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Updates on the Role of Interventional Radiology in Ischemic Patients Undergoing Aortic Valve Replacement: Systematic Review

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ABSTRACT

Recent recommendations state that considerable coronary artery disease (CAD) should be treated before the index procedure in patients with severe aortic stenosis who have a transcatheter aortic valve implant. However, the data supporting this suggestion is still limited. We aimed to assess the recent updates on percutaneous coronary intervention (PCI) among patients undergoing transcatheter aortic valve interventions. A search was performed on the PubMed, Web of Science, Science Direct, EBSCO, SCOPUS, Wiley, and Cochrane Library databases. Study articles were screened by title and abstract using Rayyan QCRI then a full-text assessment was implemented. A total of eleven studies with 6252 patients were included. The self-expandable (SE), balloon-expandable, Edwards Sapien (ES), and CoreValve are the most common valve types used in TAVI or TAVR. Most of the included studies reported that TAVI/ TAVR combined with the PCI technique is a safe and efficacious procedure for managing patients with AS. For patients with severe AS and with or without CAD, combined PCI prior to TAVI/ TAVR is a relatively safe and practical method, according to the available evidence on short- and mid-term results.

Keywords: *Percutaneous coronary intervention, Transcatheter aortic valve implantation, Transcatheter aortic valve replacement, Systematic review.*

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INTRODUCTION

Degenerative aortic stenosis (AS) and coronary artery disease (CAD) are two distinct cardiovascular conditions that frequently coexist (Van Hoang *et al*., 2019). They have many mutual risk factors, pathophysiological mechanisms, and clinical implications (Opolski *et al*., 2016; El Sabbagh & Nishimura, 2017). Both have a subendothelial buildup of oxidized low-density lipoproteins and inflammatory reactions involving lymphocytes and macrophages, which are factors in the development of the diseases (Otto, 1994; Soboleva *et al.,* 2022). For patients with severe AS and significant surgical risk, transcatheter aortic valve replacement (TAVR) or transcatheter aortic valve implantation (TAVI) has lately become a desirable and less intrusive treatment option compared to traditional surgical aortic valve replacement (SAVR) (Greason *et al*., 2014). It is still debatable how stable CAD should be managed in individuals with aortic stenosis who are undergoing TAVI. There is currently no data demonstrating the prognostic value of undergoing coronary artery revascularization either; prior to, during, or following the TAVI surgery (Ramee *et al*., 2016; Kotronias *et al*., 2017). The European Society of Cardiology's most recent myocardial revascularization guidelines advises considering prior PCI for patients undergoing TAVI who have coronary artery stenosis greater than 70% in proximal segments, even though this issue is contentious (Neumann *et al*., 2019; Sulastri *et al.,* 2022). Similarly, coronary artery revascularization is recommended prior to TAVI, according to the most recent American Society of Cardiology acceptable use criteria (Patel *et al*., 2017).

This systematic review aims to investigate the recently published literature from 2018 to 2022 on PCI among patients with AS and with/ without CAD and undergoing TAVI or TAVR.

MATERIALS AND METHODS

This systematic review was conducted following the accepted standards (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, PRISMA).

Study design

This was a systematic Review.

Study duration
From November to December 2022.

Study condition
The purpose of this systematic review is to investigate the most recent research within the last five years on PCI in patients with AS, CAD, and undergoing TAVI or TAVR.

Search strategy
A comprehensive literature search was conducted in seven major databases, including PubMed, Web of Science, Science Direct, EBSCO, Scopus, Wiley, and Cochrane Library, to identify the relevant literature. We restricted our search to English and took into account the unique requirements of each database. The following keywords were converted into Mesh terms in PubMed and used to find the appropriate studies; "Percutaneous coronary intervention," "PCI," "Transcatheter aortic valve implantation," "TAVI," "Transcatheter aortic valve replacement," "TAVR," "Coronary artery disease," and "CAD." With the help of the "OR" and "AND" Boolean operators, the appropriate keywords were paired. English-language publications with full texts, freely accessible articles, and human trials were included in the search results.

Selection criteria
Inclusion criteria
The inclusion of the subjects was decided upon based on their relevance to the research, which had the following requirements: male or female patients undergoing PCI and TAVI/ TAVR.

Exclusion criteria
We disregarded all additional publications, ongoing research, and analyses of completed studies that did not concentrate on one of these topics.

