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## Cardiovascular Revascularization Medicine



## Use of the left radial artery as vascular access for coronary angiography and as a bypass conduit: A clinical dilemma?

Eline H. Ploumen<sup>a,b,1</sup>, Frank R. Halfwerk<sup>c,d,1</sup>, Rachèl van der Kolk<sup>b</sup>, Jan G. Grandjean<sup>c,d</sup>, Clemens von Birgelen<sup>a,b,\*</sup>, Janine A. van Til<sup>b</sup><sup>a</sup> Department of Cardiology, Thoraxcentrum Twente, Medisch Spectrum Twente, P.O. Box 50 000, 7500 KA Enschede, the Netherlands<sup>b</sup> Department of Health Technology and Services Research, Faculty of Behavioural, Management and Social Sciences, Technical Medical Centre, University of Twente, P.O. Box 217, 7500 AE Enschede, the Netherlands<sup>c</sup> Department of Cardio-Thoracic Surgery, Thoraxcentrum Twente, Medisch Spectrum Twente, P.O. Box 50 000, 7500 KA Enschede, the Netherlands<sup>d</sup> Department of Biomechanical Engineering, Faculty of Engineering Technology, University of Twente, P.O. Box 217, 7500 AE Enschede, the Netherlands

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## ABSTRACT

**Purpose:** International coronary revascularization guidelines recommend both, transradial vascular access for coronary angiography/intervention and use of the radial artery as a conduit for coronary artery bypass grafting (CABG). These recommendations may pose a clinical dilemma, as transradial access exposes these arteries to vascular trauma which makes them potentially unsuitable as future grafts. In this study, we investigated the awareness and views of cardiologists on these guideline recommendations.

**Methods:** We performed semi-structured interviews with 50 cardiologists from 19 centers, who regularly perform coronary angiographies or interventions, and outlined clinical scenarios to evaluate their preference of vascular access. In addition, we assessed whether preference was related to sub-specialization.

**Results:** The interviewed cardiologists had  $16 \pm 9.3$  years of professional experience. There were 23 (46%) cardiologists from 7 centers without percutaneous coronary intervention facilities, and 27 (56%) cardiologists from 12 interventional centers. All 50 (100%) cardiologists indicated familiarity with the guidelines, yet 28 (56%) said not to be familiar with the aforementioned dilemma, and 9 (18%) stated there was no dilemma at all. Responses did not differ significantly between interventional ( $n = 28$ ) and non-interventional ( $n = 22$ ) cardiologists; however, if the right radial artery was unavailable (e.g., occluded), interventional cardiologists more often said to prefer access via the left radial artery (18/28 (64%) vs. 5/22 (23%),  $p = 0.001$ ).

**Conclusion:** More than half of the interviewed cardiologists indicated that they had not realized that left transradial access preceding CABG may preclude later use of this artery as a conduit. Notably, in case of unavailability of the right radial artery, interventional cardiologists preferred left transradial access more often than non-interventional cardiologists.

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## 1. Introduction

International guidelines for coronary revascularization recommend radial vascular access for coronary angiography and percutaneous coronary intervention (PCI) [1–3]. Studies have shown clear benefits of radial over femoral access, including a lower risk of mortality and major

bleeding [4–6]. The *right* radial artery is most commonly used for vascular access, as operators generally stand on the right-hand side of their patient. But *left* radial artery access may be required in case of challenging *right* radial artery anatomies, spasm or occlusion, or for left internal mammary artery (LIMA) graft visualization.

Nevertheless, the radial artery is also recommended to cardiothoracic surgeons for use as a conduit for coronary artery bypass grafting (CABG). As in some patients the use of bilateral internal mammary artery grafting has been associated with an increased risk of post-procedural complications [7,8], use of the radial artery – most often the *left* radial artery – is a suitable option. There is substantial variation between countries in radial artery use as a conduit for CABG: For example, between 2004 and 2014 the corresponding rates were 5% in the United States and 45% in Australia [9]. However, with recently published

**Abbreviations:** CABG, coronary artery bypass grafting; LIMA, left internal mammary artery; PCI, percutaneous coronary intervention.

