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EDUCATION

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Coronary access after ACURATE neo2 implantation for valve-in-valve TAVR: Insights from ex vivo simulations

Arif A. Khokhar BM, BCh[1,2] | **Francesco Giannini MD**[3] | **Adriana Zlahoda-Huzior MSc**[2,4] | **Ghada Mikhail MD, FRCP**[1] | **Dariusz Dudek PhD**[3,5]

[1]Department of Cardiology, Imperial College Healthcare NHS Trust, London, UK

[2]Digital Innovations & Robotics Hub, Krakow, Poland

[3]Interventional Cardiology Unit, GVM Care & Research, Maria Cecilia Hospital, Cotignola, Italy

[4]Department of Measurement and Electronics, AGH University of Science and Technology, Krakow, Poland

[5]Institute of Cardiology, Jagiellonian University Medical College, Krakow, Poland

Correspondence: Arif A. Khokhar, BM, BCh(OXON), MA(CANTAB), MRCP(London), Imperial College Healthcare NHS Trust, London, UK.
Email: arifkhokhar@doctors.org.uk

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1 | INTRODUCTION

The expansion of transcatheter aortic valve replacement (TAVR) toward lower-risk often younger populations makes coronary access (CA) an increasingly relevant issue for the lifetime management of aortic stenosis.[1] CA can be challenging or unfeasible due to anatomical, procedural, or transcatheter heart valve (THV)-related factors.[2–4] Prior studies have reported more challenging CA following use of supra-annular self-expandable valves (SA-SEV) due to the taller stent frame, higher leaflet position, and commissural posts.[2,3] Dedicated cannulation techniques have been described to help operators achieve CA following the implantation of SA-SEVs.[5,6] However, to date, these techniques have only been described for the Corevalve/Evolut SA-SEV (Medtronic). The ACURATE *neo2* (Boston Scientific) is another SA-SEV with a different design philosophy that consists of a short lower-stent frame connected to open upper stabilization arches. The potential impact of this different design on cannulation techniques, particularly in the challenging setting of valve-in-valve TAVR (ViV-TAVR) procedures has not yet been evaluated.

Therefore, we performed ex vivo simulations of CA in a patient-specific ViV-TAVR model connected to a pulsatile flow simulator to replicate in vivo conditions (Supporting Information: Figure 1). The silicone-based anatomical model was created using computed-tomography data of patients with degenerated aortic surgical bioprosthesis scheduled for ViV-TAVR. An ACURATE *neo2* size S valve was implanted inside a Carpentier-Edwards Perimount 25 (Edwards Lifesciences) surgical bioprosthesis. Simulations were performed under two different configurations; commissural alignment (defined as 60° overlap between coronary ostia and commissural post) and commissural misalignment (defined as less than 15° overlap between coronary ostia and commissural post). Expert operators cannulated both coronary ostia under fluoroscopic guidance using a range of different diagnostic and guiding catheters. The movements of the catheters and different cannulation approaches to the coronary ostia were visualized by the operators using an internally mounted borescope camera.

Multiple cannulation approaches were possible with the ACURATE *neo2* in a ViV-TAVI setting (Figure 1). These different approaches were feasible due to the unique split-level design, which consists of a short lower stent frame combined to upper open stabilization arches. CA was possible either via an internal

