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Transradial Approach for Coronary Angiography and Interventions

Results of the First International Transradial Practice Survey

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Objectives The aim of this study was to evaluate practice of transradial approach (TRA).

Background TRA has been adopted as an alternative access site for coronary procedures.

Methods A questionnaire was distributed worldwide with Internet-based software.

Results The survey was conducted from August 2009 to January 2010 among 1,107 interventional cardiologists in 75 countries. Although pre-TRA dual hand circulation testing is not uniform in the world, >85% in the U.S. perform Allen or oximetry testing. Right radial artery is used in almost 90%. Judkins catheters are the most popular for left coronary artery angiographies (66.5%) and right coronary artery angiographies (58.8%). For percutaneous coronary intervention (PCI), 6-F is now standard. For PCI of left coronary artery, operators use standard extra back-up guiding catheters in >65% and, for right coronary artery 70.4% use right Judkins catheters. Although heparin remains the routine antithrombotic agent in the world, bivalirudin is frequently used in the U.S. for PCI. The incidence of radial artery occlusion before hospital discharge is not assessed in >50%. Overall, approximately 50% responded that their TRA practice will increase in the future (68.4% in the U.S.).

Conclusions TRA is already widely used across the world. Diagnostic and guiding-catheters used for TRA remain similar to those used for traditional femoral approach, suggesting that specialized radial catheters are not frequently used. However, there is substantial variation in practice as it relates to specific aspects of TRA, suggesting that more data are needed to determine the optimal strategy to facilitate TRA and optimize radial artery patency after catheterization. (J Am Coll Cardiol Intv 2010;3:1022–31) © 2010 by the American College of Cardiology Foundation

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Although the first percutaneous transradial approach (TRA) for diagnostic coronary angiography was described by Dr. Lucien Campeau in 1989 and for intervention by Dr. Ferdinand Kiemeneij in 1993, its practice has remained somewhat limited to countries outside the U.S. (1–3). Until recently, it remained vigorously promoted by a dedicated group of operators and disregarded by a large number of operators traditionally trained in the femoral approach (FA) (4,5).

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The direct impact of peri-procedural bleeding and access-site complications on outcomes and costs to health systems has initiated an increasing awareness of the potential benefits for TRA as a default technique instead of the FA (6–9). Even in the U.S., a recent study has found a significant increase in the use of TRA for percutaneous coronary interventions (PCI); however, its use remains low (<5%) (10).

There currently are no data on the worldwide penetration of TRA and its associated strategies, such as choice of right or left radial artery, diagnostic and interventional guide catheters, selection of antithrombotic therapy, and so forth. Because the practice of TRA will likely continue to increase in the coming years, we thought to evaluate its practice around the world. With an Internet-based questionnaire, we surveyed interventional cardiologists to better understand their TRA practice regarding patient selection, technical aspects for diagnostic use and interventions, antithrombotic regimens, access-site management, and hospital discharge.

Methods

We designed a dedicated questionnaire including 39 questions covering: 1) respondent characteristics; 2) patient selection; 3) technical aspects of access site puncture and hemostasis; 4) technical aspects of diagnostic angiography and interventions; 5) antithrombotic regimens used in elective PCI and acute coronary syndrome (ACS) cases; 6) radial artery occlusion (RAO) after PCI; and 7) hospital discharge after PCI.

We used Internet-based software (SurveyMonkey, Menlo Park, California) to carry out our survey. To ensure that questions were easy to understand and covered the majority of TRA-related topics and that the survey could be completed in approximately 10 min, we sent the survey first to a group of 15 selected interventional cardiologists with extensive experience with TRA. Minor corrections were applied, and the survey was officially launched on the Internet on August 27, 2009.

Our objective was to collect at least 1,000 responses from around the world. To maximize response rate, we contacted national working groups in interventional cardiology, official societies such as the Canadian Association of Interventional Cardiology and the Society for Cardiovascular Angiography and Interventions, and we also sent personalized invitation e-mails to interventional cardiologists found after PubMed search. To ensure privacy and consistency, the identity of respondents remained unknown, and each respondent could answer the questionnaire only once. The software allows monitoring results at all times as well as downloading results in a spreadsheet anytime. Data are descriptive. Values are reported as percentages of the total number of responses.

Results

Demographic data and baseline characteristics. Responses were collected from August 27, 2009 to January 29, 2010. At this time, 1,107 interventional cardiologists had taken the questionnaire, and 874 (79%) had answered all questions. The response rate/question varied from 87% to 100%. Respondents were from 75 countries (Fig. 1). The top 5 countries were Canada (n = 107, 9.7%), Italy (n = 97, 8.8%), Japan (n = 95, 8.6%), U.S. (n = 87, 7.8%), and Spain (n = 72, 6.5%). Most respondents (65.6%) were older than 40 years, and 92.9% were men (Table 1). All age categories from ≤30 years (2.3%) to >60 years (4.2%) were represented, with 39.7% of respondents between 40 and 50 years of age. Respondents using TRA for diagnostic catheterization were either low-volume (<5% = 15.4% of respondents) or very high-volume (>90% = 42.4%) TRA operators. Still, high-volume TRA (>90%) operators use that approach less frequently for PCI (32.1%) than for diagnostic purposes (42.4%). This gap existed in all countries but is even larger in China, India, and Japan. The large majority of respondents using TRA are moderate- or high-volume operators, performing >100 PCIs/year.

