Transapical transcatheter aortic valve implantation without prior balloon aortic valvuloplasty: feasible and safe†

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Abstract

OBJECTIVES: Currently, preimplant balloon aortic valvuloplasty (BAV) is considered a prerequisite for successful subsequent transapical transcatheter aortic valve implantation (TA-TAVI) using balloon-expandable devices. However, cerebral embolization has been shown to originate at least in part from BAV procedures. Omitting BAV may therefore reduce neurological events after TAVI and facilitate the procedure while yielding non-inferior haemodynamic and clinical outcomes.

METHODS: From May 2011 through December 2012, a total of 50 consecutive patients were treated by TA-TAVI without preimplant BAV (TA-TAVI-BAV, study group) using the Edwards Sapien XT device (54% male, age 78 ± 8 years, logistic European System for Cardiac Operative Risk Evaluation I 21 ± 14%). Data were prospectively entered into a dedicated database, retrospectively analysed and compared with a consecutive series of conventional TA-TAVI using the same device (control group, n = 50). Reporting of data followed Valve Academic Research Consortium definitions.

RESULTS: Overall device success rate was 94% (47/50) and 86% (43/50) in study and control groups, respectively (P = 0.32). Procedure time was similar in the study group compared with the control group (88 ± 31 vs 91 ± 25 min, P = 0.60), while significantly less contrast was used (138 ± 68 vs 183 ± 78 ml, P < 0.001). Post-procedural peak and mean transvalvular gradients were 16 ± 7 and 8 ± 3 mmHg, respectively, in the study group with similar values in the control group (19 ± 9 and 9 ± 5 mmHg, P = 0.08 and P = 0.09, respectively). Residual paravalvular leakage (PVL) grade 2 was present in 2 and 8% in study and control groups, respectively (P = 0.36), with no PVL >grade 2 in any patient. Rates of 30-day mortality and periprocedural stroke were 4 and 10% (P = 0.44) and 2 and 6% (P = 0.62), respectively.

CONCLUSIONS: TA-TAVI-BAV is feasible and safe and has become our default technique for patients allocated to TA-TAVI with balloon-expandable devices. This approach resulted in less contrast agent used and facilitated the procedure without compromising valve performance. Possible beneficial effects of this approach on the incidence of cerebrovascular events, other periprocedural complications or haemodynamic valve performance need to be verified in larger patient numbers before general recommendations can be made.

Keywords: Transcatheter aortic valve implantation • Balloon aortic valvuloplasty • Stroke

INTRODUCTION

Transcatheter aortic valve implantation (TAVI) has been established as a routine procedure for treatment of inoperable or high-risk patients with severe aortic stenosis [1, 2]. While clinical outcomes have constantly improved with growing physician experience, technical refinement of devices and improved periprocedural care, major safety issues remain such as conduction disturbances, paravalvular leakage (PVL) or periprocedural cerebrovascular embolism.

The latter has been shown to originate from different technical steps during TAVI such as wire passage of the native aortic valve, balloon aortic valvuloplasty (BAV) or positioning and deployment of valves [3]. Reducing manipulation of the stenosed native aortic valve may therefore potentially decrease the rate of cerebrovascular events.

Performing preimplant BAV before insertion and deployment of TAVI devices is considered a mandatory step by most centres to ‘pave the way’ before valve implantation or it may also be used for final measurement of annular dimensions [4]. However, BAV in itself carries its own specific procedural risks [5]. In a multicentre study feasibility of transfemoral TAVI using a self-expandable device has been demonstrated [6]. Furthermore, Wendler et al.

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In the present study, we assessed safety and feasibility of TA-TAVI\textsuperscript{BAV} using a balloon-expandable device. Clinical and haemodynamic results were analysed and compared with a consecutive series of patients undergoing conventional TA-TAVI with prior BAV using the same device.

