Journal of the Society for Cardiovascular Angiography & Interventions 5 (2026) 105562

JSCAI

The official journal of the Society for Cardiovascular Angiography & Interventions

Original Research

Clinical Outcomes of Concurrent Impella-Assisted High-Risk PCI and TAVR in Patients With Complex Coronary Artery Disease and Severe Aortic Stenosis

Frederick Berro Rivera, MD, Brenden Ingraham, MD, Pietro Di Santo, MD, PhD, Trevor Simard, MD, PhD, Benjamin Hibbert, MD, PhD, Mandeep Singh, MD, MPH *

Department of Cardiovascular Medicine, Mayo Clinic, Rochester, Minnesota

ABSTRACT

Background: Percutaneous management of high risk, percutaneous coronary intervention (PCI) needing mechanical support for complex coronary artery disease in patients needing transcatheter aortic valve replacement for severe aortic stenosis remains incompletely defined. We report on the feasibility and safety of a single-session strategy using Impella-assisted complex high-risk PCI (IA-CHIP) followed by transcatheter aortic valve replacement (TAVR).

Methods: We conducted a multicenter retrospective study of consecutive patients undergoing simultaneous IA-CHIP and TAVR at 3 tertiary centers between January 2015 and March 2026. All patients received mechanical circulatory support with percutaneous microaxial flow pump Impella CP (Abiomed) during PCI, followed by transfemoral TAVR in the same session. Baseline demographics, procedural characteristics, and clinical outcomes were collected. The primary endpoint was in-hospital complications, including death, stroke, major bleeding (Bleeding Academic Research Consortium types 2, 3, or 5), acute kidney injury, permanent pacemaker implantation, and vascular complications.

Results: A total of 12 patients were included (median age, 79.5 years [IQR, 77.0-81.2]; 91.7% male; median Charlson Comorbidity Index of 7 [IQR, 5.8-9]). Coronary lesions mainly involved left main disease in 66% of cases. Advanced calcium modification was required in 50% of cases. The median aortic valve area was 0.86 cm^2, and median mean gradient was 38 mm Hg. Procedural success for IA-CHIP and TAVR was 100%. There were no in-hospital deaths, strokes, or major vascular complications. Conduction disturbances requiring permanent pacemaker implantation occurred in 25%. An acute kidney injury occurred in 16.7% of cases, with no requirement for dialysis. The majority of patients (91.7%) were discharged home.

Conclusions: A single-session strategy of IA-CHIP followed by TAVR is feasible and safe in selected patients with complex coronary artery disease and severe aortic stenosis.

Introduction

The management of patients with concomitant complex coronary artery disease (CAD) and severe aortic stenosis (AS) represents a significant clinical challenge from the interventional standpoint.[1] As the population ages, clinicians increasingly encounter patients with extreme frailty, high comorbidity indices, and very poor cardiovascular reserves. Traditionally, a staged approach has been the standard of care, typically separating percutaneous coronary intervention (PCI) and transcatheter aortic valve replacement (TAVR).[2,3] While intended to mitigate the risks of high contrast load and procedural fatigue, this strategy introduces a period of vulnerability in patients needing mechanical support devices for complex PCI.[4] Performing complex high risk indicated PCI (CHIP) is challenging as the stenotic valve acts as a fixed afterload, preventing the heart from increasing cardiac output to compensate for the transient myocardial ischemia inherent in complex revascularization.[5]

The emergence of mechanical circulatory support (MCS), specifically the Impella CP percutaneous microaxial flow pump (Abiomed), offers a nuanced solution. The Impella CP provides active left

Abbreviations: AS, aortic stenosis; CAD, coronary artery disease; CCI, Charlson Comorbidity Index; CTA, computed tomography angiogram; CFA, common femoral artery; IA-CHIP, Impella-assisted complex high risk indicated percutaneous coronary intervention; LMCA, left main coronary artery; PCI, percutaneous coronary intervention; TAVR, transcatheter aortic valve replacement; TTE, transthoracic echocardiography.

Keywords: aortic valve; feasibility; high-risk percutaneous coronary intervention; microaxial flow pump; safety; transcutaneous aortic valve replacement.

