ΔΙΑΡΑΡΑΧΕΣ ΡΥΘΜΟΥ ΚΑΙ ΑΓΩΓΗΣ ΣΤΙΣ ΔΙΑΚΑΘΕΤΗΡΙΑΚΕΣ ΕΜΦΥΤΕΥΣΕΙΣ ΑΟΡΤΙΚΩΝ ΒΑΛΒΙΔΩΝ

Μέλανη Κωνσταντινίδου
Επιμ. Β καρδιολογίας
ΓΝ Παπαγεωργίου
1. Transcatheter aortic valve implantation (TAVI) is an attractive, minimally invasive alternative to surgical aortic valve replacement for patients with severe aortic stenosis and intermediate or greater surgical risk.

2. Electrical conduction disturbances and need for permanent pacemaker implantation (PPM) are frequent after TAVI, and imposes an important obstacle for early discharge after TAVI.

3. Conduction disturbances are more common with self-expanding and mechanically expanded transcatheter heart valves (THVs) compared to balloon-expandable valves.
Among patients undergoing transcatheter aortic valve replacement (TAVR) heart block occurs between 5 and 20% of cases and is partly dependent on depth of implantation, valve type, and native cardiac rhythm.

The deployed valves can cause direct damage to the HIS bundle and AV node leading to worsening conduction, either transiently or permanently.
Conduction dynamics after transcatheter aortic valve implantation (TAVI) in terms of quantitative change in QRS-duration predict need for a permanent pacemaker in patients with normal baseline conduction.

Absence of QRS-dynamics may justify safe early discharge.

In patients with newly acquired QRS-prolongation after TAVI longer telemetric monitoring is warranted as opposed to those with stable normal QRS-duration.

In patients with conduction disturbances before TAVI, high degree atrioventricular block and need for a permanent pacemaker occur irrespective of QRS-dynamics, and thus QRS-dynamics should be disregarded in those patients.

Europace (2018)
Computed Tomography Predictors of Mortality, Stroke and Conduction Disturbances in Women Undergoing TAVR: A Sub-Analysis of the WIN-TAVI Registry

- Moderate or severe LVOT calcification was an independent predictor of 1-year mortality or stroke (HR = 1.91; 95% CI: 25 1.11 - 3.30; p=0.02)
- Calcium volume in the right coronary cusp was an independent predictor of new pacemaker (HR=1.18 per 100 m3 increment; p=0.04)
- Calcium volume of the non-coronary cusp had a protective effect (HR=0.78 per 100 mm3 increment; p=0.004)
- Severe calcification of the non-coronary/right-coronary commissure was an independent predictor of new AF (HR=5.1; p=0.008)

*Journal of Cardiovascular Computed Tomograph*
One-Year Follow-Up of Conduction Abnormalities After Transcatheter Aortic Valve Implantation With the SAPIEN 3 Valve

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Long-term evolution of new-onset conduction abnormalities and need of permanent pacemaker implantation (PPI) after transcatheter aortic valve implantation (TAVI) have not been extensively evaluated. We describe the incidence and time course of new conduction abnormalities and the rate of PPI with the new-generation transcatheter aortic valve prosthesis Edwards SAPIEN 3 (S3). In total, 266 patients with severe aortic stenosis who underwent TAVI were retrospectively analyzed. Twelve-lead electrocardiograms at baseline, after TAVI, at discharge, at 1-, 6-, and 12-month follow-up were evaluated to identify conduction abnormalities and PPI requirements to investigate the correlates of PPI. After TAVI, a significant increase in PR interval duration and in QRS complex width was observed. New-onset left bundle branch block was observed in 65 patients (24%) after TAVI. The number of patients with left bundle branch block was maximum at hospital discharge and decreased at 12-month follow-up (39% and 32%, respectively). Thirty-five patients (13%) required PPI during the follow-up. However, paced rhythm was only observed in 7% of the patients with a complete 12-month follow-up. Patients who underwent PPI had a higher prevalence of first-degree atrioventricular block, complete right bundle branch block, and wider QRS complex at baseline. Baseline right bundle branch block and QRS width immediately after TAVI were the only variables independently associated with PPI. In conclusion, conduction disorders have a temporary nature after TAVI and showed a trend toward stabilization during the following months. With this new-generation device, the incidence of new conduction abnormalities requiring PPI is relatively low. © 2019 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license. (http://creativecommons.org/licenses/by-nc-nd/4.0/) (Am J Cardiol 2019;00:1–7)
OBJECTIVES The authors sought to determine: 1) the global arrhythmic burden; 2) the rate of arrhythmias leading to a treatment change; and 3) the incidence of high-degree atrioventricular block (HAVB) at 12-month follow-up in patients with new-onset persistent left bundle branch block (LBBB) following transcatheter aortic valve replacement (TAVR).

