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ORIGINAL RESEARCH

STRUCTURAL

Pacing Using Cardiac Implantable Electric Device During TAVR

10-Year Experience of a High-Volume Center

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ABSTRACT

BACKGROUND Transcatheter aortic valve replacement (TAVR) is an effective and safe therapy for severe aortic stenosis. Rapid or fast pacing is required for implantation, which can be performed via a pre-existing cardiac implantable electric device (CIED). However, safety data on CIEDs for pacing in TAVR are missing.

OBJECTIVES The aim of this study was to elucidate procedural safety and feasibility of internal pacing with a CIED in TAVR.

METHODS Patients undergoing TAVR with a CIED were included in this analysis. Baseline characteristics, procedural details, and complications according to Valve Academic Research Consortium 3 (VARC-3) criteria after TAVR were compared between both groups.

RESULTS A total of 486 patients were included. Pacing was performed using a CIED in 150 patients and a transient pacemaker in 336 patients. No differences in technical success according to VARC-3 criteria or procedure duration occurred between the groups. The usage of transient pacers for pacing was associated with a significantly higher bleeding rate (bleeding type ≥2 according to VARC-3-criteria; 2.0% vs 13.1%; $P < 0.01$). Furthermore, impairment of the CIED appeared in 2.3% of patients after TAVR only in the group in which pacing was performed by a transient pacer, leading to surgical revision of the CIED in 1.3% of all patients when transient pacemakers were used.

CONCLUSIONS Internal pacing using a CIED is safe and feasible without differences of procedural time and technical success and might reduce bleeding rates. Furthermore, pacing using a CIED circumvents the risk of lead dislocation. Our data provide an urgent call for the use of a CIED for pacing during a TAVR procedure in general. (J Am Coll Cardiol Intv 2024;17:1020–1028) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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Transcatheter aortic valve replacement (TAVR) is an established, safe, and effective treatment for patients with severe symptomatic aortic stenosis (AS).[1-6] Although many innovations in valve design, delivery systems, and procedural aspects occurred during the last 10 years of TAVR treatment, 1 essential step of TAVR procedure is rapid or fast pacing during valvuloplasty and valve deployment. During this crucial step of valve deployment, when the risk of annulus rupture and prosthesis dislocation is highest, the aim of rapid or fast pacing is to compromise the hemodynamic situation with reduction of cardiac filling and ejection time, resulting in no cardiac output. This allows balloon stability during positioning and inflation in the correct position, with the possibility of returning to normal electrical and hemodynamic cardiac conditions immediately after ending pacing.[7] Usually, pacing is performed with a transient pacemaker introduced into the right ventricle via venous access at the beginning of the TAVR procedure. The pacing rate depends on the valve type; a self-deploying prosthesis should be implanted under fast pacing (120 beats/min), and balloon-deploying prostheses should be implanted under rapid pacing (180 beats/min).[8] In this paper, the term pacing is used to describe rapid and fast pacing. The usage of transient right ventricular pacemakers is associated with complications such as myocardial injury,[9,10] right ventricular dysfunction,[11,12] and right ventricular perforation with possible tamponade.[13,14]

To avoid complications, different strategies were followed; a promising novel technique is pacing via the left ventricle using the valve delivery guidewire.[13,15-18] The main advantage of left ventricular pacing is the avoidance of venous access and right ventricular perforation. When patients already have a cardiac implantable electrical device (CIED), it is obvious to use the permanent device for pacing to avoid those complications. However, transient right ventricular pacing leads are often installed regardless of a CIED to perform pacing during the TAVR procedure in daily clinical practice. The aim of our study was to elucidate if internal pacing during TAVR with a permanent CIED is safe and to evaluate the development of pacing with a CIED over the years, the practical feasibility, and the influences on the TAVR procedure.

METHODS

STUDY POPULATION. All consecutive patients with a CIED treated with transfemoral TAVR for severe symptomatic AS in our center between 2013 and 2022 were included in this analysis. The choice of using a CIED for pacing was at the operator's discretion. Baseline characteristics and procedural data were documented according to local quality control requirements and part of the EVERY-VALVE registry, as described previously.[19] Data collection was in line with the Declaration of Helsinki and was approved by the local ethics committee (project number 19-840).

