2023.6.24 13:30-15:00
CIED 4 Session

Conduction System Disorders following TVAR

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Following an aortic valve replacement surgery, conduction system disorders can occur due to various factors related to t he surgery itself or pre-existing conditions

Atrioventricular Block: Heart block refers to a delay or interruption in the conduction of electrical signals from the atria to the ventricles. It can be classified into three degrees: first-degree, second-degree, and third-degree (complete) heart block. Depending on the severity, heart block can cause a slow heart rate, fainting, or dizziness.

Bundle Branch Block: Bundle branches are pathways that transmit electrical signals to the ventricles. In bundle branch block, one or both of these branches become partially or completely blocked, causing a delay in electrical conduction. This delay can result in an abnormal QRS complex on an electrocardiogram (ECG) and may lead to an irregular heartbeat.

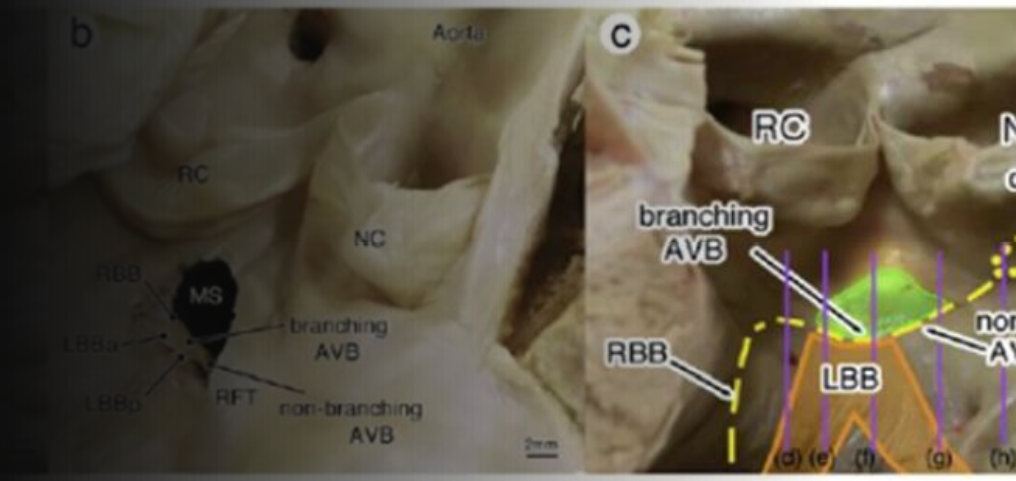
Supraventricular Tachycardia (SVT): SVT refers to a rapid heart rate originating from the atria or the junction between the atria and ventricles. It can occur after aortic valve replacement due to changes in the heart's electrical pathways. SVT episodes can cause palpitations, shortness of breath, and lightheadedness.

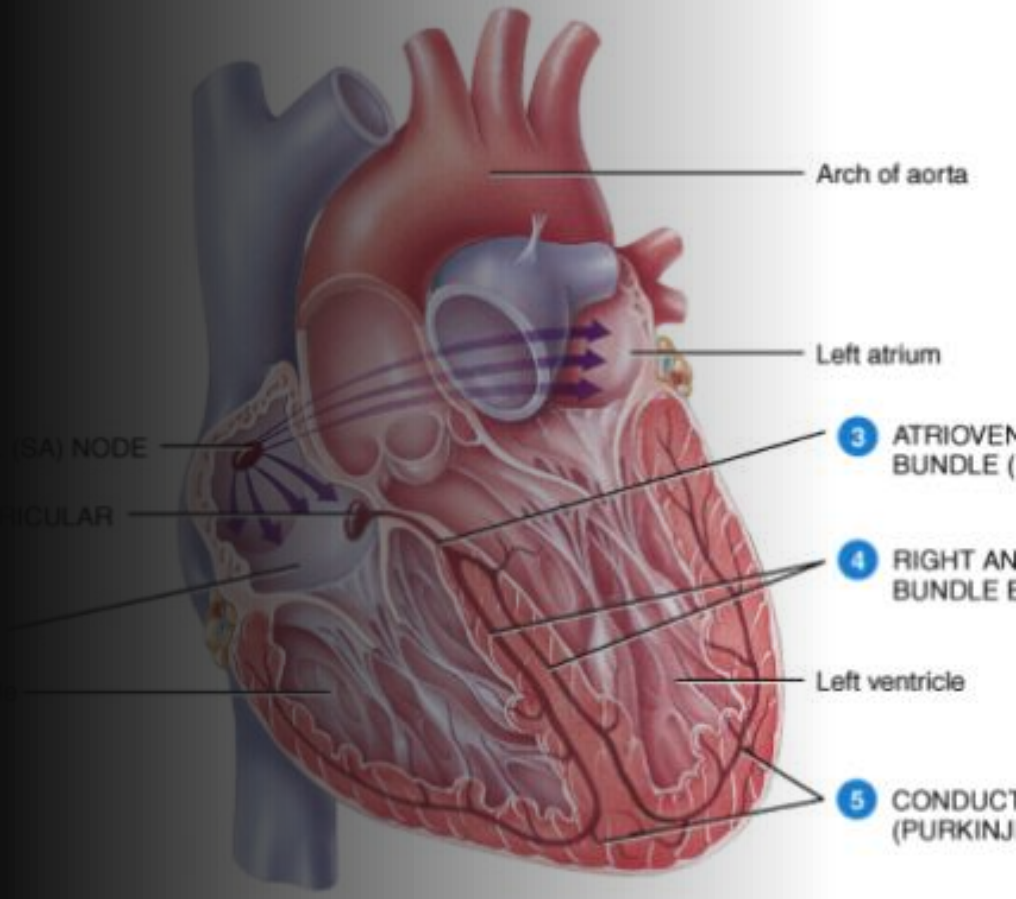
Atrial Fibrillation (AF): AF is a common arrhythmia characterized by irregular and rapid electrical activity in the atria. It can occur after aortic valve replacement, particularly in patients with pre-existing risk factors such as advanced age or heart disease. AF can lead to a higher risk of stroke and other complications if left untreated.

Ventricular Arrhythmias: Ventricular arrhythmias involve abnormal electrical activity originating from the ventricles. They can manifest as premature ventricular contractions (PVCs), ventricular tachycardia (VT), or ventricular fibrillation (VF). Ventricular arrhythmias are potentially life-threatening and may require immediate medical intervention.

Anatomical consideration

- Conduction system disorders following aortic valve replacement can be related to the anatomical approximation of the valve, specifically when the surgery involves manipulation or proximity to the conduction system pathways.