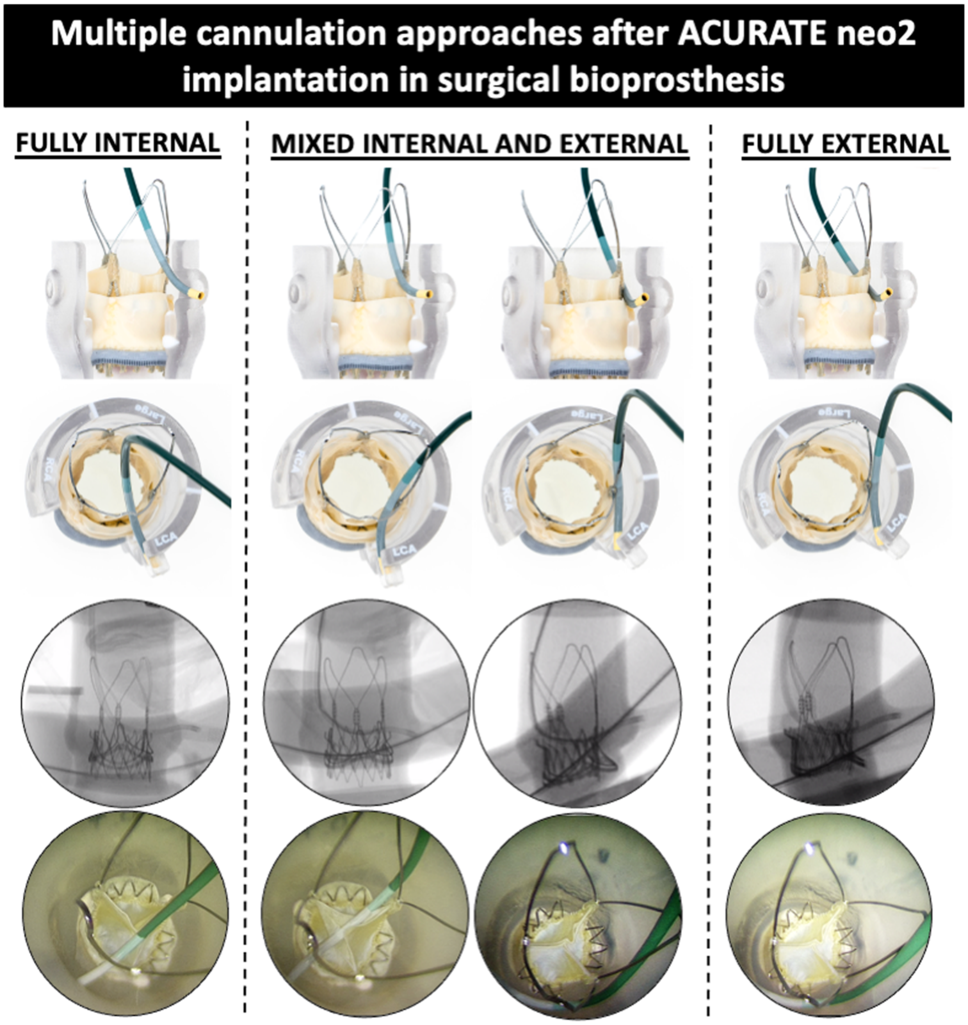

FIGURE 1 Multiple cannulation pathways with ACURATE *neo2*. Bench model, fluoroscopic, and endoscopic views of the different cannulation pathways possible with the ACURATE *neo2* valve. Fluoroscopically, there was little to distinguish between the different cannulation pathways observed using the borescope camera. [Color figure can be viewed at wileyonlinelibrary.com]

approach going from inside the valve frame between the stabilization arches or by an external approach whereby the catheter bypassed the valve frame. Additionally, a mixed internal/external approach was possible due to the open-celled stabilization arches. Fluoroscopically, it was not easy to understand whether the cannulation was performed internally, externally, or by a mixed approach (Figure 1).

The internal and external cannulation approaches for the left and right coronary ostia were possible with the use of both 6 Fr diagnostic or guiding Judkins left, Extra back-up, Amplatz Left, Judkins right, and internal mammary catheters (Boston Scientific) (Figures 1–3). Despite severe commissural misalignment, both the internal and external cannulation approaches were still feasible, with different diagnostic and guiding catheters. The open cells of the stabilization arches allowed sufficient space to manipulate a catheter for the internal approach, while in the external approach, the catheters were able to bypass the obstructive commissural post.

An internal cannulation approach resulted in more co-axial supportive cannulation, which would be favorable when performing complex percutaneous coronary interventions (PCI). However, during internal cannulation, the catheters were more likely to interact with the THV leaflets. The internally mounted camera highlighted a spectrum of catheter-leaflet interactions, from no leaflet interaction to complete leaflet pinning during systole and diastole (Figure 4). The use of more supportive guiding catheters such as the Amplatz Left 1, increased the potential for leaflet interaction and pinning. Although the hemodynamic consequences of these leaflet interactions is not known, its likely that complete pinning of leaflets, especially during diastole, would impair leaflet coaptation resulting in free aortic regurgitation and subsequent hemodynamic compromise.