Abbreviations and Acronyms

ACS = acute coronary syndrome
Cx = circumflex artery
FA = femoral approach
GPI = glycoprotein IIb/IIIa receptor inhibitors
LAD = left anterior descending artery
LCA = left coronary artery
PCI = percutaneous coronary intervention
RAO = radial artery occlusion
RCA = right coronary artery
TRA = transradial approach

Access-site selection and technical aspects. The large majority (89.4%) of operators use the right radial artery as the initial side, although in Japan, 16.8% prefer the left side (Table 2). Although 58.1% of respondents use the Allen test, and 16.4% use the more objective oximetry/plethysmography test (39.5% in the U.S.), it should be

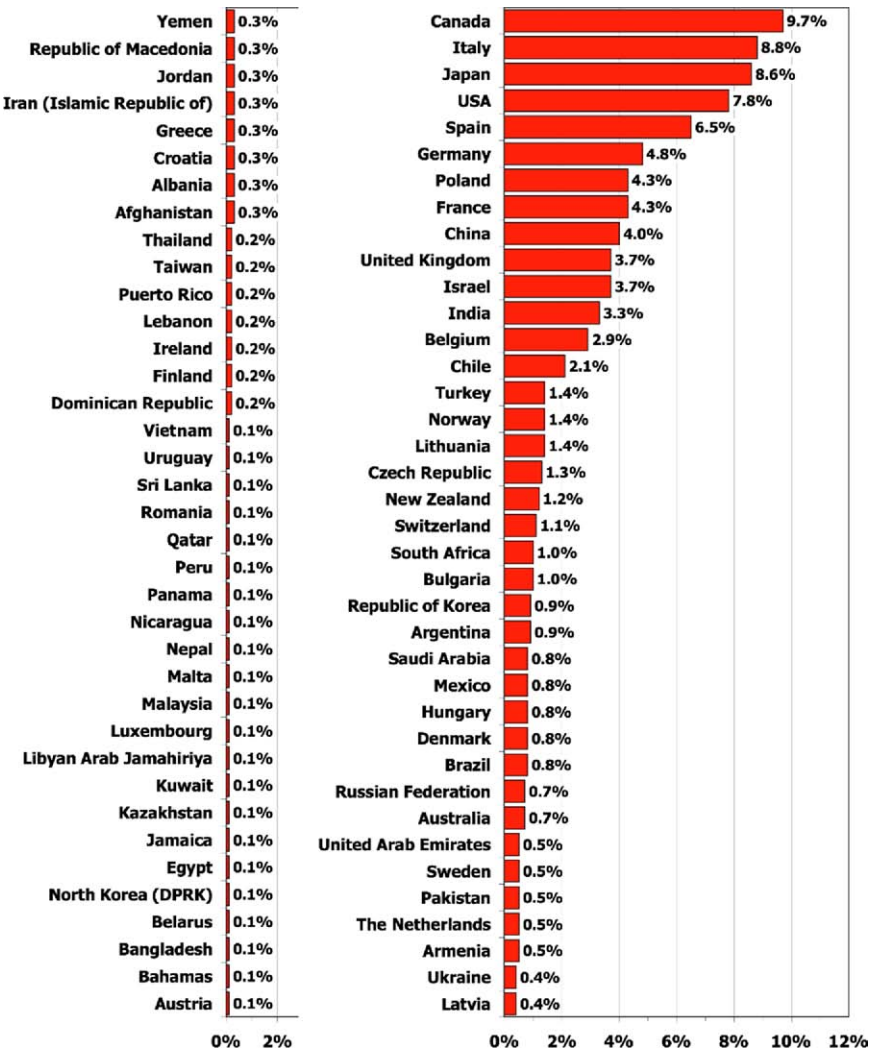

Figure 1. Participating Countries

1,107 participants from 75 different countries answered the survey.

noted that 23.4% still do not assess dual hand circulation before procedure. Interestingly, 31.3% cross over to the contralateral radial artery after initial radial access failure, whereas most (54.5%) revert to the standard FA. In Japan greater than one-third of operators attempt the homolateral brachial artery in case of initial radial artery access failure. Interestingly, after initial radial access site failure, contralateral TRA or FA will be used in 41.0% and 47.1% of operators that use TRA in ≥50% of their PCI procedures compared with 15.7% and 66.5%, respectively, in operators that use TRA in <50% of their PCI procedures.

Before entry of the patient in the catheterization suite, 41.7% of respondents prescribe anxiety relievers, 10.2% use antihistaminic drugs, and 12.5% use local Xylocaine spray or gel, but 45.7% do not use any medication (Table 2). The large majority of operators use vasodilators to prevent radial artery spasm; however, 14.1% of operators, especially in Japan, do not use any vasodilators.

For radial artery puncture, most in the U.S., Canada, and Europe use a bare needle, whereas in China, India, and Japan, operators prefer a sheath-covered needle. The sheath length is most frequently short (52.3% use 10 cm) or very short (34.7% use 7.5 cm), and few operators use longer sheaths, except in Japan. The large majority of operators prefer using hydrophilic sheaths (69.8%) compared with non-hydrophilic sheaths. After radial puncture, preference is now toward smaller-size introducing wire either 0.025 inch (43.5%) or <0.025 inch (31.4%). However, to advance catheters through the arm up to the

