



## Research Letter

# Review of Outcomes of Transcatheter Aortic Valve Replacement in Patients with Anomalous Coronary Arteries



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## Introduction

Transcatheter aortic valve replacement (TAVR) is a guideline-recommended minimally invasive procedure to replace severely stenosed aortic valves.<sup>1</sup> The increased range of approved indication for TAVR has increased the number of patients able to receive treatment of severe aortic valves with outcomes comparable with those of surgery.<sup>1</sup> One area of use for TAVR could be in patients with anomalous coronary arteries (ACAs) who are deemed high-risk surgical candidates. ACAs are congenital anomalies seen in 2.2% of autopsy specimens.<sup>2</sup> They have a reported prevalence of ~0.2%-2.3%.<sup>3,4</sup> ACAs have little clinical significance because most patients are asymptomatic except for cases in which a coronary artery transverses between the pulmonary artery and aorta, which can cause sudden cardiac death at a young age owing to extrinsic coronary arterial occlusion.<sup>5</sup> Although coronary obstruction has been reported as one of the main complications after TAVR, there is a paucity of data on the outcomes of TAVR in patients with ACAs. Hence, this study reviewed published cases on the outcomes of TAVR in patients with ACAs.

## Methods

A systematic literature search for the outcomes of TAVR in the context of coronary artery anomalies was conducted in November 2021. Two independent searches by 2 separate investigators (K.E., U.N.I.) were conducted with one investigator using the PubMed and the other using the Google Scholar. The PubMed search used a combination of 2 sets of search terms: coronary artery anomaly terms and valve replacement terms. The keyword phrases for coronary artery anomalies were "coronary artery anomaly" or "anomalous coronary artery." The keywords for valve replacement were "TAVR" or "TAVI" or "Transcatheter aortic valve replacement" or "Transcatheter aortic valve implantation." Multiple searches were performed by combining

1 keyword phrase from each set of the search terms. The Google Scholar search used the keywords "TAVR," "anomalous coronary artery," "anomalous coronary arteries," and "outcomes" in different combinations. The keywords were placed within the quotation marks to limit searches to exact results and different keywords were strung together using "+" to look for results containing multiple keywords. PubMed articles suggested by citation matching were included in the study, and an additional manual search through the citations of relevant reports found through the initial search was conducted. The Preferred Reporting Items for Systematic Review and Meta-Analysis Statement for reporting search data was used. Case reports and case series published between 2011 and 2021 were included. Abstracts and conference presentations were excluded from our analysis. This research was performed in accordance with the appropriate ethical guidelines. Because this study was a review of the literature, patient consent was not indicated.

## Results

A total of 24 publications describing 28 patients with ACAs who underwent TAVR were identified. Table 1<sup>6-25</sup> itemizes and summarizes the findings of all relevant articles included in this study. The mean age of the study population was 80.8 ± 6.6 years, and 50% of the patients were women. ACAs were incidentally diagnosed during the preprocedural catheterization or coronary computed tomography angiography. The coronary artery with the most anomalous origin was the left circumflex artery (35.7%). New York Heart Association class, surgical risk, and frailty scores were reported in <50% of the articles; therefore, we did not include the varying percentages. Balloon-expandable SAPIEN (Edwards Lifesciences) valves were used in 64.3% of the cases, whereas CoreValves (Medtronic) were used in 17.9% of the cases. ACURATE neo valves (Boston Scientific) were used in 2 patients, and the LOTUS valve (Boston Scientific) was used in 1 patient; 23 patients

Keywords: anomalous coronary artery; aortic stenosis; transcatheter aortic valve replacement.

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**Table 1.** Summary of reviewed studies and case reports.