BACKGROUND Controversial data exist on the occurrence of significant arrhythmias in patients with LBBB post-TAVR.

METHODS This was a multicenter prospective study including 103 consecutive patients with new-onset persistent LBBB post-TAVR with the balloon-expandable SAPIEN XT/3 valve (n = 53), or the self-expanding CoreValve/Evolut R system (n = 50). An implantable cardiac monitor (Reveal XT, Reveal Linq) was implanted at 4 (3 to 6) days post-TAVR, and patients had continuous electrocardiogram monitoring for 12 months. All arrhythmic events were adjudicated in a central electrocardiography core lab. Primary endpoints were the incidence of arrhythmias leading to a treatment change, and the incidence of HAVB at 12-month follow-up.

RESULTS A total of 1,553 new arrhythmic events were detected in 44 patients (1,443 episodes of tachyarrhythmia in 26 patients [atrial fibrillation/flutter/atrial tachycardia: 1,427, ventricular tachycardia 16]; 110 episodes of bradyarrhythmia in 21 patients [HAVB 54, severe bradycardia 56]). All arrhythmic events were silent in 34 patients (77%), the arrhythmic event led to a treatment change in 19 patients (18%), and 11 patients (11%) required pacemaker or implantable cardioverter-defibrillator implantation (due to HAVB, severe bradycardia, or ventricular tachycardia episodes in 9, 1, and 1 patient, respectively). A total of 12 patients died at 1-year follow-up, 1 from sudden death.

CONCLUSIONS A high incidence of arrhythmic events was observed at 1-year follow-up in close to one-half of the patients with LBBB post-TAVR. Significant bradyarrhythmias occurred in one-fifth of the patients, and PPM was required in nearly one-half of them. These data support the use of a cardiac monitoring device for close follow-up and expediting the initiation of treatment in this challenging group of patients. (Ambulatory Electrocardiographic Monitoring for the Detection of High-Degree Atrio-Ventricular Block in Patients With New-onset PerSistent LEft Bundle Branch Block After Transcatheter Aortic Valve Implantation [MARE study]: NCT02153307) J Am Coll Cardiol Intv 2018;© 2018 by the American College of Cardiology Foundation.
The Present and Future

JACC Scientific Expert Panel

Management of Conduction Disturbances Associated With Transcatheter Aortic Valve Replacement

JACC Scientific Expert Panel

Josep Rodés-Cabau, MD, Kenneth A. Ellenbogen, MD, Andrew D. Krahn, MD, Azeem Latib, MD, Michael Mack, MD, Suneet Mittal, MD, Guillem Muntané-Carol, MD, Tamim M. Nazif, MD, Lars Søndergaard, MD, Marina Urena, MD, Stephan Windecker, MD, François Philippon, MD
Although successive iterations in transcatheter heart valve systems along with increasing experience of the heart teams have translated into a reduction of the majority of periprocedural complications and death, the occurrence of conduction disturbances:

- i.e., high-degree Atrioventricular block [HAVB]
- complete heart block [CHB]) requiring permanent Pacemaker Implantation (PPM)
- new-onset left bundle branch block [LBBB])

has not decreased over time and remains the most frequent shortcoming of the procedure.

Circulation 2017

Eur Heart Journal 2018
LACK OF CONSENSUS ON THE MANAGEMENT OF THIS COMPLICATION

MAJOR DIFFERENCES BETWEEN CENTERS AND STUDIES

- IN PPM RATES post-TAVR, even with the use of similar THV systems
- PRE-PROCEDURAL ARRHYTHMIC RISK EVALUATION,
- MANAGEMENT OF NEW-ONSET LBBB,
- TIMING AND INDICATION FOR PPM in patients with periprocedural HAVB/CHB,
- the management of patients with PRIOR CONDUCTION DISTURBANCES such as right bundle branch block (RBBB).

