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ORIGINAL ARTICLE
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Transradial intervention in dialysis patients undergoing percutaneous coronary intervention: a Japanese nationwide registry study

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Aims Transradial intervention (TRI) for percutaneous coronary intervention (PCI) is used to reduce periprocedural complications. However, its effectiveness and safety for patients on dialysis are not well established. We aimed to investigate the association of TRI with in-hospital complications in dialysis patients undergoing PCI.

Methods and results We included 44 462 patients on dialysis who underwent PCI using Japanese nationwide PCI registry data (2019–21) regardless of acute or chronic coronary syndrome. Patients were categorized based on access site: TRI, transfemoral intervention (TFI). Periprocedural access site bleeding complication requiring transfusion was the primary outcome and in-hospital death, and other periprocedural complications were the secondary outcomes. Matched weighted analysis was performed for TRI and TFI. Here, 8267 (18.6%) underwent TRI, and 36 195 (81.4%) underwent TFI. Patients who received TRI were older and had lower rates of comorbidities than those who received TFI. Access site bleeding rate and in-hospital death were significantly lower in the TRI group (0.1% vs. 0.7%, $P < 0.001$; 1.8% vs. 3.2%, $P < 0.001$, respectively). After adjustment, TRI was associated with a lower risk of access site bleeding (odds ratio [OR] [95% confidence interval (CI)]: 0.19 [0.099–0.38]; $P < 0.001$) and in-hospital death (OR [95% CI]: 0.79 [0.65–0.96]; $P = 0.02$). Other periprocedural complications between TRI and TFI were not significantly different.

Conclusion In patients undergoing dialysis and PCI, TRI had a lower risk of access site bleeding and in-hospital death than TFI. This suggests that TRI may be safer for this patient population.

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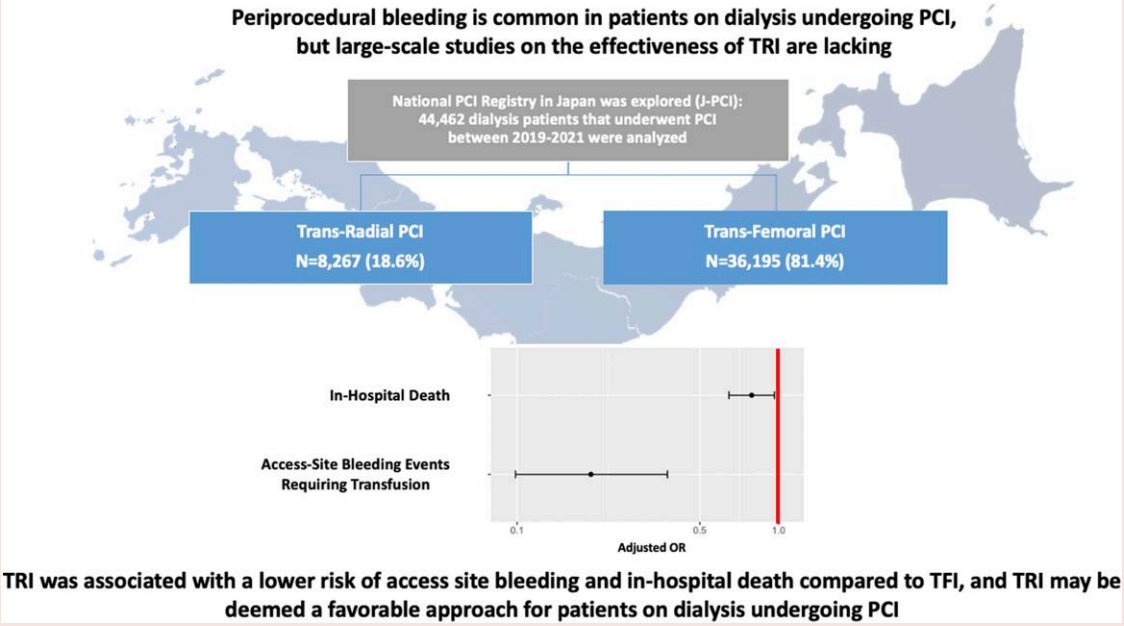
Graphical Abstract



Forest plots of adjusted odds ratios for in-hospital death and bleeding events. Bars represent confidence intervals of odds ratios. OR, odds ratio; PCI, percutaneous coronary intervention; TRI, transradial intervention.