* Corresponding author: Singh.Mandeep@mayo.edu (M. Singh).

https://doi.org/10.1016/j.jscai.2026.105562
Received 9 April 2026; Received in revised form 22 June 2026; Accepted 23 June 2026; Available online 13 August 2026
2772-9303/© 2026 The Author(s). Published by Elsevier Inc. on behalf of the Society for Cardiovascular Angiography & Interventions Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

ventricular unloading and continuous systemic perfusion, thereby minimizing the risk of the coronary intervention despite the presence of a severely stenotic valve. However, the use of a microaxial flow pump in severe AS has historically been considered a relative contraindication. The risks of deploying a transvalvular device across a severely stenotic orifice are significant.[5] First, the mechanical traversal of a 14F pump through a calcified, narrowed valve carries a risk of calcium embolization, ischemic stroke, or acute valvular trauma. Second, the catheter may further obstruct the already limited effective orifice area, paradoxically triggering hemodynamic collapse during aortic valve crossing. Finally, crossing a stenotic valve often requires aggressive wire maneuvers in a hypertrophied, noncompliant ventricle, increasing the risk of perforation.[6] The advantage of a single-session approach is that it addresses the dual need for PCI and TAVR in 1 setting, mitigating the risks of 2 separate procedures that require repeat large-bore access with potential bleeding and vascular complications in a population with a high prevalence of peripheral calcific iliofemoral atherosclerosis. This strategy eliminates the period of clinical vulnerability during delays in performing staged procedures. Data regarding the safety of this consolidated workflow remains scarce. In this multicenter retrospective study, we evaluated the feasibility, safety, and procedural issues of a simultaneous Impella-assisted CHIP (IA-CHIP) and TAVR strategy supported by a continuous percutaneous microaxial flow pump. Utilizing data from 3 Mayo Clinic sites, we analyzed a high-risk cohort to determine if this single-setting approach can be performed without increasing the risk of major in-hospital complications such as death, stroke, clinically significant bleeding, acute kidney injury (AKI), or vascular injury.

Methods

Study cohort

In this multicenter retrospective study, we included patients who underwent simultaneous IA-CHIP and TAVR in 3 Mayo Clinic Health Systems sites from January 1, 2015, to March 30, 2026 (Supplementary Figure 1). The Mayo Clinic Institutional Review Board approved this research (IRB #25-011575).

Data collection

Pertinent data on patients' demographics, past medical history, laboratory results, imaging studies, echocardiographic findings, procedural data of CHIP and TAVR, procedural outcomes, discharge disposition, and follow-up data were manually obtained from the electronic medical record. The Charlson Comorbidity Index[7] was calculated based on the patient's health record. Our primary outcome was in-hospital complications, defined as death, stroke, vascular complications, AKI, and major bleeding, defined as Bleeding Academic Research Consortium (BARC) types 2, 3, and 5.[8]

Statistical analysis

Categorical variables are reported as total count and percentage of patients, and continuous variables are presented as median with IQR. Excel (Microsoft Corp) was used for descriptive statistics.

Procedural overview. Following a multidisciplinary review of risks and benefits, multivessel access was established under ultrasound and fluoroscopic guidance (Figure 1A-G). Arterial access was secured via the radial artery, and primary large-bore access was obtained via the common femoral artery (site selected after review of pre-TAVR CTA) using a micropuncture technique. Femoral artery access sites were preclosed using 2 suture-based vascular closure devices (Perclose ProStyle, Abbott). We placed the 14F Impella sheath over the stiff wire and, using an Amplatz (AL) catheter with a straight 0.035-inch wire, obtained ventricular access. Using an exchange length wire, we positioned a pigtail apically and unfurled the 0.018-inch Impella wire. We then tracked the device, confirmed position fluoroscopically, and activated the Impella CP. AL1 catheter was used in 80% of patients.

