

Brief report

Atrioventricular Conduction Disturbances After CoreValve® Aortic Prosthesis Implantation. Predictive Role of Transesophageal Echocardiography

Carlos Almería Valera,^{a,*} Alberto de Agustín Loeches,^a Rosa Ana Hernández-Antolín,^b Eulogio García Fernández,^b Leopoldo Pérez de Isla,^a Cristina Fernández Pérez,^c Carlos Macaya Miguel,^a and Jose Luis Zamorano Gómez^a

^aUnidad de Imagen Cardiovascular, Hospital Clínico San Carlos, Madrid, Spain

^bUnidad de Hemodinámica, Instituto Cardiovascular, Hospital Clínico San Carlos, Madrid, Spain

^cUnidad de Apoyo a la Investigación, Servicio de Medicina Preventiva, Hospital Clínico San Carlos, Madrid, Spain

Article history:

Received 20 February 2011

Accepted 28 August 2011

Available online 22 October 2011

Keywords:

Percutaneous valvular prosthesis

Echocardiography

Conduction disorder

Pacemaker

Palabras clave:

Prótesis valvular percutánea

Ecocardiografía

Trastorno de conducción

Marcapasos

ABSTRACT

Atrioventricular conduction disorders can appear after the implantation of percutaneous aortic CoreValve® prostheses in patients requiring permanent pacemakers (40%-45% of these patients). The aim of our study was to detect if 2- or 3-dimensional echocardiographic variables could predict the appearance of atrioventricular conduction disorders. For this purpose, the relationship of the prosthesis with the interventricular septum was studied in 26 consecutive patients. Twelve patients (46.1%) developed atrioventricular conduction disorders. A prosthetic penetration >12 mm in the left ventricular outflow tract and a contact surface >90% between the interventricular septum and the stent of the prosthesis in diastole were strongly associated with the appearance of conduction disturbances (87.5%; $P=0.034$). The percentage of the prosthetic stent in contact with the interventricular septum in end diastole was the only independent predictor of atrioventricular conduction disorders (odds ratio=1.12; 95% confidence interval, 1.01-1.25; $P=0.03$). The results suggest that a higher implantation of the prosthesis and a reduced stent length might decrease the incidence of this complication.

© 2011 Sociedad Española de Cardiología. Published by Elsevier España, S.L. All rights reserved.

Trastornos de conducción auriculoventricular tras implantación de prótesis aórtica CoreValve®. Papel predictivo de la ecocardiografía transesofágica

RESUMEN

Tras el implante de prótesis percutánea aórtica CoreValve®, pueden aparecer trastornos de conducción auriculoventricular que precisan marcapasos permanente (un 40-45% de los pacientes). El objetivo de nuestro estudio es detectar si alguna variable ecocardiográfica de 2 o 3 dimensiones podría predecir la aparición de trastornos de conducción auriculoventricular. Para ello se estudió en 26 pacientes consecutivos la relación de la prótesis con el septo interventricular; 12 pacientes (46,1%) presentaron trastornos de conducción auriculoventricular tras el procedimiento. Una penetración protésica en el tracto de salida del ventrículo izquierdo > 12 mm y una superficie de contacto del *stent* de la prótesis con el septo interventricular en diástole > 90% se asociaron fuertemente con la aparición de trastornos de conducción auriculoventricular (87,5%; $p = 0,034$). La superficie de contacto del *stent* resultó ser el único predictor independiente de dicha complicación (*odds ratio* = 1,12; intervalo de confianza del 95%, 1,01-1,25; $p = 0,03$). Los resultados indican que la implantación más alta de las prótesis y la reducción de la longitud del *stent* podrían reducir la frecuencia de esta complicación.

© 2011 Sociedad Española de Cardiología. Publicado por Elsevier España, S.L. Todos los derechos reservados.