Keywords Transradial intervention • Dialysis • Percutaneous coronary intervention • Periprocedural access site bleeding

Introduction

Coronary artery disease is highly prevalent in patients on dialysis, resulting in increased cases of percutaneous coronary intervention (PCI) in this population.[1,2] Due to continuous platelet activation, abnormalities in platelet–platelet and platelet–vessel wall interactions, as well as the complexity of coronary lesions, periprocedural bleeding is frequently encountered in PCI for patients on dialysis and is associated with long-term morbidity and mortality.[3–5] Using bleeding avoidance strategies, including transradial intervention (TRI), may be a valid approach for PCI in patients on dialysis, as previous studies have demonstrated a decreased risk of bleeding complications with TRI for non-dialysis patients.[3,6–8]

However, TRI has not been conventionally attempted in patients on dialysis due to concerns regarding increased risk of radial artery occlusion and need to preserve potential haemodialysis access points for future use, given the frequent patency failure for arteriovenous fistula.[9–11] Although Society for Cardiovascular Angiography & Interventions expert statement mentions that haemodialysis is a relative contraindication for TRI due to concerns about arteriovenous fistula failure, it also acknowledges that whether these concerns outweigh the benefits of TRI remains undetermined, indicating a knowledge gap regarding TRI in patients on dialysis.[10] Indeed, recent studies on TRI in patients on dialysis showed relatively low rates of radial artery occlusion[12] and potential benefits of TRI for patients with advanced chronic kidney disease.[13,14] However, the data for patients on dialysis are limited. This study aimed to investigate the associations of TRI and in-hospital access site bleeding and mortality in patients on dialysis using a large-scale Japanese nationwide PCI registry.

Methods

Data source

We extracted patient-level data from the Japanese Percutaneous Coronary Intervention (J-PCI) registry. The J-PCI is a prospective multicentre Japanese nationwide registry of PCI maintained by the Japanese Association of Cardiovascular Intervention and Therapeutics (CVIT).[11,15–17] Cardiac catheterization procedures are performed in publicly and privately funded hospitals in Japan. However, registration in the J-PCI registry is mandatory for the application for board certification and renewal under both systems; hence, data completion is high. Today, more than 200 000 PCI cases are registered annually from ∼900 facilities that account for more than 90% of PCI-performing hospitals in Japan. With regard to clinically relevant items, efforts are made to gather a variety of items based on the reproducibility and feasibility of data input. Designated data entry operators and data managers per institution can access the electronic data capturing website to register and edit case data. The accuracy of submitted data is validated by a data audit (20 sites per year) performed by members of the CVIT Registry Subcommittee. Moreover, a meeting of data managers is held annually to ensure appropriate data collection.

CVIT publicly advertises research proposals in the J-PCI registry annually. The study protocol of the J-PCI registry was approved by the Institutional Review Board Committee of the Network for Promotion of Clinical Studies [a specified non-profit organization affiliated with Osaka University Graduate School of Medicine (Osaka, Japan)] and complied with the principles contained within the Declaration of Helsinki. Written informed consent was waived because of the retrospective and observational nature of the study.

Study population

We analysed the data of patients registered in the J-PCI between January 2019 and December 2021 ($n = 734\,369$) for both acute and chronic

