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Predictors of length of hospital stay and impact of a TAVI program on management and outcomes of patients undergoing transcatheter aortic valve implantation

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ABSTRACT

Background The number of transcatheter aortic valve implantation (TAVI) procedures in patients with severe aortic stenosis (AS) is increasing worldwide. We aimed to assess the impact of a TAVI program on clinical profile, management and outcomes of these patients and to describe predictors of length of hospital stay (LoS) in this context.

Methods Retrospective single center study enrolling consecutive AS patients undergoing TAVI and surviving to discharge (January 2018-December 2022). A TAVI program was implemented in may 2021. Baseline clinical characteristics, management and in-hospital complications were registered. Predictors of long hospital stay (> 7 day) were assessed by binary logistic regression.

Results We included 614 patients, with mean age 80.5 years. Most patients (438/614, 71.2%) presented conditions that precluded an early discharge. Mean hospital stay was 7.6 days. Patients admitted after the implementation of the program had a significantly lower burden of comorbidities. The rate of conduction disturbances after TAVI remained stable around 60%. However, permanent pacemaker requirement declined from 30.3% to 22.5% (P = 0.028). LoS was reduced after the implementation of the program both in patients suitable for an early discharge (from 6.5 day to 4 day, P < 0.001) and unsuitable patients (from 9.4 day to 7.7 day, P = 0.014). The final predictive model for LoS included prior pacemaker and availability of TAVI program as protectors and other valvular diseases, day of the week, emergent procedures, and conduction disturbances and other complications as independent predictors of long stay after TAVI.

Conclusions Most patients undergoing TAVI present conditions that preclude an early hospital discharge. The implementation of a TAVI program improved selection of patients, with a lower burden of comorbidities, a lower rate of complications and a marked reduction of hospital stay.

Aortic stenosis (AS) is the most common valvular disease in developed countries. Its incidence is growing because of the continuous ageing of population. Transcatheter aortic valve implantation (TAVI) has emerged as a first line therapy in AS patients at high risk of surgery,[1,2] and its indication is currently expanding to patients at intermediate[3] and low surgical risk.[4] Therefore, the number of TAVI procedures has significanlty increased during the last decade,[5] and its expected to keep growing during the upcoming years. In this sense, healthcare systems need to adapt to this changing environment and this new demand, optimizing care circuits and hospital stay.[6]

The change of the clinical profile of patients, along with the technological development of devices have contributed to reduce in-hospital complications and hospital stay in this setting. However, some structural variables of centers such as TAVI programs[7–9] may also contribute to optimize hospital stay and outcomes among AS patients undergoing TAVI. Information about predictors of hos-

pital stay in these patients is scarce.

The aim of this study was to assess trends of outcomes and hospital length of stay (LoS) and its predictors, as well as the impact of implementing a structured TAVI program among a non-selected series of patients of AS undergoing TAVI at a tertiary care hospital.

METHODS

Design and Study Population

This was a retrospective registry including all consecutive patients with severe AS treated with TAVI at a tertiary care hospital and surviving to hospital discharge between January 2018 and December 2022. Severe AS was diagnosed by transthoracic echocardiography and was defined by a mean transaortic gradent > 40 mmHg or an aortic valve area < 0.8 cm^2.

Data Collection and Definitions

Data were retrospectively collected by trained, local investigators using standardised electronic forms. Demographic, clinical, laboratory, electrocardiographic and echocardiographic data, were recorded for each patient. The overall burden of comorbidities was defined by the Charlson index,[10] with a maximum score of 37 points. Procedure related data were also recorded, such as the specific approach, elective or emergent procedure, and the day of the week on which the TAVI was performed.

