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Narrative Review

Transcatheter aortic valve implantation: Update in 2018

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ABSTRACT

During the last 15 years, transcatheter aortic valve implantation (TAVI) has gained wide acceptance with good reproducible clinical and safety outcomes. Today, TAVI has not only overtaken conventional surgery as the standard of care for the treatment of patients with symptomatic aortic stenosis at high surgical risk, but can also be considered in selected intermediate-risk patients. This follows technological improvements, better patient assessment and increased operator experience leading to a significant reduction in most procedure-related complications and long-term mortality. In this review, we provide internists, on the one hand with current data in the TAVI field including clinical outcomes from the most recent, major trials and on the other hand, highlight the remaining pitfalls of this treatment and the gaps in evidence that need to be addressed in order to further improve clinical practice and expand its indication.

1. Introduction

More than 350,000 transcatheter aortic valve implantations (TAVI) have been performed in patients with severe symptomatic aortic stenosis (AS) in > 70 countries over the last 15 years and might be considered as one of the main “practice-changing” procedures in medicine of the last decade [1]. Better patient assessment, technical device evolution -in order to allow repositioning, recapture, and retrieval- and increasing operator experience over the last decade has resulted in significant clinical and safety outcome improvements. The present review aims to report current evidence in the TAVI field, discuss the main pitfalls and present the gaps in evidence that still need to be addressed.

2. Patient assessment

Before performing TAVI, a standardized screening process including anatomical and clinical factors should be performed. Patient frailty and concomitant disease are assessed in order to evaluate the risk of surgical aortic valve replacement (SAVR). All these elements are thereafter the basis of the heart team discussion including at least interventional cardiologists, cardiac surgeons, imaging specialists and anaesthesiologists according to the revised Valve Academic Research Consortium (VARC)-2 criteria [2].

First, the severity of the AS should be confirmed using transthoracic echocardiography (TTE) as a first line exam. When TTE assessment is unequivocal (i.e. high-gradient AS with a mean gradient > 40 mm Hg), TTE is sufficient and invasive assessment of the AS severity is not required, considering the potential risk of cerebral emboli while crossing the valve [3, 4]. Severity assessment of low-gradient stenosis is more challenging. In cases with low gradient and low left ventricle ejection fraction (LVEF), low-dose dobutamine stress TTE or even an invasive stress test can be performed to differentiate between pseudo and true AS. Furthermore, a high calcium score assessed by multi-slice computed tomography (MSCT) was shown to be directly correlated to the severity of the AS and worse outcomes. It can also help in the process of differentiating between pseudo and true AS (Fig. 1) [5]. Invasive assessment using simultaneous gradient measurement in the aorta and left ventricle, as well as cardiac output assessment, should be considered for patients in atrial fibrillation, with low gradient and low LVEF or paradoxical low flow (< 35 ml/m2), low gradient (< 40 mmHg), but normal LVEF [6]. Right catheterization to measure pulmonary artery pressure provides important information especially when TTE suggests possible pulmonary hypertension.

2.1. Anatomical factors

Following the randomized trials reporting lower mortality and stroke rates among the transfemoral cohort in comparison to non-transfemoral TAVI, transfemoral access has become the preferred option, performed in > 90% of cases in most centres [7]. Major ilio-femoral tortuosity, calcification or severe atherosclerosis should be excluded prior to the procedure and minimal femoral artery diameter (≥5 mm for 14F) should be measured.

Regarding aortic root and annulus sizing and assessment, most

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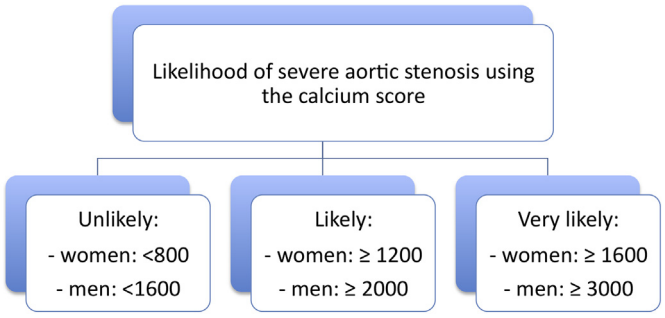

Fig. 1. Likelihood of severe aortic stenosis based on the calcium score by multisclice computed tomography according to latest guidelines of the European Society of Cardiology [14].

operators prefer to rely on three-dimensional (3D) imaging provided by ECG-gated MSCT with minimal use of contrast media (60 cc or sometimes less) providing imaging of the heart, aorta and the vessels from the subclavian arteries down to the femoral arteries. In cases of renal insufficiency, a CT scan can be performed with only 30 cc of contrast media with a slight decrease in quality. Coronary angiogram is still required to assess coronary artery disease.

2.2. Clinical factors

Traditionally, risk estimation was extrapolated from the STS score and the logistic EuroSCORE or the EuroSCORE II, that remain exclusively validated for evaluating the surgical risk for patients with AS. Recently, a predicted risk model (http://tools.acc.org/tavrrisk/#!/content/evaluate/) was developed and validated by the STS/ACC TVT Registry and the Swiss TAVI Registry for patients undergoing TAVI, exclusively [8, 9]. Although these scores should be part of the selection process, they lack several important clinical characteristics (e.g. porcelain aorta, liver disease, frailty). Furthermore, certain frailty parameters have been reported to predict mortality following TAVI, such as the individual's overall functional status, denutrition or cognitive impairment, particularly in elderly patients [10].