**PATIENTS AND METHODS**

**Patients**

From May 2011 through December 2012, a total of 50 consecutive patients were treated by TA-TAVI\textsuperscript{BAV} for severe calcified aortic stenosis using the Edwards Sapien XT device. Patient selection was guided by current international recommendations [8] and patients allocated to TAVI by mutual agreement of the local heart team according to the individual patient’s risk profile. For comparison to the study population, a control group of 50 consecutive patients treated at our centre by conventional TA-TAVI with prior BAV immediately before introduction of the new technique of TA-TAVI\textsuperscript{BAV} was retrieved from our dedicated hospital database. Written informed consent was obtained from all patients before the procedure.

**Preprocedural planning and study procedure**

All patients underwent preoperative transthoracic and transoesophageal echocardiographic screening for general evaluation of cardiac functional status. Furthermore, contrast-enhanced, electrocardiogram-gated multislice computed tomography (CT) was performed. Datasets were analyzed using the 3mensio Medical Imaging software (3mensio Medical Imaging BV, Bilthoven, Netherlands) for calculation of native aortic annulus dimensions and choice of adequately sized protheses as well as characterization of valve morphology (e.g. degree and distribution of valvular calcification), preprocedural calculation of optimal c-arm angulation, determination of the exact thoracic access site and assessment of aortoiliac and peripheral vascular status.

All procedures were performed in a joint heart-team effort by a dedicated team of cardiologists and cardiac surgeons in a specially equipped hybrid operating theatre (OT). A readily primed heart-lung machine was available in the hybrid OT for every case should haemodynamic instability require implementation of cardiopulmonary bypass.

Transapical (TA) procedures were performed under general anaesthesia. Since the thoracic access site was predictable from the preprocedural CT scans, incision size could be limited to 4–5 cm and the use of a rigid retractor avoided in many cases for decreased postoperative patient discomfort. For TA-TAVI procedures, left anterolateral minithoracotomy was followed by opening of the pericardium and placement of two felt-padded prolene 2-0 sutures just above the true anatomical apex on the anterior left ventricular wall. The left ventricle was punctured and a soft guidewire inserted in Seldinger’s technique under fluoroscopic control for antegrade passage of the aortic valve. Subsequently, a long straight 6-Fr sheath was advanced across the aortic valve and the soft wire exchanged for a superstiff guidewire (Amplatz super stiff, 260 cm, Boston Scientific, Natick, MA, USA) protected by a right Judkins catheter (Cordis Johnson&Johnson, Norderstedt, Germany). Contrary to conventional procedures, for TA-TAVI\textsuperscript{BAV}, the TA delivery sheath was then directly inserted and the Edwards Sapien XT device positioned and deployed inside the native aortic valve under rapid ventricular pacing. All subsequent steps followed previously described protocols [9].

**Statistical analysis**

Baseline, procedural and acute follow-up data to ≤30 days were prospectively entered into a dedicated standardized database and retrospectively analysed. Data are presented as absolute numbers and percentages for categorical variables and mean values and standard deviations for continuous variables. Dichotomous variables were compared using Fisher’s exact test and continuous variables by t tests. P-values were reported without correction for multiple testing. A level of significance was set to two-tailed $P < 0.05$. Statistical analysis was performed using SPSS 20. Clinical end points were adjudicated in accordance with the updated standardized Valve Academic Research Consortium (VARC-2) definitions [10].

**RESULTS**

**Baseline demographics**

A total of 50 consecutive patients (54% male, age 78 ± 8 years, logistic European System for Cardiac Operative Risk Evaluation I (logEuroSCORE I) 21 ± 14%) underwent TA-TAVI\textsuperscript{BAV} for severe symptomatic aortic stenosis. All patients presented with significant comorbid conditions making them unfit for surgery as judged by an interdisciplinary heart team. In all cases, retrograde, transarterial access was deemed inadvisable due to severe aortoiliac and/or peripheral vascular atheropathy or small calibre peripheral vessels. The control group consisted of a same size group of consecutive patients treated by conventional TA-TAVI with prior BAV. Regarding baseline demographic and haemodynamic parameters as well as prevalence of relevant risk factors or the overall risk profile as captured by standard risk stratification tools no significant inter-group differences were found (Table 1).