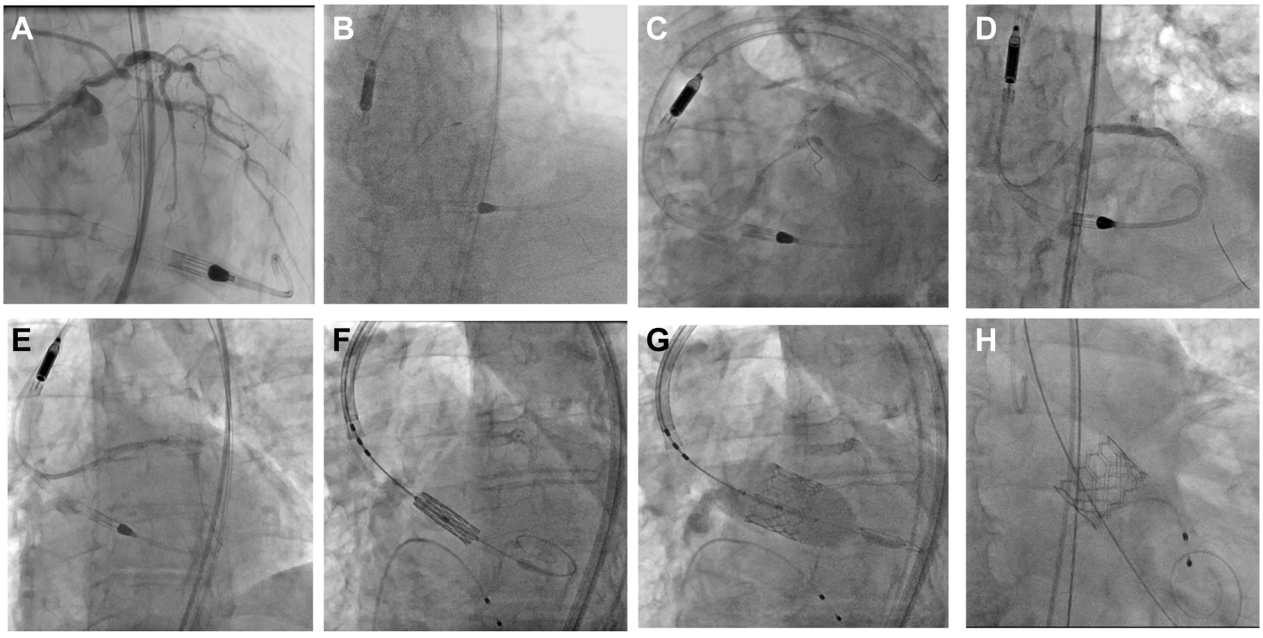


Figure 1.
Procedural steps for concurrent percutaneous microaxial flow pump-assisted complex and high-risk indicated percutaneous coronary intervention with transcatheter aortic valve replacement. (**A**) Baseline angiogram with severe ostial left main (LM) stenosis with Impella CP in place. (**B**) Rotational atherectomy of calcified LM. (**C**) LM-LAD balloon crush following LCx stent deployment. (**D**) Stenting of the distal LM-proximal LAD. (**E**) Completion angiogram after LM 2-stent bifurcation PCI. (**F**) Positioning of balloon-expandable TAVR across the aortic valve with placement of transvenous right ventricle pacing wire. (**G**) Valve deployment. (**H**) Deployed TAVR prosthesis following removal of delivery system. LAD, left anterior descending (coronary artery); LCx, left circumflex (coronary artery); PCI, percutaneous coronary intervention; TAVR, transcatheter aortic valve replacement.

AL2 was used for the 2 patients after an unsuccessful attempt with AL1. A temporary pacemaker was advanced via the femoral vein and positioned in the right ventricle, and activated clotting time was checked per protocol to maintain therapeutic systemic anticoagulation. All patients received unfractionated heparin as the form of anticoagulation. Under active MCS, IA-CHIP was performed with intravascular ultrasound guidance. Following successful revascularization and confirmation of hemodynamic stability, the Impella CP device was weaned and removed. The TAVR portion of the procedure commenced with the exchange of the Impella sheath for an Edwards expandable sheath over a Safari wire (Boston Scientific). The left ventricle was recrossed using an AL catheter and straight-tip wire, which was subsequently exchanged for a Safari wire. The SAPIEN 3 Ultra transcatheter heart valve (Edwards Lifesciences) was introduced and configured in the descending thoracic aorta. The valve was then subsequently positioned across the aortic valve and successfully deployed under rapid ventricular pacing. Final hemodynamic, echocardiographic, and angiographic assessments were performed to ensure valve function, position, and patency. Following the confirmation of stable flow and valvular function, the delivery systems were removed, and hemostasis was achieved via the preplaced suture-based closure devices after confirming no compromise in distal blood flow. Protamine sulfate was administered for heparin reversal at the end of the 2 procedures.

