Prevention and Management of Long Term Pacing Related Complications

Jae Suk Baek M.D.

Division of Pediatric Cardiology
Asan Medical Center

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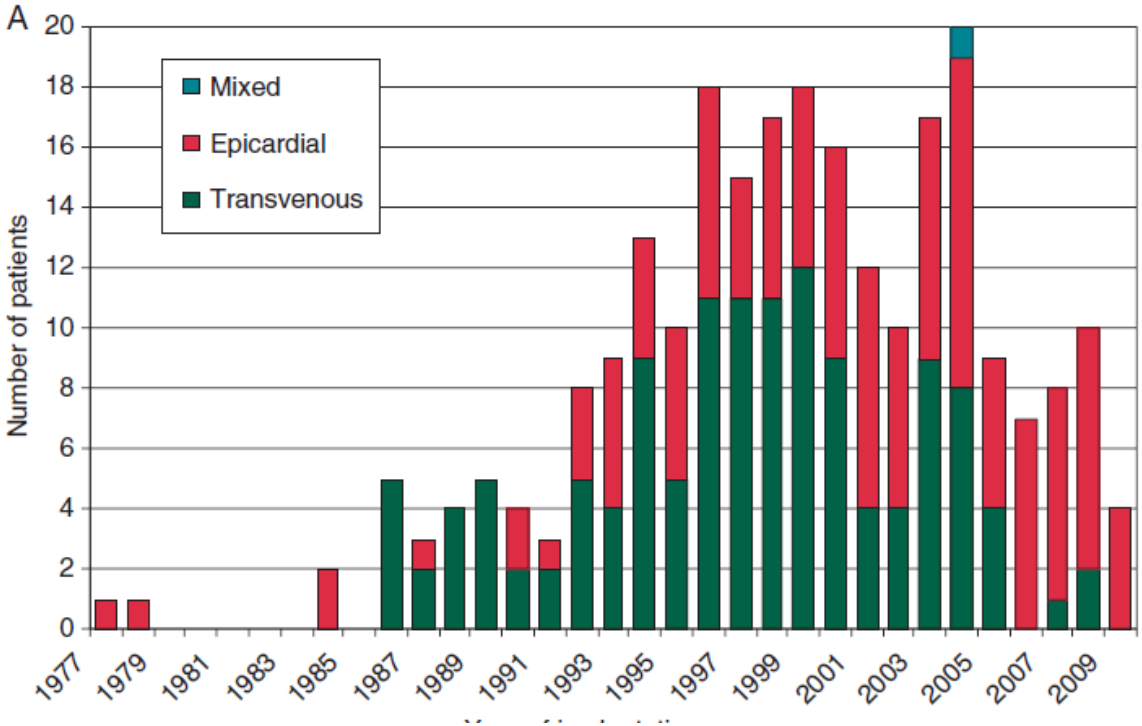
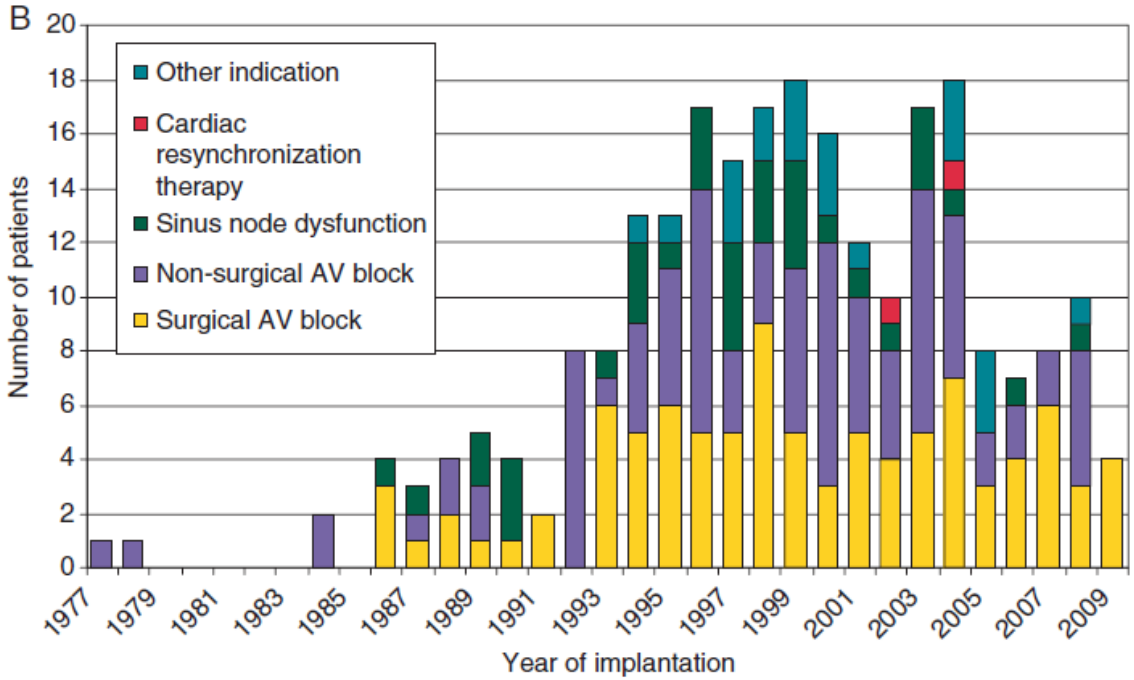
서울아산병원
소아청소년병원
Asan Medical Center Children's Hospital