\* Corresponding author at: Department of Cardiology, Thoraxcentrum Twente, Medisch Spectrum Twente, Koningsplein 1, 7512 KZ Enschede, the Netherlands.

**E-mail addresses:** [e.ploumen@mst.nl](mailto:e.ploumen@mst.nl) (E.H. Ploumen), [f.halfwerk@mst.nl](mailto:f.halfwerk@mst.nl) (F.R. Halfwerk), [j.grandjean@mst.nl](mailto:j.grandjean@mst.nl) (J.G. Grandjean), [c.vonbirgelen@mst.nl](mailto:c.vonbirgelen@mst.nl) (C. von Birgelen), [j.a.vantil@utwente.nl](mailto:j.a.vantil@utwente.nl) (J.A. van Til).

<sup>1</sup> Contributed equally.

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results showing excellent long-term outcomes after the use of radial artery bypass grafts [10–12], these arteries are likely to be more commonly used in the future.

Notably, the use of a radial artery as a bypass conduit is discouraged after recent coronary angiography through that vessel [1]. This is because transradial coronary procedures expose the artery to some degree of vascular trauma which may still be present after months [13–15] and may reduce bypass graft patency [16,17]. Consequently, a radial artery is less suitable (or even unsuitable) as a bypass conduit following a recent transradial procedure. Thus, the two options of using the radial artery interfere with each other. In a scenario in which both radial arteries have been used for vascular access and CABG is required at a later stage, a patient may lose the option of receiving a left radial artery bypass graft.

Yet, it is unknown: (1) how often a percutaneous intervention via the left radial approach precedes CABG; (2) how cardiologists deal with the problem of having multiple options for use of the radial artery that mutually exclude each other; and (3) to what extent cardiologists are aware of the most recent guidelines for myocardial revascularization. Therefore, we assessed in a database of our tertiary center for cardiac intervention the frequency of coronary angiography or PCI via left transradial approach followed by CABG. In addition, we performed semi-structured interviews with a total of 50 cardiologists to investigate their awareness of the outlined potential 'dilemma' and to evaluate their preference of vascular access in three outlined clinical scenarios.

## 2. Methods

### 2.1. Data analysis

A retrospective analysis was conducted on transradial vascular access for coronary angiography or PCI, and use of radial artery grafts for CABG, performed from 2008 to 2018 at a tertiary center for cardiac interventions (Thoraxcentrum Twente, Enschede, the Netherlands). First, all percutaneous coronary procedures (coronary angiography or PCI) with corresponding vascular access route, as well as all isolated CABG procedures, were extracted from clinical patient files. Second, a case-by-case review was conducted for all patients who received CABG after catheter-based left transradial procedures. In addition, we searched in clinical files for information about potential graft dysfunction during a period of 11 years (from January 1, 2008 to December 31, 2018).

### 2.2. Interview study

Furthermore, a prospective semi-structured interview study was performed. Cardiologists were approached by e-mail, telephone and during personal contact by two cardiologists of Thoraxcentrum Twente, Enschede, the Netherlands. Cardiologists were eligible if they regularly performed coronary angiographies. Semi-structured interviews were

performed with the participants between April and June 2019. Three clinical cases were outlined, investigating the cardiologist's preference of vascular access. Cases were designed to stimulate the cardiologist with increasing persuasiveness to consider preserving the left radial artery as a conduit for future CABG. All interviews were recorded and transcribed.

Cardiologists were informed that they would participate in an interview (for research purposes) on their preference regarding vascular access for coronary angiography or PCI. Nevertheless, they were not informed that the focus of this study was the use of the left radial artery. An informed consent was obtained from all participants, and the study was supervised by an expert in research methodology.