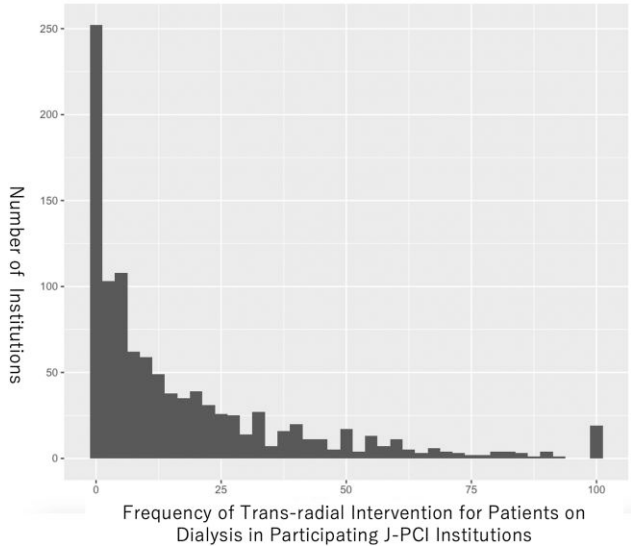


Figure 1 Histogram of the transradial intervention proportion in each institution.

coronary syndrome, resulting in a total study population of 44 462 patients on dialysis (haemodialysis or peritoneal dialysis) after excluding patients not on dialysis ($n = 681\,730$) and other access sites (i.e. brachial artery) ($n = 8177$). Among the patients on dialysis, TRI was performed in 8267 patients, transfemoral intervention (TFI) in 36 195 patients.

Definition of variables

PCI via the radial artery was defined as TRI, whereas PCI via the femoral artery was defined as TFI. According to the J-PCI protocol, patients with non-ST-segment elevation acute coronary syndrome included those with non-ST-segment elevation myocardial infarction and unstable angina. Meanwhile, patients with stable ischaemic heart disease included those with stable angina, old myocardial infarction, and silent ischaemia. Cardiogenic shock was defined as a sustained episode of systolic blood pressure < 80 mmHg, cardiac index < 1.8 L/min/m^2 determined to be secondary to cardiac dysfunction, and/or the requirement for a parenteral inotropic or vasopressor agent or mechanical support, including an intra-aortic balloon pump, to maintain blood pressure and cardiac index above the specified levels within 24 h before the PCI procedure. Acute heart failure was defined as symptoms of heart failure within 24 h before the PCI procedure, including dyspnoea on mild activity, orthopnoea, body fluid retention, moist rales, neck vein distention, and pulmonary oedema. These are equivalent to congestive heart failure of the New York Heart Association functional classification class IV. Successful PCI was defined as achieving Thrombolysis in Myocardial Infarction flow grade III with residual stenosis ≤ 25% in the target lesion.

Clinical outcomes

The primary outcome was bleeding requiring blood transfusion due to access site. The secondary outcomes were in-hospital death and other periprocedural complications. In-hospital death was defined as the rate of death before hospital discharge or within 30 days after PCI, in case of excessive hospitalization over 30 days after PCI. Periprocedural complications included cardiac tamponade, cardiogenic shock requiring mechanical and/or inotropic support, stent thrombosis ('definite' in the definition of the Academic Research Consortium),[18] emergent surgery, and bleeding requiring blood transfusion due to non-access site.

Statistical analysis

Continuous variables are presented as mean ± standard deviation and were compared using Student's *t*-test or analysis of variance. Categorical variables are presented as frequencies and percentages and were compared using χ^2 test.

A propensity score analysis was performed to adjust for the difference in baseline characteristics and pre-procedural conditions between those with TRI or TFI. Covariates to create a propensity score were selected based on clinical relevance,[15,19,20] including the following variables: age, sex, hypertension, diabetes, hyperlipidaemia, smoking status, chronic lung disease, peripheral arterial disease, history of PCI, history of myocardial infarction, history of heart failure, clinical presentation [acute coronary syndrome (ACS) vs. stable ischaemic heart disease], cardiac arrest, cardiogenic shock, acute heart failure, pre-procedural haemoglobin, number of diseased vessels, use of potent P2Y12 inhibitors, use of pre-procedural oral anticoagulant, use of debulking device (rotational atherectomy or orbital atherectomy), mechanical circulatory support, and arterial access site (femoral vs. radial). Then, we performed a matching weighted analysis to estimate the effect of TRI vs. TFI using odds ratios (ORs) with 95% confidence intervals (CIs).[21] Standardized mean difference was used to assess the balance of the two groups.

