Lateral (left-right commissural) root enlargement may reduce risk of coronary artery obstruction from transcatheter aortic valve-in-valve implantation

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PII: S2666-2507(23)00180-3
DOI: https://doi.org/10.1016/j.xjtc.2023.05.006
Reference: XJTC 1398

To appear in: JTCVS Techniques

Received Date: 17 March 2023
Accepted Date: 17 May 2023

Please cite this article as: Wong DR, Luc JGY, Nguyen Q, Latham TB, Lateral (left-right commissural) root enlargement may reduce risk of coronary artery obstruction from transcatheter aortic valve-in-valve implantation, JTCVS Techniques (2023), doi: https://doi.org/10.1016/j.xjtc.2023.05.006.

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Title: Lateral (left-right commissural) root enlargement may reduce risk of coronary artery obstruction from transcatheter aortic valve-in-valve implantation

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Disclosure Statement: D. Wong has received consulting fees from Edwards Lifesciences, and is a proctor for Artivion and Boston Scientific.

Funding Statement: None.

IRB/ERB number and date of approval: Not applicable.

Informed Consent Statement: Not applicable.

Article word count: 748/750 word limit
Central Picture

Legend: Lateral aortic root enlargement through the left-right (LR) commissure
Central Message

Lateral root enlargement at the left-right commissure may reduce risk of transcatheter aortic valve-in-valve implantation-induced coronary artery obstruction via sinus sequestration.
Glossary of Abbreviations

AVR, aortic valve replacement
CT, computed tomography
LN, left-non
LR, left-right
RN, right-non
STJ, sinotubular junction
TAVI, transcatheter aortic valve implantation
VTC, virtual transcatheter valve to coronary distance
VTSTJ, virtual transcatheter valve to sinotubular junction distance
Background

We propose a novel surgical technique for lateral root enlargement, wherein a patch splits the left-right (LR) commissure. This technique borrows heavily from root enlargement techniques described by Nicks, Manouguian, and Yamaguchi.\(^1\)\(^-\)\(^3\) In addition to enlarging the annulus, this technique modifies the shape of the root in ways that may reduce risk of coronary artery obstruction and sinus sequestration during future TAVI.

Technique

The aorta is opened anteriorly 1cm above the sinotubular junction (STJ), and extended leftward, to curve down through the STJ, to the top of the LR commissure. The aortic leaflets are excised. After separating the aorta from the pulmonary artery behind the LR commissure, the aortotomy is extended further, splitting the LR commissure along its length, into the subcommissural triangle, stopping 3mm before entering septal myocardium (Figure. 1).

A patch is sewn into the divided LR commissure, using 4-0 polypropylene suture, similar to a Nicks root enlargement. The patch suture lines are continued past the STJ, before sewing in the valve. The valve sutures should traverse the patch well above its nadir, where the patch is at least 6mm wide to upsize the valve. Once seated, there should be a few mm of space behind the tip of the LR strut and the patch. The aortotomy is closed, incorporating the patch whilst permitting it to bulge outwards slightly when the aorta is pressurized.

CT analysis
To simulate future valve-in-valve TAVI and assess risk for coronary obstruction, a virtual TAVI valve was superimposed on 3-dimensional multi-planar reconstructed postoperative CT images with Horos v4.0.0 DICOM image viewer for MacOSX. Risk of TAVI-induced coronary artery obstruction is considered high if the virtual transcatheter valve to STJ distance (VTSTJ) over a coronary ostium is <2mm and if virtual transcatheter valve to coronary distance (VTC) is <4mm. As shown in Figure 2d, the VTSTJ over the left main and right coronary arteries were 1mm and 9mm, respectively. The billowing patch material provides ample room (9mm) for blood flow from the tubular aorta into the right sinus. Critically, it also establishes a new route (up to 6mm measured between the LR strut and patch) for flow behind the LR strut into the left sinus, thus mitigating risk of left main coronary obstruction. VTC was 5 mm for both coronary ostia. As shown in Figure 2, a balloon-expandable TAVI valve, a tall self-expandable TAVI valve, and even a TAVI-in-TAVI implant would be predicted to be safe for valve-in-valve implant, with flow into the left and right sinuses supplied almost exclusively via the billowing patch.

Discussion

There are several advantages to this novel technique. First, the surgeon can easily visualize the LR commissure and suture high at the commissure rather than deep within the nadir of the posterior annulus. Second, this technique may lend itself to younger patients in whom a future valve-in-valve TAVI (and even subsequent TAVI-in-TAVI procedures) may otherwise lead to sinus sequestration. Compared to other root enlargement techniques, there is little risk of distorting the mitral valve and inducing mitral regurgitation as with the Manouguian; rotation of any of the coronary arteries, as with the Y incision technique, is not necessary; and it does not require
patching of the ventricular septum and is easier to perform than the Konno and Yamaguchi techniques. Unlike root replacement, there is no need to reattach coronary buttons, and the elastic properties of the root are maintained. Finally, for concomitant mitral and aortic valve surgery, there is no interference from the mitral prosthesis, another potential limitation of posterior techniques.