Frequency and type of pacemaker primary implantations



Indications for pacemaker implantation



Petr K et al.
Europace (2012) 14, 509–514

Difference Indication for PPM btw adults & children

Adults	Children

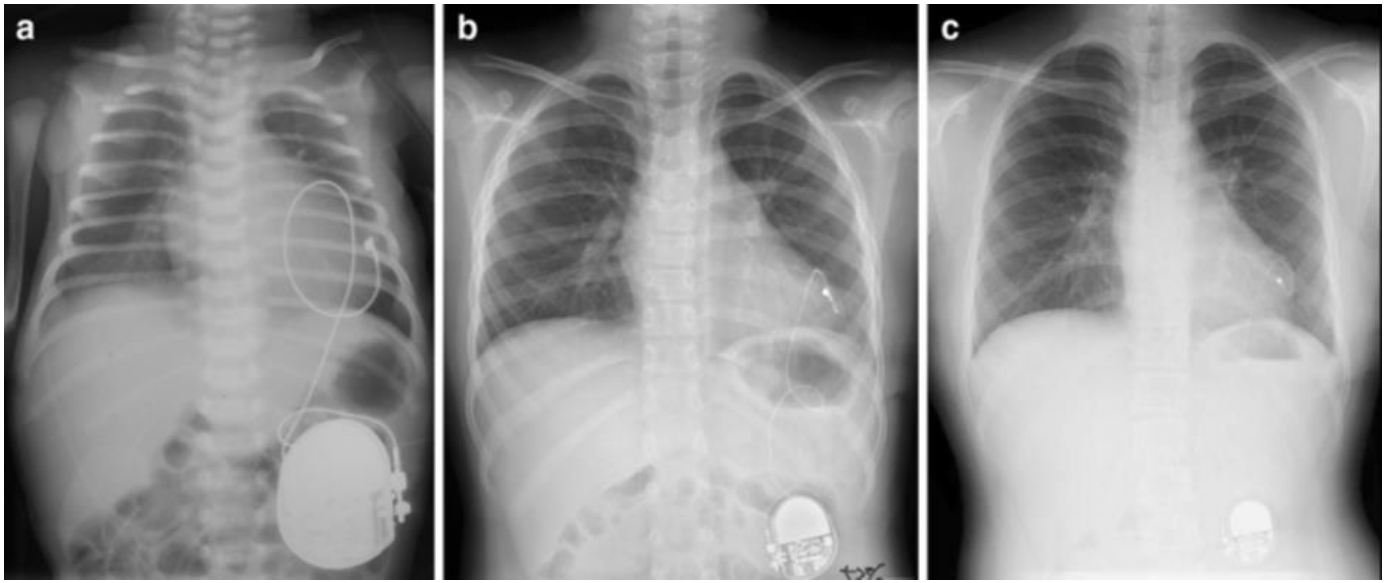
• Bradycardia, LV dysfunction, dyssynchrony due to partially diseased conduction systems often combined with degenerative diseases and infarctions of the myocardium	• Bradycardia due to complete AV conduction block usually a/w healthy myocardium
	• Structural normal heart
	  • Congenital AV block
	  • Maternal SLE
	  • Acquired AV block
	  • Infectious diseases
	  • Progressive AV-conduction tissue fibrosis
	• Congenital heart disease
	  • A/w structural ds itself
	  • Surgical or percutaneous procedures

Children and pacemakers - Long term results-

- Battery & lead longevity
  - More frequent pacemaker generator or lead changes
  - For the child undergoing an initial implantation at age 1 year, a minimum of nine electrode changes and 17 generator changes (at 100% pacing) can be expected during its lifetime.
  - Generator half- life
    - 5yr(for children < 4 years of age at implantation)
    - 7yr(for children > 4 years of age at implantation)
  - Lead failure : more in children
    - Lead fracture, insulation break, displacement, and abnormalities in sensing or pacing
    - Stretching due to somatic growth, compression of epicardial leads caused by the small space between ribs, direct impact forces during daily activities

Children and pacemakers - Long term results-

- Redundant loop of pacing lead d/t growth allowance
  - Too short – lead fracture
  - Too long – cardiac strangulation



- Systemic ventricular dysfunction

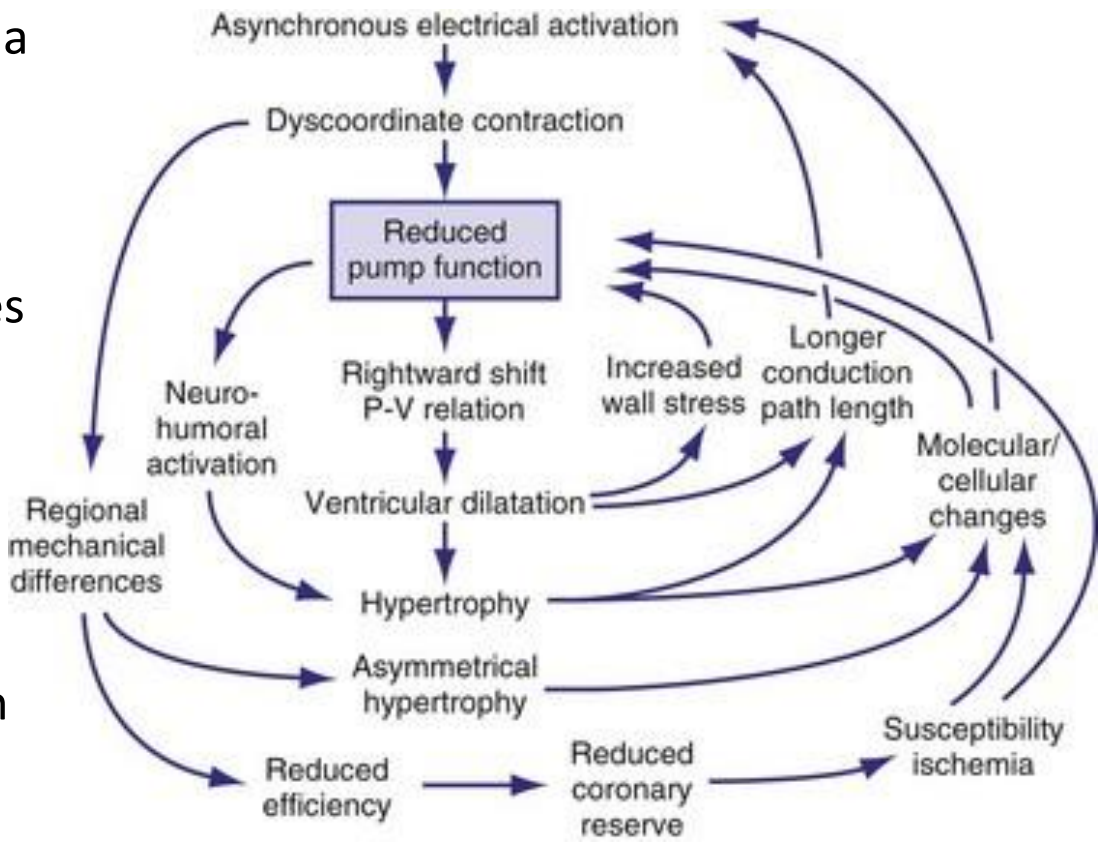
Ventricular pacing for Pt. with CAVB

- Ventricular pacing is indicated to increase heart rate, rather than to 'resynchronize' electrical activation.
- **Benefits**
  - Restoration of HR
  - Unpredictable risk of SCD as well as LV failure a/w untreated complete heart block is cured