### 2.3. Statistical methods

For statistical analysis, participants were grouped by sub-specialization (i.e., interventional cardiologist versus non-interventional cardiologist). Statistical analysis was performed with SPSS 25.0 (SPSS Inc., Chicago, IL). Results were considered statistically significant at a p-value of 0.05. Continuous variables were presented as mean  $\pm$  standard deviation or median and interquartile range, depending on data distribution. All continuous variables were tested for normality with visual inspection of histograms and skewness and kurtosis measures. A Mann-Whitney *U* test was done for comparisons between groups. Categorical variables were presented as numbers with corresponding frequencies. Categorical variables were compared using chi-square or Fischer's exact test, as appropriate. In case of multiple testing, post hoc Holm–Bonferroni corrections were performed.

## 3. Results

### 3.1. Retrospective analysis

The retrospective data analysis showed an explicit change in the preferential route of vascular access after January 2016. While from January 2008 to December 2015 diagnostic and therapeutic coronary interventions were performed via transradial access in no more than 22% of all procedures, the transradial access rate was 78% from January 2016 to December 2018 ( $p < 0.001$ ). From 2008 to 2018, there was only one case in which transulnar vascular access was used. Table 1 presents data on procedures at Thoraxcentrum Twente that involved the radial artery for vascular access or as a conduit for CABG, showing frequencies for the various procedures that were performed during the entire study period, as well as separately for the periods from 2008 to 2015 and from 2016 to 2018.

Left transradial access prior to CABG increased from 0.3% in 2008–2015 to 2.4% in 2016–2018. Similarly, the frequency of bilateral transradial access prior to CABG increased from 0.2% in 2008–2015 to 1.4% in 2016–2018. Nine patients, who received a radial artery conduit during CABG, had prior transradial procedures through that vessel. One of these patients experienced radial graft dysfunction which resulted in a need for repeating CABG.

**Table 1**

Procedures involving the radial artery for vascular access or as a conduit for CABG at our tertiary center.

	2008–2018	2008–2015	2016–2018	p value
All percutaneous coronary procedures (angiography/PCI)	36,631	26,419	10,212	
Via transradial access	13,782 (37.6)	5773 (21.9)	8009 (78.4)	<0.001
Via left transradial access	1309 (3.6)	783 (3.0)	526 (5.2)	<0.001
All isolated CABG	5800	4320	1480	
Isolated CABG using a radial artery as conduit	2520 (43.4)	1817 (42.1)	703 (47.5)	<0.001
Isolated CABG after coronary angiography with known access route <sup>a</sup>	3161	2286	875	
Left transradial access prior to CABG (including bilateral access)	31 (1.0)	10 (0.3)	21 (2.4)	<0.001
Bilateral transradial access preceding CABG	18 (0.6)	6 (0.2)	12 (1.4)	<0.001
Use of radial artery as conduit after transradial access of this artery <sup>b</sup>	9 (0.3)	1 (0.04)	8 (0.9)	<0.001

Numbers are n (%). Abbreviations: CABG = coronary artery bypass grafting; PCI = percutaneous coronary intervention.

<sup>a</sup> Access route was unknown for patients who were referred for isolated CABG from a different hospital.

<sup>b</sup> From 2008 to 2015 1 left radial artery with prior transradial access was used as a conduit, from 2016 to 2018 7 left radial arteries and 1 right radial artery with prior transradial access were used as a conduit.

**Table 2**  
Characteristics of interviewed cardiologists.

	n = 50
Age, years	51 [41–58]
Experience as cardiologist, years	16 ± 9.3
Interventional cardiologist	28 (56)
Number of annual coronary procedures	300 [144–505]
Hospital type	
Academic	9 (18)
Tertiary with cardiac surgery	11 (22)
Secondary with PCI	7 (14)
Secondary with coronary angiography	23 (46)
Personal preference for radial access, %	90% [90–95]
Observed increase in radial access in past 5–10 years in own center	
Yes	39 (78)
No	4 (8)
Employed in current center for <5 years	7 (14)
Personal preference for catheter size	
4 French	3 (6)
5 French	14 (28)
6 French	29 (58)
Other <sup>a</sup>	4 (8)

Numbers are n (%), mean ± standard deviation, or median [interquartile range].