TAVR PROCEDURE. In all patients, the TAVR procedure was performed under conscious sedation and via the transfemoral approach. To reflect real-world treatment strategies, all available prostheses types were included in the analysis including balloon-expandable valves (Edwards SAPIEN XT and S3, Edwards Lifesciences), self-expandable valves (CoreValve E, Evolut R, and Evolut Pro, Medtronic, and ACURATE neo, Boston Scientific), and mechanically expandable/repositionable valves (Lotus valve system, Boston Scientific, and JenaValve, JenaValve Technology). During the procedure, heparin or bivalirudin was applied for antithrombotic treatment and either dual antiplatelet therapy with acetylsalicylic acid (lifelong) and clopidogrel (for 3 months) or oral anticoagulation (if indicated by comorbidities) was prescribed for antithrombotic management after TAVR. If percutaneous coronary intervention (PCI) had been performed, current guidelines were followed for an antithrombotic therapy regimen.[20] The documentation of procedural details and complications was performed according to the Valve Academic Research Consortium-3 (VARC-3) criteria.[21] After the procedure, the access site was closed by suture-mediated closure systems, and manual compression was performed in the catheterization laboratory by interventionalists. The venous access catheter used for the insertion of a temporary pacer remained until the effect of heparin/bivalirudin diminished and was removed at bedside on the ward followed by manual compression.

STATISTICAL ANALYSIS. Continuous variables are presented as median (IQR). Categoric variables are presented as counts (%). Normality was tested with the Shapiro-Wilk test. Differences between study groups were analyzed with the Pearson chi-square test or the Mann-Whitney *U* test as appropriate. The results are shown as OR (95% CI) and *P* values; a P value < 0.05 was considered statistically significant. Significant parameters in univariate analysis were

ABBREVIATIONS AND ACRONYMS

AS = aortic stenosis

CIED = cardiac implantable electric device

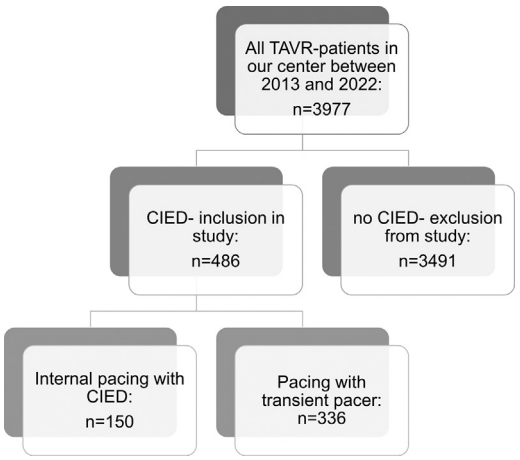
CRT = cardiac resynchronization therapy

PCI = percutaneous coronary intervention

TAVR = transcatheter aortic valve replacement

VARC-3 = Valve Academic Research Consortium-3

FIGURE 1 Study Flowchart



All patients who underwent transcatheter aortic valve replacement (TAVR) in our center in the years 2013 until 2022 were screened for a cardiac implantable electric device (CIED); 12.2% of the patients were included in the analysis because they had a CIED before the TAVR procedure. Those 486 patients were divided into 2 groups depending on the type of pacing; in 150 patients, pacing was performed internally with a CIED, and in 336 patients pacing was performed with a transient pacer.

included in the multivariate analysis. Statistical analysis was conducted using SPSS software, version 25.0.0.1 (IBM Corp).

