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Mini Review

Description and Evolution of Alternative Access Route Options for Transcatheter Aortic Valve Implantation

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Abstract

This review describes the most common alternative access routes (i.e., direct aortic, transapical, transcarotid, transcaval, and transaxillary implantation techniques), their limitations, ergonomics, procedural results, and future perspectives in comparison to transfemoral (TF) transcatheter aortic valve implantation (TAVI).

Abbreviations

AKIN: Acute Kidney Injury Network; AS: Aortic Stenosis; LOS: Length of Stay; TA: Transapical; TAO: Transaortic/Direct Aortic; TAVI: Transcatheter Aortic Valve Implantation; TAX: Transaxillary; TC: Transcarotid; TCav: Transcaval; TF: Transfemoral; THV: Transcatheter Heart Valve; TAVR: Transcatheter Aortic Valve Replacement

Introduction

Over the last two decades, TAVI has emerged as a valuable treatment option (Class I, Level B) for patients with severe aortic stenosis (AS) who are at higher or moderate surgical risk for conventional aortic valve replacement with an age of ≥ 70 years [1]. Nowadays, the most frequently used access route is definitely the common femoral artery. But whenever the TF approach for TAVI or a surgical aortic valve replacement is not feasible, an alternative access route has to be considered (Class IIa LoE C) [1]. In recent years, the transapical (TA) approach has been largely displaced by other transvascular access routes, due to accumulating evidence that the TA approach is more likely associated with higher morbidity and mortality, when compared to transvascular access routes [2]. This observation is supported by a recent study comprising 129,821 patients of the national inpatient database (NID) of the United States (years 2011 to 2017), describing a rapid decline in TA utilization. After peaking in 2013 at 27.7%, the counts decreased to 1.92% in 2017, which was accompanied by higher inpatient mortality, increased length of stay, and higher costs in those patients with TA-TAVI [3]. Nevertheless, peripheral vascular disease is a common finding in patients who are candidates for TAVI [4]. For transvascular TAVI, sheath/introducer sizes range between 14F and 20F, depending on the valve size and the transcatheter heart valve (THV) delivery system. Thus, for most devices, a minimal vessel diameter of 5 to 6 mm is still required. In addition, in at least 10 to 15% of TAVI patients, a transfemoral (TF) approach seems not to be advisable due to significant peripheral artery disease or severe vessel tortuosity. Hence, the direct aortic (TAO), transcarotid (TC), transcaval (TCav), and transaxillary (TAX) implantation routes have been developed and applied to a broader extent over the last decade, but these alternative access routes are currently more frequently utilized in experienced high-volume centers [5-9].

Literature review

A focused literature search was conducted using PubMed to identify relevant publications addressing alternative access

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routes for transcatheter aortic valve implantation (TAVI). Publications from 2008 onward were considered. The search included the terms "TAVI," "TAVR," "transapical," "direct aortic," "transcaval," "transcarotid," and "transaxillary/transsubclavian." Relevant publications addressing the use, outcomes, and evolution of alternative TAVI access routes were considered. Publications unrelated to alternative TAVI access were excluded.

According to BiBa MedTech Research, the counts demonstrated a continuous rise between 2013 and 2025 for TF access utilization (in 2025: Europe 96%, Germany 94%; figure 1). Conversely, the largest decrease was found for the TA access route (in 2025: Europe 1%, Germany 3%) with similarly stable counts for the TAX access route (in 2025: Europe 2%, Germany 1%), TC/TCav access route (in 2025: Europe 1%, Germany 1%), whereas the TAO access route seems no longer to be utilized in Europe and Germany, respectively (Figure 1).

Until today, there is a great amount of variability in access utilization among various centers with regard to their first and second choice of access for TAVI. In some hospitals, the TAX approach is used in up to 20% of the cases [10]. Unfortunately, alternative TAVI approaches have not been studied comparatively, but available data suggest better outcomes for transvascular techniques compared to TA-TAVI (Table 1).

The studies summarized in Table 1 are heterogeneous with respect to study design, patient selection, sample size, study period, number of participating centers, endpoint definitions, and methods of outcome ascertainment. Therefore, the percentages presented should not be interpreted as directly comparable estimates of the relative safety or efficacy of the different access routes.

The various levels of invasiveness with corresponding outcomes vary between different access approaches and are derived from the available literature. But the choice of alternative access routes depends mainly on the experience and judgment of the heart team. Nevertheless, judgment of invasiveness varies among different investigators, albeit "central" access routes (e.g., TA and Tao) mandate intubation and ventilation, whereas other "peripheral" transvascular approaches allow for analgesia and/or local anesthesia only (Figure 2).

Moreover, practicability, ergonomics, and costs differ between various access approaches, which have been presented at several scientific meetings (Table 2).