Table 1. Demographic Data

	All	U.S.	Canada-Europe	China	India	Japan
Age (yrs)						
≤30	2.3	1.1	1.9	9.1	0.0	1.1
30–40	32.1	29.9	31.6	45.5	37.8	36.8
40–50	39.7	31.0	37.4	38.6	35.1	50.5
50–60	21.7	29.9	24.0	6.8	27.0	11.6
>60	4.2	8.0	5.1	0.0	0.0	0.0
Male	92.9	95.4	92.0	95.5	100.0	93.7
Use of TRA in diagnostic						
<5	15.4	28.7	14.7	0.0	13.5	4.2
5–25	12.1	17.2	13.1	2.3	5.4	0.0
25–50	6.6	13.8	7.4	4.5	2.7	0.0
50–75	8.7	11.5	8.9	15.9	2.7	3.2
75–90	14.8	12.6	14.7	9.1	10.8	24.2
>90	42.4	16.1	41.2	68.2	64.9	68.4
Use of TRA in PCI						
<5	19.0	36.8	17.6	2.3	16.2	1.1
5–25	9.9	13.8	10.9	4.5	8.1	2.1
25–50	9.1	9.2	9.3	9.1	5.4	6.3
50–75	9.6	12.6	7.7	13.6	8.1	18.9
75–90	20.3	12.6	21.5	22.7	10.8	34.7
>90	32.1	14.9	32.9	47.7	51.4	36.8
PCI cases annually						
<100	12.8	16.1	8.0	20.5	13.5	29.5
100–300	52.7	59.8	53.3	31.8	56.8	50.5
>300	34.5	24.1	38.7	47.7	29.7	20.0

Values given are percentages. Canada-Europe stands for: Italy, Spain, Germany, Poland, France, United Kingdom, Belgium, Turkey, Norway, Lithuania, Czech Republic, Switzerland, Bulgaria, Hungary, Denmark, Russian Federation, Sweden, the Netherlands, Armenia, Ukraine, Latvia, Former Yugoslav Republic of Macedonia, Greece, Croatia, Albania, Ireland, Finland, Canada, Israel, Austria, Belarus, Kazakhstan, Luxembourg, Malta, and Romania.

PCI = percutaneous coronary intervention; TRA = transradial approach.

coronary ostia, standard J-shaped 0.035-inch (0.889-mm) wire remains the most frequently used wire (80.0%). In case of radial or brachial artery tortuosity or loops, most operators (74.7%) use hydrophilic wire (Glidewire, Terumo, Tokyo, Japan) or even 0.014-inch (0.356-mm) coronary wires (10.1%) in case of severe anatomical difficulties. For diagnostic angiography, although 4- or 5-F sheath sizes are used in >50% of the cases in the U.S. and Japan, 6-F size remains standard in Canada, Europe, and China (Table 2).

Antithrombotic strategies for TRA. Most operators use heparin to prevent RAO (75.8% use 2,000 to 5,000 IU heparin), but approximately 5% do not use any heparin (Fig. 2A). In case of elective and uncomplicated PCI cases, most operators outside the U.S. use 70 to 100 IU/kg heparin, whereas bivalirudin (53.2%) is frequently used in the U.S. (Fig. 2B). After aspirin and clopidogrel-loading for the treatment of ACS, heparin only (37.9%) or heparin ± glycoprotein IIb/IIIa receptor inhibitor (GPI) (46.7%) remains the most frequently used routine with little use of bivalirudin (7.4%) outside the U.S. In

Table 2. Access-Site Selection and Technical Aspects

	All	U.S.	Canada-Europe	China	India	Japan
Preferred side for TRA						
Right radial	89.4	92.0	89.5	93.2	94.6	83.2
Left radial	10.6	8.0	10.5	6.8	5.4	16.8
Test to assess dual hand circulation before TRA						
Allen	58.1	46.1	57.2	81.4	50.0	60.0
Oximetry/plethysmography	16.4	39.5	15.5	2.3	31.3	1.1
No testing	23.4	7.9	25.5	16.3	18.8	36.7
Other	2.1	6.6	1.8	0.0	0.0	2.2
If radial access fails, next choice						
Homolateral brachial	10.4	9.2	6.7	9.1	0.0	35.8
Contralateral radial	31.3	25.3	33.9	31.8	21.6	36.8
Homolateral ulnar	3.3	3.4	3.2	9.1	2.7	0.0
Contralateral ulnar	0.5	0.0	0.3	4.5	0.0	2.1
Femoral	54.5	62.1	55.9	45.5	75.7	25.3
Pre-medication						
None	45.7	51.7	45.6	43.2	43.2	49.5
Anxiety relievers	41.7	46.0	45.3	27.3	29.7	21.1
Anti-allergy	10.2	16.1	9.0	25.0	21.6	1.1
Local Xylocaine	12.5	2.3	11.8	11.4	10.8	27.4
Anti-ulcer	3.1	5.7	1.7	13.6	16.2	3.2
Other	5.7	5.7	4.5	4.5	2.7	6.3
Needle radial puncture						
Bare needle	59.6	73.5	70.2	35.3	20.6	2.2
Sheath-covered needle	40.4	26.5	29.8	64.7	79.4	97.8
Sheath length (cm)						
7.5	34.7	32.5	37.6	23.5	76.5	8.9
10	52.3	53.0	53.2	50.0	23.5	45.6
>20	13.0	14.5	9.2	26.5	0.0	45.6
Type of sheath						
Hydrophilic	69.8	88.0	62.6	76.5	85.3	88.9
Nonhydrophilic	30.2	12.0	37.4	23.5	14.7	11.1
To prevent radial artery spasm						
NTG and verapamil	31.0	53.0	31.2	32.4	38.2	1.1
NTG, verapamil, Xylocaine	6.6	8.4	5.1	17.6	14.7	1.1
NTG only	17.1	13.3	17.9	32.4	2.9	21.1
Verapamil only	27.1	14.5	33.2	2.9	17.6	2.2
No medication	14.1	2.4	9.7	11.8	0.0	72.2
Other	4.2	8.4	2.8	2.9	26.5	2.2
Introducing wire (inches)						
<0.025	31.4	50.6	31.4	11.8	14.7	27.8
0.025	43.5	38.6	44.9	29.4	55.9	51.1
0.032	10.3	2.4	10.1	32.4	5.9	5.6
0.035	14.7	8.4	13.6	26.5	23.5	15.6
Sheath size, diagnostic (F)						
4	12.0	13.3	5.6	2.9	0.0	76.7
5	41.6	50.6	40.7	29.4	91.2	23.3
6	45.7	34.9	53.0	67.6	8.8	0.0
Sheathless	0.7	1.2	0.6	0.0	0.0	0.0
Advancing wire (inches)						
0.035 J-shaped standard	80.0	80.7	88.5	44.1	67.6	35.6
0.035 soft	3.1	12.0	1.9	5.9	0.0	4.4
Hydrophilic	16.9	7.2	9.7	50.0	32.4	60.0
Wire if tortuosity or loop (inches)						
0.014	10.1	13.3	10.5	11.8	23.5	1.1
0.035 J-shaped standard	8.5	2.4	7.3	2.9	0.0	26.7
0.035 soft	4.1	13.3	2.0	8.8	0.0	4.4
Hydrophilic	74.7	69.9	78.2	76.5	73.5	56.7
Other	2.6	1.2	2.0	0.0	2.9	11.1