Results

Patient characteristics

Our cohort consists of 12 patients with a median age of 79.5 years (IQR, 77.0-81.2) and a median body mass index of 26.2 kg/m^2 (IQR, 23.6-29.3; Supplementary Table 1). Our cohort is predominantly male (11, 91.7%) with a high comorbidity burden, with a median Charlson Comorbidity Index of 7 (IQR, 5.8-9). The majority were admitted electively for planned IA-CHIP (7, 58.3%), 4 (33.3%) were admitted for symptomatic or worsening heart failure, and 1 (8.3%) was admitted following resuscitation after cardiac arrest. Diagnosis of CAD was known before AS evaluation in 7 (58.3%) cases, while AS was diagnosed during AS evaluation in 4 (33.3%) cases, and 1 case (8.3%) involved a simultaneous diagnosis. Baseline comorbidities include hyperlipidemia (12, 100%), conduction abnormalities such as atrioventricular block (AV) block or right bundle branch block (RBBB) (11, 91.7%), heart failure with New York Heart Association class II to III symptoms (10, 83.3%), hypertension (9, 75%), diabetes mellitus (7, 58.3%), chronic kidney disease (CKD 3b) or end-stage renal disease (6, 50%), and prior coronary revascularization (5, 41.7%). The heart team assessment was performed in all patients, and TAVR and IA-CHIP were recommended over surgical intervention. This decision was primarily patient driven in 7 cases (58.3%), where individuals explicitly declined surgery or chose a noninvasive approach. In the remaining 5 cases (41.7%), the heart team designated the patient as a poor surgical candidate due to prohibitive operative risk. These clinical decisions were based on advanced age, frailty, and severe concurrent conditions.

Echocardiographic characteristics. Half of the cohorts presented with low-flow low-gradient AS phenotype (see Supplementary Table 2). The median aortic valve area was 0.86 cm^2 (IQR, 0.80-0.93), the median mean gradient was 38 mm Hg (IQR, 28.25-43.75), and the median peak velocity was 3.9 m/sec (IQR, 3.3-4.18). The median left ventricular ejection fraction was 47% (IQR, 36.5-55.25), with individual values ranging from 15% to 65%. Mitral regurgitation was at moderate to moderate-severe levels. Pulmonary hypertension was present in 50% of the low-flow low-gradient cases, including 1 instance of marked severity. Regional wall motion abnormalities were identified in 50% of the total cases, with wall motion score indices of 2.06.

Structural computed tomography characteristics. All 12 cases had trileaflet aortic valve morphology with restricted leaflet motion and calcification (Supplementary Table 3).

Angiographic characteristics. Coronary angiography of the cohort reveals extensive multivessel CAD with significant left main CAD in 66% of cases. Distal left main/bifurcation disease was present in 50% of the cases. In terms of the severity of calcification, 8 (66%) cases had severe coronary calcification, and of these, 7 (58%) underwent advanced calcium modification technique (Supplementary Table 4).

Procedural characteristics. Impella CP support was utilized in 100% of cases for the entire duration of the PCI. A single-access technique was utilized in 9 of 12 cases (75%), primarily through the right common femoral artery. All coronary interventions were performed with intravascular ultrasound guidance. Two-stent bifurcation PCI was done in 42% of cases, while PCI of the left main coronary artery to the left anterior descending artery (LAD) occurred in 25% of the cohort. Other procedures included isolated or complex PCI to the right coronary artery, left circumflex artery (LCx), or LAD. Three cases had rotational atherectomy (RA), 1 case had intravascular lithotripsy, and 3 cases had a combination of RA and intravascular lithotripsy. All TAVR deployments were performed via transfemoral access using SAPIEN 3 or SAPIEN 3 Ultra valves. Procedural success was achieved in all patients. Postdeployment paravalvular regurgitation was mild to trivial, with all cases reporting no prosthetic regurgitation at all.

The median contrast volume was 247.5 mL (IQR, 212.5-303.75). Radiation exposure metrics showed a median cumulative skin dose of 1074.13 mGy (IQR, 830.10-1356.71) and a median dose area product of 91.31 Gy·cm^2 (IQR, 62.40-119.25). The median fluoroscopy time was 54.63 minutes (IQR, 42.01-66.82).

Procedural complications

CHIP-related complications. None of the patients had any procedural complications based on the Academic Research Consortium-2 definitions. One patient had significant bleeding following deployment of the femoral Perclose device, needing additional Perclose device deployment. In 1 case, the Takeru balloon shaft (Terumo Interventional System) separated and was lodged in the mid-LAD; however, it was successfully retrieved. One patient had a distal wire perforation that was managed conservatively.