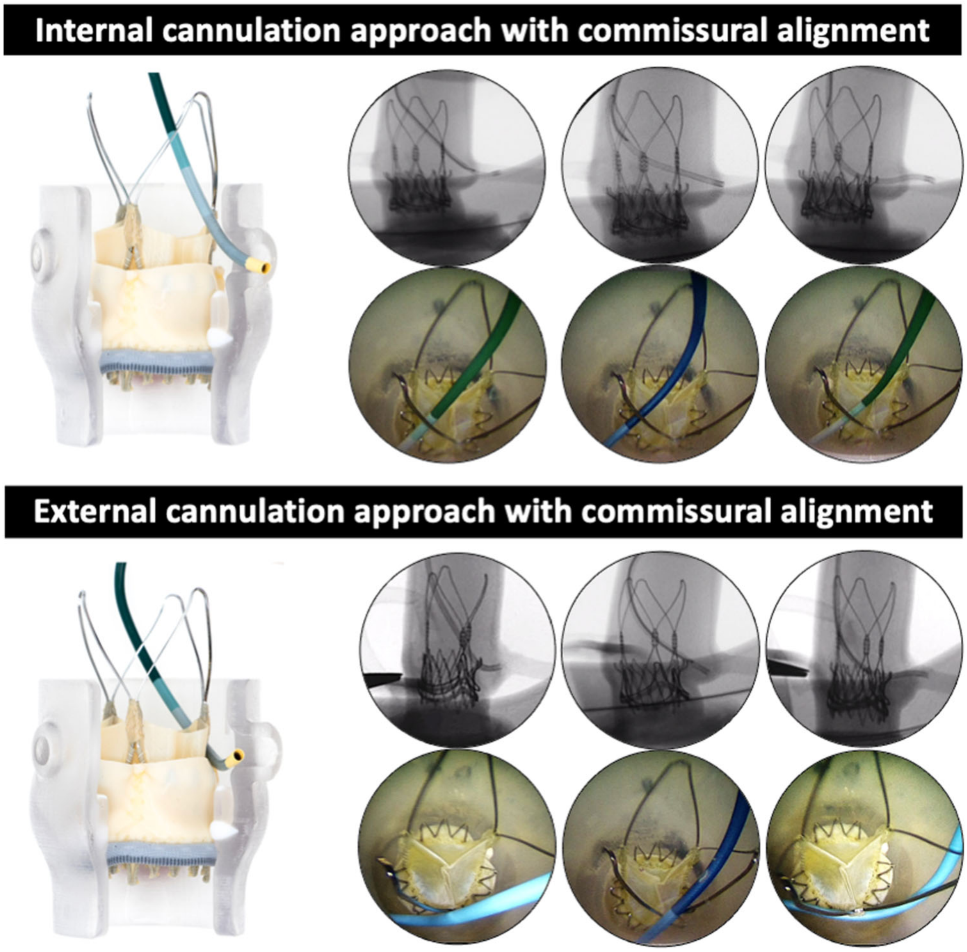

FIGURE 2 Left coronary cannulation techniques with commissural alignment. Fluoroscopic and endoscopic views demonstrating how a Judkins left, Extra back-up, and Amplatz Left 1 catheter were used to cannulate the left coronary artery via both an internal and external approach in the presence of good commissural alignment between the transcatheter valve and left coronary ostia. [Color figure can be viewed at wileyonlinelibrary.com]

Operators should be aware of this potential to disrupt valvular function and subsequent hemodynamic status when cannulating through an internal approach. To reduce the interaction and pinning of THV leaflets, operators can reposition and retract the guiding catheter upward, change the shape of the guiding catheter or select an external cannulation approach that avoids the leaflets entirely. An external approach may also reduce the interaction between coronary catheters and any additional devices placed internally through the valve, such as balloons, additional valves, or left-ventricular support devices. However, the lateral approach of the catheter toward the coronary ostium can lead to a less co-axial and selective cannulation.

2 | LIMITATIONS

Despite the growing clinical experience with this valve platform, particularly for ViV-TAVI procedures,[7,8] use of the ACURATE neo2 valve to treat degenerated surgical bioprosthesis remains off-label currently. Compared to other long-frame SEVs, the unique split-level design consisting of a short lower stent frame combined to open upper stabilization arches makes it potentially more favorable for CA. However, for ViV-TAVR procedures, consideration should be given to the implantation depth, as studies have shown that valve expansion and subsequent valvular function are optimal when the upper crown is positioned above the level of the surgical posts.[8] Furthermore, recently described techniques to achieve optimal commissural alignment should be followed to avoid interaction between the surgical valve posts and the free leaflets of the ACURATE valve.[9,10] Finally, all cannulation techniques were performed in a patient-specific ex vivo pulsatile flow simulator with a specific surgical bioprosthetic valve (Perimount 25). Therefore, further testing is required to determine the reproducibility of these findings in vivo, under different anatomical settings, and with the use of different surgical bioprosthetic valves.