RESULTS

PATIENT COHORT. All consecutive patients treated with transfemoral TAVR for severe symptomatic AS in our institution between 2013 and 2022 were screened for the pre-existence of a CIED. Of 3,977 patients undergoing TAVR in those years, 486 had a CIED at the time of the procedure. The study flowchart is depicted in Figure 1. The type of CIED was a single-chamber pacemaker (26.7%), a dual-chamber pacemaker (56.5%), or a cardiac resynchronization therapy (CRT) pacemaker (2.9%). Implantable cardioverter-defibrillators were single chamber (4.9%), dual chamber (4.3%), and CRT (4.7%). Distribution of the manufacturers and models is provided in Supplemental Table 1. All patients with a CIED were analyzed and divided into 2 groups depending on whether pacing was performed with a CIED ("internal pacing," n = 150) or a transient pacemaker (n = 336) inserted through the femoral vein despite the presence of a CIED. Comparing baseline characteristics, patients with internal pacing had a significantly lower Society of Thoracic Surgeons risk score (3.0 [Q1-Q3: 2.1-6.0] vs 4.0 [Q1-Q3: 2.9-7.1]; $P < 0.01$) and a smaller aortic valve opening area (0.7 cm^2 [Q1-Q3: 0.6-0.8 cm^2] vs 0.8 cm^2 [IQR: 0.6-0.8 cm^2]; $P < 0.01$). There were significant differences in the frequency of cardiovascular risk factors with a higher rate of diabetes (66 [44.0%] vs 106 [31.5%]; $P < 0.01$]), hypercholesterinemia (121 [80.7%] vs 229 [68.2%]; $P < 0.01$), and active or former smoking (60 [40.0%] vs 94 [28.0%]; $P < 0.01$) in the internal pacing group. However, coronary artery disease (64 [56.0%] vs 263 [78.3%]; $P < 0.01$) and a history of PCI (46 [30.7%] vs 141 [42.0%]; $P = 0.02$) were significantly lower in the internal pacing group. In the internal pacing group, significantly more patients had a prior bioprosthesis when TAVR was performed as a valve-in-valve procedure (26 [17.3%] vs 27 [8.0%]; $P < 0.01$). All baseline characteristics are shown in Table 1.

DEVELOPMENT OF INTERNAL PACING OVER TIME. When compared depending on the year of TAVR procedure, it can be seen that pacing with a CIED was performed more frequently in the last years. Although until 2017 pacing with a CIED was performed only occasionally (in 2013 and 2015, there was only 1 patient; in 2014 and 2016, only 2 patients; and in 2017, no patient at all), it became more frequent since 2018 (6 patients in 2018, 9 patients in 2019, 28 patients in 2020, 40 patients in 2021, and 61 patients in 2022), as shown in Figure 2.

PROCEDURAL DETAILS. To compare procedural duration and radiation time, patients undergoing PCI in the same procedure were excluded, so data were not confounded by PCI procedure. There were no significant differences in procedure duration (39.0 [Q1-Q3: 32.0-49.0] minutes in the internal pacing with a CIED group vs 40.0 [Q1-Q3: 30.0-50.0] minutes in the pacing with a transient pacemaker group; $P = 0.07$) or radiation time (10.2 [Q1-Q3: 8.1-14.5] minutes in the internal pacing with a CIED group vs 10.3 [Q1-Q3: 8.4-13.5] minutes in the pacing with a transient pacemaker group; $P = 0.32$) of the TAVR procedure between groups. Predilatation (53.3% in the internal pacing with a CIED group vs 61.6% in the pacing with a transient pacemaker group; $P = 0.06$) and postdilatation (8.0% in the internal pacing with a CIED group vs 6.3% in the pacing with a transient pacemaker group; $P = 0.47$) rates were statistically comparable. Valve distribution was also significantly different between both groups, with less balloon-expandable valves in the internal pacing with a