As a sensitivity analysis, multivariable logistic regression model was also created to assess the effect of TRI vs. TFI. Covariates were similar to the matching weight analysis. We also performed subgroup analyses for TRI vs. TFI; patients with ACS or those without, patients with mechanical circulatory support or those without, and patients with debulking device (rotational or orbital atherectomy) or those without.

A *P* value of <0.05 was considered statistically significant. Statistical analyses were performed using R version 4.2.3 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Among the 44 462 patients undergoing PCI for patients on dialysis, TRI was performed in 8267 (18.6%) patients while TFI was performed in 36 195 (81.4%) patients. The percentages of TRI in each institution ($N = 1051$) are shown in *Figure 1*. Median proportion of TRI was 8.7% in the whole cohort. Notably, 75% of the institutions adopted TRI with <25%. Baseline characteristics of patients who underwent PCI with TRI vs. TFI are shown in *Table 1*. Compared to TFI, patients with TRI were older and likely to be male, with comorbidities, such as diabetes mellitus and peripheral artery disease, as well as prior revascularization, cardiopulmonary arrest, and cardiogenic shock (*Table 1*). *Table 2* shows in-hospital complications, demonstrating lower rates

Table 1 Baseline characteristics of patients on dialysis who underwent transfemoral or transradial percutaneous coronary intervention

Variable	Number of missing values (%)	Transfemoral intervention (*n* = 36 195)	Transradial intervention (*n* = 8267)	*P* value
Age, y	0 (0.0%)	69.9 ± 10.4	70.4 ± 10.6	<0.001
Male	0 (0.0%)	27 993 (77.3%)	6666 (80.6%)	<0.001
History				
Hypertension	0 (0.0%)	30 001 (82.9%)	6760 (81.8%)	0.02
Diabetes	0 (0.0%)	24 582 (67.9%)	5362 (64.9%)	<0.001
Hyperlipidaemia	0 (0.0%)	20 264 (56.0%)	4435 (53.6%)	<0.001
Current/recent smoker (within 1 y)	0 (0.0%)	8785 (24.3%)	1922 (23.2%)	0.052
Chronic lung disease	0 (0.0%)	944 (2.6%)	272 (3.3%)	<0.001
Peripheral arterial disease	0 (0.0%)	9171 (25.3%)	1711 (20.7%)	<0.001
Prior PCI	398 (0.9%)	22 329 (61.9%)	4625 (57.7%)	<0.001
Prior CABG	421 (0.9%)	3389 (9.4%)	468 (5.8%)	<0.001
Prior myocardial infarction	752 (1.7%)	9096 (25.5%)	1736 (21.8%)	<0.001
Prior heart failure	768 (1.7%)	11 558 (32.3%)	2384 (30.0%)	<0.001
Pre-procedural haemoglobin (g/dL)	8419 (18.9%)	11.3 ± 1.8	11.3 ± 1.9	0.007
Pre-procedural characteristics				
Elective PCI	0 (0.0%)	29 595 (81.8%)	7015 (84.9%)	<0.001
Cardiac arrest within 24 h	444 (1.0%)	799 (2.2%)	78 (1.0%)	<0.001
Cardiogenic shock within 24 h	455 (1.0%)	1386 (3.8%)	141 (1.8%)	<0.001
Acute heart failure within 24 h	471 (1.1%)	1657 (4.6%)	263 (3.3%)	<0.001
Presentation	582 (1.3%)			<0.001
STEMI		2411 (6.7%)	415 (5.1%)	
NSTEMI		1947 (5.4%)	371 (4.6%)	
Unstable angina		5529 (15.5%)	1257 (15.4%)	
Stable angina		12 912 (36.1%)	3601 (44.2%)	
Prior myocardial infarction		1576 (4.4%)	260 (3.2%)	
Silent ischaemia		8198 (22.9%)	1599 (19.6%)	
Staged PCI		2729 (7.6%)	574 (7.0%)	
Others		431 (1.2%)	70 (0.9%)	
Number of diseased vessels	0 (0.0%)			<0.001
One-vessel		20 395 (56.3%)	5103 (61.7%)	
Two-vessel		9073 (25.1%)	1953 (23.6%)	
Three-vessel		4769 (13.2%)	896 (10.8%)	
Left main		1958 (5.4%)	315 (3.8%)	
Pre-procedural Potent P2Y12 inhibitors (ticagrelor or prasugrel)	0 (0.0%)	14 325 (39.6%)	3336 (40.4%)	0.2
Pre-procedural anticoagulant	0 (0.0%)	2145 (5.9%)	420 (5.1%)	0.003
Procedural characteristics				
Sheath size	30 216 (68.0%)			<0.001
3 Fr		1 (0.009%)	0 (0%)	
4 Fr		108 (0.9%)	56 (2.1%)	
5 Fr		285 (2.5%)	386 (14.1%)	
6 Fr		5594 (48.6%)	1813 (66.4%)	
7 Fr		4672 (40.6%)	414 (15.2%)	
8 Fr		798 (6.9%)	12 (0.4%)	
>8 Fr		31 (0.3%)	9 (0.3%)	
Sheathless		27 (0.2%)	40 (1.5%)	
Type of device used				
Bare-metal stent	0 (0.0%)	113 (0.3%)	24 (0.3%)	0.83
Drug-eluting stent	0 (0.0%)	25 432 (70.3%)	6259 (75.7%)	<0.001
Drug-coated balloon	0 (0.0%)	10 931 (30.2%)	2072 (25.1%)	<0.001