TAVR-related complications. None of the patients had any major bleeding or vascular complications. Transient hemodynamic compromise with hypotension needing additional vasopressor support was needed in 1 patient. Permanent pacemaker placement was required in 4 (25%) cases. Five patients had a trivial increase in QRS duration. Additionally, 2 patients had significant prolongation of the PR interval. One patient had intermittent left bundle branch block post Impella placement. Sixty percent of the cohort was discharged with an ambulatory cardiac monitoring (MoMe) as per Mayo Clinic Post-TAVR protocol.[9] Two patients developed complete heart block requiring permanent pacemaker insertion (PPM) before discharge. One patient developed complete heart block, but in view of depressed ejection fraction, underwent cardiac resynchronization therapy-defibrillator insertion before discharge. Only one patient developed late conduction abnormality requiring readmission for PPM.

Disposition and follow-up

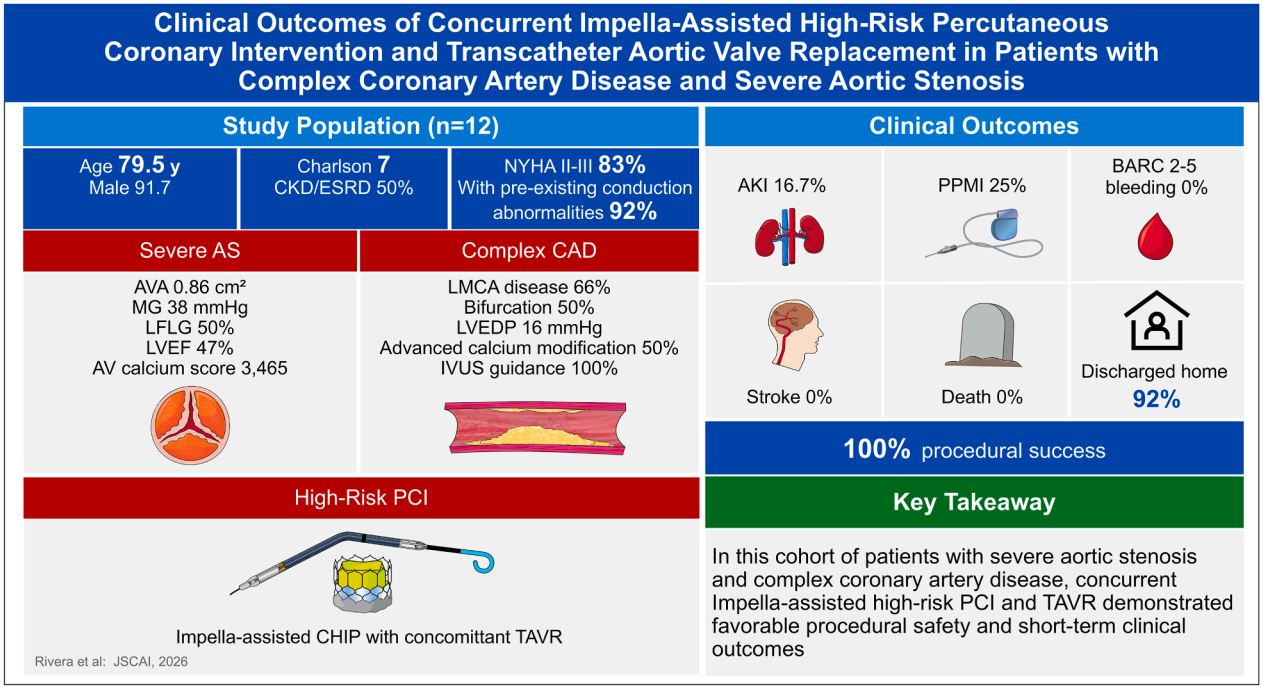
At the time of discharge, most of the cohort was transitioned to dual antiplatelet therapy (DAPT) for 6 to 12 months, with modifications for patients requiring anticoagulation for atrial fibrillation or Factor V Leiden. Regarding disposition, 11 of 12 patients were successfully discharged to home or self-care. Clinical safety outcomes were favorable, with 0% incidence of stroke across the entire cohort. Only 2 cases of AKI were reported, both of which were noted as resolving or managed by holding diuretics at the time of discharge without the need for temporary or permanent dialysis.