Values given are percentages.

NTG = nitroglycerin; other abbreviations as in Table 1.

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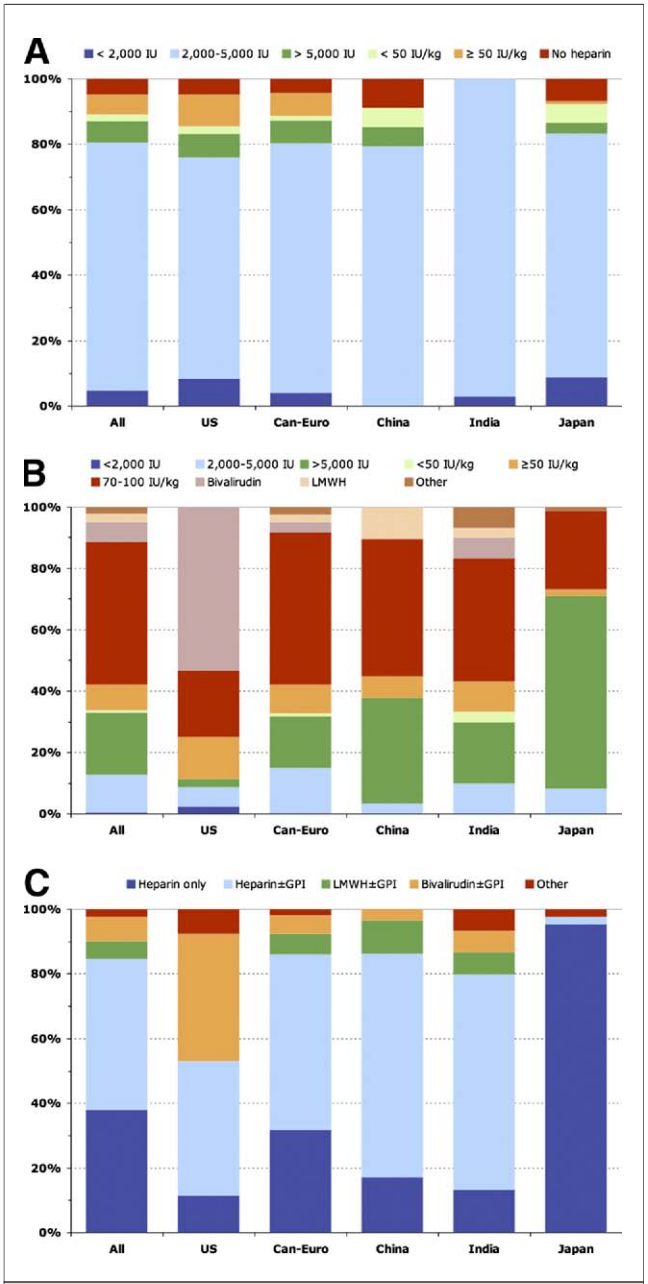

Figure 2. Heparin Dose to Prevent RAO, and Antithrombotic Therapies for Elective and Uncomplicated PCI and for ACS

Heparin dose routinely used to prevent radial artery occlusion (RAO) **(A)**, and antithrombotic therapies used for elective and uncomplicated percutaneous coronary intervention (PCI) **(B)** and for acute coronary syndrome (ACS) **(C)**. Can-Euro = Canada and Europe; GPI = glycoprotein IIb/IIIa inhibitor; LMWH = low molecular weight heparin.

the U.S., heparin ± GPI (41.8%) or bivalirudin ± GPI (39.2%) are the most frequent antithrombotic strategies in ACS (Fig. 2C).