INTRODUCTION

The implantation of aortic biological prostheses using a percutaneous approach is an alternative to conventional surgical techniques for aortic valve stenosis in high-risk patients.¹ The CoreValve® prosthesis (Medtronic-Corevalve™, LLC; Minneapolis, Minnesota, United States) is one of the devices used for this purpose. The characteristics of the native valve, perivalvular

tissues, and the prosthesis to be implanted can all influence the success of the procedure.² The diameter of the aortic valve ring is an essential parameter in the selection of the size of the prosthesis, and the left ventricle outflow tract (LVOT) is less important. The configuration of the CoreValve® prosthesis and implantation technique require that a portion of the valve stent remain lodged in the LVOT (Fig. 1). After the implantation of this type of prosthesis, atrioventricular conduction disorders (AVCD) frequently arise, requiring the placement of a permanent pacemaker (approximately 40% of patients).³⁻¹⁰

The aim of our study was to detect 2D and 3D transesophageal echocardiography (TOE) parameters associated with the development of AVCD in the 48 h following implantation of the CoreValve

* Corresponding author: Unidad de Imagen Cardiovascular, Servicio de Cardiología, Instituto Cardiovascular, Hospital Clínico San Carlos, Martín Lagos s/n, 28040, Madrid, Spain.

E-mail address: calmeria.hcsc@salud.madrid.org (C. Almería Valera).

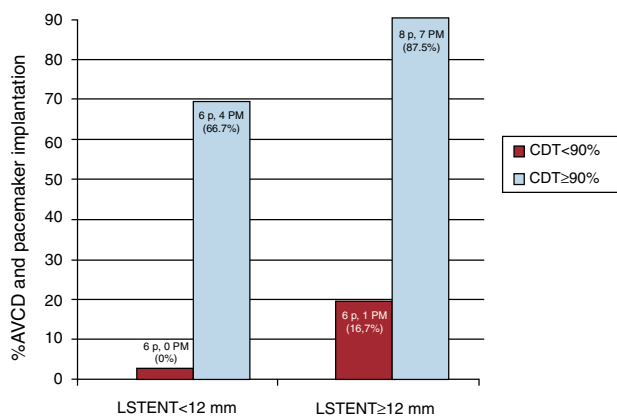


Figure 1. Incidence of atrioventricular conduction disorders and pacemaker implantations based on LSTENT and %CDT. AVCD, atrioventricular conduction disorder; CDT, percentage of the prosthetic stent in contact with the interventricular septum in end diastole; LSTENT, length of the prosthetic stent installed in the left ventricle outflow tract from the aortic ring; PM, pacemaker.

percutaneous aortic prosthesis, especially considering the relationship of the prosthesis with the basal portion of the interventricular septum (IVS), since this is the area in which the primary vessels can be damaged by the prosthetic stent.¹

METHODS

Between 14 August 2008 and 30 October 2010, CoreValve[®] percutaneous aortic prostheses were implanted in 35 patients in our hospital (San Carlos Clinical Hospital, Madrid). The hospital's Hemodynamic Department selected the patients and type of prosthesis.¹⁰ Patients who already had a pacemaker (n=5) or who died within the first 48 h after surgery (n=4) due to causes other than AVCD were excluded from the study, leaving 26 patients for the analysis. Patients signed consent forms to undergo surgery and authorized the use of their data for research purposes.

All patients were monitored during the procedure using Philips iE33 TOE equipment and a Live 3D TOE probe. The images were digitally recorded in the Xcelera system and processed using Qlab software for 3D images (Philips Electronics, Eindhoven, Netherlands). We used 2D, color Doppler, Xplane[®] biplane, and 3D techniques, choosing the appropriate technique and approach in each individual case for the observation and control of the valve implantation process (aortic valvuloplasty, valve ring-prosthesis alignment, prosthesis deployment, and immediate post-implantation control using 120°–140° views or the Xplane technique at 40°–120°). The following echocardiographic measurements were given special attention: a) length of the prosthetic stent installed in the LVOT from the aortic ring (LSTENT); b) septal contractility prior to implantation, defined as the percentage of IVS incursion into the LVOT in end systole (%IVS); and c) the percentage of the prosthetic stent installed in the LVOT in contact with the IVS in end systole (%CST) and end diastole (%CDT). We measured the penetration and contact zones of the stent (LSTENT, %CST, and %CDT) using 2D TOE in 120°–140° views, offering the best possible view of the LVOT and the prosthetic stent. Using multiple 3D TOE views, we checked for correct placement of the prosthesis immediately following implantation. The %IVS expresses the reduction in LVOT produced by IVS contraction. The %CST and %CDT were obtained by measuring the portion of the stent in contact with the IVS in end systole and end diastole, and are expressed as percentages, with 100% corresponding to complete contact between the IVS and

the stent lodged in the LVOT both in systole and diastole. We studied the appearance of AVCD and permanent pacemaker implants within the first 48 h after the procedure.