- Differences in the management of conduction disturbances can have MAJOR CONSEQUENCES IN THE HOSPITALIZATION LENGTH AND COSTS OF THE TAVR PROCEDURE and AFFECT CLINICAL OUTCOMES.
CENTRAL ILLUSTRATION: Strategy Algorithm Proposal for the Management of Patients With Conduction Disturbances Post-Transcatheter Aortic Valve Replacement

TAVR Candidate

Pre-procedural risk evaluation of conduction disturbances
Procedural aspects to minimize the risk of conduction disturbances

Procedural telemetry and 12-lead (6-lead) ECG at the end of the procedure

No ECG changes
No pre-existing RBBB

No temporary pacing
Telemetry for 24 hrs (or at least overnight)

No ECG changes
Pre-existing RBBB

ECG changes
- Further ECG changes in the presence of prior conduction disturbances
- New-onset LBBB
- HAVB/CHB

Temporary pacing for 24 hrs (or at least overnight)*

No further evaluation/observation

Further evaluation/observation (temporary pacing, EP studies, continuous ECG monitoring)

PPM

*Consider earlier discontinuation of temporary pacing if regression of ECG changes in <24 h (except for pre-existing RBBB).

The presence of RBBB

➢ the strongest and most consistent risk factor,
➢ leading to an increased risk of PPM of at least 3 to 47 times
➢ an increased risk of early and late mortality following TAVR

The presence of first-degree AVB

➢ an increased risk (4 to 11 times) of HAVB in some studies

The presence of pre-procedural LBBB or left anterior hemiblock

➢ risk factors for HAVB/CHB and PPM post-TAVR,

Anatomical factors by computed tomography

➢ (membranous septum length, calcium volume, noncoronary cusp device-landing zone calcium volume)
### TABLE 1 Conduction Disturbances After TAVR: Definitions

<table>
<thead>
<tr>
<th>Definition</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conduction tissue abnormalities (infra nodal block) definitions</strong> (9,10)</td>
<td></td>
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<tr>
<td><strong>RBBB</strong></td>
<td>• QRS duration ≥120 ms.</td>
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<td></td>
<td>• rs’r, rs’Sr, rs’Sr’, or rarely a qR in leads V₁ or V₂. The R’ or r’ deflection is usually wider than</td>
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<td>the initial R-wave.</td>
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<td></td>
<td>• In a minority of patients, a wide and often notched R wave pattern may be seen in lead V₁</td>
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<tr>
<td></td>
<td>and/or V₂.</td>
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<tr>
<td></td>
<td>• S-wave of greater duration than R-wave or ≥40 ms in leads I and V₆.</td>
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<tr>
<td></td>
<td>• Normal R peak time in leads V₅ and V₆ but peak R-wave ≥50 ms in lead V₁.</td>
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<tr>
<td><strong>LBBB</strong></td>
<td>• QRS duration ≥120 ms.</td>
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<tr>
<td></td>
<td>• Broad notched or slurred R-wave in leads I, aVL, V₅, and V₆ and an occasional RS pattern</td>
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<td>in V₅ and V₆ attributed to displaced transition of QRS complex.</td>
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<td></td>
<td>• Absent Q waves in leads I, V₅, and V₆, but in the lead aVL, a narrow Q-wave may be present in the</td>
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<tr>
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<td>absence of myocardial pathology.</td>
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<td></td>
<td>• R peak time ≥60 ms in leads V₅ and V₆ but normal in leads V₁, V₂, and V₃, when small initial R</td>
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<td>waves can be discerned in the precordial leads.</td>
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<td></td>
<td>• ST and T waves usually opposite in direction to QRS.</td>
</tr>
<tr>
<td><strong>Left anterior hemiblock</strong></td>
<td>• QRS duration &lt;120 ms.</td>
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<tr>
<td></td>
<td>• Frontal plane axis between −45° and −90°.</td>
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<tr>
<td></td>
<td>• qR pattern in lead aVL.</td>
</tr>
<tr>
<td></td>
<td>• R-peak time in lead aVL of ≥45 ms.</td>
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<tr>
<td><strong>Left posterior hemiblock</strong></td>
<td>• rS pattern in leads II, III, and aVF.</td>
</tr>
<tr>
<td><strong>Nonspecific intraventricular conduction disturbance with QRS interval ≥120 ms</strong></td>
<td>QRS interval duration ≥120 ms where morphology criteria for RBBB or LBBB are not present.</td>
</tr>
</tbody>
</table>

### Atroventricular block definitions (9,10)

**First-degree atroventricular block**

- P waves associated with 1:1 atrioventricular conduction and a PR interval >200 ms.
- HAVB is defined as any of the following:
  - Second-degree AV block type 2 (Mobitz II) in the presence of a QRS ≥120 ms.
  - 2:1 AV block in the presence of a QRS ≥120 ms.
  - 3:2 consecutive P waves at a constant physiologic rate that do not conduct to the ventricles.
  - Transient third-degree AV block.
  - In the setting of AF, a prolonged pause (>3 s) or a fixed slow (<50 beats/min) ventricular response rate.