Abbreviations: PCI = percutaneous coronary intervention.

<sup>a</sup> Other includes “both”, “depending on patient characteristics” and “don't know”.

### 3.2. Interviews

A total of 72 cardiologists were approached, of whom 51 agreed to participate (response rate: 71%). One approached cardiologist did not perform coronary angiography and was excluded. Thus, semi-structured interviews were performed with 50 cardiologists from 19 centers: 6 centers only had facilities for diagnostic coronary angiography; 4 had PCI facilities; 5 had PCI and CABG facilities; and 4 were academic centers. Key characteristics of the interviewed cardiologists are presented in Table 2.

**Table 3**

Responses of interviewed cardiologists on preference for vascular access site and familiarity with guidelines on myocardial revascularization.

	Total group n = 50	Interventional cardiologists n = 28	Non-interventional cardiologists n = 22	p value
<i>Case 1: Preferred access route for PCI in a 60-year-old patient</i>				
Right radial artery	50 (100)	28 (100)	22 (100)	
<i>Case 2: Preferred access route for PCI in a 60-year-old patient except right radial artery</i>				
Preference of vascular access route				<0.001
Left radial artery	23 (46)	18 (64)	5 (23)	
Femoral artery	18 (36)	4 (14)	14 (64)	
Depends on patient preference or situational context	9 (18)	6 (21)	3 (14)	
<i>Case 3: Preferred access route in a 60-year-old patient with three vessel disease and previous CABG</i>				
Vascular access route				0.09
Left radial artery	29 (58)	18 (64)	11 (50)	
Femoral artery	18 (36)	7 (25)	11 (50)	
Depends on patient preference or situational context	3 (6)	3 (11)	0	
<i>Familiarity with 2018 ESC/EACTS guidelines on myocardial revascularization</i>				
Yes, familiar with guidelines	50 (100)	28 (100)	22 (100)	1.00
Yes, familiar with details on radial access and graft preference	22 (44)	13 (46)	9 (41)	0.70
Familiar with clinical dilemma in guidelines				0.89
Yes	13 (26)	8 (29)	5 (23)	
This is no dilemma	9 (18)	5 (18)	4 (18)	
Not familiar with this dilemma	28 (56)	15 (54)	13 (59)	
Estimated percentage of dilemma in own hospital (n = 32)	3% [0.5–5%]	3% [0–5%]	3% [0.5–5%]	0.48
Personal experience with problem	5 (10)	3 (11)	2 (9)	0.85
Change of vascular access after this interview				0.18
Yes	18 (36)	12 (43)	6 (27)	
No	27 (54)	12 (43)	15 (68)	
Unclear	5 (10)	4 (14)	1 (5)	

Numbers are n (%), or median [interquartile range]. Abbreviations: PCI = percutaneous coronary intervention; CABG = coronary artery bypass grafting; ESC = European Society of Cardiology; EACTS = European Association of Cardio-Thoracic Surgery.

### 3.3. Case 1: preferred vascular access route for PCI in 60-year-old patient

A clinical case was introduced of a relatively young patient who required PCI. Cardiologists were asked about their preference for vascular access. All cardiologists preferred using the right radial artery (100%). The main reasons for this choice were convenience of vascular access (82%) followed by a reduction in bleeding risk (Supplementary Table 1). None of the interviewed cardiologists mentioned quality of the left radial artery as a possible conduit for future CABG.

### 3.4. Case 2: preferred vascular access for PCI in 60-year-old patient with non-availability of the right radial artery

The second case narrowed the options for vascular access, as the right radial artery was (temporarily) unavailable in the same 60-year-old patient. Most cardiologists preferred the left radial artery (46%) over the femoral artery (36%). The most common motivation for preferring left transradial access was reduced bleeding risk, while the most common motivation for transfemoral access was technical setup of the catheterization laboratory (which rendered left radial access difficult). In 18% of all cardiologists, the patient's preference or the situational context determined their choice of vascular access (Table 3). Interventional cardiologists preferred left transradial access significantly more often than non-interventional cardiologists ( $p = 0.001$ ).