**Procedural data**

Acute procedural device success was observed in 94% (47/50) and 86% (43/50) of cases in study and control groups, respectively ($P = 0.32$). Reasons for failed interventions according to VARC-2 criteria in the study group were: conversion to surgical aortic valve replacement due to valve embolization in 1 patient, severe PVL due to low deployment of the first prosthesis requiring implantation of a second device as a valve-in-valve procedure in 1 patient and residual PVL grade 2 in 1 patient. In the control group, intervention was classified as unsuccessful for: implantation of a second device due to too low implantation of the first prosthesis in 1 patient, mean transvalvular gradient >20 mmHg in 2 patients and residual PVL grade 2 in 4 patients. In the study group, no further intraprocedural complications occurred. In the control group, rupture of the balloon occurred during valve deployment in 1 patient requiring retrieval of embolized balloon material from
the aortic bifurcation using a snare. In another patient, mitral chordal rupture was noted with worsening of pre-existent moderate mitral regurgitation and subsequent elective percutaneous mitral valve repair by implantation of a MitraClip 6 days after the index procedure.

The procedure time was similar in the study group compared with the control group (88 ± 31 vs 91 ± 25 min, \( P = 0.60 \)), while significantly less contrast was used (138 ± 68 vs 183 ± 78 ml, \( P < 0.01 \)). Post-dilatation of deployed prostheses was performed in 8% (4/50) and 4% (2/50) in study and control groups, respectively, \( (P = 0.68) \) for >moderate PVL or increased transvalvular gradients. Detailed procedural data are summarized in Table 2.

### Echocardiographic outcome data

Significant improvements were observed in both groups comparing baseline and discharge transthoracic echocardiographic data.
In the study group, peak and mean transvalvular gradients decreased from 49 ± 22 and 28 ± 14 mmHg to 16 ± 7 and 8 ± 3 mmHg (both \( P < 0.01 \)), while EOA increased from 0.9 ± 0.4 to 1.6 ± 0.3 cm\(^2\) (\( P < 0.01 \)). Corresponding data in the control group were: decrease of peak and mean gradients from 54 ± 28 mmHg and 31 ± 17 mmHg to 19 ± 9 and 9 ± 5 mmHg (both \( P < 0.01 \)) and increase of EOA from 0.8 ± 0.2 to 1.7 ± 0.5 cm\(^2\) (\( P < 0.01 \)).

Comparison of haemodynamic results between study and control groups revealed no statistically significant differences regarding peak and mean transvalvular gradients (\( P = 0.08 \) and \( P = 0.09 \)) or resultant EOA (\( P = 0.23 \); Fig. 1).

Residual PVL grade 2 was present in 2% (1/50) and 8% (4/50) in study and control groups, respectively (\( P = 0.61 \)), while PVL >grade 2 was not observed in any patient (Fig. 2).

### Clinical outcome data

All-cause mortality was 4% (2/50) and 10% (5/50) in study and control groups, respectively (\( P = 0.44 \)). Mortality was classified as cardiovascular or of unknown cause in both cases in the study group and in 2 cases in the control group. Non-cardiovascular causes of death in the remaining 3 patients in the control group were: previously unknown advanced malignant disease, multiorgan failure and pneumonia following aspiration.

Periprocedural stroke occurred in 2% (1/50) and 6% (3/50, \( P = 0.62 \)), respectively. Severity of stroke was classified as disabling in 1 patient in the study group and as disabling in 1 and non-disabling in 2 cases in the control group. There was 1 case of major access site complications in each group. No myocardial infarctions occurred. Composite early safety end point according to VARC-2 definitions was reached in 14% (7/50) and 24% (12/50, \( P = 0.31 \)) in study and control groups, respectively. Further clinical outcome parameters are listed in Table 3.