**Third-degree atroventricular block (CHB)**

- P waves with a constant rate with dissociated ventricular rhythm (no association between P waves and R waves) or fixed slow ventricular rhythm in the presence of atrial fibrillation.

### Periprocedural conduction abnormalities according to time apporition

- **Procedural HAVB/CHB**: Any HAVB/CHB episode occurring during the TAVR procedure (before the patient leaves the procedure room).
- **Delayed HAVB/CHB**: Any HAVB/CHB episode occurring after the TAVR procedure (any HAVB/CHB occurring after the patient has left the procedure room).
- **New-onset conduction disturbances post-TAVR**: Any conduction disturbance that occurs in the periprocedural TAVR period (procedure + hospitalization period).
- **New-onset persistent conduction disturbances**: Any conduction disturbance that occurs during the periprocedural TAVR period (procedure + hospitalization period) and persists at hospital discharge (or until day 7 post-TAVR in case of prolonged hospitalization).
• advanced age of most TAVR candidates
• the presence of calcific aortic stenosis
• one-third of the patients requiring PPM post-TAVR exhibited episodes of HAVB/CHB or severe bradycardia diagnosed by 24-h continuous ECG monitoring pre-TAVR
• Longer periods (1 to 4 weeks) of ECG monitoring pre-TAVR.

Implementation of the appropriate therapies (i.e., PPM or changes in medical therapy) before the procedure

Reduce both the global rate of PPM post-TAVR hospitalization length.
PROCEDURAL CONSIDERATIONS

BALLOON VALVULOPLASTY

pre-dilation before the implantation of the THV
an increased risk of conduction disturbances

THV type

VALVE POSITIONING

higher (more aortic) valve positioning is associated with a lower risk of conduction disturbances post-TAVR
implantation depth >5 to 7 mm = an increased risk of new-onset LBBB and need for PPM post-TAVR
**FIGURE 1** Pre-Procedural and Procedural Aspects Regarding Conduction Disturbances in TAVR Recipients

**TAVR Candidate**

**Pre-Procedural Evaluation**
- Risk evaluation of conduction disturbances (RBBB)
- Consider continuous ECG monitoring (≥24 hrs)

**Procedural Aspects**
- Continuous ECG monitoring during the procedure
- Venous access / Temporary pacemaker
- Consider avoiding pre-dilation
- Consider a valve type with lower risk of conduction disturbances in high-risk patients (e.g. RBBB)
- Aim to minimize depth of valve implantation

**Procedural telemetry and 12-lead (6-lead) ECG at the end of the procedure**

**Group 1**
No ECG changes in patients without RBBB pre-procedure

**Group 2**
No ECG changes in patients with pre-existing RBBB

**Group 3**
ECG changes (persistent increase of PR or QRS duration ≥20 ms) in patients with pre-existing RBBB, LBBB, IVCD with QRS ≥120 ms or 1st degree AVB

**Group 4**
New-onset LBBB

**Group 5**
HAVB/CHB during the procedure
**Group 1**
No ECG changes in patients *without* RBBB pre-procedure

Temporary pacemaker removal at the end of the procedure and telemetry for 24 hrs (or at least overnight)

Bradyarrhythmia or new conduction disturbances

- **No**
  - Hospital discharge at day 1 post-TAVR

- **Yes**
  - See strategies for Groups 3-5
Group 2
No ECG changes in patients with pre-existing RBBB

Maintain temporary pacemaker for 24 hrs (or at least overnight)

HAVB/CHB

PPM

No ECG changes or bradyarrhythmias

Remove temporary pacemaker; continue telemetry and daily ECG for 1 day

ECG changes (increase ≥20 ms in PR or QRS duration)

See management strategies for Group 3

HAVB/CHB

PPM

No arrhythmias or ECG changes at day 2

Hospital discharge at day 2 post-TAVR

ECG changes (increase ≥20 ms in PR or QRS duration)

See management strategies for Group 3
**Group 3**

ECG changes (persistent increase of PR or QRS duration ≥ 20 ms) in patients with pre-existing conduction disturbances (RBBB, LBBB, IVCD with QRS ≥ 120 ms, 1st degree AVB)

Maintain temporary pacemaker for 24 hrs (or at least overnight)
The occurrence of HAVB/CHB any time during the hospitalization period would be an indication for PPM

Regression of ECG changes (to baseline values, irrespective of QRS/PR interval duration)  
OR  
No further ECG changes and QRS ≤ 150 ms and PR ≤ 240 ms