Reference, year	Age, y	Sex	Valve type	Valve size	Approach	Type of anomaly	Outcome	Timing of outcome
Cho et al, <sup>6</sup> 2019	77	F	SAPIEN 3	26 mm	Transfemoral	LCA from RCS	Normal	NA
Mennuni et al, <sup>7</sup> 2011	84	M	CoreValve	26 mm	Transfemoral	LCx from RCA	Normal	NA
Ujihira et al, <sup>8</sup> 2019	80	M	SAPIEN 3	29 mm	Transfemoral	LCx from the right sinus of Valsalva	Normal	NA
	87	M	SAPIEN 3	29 mm	Transfemoral	LCx from the right sinus of Valsalva	Normal	NA
	80	M	SAPIEN 3	29 mm	Transfemoral	LCx from the right sinus of Valsalva	Normal	NA
Alameddine et al, <sup>9</sup> 2019	79	F	SAPIEN 3	23 mm	Not reported	LCx from the right aortic sinus	Normal	NA
	85	M	SAPIEN 3	29 mm	Not reported	LCx from the right aortic sinus	Normal	NA
Bertin et al, <sup>10</sup> 2020	65	F	Evolut PRO	26 mm	Transfemoral	Single RCA	Normal	NA
Tzani et al, <sup>11</sup> 2020	84	M	ACURATE neo	25 mm	Not reported	LM from RCS	Normal	NA
Fumiaki et al, <sup>12</sup> 2021	89	M	CoreValve Evolut PRO+	29 mm	Transfemoral	LCA origin from near the commissure of the noncoronary and left coronary cusps	Left main trunk coronary occlusion from extramural compression by Evolut PRO+	Intraoperative; treated with 4.0 mm drug-eluting stent with a resolution of ST elevation
Birkel et al, <sup>13</sup> 2020	76	M	SAPIEN 3	26 mm	Transfemoral	RCA from LAS	Ischemic right ventricular infarction and occlusion of RCA	Intraoperative; single-vessel venous bypass graft surgery to the RCA with good outcomes
Soberts et al, <sup>14</sup> 2012	89	F	CoreValve Accutrak	26 mm	Transfemoral	Single coronary artery originating from the right sinus of Valsalva	Normal	NA
	87	F	SAPIEN XT	23 mm	Transfemoral	Single coronary artery originating from the right sinus of Valsalva	Normal	NA
Mizote et al, <sup>3</sup> 2017	81	F	LOTUS	23 mm	Transfemoral	ALCA from the right coronary cusp	Coronary obstruction of the ALCA requiring stent placement	Intraoperative; treated with 2 drug-eluting stents to the LM with good outcomes
Aldauig et al, <sup>15</sup> 2021	82	F	SAPIEN	Not reported	Transfemoral	LCx from the right coronary cusp	Normal	NA
Dursun et al, <sup>16</sup> 2016	81	F	CoreValve	26 mm	Transfemoral	Single coronary artery arising from right sinus of Valsalva bifurcation into RCA	Normal	NA
Mbai et al, <sup>17</sup> 2020	72	M	SAPIEN S3	26 mm	Transfemoral	LCx from the right coronary cusp	Normal	NA
Alrifai et al, <sup>18</sup> 2018	89	M	SAPIEN S3	26 mm	Transfemoral	Single coronary ostium	Normal	NA
Giri et al, <sup>19</sup> 2012	88	F	SAPIEN	Not reported	Transfemoral	Single coronary ostium anomalous LCA from the RCA	Normal	NA
Acosta-Velez et al, <sup>20</sup> 2014	86	F	SAPIEN XT	26 mm	Transfemoral	LCx from the RCA	Acute LCx occlusion due to extrinsic compression by TAVR prosthesis	Intraoperative; treated with a bare metal stent to the LCx with good outcomes
Weich et al, <sup>2</sup> 2011	79	M	SAPIEN	26 mm	Transapical	NA	NA	NA
Gort et al, <sup>21</sup> 2016	86	F	SAPIEN XT	26 mm	Transfemoral	Single coronary artery	NA	NA
Khan et al, <sup>4</sup> 2020	69	F	Not reported	Not reported	Not reported	NA	Normal	NA
Yagamata et al, <sup>22</sup> 2021	79	F	CoreValue Evolut R	26 mm	Transfemoral	RCA from the left coronary sinus	Normal	NA
Costa et al, <sup>23</sup> 2022	82	F	ACURATE neo 2	23 mm	Transfemoral	LCA from the noncoronary cusp	Normal	NA
Kang et al, <sup>24</sup> 2020	65	M	SAPIEN 3	29 mm	Transfemoral	LCx from RCS	Normal	NA
Rubinshtein et al, <sup>25</sup> 2017	80	M	SAPIEN XT	29 mm	Transfemoral	LM from RCS	Normal	NA
Qavi and Ilyas, <sup>5</sup> 2019	86	M	Not reported	Not reported	Not reported	Single coronary ostium	Normal	NA

ALCA, anomalous left main coronary artery; F, female; LCA, left coronary artery; LCx, left circumflex artery; LM, left main coronary artery; M, male; NA, not applicable; RCA, right coronary artery; RCS, right coronary sinus; TAVR, transcatheter aortic valve replacement.