Discussion

This multicenter study demonstrates that a single-session IA-CHIP and TAVR strategy is a safe and technically feasible solution for the dual-disease phenotype of complex, high-risk CAD and severe AS (Central Illustration). Our primary finding of 100% procedural success and zero in-hospital mortality is significant when viewed alongside the NOTION-3 trial (2024).[3] While NOTION-3 confirmed that treating CAD in TAVR candidates improves long-term outcomes, the single-setting approach we utilized takes this a step further. By treating both problems in 1 session, we eliminated the period during which a patient remains at risk for MACE while limiting large-bore access to a single procedure. Severe AS creates a fixed afterload that prevents compensatory increases in cardiac output during the transient ischemia of CHIP. Our results show that percutaneous microaxial flow pump (Impella CP) effectively mitigated this risk. Despite majority of patients requiring advanced calcium modification—procedures often associated with hemodynamic instability—the continuous MCS maintained systemic perfusion. This mirrors the real-world benefits seen in the PROTECT III[10] and RECOVER III[11] registries, where MCS provided a buffer for the most complex CHIP cases. Our study reinforces the findings of Yeo et al,[5] confirming that Impella can be safely deployed across the aortic valve. We observed no stroke or major vascular complications, proving that the presence of the pump does not necessarily increase embolic risk or hinder subsequent valve deployment. The most notable complication in our results was the 25% rate of new conduction abnormalities requiring PPM. This is higher than standard TAVR benchmarks (typically 10%-15%)[12,13] and may represent a patient population with underlying high risk and/or institution-specific protocols for post-TAVR permanent pacemaker insertion. In our cohort, electrocardiogram conduction abnormalities include first- and second-degree AV block in 42% and RBBB in 16%.

A higher AKI rate (16.7%) in our study is notable and likely multifactorial, reflecting a sicker population with hemodynamic instability, greater procedural complexity, older age, and higher cumulative contrast exposure (247.5 mL).[14,15] Importantly, this rate exceeds contemporary post-TAVR benchmarks of less than 5%, and without a comparator group undergoing staged PCI and TAVR, we cannot determine the difference in renal outcomes between the 2 approaches. Flaherty et al[16] have demonstrated that active unloading with the Impella CP may help maintain renal perfusion pressure, providing a physiologically plausible mechanism by which microaxial support could mitigate contrast nephrotoxicity. Our data do not allow us to draw any firm conclusions about whether this mechanism translated into a renal-protective benefit in our cohort, and further comparative studies are needed to evaluate AKI outcomes in simultaneous vs staged TAVR and IA-CHIP procedures.

It is important to contextualize the use of Impella CP in light of recent randomized trial evidence. The CHIP-BCIS3 (Controlled Trial of High-Risk Coronary Intervention With Percutaneous Left Ventricular Unloading) trial did not demonstrate a mortality reduction with routine Impella use in unselected patients undergoing high-risk PCI. These findings have prompted reevaluation of the routine use of



Central Illustration.

Clinical outcomes of concurrent Impella-assisted high-risk percutaneous coronary intervention and transcatheter aortic valve replacement in patients with complex coronary artery disease and severe aortic stenosis. AKI, acute kidney injury; AS, aortic stenosis; AV, aortic valve; BARC, Bleeding Academic Research Consortium; CHIP, complex high risk indicated percutaneous coronary intervention; CKD, chronic kidney disease; ESRD, end-stage renal disease; IVUS, intravascular ultrasound; LFLG, low-flow, low-gradient, LMCA, left main coronary artery; LVEDP, left ventricular end diastolic pressure; LVEF, left ventricular ejection fraction; MG, mean gradient; NYHA, New York Heart Association; PCI, percutaneous coronary intervention; PPMI, periprocedural myocardial infarction; TAVR, transcatheter aortic valve replacement.

microaxial flow pumps in the broader CHIP population. However, in contrast to the patients enrolled in CHIP-BCIS3 and related trials with largely preserved ejection fraction and no AS, our patients represented a higher risk subset with concomitant severe AS and complex CAD. Concomitant severe AS imposes a fixed afterload that prevents the heart from augmenting cardiac output during the transient myocardial ischemia inherent in complex revascularization. In this specific physiological context, MCS with the Impella CP allows hemodynamic stability and enables complex coronary intervention while maintaining systemic perfusion. We acknowledge that none of the existing MCS trials have specifically studied patients with concomitant severe AS undergoing simultaneous CHIP and TAVR, and prospective data in this niche population are needed before broader conclusions can be drawn.