Statistical Analysis

Qualitative variables were described as relative frequency, and quantitative variables as mean (standard deviation) or median [interquartile range] in the case of asymmetry. The differences between groups were analyzed using Student t test for quantitative variables and the chi-square test for qualitative variables. We also assessed the interaction between independent variables (%IVS, LSTENT, %CST, and %CDT) to determine if the combined variation of 2 variables modified the studied effect. To evaluate the predictive power of this interaction on AVCD and pacemaker implantation, we categorized quantitative variables by their medians. We performed a multivariate logistic regression in order to detect independent variables in the appearance of AVCD. We analyzed interobserver variability in the measurements made by 2 cardiologists highly experienced in the echocardiographic techniques used, applying kappa indexes. We used SPSS 15.0 (SPSS Inc., Chicago, Illinois, United States) for all statistical analyses.

RESULTS

Mean patient age was 82.8 (6) years, and 15 (57.6%) of them were women. The principal results are summarized in Table 1. The %CDT was associated with the appearance of AVCD after the

Table 1
Characteristics of the Two Groups According to Implantation or Not of a Pacemaker Following the Procedure

	No PM	With PM	P
Patients	14 (53.9%)	12 (46.1)	
Age, year	83±7.1	82.5±4.9	.930
Women	8 (57.1)	7 (58.3)	.820
LVEF, %	63.9±11.5	67.8±10	.470
Mean gradient	52.8±12.9	46.8±13	.420
Mitral ring calcium	14 (100)	13 (100)	1
IVS, cm	1.5±2.8	1.6±1.1	.910
LVOT	18±1.7	18±2.3	.980
LSTENT, mm	10.3±5	13.5±5.1	.100
%IVS	15±9.1	13.9±7.3	.680
%CST	73±37	91.9±27.7	.140
%CDT	52±34.5	89.2±27.3	.005
Normal ECG	12 (85.7)	7 (58.3)	.210
LBB ECG	1 (7.1)	1 (8.3)	.820
RBB ECG	0	1 (7.6)	.520
HMB ECG	1 (7.1)	2 (16.7)	.520
IAVB ECG	0	1 (8.3)	.700
EuroSCORE	18.3±8.3	18.6±7.5	.900
No. 26 CoreValve	12 (85.7)	9 (75)	.210
No. 29 CoreValve	2 (14.2)	3 (25)	.260

%CDT, percentage of the prosthetic stent in contact with the IVS in end diastole; %CST, percentage of the prosthetic stent in contact with the IVS in end systole; %IVS, percentage excursion of the IVS into the LVOT in end systole; HMB, hemiblock; IAVB, first-degree atrioventricular block; ECG, electrocardiogram; IVS, interventricular septum; LBB, left branch block; LSTENT, length of the prosthetic stent installed in the LVOT from the aortic ring; LVEF, left ventricle ejection fraction; LVOT, left ventricle outflow tract; PM, pacemaker; RBB, right branch block. Data are expressed as n (%) or mean ± standard deviation.

procedure. There were also correlation trends between AVCD and LSTENT, although these values were not statistically significant. The analysis of interactions between the different independent variables showed an added value for the association of %CDT and LSTENT (Fig. 1). There were no AVCD in 6 patients with %CDT<90% and LSTENT<12 mm; these did occur in 1 of 6 patients (17%) with %CDT<90% and LSTENT≥12 mm, 4 of 6 (67%) with %CDT≥90% and LSTENT<12 mm, and 7 of 8 (87.5%) with %CDT≥90% and LSTENT≥12 mm ($P=.034$). In the septal contractility study (%IVS), there was no apparent association with the appearance of AVCD. The multivariate analysis (Table 2) suggested that %CDT was the only independent predictor of AVCD (odds ratio: 1.12; 95% confidence interval, 1.01-1.25; $P=.03$). The interobserver variability was $\kappa=0.71$.

DISCUSSION

The appearance of AVCD is a frequent complication^{4-6,9,10} following the implantation of CoreValve® percutaneous aortic

Table 2

Multivariate Logistic Regression Analysis for the Study of Predictive Variables for Atrioventricular Conduction Disorders Following the Procedure

	OR (95% CI)	P
Age	0.94 (0.74-1.18)	.62
Ejection fraction	1.06 (0.83-1.35)	.60
Mean gradient	0.87 (0.70-1.07)	.20
LVOT diameter	0.59 (0.13-2.67)	.49
Prosthesis number	0.95 (0.43-2.09)	.90
LSTENT	1.22 (0.86-1.72)	.20
%CST	1.46 (0.83-2.56)	.20
%CDT	1.12 (1.01-1.25)	.03

%CDT, percentage of the prosthetic stent in contact with the IVS in end diastole; %CST, percentage of the prosthetic stent in contact with the IVS in end systole; 95% CI, 95% confidence interval; LSTENT, length of the prosthetic stent installed in the LVOT from the aortic ring; LVOT, left ventricle outflow tract; OR, odds ratio.