- Ventricular pacing induces an abnormal electrical activation pattern, which may cause mechanical dyssynchrony, associated with impairment of pump function, LV remodeling, and increased risk of heart failure.

Pathophysiology of ventricular pacing

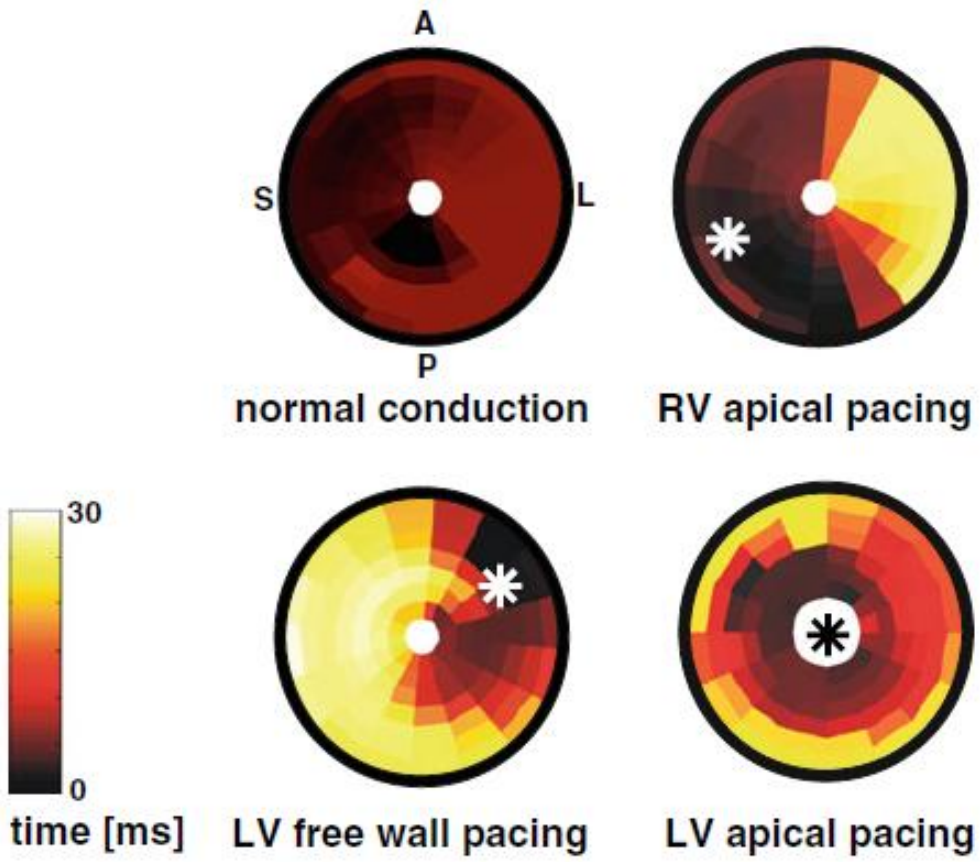
- Electrical asynchrony, as induced by ventricular pacing, results in a **dyssynchronous contraction pattern.**
  - Early systolic shortening of the early-activated myocytes results in stretch of late-activated myocytes.
  - When myocytes in remote regions are subsequently activated and start to contract, they contract even more powerfully due to the early systolic pre-stretching



Pacing induced Cardiomyopathy

- Significant LV systolic dysfunction attributable to the effects of RV pacing
  - LV EF <45 %
  - Absence of other known causes of cardiomyopathy
  - RV pacing creates a constellation of adverse electromechanical changes including dyssynchronous left ventricular (LV) contraction and impaired hemodynamics that have deleterious effects on ventricular structure and function.

Pathophysiology of ventricular pacing



- Electrical activation of the LV is fast and synchronous during normal activation.
- During ventricular pacing, the region in the proximity of the pacing site is early-activated, whereas myocardium remote from the pacing site is late-activated.
- In LV apical pacing, electrical activation is circumferentially synchronous.

Heart Fail Rev (2011) 16:305–314

Pacing strategies to avoid PiCMP

- Programmed algorithms to minimize unnecessary ventricular pacing and promote intrinsic activity in paced patients
- Adequate ventricular pacing site
  - RV apex & free wall
  - Alternative- site RV pacing
  - Biventricular pacing
  - Single- site LV pacing