Another advantage of the simultaneous IA-CHIP and TAVR strategy is lowering the bleeding risk through the consolidation of vascular access and the synchronization of anticoagulation. In our cohort, the procedure utilized a single-access technique.[17] In such a high-risk population, each independent vessel puncture with a large-bore access potentially increases the risk of hematoma, vessel damage from sheath/closure device, retroperitoneal hemorrhage, and closure device failure. By maintaining a single large-bore femoral access site for the duration of both procedures, the interventional team manages the arteriotomy only once, concludes the session with a definitive closure under a single setting, while maintaining a unified anticoagulation strategy that is impossible in a staged workflow. Upon completion of both the revascularization and valvular deployment, partial heparin reversal is achieved with single, low-dose protamine sulfate. In contrast, a staged approach subjects the patient to 2 independent periods of systemic heparinization. Furthermore, if the initial PCI is complex, patients are often transitioned to potent P2Y12 inhibitors while awaiting TAVR. The period between staged procedures heightens both the risk from untreated AS and the bleeding risk from large-bore access and initiation of DAPT. By performing both procedures in a single session, the TAVR is completed before the patient is transitioned to long-term DAPT, decoupling the necessity of complex revascularization from the bleeding risks traditionally associated with multistage large-bore interventions.

Another critical advantage of the simultaneous IA-CHIP and TAVR strategy is the elimination of the initial fluoroscopic set-ups inherent in staged protocols that require a baseline of noninterventional radiation to establish the procedural environment. By consolidating 2 interventions, these preliminary steps occur only once, effectively converting a redundant step into a streamlined workflow, eliminating the need for additional fluoroscopy and potentially reducing the radiation exposure.

Strengths and limitations

This is one of the first multicenter studies to evaluate a truly simultaneous, single-session approach for IA-CHIP and TAVR. As a retrospective analysis, the study is subject to inherent selection bias. The decision to perform a simultaneous procedure rather than a staged 1 was left to the discretion of the Heart Team, potentially selecting for patients who were deemed too unstable to wait for a staged approach. While the cohort is representative of this niche dual-disease population, the absolute number of patients is small; therefore, while we can conclude the simultaneous approach is feasible, we cannot definitively state it is superior to a staged approach in terms of MACE. In addition, attributing shared bleeding or ischemic complications to either PCI or TAVR, and reimbursement issues need to be sorted out for PCI and TAVR. It is also yet uncertain how higher complication rates (eg, AKI and permanent pacemaker implantation) observed in our cohort with combined procedures impact long-term survival and whether there is any advantage of combining these procedures in terms of lowering bleeding/vascular events and improving short-term survival.

Conclusion

The single-setting IA-CHIP and TAVR approach represents a technically feasible and potentially safe alternative strategy for highly selected patients with concomitant complex CAD and severe AS. Prospective randomized data are needed to determine whether this approach reduces MACE compared with staged procedures, and we hope this multicenter experience provides a framework for collaborative trials with larger patient numbers.

CRediT authorship contribution statement

Frederick Berro Rivera: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Brenden Ingraham:** Writing – review & editing, Supervision. **Pietro Di Santo:** Writing – review & editing, Supervision. **Trevor Simard:** Writing – review & editing, Supervision. **Benjamin Hibbert:** Supervision, Conceptualization. **Mandeep Singh:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding sources

This work was not supported by funding agencies in the public, commercial, or not-for-profit sectors.

Ethics statement and patient consent

This study was conducted with approval from the Mayo Clinic Institutional Review Board (IRB #25-011575). Given the retrospective nature of the study, a waiver of individual patient informed consent was granted in accordance with applicable guidelines.

Supplementary material

To access the supplementary material accompanying this article, visit the online version of the *Journal of the Society for Cardiovascular Angiography & Interventions* at 10.1016/j.jscai.2026.105562.

