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# Off-pump Coronary Surgery Combined With Aortic Valve Replacement Under Hypothermic Circulatory Arrest Within an Unexpected Porcelain Aorta

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**Abstract**

**Unexpected porcelain aorta is a real challenge to safely completing aortic valve replacement combined with coronary artery surgery. This condition often leads to an aborted sternotomy in the hope of performing transcatheter procedures, the feasibility of which may be hampered by anatomical considerations. We report the case of a 71-year old man with history of hypertension, type 2 diabetes mellitus and chronic kidney disease, which was referred for severe aortic valve stenosis and severe coronary artery disease. He benefited from an anaortic off-pump coronary surgery and clampless aortic valve replacement under hypothermic circulatory arrest to overcome an unexpected porcelain aorta.**

*Keywords:* Aortic calcification, Off pump coronary artery bypass, Circulatory arrest, Aortic valve stenosis

## 1. Introduction

Porcelain aorta (PA) is a nearly or completely circumferential calcification of the ascending aorta and/or aortic arch precluding safe aortic cross-clamping or cannulation [1].

Surgical aortic valve replacement (SAVR) combined with coronary surgery is a real challenge in the presence of an unexpected PA. Indeed, cross-clamping of such an aorta may induce cerebral embolization, aortic dissection, or death from uncontrollable hemorrhage [2].

In the era of transcatheter aortic valve replacement (TAVR) and percutaneous coronary intervention (PCI), the proportion of patients in whom SAVR was attempted but aborted because of intraoperative discovery of PA is constantly increasing [3].

However, for anatomical considerations, the feasibility of these tanscatheter procedures in the context of aborted sternotomy is not guaranteed for all patients, with more frequent valve malposition requiring implantation of a second valve [4].

For this reason and to avoid aborted sternotomy, off-pump coronary artery bypass surgery (OPCAB) combined with a clampless SAVR under hypothermic circulatory arrest (HCA) have been performed in order to tackle this unexpected trap.

## 2. Case presentation

A 71-year old men with a history of hypertension, type 2 diabetes mellitus, severe chronic kidney disease, unstable angina and dyspnoea (New York Heart Association class II) was referred for severe aortic stenosis (aortic valve area: 0.7 $cm^2$, mean pressure gradient: 53 mmHg) and severe proximal stenosis of the left anterior descending artery (LAD).

Chest X-ray revealed aortic calcifications in the aortic knuckle with no evident calcifications of the ascending aorta (Fig. 1). The parasternal long-axis

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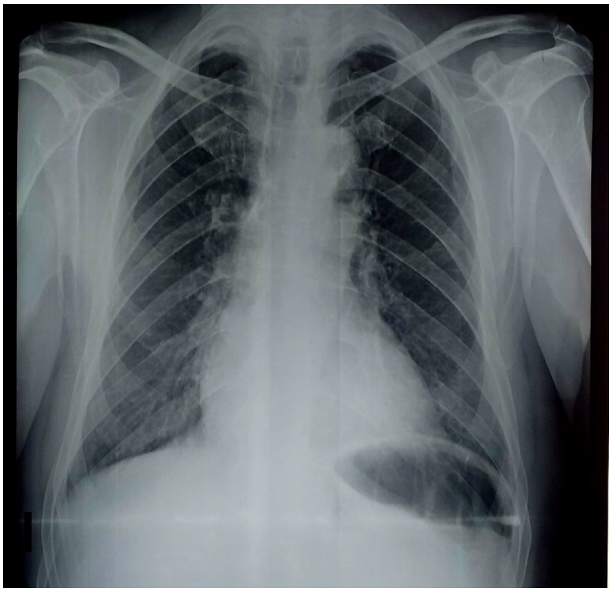

*Fig. 1. Preoperative chest X-ray revealed aortic calcification only in the aortic knuckle with no evident calcification of the ascending aorta.*

view of the transthoracic echocardiography showed an ascending aorta of normal size with increased echogenicity of its wall (Fig. 2).

After performing a median sternotomy and opening the pericardium, manual palpation revealed calcified atherosclerotic plaques involving almost the entire circumference of the ascending aorta and the aortic arch, with the exception of the sinuses of Valsalva, which were more supplied, prohibiting any cannulation or clamping of the aorta.

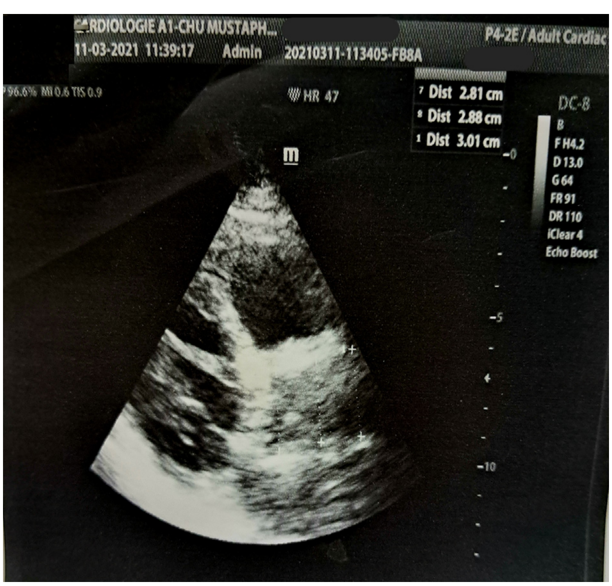


*Fig. 2. The parasternal long-axis view of the transthoracic echocardiography showed an ascending aorta of normal size with increased echogenicity of its wall.*

| Abbreviations | |
|---|---|
| HCA | Hypothermic circulatory arrest |
| LAD | Left anterior descending artery |
| OPCAB | Off-pump coronary artery bypass |
| PCI | Percutaneous coronary intervention |
| PA | Porcelain aorta |
| SAVR | Surgical aortic valve replacement |
| TAVR | Transcatheter aortic valve replacement |

In the setting of this unexpected PA, we changed our initial plan and performed an off-pump grafting of the LAD using the left internal thoracic artery. We then instituted a cardiopulmonary bypass between the brachiocephalic arterial trunk, which was free of calcifications, and the right atrium (Fig. 3) and the patient was cooled to 20 °C. After initiating HCA, the innominate artery was cross-clamped at its origin, and anterograde cerebral perfusion was started with a perfusate temperature of 20 C.

With the patient in the Trendelenburg position, a transverse aortotomy was made towards the non-coronary sinus, then passing a few millimeters above the right coronary ostium (Fig. 3).

We then performed an SAVR using a No: 23 stented bioprosthesis with a single dose of selective anterograde cold blood cardioplegia.

After deairing the aorta, general rewarming was initiated after 33 min of HCA. This patient had uneventful postoperative courses without any neurological disorders, worsening of his initial renal failure, or reoperation for bleeding. He was discharged within postoperative day 15. After 12 months of follow-up, he was asymptomatic and his echocardiography showed a transprosthetic mean

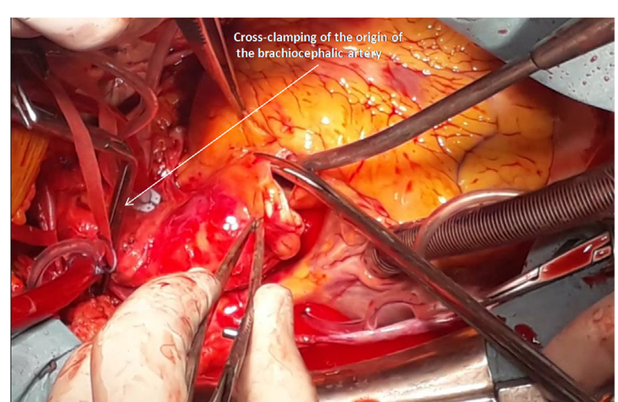


*Fig. 3. Transverse aortotomy under hypothermic circulatory arrest and anterograde cerebral perfusion.*

pressure gradient of 23 mmHg without any structural deterioration of the bioprosthesis.

## 3. Discussion

In the presence of an unexpected PA, SAVR combined with a coronary artery surgery become a real challenge.

Chest X-ray film or cine angiography are not able to determine whether there is nearly or completely circumferential calcification and cannot detect atherosclerotic plaques with little or no calcification. For this reason, preoperative screening of the PA by computed tomography angiography before planning surgery for valvular or coronary lesions should be systematically performed in the following situations: advanced age, diffuse peripheral atherosclerosis, chronic kidney disease, diabetes mellitus, history of radiation and vascular inflammation (Takayasu arteritis, systemic lupus erythematosus, and rheumatoid arthritis) [5].

