricular pacing **more than 40%** of the time, it is reasonable to choose pacing methods that maintain physiologic ventricular activation (e.g. CRT-P or His bundle pacing) over right ventricular pacing.

Permanent His bundle pacing

In 2000 Deshmukh el al. reported the first experience in 18 patients[1].
Advantages:

- true physiological pacing by using the native conduction system
- less hardware use compared to CRT
- lead tip likely rests in RA resulting in less tricuspid valve injury or TR

Disadvantages:

- longer procedure time
- higher pacing threshold
- issue of lead dislodgement

1. Deshmukh et al. Permanent, direct His bundle pacing: a novel approach to cardiac pacing in patients with normal His-Purkinje activation. Circulation 2000;101(8):869-77.

Benefits of Permanent His Bundle Pacing Combined With Atrioventricular Node Ablation in Atrial Fibrillation Patients With Heart Failure With Both Preserved and Reduced Left Ventricular Ejection Fraction

Weijian Huang, MD; Lan Su, MD; Shengjie Wu, MD; Lei Xu, MD; Fangyi Xiao, MD; Xiaohong Zhou, MD; Kenneth A. Ellenbogen, MD

Background—Clinical benefits from His bundle pacing (HBP) in heart failure patients with preserved and reduced left ventricular ejection fraction are still inconclusive. This study evaluated clinical outcomes of permanent HBP in atrial fibrillation patients with narrow QRS who underwent atrioventricular node ablation for heart failure symptoms despite rate control by medication.

Methods and Results—The study enrolled 52 consecutive heart failure patients who underwent attempted atrioventricular node ablation and HBP for symptomatic atrial fibrillation. Echocardiographic left ventricular ejection fraction and left ventricular end-diastolic dimension, New York Heart Association classification and use of diuretics for heart failure were assessed during follow-up visits after permanent HBP. Of 52 patients, 42 patients (80.8%) received permanent HBP and atrioventricular node ablation with a median 20-month follow-up. There was no significant change between native and paced QRS duration (107.1±25.8 versus 105.3±23.9 milliseconds, P=0.07). Left ventricular end-diastolic dimension decreased from the baseline (P<0.001), and left ventricular ejection fraction increased from baseline (P<0.001) in patients with a greater improvement in heart failure with reduced ejection fraction patients (N=20) than in heart failure with preserved ejection fraction patients (N=22). New York Heart Association classification improved from a baseline 2.9±0.6 to 1.4±0.4 after HBP in heart failure with reduced ejection fraction patients and from a baseline 2.7±0.6 to 1.4±0.5 after HBP in heart failure with preserved ejection fraction patients. After 1 year of HBP, the numbers of patients who used diuretics for heart failure decreased significantly (P<0.001) when compared to the baseline diuretics use.

Conclusions—Permanent HBP post–atrioventricular node ablation significantly improved echocardiographic measurements and New York Heart Association classification and reduced diuretics use for heart failure management in atrial fibrillation patients with narrow QRS who suffered from heart failure with preserved or reduced ejection fraction. (***J Am Heart Assoc.*** **2017;6:e005309. DOI: 10.1161/JAHA.116.005309.)**