### 3.5. Case 3: preferred access route in 60-year-old patient with 3-vessel disease and previous CABG

The third case further closed in on considering to preserve the left radial artery for a potential future repeated CABG. A 60-year-old patient with 3-vessel disease and a previous CABG with LIMA on the left anterior descending artery and a saphenous vein graft was presented. The right radial artery was not accessible, and non-invasive myocardial perfusion imaging showed multiple reversible perfusion defects, indicating a reasonable likelihood of a potential need for repeating CABG. The majority of participants (58%) still chose the left radial access for coronary

angiography due to its convenience for visualizing the LIMA graft. A smaller proportion of the participants chose the femoral artery for vascular access because of convenient visualization of the grafts (36%). Only four cardiologists (8%) mentioned preserving the left radial artery as a possible conduit for CABG as reason for using the transfemoral approach, and none of the cardiologists mentioned transulnar vascular access as an alternative approach. In 6% of the participants, patient preference or situational context determined the preferred vascular access route (Table 3). There was no significant difference between interventional cardiologists and non-interventional cardiologists in choosing left radial access (64% vs. 50%,  $p = 0.09$ ). Participants who indicated at the very start of the interview to have a particularly strong preference (>90%) for the transradial approach were in this case more likely to choose left radial access as compared to all other participants (79% vs. 39%,  $p < 0.001$ ).

### 3.6. Familiarity with the current guidelines on myocardial revascularization

The last part of the interview reflected on familiarity with the current guidelines on myocardial revascularization. Cardiologists were asked about their knowledge of the 2018 ESC/EACTS guidelines [1], as they all worked in the Netherlands. All cardiologists indicated to be familiar with these guidelines, while 44% said to be familiar with all details about the recommended vascular access route and use of arterial grafts. A minority of cardiologists was familiar with the clinical dilemma of having multiple options for radial artery use that mutually exclude each other (26%), and another 18% felt that there was no dilemma at all. There was no difference between interventional or non-interventional cardiologists in their awareness of this dilemma (Table 3,  $p = 0.89$ ). While only 10% of all participants indicated that they had personal experience with this potential problem, 36% said that they would change their choice of vascular access following the study-interview in order to preserve the (left) radial artery for CABG in selected patients.

## 4. Discussion

### 4.1. Main findings

During study period from 2008 to 2018, transradial coronary procedures preceded use of this radial artery as a bypass conduit in no more than 9 (0.3%) of all 3161 patients, who underwent CABG at our center. With the current recommendation of transradial vascular access for percutaneous coronary procedures [1–3], this issue is likely to become more common. Indeed, 8 of these 9 patients were treated during the last 3 years of the entire period, and one of these 9 patients experienced radial graft dysfunction that required repeating CABG.

In the semi-structured interviews, all 50 interviewed cardiologists indicated that right transradial access was their first choice for coronary angiography or PCI. This choice was mainly based on a reduction in bleeding risk and greater convenience. If the right radial artery was not available for vascular access, most cardiologist preferred left transradial access. In absence of an accessible right radial artery, interventional-cardiologists showed a particular preference for use of the left radial artery, whereas non-interventional cardiologists more frequently chose transfemoral access. If the interviewed cardiologists had to perform a coronary angiography on a patient with previous CABG (including LIMA and vein grafts) and a high likelihood of requiring a repeated CABG, the majority of cardiologists still preferred using the left radial artery for vascular access.

When asked about familiarity with the guidelines, 44% of the cardiologists indicated to be familiar with all details of the recommended vascular access route and arterial grafts. But only one in four cardiologists said to have realized the conflicting guideline recommendations on radial artery use before the interview. Various factors may have contributed to this limited recall of information from the guidelines [18]. International cardiac societies may consider investing in easy delivery of

guideline information to practicing physicians and assessing the information transfer in surveys. After the interview, one in three cardiologists indicated (in specific cases) to be willing to use a vascular access site different from the left radial artery in order to preserve this vessel for potential use as a bypass conduit.

