Concomitant Anaortic OPCAB and Transfemoral TAVR for High-Risk Patients: A Case Series

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Abstract

Background Combined ONCAB and SAVR is the treatment of choice for concomitant severe aortic stenosis and coronary artery disease not amenable to PCI intervention. Extensive aortic calcification and atheromatous disease may prohibit cardiopulmonary bypass and aortic cross clamping. In these cases Anaortic OPCAB is a Class I (EACTS 2018) and Class IIA (AHA 2021) indication for surgical coronary revascularization. TAVR has similar benefits when compared to SAVR for this population (Partner 2 & 3). Herewith we describe a case series of concomitant Anaortic OPCAB and TAVR via the transfemoral approach for patients with coronary artery and valve disease considered too high risk for traditional CABG and SAVR due to severe aortic disease. **Methods/Results** Eight patients underwent anaortic OPCAB and transfemoral TAVR during the same anesthetic in a hybrid operating room. Seven patients with multi-vessel disease had anaortic OPCAB via a sternotomy using composite grafts, one patient with LAD disease had anaortic OPCAB using a Da Vinci assisted MIDCAB approach. All patients then had an Edwards Sapien 3 TAVR placed percutaneously via the common femoral artery. There was no thirty-day mortality or CVA in the series and all patients were discharged to home or a rehabilitation facility on day 4-13. **Conclusions** Combined anaortic OPCAB and transfemoral TAVR is a safe and feasible approach to treating concomitant extensive coronary artery disease and severe aortic stenosis. The aortic no-touch technique provides benefits in the elderly high-risk patients by reducing the risk of post-operative myocardial infarction and cerebrovascular stroke.

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ABBREVIATIONS:

Aortic Stenosis (AS)

American Heart Association (AHA)

European Association for Cardio-Thoracic Surgery (EACTS)

Chronic obstructive pulmonary disease (COPD)

Coronary Artery Disease (CAD)

Cerebrovascular accident (CVA)

Coronary artery bypass grafting (CABG), off-pump OPCAB, on-pump ONCAB

Porcelain Aorta (PA)

Percutaneous coronary intervention (PCI)

Transcatheter aortic valve replacement (TAVR)

surgical aortic valve replacement (SAVR)

internal mammary artery (IMA), left LIMA, right RIMA

Myocardial infarction (MI)

IRB: N/A. Determined to be exempt as case report, no additional treatment or patient interaction was undertaken.

Consent: N/A

Clinical trial registration number: N/A

Abstract

Background

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Methods/Results

Eight patients underwent anaortic OPCAB and transfemoral TAVR during the same anesthetic in a hybrid operating room. Seven patients with multi-vessel disease had anaortic OPCAB via a sternotomy using composite grafts, one patient with LAD disease had anaortic OPCAB using a Da Vinci assisted MIDCAB approach. All patients then had an Edwards Sapien 3 TAVR placed percutaneously via the common femoral artery. There was no thirty-day mortality or CVA in the series and all patients were discharged to home or a rehabilitation facility on day 4-13.

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Introduction

A vast proportion of cardiac surgery manages conditions whose pathophysiology is driven by shared biologic mechanisms of atherosclerosis, such as coronary artery disease (CAD) and calcific aortic stenosis (AS)[1]. A third member of this cluster is aortic atherosclerotic disease[2,3], which at its most severe, results in nearly circumferential heavy calcification referred to as porcelain aorta (PA). Due to the common pathophysiology, there is significant overlap in the risk factors predisposing to each disease and thus it is not uncommon for patients to develop concomitant disease. Indeed, severe aortic stenosis requiring intervention is associated with significant coronary artery disease in up to 50% of cases[4]. Porcelain aorta has been found in 7.5% of all patients evaluated for AS and in up to 9.3% of patients undergoing coronary artery bypass grafting (CABG)[5].

These are diseases of the elderly - all are increasingly recognized in patients older than 60 and their prevalence and severity worsen with increasing age[1,5]. Clinicians and surgeons alike must be prepared to manage these aging high-risk patients with concomitant atherosclerotic disease as the elderly are the fastest-growing segment of the population[6]. Life expectancy is predicted to increase from 79.7 years in 2017 to 85.6 years, with people >65 forecasted to make up 1/4 of the US population by 2060[7].

Management must carefully weigh the risks and benefits of intervention. While old age, severe disease, and an accruing number of comorbidities all increase the risk of negative outcomes, such as stroke and death, surgical intervention is nonetheless necessary in this population. Once symptomatic, mortality in patients with AS is >90% by 2 years[8]. There is no effective preventative nor curative medical treatments for AS[1]. However following aortic valve replacement, the 15-year survival rate returns to that of an age- and sex-matched population without AS, even in the most elderly[9]. Surgical revascularization in stable coronary disease has been proven to decrease the rates of myocardial infarction (MI) and emergency revascularization, both of which are independent predictors of mortality[10]. Further, surgical intervention has been proven to significantly improve quality of life outcomes in both CAD and AS when compared to medical management alone[6,11].

As CAD and AS commonly co-exist, extensive research has been done to evaluate the best course of surgical management. Current 2021 American Heart Association (AHA) guidelines recommend coronary artery bypass grafting (CABG) to be performed on patients who have significant disease burden and are undergoing other non-coronary cardiac surgery, as concomitant management improves outcomes[12,13]. Conventionally, in patients not amenable to percutaneous coronary intervention (PCI), CABG and surgical aortic valve replacement (SAVR) are the treatment of choice. However, aortic manipulation employed in CABG and SAVR carries prohibitive risk in patients with PA. These techniques disrupt and dislodge atheromatous emboli which significantly increase the risk of perioperative stroke[14,15].

Thus, a novel and entirely anaortic approach must be created and utilized in the treatment of this select patient population. Anaortic OPCAB is a Class I (EACTS 2018) and IIa (AHA 2021) indication for surgical coronary revascularization in patients with a diseased aorta[13,16]. Transcatheter aortic valve replacement (TAVR) is non-inferior at all patient risk levels and significantly decreases all-cause death and stroke in intermediate and high risk populations compared to SAVR[17]. Like anaortic OPCAB, the transfemoral approach for TAVR avoids all aortic manipulation. Several authors have previously described concomitant

OPCAB and TAVR[18-21], however these series have involved aortic manipulation during proximal anastomoses and/or transaortic delivery of the TAVR. Herewith we describe a case series of concomitant anaortic OPCAB and transfemoral TAVR for patients with coronary artery and valve disease considered too high risk for traditional CABG and SAVR due to porcelain aorta.

Methods

Study design and population:

Between July 2020 and October 2021, 8 patients underwent concomitant Anaortic OPCAB and transfemoral TAVR during the same anesthetic. All patients had severe aortic stenosis noted on pre-operative echocardiographic evaluation, as defined by the AHA guidelines, and concomitant coronary disease that was considered not amenable to PCI. Furthermore, significant aortic calcification and atheromatous disease were also seen in all 8 patients with all patients being diagnosed with a porcelain aorta prior to surgical intervention (Table 1). Patients were evaluated by the institutional, multidisciplinary structural heart team including cardiac surgeons, imaging and interventional cardiologists. Once approved, the patients were scheduled for concomitant anaortic OPCAB and TAVR.

Surgical technique:

The procedures were conducted in a hybrid operating room. Our technique for multi-vessel anaortic OPCAB has been described in detail[22,23] and a representative illustration of the most common vessel arrangements is reproduced in Figure 1 with permission from Seco et al. Eight patients underwent a no-touch anaortic OPCAB via median sternotomy. One patient with isolated LAD disease received a no-touch anaortic OPCAB using a Da Vinci assisted MIDCAB approach, via a left anterior mini-thoracotomy and an in situ LIMA graft. Internal mammary arteries were harvested as in-situ conduits using skeletonized technique. The left internal mammary artery (LIMA) was used to graft the LAD in all cases. The remaining vessels were grafted using a composite arrangement, either using a "T" graft from the LIMA or a tandem graft from an in-situ right internal mammary artery. The radial artery or saphenous vein were harvested in cases of multi-vessel disease using an endoscopic technique to use as free conduits in a composite graft format, with IMA in-flow as described above. The anaortic OPCAB was performed using the Medtronic Octopus stabilizer and silastic intracoronary shunts were used for all anastomoses. The Medistime MiraQ TTFM flow probe was used to assess all grafts at the completion of the anastomoses. Following completion of the operation, protamine was given to fully reverse the heparin. The patient's chest was closed and the patient was moved to the angiography bed. All patients then had an Edwards Sapien 3 TAVR placed percutaneously via the common femoral artery.

Assessment of valvular and ventricular function were evaluated using transesophageal echocardiography intraoperatively. Postoperative evaluation of valvular and ventricular function was performed using transthoracic echocardiography prior to hospital discharge. Patients received outpatient follow up within 30 days of the procedure.

Outcomes and definitions

The primary end-points of the study were 30-day mortality and device success. The secondary end-point was the development of any postoperative adverse events as defined by the Valve Academic Research Consortium (VARC-2)[24].

Results

The mean age at the time of surgery was 77 +/- 5.67 years old (Table 1). All patients presented with severe aortic stenosis by AHA criteria[7]. Mean aortic valve area was 0.78 ± 0.13 cm^2 with a mean pressure gradient of 44 ± 12.7 mmHg. All patients presented with coronary artery disease requiring revascularization via CABG. 4 (50%) patients presented with 3 vessel disease, 2 (25%) with L MCA stenosis, and 3 (38%) with proximal LAD stenosis. All 8 (100%) patients presented with a porcelain aorta and multiple other comorbidities precluding safe use of cardiopulmonary bypass and aortic cross-clamping (Table 1). 1 (14%) patient had previous PCI with restenosis requiring repeat intervention.

All patients underwent TAVR without any findings of postoperative leak on TEE. An average of 2.25 ± 0.89 vessels were bypassed. Interventional details are listed in Table 2.

Device success was achieved in 100% of patients. In-hospital and 30-day mortality were 0%. Complications included heart block in 2 (25%) patients, atrial fibrillation in 3 (38%), and 1 (13%) patient requiring pacemaker implantation. Postoperative outcomes are presented in Table 3.

Discussion

Combined ONCAB and SAVR remains the treatment of choice for patients presenting with extensive coronary artery disease and concomitant aortic stenosis. In our study, we utilized a novel entirely anaortic approach by performing concomitant anaortic OPCAB and transfemoral TAVR. We achieved excellent results in a hitherto prohibitive operative risk cohort attributed to their porcelain aortas, demonstrating feasibility and efficacy of this combined technique. We propose this hybrid technique in patients who have severe coronary artery disease not amenable to PCI , aortic stenosis requiring intervention, and where the aortic calcific burden prevents aortic cross-clamping or where aortic manipulation or cardiopulmonary bypass would pose undue risk to the patient.

Quality of Life

In this high-risk elderly population it is paramount to carefully weigh the cost and benefit of intervention. The goal of care is not only to prolong survival, but to provide symptomatic relief allowing patients to enjoy their life and minimize undue risks of adverse events which may take away from it. Coronary revascularization and AVR both greatly increase patient functional status and quality of life compared to medical management[6,11]. TAVR and anaortic OPCAB minimize operative trauma, thus decreasing length of ICU and hospital stay, prolonged ventilation, and need for re-exploration due to bleeding[25,26]. In line with this, all of our patients enjoyed a short length of stay in the ICU as well as the hospital with minimal morbidities associated with our operation. This allowed them to return to their daily lives with improved symptoms, which is the ultimate goal of surgical intervention. Without this technique, many surgeons would deny these high risk, elderly patients an operation as it would technically be contraindicated. We have shown that with this novel technique, surgeons can safely provide these patients with an option to solve both their coronary artery disease and aortic stenosis and overall improve their quality of life. We do anticipate that with our aging population and increased prevalence of atherosclerotic disease, surgeons will be faced with patients like our patients in this cohort more frequently in the coming years.

Survival and post-operative outcomes

Coronary revascularization is employed in stable disease to reduce cardiovascular events, prevent emergency revascularization, and improve symptoms in disease refractory to medical management[10,13]. CABG is preferred over PCI for revascularization of extensive, high-complexity, or significant left main CAD[13]. In this population CABG has been proven to decrease all-cause mortality, reduce risk of late spontaneous MI, and lower likelihood of requiring repeat revascularization. Surgical intervention is likewise necessary for aortic stenosis. While survival is excellent during the asymptomatic phase, mortality spikes to >90% within two years of symptom onset[8]. In the United States, TAVR is approved for use in patients regardless of risk strata and has shown non-inferiority at all risk levels. In high-risk population, TAVR significantly lowers all-cause mortality and stroke rates when compared to SAVR[17]. When extensive CAD and severe AS exist concomitantly, treating one but not the other is associated with worse outcomes regardless of sequence of procedures, thus hybrid techniques are recommended[12,13].

Stroke and anaortic technique

Stroke is one of the most devastating adverse events of cardiac surgery and one that is most likely to impact long-term physical function, independence, and quality of life of our patients. Incidence of peri-operative stroke after CABG in the general population is 0.48-2.9%[5]. These cerebrovascular events arise from the disruption and dislodgment of atheromatous emboli by manipulation of the ascending aorta[14,15]. The risk is determined by the extent and severity of atherosclerotic aortic disease[5]. Van der Linden have found a nearly 5-fold increase in peri-operative stroke in patients with atherosclerotic ascending aorta disease compared to those without (8.7% vs 1.8%, p<.001)[27]. Involvement of more than half of the ascending aorta increased the risk of stroke to 33%. The risk of stroke is also determined by the degree of aortic manipulation as demonstrated by Zhao et al. Their meta analysis showed anaortic OPCAB to be the most effective technique in reducing stroke risk, decreasing cerebrovascular events by 78% compared to traditional on-pump CABG[14]. Further, fully anaortic OPCAB was demonstrated to be superior compared to OPCAB utilizing a proximal clamp and heart-string device, reducing stroke by 66% and 52% respectively[14]. Anaortic OPCAB is a well-established technique which in dedicated high-volume practices has been shown to lower risk of 30-day mortality (OR 0.42, p<.001), early complications, and length of hospital stay while providing equivalent long-term outcomes compared to standard CABG decades after surgery [25,26,28-31]. Further, OPCAB reduces operative blood loss and thus need for transfusion of blood products which are associated with adverse outcomes[32]. Further, OPCAB has been shown to benefit elderly patients, especially those with high calcific load, diabetes, and COPD, reducing their risk of death, stroke, and MI[13,16,33-35]. Finally, the anaortic approach allows for safe intervention in patients with a porcelain aorta, such as in our cohort, mitigating both the technical limitations the condition imposes and the excessive risk of stroke described above. This is reflected in the current guidelines - anaortic OPCAB is recognized as a Class I and Class 2a indication for surgical coronary revascularization in patients with a diseased aorta by EACTS 2018 and ACC/AHA 2021 guidelines respectively[13,16].

Likewise, transfemoral TAVR provides a safe and effective option for surgical treatment of aortic stenosis which is minimally invasive and does not require the manipulation of the aorta unlike traditional SAVR. In fact it is the only truly anaortic AVR technique. Strategies such as deep hypothermic circulatory arrest and use of apico-aortic conduit have been proposed, but none completely avoid aortic manipulation. Analysis of the TAVR arm of the PARTNER trial revealed severe aortic atherosclerotic disease to be the most common reason (46%) for patients to be considered inoperable due to technical reasons[36]. TAVR carries similar benefits to that of OPCAB - it reduces risk of mortality, bleeding and transfusion rates, while allowing for shorter hospital stays than SAVR[12] and has been found to carry a lower risk of postoperative stroke in high risk patients[17,37]. The choice of access site further dictates the outcomes of the TAVR procedure. The transfemoral approach has been shown to be definitively superior to transapical and transaortic in regards to risk of mortality and stroke[38,39]. The transaxillary approach is a reasonable alternative, however the most recent meta-analysis comparing the two access sites found it to carry significantly higher risk of mortality, stroke, and major vascular complications than transfemoral access[40]. The carotid artery is the most novel access site with equivocal mortality risk, but higher risk of stroke than the transfemoral approach[41]. The fully anaortic technique allowed by femoral access, as opposed to transaortic or transapical, is crucial in these high risk populations.