Continued

Table 1 *Continued*

Variable	Number of missing values (%)	Transfemoral intervention (*n* = 36 195)	Transradial intervention (*n* = 8267)	*P* value
Thrombus aspiration	0 (0.0%)	1114 (3.1%)	218 (2.6%)	0.04
Filter-based distal protection	0 (0.0%)	268 (0.7%)	84 (1.0%)	0.01
Rotational atherectomy	0 (0.0%)	5778 (16.0%)	683 (8.3%)	<0.001
Directional coronary atherectomy	0 (0.0%)	227 (0.6%)	7 (0.08%)	<0.001
Orbital atherectomy	0 (0.0%)	1337 (3.7%)	208 (2.5%)	<0.001
Excimer Laser Coronary Atherectomy	0 (0.0%)	102 (0.3%)	15 (0.2%)	0.14
PCI unsuccess	0 (0.0%)	1769 (4.9%)	279 (3.4%)	<0.001
Procedure time, min	14 796 (33.3%)	122.3 ± 65.0	98.3 ± 54.5	<0.001
Contrast volume, mL	10 844 (24.4%)	146.6 ± 73.1	137.1 ± 71.7	<0.001
Fluoroscopy time, min	4129 (9.3%)	37.2 ± 28.7	32.0 ± 29.4	<0.001
Mechanical circulatory support				
Intra-aortic balloon pump	0 (0.0%)	1461 (4.0%)	161 (1.9%)	<0.001
VA-ECMO	0 (0.0%)	320 (0.9%)	45 (0.5%)	0.003
Impella	0 (0.0%)	84 (0.2%)	11 (0.1%)	0.1

Data are expressed as mean (standard deviation) or *n*/*N* (%) of patients.
CABG, coronary artery bypass grafting; NSTEMI, non ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction; VA-ECMO, veno-arterial extracorporeal membrane oxygenation.

Table 2 **Incidence of in-hospital complications**

	Transfemoral intervention (*n* = 36 195)	Transradial intervention (*n* = 8267)	*P* value
Bleeding requiring blood transfusion due to access site	268 (0.7%)	11 (0.1%)	<0.001
In-hospital death	1160 (3.2%)	149 (1.8%)	<0.001
Myocardial infarction	271 (0.7%)	47 (0.6%)	0.09
Cardiac tamponade	64 (0.2%)	12 (0.1%)	0.63
Shock requiring mechanical and/or inotropic support	410 (1.1%)	56 (0.7%)	<0.001
Stent thrombosis	24 (0.07%)	6 (0.07%)	1
Requirement for emergency surgery	47 (0.1%)	7 (0.08%)	0.37
Bleeding requiring blood transfusion due to non-access site	99 (0.3%)	10 (0.1%)	0.02
Other complications	331 (0.9%)	49 (0.6%)	0.005