TABLE 1 Baseline Characteristics

	Total Population (N = 486)	Internal Pacing (n = 150)	Pacing With Transient Pacemaker (n = 336)	*P* Value
Age, y	82.0 (78.0-86.0)	82.0 (78.0-85.3)	83.0 (78.0-86.0)	0.44
Sex				0.83
Male	308 (63.4)	94 (62.7)	214 (63.7)	
Female	178 (36.6)	56 (37.3)	122 (36.3)	
STS score	4.0 (2.5-7.0)	3.0 (2.1-6.0)	4.0 (2.9-7.1)	<0.01
BMI, kg/m^2	25.4 (23.1-28.2)	24.6 (22.6-28.3)	25.7 (23.4-28.2)	0.40
Type of CIED				0.11
VVI pacemaker	130 (26.7)	32 (21.3)	98 (29.2)	
DDD pacemaker	274 (56.5)	92 (61.3)	182 (54.2)	
CRT pacemaker	14 (2.9)	1 (0.7)	13 (3.8)	
CRT defibrillator	23 (4.7)	7 (4.7)	16 (4.7)	
VVI defibrillator	24 (4.9)	9 (6.0)	15 (4.5)	
DDD defibrillator	21 (4.3)	9 (6.0)	12 (3.6)	
Aortic valve mean gradient, mm Hg	30.0 (22.0-40.0)	30.0 (22.0-41.0)	30.0 (22.0-40.0)	0.90
Aortic valve opening area, cm^2	0.8 (0.6-0.9)	0.7 (0.6-0.8)	0.8 (0.6-0.9)	<0.01
LVEF, %				0.19
Normal, ≥50%	293 (60.3)	102 (68.0)	191 (56.8)	
Slightly impaired, 40%-49%	52 (10.7)	16 (10.7)	36 (10.8)	
Moderately impaired, 31%-39%	88 (18.1)	19 (12.7)	69 (20.5)	
Severely impaired, <30%	53 (10.9)	13 (8.6)	40 (11.9)	
Cardiovascular risk factors				
History of				
Hypercholesterinemia	350 (72.0)	121 (80.7)	229 (68.2)	<0.01
Hypertension	455 (93.6)	138 (92.0)	317 (94.3)	0.33
Smoking	154 (31.7)	60 (40.0)	94 (28.0)	<0.01
Diabetes	172 (35.4)	66 (44.0)	106 (31.5)	<0.01
Positive family history for vascular disease	68 (14.0)	26 (17.3)	42 (12.5)	0.11
Renal function				
Impaired renal function, GFR <60 mL/min	278 (57.2)	80 (53.3)	198 (58.9)	0.40
Dialysis	23 (4.7)	4 (2.7)	19 (5.7)	0.17
Coronary artery disease	347 (71.4)	64 (56.0)	263 (78.3)	<0.01
History of				
PCI	187 (38.5)	46 (30.7)	141 (42.0)	0.02
CABG	63 (13.0)	15 (10.0)	48 (14.3)	0.50
Myocardial Infarction	75 (15.4)	18 (12.0)	57 (17.0)	0.50
Prior bioprosthesis	53 (10.9)	26 (17.3)	27 (8.0)	<0.01

Values are median (Q1-Q3) or n (%).

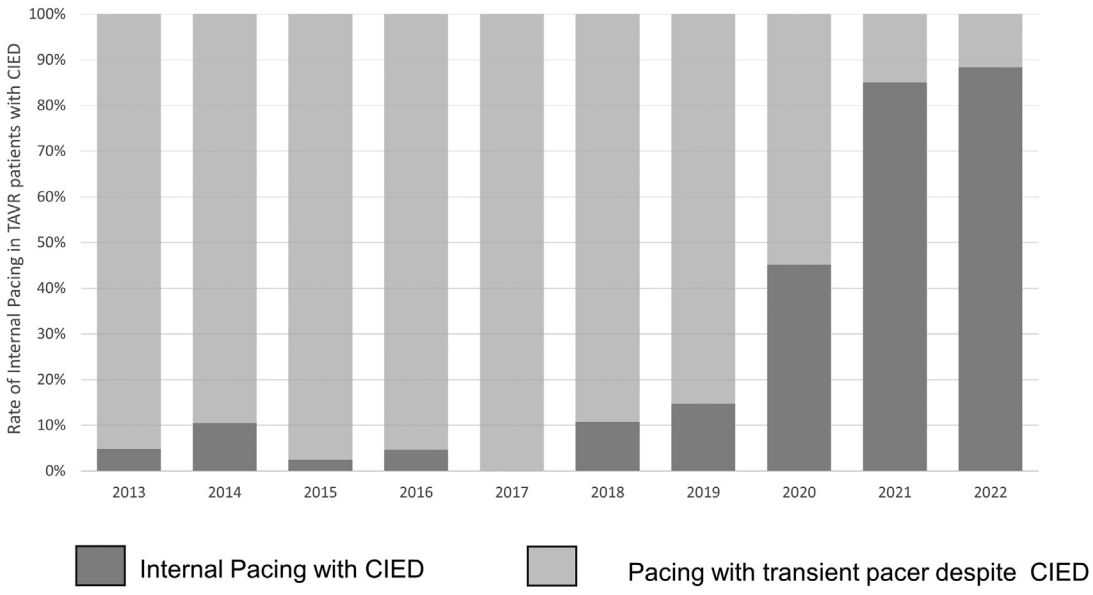
BMI = body mass index; CABG = coronary artery bypass graft; CIED = cardiac implantable electric device; CRT = cardiac resynchronization therapy; DDD = dual-chamber antibradycardia (pacer/defibrillator); GFR = glomerular filtration rate; LVEF = left ventricular ejection fraction; PCI = percutaneous coronary intervention; STS = Society of Thoracic Surgeons; VVI = single-chamber antibradycardia.