Potential pitfalls include extension of the enlargement into septal myocardium, which risks bleeding from friable tissue. Second, it is unlikely that this technique will permit upsizing by more than 1-2 valve sizes, although it may be possible to perform concurrent lateral and posterior (bilateral) root enlargements. Finally, this technique is not advisable in the presence of anomalous coronaries between the great vessels, or in patients with pulmonary hypertension, pulmonary artery dilatation, or existing or planned surgical or percutaneous pulmonic valve replacements which can compress the patch.

With increasing use of TAVI to treat failing surgical bioprostheses, technical considerations at the initial operation play a role in the lifetime management of aortic valve disease. Lateral (LR-commissural) root enlargement is a simple method for enlarging the aortic annulus and modifying the risk of future TAVI-induced coronary artery obstruction and sinus sequestration.
109 References


**Figure Legends**

**Figure 1:** Operative technique illustrated.  

- **a.** After cardioplegic arrest, the main pulmonary artery (PA) and proximal ascending aorta are separated (blue arrowhead); an aortotomy is made starting 1cm above the sinotubular junction (STJ) anteriorly above the right coronary artery, and curved towards the top of the left-right (LR) commissure laterally, and transversely in a medial direction.  
- **b.** Retraction sutures are placed, and the diseased aortic valve is inspected and excised.  
- **c.** Using cautery and scissors, the plane between the aorta and PA behind the LR commissure is developed (blue arrowhead), and then the aortotomy is extended 1-1.5cm further down the middle of the LR commissure (blue dotted line), remaining within aortic tissue (in the subcommissural triangle) and avoiding septal myocardium (red X).  
- **d.** This opens a “V”-shaped cleft through the commissure.  

The plane between aorta and PA (blue arrowhead) may need to be developed more thoroughly so as to mobilize the cut aortic edges.  

- **e.** A 4x4cm piece of bovine pericardium or 5cm length of 8mm Dacron tube graft split open down its length (Boston Scientific Corporation, Natick, MA) is then fashioned into a 5-6cm long and 2-2.5cm wide patch with 45-degree diamond-shaped short ends, and is sewn smooth side facing inwards, to the cleft in the LR commissure using a 4-0 polypropylene continuous suture line with small, closely-spaced bites.  

After parachuting the valve down into place, care is taken to invert the edges of the patch, especially for the portion of the suture line above the annulus, so that the rough side of the patch meets the adventitia of the aorta; this encourages the patch to bulge outwards from the aorta.  

- **f.** It is best if the suture line is continued on both sides of the patch beyond the STJ, before implanting the valve.  

The surgical aortic valve suture line (blue dotted line) should pass through the patch; and the patch should have been fashioned so it is at least 6mm wide at the level where the annulus and valve suture line intersect it.  

- **g.** Once the valve is seated and tied down, there will be a few mm of separation behind
the left-right strut of the surgical bioprosthesis in front of the patch. h, Finally, the remainder of
the patch is incorporated into the closure and billows outwards when pressurized after completion
of the closure.

**Figure 2:** Post-operative computed tomography of the aortic root with 3-dimensional multi-planar
reconstruction. The 4 upper images (a through d) show a plane (parallel to the annular plane
through the surgical bioprosthesis) at the level of the coronary ostia (a through c) and at the level
of the sinotubular junction and tops of the surgical valve struts (d); the 4 lower images (e through
h) show orthogonal side view planes corresponding to the *thick yellow lines* in the image above
each one respectively (*purple lines* in the lower images mark the height of the planes corresponding
to the upper images). The left-non, right-non, and left-right valve struts are labeled LN, RN, and
LR, respectively. Virtual transcatheter valves (as a valve-in-valve within the surgical bioprosthesis)
appear as superimposed 20mm *orange circles* in a through d, and as *orange box outlines* (to
illustrate a balloon-expandable valve with 20mm width) and *green solids* (to illustrate a self-
expandable valve with 20mm width inflow and 45mm height) in e through h. Flow of blood (*white
arrows*) into the sinuses of Valsalva and coronary arteries is facilitated by the extra space created
by the billowing patch (*curved red lines*); coronary flow is likely to be preserved even if a self-
expandable TAVI valve were to require subsequent TAVI-in-TAVI implant, which would extend
the chimney of leaflet tissue up to the *dotted green line*. g corresponds to a 2-cusp overlap
fluoroscopy view, and conveniently demonstrates well the area of enlargement behind the LR strut;
* denotes the right coronary artery, ** denotes the left main coronary artery.