Data are expressed as no. (%) of patients.

of access site bleeding requiring blood transfusion (0.1% vs. 0.7%, $P < 0.001$) and in-hospital death (1.8% vs. 3.2%, $P < 0.001$) in TRI than those in TFI. Other periprocedural complications are shown in *Table 2*. Among patients who had sheath sizes (obtained only in 2021 in this registry), the proportions of access site bleeding requiring blood transfusion in TFI and TRI sites are shown in *Figure 2*, demonstrating higher rates of bleeding in each comparison with the same sheath size.

Using matching weighted analysis, baseline characteristics were well balanced with standardized mean difference < 0.10 (see Supplementary material online, *Table S1*). Transradial intervention was associated with a lower rate of access site bleeding requiring blood transfusion (OR [95% CI]: 0.19 [0.099–0.38]; $P < 0.001$), as well as in-hospital death (OR [95% CI]: 0.79 [0.65–0.96]; $P = 0.02$) (*Table 3*). A multivariable logistic regression analysis also showed similar results (*Table 3*).

Subgroup analyses of ACS or non-ACS, use of mechanical circulatory support or no use of mechanical support, and use of debulking device or no use of debulking device were performed (*Table 3*). The primary outcome was significantly improved after TRI in non-ACS, as well as no use of mechanical circulatory support or debulking device. Moreover, this was apparent in ACS cases after matching weighted analyses as well as multivariable logistic regression analyses.

Discussion

The present study demonstrated that TRI may have significant advantages in reducing in-hospital bleeding complications related to access site and in-hospital mortality in patients on dialysis undergoing PCI (*Graphical Abstract*). Moreover, TRI may be a preferred approach in these patients to improve patient outcomes. Our findings are particularly meaningful as there are limited data available on the effects of TRI in patients on dialysis undergoing PCI, especially within large-scale registry studies.

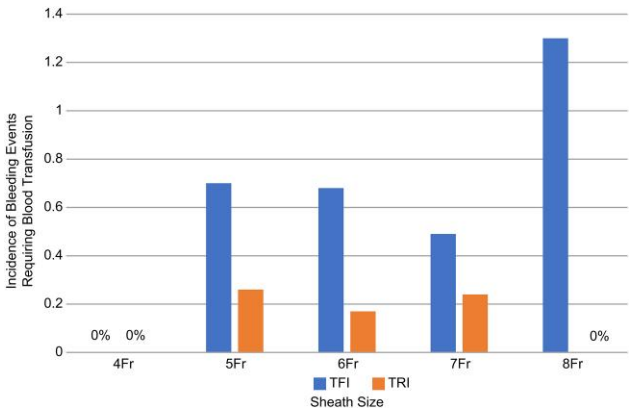


Figure 2 Bleeding complication requiring blood transfusion due to access site in each sheath size; TFI and TRI (bar graph). TFI, transfemoral intervention; TRI, transradial intervention.

Table 3 Adjusted odds ratios for in-hospital complications (transradial vs. transfemoral)