Remove temporary pacemaker; continue telemetry and daily ECG for 1 day*

No further ECG changes  
No bradycardias

Hospital discharge at day 2 post-TAVR

Further ECG changes (increase ≥ 20 ms PR or QRS)  
OR  
No further changes and QRS > 150 ms or PR > 240 ms

Maintain temporary pacemaker for 24 hrs

Regression of ECG changes (to baseline values, irrespective of QRS/PR interval duration)  
OR  
No further ECG changes with QRS ≤ 150 ms and PR ≤ 240 ms

No further ECG changes  
Higher risk of HAVB/CHB†

Higher risk of HAVB/CHB†

*Consider earlier discontinuation of temporary pacing and discharge at day 1 post-TAVR if regression of ECG changes in <24 h (except for RBBB).
†Consider: 1) invasive EPS to guide the decision about PPM; 2) continuous ECG monitoring; 3) PPM (not in patients with PR > 240 ms but QRS < 120 ms).
**FIGURE 5** Strategy Algorithm Proposal for the Management of Patients With New-Onset LBBB Post-TAVR

**Group 4**
New-onset LBBB

- Maintain temporary pacemaker for 24 hrs (or at least overnight)*

**HAVB/CHB**

- PPM

- LBBB resolution or no further ECG changes
  - Remove temporary pacemaker; continue telemetry and daily ECG for 1 day
    - No arrhythmias or ECG changes at day 2
      - LBBB resolution
        - Hospital discharge at day 2 post-TAVR*
      - LBBB with QRS ≤150 ms and PR ≤240 ms
        - Hospital discharge at day 2 post-TAVR†
      - LBBB with QRS >150 ms or PR >240 ms
        - Higher risk of HAVB/CHB‡

- Further ECG changes (change in PR and/or QRS duration)
  - Maintain temporary pacemaker for 24 hrs
    - Further ECG changes (change in PR and/or QRS duration)
      - HAVB/CHB
      - PPM

*Consider earlier discontinuation of temporary pacing along with hospital discharge at day 1 if partial/complete resolution of LBBB in <24 h.
†Consider continuous ECG monitoring at hospital discharge.
‡Consider: 1) invasive EPS to guide the decision about PPM; 2) continuous ECG monitoring at hospital discharge; 3) PPM.
**FIGURE 6** Strategy Algorithm Proposal for the Management of Patients With HAVB (Transient or Persistent) During the TAVR Procedure

**Group 5**
HAVB/CHB (transient or persistent) during the procedure

- Maintain temporary pacemaker for 24 hrs (or at least overnight)*

  - Persistent or recurrent HAVB/CHB
    - PPM
  - HAVB/CHB resolution, no recurrent HAVB/CHB
    - Remove temporary pacemaker; continue telemetry and daily ECG for 1 day
      - HAVB/CHB recurrence
        - No
          - ECG with conduction abnormalities
            - No
              - Hospital discharge at day 2 post-TAVR†
            - Yes
              - See management strategies Groups 1-4
        - Yes
          - PPM

*Consider earlier discontinuation of temporary pacing if very brief procedural episode of HAVB/CHB and normal ECG (no conduction disturbances).
†Consider hospital discharge at day 1 if very brief procedural episode of HAVB/CHB and normal ECG.
The high incidence and variety of conduction disturbances post-TAVR represents a major challenge in the periprocedural management of TAVR recipients.

The large variability in the management of these complications has translated into a high degree of uncertainty regarding the most appropriate treatment of a large proportion of such patients.

A more uniform practice regarding the management of conduction disturbances post-TAVR is needed.

This may help to improve both the management and clinical outcomes of the complex group of patients with conduction disturbances associated with TAVR.
Σας ευχαριστώ για την προσοχή σας
The vicinity of the atrioventricular His-bundle to the aortic valve contributes to the risk for conduction disturbances and PPM after aortic valve replacement in general and TAVI in particular.

- balloon-expandable TAVI is associated with more stable QRS duration,
- up to 40% of patients are no longer pacemaker dependent during follow-up.
stable normal QRS-duration, transient QRS-prolongation, and persistent QRS-prolongation

patients with newly acquired QRS prolongation after TAVI require longer telemetric monitoring than those with stable normal QRS duration and if persistent they have a high need for PPM

in patients with pre-existing conduction disturbances before TAVI, high degree AVB, and PPM occur irrespective of QRS dynamics

QRS prolongation typically peaks within 1 day after TAVI,

(v) balloon-expandable TAVI is associated with more stable QRS duration, and

(vi) up to 40% of patients are no longer pacemaker dependent during follow-up.

Three distinct patterns of QRS dynamics can be identified after TAVI: