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Case Report

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Systemic Hyperkalemic Cardiac Arrest without Aortic Cross-Clamping for Coronary Artery Bypass Grafting in a Patient with a Severely Calcified Ascending Aorta: A Case Report

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Abstract

Aortic calcification is an advanced atherosclerotic manifestation strongly linked to perioperative stroke and neurological sequelae following coronary artery bypass grafting (CABG). This case report delineates the successful utilization of systemic hyperkalemic cardiac arrest as an innovative, cross-clamp-free operative strategy during urgent CABG in a 72-year-old man presenting with critical triple-vessel disease and progressive hemodynamic instability that precluded safe off-pump revascularization. Preoperative computed tomography revealed dense calcified plaques along the ascending aorta, specifically encompassing the prospective cross-clamp site. By employing systemic hyperkalemic cardiac arrest under moderate systemic hypothermia (29°C) combined with adjunctive external cranial cooling and meticulous intraoperative glucose-insulin management during rewarming, complete myocardial revascularization was safely achieved without any direct mechanical manipulation or clamping of the diseased aortic wall. Total cardiopulmonary bypass and cardiac arrest times were 115 and 74 minutes, respectively. The patient experienced an uneventful postoperative recovery, maintaining stable hemodynamics, and was successfully discharged on postoperative day 7 free of any focal or global neurological deficits. This case highlights that vigilant preoperative aortic mapping and the complete avoidance of mechanical cross-clamping via controlled systemic hyperkalemic arrest represent an effective and cerebral-protective therapeutic alternative for high-risk patients with severely calcified or porcelain aortas.

Keywords: Aortic Calcification, Coronary Artery Bypass, Cardiopulmonary Bypass, Cardiac Arrest, Hyperkalemia

Introduction

Circumferential calcification of the aortic wall represents an asymptomatic atherosclerotic process that affects an estimated 2% to 9.3% of individuals scheduled for elective coronary artery bypass grafting (CABG), often rendering the ascending aorta virtually impossible to manipulate. Perioperative micro- and macroemboli during CABG occur predominantly at the moments of aortic cross-clamp application and side-biting clamp placement. Marked ascending aortic atherosclerosis serves as a potent determinant of atheroembolic injury, thereby driving up surgical morbidity and mortality. Encountering a porcelain or unclampable aorta (UCA) presents a critical dilemma in cardiac surgery, as mechanical compression of a heavily calcified aortic wall considerably increases the risk of cerebral embolic events. Systemic embolization originating from a severely diseased ascending aorta, along with the heightened rate of

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cerebrovascular accidents following direct cannulation and cross-clamping, is extensively documented in the literature [1-3]. Extensive atheromatous involvement that precludes safe clamp application and handling remains a formidable hurdle during myocardial revascularization; indeed, a UCA is recognized as an independent predictor of perioperative cerebrovascular accidents and overall mortality because direct manipulation can fracture atheromatous plaques and precipitate downstream embolization [4].

Standard CABG pathways traditionally rely on ascending aortic cannulation, total cross-clamp application for cardioplegic arrest, and partial-occlusion clamping to construct proximal graft anastomoses. Consequently, whenever operative steps necessitate direct aortic handling, rigorous preoperative evaluation of aortic atherosclerotic burden becomes imperative.

When severe atheromatous disease prevents conventional ascending aortic maneuvers, surgeons often adapt their technique to safeguard neurological function. These modifications include switching arterial inflow to the axillary, subclavian, femoral, or innominate arteries, adopting hypothermic ventricular fibrillation, or relying exclusively on *in situ* arterial conduits [3,5].

Nevertheless, each of these alternative modalities carries inherent technical difficulties and procedural drawbacks. In this report, we present a surgical technique in which complete revascularization was achieved without applying an aortic cross-clamp using systemic hyperkalemia, resulting in a satisfactory outcome with no neurological impairment at discharge.

The ideal operative and cardiopulmonary bypass protocols for patients with an extensively calcified ascending aorta who cannot tolerate off-pump revascularization remain a subject of ongoing debate. Herein, we delineate the application of systemic hyperkalemic cardiac arrest coupled with moderate hypothermia to perform clampless CABG, emphasizing key considerations regarding perfusion mechanics, intraoperative electrolyte homeostasis, and cerebral protection.

Case presentation

Preoperative

The patient was a 72-year-old man who presented to our center with dyspnea and chest pain and had a history of percutaneous coronary intervention (PCI) in 2022. He was 167cm tall, weighed 72 kg, and had a blood group of B negative. Coronary angiography demonstrated severe three-vessel coronary artery disease, and transthoracic echocardiography showed a left ventricular ejection fraction of 40%; therefore, CABG was indicated. Preoperative neurologic evaluation revealed no documented focal neurologic deficits.

Initial laboratory findings were as follows: hemoglobin 13.4 g/dL, platelet count 226 × 10^3/μL, PT 12 seconds, PTT 54 seconds, INR 1, blood glucose 103 mg/dL, urea 36 mg/dL, creatinine 1 mg/dL, sodium 146 mEq/L, potassium 4.1 mEq/L, and calcium 10 mg/dL. As part of the preoperative management, a 500 mg dose of methylprednisolone was administered.

Carotid Doppler ultrasonography was normal on the left side, whereas the right carotid bulb showed a hypoechoic plaque measuring 3 × 22 mm, causing approximately 34% stenosis. High-resolution spiral computed tomography demonstrated an enlarged ascending aorta with a diameter of 37 mm and a pulmonary trunk diameter of 28 mm, along with calcification of the ascending aorta. Because the location was at the intended cross-clamp site and the patient was hemodynamically unstable, off-pump CABG was not considered feasible. Therefore, a systemic cardiac arrest strategy without aortic cross-clamping was selected.

Intraoperative

Given the location and severity of calcification in the ascending aorta, particularly at the planned cross-clamp site, a systemic hyperkalemic cardiac arrest strategy without aortic cross-clamping was selected to reduce the risk of atheroembolic neurologic injury. The patient received 70 cc of potassium solution per institutional protocol. Moderate hypothermia was used, and the patient was cooled to 29°C. For cerebral protection, external head cooling with ice packs was applied during the procedure. The duration of cardiac arrest was 74 minutes, and the total cardiopulmonary bypass time was 115 minutes. The patient was subsequently weaned from bypass without major difficulty.

Postoperative

Postoperative laboratory evaluation showed a pH of 7.31, sodium of 144 mEq/L, potassium of 4.7 mEq/L, and hemoglobin of 11 g/dL. The postoperative course was uneventful, and no neurological complications were documented. The patient was discharged after 7 days in stable condition.

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The patient was a 72-year-old man who presented to our center with dyspnea and chest pain and a history of PCI in 2022. He had a history of hyperlipidemia and hypertension. Echocardiography showed an ejection fraction of 50% and structurally normal valves. The patient weighed 72 kg and was 167 cm tall.

The patient received 70 cc of potassium solution, corresponding to 2 mEq per kilogram of body weight, along with other cardioplegic solutions according to the del Nido formula. The patient's potassium level increased to 9 mEq/L, and he was cooled to 29°C. To protect the cerebral cells, ice packs were placed on the patient's head. Finally, after 74 minutes of cardiac arrest and 115 minutes of cardiopulmonary bypass time, he was easily weaned from bypass.

The patient was discharged after 7 days without neurological complications. (Figure 1)

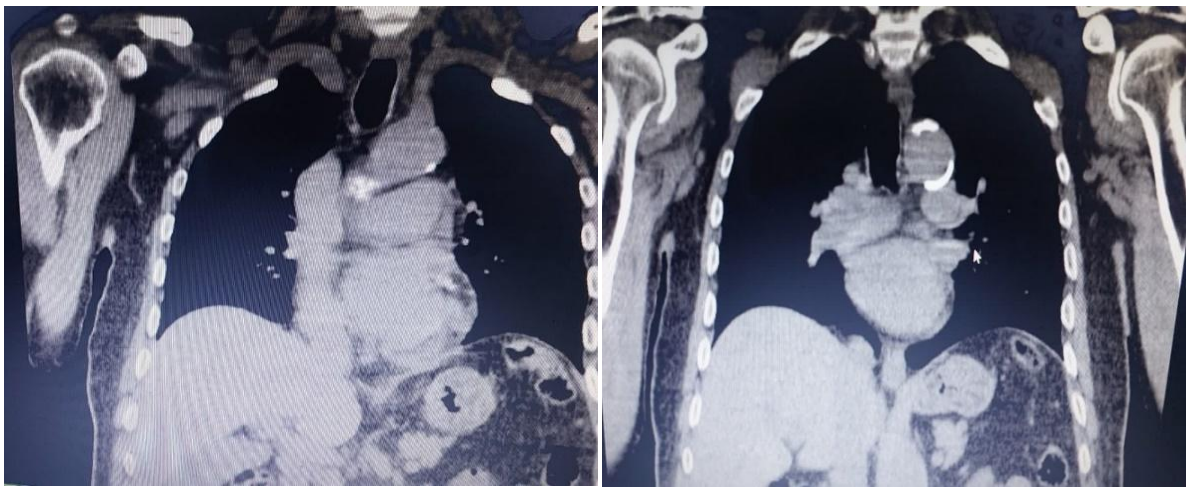


Figure 1. Computed Tomography Reconstructions Demonstrating Calcification of the Ascending Aorta