The current guidelines favour TAVR over SAVR in the case of a PA diagnosed preoperatively [6], leading many surgeons to abort the operation upon its intraoperative discovery, in the hope of offering these patients a TAVR with or without PCI [7].

However, it is important to note that, in a prospective Swiss single-center registry, Asami objectified that within 30 days after TAVR, the 114 patients with PA (5.2%) had a more than three-fold increased risk of periprocedural disabling stroke compared to patients without PA ($HR_{adj}$, 3.70; 95% CI, 1.52–9.03) [8]. In addition, in a relatively large German multicenter real world registry, Zahn [9]. reported the results of TAVR in 147 patients (10.7%) with PA compared with 1227 patients without PA. There was a trend towards a higher rate of stroke at 30 days (5.5% versus 2.8; P = 0.08). 30-day mortality was higher in patients with PA (12.9% versus 7.6%; P = 0.03), but multivariate analysis did not show that PA was an independent predictor of hospital mortality or stroke after TAVR procedure.

Moreover, Rodés-Cebau [4] reported more frequent valve malposition requiring implantation of a second valve in patients with PA than in patients without heavily calcified aorta (6.6% of patients with PA versus 1.8% in patients without PA; $P = 0.059$).

Furthermore, for anatomical reasons, TAVR is not always feasible, and SAVR was the only option in 36.8% (n = 7/19) of patients referred to a high-risk valve centre after an aborted sternotomy [3].

Several strategies have been proposed to overcome this issue, combining OPCAB surgery with: (a) transapical TAVR [10] which represents a hybrid approach and less invasive alternative for resolving this critical clinical scenario, (b) SAVR with sutureless Perceval valve, in order to reduce the HCA duration [11], (c) aortic root replacement with a composite valve graft during a relatively brief HCA [12]. (d) the use of aortic endoclamps to replace aortic valve only requires a brief period of HCA, but there is still the risk of embolization [12], (e) extensive ascending aortic endarterectomy combined with HCA, which carries a postoperative stroke rate of 34.9% and an unknown risk of aneurysmal degeneration [12], (f) apicoaortic conduits where the risk is the formation of thrombus or the occurrence of stagnation due to competition between antegrade and retrograde flow [12].

Kaneko [13] reported excellent results in 122 consecutive patients who underwent SAVR using deep HCA for severely atherosclerotic aorta between October 2004 and December 2012. The operative mortality rate was 8.2% and permanent stroke was seen in 10.7%. However, the octogenarian group of this cohort, had higher operative mortality and permanent stroke rate compared with the non octogenarian group, (15.9% vs 3.8%, P = 0.035). and (18.2% vs 6.4,P = 0.065), respectively.

Although the operative outcomes of SAVR using deep HCA for PA are satisfactory, the incidence of neurologic events and the operative mortality rate remain higher compared with the results of standard SAVR in patients without PA. Wu [14] noted in a retrospective cohort study using the administrative database of the U.S. national inpatient sample from 2012 to 2018, that in-hospital mortality and stokes rate for SAVR combined to CABG was 3.9% and 3.2%, respectively.

## 4. Conclusion

Clampless aortic valve replacement under hypothermic circulatory arrest combined to an off-pump LITA-LAD grafting is a reasonable treatment option to overcome an unexpected porcelain aorta and avoid aborted sternotomie in patients with severe aortic stenosis and isolated LAD lesion.

Elderly patients, those with chronic kidney disease, vascular inflammation or diffuse atherosclerosis should undergo routine preoperative screening of porcelain aorta, using multi-slice computed tompgraphy, in order to consider and plan all possible treatment options.

## Author contribution

Conception and design of Study: AB, KK. Literature review: AB. Acquisition of data: AB, YD.

Analysis and interpretation of data: AB, KK, YD. Research investigation and analysis: AB, KK, YD. Data collection: AB, KK, YD. Drafting of manuscript: AB. Revising and editing the manuscript critically for important intellectual contents: AB, YD. Data preparation and presentation: KK, YD. Supervision of the research: AB. Research coordination and management: AB. Funding for the research: AB.

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## Conflicts of interest

Nothing to declare.

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