Choice of coronary catheters for diagnostic TRA procedures. For angiography of the left coronary artery (LCA) and right coronary artery (RCA), the Judkins left 3.5 (44.9%) or 4.0 (21.6%) for LCA and Judkins right 4.0 (58.8%) for RCA remain the most commonly used catheters (Table 3). Few operators still use first-generation dedicated single catheters for LCA and RCA angiography, although multipurpose catheters are used in China and the recently developed Tiger II (Terumo) catheters are popular in India. For angiography of left or right bypass grafts, Judkins right remains the most frequently used catheter shape—48.6% and 46.8%, respectively. Not

Table 3. Diagnostic Catheters

	All	U.S.	Canada-Europe	China	India	Japan
LCA						
Judkins left 3.5	44.9	37.8	49.4	25.8	15.2	26.4
Judkins left 4.0	21.6	14.6	23.1	12.9	0.0	35.6
Kimny	1.8	7.3	1.1	3.2	3.0	2.3
Multipurpose	6.2	4.9	4.3	45.2	0.0	11.5
Tiger/Tiger II	16.1	12.2	15.1	12.9	75.8	1.1
Amplatz left	2.2	1.2	2.9	0.0	0.0	1.1
Barbeau	0.2	0.0	0.3	0.0	0.0	0.0
Fajadet left	0.1	0.0	0.0	0.0	0.0	0.0
Other	7.0	22.0	3.8	0.0	6.1	21.8
RCA						
Judkins right 4.0	58.8	46.3	64.6	38.7	12.1	52.9
Kimny	1.7	7.3	1.0	3.2	3.0	2.3
Multipurpose	6.7	7.3	4.6	45.2	0.0	11.5
Tiger/Tiger II	14.9	11.0	14.4	9.7	66.7	1.1
Amplatz left	2.4	2.4	2.9	0.0	0.0	1.1
Amplatz right	2.2	3.7	2.9	0.0	0.0	0.0
Barbeau	0.5	0.0	0.8	0.0	0.0	0.0
Fajadet right	0.1	0.0	0.0	0.0	0.0	0.0
Other	12.7	22.0	8.8	3.2	18.2	31.0
SVG to LCA						
Judkins right	48.6	41.5	51.6	41.9	27.3	40.2
Left bypass	11.5	6.1	11.7	16.1	3.0	3.4
Amplatz left	22.6	26.8	23.4	12.9	18.2	36.8
Multipurpose	7.3	7.3	5.6	19.4	21.2	5.7
Tiger/Tiger II	3.9	6.1	3.4	9.7	6.1	0.0
Kimny	0.7	1.2	0.8	0.0	0.0	0.0
Barbeau	0.1	0.0	0.2	0.0	0.0	0.0
Fajadet	0.1	0.0	0.0	0.0	0.0	0.0
Other	5.3	11.0	3.4	0.0	24.2	13.8
SVG to RCA						
Judkins right	46.8	25.6	48.1	41.9	39.4	43.7
Right bypass	8.0	3.7	8.5	6.5	3.0	3.4
Amplatz left	12.0	7.3	10.3	25.8	18.2	34.5
Multipurpose	23.8	53.7	25.2	16.1	12.1	4.6
Tiger/Tiger II	3.1	2.4	2.9	6.5	3.0	0.0
Kimny	0.4	0.0	0.5	0.0	0.0	1.1
Barbeau	0.4	0.0	0.6	0.0	0.0	0.0
Fajadet	0.0	0.0	0.0	0.0	0.0	0.0
Other	5.6	7.3	4.0	3.2	24.2	12.6

Values given are percentages.
LCA = left coronary artery; RCA = right coronary artery; SVG = saphenous vein graft.

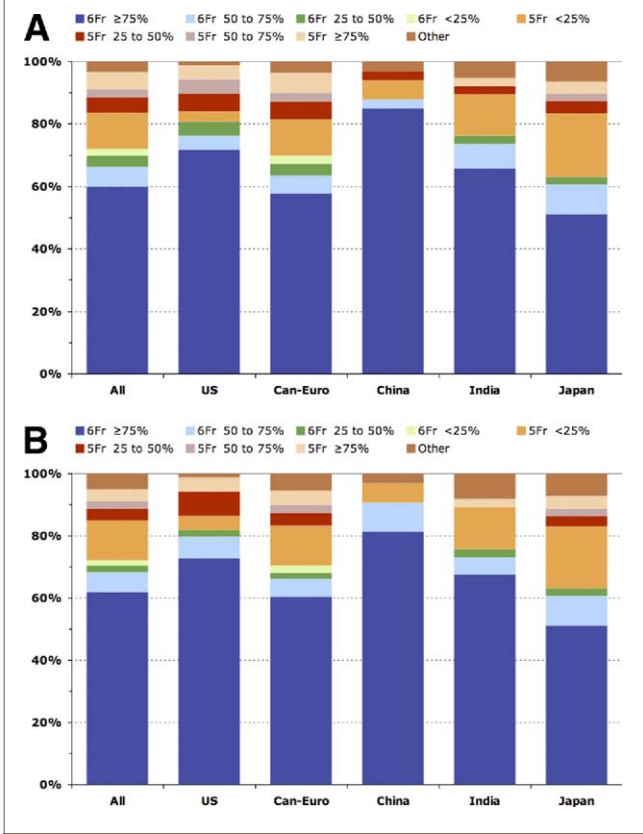

Figure 3. Guiding Catheters Sizes for PCI of RCA and LCA

Guiding catheters sizes for PCI of right coronary artery (RCA) **(A)** and left coronary artery (LCA) **(B)**. Abbreviations as in Figure 2.

surprisingly, left bypass (11.5%) or Amplatz left (22.6%) catheters for left bypass grafts and Amplatz left (12.0%) or multipurpose (23.8%) catheters for right bypass grafts are also frequently used.