Discussion

A spectrum of surgical strategies has been proposed to mitigate perioperative neurocognitive deficits during coronary revascularization, with off-pump coronary artery bypass grafting frequently cited as a primary option. However, due to critical triple-vessel disease and progressive hemodynamic instability, off-pump maneuvers could not be safely tolerated in our patient.

Induced hypothermic ventricular fibrillation has also been utilized in similar clinical scenarios; nevertheless, literature indicates that this approach is fraught with a heightened incidence of adverse neurological sequelae—such as stroke and transient ischemic attacks—alongside renal dysfunction and extended intensive care unit and hospital stays [3].

Aortic endarterectomy is another surgical alternative in the presence of extensive wall calcification. Prior reports examining total thromboendarterectomy of the ascending aorta and arch under hypothermic circulatory arrest demonstrated an operative mortality of 4.5% and a 9% rate of neurological morbidity, encompassing both early and late deficits. Conversely, in another study involving 40 patients, a disease-free clamping zone was successfully mapped in 21 cases, whereas 19 underwent localized endarterectomy—two of whom subsequently required reoperation owing to late pseudoaneurysm formation [6-7].

In the present case, we employed systemic hyperkalemic cardiac arrest via the intravenous delivery of potassium at 1 mL/kg body weight directly into the extracorporeal circuit. With concurrent moderate systemic hypothermia, meticulous metabolic and electrolyte surveillance is paramount—particularly regarding serum potassium and glucose homeostasis—and is effectively managed with targeted glucose-insulin regimens.

Although intraoperative digital palpation of the aorta is still routinely practiced, its diagnostic sensitivity remains remarkably poor and frequently underestimates the true extent and severity of atheromatous burden. Employing advanced imaging modalities, such as preoperative multidetector computed tomography or intraoperative epiaortic ultrasonography, is essential to accurately characterize plaque distribution and tailor the surgical approach accordingly [3].

In our patient, standard cross-clamp placement was deemed unsafe because circumferential

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calcification was localized directly at the prospective clamp site. Given that hemodynamic compromise precluded OPCAB [8], systemic hyperkalemic arrest under moderate hypothermia provided an effective, clampless operative field for CABG. Alongside adequate myocardial preservation, this technique necessitates rigorous control over systemic temperature, metabolic balance, and brain protection strategies. The patient achieved an uneventful neurological recovery, although conclusions regarding procedural safety and broad efficacy warrant caution given the single-case design.

Conclusion

This case underscores the critical need for a customized surgical and perfusion roadmap when treating patients with extensive ascending aortic calcification. Comprehensive preoperative aortic imaging, early identification of the hazards linked to standard aortic clamping, and the thoughtful adoption of alternative perfusion paradigms can substantially minimize perioperative morbidity in carefully selected patients. Nonetheless, given the inherent constraints of a single-case experience, these findings should be interpreted with prudence, and larger clinical studies are required to validate the reproducibility and clinical outcomes of this technique.

Ethics Approval and Consent to Participate

Ethical approval was not required for this retrospective case report in accordance with institutional guidelines. Written informed consent was obtained from the patient before treatment and for participation in this report.

Consent for Publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images.

Data Availability Statement

All data generated or analyzed during this study are included in this published article. No additional datasets were generated

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Authors' Contributions

Author Contributions ANM and MDM conceptualized and designed the study. MDM developed the methodology and provided guidance on the clinical and perfusion methodology. ANM, SEHZ, and AA contributed to data collection and analysis. SEHZ and ANM prepared the manuscript. All authors critically reviewed and revised the manuscript, approved the final version of the manuscript, and agreed to be accountable for all aspects of the work.

Conflict of Interest

The author declared no conflicts of interest.

Declaration of Generative Artificial Intelligence (AI) in Scientific Writing

The authors declare that ChatGPT, a generative artificial intelligence tool developed by OpenAI, was used solely for language editing and improving the grammar, readability, and clarity of the manuscript.

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