CIED group (57.3% vs 72.2%; $P < 0.001$). For the exact distribution of the different prosthesis types and procedural details, refer to Table 2.

PROCEDURAL OUTCOME. Technical success according to VARC-3 criteria was very high in both groups (internal pacing vs transient pacemaker; 96.7% vs 97.9%; $P = 0.96$). Procedural complications are depicted in Table 3. Cardiac structural complications according to VARC-3 criteria were rare (0.8%) and occurred only in the transient pacemaker group (0% vs 1.2%; $P = 0.18$). Bleeding type ≥2 according to VARC-3 criteria was significantly lower in the internal pacing group (2.0% vs 13.1%; $P < 0.01$) with an OR in univariate regression analysis of 7.3 (95% CI: 2.2-23.9) and an adjusted OR of 6.8 (95% CI: 1.9-25.0) after adjustment for the year of implantation and PCI during TAVR.

In the transient pacemaker group, 2.3% of the patients had complications with their CIED, whereas in

FIGURE 2 Development of Internal Pacing by Years



The rate of internal pacing with a CIED depends on the year of the TAVR procedure. Since 2018, it has become more frequent, and nowadays it is the predominant way of pacing in patients with a CIED. Abbreviations as in Figure 1.

the internal pacing group no measurable relevant differences in CIED function (ie, stimulation threshold, impedance, sensing, or battery capacity) occurred. In one-half of the affected patients (4 patients [1.15%]), lead concerns were so serious that immediate surgical revision of the pacemaker/defibrillator lead was inevitable; in 3 patients, capture loss of right ventricular pacing lead occurred, and in 1 patient the defibrillating lead showed relevant artifact entrance sensing, as shown in Supplemental Table 2.

TABLE 2 Procedural Details

	Total Population (N = 486)	Internal Pacing With CIED (n = 150)	Pacing With Transient Pacemaker (n = 336)	*P* Value
Prosthesis type				<0.01
SAPIEN	330 (67.9)	87 (58.0)	243 (72.3)	
CoreValve	86 (17.7)	43 (28.7)	43 (12.8)	
Accurate Neo	50 (10.3)	18 (12.0)	32 (9.5)	
Lotus	19 (3.9)	2 (1.3)	17 (5.1)	
JenaValve	1 (0.2)	0	1 (0.3)	
Duration, min[a]	40.0 (30.0-50.0)	39.0 (32.0-49.0)	40.0 (30.0-50.0)	0.07
Radiation time, min[a]	10.3 (8.2-14.1)	10.2 (8.1-14.5)	10.3 (8.4-13.5)	0.32
PCI during TAVR	59 (12.1)	12 (8.0)	47 (14.0)	0.06
Predilatation	287 (59.1)	80 (53.3)	207 (61.6)	0.06
Postdilatation	33 (6.8)	12 (8.0)	21 (6.3)	0.47

Values are n (%) or median (Q1-Q3). [a]Patients undergoing PCI in the same procedure were excluded from the analysis of procedure duration, radiation time, and amount of contrast; 427 patients underwent only the TAVR procedure without PCI (88.9%). In 137 patients, rapid pacing was performed internally with a CIED, whereas in 290 patients rapid pacing was performed with a transient pacemaker during TAVR.