Anatomical approximation during AVR contribute to conduction system disorders

- **Proximity to the Conduction System (also related during TAVR procedure)**

The aortic valve is situated close to the conduction system of the heart. During the replacement procedure, manipulation of the valve or the surrounding tissues can inadvertently affect the conduction pathways. Direct trauma or disruption of the conduction system can occur, leading to conduction abnormalities.

- **Suture Placement**

Sutures used to secure the new valve may inadvertently penetrate or interfere with the conduction system pathways. If a suture inadvertently damages or compresses the conduction tissue, it can disrupt the normal conduction of electrical signals and result in conduction system disorders.

- **Scarring and Fibrosis (also related during TAVR procedure)**

Following surgery, the healing process can lead to scar tissue formation around the surgical site. If the scar tissue involves the conduction system or interferes with its function, it can cause conduction abnormalities.

- **Inflammation and Edema (also related during TAVR procedure)**

Surgical trauma can trigger an inflammatory response and temporary swelling or edema in the surrounding tissues. Inflammation and edema can affect the conduction system and impede the normal propagation of electrical signals, leading to conduction system disorders.

Conduction disturbance related to SAVR

Conduction disturbance after isolated surgical aortic valve replacement in degenerative aortic stenosis

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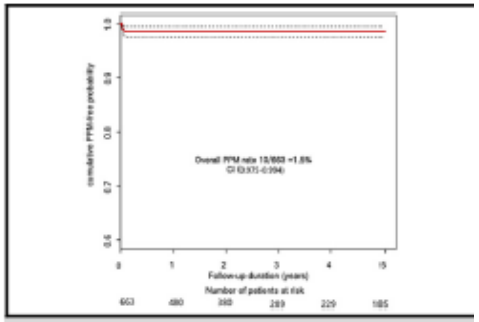
ABSTRACT

Objective: Conduction disturbances are common in patients with aortic stenosis. We investigated the incidence, reversibility, and prognosis of conduction disorders requiring permanent pacemaker implantation in patients with degenerative aortic stenosis after isolated aortic valve replacement.

Methods: This was a retrospective study conducted at a tertiary care center. We evaluated the incidence of conduction disturbances in patients who underwent isolated surgical aortic valve replacement for aortic stenosis between January 2005 and May 2015. Relevant clinical information was obtained from the patients' medical records.

Results: We reviewed results of 663 patients with pathologically proven degenerative aortic stenosis (bicuspid aortic valve, n = 285 [43.0%]) who underwent isolated aortic valve replacement (mechanical valve, n = 310 [46.8%]). Patients' mean age was 67.1 ± 8.1 years, and 362 were male (54.6%). Immediate postoperative intraventricular conduction disorders occurred in 56 patients (8.4%), and atrioventricular block occurred in 68 patients (10.3%). Ten patients with symptomatic second-degree or third-degree atrioventricular block underwent permanent pacemaker implantation within 30 days of aortic valve replacement. During the mean follow-up period of 1288 ± 1122 days, 64 patients (9.7%) developed irreversible conduction disorders (bundle branch block n = 24 and first-degree atrioventricular block n = 42). Of the 10 patients requiring permanent pacemakers, 4 remained depend on the permanent pacemaker during follow-up. Beyond 30 days after aortic valve replacement, 1 patient underwent permanent pacemaker implantation for de novo conduction disturbance 44 months postoperatively.

Conclusions: After isolated aortic valve replacement, permanent pacemaker implantation for conduction disturbance is rare (n = 10/663, 1.5%). Isolated aortic valve replacement for degenerative aortic stenosis has a low risk of conduction disturbances during long-term follow-up. (J Thorac Cardiovasc Surg 2017;154:1556-65)



Kaplan–Meier curve of PPM-free survival.

Central Message

The incidence of conduction disorders requiring PPM implantation after isolated AVR in patients with AS is low.

Perspective

Eleven patients (1.5%) underwent PPM implantation for treating conduction disorders after isolated AVR. During an average 3.5-year follow-up, most conduction disorders were reversible. This suggests that close observation and delayed PPM implantation are clinically reasonable in such patients.

See Editorial Commentary page 1566.

TABLE 1. Characteristics of the patients

Clinical variables	Total (N = 663)	No PPM (N = 653)	PPM (N = 10)	*P* value
Baseline characteristics				
Age (y)	67.1 ± 8.1	67.1 ± 8.0	67.5 ± 8.6	.61
Sex, male	362 (54.6%)	357 (54.8%)	5 (50.0%)	.68
BMI (kg/m^2)	24.6 ± 3.4	24.6 ± 3.4	24.4 ± 3.0	.69
Hypertension	294 (44.3%)	287 (44.2%)	6 (60.0%)	.51
Diabetes mellitus	111 (16.7%)	110 (16.9%)	1 (9.1%)	.43
Cerebral vascular attack	21 (3.2%)	21 (3.2%)	0	.49
Chronic pulmonary disease	17 (2.6%)	17 (2.6%)	0	.54
Congestive heart failure	11 (1.7%)	10 (1.5%)	1 (10.0%)	.10
Chronic kidney disease	32 (4.8%)	31 (4.8%)	1 (10.0%)	.48
Coronary artery disease	51 (7.7%)	49 (7.5%)	2 (20.0%)	.29
Arrhythmia	36 (5.4%)	35 (5.4%)	1 (10.0%)	.58
Operative characteristics				
Bicuspid aortic valve	285 (43.0%)	280 (42.9%)	5 (50.0%)	.59
Valve type, mechanical	310 (46.8%)	304 (46.6%)	5 (50.0%)	.62
Valve size (mm)	21.7 ± 2.1	21.8 ± 2.1	21.9 ± 1.7	.81
Cardiopulmonary bypass time (min)	110.5 ± 32.9	110.5 ± 32.9	113.5 ± 37.1	.16
Aortic crossclamping time (min)	70.3 ± 21.8	70.4 ± 21.9	70.3 ± 21.0	.83
Baseline ECG				
Sinus rhythm	518 (78.1%)	515 (78.8%)	3 (30.0%)	<.01
Atrial arrhythmia*	31 (4.7%)	29 (4.4%)	2 (20.0%)	<.01
Conduction disorders†	114 (17.2%)	109 (16.7%)	5 (45.5%)	<.001
Intraventricular	55 (8.3%)	50 (7.7%)	6 (60.0%)	<.001
LBBB	38 (5.7%)	36 (5.5%)	3 (30.0%)	<.001
RBBB	16 (2.4%)	13 (2.0%)	3 (30.0%)	<.001
Other intraventricular conduction disorders	1 (0.2%)	1 (0.2%)	0	.84
Atrioventricular	72 (10.9%)	70 (10.7%)	0	<.001
First-degree AVB	70 (10.6%)	70 (10.6%)	0	<.001
Second-degree AVB (Mobitz type 1)	2 (0.3%)	2 (0.3%)	0	.71

PPM, Permanent pacemaker; *BMI*, body mass index; *ECG*, electrocardiogram; *LBBB*, left bundle branch block; *RBBB*, right bundle branch block; *AVB*, atrioventricular block.
*Overlapping cases exist between atrial arrhythmia and conduction disorders. †Overlapping cases exist between atrioventricular and intraventricular block.