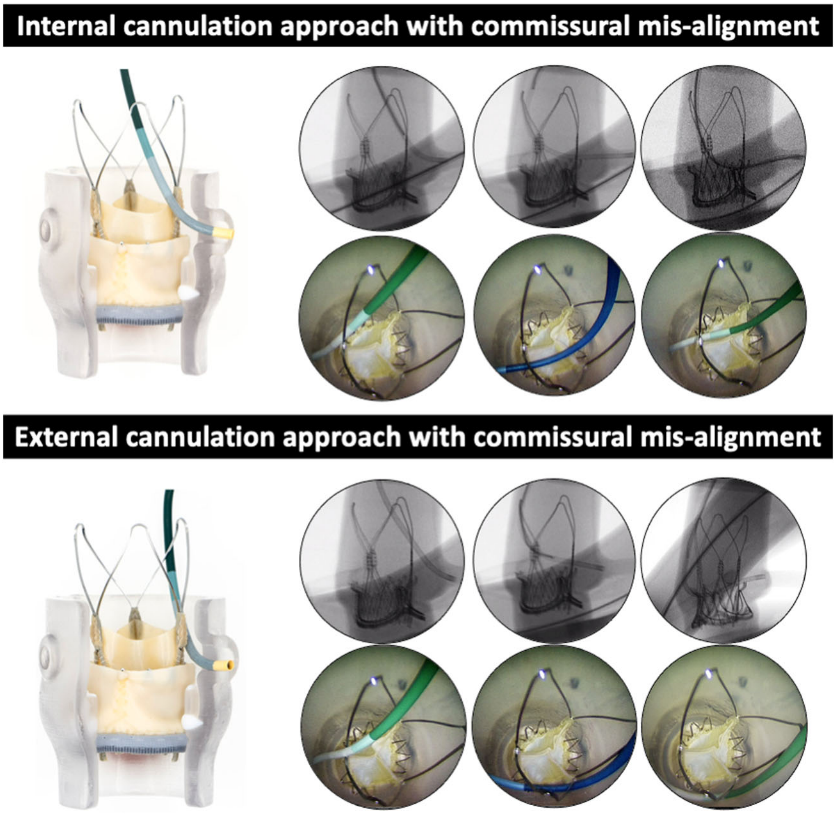

FIGURE 3 Left coronary cannulation techniques with commissural misalignment. Fluoroscopic and endoscopic views demonstrating how a Judkins left, Extra back-up, and Amplatz Left 1 catheter was used to cannulate the left coronary artery via both an internal and external approach in the presence of commissural misalignment between the transcatheter valve and left coronary ostia. [Color figure can be viewed at wileyonlinelibrary.com]