(79.3%) recorded a normal outcome after the TAVR procedure, whereas complications were reported in 4 cases. One article did not report the study outcome. The most common complication was acute occlusion of the coronary artery, which was resolved with stent placement in 3 patients and single-vessel venous bypass graft in 1 patient, all with good outcomes.

## Discussion

In patients with severe aortic valve stenosis, TAVR has become an increasing popular alternative to surgery. However, its application in patients with ACAs is not well studied. TAVR in patients with ACAs can be a challenging procedure.<sup>6</sup> Favorable outcomes depend on the meticulous assessment of the patient, appropriate preprocedural and intra-procedural imaging, and measures to bail out complications if they occur.<sup>7</sup> ACAs are diagnosed during pre-TAVR coronary angiography. Multislice computed tomography of the heart performed as part of the pre-TAVR workup helps to define the coronary anatomy and course and to carefully analyze the aortic root and coronary heights. In patients with low coronary heights and adequate sinus of Valsalva, coronary angiography during balloon aortic valvuloplasty can be useful in assessing for adequate coronary perfusion during appropriately sized balloon inflation in the aortic valve annulus and aortic root to anticipate and avoid any risk of coronary obstruction during valve implantation. Balloon predilation is also useful to evaluate for the risk of extrinsic compression of the ACA. Although appropriate measures are taken to ensure the best patient outcomes, complications can sometimes occur during this procedure. In the reviewed cases, successful valve replacement was seen in >70% of the total subjects. The most fatal complication of TAVR in patients with ACA was coronary artery obstruction. Risk factors for coronary obstruction were low origin of the coronary arteries (<10.0 mm), narrow sinus of Valsalva (<30.0 mm), bulky calcifications, bulky leaflets, a small sinus of Valsalva and valve misplacement, or coronary emboli. Acute coronary obstruction during TAVR is fatal and manifests as persistent hypotension, arrhythmias, and myocardial infarction, which occurred in 4 of the 28 reported cases, with all of them occurring intraoperatively. To prevent and/or intervene in a timely fashion in the case of a coronary artery occlusion, most operators placed a coronary wire provisionally before valve deployment (Table 1). One patient experienced intraoperative right ventricular infarction and occlusion of the right coronary artery that could not be treated percutaneously, leading to emergent single-venous bypass graft surgery of the right coronary artery (Table 1). A provisional coronary wire was not placed in this case, which could have resulted in stent placement instead of open-heart surgery.

In this review, the choice of TAVR valve used did not significantly affect the observed outcomes. For some authors, the choice to use a balloon-expandable valve was made based on suitable anatomical features such as acceptable coronary height and proposed easy access to the coronaries in a case of complication. A self-expanding valve was the preferred TAVR valve by some operators (Table 1) because it can be recaptured until two-thirds of the bioprosthetic is implanted. This offers the advantage of recapture in the event of an intraprocedural complication. Although this might offer an advantage in preventing coronary obstruction, there is no direct evidence that using a self-expanding valve reduces the risk of coronary obstruction.<sup>7</sup> One case of acute coronary obstruction was seen in a case in which there was a 20% oversizing of the balloon-expandable valve used (Table 1), and some operators have proposed the use of smaller prosthetics to prevent a coronary obstruction (Table 1). Although there were no reported cases of late complications, there is the possibility of a late obstruction from the continued expansion of the nitinol of self-expanding valves. Overall, there was comparable outcomes between the balloon-expandable and self-expanding TAVR valves (Table 1). Most of the operators in our series used the balloon-expandable SAPIEN valve (Table 1). Some of the

techniques used by some operators to ensure a good patient outcome include commissural or coronary alignment to orient the transcatheter valves properly and enable future cannulation of the coronary artery. Other known complications of TAVR in normal coronary arteries such as device embolization, valve malpositioning, conduction disturbances, and stroke were not reported in the reviewed cases.

The occurrence of ACAs can potentially complicate TAVR procedure for patients with severe aortic stenosis. However, with careful planning such as provisional wiring of the ACA, TAVR can be successfully performed in this patient population.

## Declaration of competing interest

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## Ethics statement and patient consent

This research was performed in accordance with the appropriate ethical guidelines. Because this study was a review of the literature, patient consent was not indicated.

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