Clinical management was up to each medical team according to current recommendations. Antithrombotic treatment, vascular access, and the choice of stents and other devices were left to the operator's decision. In may 2021, a structured TAVI program was implemented, including scheduled multidisciplinary meetings of the working group on TAVI, protocolization of post TAVI care and management of conduction disturbaces and the performance of early TAVI nurse visits one week after discharge. A specific variable was built considering if TAVI procedures were performed before or after the implementation of this TAVI program. Patients were e considered suitable for an early discharge in the absence of conduction disturbances after TAVI or in-hospital complications. Conduction disturbances after TAVI were defined as the presence of 2nd or 3rd degree AV block after TAVI, transient or persistent left nundle brach block or permanent pacekamer requirement. In-hospital complications included clinically relevant femoral hematoma, retroperitoneal hematoma, acute limb ischemia, stroke, pericardial tamponade, anular rupture, acute kidney injury and need for blood cell transfusion.

Outcomes

The main outcome measured for the purpose of this study was LoS.

Statystical Analysis

Categorical variables were described as a percentatge, while quantitative variables were described as a mean (standard deviation). In the case of quantitative variables, a distribution different from the normal one is described as the median (p25–p75). The normality in the distribution of the variables will be analyzed using the Kolmogorov-Smirnoff test.

The impact of the TAVI program on the clinical profile, management and outcomes of these patients was assessed by comparing clinical characteristics, management related data and in-hospital complications between patients treated before and after the implementation of the program. The association between categorical variables was analyzed with the Chi-square test, with the correction of continuity when indicated. The analysis of quantitative variables according the implementation of the TAVI program was performed by Student's *t* test.

The analysis of predictors of LoS was carried out by a binary logistic regression model, considering hospital stay with a dichotomous variable (above and below the median value (7 day)) as dependent variable and the rest of variables with a significant association with LoS in the univariate analysis ($P < 0.05$). The final model was built by a backward stepwise binary logistic regression model. The predictive capacity of the final model was analyzed by calculating the receiver operating characteristics (ROC) curves and the corresponding area under the curve (AUC). All analyses were perfomed by using the SPSS 25 statistical package.

Ethics

This observational study was performed in accordance with the ethical principles set out in the Declaration of Helsinki. Confidential patient information was protected according to national regulations. The protocol was revised and approved by the Clinical Research Ethics Committee of Bellvitge University Hospital (IRB-00005523).

RESULTS

Baseline Clinical Characteristics

During the study period, a total of 629 AS patients underwent TAVI, of whom 614 (97.6%) survived at hospital stay. Mean age of these patients was 80.5 years, and most of them (329/614, 53.5%) were female. The proportion of comorbidities such as hypertension, diabetes mellitus, prior stroke, prior myocardial infarction or chronic kidney disease was significant (Table 1). Mean Charlson comorbidity index was 2.6.

Almost one of each ten patients had a previous permanent pacemaker inserted. The proportion of baseline conduction disturbances was also significant (8.2% right bundle branch block (RBBB) and 10.2% left bundle branch block (LBBB) before the TAVI procedure). TAVI was performed by a transfemoral approach in almost all cases, and the proportion of urgent or emergent procedures was 101/614 (16.4%).

Clinical Outcomes

Overall, most patients presented conditions that precluded an early hospital discharge (438/614, 71.2%), either conduction disturbances or in-hospital complications. A total of 373/614 patients (60.7%) presented conduction disturbances after TAVI, mostly new onset LBBB (276/614, 45%). The propotion of patients requiring permanent pacemaker inserton (PPI) post TAVI was 26.4%. The proportion of in-hospital complications was 164/614

Table 1 Clinical profile, management and outcomes according to length of hospital stay.