### DISCUSSION

In the present study, we were able to demonstrate safety, feasibility and effectiveness of TA-TAVI−BAV in a routine sample population of elderly, high-risk patients undergoing TA-TAVI. Compared with a control group of patients undergoing conventional TA-TAVI with prior BAV, device success rate according to VARC-2 criteria was high at 94%. This compares favourably to results reported by others [11–14], even though most analyses to date conform to the initial VARC definitions [15] and employ various access routes and types of prostheses hampering direct comparison. These preliminary results suggest, BAV preceding TA-TAVI with balloon-expandable devices may be omitted without compromising technical success of valve deployment. Since BAV carries its own inherent procedural risks and needs to be performed under rapid ventricular pacing which in turn may lead to haemodynamic instability, especially in patients with impaired left ventricular function, TA-TAVI−BAV may result in increased overall safety of the procedure. On the other hand, it has been advocated that BAV preceding valve deployment may have strategic advantages in selected cases for example as a final confirmation of annular dimensions or to rule out coronary ostia obstruction by displacement of native aortic valve leaflets. Nowadays, many groups including our own find that proper
planning of the procedure using contrast-enhanced ECG-gated multislice CT scans—if adequately reconstructed and analysed—are extremely reliable for determination of annular dimensions and other crucial anatomical characteristics such as distance of coronary ostia from the aortic annular plane or width of the aortic root, etc. Therefore, balloon sizing may prove not to be of such importance after all.

Similar to results by Wendler et al. [7], the amount of contrast agent needed during the procedure was significantly reduced compared with the control group. Even though in 50 patients treated within this study, no statistically significant advantages were seen regarding incidence of acute renal failure, a beneficial effect of decreased amounts of contrast agent can likely be anticipated if this simplified procedure is applied in larger patient numbers. Potentially, procedure time and fluoroscopy time may also be reduced by omitting BAV even though this reduction did not reach statistical significance in our early experience.

The early safety end point as defined in the VARC-2 consensus document was reached in 14% in the study group compared with 24% in the control group (P = 0.31) with stroke rates of 2 and 6% in study and control groups, respectively (P = 0.62). Even though BAV is known to carry a risk of cerebral embolism with reported incidence ranging from 0.4 to 4% [5, 16–18], the difference observed in our comparative study was statistically insignificant and it remains speculative if TA-TAVI—BAV proved non-inferior to conventional TA-TAVI with prior BAV. Possible advantages regarding the incidence of periprocedural cerebrovascular events if evaluated in larger patient numbers will need to be investigated in larger patient numbers before general recommendations can be made.

At least theoretically, however, this appears likely to be the case.

Regarding acute haemodynamic effects, results in the study population proved non-inferior to those achieved by conventional TA-TAVI with significant reduction of peak and mean transvalvular gradients and increase in EOA in both groups and very similar values between groups for the respective parameters (Fig. 1).

Rates of residual PVL in the study group compare favourably to other contemporary series [19, 20] with PVL grade 2 in only 1 case (2%) and no or PVL grade 1 in all other patients. It has to be noted, however, that the rate of post-dilatation of deployed prostheses was higher in the study group with 8% as opposed to 4% in the control group even though this difference was statistically not significant.

**LIMITATIONS**

The present study represents a retrospective, single-centre experience with limited patient numbers. Patients were not randomized to the respective treatment groups. Furthermore, patients in study and control groups were treated during different periods of time and even though analysis of baseline patient characteristics did not reveal statistically significant inter-group differences, results may have been biased by hidden confounders. Furthermore, since this is a retrospective assessment, the impact of a learning curve with the relatively young technique of TA-TAVI is likely inherent in the data presented.

**CONCLUSIONS**

In conclusion, preliminary experience in a limited number of patients suggests TA-TAVI—BAV using balloon-expandable devices is feasible and safe. Regarding valve function and rates of PVL, TA-TAVI—BAV proved non-inferior to conventional TA-TAVI with prior BAV. Possible advantages regarding the incidence of periprocedural cerebrovascular events will need to be investigated in larger patient numbers before general recommendations can be made.