It is worth noting that while the anaortic technique is most valuable in this highly selected high risk population, it's benefits through relative decrease in invasiveness, avoidance of aortic manipulation and cardiopulmonary bypass are also useful in those without above prohibitions and/or at lower surgical risk. These are proven, safe, non-inferior alternatives to traditional surgical management.

Combined OPCAB and TAVR have been described in previous studies, however aortic manipulation was involved in each one due to transaortic TAVR placement or proximal anastomoses in at least a subset of patients[18-21]. Our case series is the first to describe an entirely anaortic OPCAB combined with a transfemoral TAVR procedure. We have shown excellent results with device success achieved with no paravalvular leak on TEE in 100% of our cohort and complete revascularization achieved in 100% of patients. Our 30-day mortality rate was 0% and no patient suffered from myocardial infarction, stroke, or acute kidney injury in our cohort despite having significant atherosclerotic load. Removing significant aortic manipulation with the utilization of an anaortic OPCAB technique and a transfemoral TAVI is crucial in the avoidance of significant morbidity and mortality.

This study follows in the footsteps of many others in describing advances in techniques which allow us to now intervene in patients who hitherto have been prohibitively high risk or had anatomy, eg due to porcelain aorta, which did not allow for surgery. Despite the extent and invasiveness of the surgical intervention, risk of mortality and major adverse events is low even in octogenarians and nonagenarians[9,42-44]. By adopting and employing new techniques such as anaortic OPCAB and TAVR, we can minimize the cerebrovascular burden of intervention while providing excellent long-term results equivalent to standard therapy.

Study Limitations

Our study utilized a small cohort of highly complex patients to show feasibility of a combined surgical intervention in the setting of prohibitive operative risk. More data is required to elucidate the long-term benefits of the proposed hybrid technique compared to the standard approach.

Conclusions

Combined anaortic OPCAB and transfemoral TAVR is a safe and feasible approach to treating concomitant extensive coronary artery disease and severe aortic stenosis. The aortic no-touch technique provides benefits in the elderly high-risk patients by reducing the risk of aortic injury, including dissection and embolic cerebrovascular stroke.

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Table 1. Patient Demographics

	N=8
Gender	**Gender**
Female	0 (0%)
Male	8 (100%)
Age	77 [68-84]
Comorbidities	**Comorbidities**
Hyperlipidemia	8 (100%)
Diabetes Mellitus	7 (88%)
Smoker	7 (88%)
*** Porcelain Aorta**	8 (100%)
Previous Stroke	1 (13%)
COPD	2 (25%)
GERD	1 (13%)
Coronary artery disease	**Coronary artery disease**
1 vessel disease	2 (25%)
2 vessel disease	2 (25%)
3 vessel disease	4 (50%)
L MCA stenosis	2 (29%)
Proximal LAD stenosis	3 (38%)
CTO	0 (0%)
Aortic Stenosis	**Aortic Stenosis**
Aortic valve area (cm2)	0.78 [0.63-1.02]
Pressure gradient (mmHg)	44 [26-63]
Data are presented as counts (%) or mean [range].	Data are presented as counts (%) or mean [rang
PA diagnosed based on CT images, with representative images displayed.	* PA diagnosed based on CT images, with repre