Variables	Whole cohort (*n* = 614)	Hospital stay < 7 day (*n* = 287)	Hospital stay > 7 day (*n* = 327)	*P*-value
Baseline clinical characteristics				
Age, yrs	80.5 ± 6	80.3 ± 6	80.8 ± 7	0.352
Male gender	285 (46.4%)	130 (45.3%)	155 (47.4%)	0.602
Hypertension	535 (87.1%)	251 (87.5%)	284 (86.9%)	0.823
Diabetes mellitus	241 (39.3%)	110 (38.3%)	131 (40.1%)	0.661
Dyslipidemia	465 (75.7%)	216 (75.3%)	249 (76.1%)	0.798
Active smoker	22 (3.6%)	9 (3.1%)	13 (4%)	0.610
Obesity	264 (43%)	129 (44.9%)	135 (41.3%)	0.360
Peripheral artery disease	46 (7.5%)	17 (5.9%)	29 (8,9%)	0.167
Prior stroke	65 (10.6%)	26 (9%)	39 (11.9%)	0.497
Prior myocardial infarction	80 (13%)	31 (10.8%)	49 (15%)	0.124
Prior CABG	31 (5%)	10 (3.5%)	21 (6.4%)	0.097
Prior pacemaker	59 (9.6%)	37 (12.9%)	22 (6.7%)	0.010
Prior anemia	259 (42.2%)	112 (39%)	147 (45%)	0.138
Chronic kidney disease	253 (41.2%)	108 (38%)	145 (44.3%)	0.236
Previous bleeding	39 (6.4%)	15 (5.2%)	24 (7.3%)	0.284
Previous neoplasm	136 (22.1%)	58 (20.2%)	78 (23.9%)	0.278
Charlson index	2.64 ± 2%	2.34 ± 2%	2.90 ± 2%	< 0.001
Left ventricle ejection fraction	62% ± 12%	63% ± 11%	61% ± 13%	0.016
Baseline ECG				
PR interval, ms	172 ± 40	167 ± 34	176 ± 44	0.017
Prior RBBB	50 (8.2%)	25 (8.7%)	25 (7.6%)	0.533
Prior LBBB	62 (10.1%)	20 (7%)	42 (12.8%)	0.016
Procedure-related data				
TAVI program available	307 (50%)	183 (63.8%)	124 (37.9%)	< 0.001
Day				0.017
Monday-Tuesday	149 (24.3%)	57 (19.9%)	92 (28.1%)	
Wednesday-Friday	465 (75.7%)	230 (80.1%)	235 (71.9%)	
Urgent or emergent procedure	101 (16.4%)	35 (12.2%)	66 (20.2%)	0.008
Transfemoral approach	610 (99.3%)	287 (100%)	323 (98.8%)	0.080

Continued

Variables	Whole cohort (n = 614)	Hospital stay < 7 day (n = 287)	Hospital stay > 7 day (n = 327)	P-value
In-hospital complications				
Conduction disturbances	373 (60.7%)	136 (47.4%)	237 (72.5%)	< 0.001
2nd/3rd degree AV block	92 (15%)	23 (8%)	69 (21.1%)	
New LBB	276 (45%)	94 (32.8%)	182 (55.7%)	
Permanent pacemaker	162 (26.4%)	40 (13.9%)	122 (37.3%)	
Other complications	164 (26.7%)	36 (12.5%)	128 (39.1%)	< 0.001
Femoral hematoma	44 (7.2%)	14 (4.9%)	30 (9.2%)	
Retroperitoneal hematoma	7 (1.1%)	0	7 (2.1%)	
Acute limb ischemia	4 (0.7%)	0	4 (1.2%)	
Acute stroke	20 (3.3%)	2 (0.7%)	18 (5.5%)	
Anular rupture	1 (0.2%)	1 (0.3%)	0	
Pericardial tamponade	7 (1.1%)	0	7 (2.1%)	
Cardiac arrest	10 (1.7%)	2 (0.7%)	8 (2.4%)	
Need for transfusion	72 (11.7%)	14 (4.9%)	58 (17.7%)	
Acute kidney injury	46 (7.5%)	6 (2.1%)	40 (12.2%)	
Overall complications	438 (71.3%)	160 (55.7%)	278 (85%)	< 0.001

Data are presented as mean ± SD or n (%). CABG: coronary artery bypass surgery; LBBB: left bundle branch block; RBBB: right bundle brach block; TAVI: transcatheter aortic valve implantation.

(26.7%), mainly driven by significant femoral hematoma, need for tansfusion and acute kidney injury. Mean hospital stay was 7.6 days (SD 6), and 327/614 patients had a hospital stay 7 days (Table 1).