Strategies to Minimize Right Ventricular Pacing

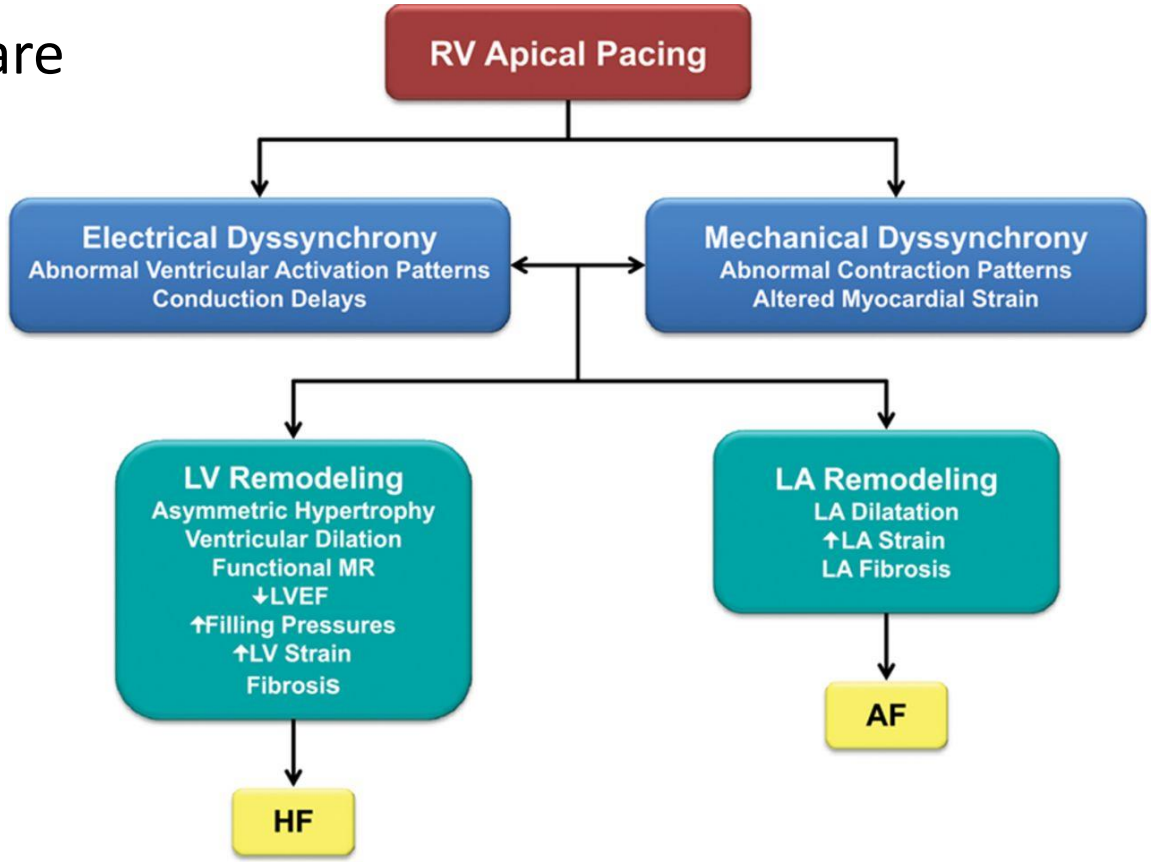
- AAI: Where clinically indicated—young patient with normal AV conduction
- VVI backup 40–50 beats per minute
  - Patients with ICD without bradycardia
  - Patients with syncope 2° to transient AV block (eg, setting of bifascicular
  - block where infrequent pacing expected)

Limited use for high-grade atrioventricular block

  - AV hysteresis (Biotronik)
  - AS search hysteresis (Boston Scientific)
  - Search AV+ (Medtronic)
  - Ventricular Intrinsic Preference (St Jude Medical)
- Pacing Mode Switch from AAI to DDD
  - AAISafeR, AAISafeR2 (Sorin Group)
  - Managed Ventricular Pacing (Medtronic)
  - Reverse Mode Switch/RhythmIQ (Boston Scientific)

Conventional pacing sites - RV apex and free wall

- RV apex and free wall are easily accessible
- Mimic LBBB
- Paradoxical septal motion during early systolic phase
- RV pacing is well tolerated in most children



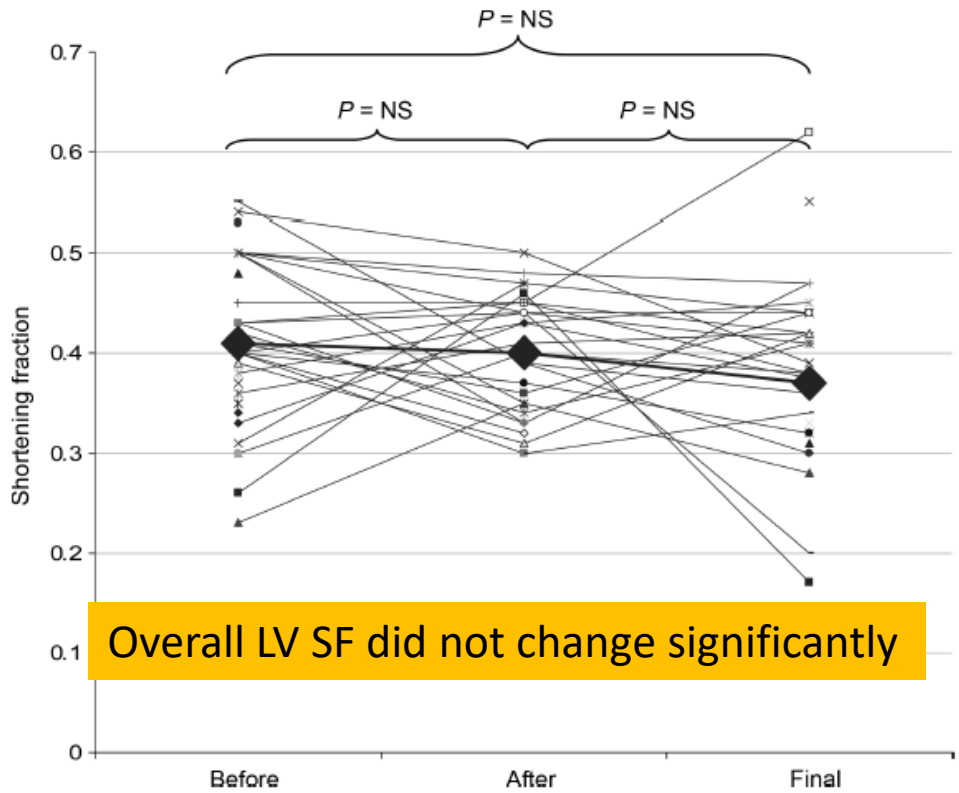
Anne M. Gillis Circ Arrhythm Electrophysiol. 2014;7:968-977

Radu Vatasescu. et al.