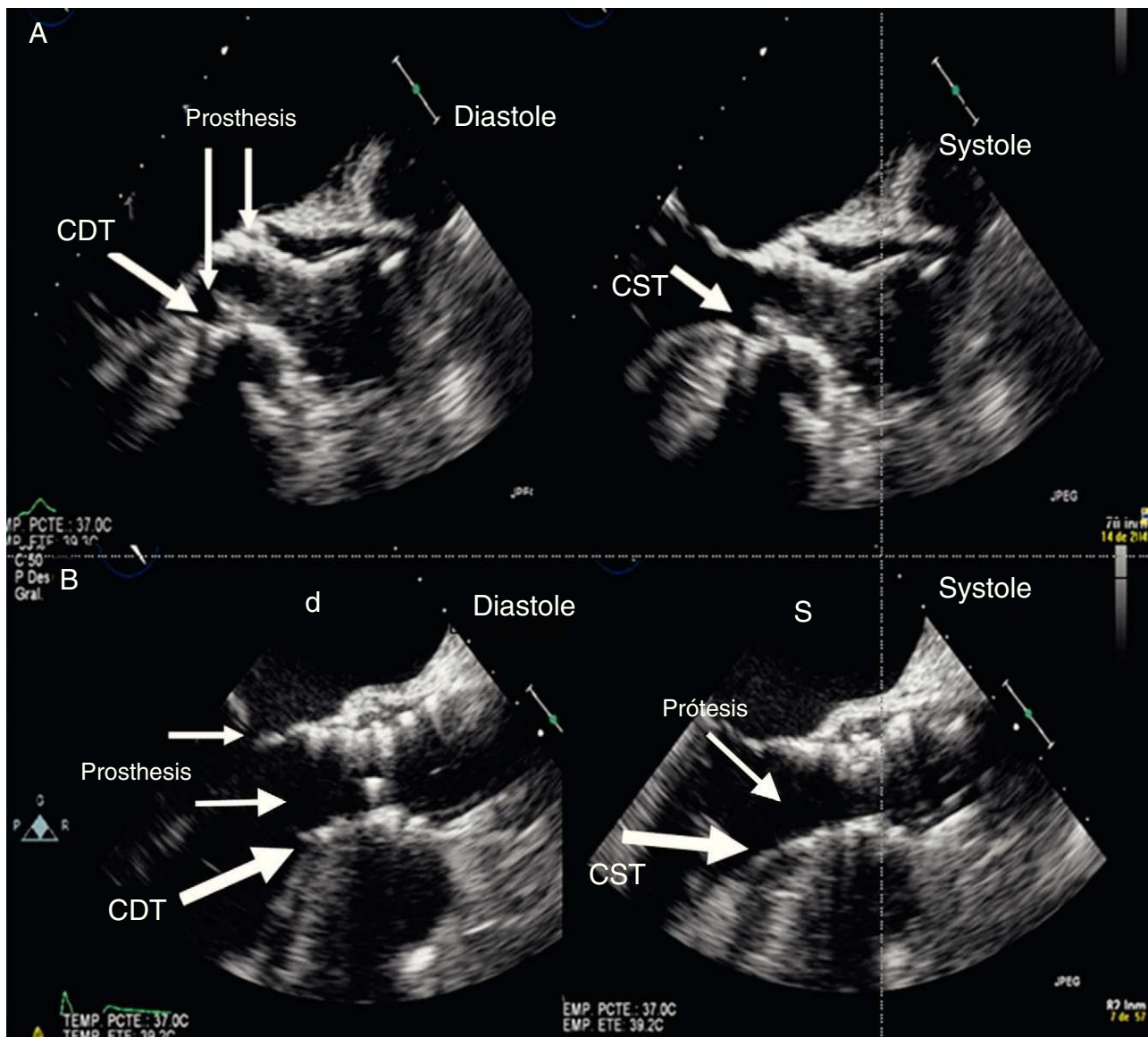


Figure 2. Contact surface between the interventricular septum and the prosthetic stent. A, patient with no contact. B, patient with contact in systole and slight contact in diastole. CDT, contact in diastole; CST, contact in systole.