Predictors of LoS

No significant differences were observed regarding age, gender or the proportion of most comorbidities according the duration of hospital stay (Table 1). However, patients with a longer LoS had a lower proportion of prior pacemaker, higher Charlson index value and lower left ventricle ejection fraction. Likewise, patients with longer LoS had higher baseline PR interval and higher proportion of baseline LBBB in ECG.

In addition, among patients with longer LoS, the proportion of urgent procedures was higher and the number of cases performed after the implementation of the TAVI program was significantly lower. Significant differences were also observed regarding the day of the week in which the procedure was performed, with longer LoS among patients undergoing TAVI on monday or tuesday. Finally, both the incidence of conduction disturbances and in-hospital complications were strongly associated with a longer LoS (Table 1). The final predictive model for longer LoS included prior pacemaker and availability of TAVI program as protectors and the presence of other valvular diseases, day of the week, emergent procedures, and the development of conduction disturbances and in-hospital complications as independent predictors of long LoS after the TAVI procedure (Table 2). This predictive model showed an optimal ability for predicting LoS after TAVI, with an area under the ROC curve of 0.79 (95% CI: 0.76-0.83, P < 0.001, Figure 1).

Clinical Profile, Management and Outcomes Before and After the Implementation of TAVI Program

Patients undergoing TAVI after the implementation of the TAVI program were slightly younger and had a significantly lower prevalence of comorbidities such as diabetes mellitus, prior myocardial infarction or chronic kidney disease (Table 3). The overall burden of comorbidities as measured by the Charlson index was significantly lower in these patients. No significant differences were observed regarding baseline ECG data, TAVI approach and the proportion of emergent procedures. The rate of conduction disturbances after TAVI remained stable around 60%. However, PPI requirement significantly declined from 30.3% to 22.5% (P = 0.028). Likewise, the incidence of complications such as the need for blood transfusion or acute kidney injury was significantly reduced in this second period. The overall incidence of conditions precluding an early hospital discharge was reduced form 76.2% to 66.4% after the start of the TAVI

Table 2 Predictors of hospital stay.

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Baseline clínical characteristics				
Male gender	1.09 (0.79–1.49)	0.602		
Age	1.01 (0.99–1.04)	0.352		
Hypertension	0.95 (0.59–1.52)	0.823		
Diabetes mellitus	1.08 (0.78–1.49)	0.661		
Dislypidemia	1.05 (0.72–1.52)	0.798		
Active smoking	1.17 (0.86–1.58)	0.323		
Obesity	0.86 (0.62–1.19)	0.360		
Peripheral artery disease	1.55 (0.83–2.88)	0.169		
Prior stroke	1.34 (0.82–2.19)	0.241		
Prior myocardial infarction	1.45 (0.90–2.35)	0.126		
Prior CABG	1.90 (0.88–4.11)	0.102		
Prior pacemaker inserted	0.49 (0.28–0.85)	0.011	0.25 (0.13–0.48)	< 0.001
Anemia	1.28 (0.92–1.76)	0.138		
Chronic kidney disease	1.31 (0.95–1.8)	0.099		
Prior bleeding	1.44 (0.74–2.79)	0.286		
Prior neoplasm	1.24 (0.84–1.82)	0.278		
Charlson comorbidity index	1.17 (1.07–1.27)	< 0.001		
Left ventricle ejection fraction (%)	0.98 (0.97–0.99)	0.018		
Other valve abnormalities	1.98 (1.41.279)	< 0.001	1.73 (1.15–2.59)	0.008
Prior RBBB	0.81 (0.53–1.23)	0.324		
Priot LBBB	1.97 (1.13–3.44)	0.017		
Procedure-related data and in-hospital clinical course				
Day of the week	0.86 (0.72–1.06)	0.081	0.44 (0.28–0.70)	0.009
Non elective procedure	1.82 (1.17–2.84)	0.008	1.88 (1.11–3.19)	0.020
Conduction disturbances after TAVI	2.92 (2.09–4.09)	< 0.001	3.61 (2.43–5.36)	< 0.001
In-hospital complications	4.49 (2.96–6.78)	< 0.001	4.75 (2.99–7.56)	< 0.001
TAVI programa availability	0.35 (0.25–0.48)	< 0.001	0.32 (0.22–0.48)	< 0.001