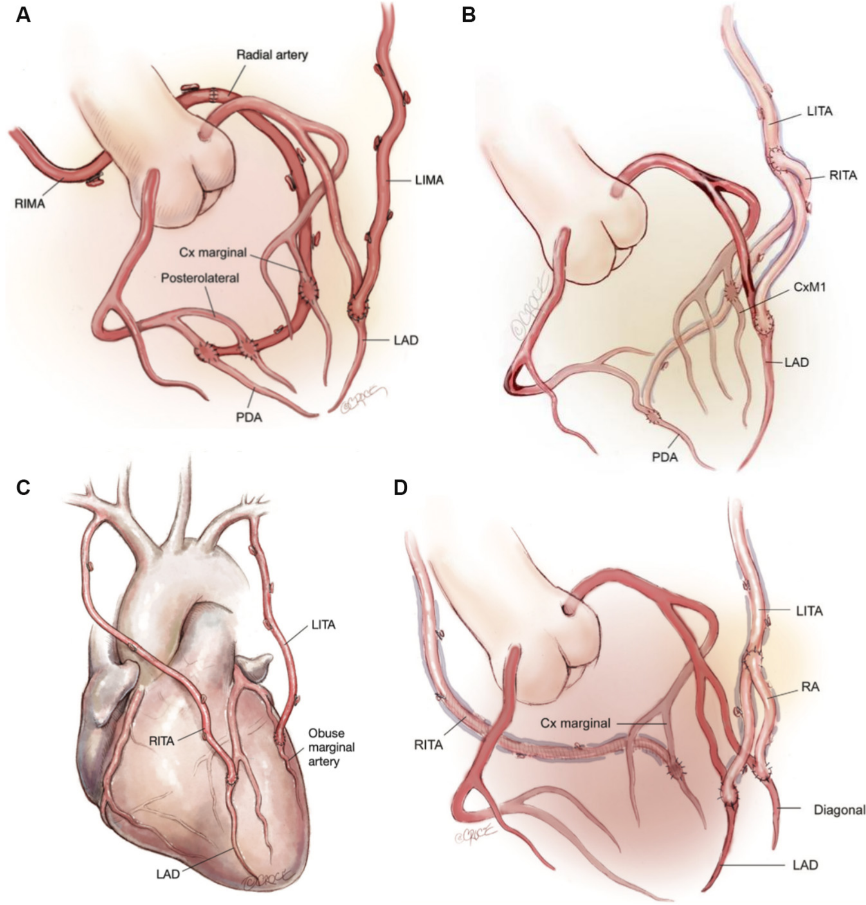
Table 2. Intervention Details

Age	**Approach**	**CABG x**	**Target Ves**
76	Anterolateral thoracotomy	1	LIMA-LAD
82	Sternotomy	3	LIMA-LAD,
75	Sternotomy	3	LIMA-LAD,

Age	Approach	CABG x	Target Ves
82	Sternotomy	2	LIMA-LAD,
71	Sternotomy	3	LIMA-LAD,
84	Sternotomy	1	LIMA-LAD
79	Sternotomy	3	LIMA-LAD,
68	Sternotomy	2	LIMA-LAD,
Mean	-	**2.25**	**-**
PVR = paravalvular regurgitation	PVR = paravalvular regurgitation	PVR = paravalvular regurgitation	PVR = para

Table 3. Post-operative outcomes

	N=7
Heart block	2 (28%)
Pacemaker implantation	1 (14%)
Atrial fibrillation	3 (43%)
Stroke	0 (0%)
MI	0 (0%)
AKI	0 (0%)
Life threatening bleeding	0 (0%)
Length of stay	7 [4-14]
ICU length of stay	3 [2-8]
Data are presented as counts (%) or mean [range]	Data are presented as counts (%) or mean [range]


A
Radial artery
RIMA
LIMA
Cx marginal
Posterolateral
LAD
PDA
B
LITA
RITA
CxM1
LAD
PDA
C
LITA
RITA
Obuse
marginal
artery
LAD
D
LITA
RA
RITA
Cx marginal
Diagonal
LAD