Original Article

Early Experience of Transaortic TAVI—The Future of Surgical TAVI?

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Abstract:

Background: **Trans-catheter aortic valve implantation (TAVI) is now a well recognised procedure for the high risk surgical patient with native or bioprosthetic aortic valve stenosis. Transfemoral and transapical implantation techniques are well described. With increasing referral of more marginal transapical patients, we describe our experience of a transaortic TAVI approach which we believe reduces the postoperative wound pain, respiratory complications, operative risk and hospital stay.**

Methods: **Patients referred for surgical TAVI underwent trans-catheter aortic valve implantation via an upper sternotomy and direct cannulation of the ascending aorta.**

Results: **Thirteen patients with a mean age of 81 years underwent transaortic Edwards SAPIEN valve implantation. There was no in hospital mortality in our series. One patient required insertion of a permanent pacemaker for complete heart block. There were no aortic cannulation complications.**

Conclusion: **The transaortic TAVI approach provides good exposure of the distal ascending aorta, a familiar cannulation site for cardiac surgeons. Our initial experience demonstrates the approach to be a safe technique with the potential for faster and less complicated recovery in patients undergoing surgical TAVI procedures. With further experience and greater acceptance, the transaortic approach may ultimately become the procedure of choice for patients unsuitable for a transfemoral approach.**

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Keywords. Aortic valve; Aortic valve stenosis; Heart valve prosthesis implantation; Transcatheter aortic valve implantation

Introduction

With an ageing population there is an increased frequency of patients presenting with symptomatic aortic stenosis. Transcatheter aortic valve implantation (TAVI) has been shown to be a viable alternative to medical therapy or surgical aortic valve replacement in patients with severe aortic stenosis at prohibitive or high risk of mortality with traditional surgical intervention [1,2]. Transapical TAVI has been the approach of choice for patients with heavily diseased iliofemoral systems or aortic disease that prevents transfemoral implantation. Although effective and with comparable results to transfemoral TAVI, the transapical approach has well described procedural and postoperative risks [3,4].

Open aortic valve replacement via an upper hemi-sternotomy has been well described. Reported results describe less wound pain, improved post-operative respiratory function and faster post-operative recovery [5]. We initially employed the transaortic approach via upper hemi-sternotomy following a failed transapical procedure (inability to pass a wire across the aortic valve due to ventricular septal hypertrophy). The valve was successfully deployed via this approach. Postoperatively the patient appeared to have a faster recovery with little or no wound pain and no respiratory issues.

Following that initial experience we have employed the transaortic approach for all TAVI patients that have been unsuitable for a transfemoral approach. We describe our technique and early experience with 13 patients using the Edwards SAPIEN THV system (Edwards Lifesciences, Irvine, CA).

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Patients and Methods

The transcatheter aortic valve implantation (TAVI) program commenced at The Prince Charles Hospital in 2008. The first transapical TAVI was performed in February 2010, with the Edwards-SAPIEN Edwards SAPIEN THV system.

All transaortic TAVI patients were processed through a combined cardiac surgical and cardiologic review process. Patients were reviewed by our cardiac surgical team members and if deemed inoperable or high risk for open AVR the patients were then considered for the TAVI program. All patients were rigorously investigated for TAVI suitability. Patients with significant obstructive coronary artery disease would undergo percutaneous coronary interventions for complete revascularisation. Patients with aorto-ilio-femoral anatomy or calibre prohibitive of transfemoral access were referred for surgical TAVI.

All our procedures were performed in a purpose built hybrid operating room with full cardiac surgical and cardiac catheter lab capabilities. Rotational angiography was utilised in all procedures. Procedures were performed under general anaesthesia with transoesophageal echocardiophy (TOE) guidance. A cardiopulmonary bypass machine is primed and kept in the room for the entire procedure.

The sizing of the transcatheter heart valve (THV) would be echocardiographically determined preprocedure, and the final THV size confirmed on periprocedural 3-dimensional TOE to define the appropriate 23, 26 or 29 mm SAPIEN valve to be used.