Day of the week: Wednesday to Friday *vs.* Monday or Tuesday. Conduction disturbances after TAVI were defined as the presence of 2nd or 3rd degree AV block after TAVI, transient or persistent left bundle branch block or permanent pacemaker requirement. In-hospital complications included clinically relevant femoral hematoma, retroperitoneal hematoma, acute limb ischemia, stroke, pericardial tamponade, anular rupture, acute kidney injury and need for blood cell transfusion. CABG: Coronary artery bypass surgery; LBBB: Left bundle branch block; RBBB: right bundle branch block; TAVI: Transcatheter aortic valve implantation.

program ($P < 0.001$). A marked reduction in LoS was also observed after the implementation of the program, from 8.7 to 7.5 days. This significant reduction was observed both in patients suitable for an early discharge (from 6.5 to 4 days, $P < 0.001$) and in unsuitable patients (from 9.4 to 7.7 days, $P = 0.014$, Figure 2)

DISCUSSION

Main findings from this study are: (1) most older patients with AS undergoing TAVI (> 70%) present conditions that preclude an early hospital discharge, especially conduction disturbances after TAVI; (2) predictors of LoS were non-elective TAVI procedures, previous permanent pacemaker inserted, day of the week on which TAVI was performed, availability of a TAVI program, other concomitant valvular diseases and the occurrence of conduction disturbances or in-hospital complications; and (3) the implementation of a TAVI program was associated with a better selection of patients, a lower rate of complications and a marked reduction of LoS.

The progressive description of the safety and efficacy of TAVI among patients with symptomatic severe AS in

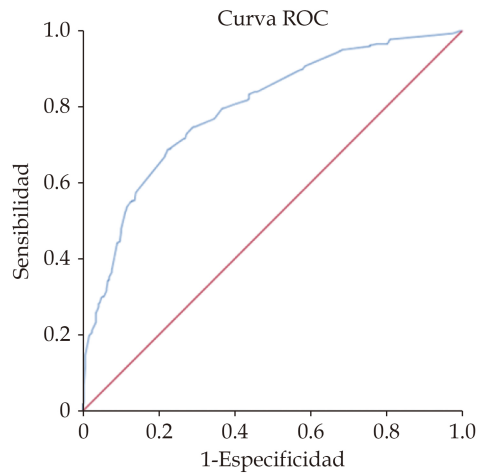

Figure 1 ROC curve for the prediction of long hospital stay by the final predictive model. ROC: receiver operating characteristics.

diferent clinical settings has led to a significant increase of the anual performance of TAVI procedures worldwide.[5] This fact implies the need of healthcare systems to adapt to this new demand, thus requiring optimizing patient pathways and LoS.[11] In this sense, the progressive technological development of TAVI devices, the learning curves of TAVI teams and the reduction of the profile of risk of AS patients undergoing TAVI since the PARTNER trial was published[1] have contributed to a significant reduction of the rate of complications and LoS.[12] However, the proportion of patients presenting conduction disturbances and need for permanent pacemaker insertion after TAVI remains significant, thus precluding an early hospital discharge in a significant proportion of cases.[13] In this sense, some factors such as protocolization of post TAVI care, the implementation of multidisciplinary TAVI programs and other estructural variables of TAVI centers may contribute to optimize hospital pathways and hospital stay in this context. However, data regarding predictors of LoS and the potential impact of these variables in routine clinical practice is scarce.

Data from this study showed that LoS remains long in a significant proportion of patients. Importantly, more than 70% of patients present conditions that preclude an early discharge, especially conduction disturbances after TAVI. This is an important point, since a fast track admission after TAVI might only be achieved in a minority of non selected AS patients from routine clinical practice. However, hospital stay might be reasonably shortened also in these more complex patients.

Table 3 Clinical profile, management and outcomes according to TAVI program availability.