TAVR = transcatheter aortic valve replacement; other abbreviations as in Table 1.

DISCUSSION

This is the first study to systematically investigate the impact of internal pacing on event rates and procedural success on a huge cohort treated with TAVR. In a preliminary work, Jones et al[22] reported 28 valve procedures, including TAVR, balloon aortic valvuloplasty, and mitral valve-in-valve, in which a CIED was used effectively for pacing. Internal pacing is feasible with most CIEDs. However, some difficulties, which are predominantly of organizational nature, might occur. During the TAVR procedure, a manufacturer-specific CIED programmer is needed, and the operator in charge of pacing must be trained in programming options of CIEDs. Programming options differ depending on the manufacturer as well as the device type (pacemaker, defibrillator, or CRT); therefore, operators need profound and specific knowledge. Consequently, concerns about the feasibility of internal pacing might keep interventionalists

TABLE 3 Procedural Complications

	Total Population (N = 486)	Internal Pacing With CIED (n = 150)	Pacing With Transient Pacemaker (n = 336)	OR (95% CI)	*P* Value
Technical success according to VARC-3	474 (97.5)	145 (96.7)	329 (97.9)	0.62 (0.19-1.98)	0.96
Cardiac structural complications according to VARC-3	4 (0.8)	0	4 (1.2)	0.25 (0.01-4.59)	0.18
Major vascular complications according to VARC-3	18 (2.5)	8 (5.3)	10 (3.0)	1.84 (0.71-4.75)	0.20
Bleeding type ≥2 according to VARC-3	47 (9.7)	3 (2.0)	44 (13.1)	0.14 (0.04-0.44)	<0.01

Values are n (%) unless otherwise indicated.
CIED = cardiac implantable electric device; VARC-3 = Valve Academic Research Consortium-3.

from practical implementation but should be cleared out by this study. The following key findings can be summed up:

Pacing with CIEDs during TAVR procedure is feasible and safe with no measurable negative effects on procedural time and technical success. The comparability of procedural times might be an effect of growing experience in the context of a steadily increasing number of procedures with internal pacing, and, by now, internal pacing is used nearly entirely during TAVR in our high-volume single-center TAVR collective (as seen in **Figure 2**).