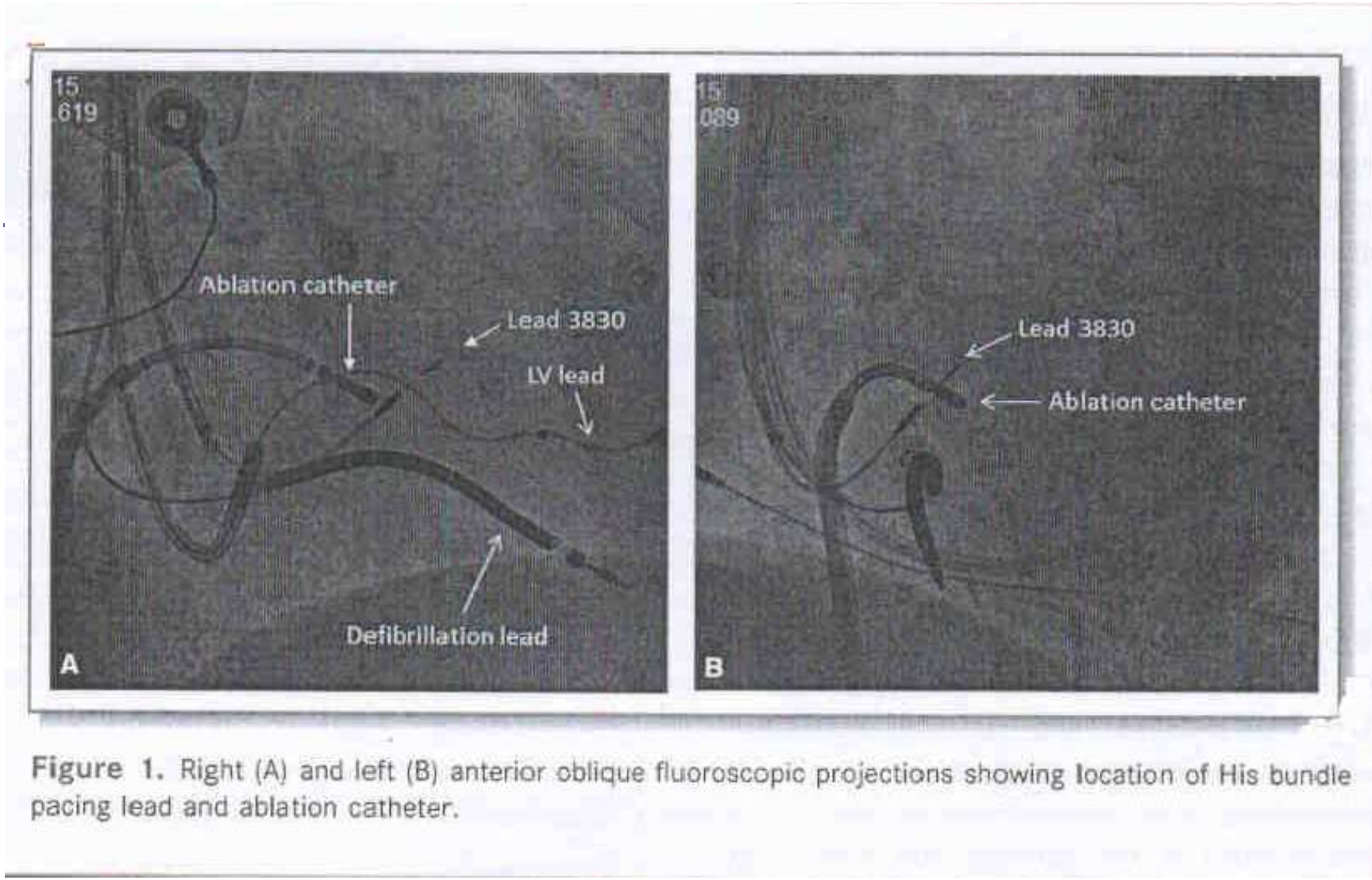


Figure 1. Right (A) and left (B) anterior oblique fluoroscopic projections showing location of His bundle pacing lead and ablation catheter.

"Permanent His bundle pacing post AVN ablation in AF patients with narrow QRS and heart failure (preserved or reduced LVEF) improved echo measurements, NYHA class and diuretic use for heart failure."

Sleep Apnea

Class I recommendation

In patients with documented/suspected bradycardia or conduction disorder during sleep, **screening** for symptoms of sleep apnea syndrome is recommended with subsequent confirmatory testing directed by clinical suspicion.

In patients with sleep-related bradycardia or conduction disorder and documented obstructive sleep apnea, **treatment directed specifically** at the sleep apnea (e.g. cPAP and weight loss) is recommended.

* Nocturnal bradycardia is **not** in itself an indication for permanent pacing

2018 ACC/AHA/HRS Guideline on the evaluation and management of patients with bradycardia and cardiac conduction delay

Leadless Pacemaker

- Micra
- FDA approval in April 2016

Leadless Pacemaker

	Conventional	Micra TPS
		
Total volume	10.6 cc*	0.8 cc
Mass	21.5 grams	2.0 grams
Rate Response	Subcutaneous Accelerometer	Intracardiac Accelerometer
Communication	Model 2090 Programmer	Model 2090 Programmer
Fixation	Helical coil or tines	Flexible tines
MR conditional	1.5 T	1.5 T + 3 T
Battery Service Life	10.3 years†	9.6 years†

*Medtronic model ADSR01 with 30 cm by 6 Fr lead
†Projected based on ADSR01 and Micra use conditions of 100% pacing at 60 bpm, 1.5 V at 0.24 ms, and 500 Ω