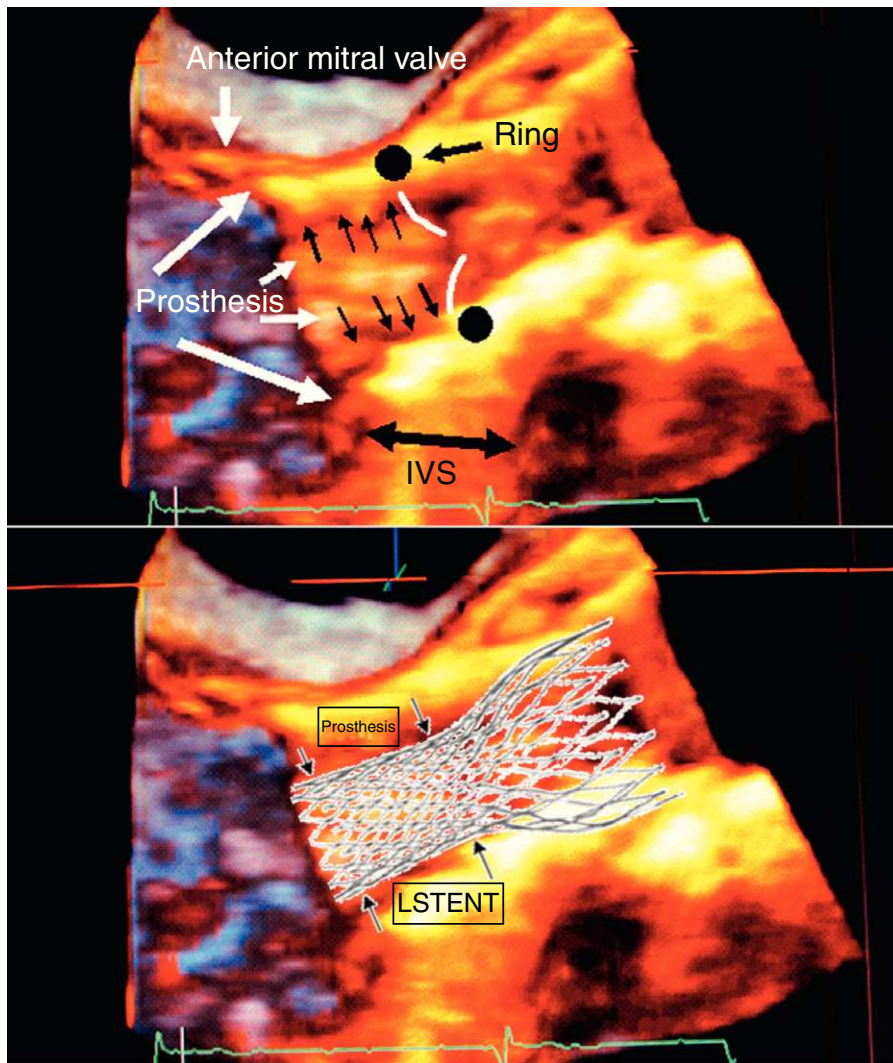


Figure 3. 3D transesophageal echocardiogram of a CoreValve® and diagram of the superimposition on the echocardiographic image. IVS, interventricular septum; LSTENT, protrusion of the prosthetic stent into the left ventricular outflow tract.

prostheses. The implantation process attempts to align the prosthesis as closely as possible with the native valve ring. Once the prosthesis is deployed, the prosthetic stent penetrates up to 17 mm into the LVOT (Figs. 2 and 3), according to the results obtained in our study. This causes contact between the stent and the underlying IVS to a varying extent. In this region, the distal portion of the bundle of His and the left branch are more superficial and vulnerable to compression.¹ Furthermore, these patients usually have hypertrophy of the basal portion of the IVS. The incidence of AVCD and need for pacemaker varies depending on the level of hypertrophy of the basal septum, its contractility, and the size of the prosthesis.^{4,5} The echocardiographic analysis shows the contact between the stent and the IVS both in diastole and systole. The extent of contact could explain the incidence of AVCD. In our study, %CDT was the best predictor of AVCD and the need for implanting a pacemaker, better than LSTENT, although the interaction between %CDT and LSTENT was strongly associated with the appearance of AVCD (Fig. 1). Septal contractility (%IVS) was not associated with the appearance of AVCD in our study. Based on our data, it appears that the level of contact between the IVS and the stent in diastole is more important. The results from our study could explain the lower number of patients requiring pacemakers after the implantation of an Edwards⁸ prosthesis, since the penetration into the LVOT and thus the contact with the

IVS are lower than with the CoreValve prosthesis. In our study, 3D TOE was a useful technique that facilitated the observation of the prosthesis, its relationship with the native aortic root, and also the configuration of the aortic root. However, it did not provide any advantages over 2D TOE in the measurement of the aortic ring, LVOT, LSTENT, CDS, or CDT, since these measurements cannot be made directly with 3D imaging and require offline analysis.