J Thorac Cardiovasc Surg 2017;154:1556-65

TABLE E2. Characteristics of patients with permanent pacemaker implantations according to date of implantation

Patient	Baseline rhythm	POD to PPM (d)	Native valve type	Valve type, valve size (mm)	Rhythm before PPM	PPM dependency*	Rhythm after PPM
PPM <30 d (n = 10)							
M, 56 y	RBBB	8	Bicuspid	Mechanical, 25	Trifascicular block	N	First AVB
F, 65 y	Sinus	9	Bicuspid	Mechanical, 21	CAVB, AF with SVR	Y	AF, pacing
M, 68 y	AF with SVR, LBBB	10	Bicuspid	Mechanical, 23	CAVB	N	AF, LBBB
M, 73 y	LBBB	11	Tricuspid	Mechanical, 23	Trifascicular block	Y	Pacing
M, 80 y	LBBB	13	Tricuspid	Tissue, 19	Bifascicular block	N	LBBB
F, 77 y	Sinus	13	Tricuspid	Tissue, 19	CAVB	Y	Pacing
F, 81 y	RBBB	13	Bicuspid	Tissue, 19	CAVB	N	First AVB, RBBB
F, 78 y	RBBB	14	Tricuspid	Tissue, 21	CAVB	N	RBBB
M, 58 y	AF with SVR	19	Bicuspid	Mechanical, 19	AF with SVR, Bifascicular block	N	AF
F, 64 y	Sinus	28	Tricuspid	Mechanical, 23	Bifascicular block	Y	Pacing

POD, Postoperative day; *PPM*, permanent pacemaker; *M*, male; *RBBB*, right bundle branch block; *N*, no; *AVB*, atrioventricular block; *F*, female; *CAVB*, complete atrioventricular block; *AF*, atrial fibrillation; *SVR*, slow ventricular response; *Y*, yes; *LBBB*, left bundle branch block. *PPM dependency was defined as pacing rate greater than 80%.

TABLE 3. Irreversible conduction disorders in 64 patients

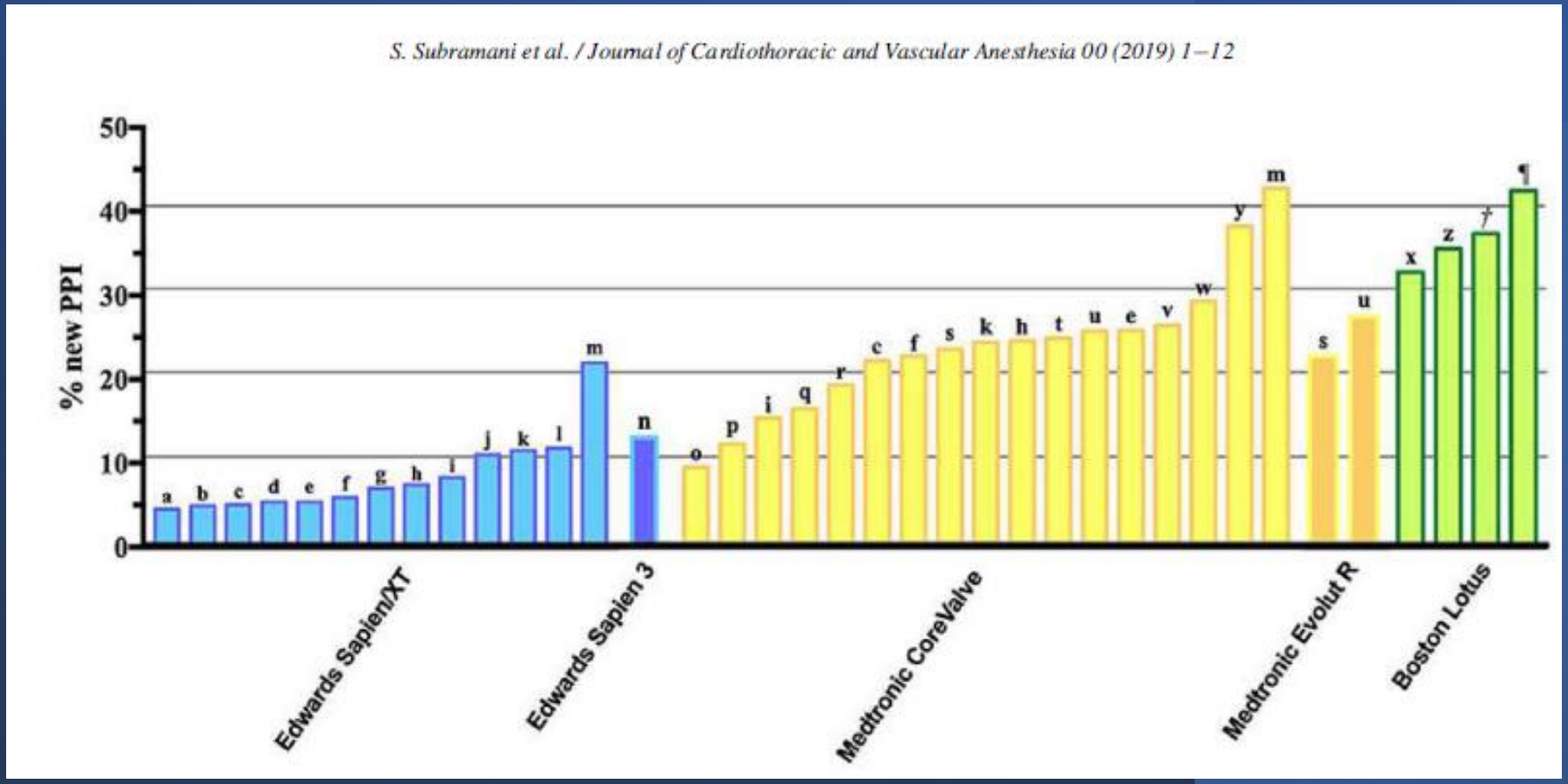
Intraventricular*	24
LBBB	8
RBBB	16
Other intraventricular conduction disorder	0
Atrioventricular*	46
First-degree AVB	42
Second-degree AVB (Mobitz type 1)	0
Symptomatic second- or third-degree AVB (including Mobitz type 2 and third-degree AVB)	4

LBBB, Left bundle branch block; *RBBB*, right bundle branch block; *AVB*, atrioventricular block. *Six patients had comorbid intraventricular block and AVB.