Variable	Whole cohort (n = 614)	Before TAVI program available (n = 307)	After TAVI program available (n = 307)	P-value
Baseline clinical characteristics				
Age, yrs	80.5 ± 6	80.9 ± 7	80.2 ± 6	0.154
Male gender	285 (46.4%)	147 (47.9%)	138 (45%)	0.466
Hypertension	535 (87.1%)	273 (88.9%)	262 (85.3%)	0.185
Diabetes mellitus	241 (39.3%)	133 (43.3%)	108 (35.2%)	0.039
Dyslipidemia	465 (75.7%)	236 (76.9%)	229 (74.6%)	0.510
Active smoker	22 (3.6%)	15 (4.9%)	7 (2.3%)	0.188
Obesity	264 (43%)	129 (42%)	135 (44%)	0.625
Peripheral artery disease	46 (7.5%)	24 (7.8%)	22 (7.2%)	0.759
Prior stroke	65 (10.6%)	31 (10.1%)	34 (11.1%)	0.221
Prior myocardial infarction	80 (13%)	51 (16.6%)	29 (9.4%)	0.008
Prior CABG	31 (5%)	22 (7.2%)	9 (2.9%)	0.017
Prior pacemaker	59 (9.6%)	32 (10.4%)	27 (8.8%)	0.494
Prior anemia	259 (42.2%)	129 (42%)	130 (42.3%)	0.935
Chronic kidney disease	253 (41.2%)	144 (46.9%)	109 (35.6%)	0.004
Previous bleeding	39 (6.4%)	24 (7.8%)	15 (4.9%)	0.136
Previous neoplasm	136 (22.1%)	66 (21.5%)	70 (22.8%)	0.697
Charlson index	2.64 ± 2%	2.94 ± 2%	2.34 ± 2%	< 0.001
Left ventricle ejection fraction	62% ± 12%	61% ± 12%	63% ± 12%	0.136

Continued

Variable	Whole cohort (n = 614)	Before TAVI program available (n = 307)	After TAVI program available (n = 307)	P-value
Baseline ECG				
PR interval, ms	172 ± 40%	173 ± 40%	170 ± 40%	0.407
Prior RBB	50 (8.2%)	21 (6.8%)	29 (9.4%)	0.348
Prior LBB	62 (10.1%)	35 (11.4%)	27 (8.8%)	0.284
Procedure-related data				
Day				< 0.001
Monday-Tuesday	149 (24.3%)	53 (17.3%)	96 (31.3%)	
Wednesday-Friday	465 (75.7%)	254 (82.7%)	211 (68.7%)	
Urgent or emergent procedure	101 (16.4%)	50 (16.3%)	51 (16.6%)	0.913
Transfemoral approach	610 (99.3%)	306 (99.7%)	304 (99%)	0.135
In-hospital clinical course				
Conduction disturbances	373 (60.7%)	193 (62.9%)	180 (58.6%)	0.283
2nd/3rd degree AV block	92 (15%)	57 (18.6%)	35 (11.4%)	
New LBB	276 (45%)	140 (45.6%)	136 (44.3%)	
Permanent pacemaker	162 (26.4%)	93 (30.3%)	69 (22.5%)	
In-hospital complications	164 (26.7%)	102 (33.2%)	62 (20.2%)	< 0.001
Femoral hematoma	44 (7.2%)	23 (7.5%)	21 (6.8%)	
Retroperitoneal hematoma	7 (1.1%)	0	7 (2.3%)	
Acute limb ischemia	4 (0.7%)	3 (1%)	1 (0.3%)	
Acute stroke	20 (3.3%)	10 (3.3%)	10 (3.3%)	
Anular rupture	1 (0.2%)	1 (0.3%)	0	
Pericardial tamponade	7 (1.1%)	5 (1.6%)	2 (0.7%)	
Cardiac arrest	10 (1.7%)	5 (1.6%)	5 (1.6%)	
Need for transfusion	72 (11.7%)	45 (14.7%)	27 (8.8%)	
Acute kidney injury	46 (7.5%)	38 (12.4%)	8 (2.6%)	
Overall complications	438 (71.3%)	234 (76.2%)	204 (66.4%)	< 0.001
Hospital stay (days)	7.6 ± 6	8.7 ± 6	6.5 ± 6	< 0.001
Long hospital stay (> 7 day)	327 (53.3%)	203 (66.1%)	124 (40.4%)	< 0.001

Data are presented as mean ± SD or n (%). CABG: Coronary artery bypass surgery; LBBB: Left bundle branch block; RBBB: right bundle brach block.