Choice of coronary guide catheters for PCI via TRA. For PCI of LCA and RCA, the large majority of operators prefer to use 6-F catheter size (Figs. 3A and 3B). Only approximately 10% of operators use 5-F guiding catheters for RCA PCI, and <10% use 5-F guiding catheters for LCA PCI in ≥50% of cases. For left anterior descending (LAD) and circumflex (Cx) coronary artery lesions, operators routinely use standard extra back-up guiding catheters, the most popular being the EBU 3.5 (Medtronic, Minneapolis, Minnesota)—27.9% for LAD and 26.1% for Cx arteries (Table 4). Interestingly, a significant number of operators still use guiding catheters offering less support, such as Judkins left in 22.5% for LAD lesions and in 12.5% for Cx lesions. Similarly, the most popular guiding catheter shape for RCA lesions remains the Judkins right in 70.2% of cases. For left bypass graft PCI, Amplatz left (37.3%), Judkins right (31.0%), and left bypass graft (19.4%) guiding catheters

Table 4. PCI-Guiding Catheters

	All	U.S.	Canada-Europe	China	India	Japan
LAD						
Judkins left	22.5	6.3	21.6	20.7	10.0	38.4
XB 3.0	8.1	10.1	7.0	20.7	16.7	0.0
XB 3.5	18.2	26.6	18.9	13.8	6.7	5.8
Amplatz left	1.4	2.5	1.3	0.0	3.3	0.0
Tiger II	0.6	1.3	0.5	0.0	3.3	0.0
EBU 3.5	27.9	35.4	26.9	41.4	50.0	20.9
EBU 3.75	6.5	7.6	7.9	3.4	3.3	5.8
EBU 4.0	5.6	1.3	8.0	0.0	0.0	2.3
Kimny	0.8	2.5	0.8	0.0	0.0	0.0
Fajadet left	0.5	1.3	0.5	0.0	0.0	0.0
MUTA left	0.7	0.0	1.1	0.0	0.0	0.0
Other	7.1	5.1	5.4	0.0	6.7	26.7
Cx						
Judkins left	12.5	5.1	11.0	3.4	0.0	26.7
XB 3.0	6.5	6.3	4.9	13.8	13.3	1.2
XB 3.5	20.8	30.4	21.3	17.2	20.0	8.1
Amplatz left	10.8	3.8	13.0	10.3	6.7	5.8
Tiger II	0.3	0.0	0.3	0.0	3.3	0.0
EBU 3.5	26.1	26.6	25.1	48.3	43.3	25.6
EBU 3.75	6.2	15.2	6.1	3.4	6.7	7.0
EBU 4.0	8.7	2.5	11.8	0.0	3.3	3.5
Kimny	0.8	1.3	1.0	0.0	0.0	0.0
Fajadet left	0.5	2.5	0.2	3.4	0.0	0.0
MUTA left	0.4	0.0	0.7	0.0	0.0	0.0
Other	6.3	6.3	4.8	0.0	3.3	22.1
RCA						
Judkins right	70.2	69.6	70.3	93.1	80.0	48.8
Amplatz right	10.2	11.4	12.0	0.0	6.7	2.3
Amplatz left	5.8	7.6	5.4	0.0	6.7	10.5
Barbeau	1.9	1.3	2.6	3.4	0.0	0.0
Kimny	1.3	3.8	1.3	0.0	0.0	0.0
Fajadet right	0.4	0.0	0.5	0.0	0.0	0.0
MUTA right	0.2	0.0	0.3	0.0	0.0	0.0
Other	9.8	6.3	7.5	3.4	6.7	38.4
Left SVG						
Left bypass graft	19.4	16.5	21.0	24.1	3.3	7.0
Amplatz left	37.3	39.2	36.6	24.1	26.7	62.8
Multipurpose	6.2	8.9	4.8	6.9	30.0	2.3
Judkins right	31.0	22.8	33.4	41.4	26.7	16.3
Barbeau	0.4	0.0	0.5	3.4	0.0	0.0
Kimny	0.7	1.3	0.8	0.0	0.0	0.0
Fajadet	0.2	0.0	0.0	0.0	0.0	0.0
Other	4.7	11.4	3.0	0.0	13.3	11.6
Right SVG						
Left bypass graft	3.5	3.8	3.1	0.0	0.0	3.5
Amplatz left	20.8	5.1	17.5	41.4	20.0	59.3
Multipurpose	29.2	65.8	30.8	13.8	26.7	4.7
Judkins right	39.6	17.7	41.8	44.8	40.0	20.9
Barbeau	0.9	0.0	1.5	0.0	0.0	0.0
Kimny	0.5	0.0	0.7	0.0	0.0	0.0
Fajadet	0.0	0.0	0.0	0.0	0.0	0.0
Other	5.5	7.6	4.6	0.0	13.3	11.6

Values given are percentages.

Cx = circumflex artery; LAD = left anterior descending coronary artery; other abbreviations as in Tables 1 and 3.

Table 5. Acces-Site Management After PCI

	All	U.S.	Canada-Europe	China	India	Japan
Hemostasis technique						
"Air bag"-based bracelet	39.7	54.4	34.8	42.9	34.5	69.8
"Plastic" bracelet	20.6	32.9	24.4	25.0	3.4	5.8
Gauze + bandage	29.7	2.5	31.2	14.3	58.6	7.0
"Plastic" + "elastic" strap	8.1	8.9	7.8	17.9	3.4	12.8
Other	2.0	1.3	1.8	0.0	0.0	4.7
RAO assessment before hospital discharge						
Yes	47.5	48.1	41.0	64.3	58.6	64.0
No	52.5	51.9	59.0	35.7	41.4	36.0
Estimated RAO before hospital discharge						
0%	7.9	8.9	5.5	7.1	17.2	4.7
<5%	52.6	45.6	53.1	64.3	44.8	67.4
5%–10%	10.4	7.6	9.6	21.4	17.2	16.3
>10%	0.7	0.0	0.7	0.0	0.0	0.0
Unknown	28.3	38.0	31.2	7.1	20.7	11.6
RAO assessment before hospital discharge						
Doppler	7.1	7.6	7.5	14.3	13.8	0.0
Oximetry/plethysmography	5.5	11.4	5.1	3.6	17.2	0.0
Pulse check	55.2	44.3	49.8	71.4	44.8	79.1
None	31.1	36.7	36.3	10.7	20.7	19.8
Other	1.0	0.0	1.3	0.0	3.4	1.2