	Matching weight		Logistic regression	
	Odds ratio (confidential interval)	*P* value	Odds ratio (confidential interval)	*P* value
All cohort (*N* = 44 462)				
Bleeding requiring blood transfusion due to access site	0.19 (0.099–0.38)	<0.001	0.19 (0.098–0.37)	<0.001
In-hospital death	0.79 (0.65–0.96)	0.02	0.73 (0.59–0.91)	0.005
Post-PCI myocardial infarction	0.75 (0.52–1.07)	0.11	0.745 (0.52–1.07)	0.11
Cardiac tamponade	1.04 (0.54–2.02)	0.9	0.99 (0.51–1.93)	0.98
Shock requiring mechanical and/or inotropic support	1.02 (0.74–1.39)	0.92	0.99 (0.721–1.37)	0.97
Stent thrombosis	1.23 (0.46–3.33)	0.68	1.28 (0.47–3.50)	0.63
Requirement for emergency surgery	1.07 (0.47–2.43)	0.86	1.09 (0.48–2.48)	0.84
Bleeding requiring blood transfusion due to non-access site	0.63 (0.31–1.27)	0.19	0.58 (0.29–1.18)	0.13
Other complications	0.76 (0.55–1.05)	0.1	0.77 (0.56–1.07)	0.12
ACS (*N* = 11 875)				
Bleeding requiring blood transfusion due to access site	0.32 (0.13–0.80)	0.01	0.33 (0.13–0.81)	0.02
In-hospital death	0.86 (0.65–1.05)	0.12	0.77 (0.59–1.000)	0.0499
Non-ACS (*N* = 32 004)				
Bleeding requiring blood transfusion due to access site	0.13 (0.047–0.35)	<0.001	0.13 (0.046–0.34)	<0.001
In-hospital death	0.73 (0.51–1.06)	0.10	0.69 (0.47–1.01)	0.06
MCS (*N* = 1946)				
Bleeding requiring blood transfusion due to access site	0.78 (0.23–2.64)	0.70	0.70 (0.20–2.40)	0.56
In-hospital death	1.00 (0.69–1.43)	0.98	1.02 (0.69–1.52)	0.92
Non-MCS (*N* = 42 516)				
Bleeding requiring blood transfusion due to access site	0.14 (0.061–0.31)	<0.001	0.14 (0.061–0.31)	<0.001
In-hospital death	0.69 (0.53–0.89)	0.005	0.66 (0.51–0.86)	0.002
Debulking device (*N* = 7436)				
Bleeding requiring blood transfusion due to access site	0.80 (0.28–2.23)	0.66	0.69 (0.24–1.98)	0.49
In-hospital death	0.57 (0.27–1.24)	0.16	0.51 (0.22–1.15)	0.11
Non-debulking device (*N* = 36 756)				
Bleeding requiring blood transfusion due to access site	0.12 (0.049–0.29)	<0.001	0.12 (0.049–0.29)	<0.001
In-hospital death	0.81 (0.66–1.00)	0.0496	0.76 (0.60–0.95)	0.02

ACS, acute coronary syndrome; MCS, mechanical circulatory support.

The number of patients on dialysis undergoing PCI is increasing but they have higher risks of bleeding and in-hospital death than non-dialysis patients.[2,11] Despite beneficial data on TRI for patients with advanced kidney disease,[14] the data of TRI on dialysis patients are quite limited. There may be hesitancy among PCI operators to choose TRI for patients on dialysis to preserve the radial artery for future arteriovenous fistula use, leading to underutilization of TRI in this population.[9] Although prognostic data on patients on dialysis undergoing PCI via radial artery are limited, our findings of TRI for these patients (with a 15% adaption rate) are valuable since we demonstrate that TRI is performed safely in most of these patients and is associated with overall better in-hospital outcomes compared to patients with TFI after rigorous statistical adjustment. This may reassure PCI operators about the safety of TRI and promote its more frequent use in these patients. The main reason for avoiding TRI in patients on dialysis, which is the preservation of the additional access point for possible future haemodialysis, remains controversial, as overall survival rates for patients on dialysis are highly variable.[13,14] Moreover, the increasing use of various devices, such as cutting balloons, drug-coated balloons, or stent grafts, may improve arteriovenous fistula patency and decrease the risk of radial artery occlusion.[22–25] Considering all these, adapting TRI in these patients may be a reasonable approach to decrease the risk of periprocedural bleeding.