Leadless Pacemaker

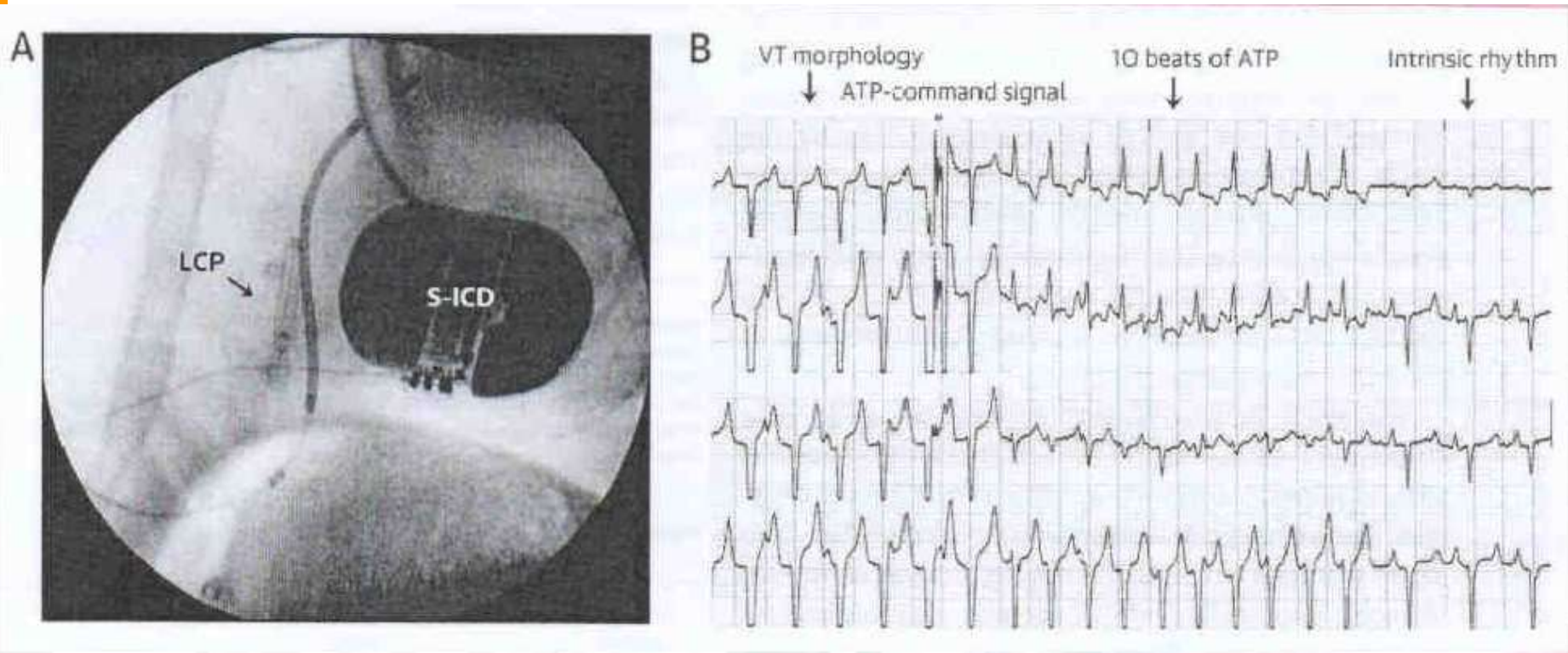
- Single Chamber only (VVIR mode)
- N**o magnet mode**
- You can turn off Micra, i.e. OOO mode

  →It is to avoid the EOL Micra affecting the newly implant Micra
- No explosion risk in cremation. Thus no need to remove after patient passed away.

Future development

S-ICD: Possibility of ATP therapy Communication between leadless pacemaker and S-ICD

First proof of concept in animal model (2016): wireless, intrabody, unidirectional device-device communication (S-ICD to leadless pacemaker) and ATP-delivery by leadless pacemaker.



Tjong et al. Communicating antitachycardia pacing enabled leadless pacemaker and S-ICD. JACC 2016;2:039.

Communication between leadless pacemaker and S-ICD: 12-month follow-up

Chronic performance at 12 months measured in 10 canine models:

- mean communication threshold remained stable.
- leadless pacemaker electrical performance
  pacing threshold 0.74±0.58V
  R-wave amplitude 23.4±10.4mV
  pacing impedance 620±93ohm
- no leadless pacemaker dislodgement.
- human pivotal trial in 2019

"first step toward establishing multicomponent device systems that eliminate transvenous leads"

Tjong et al. 12-month performance of communicating leadless anti-tachycardia pacemaker and S-ICD. HRS 2018 abstract presentation.

Thank you