Evolution of left ventricular function in paediatric patients with permanent right ventricular pacing for isolated congenital heart block: a medium term follow-up

Europace (2007) 9, 228–232

- 45 children with RVA pacing for ICHB
- 58.69±45.23 months



Overall LV SF did not change significantly

Figure 1 Evolution of individual (thin lines) and mean (thick line) LV SF.

Roman AG. et al.

Predictors of left ventricular remodelling and failure in right ventricular pacing in the young

European Heart Journal (2009) 30, 1097–1104

- 82 pediatric patients
- Non-surgical (n = 41) or surgical (n= 41) complete atrioventricular block
- 100% RV paced, mean F/U = 7.4 years

Table 3 Changes in left ventricular size and function

Parameter		Preimp (*n* = 77)	Postimp (*n* = 62)	Last (*n* = 82)	*P*-value (overall)	*P*-value (preimp vs. postimp)	*P*-value (postimp vs. last)	*P*-value (preimp vs. last)
LVEDD (z-score)	Median (range)	+0.9 (−6.3 to +8.5)	+0.3 (−4.0 to +6.9)	+0.9 (−3.4 to +11.3)	0.017	NS	<0.05	NS
LV SF (%)	Median (range)	39 (24–62)	37 (15–58)	32 (8–49)	<0.001	NS	<0.05	<0.05
Left ventricular dilatation and dysfunction[a]	*n* (%)	1 (1.3)	1 (1.6)	11 (13.4)	0.001	0.574	0.026	0.010

Last, last follow-up; LVEDD, left ventricular end-diastolic diameter; LV SF, left ventricular shortening fraction; Preimp, pre-implantation; Postimp, post-implantation.
[a]LVEDD >+2z, SF <26%.

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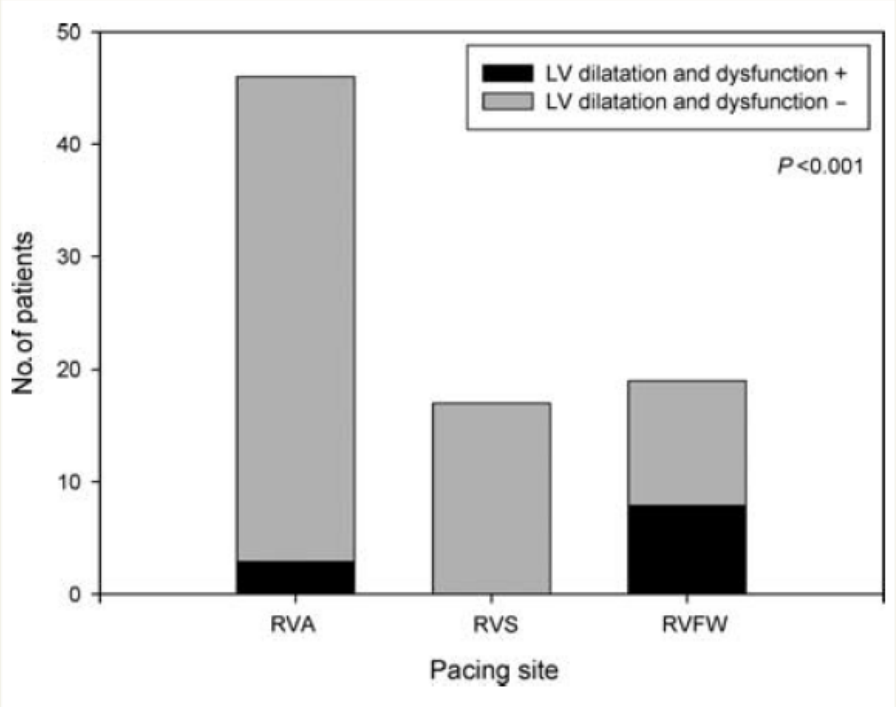

Figure 1 Proportion of patients developing LV dilatation and dysfunction (SF<26% and LVEDD >+2z-values) according to the pacing site. RVA, endocardial RV apical pacing; RVS, endocardial RV septal pacing; RVFW, epicardial RV free wall pacing.

- **Epicardial RV free wall pacing** (OR ¼ 14.3, 95% CI = 2.3–78.2, P , 0.001) as the only significant predictor of the development of late LV dilatation and dysfunction

서울아산병원 소아청소년병원
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Alternative-site RV pacing

- His-bundle pacing
  - Normal physiological sequence of activation
  - In children
    - ✓Challenging procedure and seems not very applicable in children
    - ✓Post-surgical AVB/ Congenital AVB
      - His bundle may be involved in the pathological interruption of the conduction system
- RV outflow tract
  - The inferior part of septal side of RVOT

Biventricular pacing

- Biventricular pacing is mainly applied in adult heart failure patients with normal cardiac anatomy, suffering from LV dysfunction in association with LV dyssynchrony due to intrinsic LBBB
- Based on the rationale that the sequence of activation in RV pacing similar to the activation pattern in LBBB, application of biventricular pacing has been extended to heart failure patients with RV-pacing-associated dyssynchrony.
- Data from large randomized adult CRT trials cannot simply be translated to children with cardiac failure
  - Mixed etiology (normal cardiac anatomy with LV HF + UVH + systemic RV + RV failure)

Dubin et al.

Resynchronization Therapy in Pediatric and Congenital Heart Disease Patients- An International Multi-Center Study

JACC Vol. 46, No. 12, 2005

- 103 patients from 22 institutions
- Age at time of implantation : 12.8 yrs (3 m- 55.4 yr)
- F/U duration : 4mon (22day~1yr)
- 73 CHD, 16 CMP, 14 CAVB
- **Upgrade of pacemaker to CRT**
  - 46 patients
  - Significant improvement in EF with CRT therapy