Data extraction
When examining the search strategy's results, we used Rayyan (QCRI) to check for duplicates (Ouzzani *et al*., 2016). The researchers narrowed the combined search results based on a set of inclusion/exclusion criteria to determine the relevance of the titles and abstracts. The reviewers looked at the entire texts of the papers that met the criteria for inclusion. The authors discussed and resolves conflicts in the articles. The approved study was added using a created data extraction form. The authors extracted data about the study titles, authors, study year, study designs, country, population type, participant number, mean age, gender, type of valves, type of approach, success rate, and main outcomes.

Strategy for data synthesis
To provide a qualitative summary of the included study components and outcomes, summary tables made from the data collected from the eligible studies were created. After data extraction for the systematic review, it was decided how to use the included study articles' data best. Studies that met the full-text inclusion criteria but did not provide any data on PCI among patients undergoing TAVI/ TAVR were excluded.

Risk of bias assessment
The standard of the included studies was evaluated using the ROBINS-I risk of bias assessment method for non-randomized trials of treatments (Jüni *et al*., 2016). Seven different topics were covered: confounding and participant selection for the study, classification of interventions, deviations from intended interventions, missing data, assessment of outcomes, and selection of the reported result.

RESULTS AND DISCUSSION

Search results
A total of 432 study articles resulted from the systematic search, then 89 duplicates were deleted. Title and abstract screening were conducted on 343 studies, and 223 studies were excluded. 120 reports were sought for retrieval, and only 10 articles were not retrieved. Finally, full-text assessments were performed on the 110 studies; 40 were excluded for wrong study outcomes, 9 for unavailable data on PCI, TAVI, and/ or TAVR, and 50 for the wrong population type. Eleven eligible study articles were included in this systematic review. A summary of the study selection process is presented in **Figure 1.**

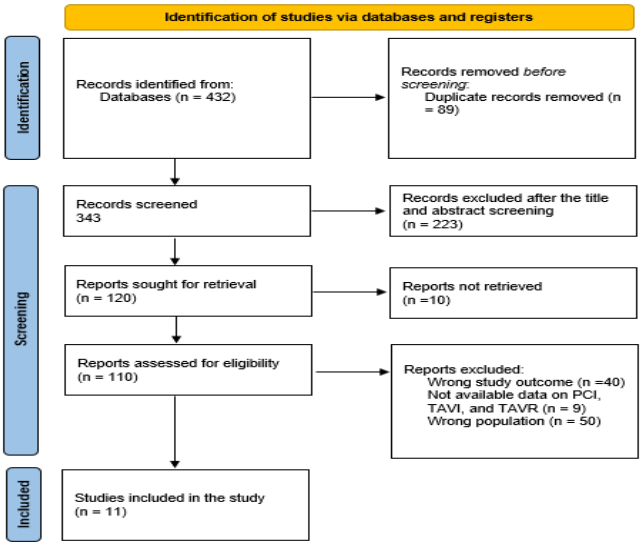

Figure 1. PRISMA flowchart summarizes the study selection process

Table 1. Sociodemographic characteristics of the participants of the included studies

Study	Country	Population type	Participants (n)	Mean age	Males (%)
Perrin *et al.* (2020)	Switzerland	Patients with CAD	19	77.7 ± 7.2	68.4
Denimal *et al.* (2021)	France	Patients with and without CAD	137	82.3 ± 6.5	38
Guedeney *et al.* (2019)	USA	Patients with CAD	81	83 ± 7	0
Matta *et al.* (2021)	France	Patients with and without CAD	1030	84.3 ± 7	45.2
Kaihara *et al.* (2021)	Japan	Patients with and without CAD	186	84 ± 6	31.7
Jeroudi *et al.* (2018)	USA	Patients with CAD	20	73.7 ± 12.7	55
Ferreira-Neto *et al.* (2019)	Canada	Patients with CAD	13	70.31 ± 7.99	69.2
Ghrair *et al.* (2020)	USA	Patients with CAD	852	80.5 ±8.3	54.1
Winter *et al.* (2021)	Switzerland	Patients with CAD	449	77-85	51.7
Tran *et al.* (2022)	USA	Patients without CAD	843	80.4 ± 8	50.1
Abugroun *et al.* (2020)	USA	Patients with CAD	2622	74-87	52.4