Several variables were independently associated with LoS in our series. Overall complexity of patients is clearly associated with longer hospitalizations in most studies.[14-18] In this sense, some characteristics of our patients such as the presence of additional baseline valvular abnormalities (mostly mitral regurgitation) predicted a longer LoS. This is probably related to the higher risk for heart failure or other in-hospital complications. Likewise, patients undergoing urgent or emergent TAVI had longer LoS. This fact has been previously described,[19,20] and is undoubtely related to the higher profile of risk of these patients (acute heart failure, poorer left ventricle ejection farction, higher burden of comorbidities) and their higher rate of complications.

The occurrence of in-hospital complications (femoral hematoma, stroke, acute kidney injury, blood transfusions) was closely related to longer LoS, due to the obvious need for stabilization and treatment of these conditions. Likewise, the occurrence of conduction disturbances after TAVI implied a need for additional observation and monitoring time and PPI in some cases, thus leading to longer LoS. In this sense, the day of the week on which TAVI was performed was associated with diferent LoS, with longer hospitaizations among pa-

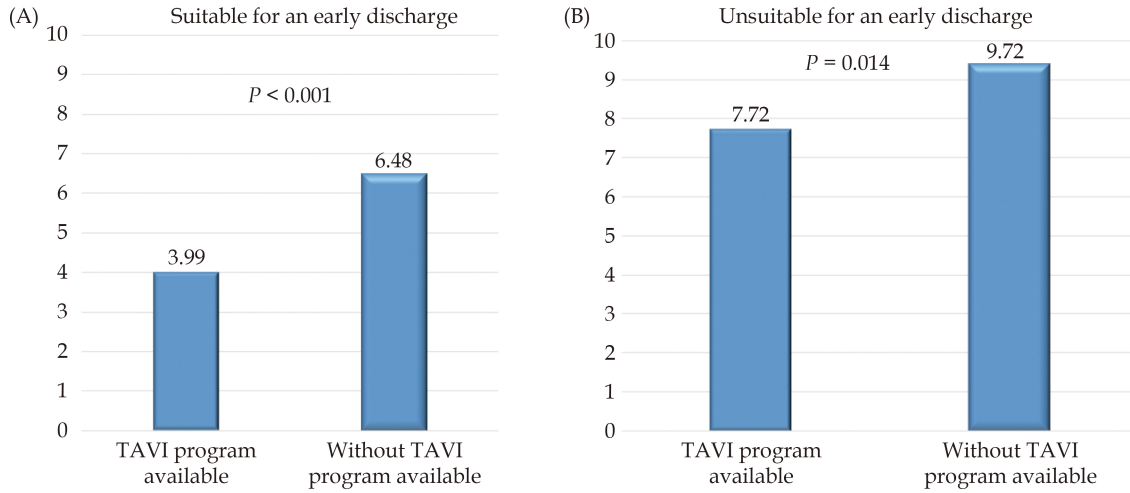

Figure 2 Length of hospital stay according to the availabiliy of the TAVI program in (A) patients suitable for an early discharge and (B) unsuitable patients. TAVI: transcatheter aortic valve implantation.

tients treated on monday or tuesday as compared to those treated on wednesday to friday. This fact, which has not been previously described, is probably related to the monitoring time required in patients with conduction disturbances and the unavailability of PPI during weekend, and should be taken into account when planifyng TAVI agenda according to the risk of AV block and PPI requirements after TAVI. Likewise, the presence of a previous permament pacemaker inserted before TAVI was associated with shorter LoS, which was also been extensively described before.[18,21]