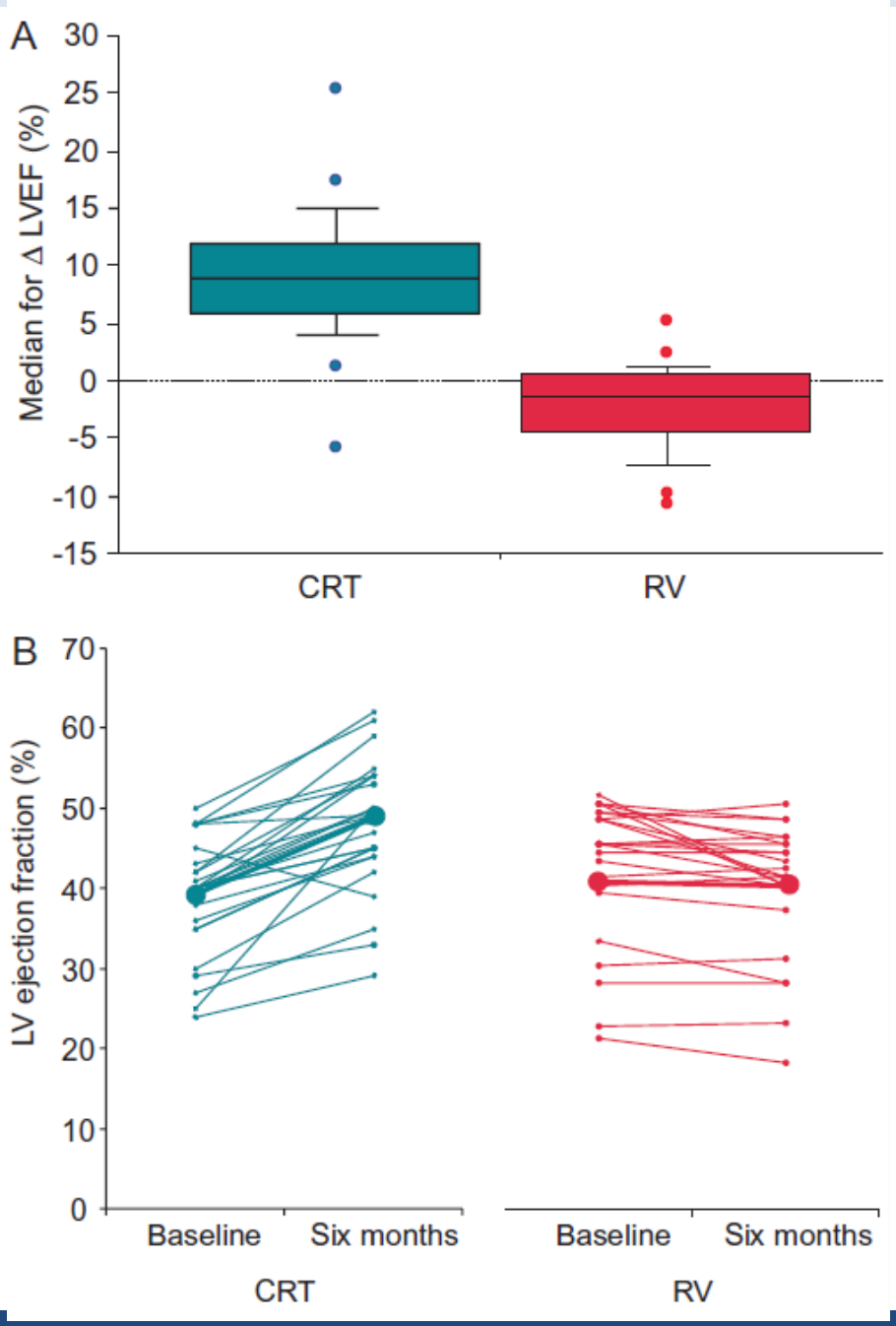
    => 14.5 ± 11.4 EF units ($p < 0.05$).

John G. et al.

Cardiac resynchronization therapy in pacemaker-dependent patients with left ventricular dysfunction

Europace (2013) 15, 1609–1614

- 50 patients with unavoidable RV pacing, LVSD, and mild or no symptoms of heart failure
- At the time of pulse generator replacement
- Randomized 1 : 1 to either standard RV-PGR (comparator) or CRT



2013 ESC guideline

Recommendations for cardiac resynchronizatin therapy directly or upgrade from a conventional pacing system in patients with heart failure and formal indication for cardiac pacing therapy.

Recommendation	Class	Level of evidence
1. Upgrade of conventional PM or ICD. CRT is indicated in HF pa tients with LVEF <35% and a demand for high percentage of ventricular pacing who persist in the NYHA functional class III or IV even with optimized medical treatment	I	B
2. CRT in a direct way. CRT should be considered in patientis with HF, depressed LVEF and a demand for high percentage of ventricular pacing under risk of worsening od HF symptoms	IIa	B

Eur Heart J. 2013;34(29):2281

Single- site LV pacing

LV apical pacing

Circumferential synchronous activation pattern

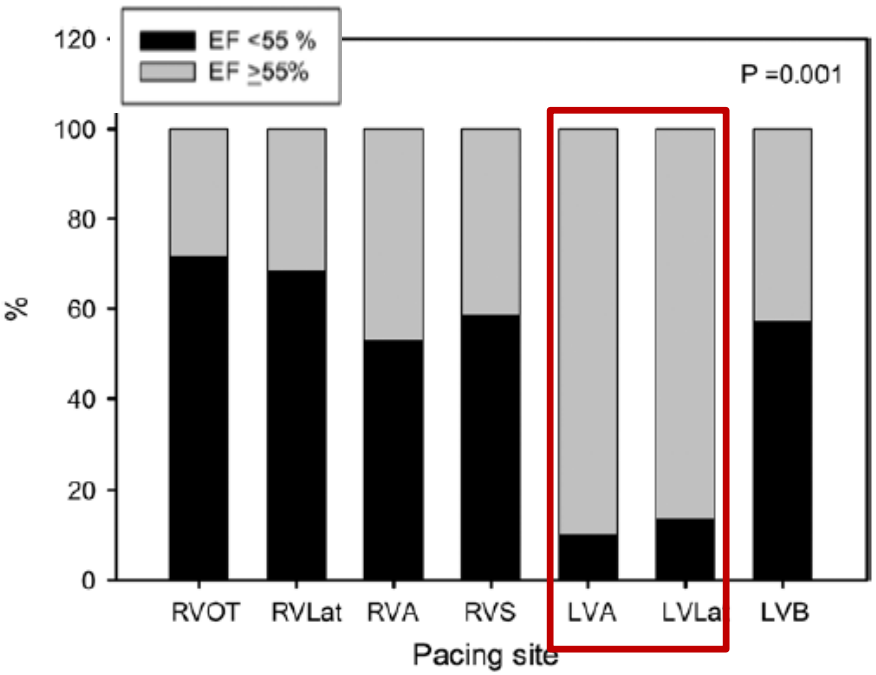
- Comparable to that of upgrade to biventricular pacing, in children with LV dysfunction after chronic RV pacing, functional improvement and reverse remodeling are reported for LV single-site pacing.