Conflict of interest: none declared.

**REFERENCES**


APPENDIX. CONFERENCE DISCUSSION

Dr V. Bapat

(London, UK): I have a couple of questions. I think, technically, it becomes easier to do with one fewer step, but we have seen from the previous paper that the new post-dilatation rate might be higher. I think your title should probably suggest very clearly that this is only a balloon-expandable valve. At present, it sounds like it is any transapical device. The BAV procedure time will still remain the same, which was one of the observations. Maybe you can comment a bit more on that later.

Paravalvular leak reduction probably has happened because we have size 29 mm valves. In your study population, the 50 patients had their procedures later than the control group of 50. The results are better because our sizing understanding has become better, so I wouldn’t read too much into it at all. My comment is that I think the results are definitely better because of experience, which the learning curve has achieved.

My question to you is the same: One, your procedure time, why has it remained the same? I would have expected it to go down.

The second question is: If we prove, as you might suggest and what the TAVI community thinks, that BAV will bring a reduction of stroke, should we stop using self-expandable stents? It’s quite provocative because with a self-expandable stent, you still need a BAV, or you need 40% of them post-dilatation.

And the third question is: Do you think there is still a role for BAV in the transapical approach for Sapien? Because BAV can be used for a variety of things, such as if you are worried about coronary obstruction or if you are not sure about sizing.

I know you have done a consecutive 50 patients, but in the last one year, I have reviewed three complications because patients had it done without BAV. Two of them were mitral chordae, where the Sapien had gone through the chordae, and one was inability to cross because of a very difficult angle and a very heavily calcified valve. Have you come across anything similar after this study was over?

Dr Conradi: I will try to remember the questions in the correct order. I think in the beginning, you were correctly alluding to the fact that, of course, both groups were treated in different time periods, and I tried to express that at the beginning of the talk. Of course there is a learning curve incorporated in this, and I will readily agree (and I pointed to that in regard to procedural data) that the use of larger valves and maybe, even though it’s not statistically significant, the reduced rate of paravalvular leakage, stem from more accurate sizing. But I guess this is something that you would expect from any retrospective series that you do because you can’t get rid of the problem. The learning curve is there; all of us go through it. So that is clearly one of the limitations of the study. I will agree to that, of course.

Regarding the place of balloon valvuloplasty in balloon-expandable valves, of course, you are correct. This is a technique that, for the majority of patients, works for balloon-expanding aortic valves only, so that should be very clear. However, I can say that occasionally, we have implanted transapical nitinol-based valves without pre-balloonng. Of course, that depends on the degree and the amount of calcium that we find. And, of course, I think it’s obvious, that will lead to a high rate of post-dilatation, if that’s your strategy.

Now, if post-dilatation has less clinical impact on patients than pre-dilatation is again another topic. I would only speculate. I don’t think there is much data around. And, again, you’re right that not doing the pre-dilatation did not have an impact regarding procedural times. But that’s actually not something we were looking for. We were not trying to quicken the procedure in any way; we were trying to simplify it. We were trying to minimize manipulation in the heart and in the annulus within the calcified structures. And if it works the same from an outcome or from a functional point of view, and if in the future there may be an advantage regarding safety, why not do it?

Hendrik, correct me if I’m wrong, but I don’t remember that we were unable to antegrade cross a stenosed aortic valve with a Sapien device up to now. I’m not saying it can’t happen, but we haven’t had the experience so far.

Dr H. Heijmen (Nieuwegein, Netherlands): I have one question. It is about the HITS. You showed us clearly that study from Kahlerl showing the HITS, and the HITS are there, but minimal during balloon valvuloplasty prior to TAVI. Isn’t there a chance that you now shift the HITS from prior balloonng to the deployment and positioning of the valve in your post-deploying? Although it does not show in the stroke rate.

Dr Conradi: Interesting question. I guess it’s the topic for the next Doppler study. I can’t answer. I don’t know. Certainly, theoretically it is possible, but I could only speculate.

Dr Heijmen: Okay.