J Thorac Cardiovasc Surg 2017;154:1556-65

- The incidence of conduction disorders requiring PPM implantation after isolated SAVR in AS patients is very low nowadays.
- Moreover, a significant proportion of patients only developed transient conduction disorders, confirming that persistent conduction disorders with PPM dependency after SAVR are rare.

Conduction disturbance related to TVAR



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- **Conduction System Disturbance**:

The manipulation and placement of the prosthetic valve can lead to trauma or mechanical stress on the conduction system, including the atrioventricular (AV) node or bundle branches. This trauma can result in conduction disturbances and the need for a pacemaker.

- **Valve Design and Sizing:**

The early-generation TAVI valves had a relatively larger profile, which could cause more compression or displacement of the surrounding tissues, including the conduction system. Improper sizing of the valve in relation to the patient's anatomy could also contribute to conduction disturbances.

- **Procedural Technique and Experience**:

TAVI was a relatively new procedure, and as with any new technique, there was a learning curve for the operators.

FIGURE 5 Pre-TAVR Patient Assessment and Guidance

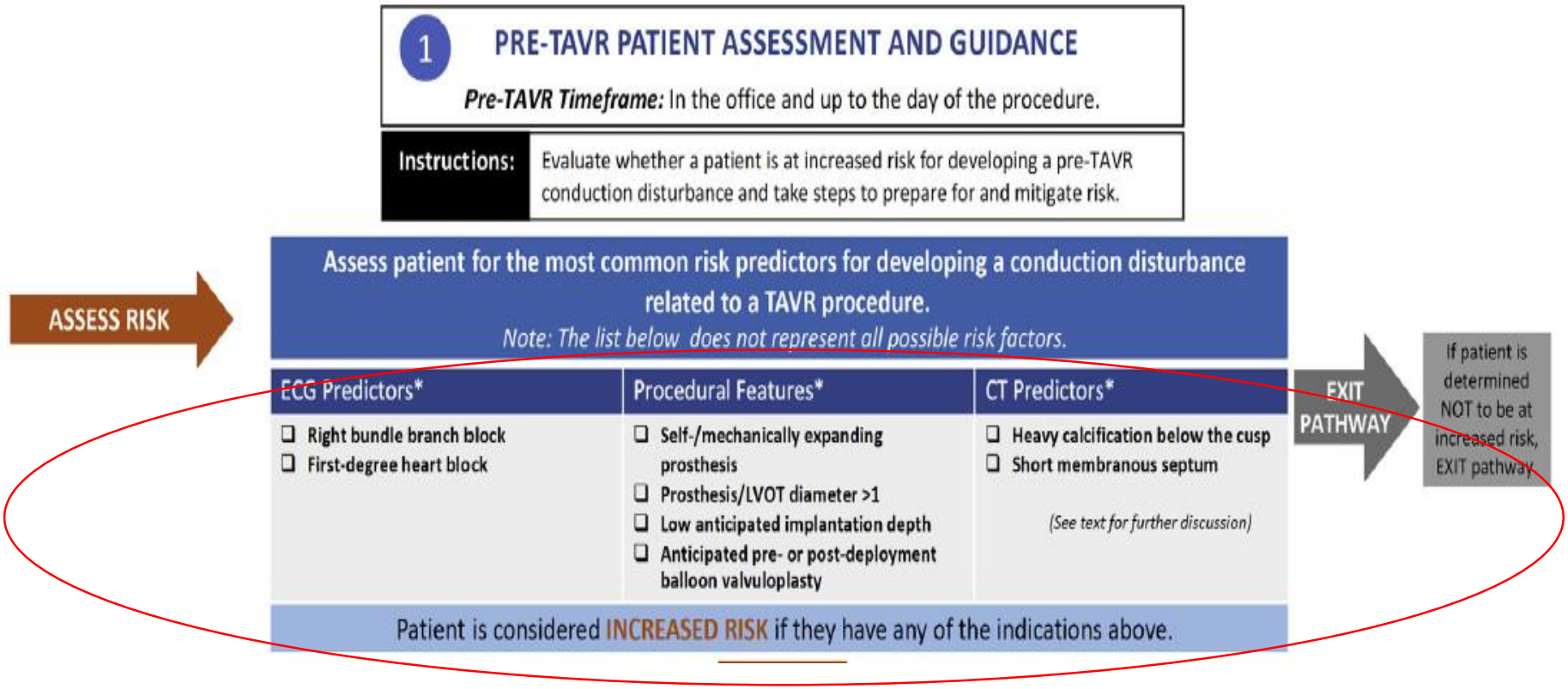

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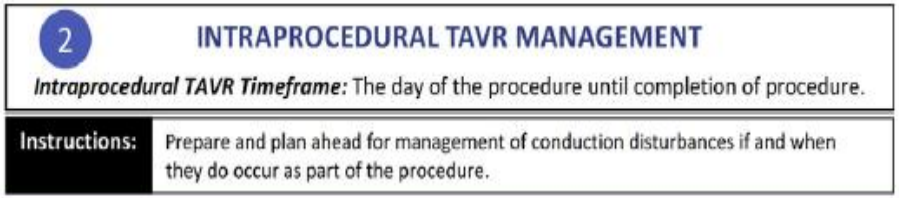
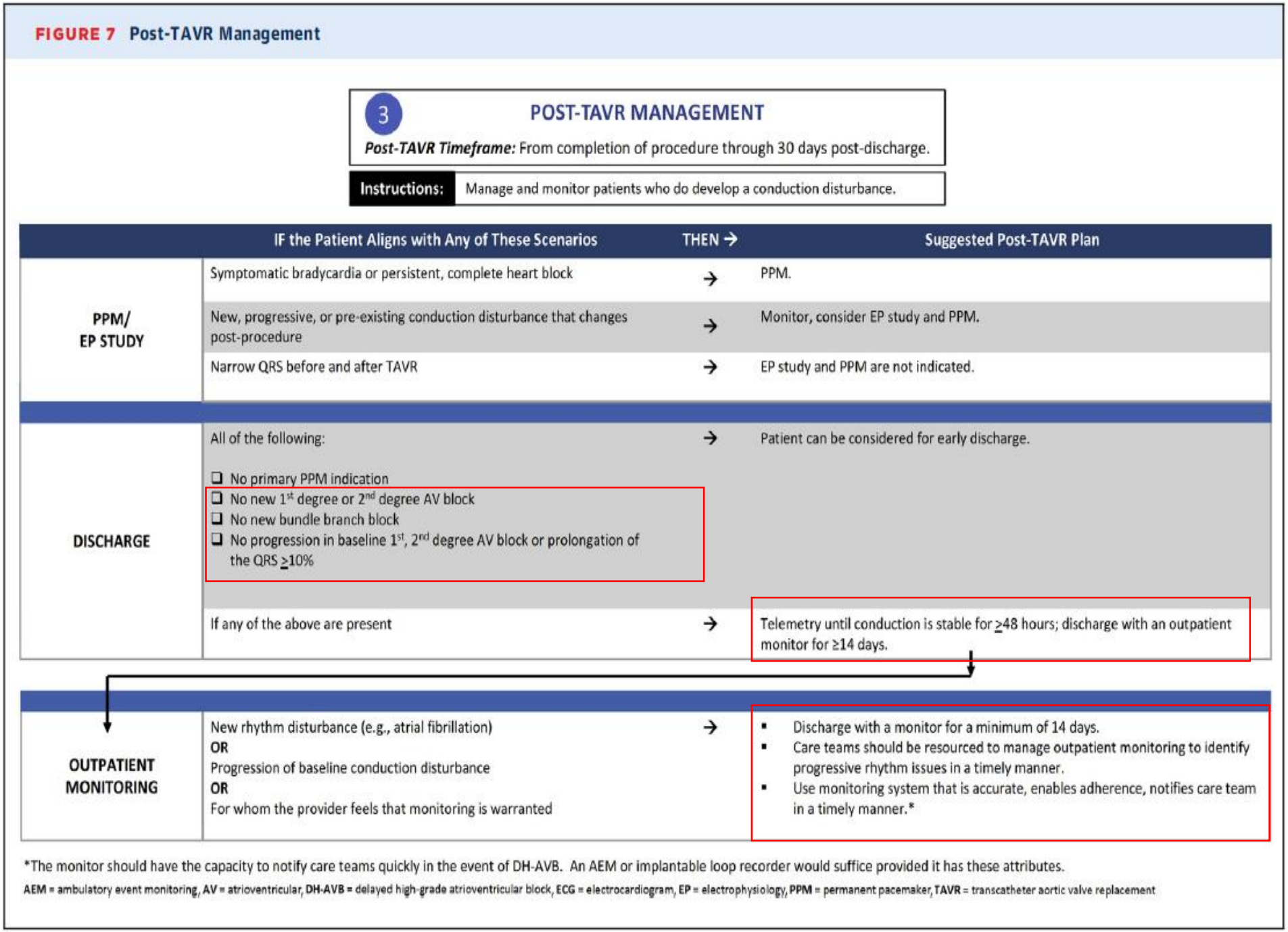
FIGURE 6 Intraprocedural TAVR Management



	IF...	THEN →	Suggested Intraprocedural TAVR Plan
PRIOR TO START OF PROCEDURE	Pre-TAVR assessment indicated that patient is at increased risk for conduction disturbances: Patient has increased-risk **procedural** factors (Figure 5):	→	Continue guideline-based medications for coronary artery disease and/or heart failure despite identified risk of need for PPM after TAVR. Revisit the necessity of a secure pacing lead, internal jugular versus femoral venous access, given increased risk of need for PPM. – Consider implantation of secure pacing lead prior to the procedure, usually via an internal jugular vein. – Access and use the internal jugular vein for both pacing during the procedure and temporary pacing if the need arises as a result of the procedure. Discuss potential for PPM and obtain consent in clinic where feasible.