### 4.2. Previous research

Previous studies that investigated radial arteries following transradial coronary procedures observed severe functional and morphological vascular damage [19] that sometimes even deteriorated over time [20,21]. Catheter-induced morphological alterations such as intimal tears and medial dissections may cause intimal hyperplasia and adventitia inflammation that can lead to a reduction in radial artery lumen [17]. Two observational studies showed that such histological findings also translated into inferior clinical outcome, as they found radial artery graft patency was reduced following transradial catheterization [22,23].

A systematic review suggested that smaller catheter size, high dose heparin use, and shorter duration of post-procedural compression of the radial artery can decrease the risk of radial artery occlusion after cardiac catheterization [24]. However, it is unclear whether these factors also have an impact on later patency of radial artery grafts.

There is a growing body of evidence regarding the use of alternative access sites (other than the femoral artery), such as distal (dorsal) radial or ulnar access [25,26]. Although not yet broadly applied, these alternatives can be considered when trying to preserve the left radial artery as a possible bypass conduit while the traditional site for right transradial access is not available. There is extensive evidence showing the feasibility and safety of transulnar access, and recent meta-analyses investigating this approach have shown outcomes similar to transradial access [27,28]. Furthermore, a number of observational studies showed successful ipsilateral transulnar access in case of failed transradial attempts or unavailability of the radial artery, without reports of hand ischemia or other major vascular complications [29–31]. Distal (dorsal) radial access, performed by experienced operators, was also shown to be safe and feasible [26,32]. If the right wrist area is inaccessible, distal (dorsal) radial access may be considered as an alternative in order to avoid switching to the left arm.

### 4.3. Clinical implications

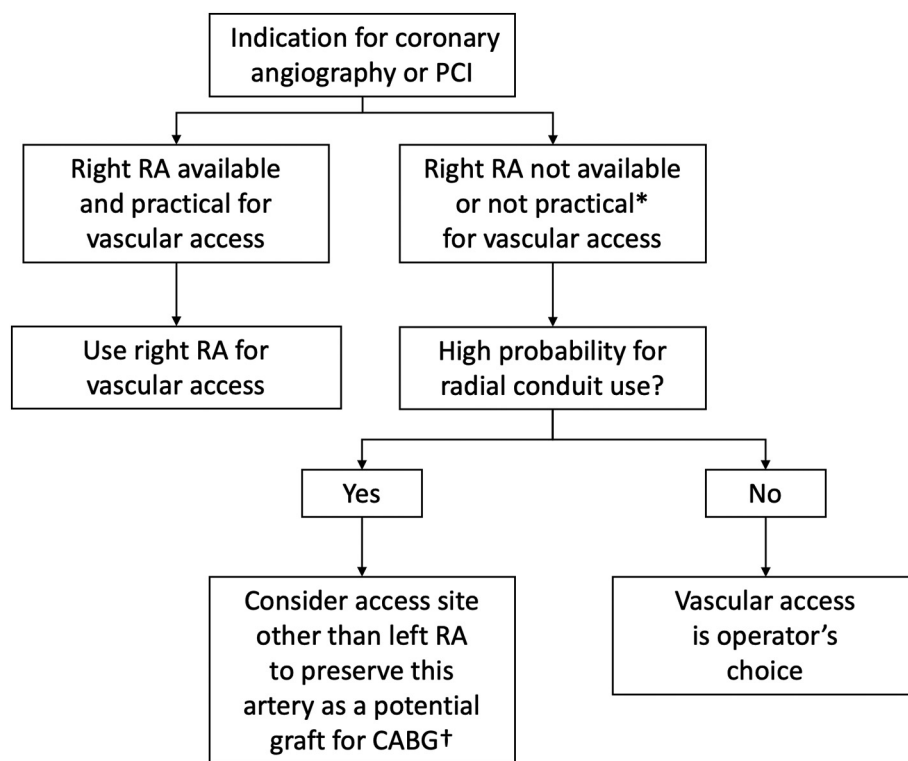
The available evidence suggests that the use of transradial vascular access for percutaneous coronary procedures may preclude future use of that vessel as a bypass graft. A recent expert opinion paper recommended to consider the use of the femoral instead of the radial artery for coronary angiography in patients who might be eligible for future CABG in centers that routinely use radial artery bypass grafts [33], while others suggested a reduction in catheter size [34]. This was also addressed in a 2016 scientific manuscript [19] which advised to weigh the benefits of the transradial approach against the risk of damaging the radial artery when choosing the access site for percutaneous coronary procedures. In Fig. 1, we offer a flowchart that suggests a practical approach that operators may consider for preserving the left radial artery as a bypass conduit when making their choice of vascular access.