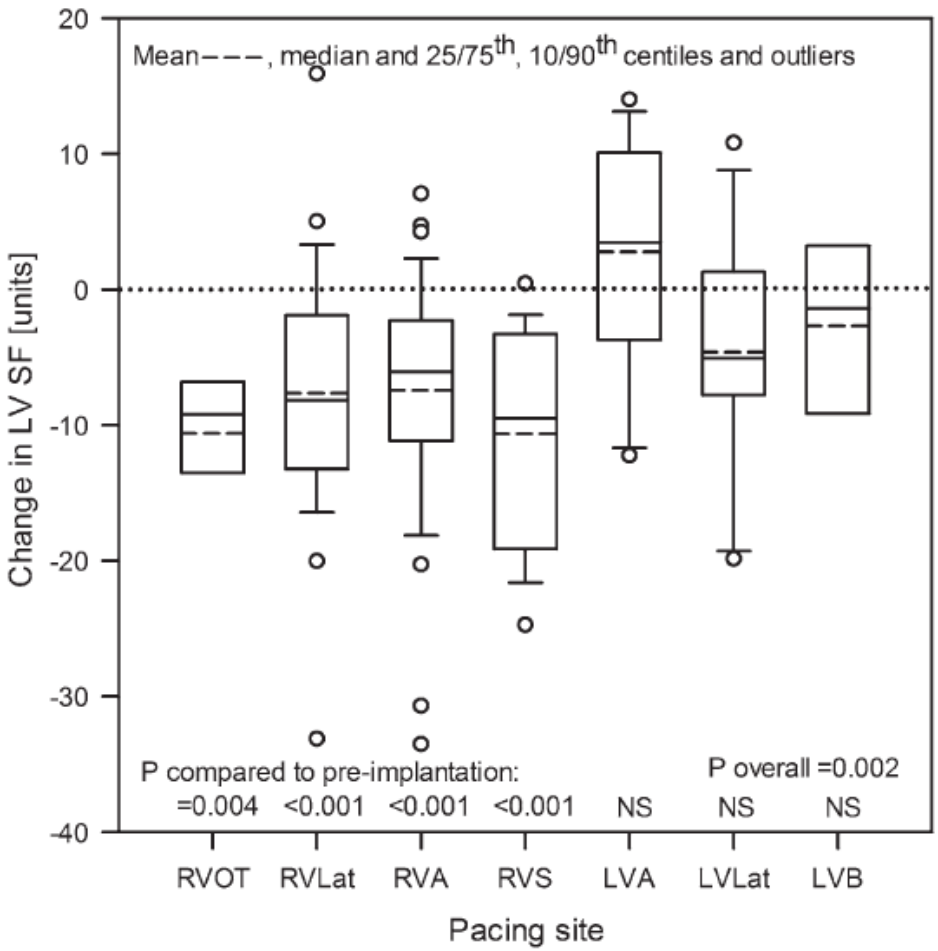
Janoušek. et al.

Permanent Cardiac Pacing in Children:Choosing the Optimal Pacing Site- A Multicenter Study

Circulation. 2013;127:613-623

- 178 children(<18yrs), 21 center
- AV block, normal heart
- Median age – 11.2yr(6.3-15.0)