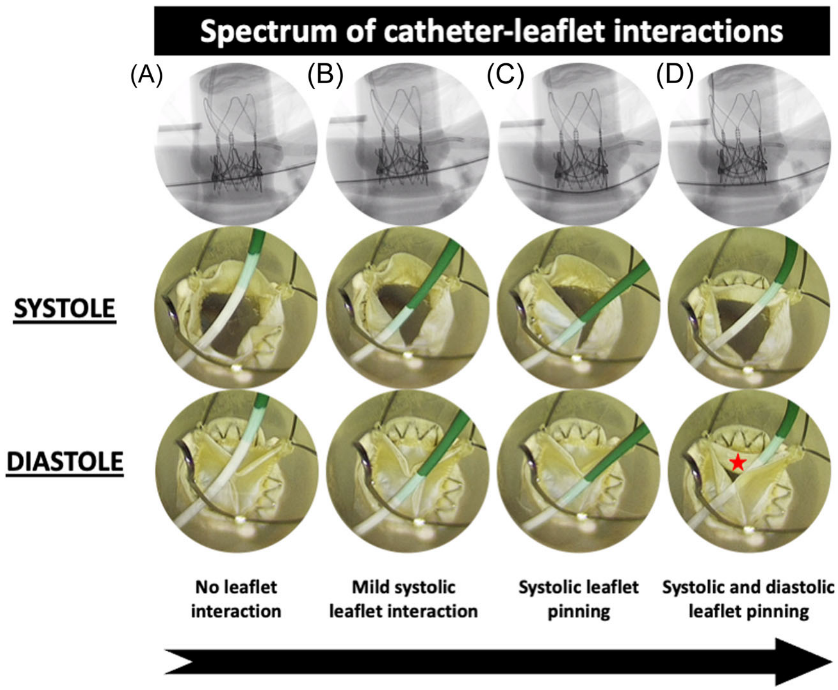

FIGURE 4 Spectrum of catheter-leaflet interactions during left coronary access. Fluoroscopic and endoscopic views during systole and diastole demonstrating the interaction between a 6 Fr Amplatz Left 1 guiding catheter and the leaflets of the ACURATE *neo2* valve. (A) Initially, as the catheter approaches the left coronary ostium, there is no restriction of leaflet mobility. (B) Selective cannulation leads to mild systolic leaflet interaction with (C) systolic leaflet pinning observed as the catheter is advanced into a more supportive position. (D) Attempts to further increase the support by advancing the catheter can lead to leaflet pinning throughout both systole and diastole. [Color figure can be viewed at wileyonlinelibrary.com]

3 | CONCLUSION

We demonstrate for the first time, via ex vivo simulations, the different cannulation techniques possible with the ACURATE *neo2* valve in the setting of ViV-TAVR. Knowledge of these different cannulation techniques and how they may interact with valve leaflets will be useful for operators when faced with challenging coronary cannulation after TAVR.

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CONFLICTS OF INTEREST

Dariusz Dudek, scientific advisory board for Boston Scientific. Arif A. Khokhar, speaker fees for Boston Scientific.

DATA AVAILABILITY STATEMENT

Data available on request of authors.

ORCID

Arif A. Khokhar http://orcid.org/0000-0002-4455-2865
Francesco Giannini http://orcid.org/0000-0002-3391-9860

REFERENCES

1. Yerasi C, Rogers T, Forrestal BJ, et al. Transcatheter versus surgical aortic valve replacement in young, low-risk patients with severe aortic stenosis. *JACC Cardiovasc Interv*. 2021;14(11):1169-1180. doi:10.1016/j.jcin.2021.03.058
2. Tarantini G, Nai Fovino L, Scotti A, et al. Coronary access after transcatheter aortic valve replacement with commissural alignment: the ALIGN-ACCESS study. *Circ Cardiovasc Interv*. 2022;15(2):e011045. doi:10.1161/CIRCINTERVENTIONS.121.011045
3. Barbanti M, Costa G, Picci A, et al. Coronary cannulation after transcatheter aortic valve replacement. *JACC Cardiovasc Interv*. 2020;13(21):2542-2555. doi:10.1016/j.jcin.2020.07.006
4. Ochiai T, Chakravarty T, Yoon SH, et al. Coronary access after TAVR. *JACC Cardiovasc Interv*. 2020;13(6):693-705. doi:10.1016/j.jcin.2020.01.216
5. Yudi MB, Sharma SK, Tang GHL, Kini A. Coronary angiography and percutaneous coronary intervention after transcatheter aortic valve replacement. *J Am Coll Cardiol*. 2018;71:1360-1378. doi:10.1016/j.jacc.2018.01.057
6. Valvo R, Costa G, Tamburino C, Barbanti M. Coronary artery cannulation after transcatheter aortic valve implantation. *EuroIntervention*. 2021;17(10):835-847. doi:10.4244/eij-d-21-00158
7. Khokhar AA, Laricchia A, Ponticelli F, et al. Computed tomography analysis of coronary ostia location following valve-in-valve transcatheter aortic valve replacement with the ACURATE neo valve: implications for coronary access. *Catheter Cardiovasc Interv*, 98(3): 595-604. doi:10.1002/CCD.29503
8. Holzamer A, Kim WK, Rück A, et al. Valve-in-valve implantation using the ACURATE neo in degenerated aortic bioprostheses: an international multicenter analysis. *JACC Cardiovasc Interv*. 2019;12(22):2309-2316. doi:10.1016/j.jcin.2019.07.042
9. Bieliauskas G, Wong I, Bajoras V, et al. Patient-specific implantation technique to obtain neo-commissural alignment with self-expanding transcatheter aortic valves. *JACC Cardiovasc Interv*. 2021;14(19): 2097-2108. doi:10.1016/j.jcin.2021.06.033
10. Wong I, Bieliauskas G, De Backer O, Søndergaard L. Technical considerations for transcatheter aortic valve replacement with ACURATE neo2. *JACC Cardiovasc Interv*. 2021;14(2):224-226. doi:10.1016/j.jcin.2020.10.022

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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