3. Current TAVI devices

Since the first in man in 2002 by Cribier, major improvements in the design of transcatheter aortic valves (THV) have been made [11]. According to their delivery characteristics, current THV are categorized as either balloon-expandable, mechanically-expandable, or self-expanding. Fig. 2 presents THV with CE (Conformité Européenne) mark approval. Among them, the SAPIEN family (Edwards Lifesciences; Irvine, California, USA) and the Medtronic self-expanding devices (Medtronic, Minneapolis, Minnesota, USA) are the most implanted and studied prosthesis on the market.

The delivery catheter profile of the latest generations of THV have been significantly reduced (down to 14F) leading to a reduction in vascular complications. Facilitated deployment properties (e.g. recapture, true repositioning and retrieval) have addressed issues of malpositionning or embolization and an additional sealing skirt (Edwards) or wrap (Medtronic) have reduced paravalvular leak (PVL).

The SAPIEN 3 (S3), the latest evolution of the Edwards balloon-expandable prosthesis is made from 3 bovine leaflets sutured on a cobalt-chromium stent frame. The new polyethylene terephthalate outer skirt was designed to reduce PVL (Fig. 3). Even though the modified frame geometry will be compatible with low delivery catheter profiles (14F for all sizes 20, 23, 26 and 29 with the Ultra delivery system, CE Mark awaited), this device does not allow repositioning or recapture after valve deployment. Among inoperable or high-risk (n = 583) and intermediate-risk (n = 1078) patients who received the S3 prosthesis, mortality and stroke rate at 30 days was low (respectively 2.2% and 0.9% for inoperable/high-risk patients, and 1.1% and 1% for intermediate-risk patients) [12]. PVL incidence was reduced with the redesigned skirt of the S3 in comparison to previous generations (3.4% of PVL > mild). However, there was a trend toward higher pacemaker implantation rates (respectively 13.3% and 10.1% for the inoperable/high-risk patient versus 3.8% among the initial Placement of Aortic Transcatheter Valves (PARTNER)-IA trial). Of note, a higher implantation position led to a decrease in the need for pacemaker implantation.

The Medtronic Evolut R (available sizes 23, 26, 29 and 34) – the replacement of the Medtronic CoreValve (sizes 26, 29 and 31) - is designed with a self-expanding nitinol support frame covered by porcine pericardium skirt on its lower 13 mm. The trileaflet valve (porcine pericardium) has a supra-annular functioning. In this device, the shorter frame geometry (45 mm instead of 55 mm) shows improved conformability to the annulus with an extended skirt in the outflow track, limiting PVL. The delivery system EnVeo R (14F for the 23, 26 and 29 devices and 16F for the 34) does not require a separate introducer sheath and has the capability to recapture, reposition and retrieve the prosthesis up to the point of 80% of full deployment. At this time, the report from the STS/American College of Cardiology Transcatheter Valve Therapy Registry provides the largest available data of this last generation prosthesis including 3810 patients receiving the Evolut R compared to 5806 patients the CoreValve [13]. Whereas 30-day mortality was lower among the Evolut R group (respectively 3.7% vs. 5.3%, $p < 0.0001$), stroke rate was similar (3.1% for both groups, $p = 0.94$). Similarly to the Edwards valve system, Evolut R showed a significant reduction in ≥ moderate PVL (respectively 4.4% vs. 6.2%; $p < 0.0001$). Even though a reduction of pacemaker implantation was reported in this study, the rates remain higher than with the Edwards valve system and need to be specifically addressed for the future (varying between 15 and 25% in the literature). Recently the Evolut PRO became available in sizes 23, 26 and 29. This latest generation device is 16F compatible and has an additional external pericardial wrap at the level of the skirt in order to further decrease PVL (Fig. 3).

4. The latest pivotal randomized controlled trials

TAVI became a class I indication for inoperable and high-risk patients with severe AS in both the European and American guidelines [14, 15]. Recently, favourable clinical data targeting intermediate-risk patients were published [7, 16]. Subsequently, a class I and IIa were given for this subgroup of patients in the European and American guidelines, respectively [14, 15].

a. Placement of Aortic Transcatheter Valves (PARTNER) 2 trial [7]
   This multicenter non-inferiority study randomized 2032 intermediate-risk patients with severe symptomatic AS between TAVI and SAVR. Patients with an STS score between 4% and 8%, or < 4% if associated with major comorbidities not included in the risk score, were considered as intermediate-risk. Patients with a mean STS score of 5.8% underwent either TAVI with the balloon-expandable Edwards SAPIEN XT prosthesis (former generation) or SAVR in a 1:1 randomized ratio. TAVI met the non-inferiority criteria for the primary outcome, namely a composite endpoint of all-cause mortality or disabling stroke at 2 years which was similar in both groups (respectively 19.3% vs. 21.1%, $p = 0.25$ for the TAVI vs SAVR group). Among the 76% of patients undergoing transfemoral TAVI, mortality or disabling strokes at 2 years were significantly lower in comparison to surgery. This study is the first strong evidence suggesting that TAVI is a reasonable option for selected intermediate-risk patients, especially when transfemoral approach is feasible.
b. SUrgical Replacement and Transcatheter Aortic Valve Implantation (SURTAVI) trial [16]
   SURTAVI, published more recently, was also a non-inferiority trial