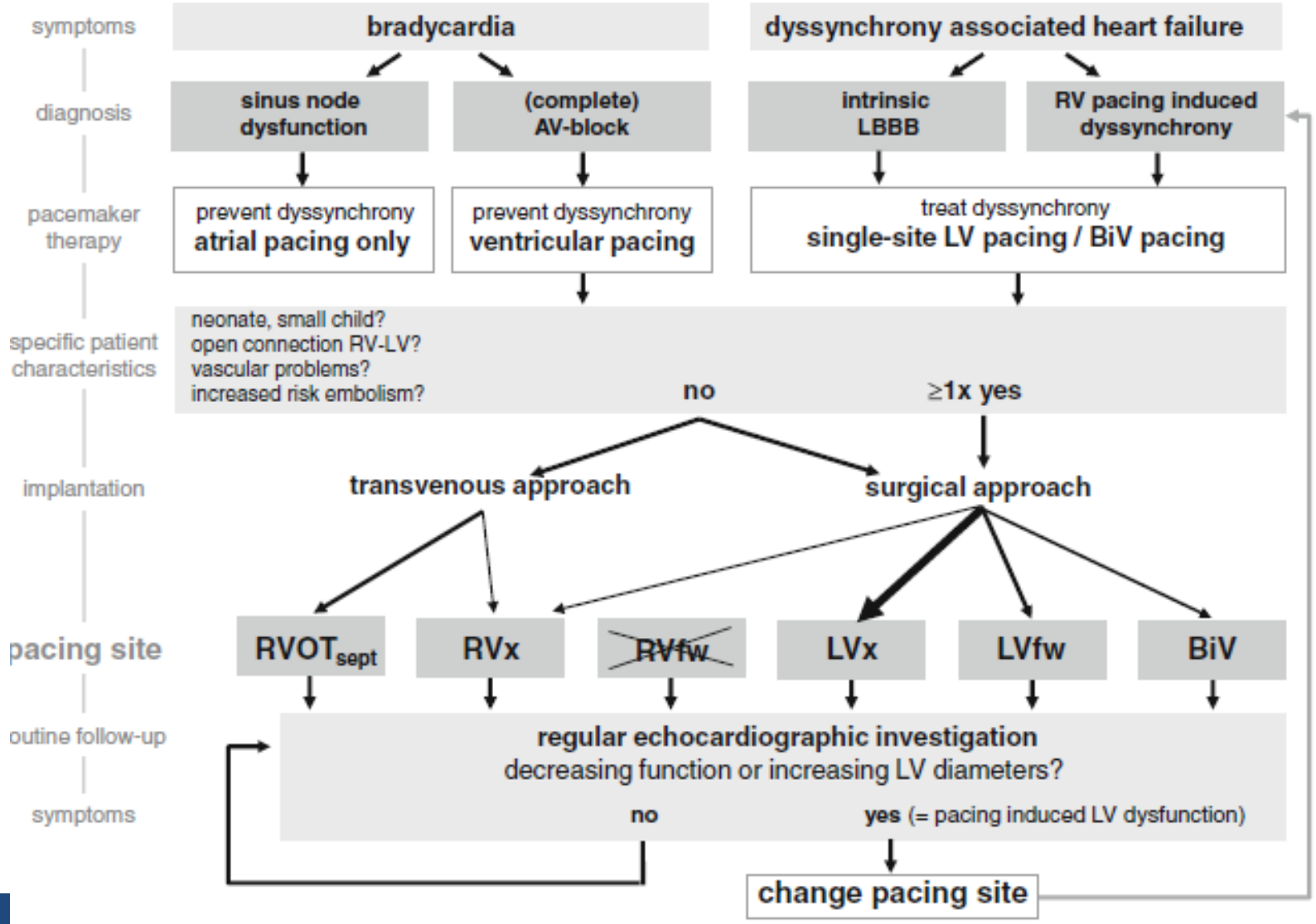




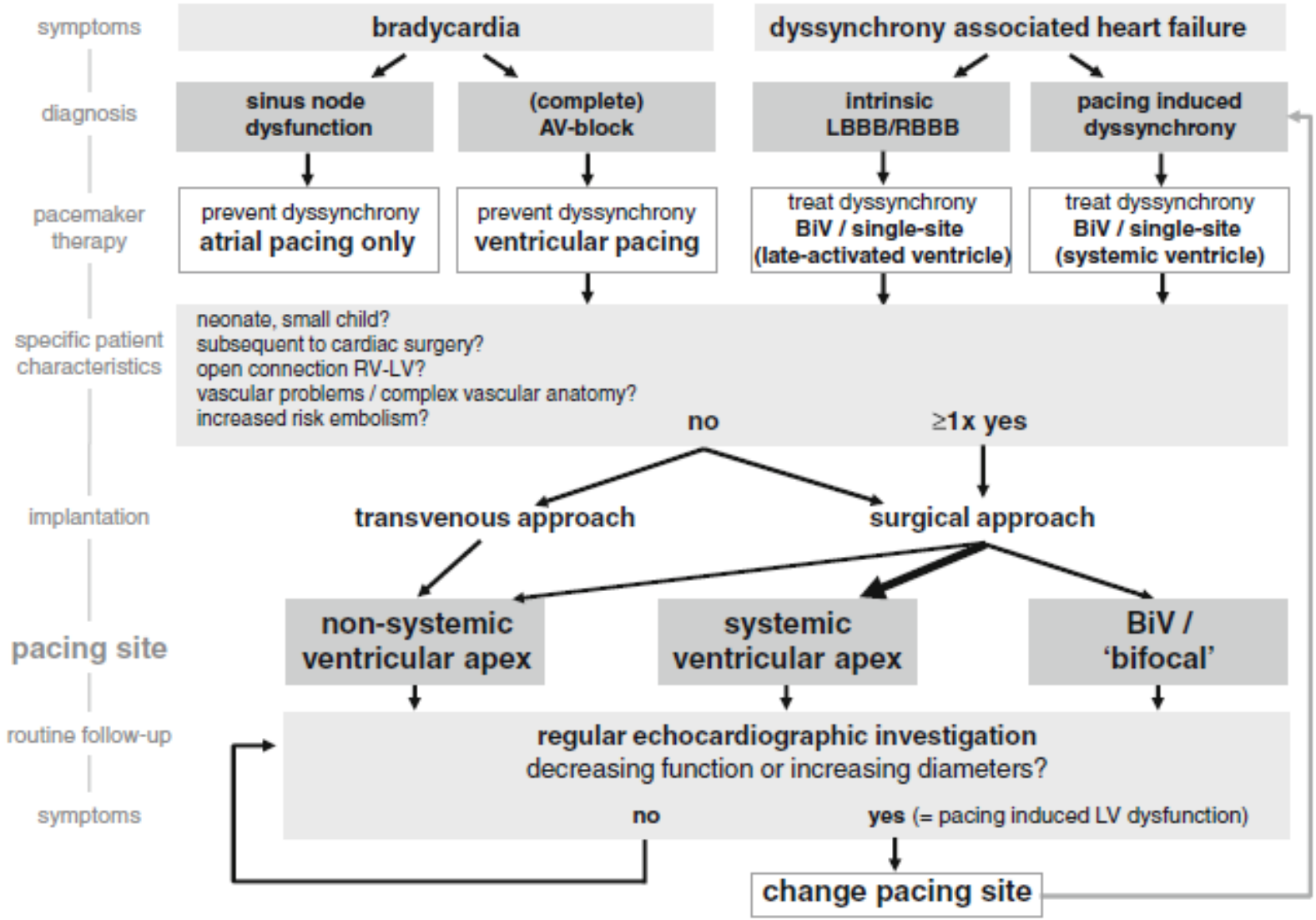
Recommendations for optimal pacing in children

- Ventricular pacing should be minimized in patients with (partially) preserved AV conduction & intact His-Purkinje system, such as sick sinus syndrome.
- Surgically induced AV block
  - Regularly check-up for re-established AV conduction
- In children with CAVB & normal heart
  - Use of single LV apex and LV free wall sites
- Regular echocardiographic checkup is warranted
  - Esp. in children with RV pacing
  - BV pacing /single site LV pacing should be considered as soon as echocardiography reveals signs of ventricular dilatation or dysfunction

Optimal pacing site in children with Normal heart



Optimal pacing site in children with Structural HD



경청해 주셔서

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