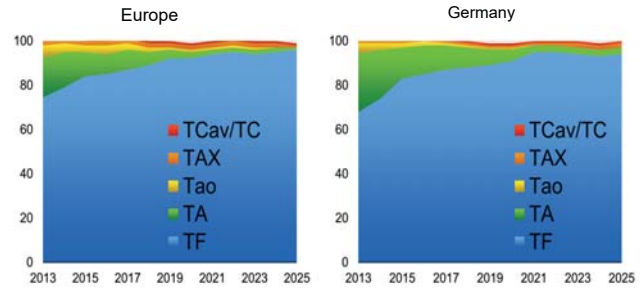


Figure 1: Europe and Germany

Table 1: Selected clinical and procedural outcomes reported in studies eveluating alternative access routes for transcatheter aortic valve implantion.

	Apical	Aortic	Axillar	Axillar (perc.)	Carotid	Caval
	Thourani 2015 [17]	Babat 2016 [16]	Petronio 2012 [10]	Schäfer 2010 [11], 2016 [12]	Mylotte 2016 [13]	Greenbaum 2017 [15]
N	4085	301	141	100	96	100
Centers	Many	18	10	2	3	17
STS	8.8 (5.8,13)	9.0 ± 7.6	no data	7.2±5.2	7.1 ± 4.2	9.6 ± 6.3
LOS - days	8.9 ± 6.4	9.9 ± 8.5	no data	7.9 ± 9.4	11 (9, 15)	4 (2, 6)
AKIN	38.8%	9.5%	4.3%	3 %	7.3%	3%
LT Bleeding	no data	3.4%	7.8%	0 %	4.2%	7%
Vascular comp (maj.)	<1%	3.4%	2.2%	1 %	4.2%	12%
30-day Stroke/TIA	2.4%	1.3%	2.1%	1 %	6.3%	5%
30-day Mortality	8.8%	6.1%	5.7%	6 % 8.4% vs. 4.9%*	6.3%	8%
Notes	Self-reported	>5 Cases before enrollment	Self-reported	Self-reported	No systematic imaging	Adjudicated Systematic CT

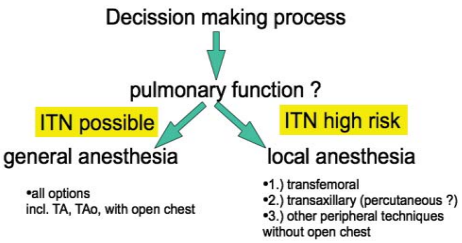


Figure 2: Original schematic illustrating considerations in selecting alternative TAVI access routes.

Table 2: Qualitative comparison of clinical, procedural, ergonomic, and cost-related characterstics of alternative transcatheter aortic valve implantation access routes.

	Apical	Aortic	Axillar	Carotid	Caval
Pain	Poor	Poor	Good	Good	Good
Bleeding	Poor	Fair	Good	Good	Poor
LOS	Poor	Poor	Good	Good	Fair
Outcomes	Poor	Good	Good	Good	Fair
Supportive Evidence	Good	Good	Good	Poor	Fair
TAVI Ergonomics	Poor	Poor	Fair	Poor	Fair
Procedure Complexity	Good	Fair	Fair	Fair	Poor
Costs	Low	Low	Low	Low	Fair

Last but not least, as previously mentioned, the various levels of invasiveness with corresponding outcomes significantly differ between the described access approaches and are derived from the available literature (Figure 3).

In summary, the frequencies of alternative access routes are significantly declining in recent years, but they still serve as an important supplement for those patients in whom the

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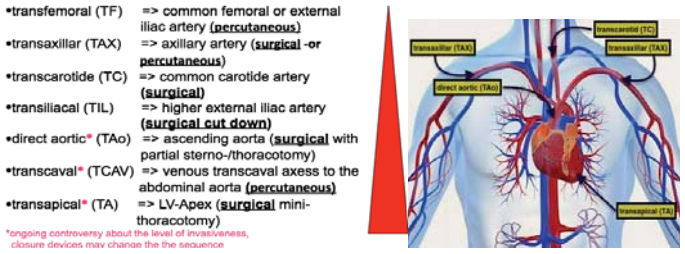


Figure 3: Schematic overview of the principal transcatheter aortic valve implantation access routes.

TF access route is not advisable. Each alternative access has advantages and disadvantages, so the access route should be tailored to the patients' characteristics and needs. However, there is no standardized algorithm for choosing the optimal alternative vascular access. In addition, the TA access seems to be limited to a very select subset of patients with no other options. Possibly TA-TAVI will be eliminated in the near future, since the industry is no longer pursuing sales in a significantly declining market.

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