Despite the potential benefits of using TRI in patients on dialysis, real-world implementation of TRI in this population remains challenging. Shouwen *et al.*[26] summarized the advantages and disadvantages of TRI for patients on dialysis as follows: (i) using TRI for patients on dialysis is not conventionally recommended; (ii) however, the potential benefit of TRI should be evaluated on a case-by-case basis (such as for cases with high bleeding risk or too small forearm veins for future creation of arteriovenous fistula); (iii) TRI should be considered only on the contralateral side of arteriovenous fistula; (iv) transbrachial approach may be associated with a higher risk than TRI; and (v) when radial artery occlusion occurs, the proximal radial artery can be used if it is patent.[27] Consequently, current consensus documents weakly recommend access site preservation for future arteriovenous fistula creation and avoidance of TRI in patients on dialysis,[10,28] with reported rates ranging from 1% to 10% in contemporary observational studies.[29–35] This wide range of reported events is due to various factors, including patient characteristics and sheath size requirements.[29,36] Arterial intimal thickening in patients on dialysis can also induce arterial tears, which may lead to a higher rate of radial artery occlusion.[37–39] Decreasing radial artery occlusion rates in patients on dialysis undergoing PCI should be prioritized to further improve their outcomes. This can be achieved by implementing patent haemostasis techniques, reducing compression time, and considering ulnar artery compression.[32–34,40,41] Hospitals performing PCI via radial artery for patients on dialysis should develop protocols that include a pathway to achieve optimal patent haemostasis and compression time to minimize the rate of radial artery occlusion.

This study had several limitations. First, this was an observational clinical trial and not a randomized trial. Using TRI depended on the operator's decision. We could not eliminate all confounding factors or selection bias despite rigorous adjustment. So far, there are no randomized data to reveal the benefit of TRI in patients with dialysis because clinical trials addressing the benefit of TRI excluded patients with dialysis.[42] Second, we only evaluated in-hospital or 30-day short-term outcomes. Long-term outcomes for patients with dialysis who underwent PCI via radial artery are warranted. Third, we did not have data on radial artery occlusion or hand ischaemia. Fourth, most of the patients did not have information on sheath size in the total cohort, resulting in that we could not include the information on sheath size in the variables for adjustment, However, sheath size may not affect vascular complications in TRI while sheath size affects vascular complications in TFI; we did not have information on closure device and the right or left side of TRI or failure of attempt or cross over from TRI to TFI as well as the location of arteriovenous fistula.[43,44] Moreover, at the time of our study, we did not have information regarding the distal radial approach, which is emerging as a popular method to reduce bleeding complications during PCI. This may be a viable option for patients on dialysis due to its lower incidence of radial artery occlusion compared to the conventional radial artery approach. Previous studies have demonstrated promising outcomes in complex PCIs, and more research is needed to validate its effectiveness.[45–48] Fifth, we did not have information on post-procedural haemoglobin or bleeding outcomes defined as Bleeding Academic Research Consortium criteria.[49] Sixth, bivalirudin is not available in Japan, which eventually mandates operators to use periprocedural heparin with active clotting time as 250–350 s.[50,51] Seventh, we could not differentiate bleeding from PCI access sites (TRI or TFI) or access sites for mechanical circulatory support; however, the subgroup analysis without mechanical circulatory support showed the robustness of our study. Eighth, we do not have the information of haemodialysis or peritoneal dialysis, which could affect the decision on whether to perform TRI. Finally, we do not have the detailed information on the interruption of the antiplatelet treatment due to bleeding events.

In conclusion, our study demonstrates that TRI was performed in 15% of the patients on dialysis undergoing PCI and was associated with a lower risk of access site bleeding and in-hospital death than TFI. These findings suggest that TRI may be a safer approach in this patient population, when feasible. However, due to potential residual confounders despite rigorous adjustments, our results should be cautiously interpreted. Further randomized controlled trials investigating TRI vs. TFI in patients on dialysis are warranted to confirm our findings and provide more robust evidence.

Lead author biography

Dr Toshiki Kuno is a cardiology fellow at Montefiore Medical Center, Albert Einstein College of Medicine in NY, and a future interventional cardiology fellow at Massachusetts General Hospital starting in 2024. He obtained an MD and a PhD from Keio University School of Medicine and worked as an attending interventional cardiologist in Japan. He moved to the USA in 2018 to broaden his clinical and research skills. His clinical and research interests focus on the field of interventional cardiology. He has been a FESC since 2019.

Data availability

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Supplementary material

Supplementary material is available at *European Heart Journal Open* online.

Disclosure statement

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