FOR ALL PATIENTS DURING PROCEDURE			*Irrespective of the type of temporary lead implanted, all patients should be monitored on a telemetry unit with ability to do emergency pacing if required.*
DURING AND UNTIL COMPLETION OF PROCEDURE	No new conduction disturbance	→	Temporary pacemaker and venous sheath can be removed before the patient leaves the procedure room.
	Develops conduction disturbance (e.g., LBBB, PR/QRS duration ≥20 msec) that may require further pacing	→	Internal jugular venous access with a secure pacing lead prior to leaving the procedure room is **reasonable** for patients with new conduction disturbance but ultimately at the discretion of the implantation team.
	Develops transient complete heart block	→	Internal jugular venous access with a secure pacing lead prior to leaving the procedure room is **reasonable** for patients with transient heart block but ultimately at the discretion of the implantation team.
	Develops persistent complete heart block	→	Internal jugular venous access with a secure pacing lead prior to leaving the procedure room is **indicated** for patients with sustained heart block.
	Pre-existing conduction disturbance with indication for PPM	→	It is preferable to separate the procedures so that informed consent can occur, and the procedures can be performed in their respective spaces with related necessary equipment and staff. It may be reasonable to perform the PPM procedure on the same day as the TAVR procedure if: – PPM is indicated – Informed consent has occurred – Appropriate teams and specialty equipment are available.
	Pre-existing conduction disturbance and a secure pacing lead in place	→	Monitor on a telemetry unit, with temporary pacemaker attached and programmed to provide back-up pacing if required.
	Multiple factors that additively confer increased risk but individually do not	→	Monitor on a telemetry unit, with temporary pacemaker attached and programmed to provide back-up pacing if required.

LBBB = left bundle branch block, **PPM** = permanent pacemaker, **TAVR** = transcatheter aortic valve replacement

FIGURE 7 Post-TAVR Management



*The monitor should have the capacity to notify care teams quickly in the event of DH-AVB. An AEM or implantable loop recorder would suffice provided it has these attributes.

AEM = ambulatory event monitoring; AV = atrioventricular; DH-AVB = delayed high-grade atrioventricular block; ECG = electrocardiogram; EP = electrophysiology; PPM = permanent pacemaker; TAVR = transcatheter aortic valve replacement