Among the cardiologists who were interviewed in our study, awareness of this issue still appears to be limited. The common use of transradial access for percutaneous coronary procedures [35] and the current rise in using radial artery grafts for CABG [36] may more frequently result in conflicting use of the left radial artery. This, in turn, may reduce the patency of radial artery bypass grafts, which can lead to serious complications and inferior clinical outcomes.

### 4.4. Limitations

As a result of the study design, convenience sampling cannot be excluded. Nevertheless, while some interviewed cardiologists from





\*e.g. when LIMA needs to be visualized

†Consider transulnar, distal (dorsal) right radial, or transfemoral access, while keeping in mind bleeding risk, peripheral vascular disease, accessibility, and operator's experience

**Fig. 1.** Flowchart of considerations for vascular access for coronary angiography or PCI. Abbreviations: CABG = coronary artery bypass grafting; LIMA = left Internal mammary artery; PCI = percutaneous coronary intervention; RA = radial artery.

general hospitals refer patients to our center, other independent tertiary centers for cardiac interventions including academic hospitals are well-represented in this sample. Therefore, the potential bias for the total group may be limited. In the present series of interviews, the use of ulnar or distal (dorsal) right radial access were not offered as alternatives to traditional radial or femoral vascular access, while these approaches can be used to spare the left radial artery. Although the clinical cases reflect clinical practice, we cannot exclude that other cases might have given other results. These three cases are meant to create three levels of awareness for preserving the (left) radial artery and were framed to receive authentic answers for each case. Interviewing cardiothoracic surgeons might broaden the view on this issue and should be addressed by future studies. The clinical dilemma of multiple interfering uses of the radial artery is limited to centers that use the radial artery as a bypass conduit and to hospitals referring to these centers. Yet, the use of radial access for coronary angiography and PCI is currently considered as the primary approach, and utilization of the radial artery as a bypass conduit may soon increase due to the recently published favorable long-term results [10–12]. As a result, it may be expected that in the future cardiologists may face this issue increasingly often. Therefore, awareness of this issue and potential alternatives of vascular access is highly desirable.

## 5. Conclusion

More than half of the interviewed cardiologists indicated that they had not realized left transradial access preceding CABG may preclude later use of this artery as a conduit. Notably, in case of unavailability of the right radial artery, interventional cardiologists preferred left transradial access more often than non-interventional cardiologists.

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## CRediT authorship contribution statement

**Eline H. Ploumen:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Visualization. **Frank R. Halfwerk:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Visualization. **Rachèl van der Kolk:** Investigation, Formal analysis, Writing – review & editing, Visualization. **Jan G. Grandjean:** Conceptualization, Writing – review & editing, Supervision. **Clemens von Birgelen:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Janine A. van Til:** Conceptualization, Methodology, Writing – review & editing, Supervision.

## Declaration of competing interest

There was no conflict of interest related to the present study. Outside this research, Thoraxcentrum Twente has received institutional research grants from Abbott Vascular, Biotronik, Boston Scientific and Medtronic.

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