Values given are percentages.
PCI = percutaneous coronary intervention; RAO = radial artery occlusion.

are the most frequently used. For right bypass graft PCI, the preferred guiding catheters are the Judkins right (39.6%), multipurpose (29.2%), and Amplatz left (20.8%).

Hemostasis and radial occlusion. To obtain hemostasis, the recently introduced "air-bag"-based bracelet (TR band, Terumo) is becoming the most frequently used hemostasis device, especially in the U.S. (54.4%) and Japan (69.8%) (Table 5). Nevertheless, simple gauze and elastic bandage are used in 29.7% of cases, especially in Canada and Europe (31.2%) and India (58.6%). More than 50% of operators in the U.S., Canada, and Europe do not routinely assess radial artery patency before hospital discharge. Most estimate that early RAO occurs in <5% of cases, although a significant number do not know, and >10% estimate the incidence of RAO is between 5% and 10%. To assess radial artery patency before hospital discharge, >50% simply check the pulse before hospital discharge. In the U.S., approximately 20% will assess RAO incidence with echo-Doppler or oximetry/plethysmography testing.

Hospital discharge and TRA practice. Same-day home discharge or same-day transfer to referring hospitals after uncomplicated PCI is performed on at least 50% of the patients by 13.3% and 24.2% of operators, respectively (Figs. 4A and 4B). Of note, 52.2% and 45.4% of operators never discharge patients to home the same day or transfer them to referring hospitals, respectively.

Overall, approximately 50% of respondents declare that their TRA practice will increase in the future (Fig. 5). This number rises to 68.4% in the U.S., 62.1% in India, and 60.7% in China, compared with 43.4% in Canada and Europe and 32.6% in Japan.

Discussion

We report the results of the first large international survey analyzing the current practice of TRA for coronary diagnostic angiography and interventions. Our main findings can be summarized as follows: 1) TRA is used by interventional cardiologists around the world; 2) although dual hand circulation is assessed in most cases before procedure, 23.4% do not perform any pre-test; 3) in case of first radial access-site failure, >50% of operators revert to standard FA; 4) diagnostic and PCI

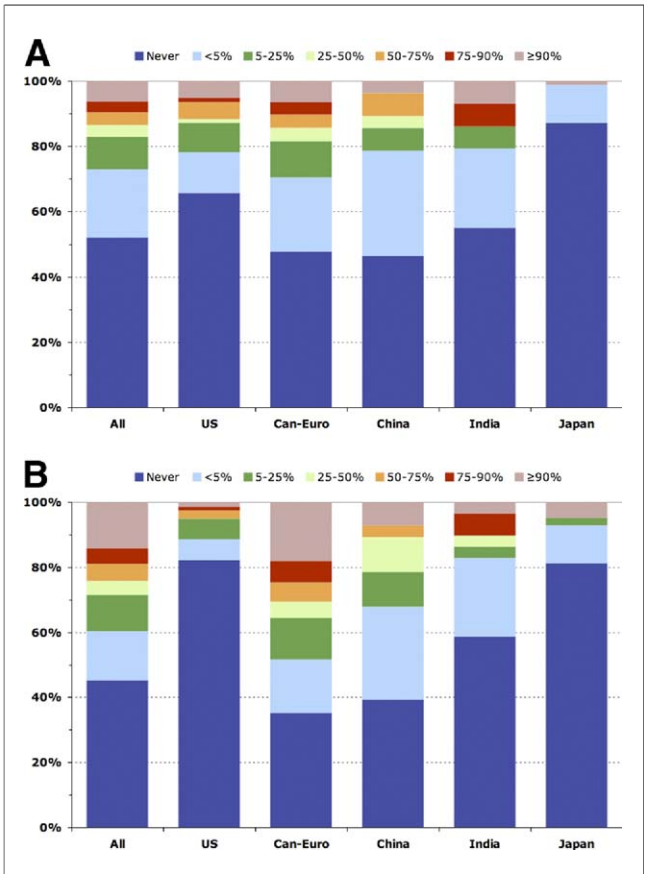

Figure 4. Same-Day Home Discharge or Hospital Transfer After Percutaneous Coronary Intervention

Proportion of same-day home discharge **(A)** or hospital transfer **(B)** in patients after percutaneous coronary intervention by transradial approach. Can-Euro = Canada and Europe.