Post-TAVR new onset LBBB

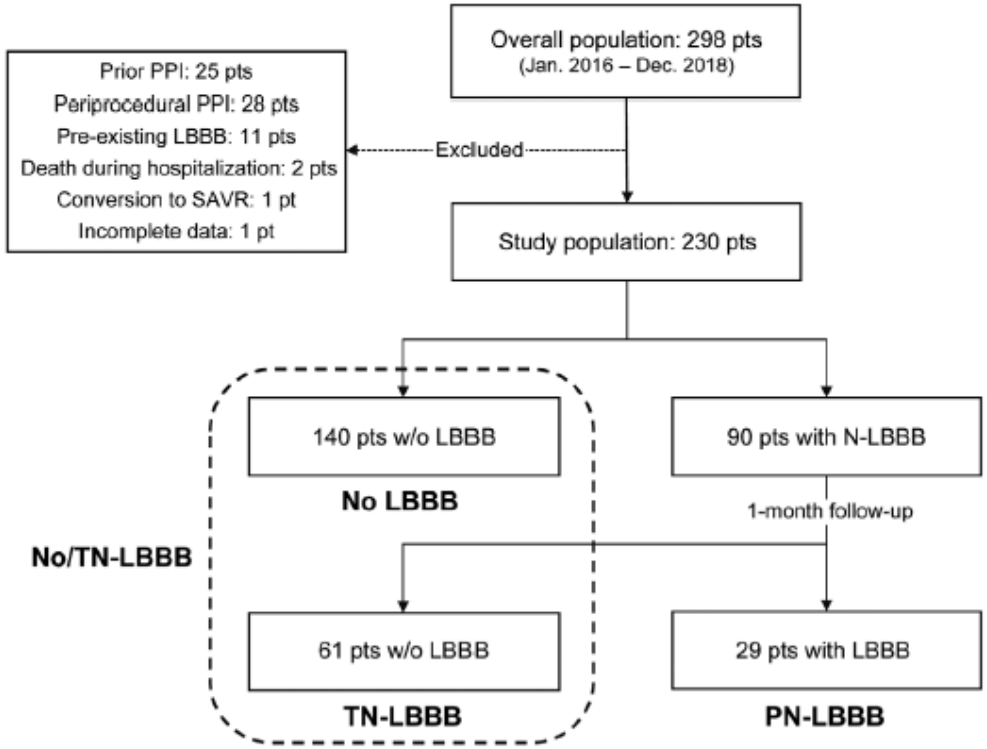


Figure 1. Flow chart of study population. Pt, patient; PPI, permanent pacemaker implantation; LBBB, left bundle branch block; SAVR, surgical aortic valve replacement; w/o, without; N-LBBB, new-onset LBBB; TN-LBBB, transient new-onset LBBB; PN-LBBB, persistent new-onset LBBB.

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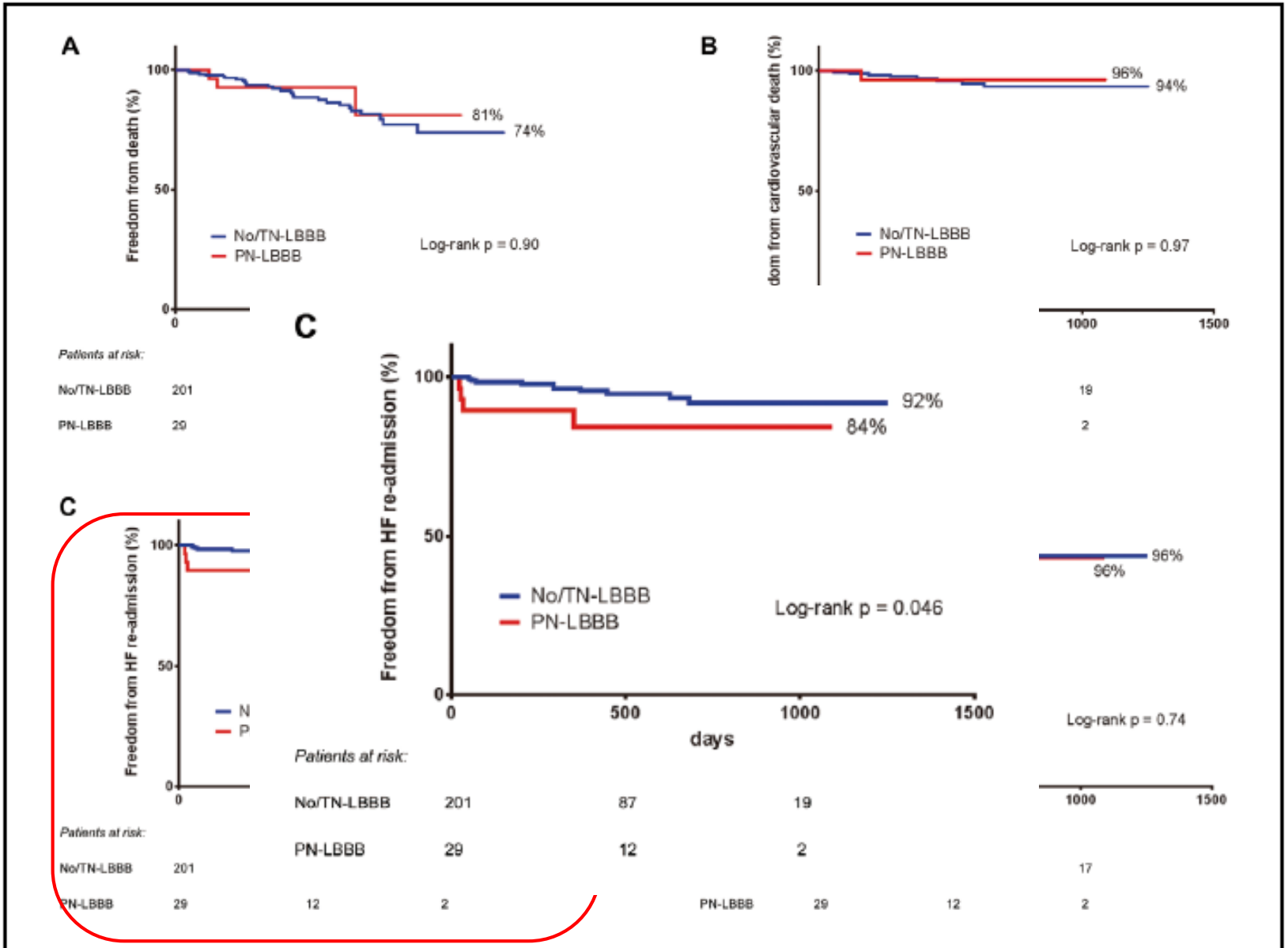

Figure 2. Kaplan-Meier survival curves for (**A**) overall mortality, (**B**) cardiovascular mortality, (**C**) re-hospitalization for heart failure, and (**D**) late need for permanent pacemaker implantation. Abbreviations as in Figure 1.