Femoral or radial arterial and femoral venous catheter assess is gained. A right ventricular pacing wire is placed. A pigtail catheter is placed in the noncoronary sinus of the aortic root.

A 6 cm midline skin incision is made over the upper sternum. Retrosternal blunt dissection, especially in redo-sternotomy patients, is performed to allow the innominate vein to fall away from the back of the sternum. The midline sternal incision is made with a bone saw, with an extension into the 2nd right intercostal space (Fig. 1). A Tuffier retractor is used to gain exposure, the thymic tissue dissected and the pericardium opened and retracted to expose the aorta. Two felt pledgetted 3/0 prolene pursestrings are placed in the distal ascending aorta.

After heparinisation the aorta is punctured and a 6Fr long sheath inserted. A J-wire is used to retrogradely cross the aortic valve and a JR4 catheter used to exchange to an amplatz extra-stiff wire that is then looped in the left ventricle to provide procedural stability. The 26Fr ASCENDRA introducer sheath (Edwards LifeSciences, Irwine, CA) is then introduced into the aorta. The ASCENDRA balloon catheter is positioned across the aortic valve and under rapid ventricular pacing, the aortic valve is dilated. The prepared SAPIEN valve is then passed into the ASCENDRA introducer sheath. The introducer sheath with the valve still in situ is passed across the aortic valve and into the left ventricle (Fig. 2). The valve is then passed out of the ASCENDRA introducer sheath into the left ventricle and the sheath retracted back into the ascending aorta. The aortic pusher is pulled back from the SAPIEN valve before the valve is carefully positioned across the aortic annulus. After confirming appropriate position radiologically and on TOE, rapid ventricular pacing is initiated and the balloon is then inflated over a 5–8 s period to fully deploy the valve in the native annulus. The balloon is then fully deflated before rapid ventricular pacing is ceased. The valve balloon is then retracted into the ASCENDRA sheath. Satisfactory deployment is confirmed on angiography and TOE before the ASCENDRA delivery system is extracted from the aorta under rapid ventricular pacing and the aortic purse strings tied down. A single intercostal blake drain is placed from the right anterior chest wall and into the upper mediastinal

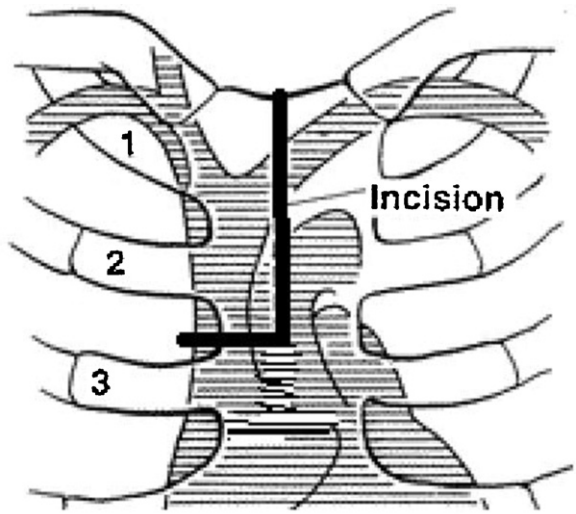

Fig. 1. *Hemi-sternotomy extending into right second intercostal space.*

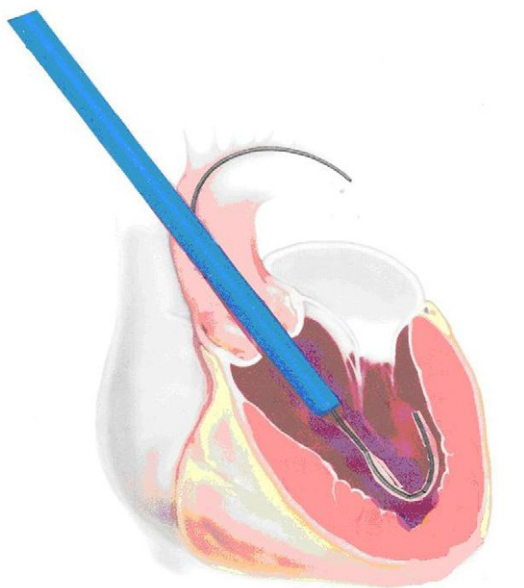

Fig. 2. *ASCENDRA introducer sheath with the valve still in situ passed across the aortic valve and into the left ventricle.*