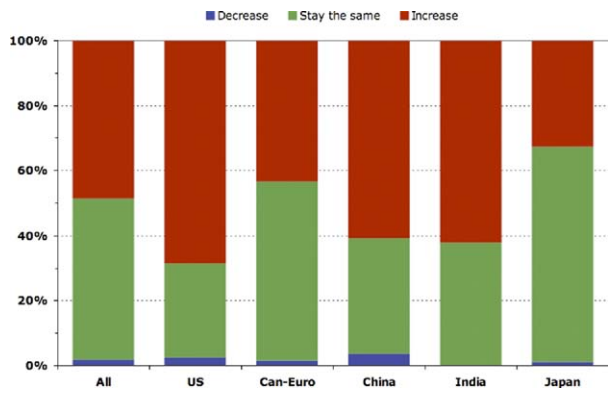

Figure 5. Future Practice of TRA

Estimated personal use of transradial approach (TRA) in future practice compared with current practice. Can-Euro = Canada and Europe.

catheters are similar to those used for FA; 5) to prevent RAO, >95% use heparin; 6) for elective PCI and PCI in ACS, the most popular antithrombotic regimen remains heparin-based; 7) although >50% do not assess RAO before hospital discharge, >10% of operators assume that the incidence of RAO is >5%; and 8) the practice of same-day home discharge or transfer to referring centers remains infrequent after PCI performed by TRA.

Respondent characteristics. Age of the operator and long-time expertise with FA is often cited as a reason why traditionally trained (i.e., FA) operators are not keen to use TRA (11). In fact, all age categories were represented in our survey, with approximately 25% of current TRA operators >50 years of age. It is interesting to note that there were more high-volume TRA operators performing diagnostic cases than PCI cases. This might seem at first paradoxical, because primary benefits of TRA are linked to a reduction of bleeding due to antithrombotic regimens used for PCI. It might reflect, however, that in some cases (i.e., requiring >6-F catheters) TRA operators still prefer other access site, most probably standard FA.

Patient selection. Since the introduction of TRA, it has been recommended to assess dual-hand circulation before use (12). The most popular test remains the Allen test, which is easy to use but remains subjective. Moreover, because this test or the more objective oximetry/plethysmography tests have not been shown to be predictive of hand ischemia in case of RAO, some operators have questioned the utility of assessing dual-hand circulation (13). Indeed, 23.4% of operators do not assess dual hand circulation at all, and this proportion even reaches 30.8% among operators that use TRA in ≥50% of their PCI procedures. It remains uncertain whether assessment of dual hand circulation before TRA is required.

Technical aspects. Navigation through the brachial and subclavian arteries with wires and catheters might sometimes be technically challenging, due to vessel loops or tortuosity (14). For diagnostic cases, Judkins left 3.5 (most common) and 4.0 and right catheters remain the most frequently used catheter shapes. Indeed, although TRA pioneers designed several catheter shapes to cannulate LCA and RCA with a single catheter, these catheters are rarely used. To perform angiography of saphenous vein grafts, operators also use the same catheters as those used for FA.

For LCA and Cx PCI, the large majority of TRA operators use extra back-up guiding catheters, although 20% still prefer to use Judkins left. For RCA PCI, Judkins right remains the most popular, probably due to its versatility, because it may be intubated into the vessel to gain additional support if required. For saphenous vein grafts PCI, TRA operators also use the same guiding catheters as for FA. Overall, the use of TRA does not require using different catheter shapes than for FA (15). The 5-F catheters have been associated with increased patient comfort and reduced risk of RAO but remain less frequently used (16). In Japan, TRA operators have recently developed miniaturized devices called "slender systems" (17,18). Further research will be required to evaluate whether this might be applicable to Caucasian patients, but obviously TRA is a strong incentive for device manufacturers to constantly miniaturize their products.

Antithrombotic strategies. To prevent RAO, heparin has been recommended even for diagnostic cases (19). With current practice using smaller catheter sizes, aspirin, and thienopyridines pre-treatment, the direct impact of heparinization on RAO after diagnostic cases remains largely unknown. For elective cases and ACS, heparin remains the most popular antithrombotic agent outside the U.S., where bivalirudin is used frequently. Further research with the use of bivalirudin and TRA is clearly required to better define the gain in the reduction of nonaccess site bleeding as well as its impact on RAO (20,21).

Hemostasis. Completing hemostasis after TRA is relatively simple, because the artery is superficial and easy to compress. The concept of patent radial artery hemostasis has been recently promoted to reduce the incidence of RAO (22). It is somewhat surprising that >50% of TRA operators do not assess the incidence of RAO before hospital discharge. Many operators are probably biased, because RAO is most often asymptomatic and frequently transient. Because permanent RAO might prevent recurrent use of radial artery access, it is probable that this complication has been underestimated. With the emergence of reduced or new antithrombotic strategies, it will be essential to better evaluate the incidence of RAO and

define means to minimize the risk of post-procedure RAO.

Hospital discharge. Because TRA offers rapid hemostasis and allows patients to be ambulatory immediately after completion of the procedures, same-day discharge or transfer to referring centers of hospitalized patients is simpler than after FA. A few randomized studies have also confirmed the safety of outpatient practice after uncomplicated PCI, even in ACS patients (23–25). Despite proven safety, there might be several negative incentives for same-day discharge or transfer, and further research is required to promote outpatient practice.

Study limitations. This survey provides a snapshot of transradial practice around the world and cannot take into account changes over time. It is possible that operators with interest in TRA were more likely to respond, which could inflate the percentage of procedures performed via TRA in this study. Furthermore, it is likely that some technical aspects differ significantly between continents. Finally, high-volume transradial operators can possibly handle technical aspects differently compared with low-volume operators.

Conclusions

This survey provides several teaching points with TRA. Today, TRA is used in a large number of countries for diagnostic and PCI. Few technical points need to be learned to practice TRA. Most TRA operators use standard diagnostic and guiding catheters initially designed for FA. Therefore, we believe that most PCI programs should involve specific TRA training and exposure. With current devices and practice, TRA could become rapidly the default technique for diagnostic angiography and interventions, instead of being reserved for patients at high risk of bleeding.

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