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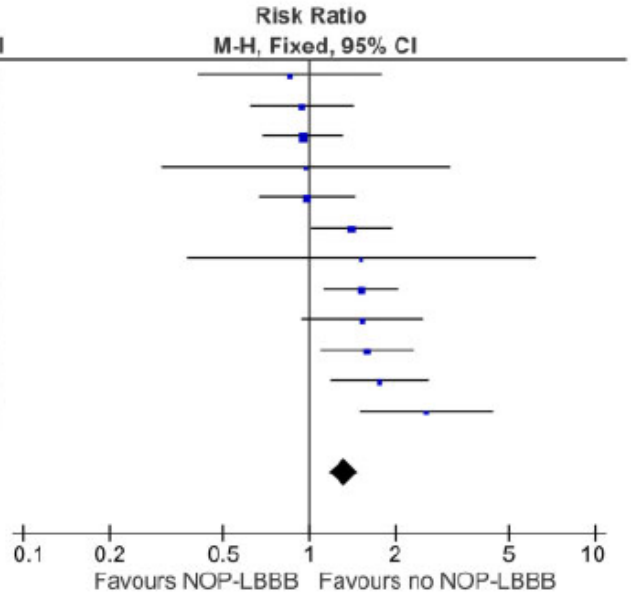
A

1-year RR of all-cause death

Study or Subgroup	NOP-LBBB Events	NOP-LBBB Total	No NOP-LBBB Events	No NOP-LBBB Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Franzoni et al. 2013	8	63	26	175	3.8%	0.85 [0.41, 1.79]
Nazif et al. 2014	21	121	190	1030	11.0%	0.94 [0.62, 1.42]
Testa et al. 2013	42	224	117	594	17.6%	0.95 [0.69, 1.31]
Carrabba et al. 2015	4	34	7	58	1.4%	0.97 [0.31, 3.09]
Urena et al. 2014	22	79	167	589	10.8%	0.98 [0.67, 1.43]
Chamandi et al. 2019	42	212	114	808	13.0%	1.40 [1.02, 1.93]
Lopez Aguilera et al. 2016	5	80	3	73	0.9%	1.52 [0.38, 6.14]
Houthuizen et al. 2012	62	233	78	446	14.7%	1.52 [1.13, 2.04]
Nazif et al. 2019	19	179	69	1000	5.8%	1.54 [0.95, 2.49]
Schymik et al. 2015	41	197	57	437	9.7%	1.60 [1.11, 2.30]
Houthuizen et al. 2014	30	111	56	365	7.2%	1.76 [1.19, 2.60]
Jorgensen et al. 2019	30	237	22	447	4.2%	2.57 [1.52, 4.36]
Total (95% CI)		**1770**		**6022**	**100.0%**	**1.32 [1.17, 1.49]**
Total events	326		906			

Heterogeneity: Chi² = 21.43, df = 11 (P = 0.03); I² = 49%

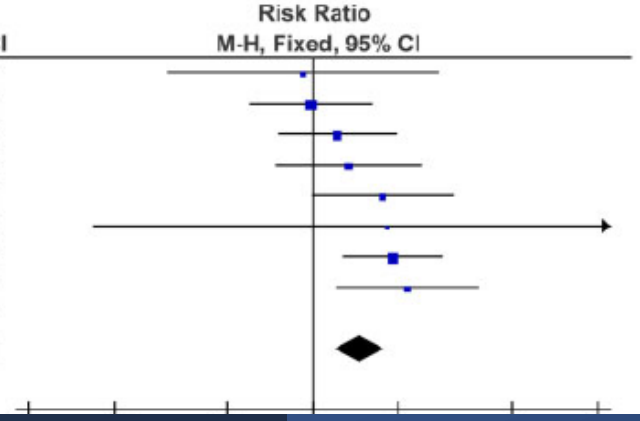
Test for overall effect: Z = 4.57 (P < 0.00001)



B

1-year RR of cardiac death

Study or Subgroup	NOP-LBBB Events	NOP-LBBB Total	No NOP-LBBB Events	No NOP-LBBB Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Franzoni et al. 2013	4	63	12	175	4.9%	0.93 [0.31, 2.77]
Testa et al. 2013	20	224	54	594	22.6%	0.98 [0.60, 1.60]
Urena et al. 2014	16	79	98	589	17.7%	1.22 [0.76, 1.95]
Chamandi et al. 2019	14	212	40	808	12.7%	1.33 [0.74, 2.41]
Nazif et al. 2014	13	121	63	1030	10.1%	1.76 [1.00, 3.10]
Lopez Aguilera et al. 2016	2	80	1	73	0.8%	1.82 [0.17, 19.71]
Houthuizen et al. 2012	42	233	42	446	22.1%	1.91 [1.29, 2.85]
Nazif et al. 2019	15	179	39	1000	9.1%	2.15 [1.21, 3.81]
Total (95% CI)		**1191**		**4715**	**100.0%**	**1.46 [1.20, 1.78]**
Total events	126		349			