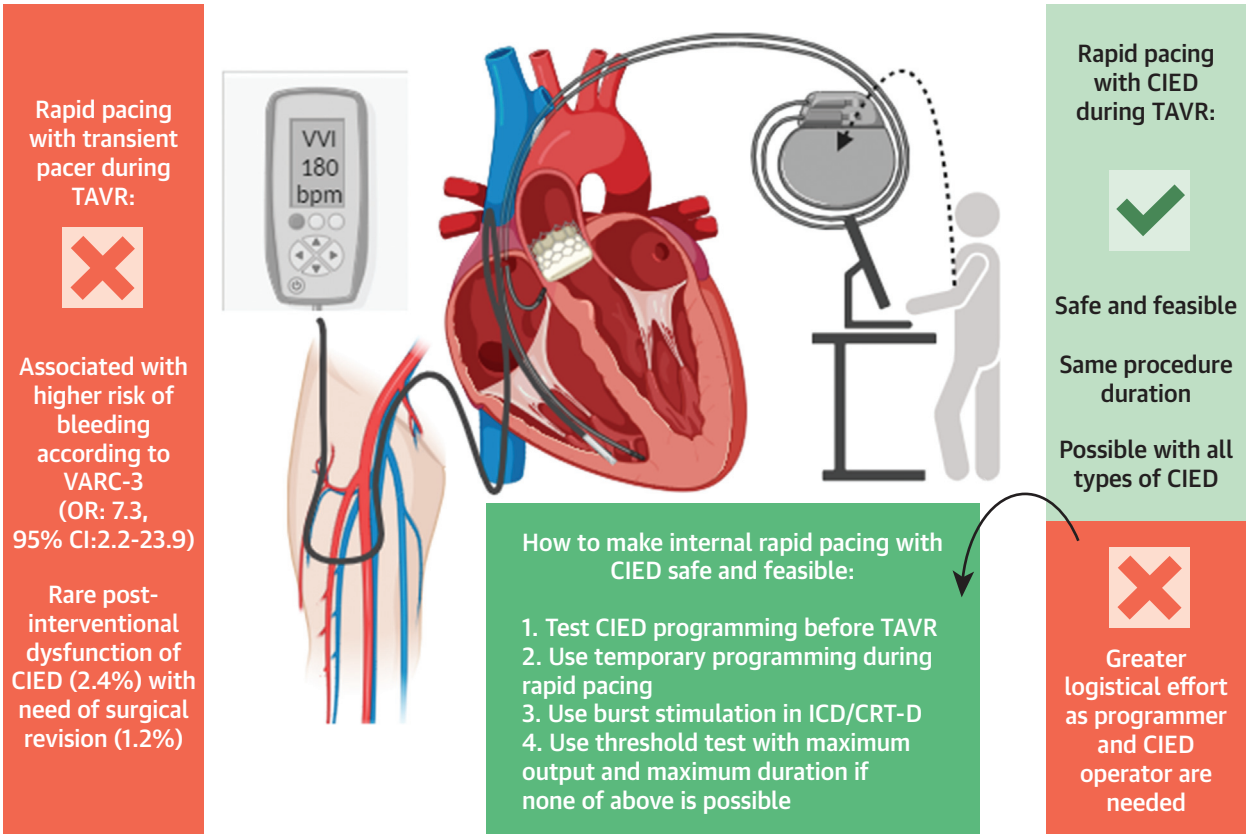
If a CIED was not used for internal pacing, the patient is put at an avoidable risk of functional deterioration of the CIED with the need for immediate surgical revision of the CIED leads. In our cohort, one-half of the affected patients needed surgical revision of CIED systems within the index hospitalization. Clearly, this increases the overall risk for complications during TAVR procedures because loss of capture in pacemaker-dependent patients may be a lethal complication.

Overall bleeding complications, especially relevant bleedings classified as type ≥2 according to VARC-3 criteria, occurred more frequently after TAVR when a transient pacemaker was used. This might be interpreted as a consequence of the omission of venous femoral access in patients with internal pacing. This finding must be interpreted in the context of technical evolution because the rate of patients with internal pacing rose during the last 3 years with 90% internal pacing in 2022, whereas it was used rather sporadically in earlier years. Within this large time span, closure devices became more elaborated and reliable.[23-25] Moreover, vascular access site devices became smaller following smaller diameters and more flexible introduction devices for TAVR systems. However, multivariate regression analysis still showed a significant impact of internal pacing on bleeding complications after the adjustment for year of implantation. To avoid confounding by PCI-related bleedings that might result from stronger antiplatelet therapy after PCI, bleeding rates were additionally adjusted for concomitant PCI during TAVR. Fortunately, most of the bleeding events in this analysis were type 2 VARC-3 bleedings, which are defined by a hemoglobin drop >3 g/dL but <5 g/dL or the requirement of transfusion of 2 to 4 U of hemoglobin concentrates. Although clinically relevant, these rather mild bleedings might often be caused by venous access site bleedings that remain unnoticed more often than arterial access site bleeding, which are prevented by the usage of closure systems and exact manual compression by experienced interventionalists.

Serious procedural adverse events such as cardiac structural complications according to VARC-3 criteria were numerically lower in patients using internal pacing. The cause of cardiac structural complications (eg, pericardial effusion) is difficult to attribute in our retrospective cohort; nevertheless, it has been shown that a transient right ventricular pacemaker might account for this complication.[13,14] It is obvious that synchronized stable stimulation, which can be achieved by a CIED with a stable pacing threshold in a higher quality than with a transient pacer, might affect TAVR positioning in a positive way and could thereby influence procedural outcomes such as relevant TAVR regurgitation. In addition, with better sensing options of CIEDs, the risk of causing life-threatening ventricular arrhythmia either mechanically or caused by undersensing is minimized.