working space. The sternum is reapproximated with multiple figure of eight size 0 PDS monofilament sutures through the anterior table of the sternum. Sternal wires were not used due to the difficulty of manipulating the sternal wire needle in the poststernal space. The patients are recovered in the intensive care unit.

Results

Thirteen patients underwent transaortic Edwards SAPIEN valve implantation between November 2011 and June 2012.

The mean age of the patients was 81 years (range 65–90). All patients were symptomatic with dyspnoea NYHA classes II–IV. The mean logistic Euroscore was 17.4 (range 6.75–35.60, median 16.86). All patients had severe aortic stenosis on valve area assessment (AVA < 0.95 cm^2). The mean left ventricular ejection fraction was 54.5% via Simpson method (range 35–68%). Six of the 13 cases had previous coronary artery bypass surgery.

Transfemoral access was deemed inappropriate because of small iliofemoral arteries in nine cases (one patient had had a previously failed apical approach due to severe septal hypertophy), a proposed large aortic annulus (29 mm) in one case (although intraoperatively was found to be suitable for a 26 mm valve), an abdominal aortic aneurysm in one case and severely tortuous iliofemoral vessels in two cases.

Nine 26 mm and four 23 mm Edwards SAPIEN valves were successfully implanted. One patient had a second 23 mm valve implanted due to concern of native aortic leaflet overhang. Native leaflet overhang following deployment of the SAPIEN valve has been shown to impair the function of the valve due to reduction in closing forces which may lead to transvalvular regurgitation [6]. Given the native leaflet overhang observed on post-deployment imaging the decision was made to deploy a second valve in a valve-in-valve fashion slightly higher to negate this overhang with a satisfactory result. All patients had transthoracic echocardiograms (TTE) performed day 5 revealing a mean pressure gradient (MPG) of 14.8 vs. 48 mmHg pre-operatively ($p = 0.0005$). Twelve of the 13 patients had 0 or 1/4 paravalvular AR while one patient had 2/4 paravalvular AR post-operatively.

There was no in-hospital mortality among the 13 patients. One patient required a permanent pacemaker inserted for new complete heart block and one patient suffered from delirium that resolved. A CT brain scan in this patient revealed no acute changes to suggest a new cerebrovascular accident. There was no significant blood loss or aortic cannulation issues. Patients subjectively had less wound pain in the postoperative period and there appeared subjectively to be less impact on respiratory function.

Discussion

TAVI has become a well-established treatment option for patients that are regarded to be prohibitive or high risk for conventional open aortic valve surgical techniques [1,2]. Transapical TAVI is employed in patients that are unsuitable for transfemoral implantation due to technical issues (small ileofemoral vessels, large valve annulus size, abdominal aortic aneurysm or unfavourable aortic arch anatomy). Although transapical TAVI is an effective technique, a number of serious complications have been described. These include apical cannulation bleeding and late false aneurysm development, difficulty in wire and valve placement in patients with marked septal hypertrophy and access difficulties in patients with left chest problems such as previous thoracic pleurodesis or chest wall deformities [3,4,7–10].

Transaortic TAVI has recently emerged in the literature as a viable and safe technique of valve implantation [11,12]. The technique we describe of transaortic TAVI via a hemisternotomy, has a number of advantages.

Firstly, ease of access. The aorta is a familiar cannulation site for cardiac surgeons. The upper hemisternotomy approach from the supra-sternal notch extending out into the right 2nd intercostal space provides good exposure to the distal ascending aorta. Access and visualisation, even in reoperative sternotomy patients, was excellent. Care was taken with all reoperative patients to assess the proximity of the innominate vein to the back of the sternum to avoid injury at reoperation.