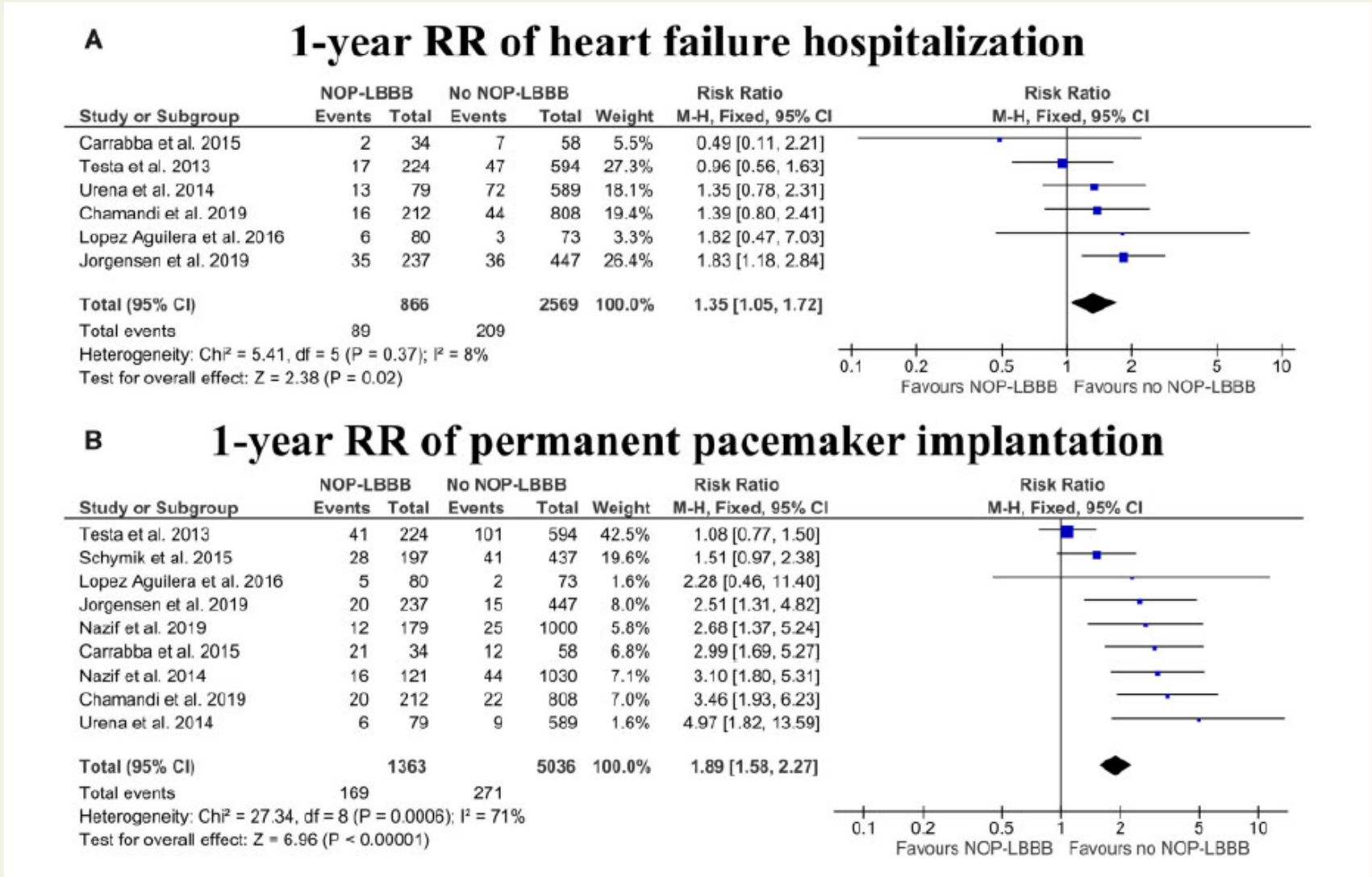
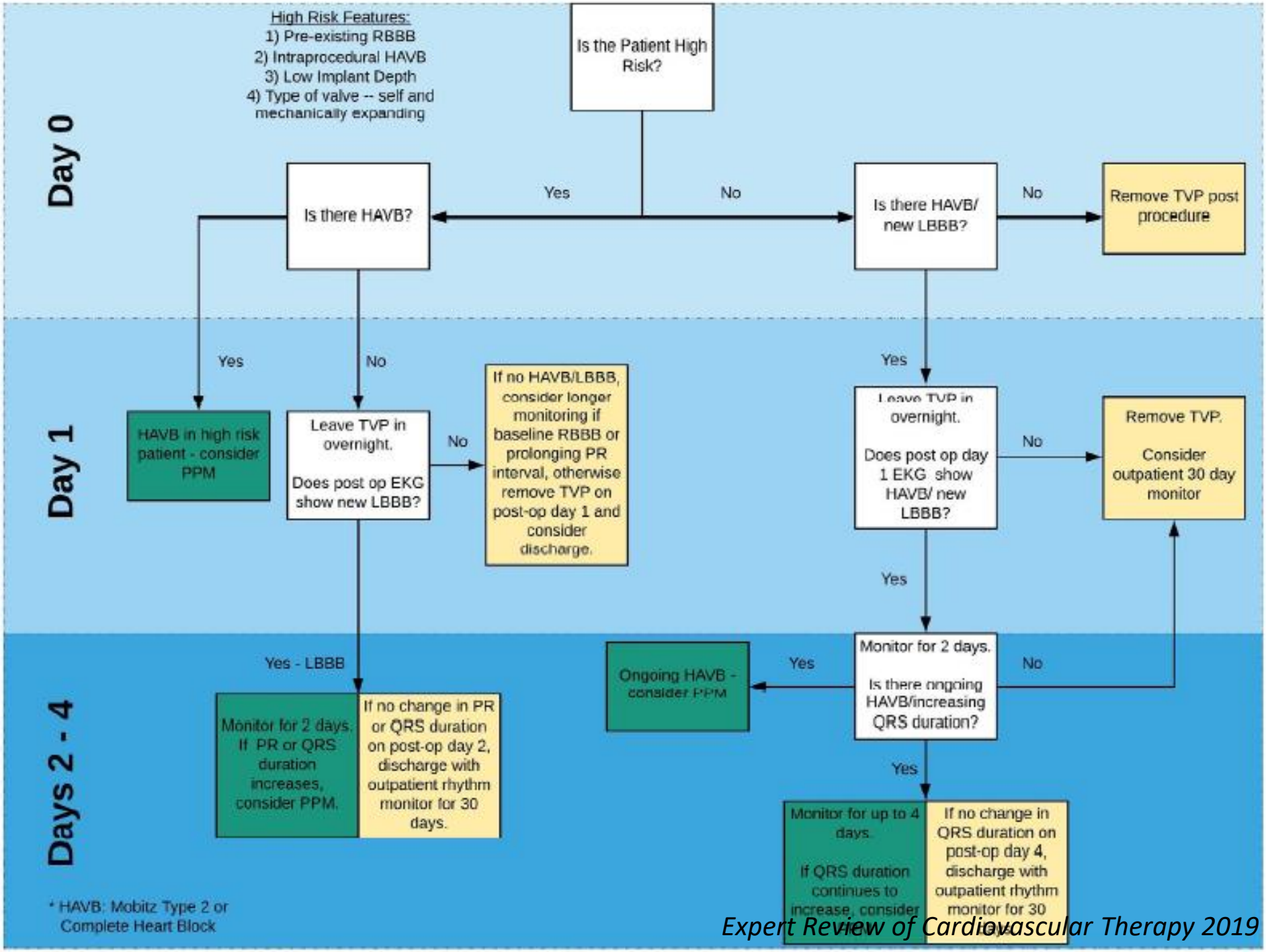


Figure 3 Risk of heart failure hospitalization and permanent pacemaker implantation in patients with new-onset persistent left bundle branch block after transcatheter aortic valve replacement. (*A*) Risk of heart failure hospitalization according to the occurrence of new-onset persistent left bundle branch block after transcatheter aortic valve replacement.[1,2,5,8,9,11] (*B*) Risk of permanent pacemaker implantation according to the occurrence of



Expert Review of Cardiovascular Therapy 2019

Post-TAVR PPM concerns

- Possibility of Pacing induced CMP
- CHF admission ↑
- Increased mortality in ventricular pacing rate >40%

→ Conduction system pacing/CRT upgrade if needed

Post-TAVR LBBB concerns

- Possibility of dys-synchrony induced CMP
- Possibility of SCD d/t progression of AVB
- CHF admission ↑
- Increased mortality

→Continue rhythm monitoring??

(ILR with remote monitoring?)

Summary

- After TAVR, **emphasis in rhythm monitoring is placed on identifying high risk patients** for PPM and for **mo nitoring** with **long term EKG (upto daily 30 days or ILR?).**

***High risk patients** are patients with

-pre-existing intraventricular conduction delay,

-pre-existing right bundle branch block,

-self-expandable valves

-predilation

-post TAVR new onset LBBB/HAVB