References

1. Patel KP, Michail M, Treibel TA, et al. Coronary revascularization in patients undergoing aortic valve replacement for severe aortic stenosis. *JACC Cardiovasc Interv*. 2021;14(19):2083–2096. https://doi.org/10.1016/j.jcin.2021.07.058
2. Louca A, Petursson P, Sundström J, et al. PCI versus conservative management before TAVR in patients with significant coronary artery disease: a nationwide instrumental variable analysis. *Circ Cardiovasc Interv*. 2026;19(4):e016337. https://doi.org/10.1161/CIRCINTERVENTIONS.125.016337
3. Lønborg J, Holm NR, Bøtker HE, et al. PCI in patients undergoing transcatheter aortic-valve implantation. *N Engl J Med*. 2024;391(23):2189–2200. https://doi.org/10.1056/NEJMoa2407985
4. Park DY, Kim BK, Hong SJ, et al. Insight into the optimal timing of percutaneous coronary intervention and transcatheter aortic valve replacement. *Curr Probl Cardiol*. 2024;49(1 Pt A):102050. https://doi.org/10.1016/j.cpcardiol.2023.102050
5. Yeo I, Shlofmitz E, Khalique OK, et al. Feasibility and safety of Impella-assisted high-risk PCI before TAVR in patients with severe aortic stenosis. *J Soc Cardiovasc Angiogr Interv*. 2023;2(5):101061. https://doi.org/10.1016/j.jscai.2023.101061

6. Velagapudi P, Meraj PM, Doshi R, et al. Clinical outcomes of aortic stenosis patients undergoing Impella-supported high-risk percutaneous coronary intervention. *Front Cardiovasc Med*. 2025;12:1638259. https://doi.org/10.3389/fcvm.2025.1638259
7. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373–383. https://doi.org/10.1016/0021-9681(87)90171-8
8. Hicks KA, Stockbridge NL, Targum SL, et al. Bleeding Academic Research Consortium consensus report: the Food and Drug Administration perspective. *Circulation*. 2011; 123(23):2664–2665. https://doi.org/10.1161/CIRCULATIONAHA.111.032938
9. Alabdaljabar MS, Shah PB, Gertz ZM, et al. Thirty-day high-grade aortic valve block post-transcatheter aortic valve replacement in patients discharged on heart rhythm monitor. *Struct Heart*. 2024;8(4):100317. https://doi.org/10.1016/j.shj.2024.100317
10. Shah T, Kaki A, Alaswad K, et al. Sex differences in pLVAD-assisted high-risk percutaneous coronary intervention: insights from the PROTECT III study. *JACC Cardiovasc Interv*. 2023;16(14):1721–1729. https://doi.org/10.1016/j.jcin.2023.05.030
11. Hanson ID, O'Neill WW, Basir MB, et al. Treatment of acute myocardial infarction and cardiogenic shock: outcomes of the RECOVER III postapproval study by Society of Cardiovascular Angiography and Interventions shock stage. *J Am Heart Assoc*. 2024;13(3):e031803. https://doi.org/10.1161/JAHA.123.031803
12. Vora AN, Fendler TJ, Kumbhani DJ, et al. National variability in pacemaker implantation rate following TAVR: insights from the STS/ACC TVT Registry. *JACC Cardiovasc Interv*. 2024;17(3):391–401. https://doi.org/10.1016/j.jcin.2023.11.018
13. Rivera FB, Khan MS, Memon MM, et al. Sex differences in permanent pacemaker implantation after transcatheter aortic valve replacement: a systematic review and meta-analysis. *Expert Rev Cardiovasc Ther*. 2023;21(9):631–641. https://doi.org/10.1080/14779072.2023.2253454
14. Rivera FB, Khan MS, Memon MM, et al. Transcatheter aortic valve replacement-associated acute kidney injury: an update. *Cardiorenal Med*. 2023;13(1):143–157. https://doi.org/10.1159/000529203
15. Rivera FB, Khan MS, Memon MM, et al. Aortic stenosis and aortic valve replacement among patients with chronic kidney disease: a narrative review. *Cardiorenal Med*. 2023;13(1):74–90. https://doi.org/10.1159/000529202
16. Flaherty MP, Pant S, Patel SV, et al. Hemodynamic support with a microaxial percutaneous left ventricular assist device (Impella) protects against acute kidney injury in patients undergoing high-risk percutaneous coronary intervention. *Circ Res*. 2017;120(4):692–700. https://doi.org/10.1161/CIRCRESAHA.116.309648
17. Tarantini G, Fabris T. Single-access technique for Impella-assisted PCI: how to take hold of Impella by the smooth handle. *Catheter Cardiovasc Interv*. 2022;100(6): 1043–1044. https://doi.org/10.1002/ccd.30429