The primary limitation in this study was the inability to predict the appearance of AVCD before implanting the valve, since we could not estimate the portion of the stent that would remain in contact with the IVS. Another limitation was the small sample size, although we must keep in mind that this is a rare therapeutic procedure that is still under study. On the other hand, some of the AVCD that appeared in our study might have been resolved if given more time than that established by guidelines for implantation of a permanent pacemaker.

Our results suggest that broad contact between the IVS in diastole and the CoreValve® prosthetic stent, especially when associated with greater stent penetration into the IVS, is correlated with the appearance of AVCD and the need for a permanent pacemaker.

A higher implantation of the prosthesis and smaller stent size could reduce the incidence of these complications, although more studies are needed to confirm this hypothesis.

CONFLICT OF INTERESTS

None declared.

REFERENCES

1. Hernández-García JM, Muñoz-García AJ, Alonso-Briales JH, Jiménez-Navarro MF, Domínguez-Franco AJ, Rodríguez-Bailón I, et al. Tratamiento percutáneo de las bioprótesis aórticas disfuncionantes con la prótesis CoreValve®. *Rev Esp Cardiol*, 2011;64:155–8.
2. Piazza N, Jaegere P, Schultz C, Becker A, Serruys P, Anderson R. Anatomy of the aortic valvar complex and its implications for transcatheter implantation of the aortic valve. *Circ Cardiovasc Interv*, 2008;1:74–81.
3. Rubín JM, Avanzas P, Calvo D, Morís C. Bloqueo intrahisiano durante el implante de la prótesis aórtica percutánea CoreValve. *Rev Esp Cardiol*, 2011;64:168–9.
4. Moreno R, Dobarro D, López de Sa E, Prieto M, Morales C, Calvo Orbe L, et al. Cause of complete atrioventricular block after percutaneous aortic valve implantation: insights from a necropsy study. *Circulation*, 2009;120:e29–30.
5. Jilaihawi H, Chin D, Vasa-Nicotera M, Jeilam M, Spyt T, Ng GA, et al. Predictors for permanent pacemaker requirement after transcatheter aortic valve implantation with the CoreValve bioprosthesis. *Am Heart J*, 2009;157:860–6.
6. Avanzas P, Muñoz-García AJ, Segura J, Pan M, Alonso-Briales JH, Lozano I, et al. Implante percutáneo de la prótesis valvular aórtica autoexpandible CoreValve en pacientes con estenosis aórtica severa: experiencia inicial en España. *Rev Esp Cardiol*, 2010;63:141–8.
7. Bleiziffer S, Ruge H, Roer J, Hutter A, Geisbüsch S, Brockm G, et al. Predictors for new-onset complete heart block after transcatheter aortic valve implantation. *JACC Cardiovasc Interv*, 2010;3:524–30.
8. Baan J, Yong ZY, Koch KT, Henriques JP, Bouma BJ, Vis MM, et al. Factors associated with cardiac conduction disorders and permanent pacemaker implantation after percutaneous aortic valve implantation with the CoreValve prosthesis. *Am Heart J*, 2010;159:497–503.
9. Muñoz-García AJ, Hernández-García JM, Jiménez-Navarro MF, Alonso-Briales JH, Rodríguez-Bailón I, Peña-Hernández J, et al. Alteraciones de la conducción auriculoventricular y predictores de la necesidad de marcapasos tras el implante percutáneo de la prótesis aórtica de CoreValve. *Rev Esp Cardiol*, 2010;63:1444–51.
10. Hernández-Antolín RA, García E, Sandoval S, Almería C, Cuadrado A, Serrano J, et al. Resultado de un programa mixto de implantación de prótesis aórtica por vía transfemoral con los dispositivos de Edwards y CoreValve. *Rev Esp Cardiol*, 2011;64:35–42.