Secondly we feel the risk of haemorrhage or late false aneurysm is low. Generally the aortic tissue is much more robust than ventricular muscle and more easily controlled after explanting the ASCENDRA delivery system. Bleiziffer et al. reported severe apical bleeding complications in 7% of patients undergoing transapical TAVI. A further 2% of patients developed an apical pseudoaneurysm. Apical bleeding and pseudo-aneurysm formation adversely affected mortality in Bleiziffer's series [8]. We did not observe vascular or bleeding complications in any of our 13 patients. This is consistent with results published by Bapat et al. who reported no vascular complications in the largest transaortic TAVI series to date (17 patients) [11].

Thirdly, wound pain and respiratory dysfunction subjectively seemed much less in this transaortic group. In our transapical patients, with access to the apex gained through a minithoracotomy, postoperative wound pain was common and often respiratory performance was impaired, increasing the risk of postoperative respiratory problems such as infections, atelectasis and pleural effusions. A recently published series by Walther et al. of 150 patients undergoing transapical TAVI demonstrated significant respiratory morbidity (8.7% of patients in Walther's series developed respiratory failure requiring respiratory assistance while 26% of patients developed pleural effusions requiring therapy) [4]. Upper hemisternotomy, or ministernotomy, is well recognised as a minimally invasive approach for surgical AVR. It has been shown to lead to improved recovery of respiratory function when compared to patients undergoing a median sternotomy for surgical AVR [5]. Bapat et al. reported similar clinical outcomes in their 17 patients undergoing transaortic TAVI via a hemisternotomy in comparison to transapical TAVI patients despite the transaortic group

Fig. 3. *Crimped valve (A) without nose cone (B) with nose cone (ASCENDRA + delivery system; Edwards LifeSciences, Irwine, CA).*

having a higher prevalence of significant respiratory disease [11].

Fourthly, the transapical approach requires suture closure of the apex of the left ventricle. Although difficult to assess postoperatively, there is likely some degree of diastolic stiffness associated with a localised apical left ventricular infarct and oedema in the surrounding tissues associated with surgical closure. Bleiziffer et al. have demonstrated new apical hypokinesis or akinesia in a significant proportion of patients undergoing tranapical TAVI [8]. A transaortic approach avoid these local deleterious effects on the left ventricular apex which may be particularly advantageous in low ejection fraction patients.

Lastly, in the event of an intraoperative problem, the wound can be extended to a full sternotomy, in cases that are suitable, allowing open surgical access to the heart.

Our technique employs the transapical ASCENDRA delivery system. Initially we had some difficulty passing the SAPIEN valve across the native aortic valve due to the absence of a nose cone that is available for the transfemoral device and, more recently, newer generation trans-apical delivery devices. Without the nose cone the flat edge of the crimped valve is not a smooth linear surface (Fig. 3). We were concerned that forceful placement of the valve across the annulus could cause embolic events from the native valve or could damage the SAPIEN valve. To avoid this we passed the ASCENDRA delivery sheath, with the valve inside, across the annulus and into the left ventricle. The valve was then delivered into the ventricle, the sheath pulled back into the aorta and the valve pulled antegrade to sit across the annulus ready for deployment. Using this technique we have not had any difficulty with delivery and no embolic events.

Contra-indications for this technique would include patients with a heavy calcific burden in the ascending aorta. However, in our early experience, we were generally able to find an area that was soft and able to be cannulated. Previous sternotomy patients also represent a potential relative contra-indication if the innominate vein is closely adherent to the sternum. In our experience this has not been a significant problem to date.

Conclusion

We believe that the transaortic TAVI approach provides good exposure, is a safe technique and has potential for faster and less complicated recovery in patients undergoing TAVI procedures. With further experience and greater acceptance, the transaortic approach may ultimately become the procedure of choice for patients unsuitable for a transfemoral approach.

Conflict of Interest

None.

Acknowledgement

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.hlc.2012.11.002.

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