Importantly, one of the strongest predictors of LoS in our series was the availability of a TAVI program. This is a crucial point for optimizing pathways in patients undergoing TAVI, since it can contribute to a better selection of patients, planification of the admission and procedure, a better management of complications and an early discharge in safe conditions. Frank, *et al.*[9] assessed the impact of a streamlined TAVI pathway on LoS by implementing best practices in a series of 2388 patients with AS undergoing TAVI (897 prior and 1491 patients after the implementation of BENCHMARK practices). Peri-procedure best practices included use of local anaesthesia and decreased procedure and intervention times. Mean LoS was reduced from 7.7 ± 7.0 to 5.8 ± 5.6 days. No differences were observed regarding 30-day all-cause mortality, stroke/transient ischaemic attack, life-threatening bleeding, acute kidney injury, and valve-related readmission. Likewise, the FAST TAVI II trial assessed,[22] on patients with AS undergoing TAVI, the impact of a dedicated training programme consisting of 10 quality of care measures on LoS in 969 patients as compared to 860 patients in the control group. Early discharge was achieved in 563 (58.1%) patients in the intervention group *vs.* 364 (42.3%) patients in the control group ($P < 0.0001$). Thirty-day mortality was low and similar in the two groups. Other authors have described a significant impact of TAVI programs on LoS and total costs reduction,[7] and an improvement on staff working hours and patients' satisfaction.[8]

The TAVI program in our center consisted in multidisciplinary meetings for a continuous assessment of selected patients profile and local outcomes, protocolized baseline geriatric assessment beore the admission, implementing multidisciplinary protocols for in-hospital post TAVI care and management of conduction disturbances and the implementation of a routine early TAVI nurse 7 days after disharge. This holistic approach significantly contributed to optimize in hospital pathways by several ways. First, the baseline geriatric assessment, along with scheduled multidisciplinary meetings for discussing patients' characteristics allowed a better selection of TAVI candidates. The burden of comorbiities of patients after the implementation of the program was significantly reduced, thus enabling a reduction of in-hospital complications and the avoidance of futility in complex frail patients.[23] On the other hand, protocolization of postTAVI in-hospital care led to a reduction of in-hospital complications and its better management. Importantly, while the rate of conduiction disturbances remained stable around 60%, the proportion of patients requing PPI significantly declined, thus reflecting a significant improvement of post TAVI conduction disturbances management and allowing a reduction of LoS. In

addition, the TAVI nurse visit a few days after the admission included an early reassessment of ECG and access site puncture, allowing an early discharge in safe conditions. This fact reflects the importance of an active participation and leadership by nurses on the TAVI programs.[24] To our judgement, all of these components of the TAVI program allowed a marked reduction of LoS, both in uncomplicated and complicated TAVI procedures.

Limitations

This study has some limitations, such as its retrospective and observational nature, so we cannot rule out the presence of selection bias and unmeasured confounding. This was a single center study with a moderate sample size. Therefore, our findings might not be aplicable to other series with diferent clinical profile and management. Finally, for the purpose of this study we focused on in-hospital management and outcomes, so the impact of the TAVI program on post discharge outcomes was not assessed.

Despite these limitations, we believe that this study adds novel and interesting data about predictors of LoS and the impact of TAVI program on management and outcomes of elderly patients with AS undergoing TAVI. Refining risk stratification and management of these patients could be crucial to improve their quality of life and outcomes, along with a more rational healthcare resources management.

Conclusions

Most older patients with AS undergoing TAVI (>70%) present conditions that preclude an early hospital discharge, especially conduction disturbances after TAVI. Predictors of LoS were non elective TAVI procedures, previous permanent pacemaker inserted, day of the week on which TAVI was performed, availability of a TAVI program, other concomitant valvular diseases and the occurrence of conduction disturbances or in-hospital complications. Implementation of a TAVI program was associated with a better selection of patients, a lower rate of complications and a marked reduction of hospital stay.

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