Table 2. Characteristics and outcomes of the included studies

Study	Study design	Type of valve	Type of approach	Success rate (%)	Key findings	ROBIN-I
Perrin *et al.* (2020)	Retrospective study	CoreValve, Evolut R, Evolut PRO, ES	TF	100	Even after the installation of a supra-annular SE valve, post-TAV CA and PCI are difficult but doable. High TAVI implantation decreases the need for new pacemaker implantation, but it may make coronary artery cannulation more difficult, particularly if coronary ostia are low.	High
Denimal *et al.* (2021)	Retrospective study	SE	TF	94.2	TF-TAVI conducted on a small group of patients entirely under a PCI method has similar efficacy and safety to TF-TAVI performed in the presence of a full anesthetic care team.	Moderate
Guedeney *et al.* (2019)	Prospective study	SE and balloon-expandable valves	TF	NA	The presence of CAD at baseline, with or without recent PCI, was related to poor 1-year outcomes in women receiving contemporary TAVR. In comparison to patients without CAD, women who underwent PCI within 30 days following TAVR had a higher 1-year risk of death and stroke.	Moderate
Matta *et al.* (2021)	Retrospective study	SE and balloon-expandable valves	TF	NA	This study offers immediate clinical significance that is helpful in everyday practice. Concomitant CAD and/or preoperative PCI have not been shown to have any deleterious effects on the length of the TAVI hospital stay.	Moderate
Kaihara *et al.* (2021)	Retrospective study	CoreValve and ES	TF	15.6% without complications	In patients with severe AS treated with TAVI, CAD with an LM or LAD proximal lesion is a potent independent predictor of mid-term major adverse cardiovascular and cerebrovascular events (MACCEs) and all-cause mortality. PCI performed prior to TAVI did not affect the results.	Moderate
Jeroudi *et al.* (2018)	Retrospective study	CoreValve	NA	NA	The majority of patients with pre-existing CoreValve TAVI can undergo coronary operations successfully. But after TAVI, selective engagement of the RCA ostium proved to be very challenging.	Moderate

Ferreira-Neto *et al.* (2019)	Retrospective study	Balloon-expandable ES or SAPIEN XT valve	TF and nontransfemoral	92.3	After TAVR, PCI is possible and can be done without significantly affecting the inserted transcatheter heart valves (THV).	High
Ghrair *et al.* (2020)	Retrospective study	NA	Transapical	NA	A greater incidence of in-hospital morbidity and mortality was linked to combined TAVR-PCI.	Moderate
Winter *et al.* (2021)	Prospective study	SE and balloon-expandable valves	NA	NA	In intermediate- and low-risk patients, full revascularization prior to TAVR implantation is a safe and practicable technique.	Moderate
Tran *et al.* (2022)	Retrospective study	NA	TF, transaxillary, transaortic, and transaortic	NA	In-hospital mortality rates were similar when PCI and TAVR were combined, but rates of acute renal injury were lower, and resource usage was lower.	Moderate
Abugroun, *et al.* (2020)	Retrospective study	NA	Transapical	NA	While there was no difference in the rate of stroke, TAVR and PCI procedures had greater rates of vascular injury, the requirement for pacemaker implantation, and expense while having lower rates of in-hospital mortality, acute renal injury, sepsis, and shorter lengths of stay.	Moderate

Characteristics of the included studies

Table 1 includes the sociodemographic characteristics. All of the included studies comprised patients with underlying CAD except four studies (Denimal *et al*., 2021; Kaihara *et al*., 2021; Matta *et al*., 2021; Tran *et al*., 2022). A total of 6252 patients were included. Five studies were conducted in the USA (Jeroudi *et al*., 2018; Guedeney *et al*., 2019; Abugroun *et al*., 2020; Ghrair *et al*., 2020; Tran *et al*., 2022), two in Switzerland (Winter *et al*., 2021; Perrin *et al*., 2022), two in France (Denimal *et al*., 2021; Matta *et al*., 2021), one in Japan (Kaihara *et al*., 2021), and one in Canada (Ferreira-Neto *et al*., 2019).