To achieve a high level of safety during internal pacing, we recommend planning a CIED control before TAVR when best options for programming of pacing can be checked without fear of extending procedural times. Furthermore, the CIED programmer operator is more flexible and can join the TAVR

CENTRAL ILLUSTRATION **Using Cardiac Implantable Electric Device for Pacing During TAVR**



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CIED = cardiac implantable electric device; CRT-D = cardiac resynchronization therapy defibrillator; ICD = implantable cardioverter-defibrillator; TAVR = transcatheter aortic valve replacement; VARC-3 = Valve Academic Research Consortium-3; VVI = single-chamber antibradycardia pacing.

procedure only for the crucial moment of pacing. To optimize internal pacing during the TAVR procedure, we recommend being familiar with the programming options for different modes and frequency of stimulation for pacing. Refer to Supplemental Figures 1 to 5 for examples of possible programming options in CIEDs of different manufacturers. Whenever possible, use temporary programming during pacing because it allows pacing without changes in permanent programming and can be turned on and off easily. If the CIED does not support temporary programming, another option to achieve pacing is to use burst stimulation in an ICD or CRT defibrillator. This modality can be found in an electrophysiology program and allows controlled pacing for the needed time span. Make sure to use right ventricular burst stimulation at high output for a safe capture of pacing. Especially in pacemakers, where an electrophysiology program is not available in all models, the only possibility for pacing might be stimulation via a threshold test with maximum output and maximum duration. Alternatively, the permanent programming of CIEDs might be changed if none of the options are available. Clearly, this is the less desired option because many changes in the programming of CIEDs need to be done. The stimulation mode has to be changed to single-chamber antibradycardia pacing, and other details (eg, deactivating of the R mode and the upper rate limit) have to be taken into account to unlock the

high frequencies needed for rapid or fast pacing. This requires good CIED programming skills and experience, but this also is more time-consuming than the previous recommended options. In the end, it is always required to ensure that changes in programming are reversed and individually optimized.

STUDY LIMITATIONS. With this study, data on internal pacing during TAVR with CIEDs are provided for the first time. However, some limitations must be considered when interpreting the results. First, this was a retrospective, single-center analysis. Furthermore, the TAVR routine changed remarkably over the study period, and not all changes and their impact on outcome after TAVR can be acknowledged by this analysis. It is similar when it comes to patient selection. Although TAVR used to be a bailout strategy for old and inoperable patients, it is an alternative to surgical procedure for relatively younger and fitter patients. This change over the years results in slight differences in baseline characteristics between both groups. Finally, the decision on using CIEDs for pacing was left to the interventionalists' preference. This possible selection bias may explain slight differences in baseline characteristics between the groups.

CONCLUSIONS

Internal pacing in TAVR is safe and feasible without differences in procedural time and success. The use of internal pacing was associated with lower rates of relevant bleeding according to VARC-3 criteria. Furthermore, potentially fatal dislocation of pacing/defibrillator leads of CIEDs can be avoided when pacing is performed by a CIED. Our findings encourage the general use of internal pacing in TAVR as the standard to minimize patients' procedural risk (**Central Illustration**).

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PERSPECTIVES

WHAT IS KNOWN? Rapid or fast pacing during a TAVR procedure is usually performed via a transvenous pacer even if patients already have a CIED.

WHAT IS NEW? Internal pacing with CIEDs is safe and feasible because it decreases the risk of dislocation of CIED leads and is associated with a lower risk of bleeding complications and serious procedural adverse events.

WHAT IS NEXT? To use internal pacing with a CIED in a safe and feasible way, a CIED check before a TAVR procedure is needed to identify device and manufacturing special features usable for pacing. Temporary programming of the CIED for pacing provides the simplest and most flexible operation mode and should be preferred. Alternatively, the burst stimulation mode in an implantable cardioverter-defibrillator or a threshold test with maximum output and maximum duration in pacemakers can be used.

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APPENDIX For supplemental tables and figures, please see the online version of this paper.