Table 2 presents the characteristics of the included studies. Nine studies are retrospective in nature (Ferreira-Neto *et al*., 2017; Jeroudi *et al*., 2018; Ghrair *et al*., 2020; Denimal *et al*., 2021; Kaihara *et al*., 2021; Matta *et al*., 2021; Perrin *et al*., 2022), and two are prospective studies (Guedeney *et al*., 2019; Winter *et al*., 2021). The SE, balloon-expandable, ES, and CoreValve are the most common valve types used in TAVI or TAVR. The transfemoral approach (TF) was the most common approach used. Only three studies reported a clear percentage of the success rate, which ranged from 92.3% (Ferreira-Neto *et al*., 2019) to 100% (Perrin *et al*., 2022). One study reported that 15.6% of cases demonstrated a success rate without any complications (Kaihara *et al*., 2021). The majority of the included studies reported that TAVI/ TAVR combined with the PCI technique is a safe and efficacious procedure for managing patients with AS. A high risk of mortality was reported in three studies (Guedeney *et al*., 2019; Ghrair *et al*., 2020; Tran *et al*., 2022). Complications such as stroke (Guedeney *et al*., 2019), vascular injury (Abugroun *et al*., 2020), and hospital morbidity (Ghrair *et al*., 2020) were recorded.

It is challenging to determine the best method to manage significant aortic stenosis with TAVI/ TAVR. This systematic review included a wide variety of populations undergoing PCI: AS patients with or without CAD, those who used TAVI or TAVR, variable procedure approaches, and numerous valve types. This carries a considerable heterogeneity between studies. Our review is also limited by its lack of a quantitative assessment. Moreover, most of the included studies lacked substantial data, such as the success rates of the applied procedures.

However, we found that the success rate of TAVI or TAVR combined with PCI ranged from 92.3% (Ferreira-Neto *et al*., 2019) to 100% (Perrin *et al*., 2022). The pooled periprocedural mortality reported in this review was comparable to the results from sizable, separate TAVI registries (Gilard *et al*., 2012; Thomas *et al*., 2012). Additionally, it contrasted favorably with the 9.7% perioperative mortality rate reported after concurrent CABG and SAVR. Concomitant SAVR and CABG, however, have shown to have very good long-term results even in octogenarians, with 1-, 2-, 3-, and 5-year survival rates of 83.2%, 78.8%, 72.9%, and 60.8%, respectively (Vasques *et al*., 2012).

According to the majority of the papers that were reviewed, managing patients with AS using TAVI/TAVR and the PCI approach is a safe and efficient procedure. These results were consistent with a previous systematic review conducted by Virk *et al.* (2015). The use of TAVR to treat severe AS in patients who are at high risk for surgery has expanded rapidly and universally over the past several years. Recent studies have also

demonstrated TAVR's superior results over SAVR in patients with low to moderate risk. We need to understand how to handle patients with concurrent CAD because TAVR is being increasingly used (Leon *et al*., 2016). TF-TAVI conducted on a small group of patients entirely under a PCI method has similar efficacy and safety to TF-TAVI performed in the presence of a full anesthetic care team. The PCI technique could be adopted for the majority of TF-TAVI treatments since it seems to be a safe and effective therapeutic pathway that offers an adequate and sensible usage of anaesthesiology resources (Denimal *et al*., 2021).

We also found a high mortality risk and complications such as stroke (Guedeney *et al*., 2019), vascular injury (Abugroun *et al*., 2020), and hospital morbidity (Ghrair *et al*., 2020; Jamal, 2022) among the target population. Temporary circulatory disturbances during balloon valvuloplasty or rapid ventricular pacing, embolism due to the separation of calcium deposits, and enhanced thrombogenicity brought on by tissue factor release are some of the reasons that may affect stroke and vascular damage in TAVR. There was no major stroke reported in other studies except by Matta *et al.* (2021), who used SE and balloon-expandable valves

Future studies should concentrate on selecting the most qualified people for pre-TAVI PCI, given the limitations of the existing literature. Quantifying the degree of CAD that indicates pre-TAVI intervention is especially important. To evaluate the relative advantages and dangers of a staged versus concurrent strategy to pre-TAVI PCI, additional research is also necessary. Concurrently performing these two operations in the same location allows for better resource use and the use of a shared artery, but these advantages may be outweighed by the long process and higher contrast burden. Additionally, more clinical data is needed in the case of a staged approach to establish the right interval between the two procedures, the kind of stents to use, and the best anti-platelet regimen. The cost-effectiveness and quality of life following combined PCI and TAVI procedures, both of which are emerging as crucial outcomes for actual clinical application, are currently not covered by any pertinent studies.

CONCLUSION

For patients with severe AS and with or without CAD, combined PCI before TAVI/ TAVR is a relatively safe and practical method, according to the available evidence on short- and mid-term results. However, to choose the best percutaneous treatment plans for individuals with severe AS and concurrent CAD, more randomized controlled trials are required.

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