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Barriers for transradial coronary angiography and interventions in 2016☆

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1. Background

Dr. Lucien Campeau reported the first transradial angiography in 1989 followed by Drs. Kiemeneij and Laarman (1992) who performed the first transradial coronary stenting in Amsterdam, The Netherlands. But since then the acceptance rates of transradial catheterization (TRC) have varied considerably and are hugely influenced by the operator and demography of a particular lab — academic training centers have a significantly higher TRC implementation rates compared to community hospitals. In the past few years there has been impressive growth of TRC in the US — from less than 3% (2007) to 16% (2012) to current ~**36% (2016)** of all cardiac catheterizations nationwide in the US according to the Cath-PCI National Cardiovascular Data Registry (NCDR), with wide variation among hospitals (Fig. 1). However, this still compares very poorly against contemporary European practices (67% radial PCI rate in the Swedish SWEDEHEART registry in 2011 and TRC utilization increased from 17.5% to 65.6% in the age group <60, and 16.6% to 54.5% in the age group ≥80 between 2006 and 2012 in the UK [1] per the British Cardiovascular Intervention Society database). Theoretically, this might be related to the lower average operator volume in the US compared to other Western nations which makes it tougher for US interventionalists to develop earlier proficiency in TRC.

1.1. Why should every interventional cardiologist prefer to master the transradial approach?

The unmet need for greater adoption of TRC in the US was reflected in the class IIA recommendation in the 2011 ACC/AHA/SCAI PCI guidelines for the prevention of access site complications [2] and a class IA recommendations from the European Society of Cardiology (ESC). Most recently, Ferrante et al. in the journal JACC Interventions pointed out the merits of radial access during cardiac catheterization and interventions versus the traditional femoral artery access [3]. A meta-analysis of radial versus femoral access for PCI (1980 to 2008) published in 2009 showed that radial artery access significantly reduced rates of major bleeding compared to femoral access (0.05% vs. 2.3%, $p < 0.05$). In this high-quality meta-analysis there were 10 fewer hemorrhages (95% CI: 7 to 12) and 6 less deaths (95% CI: 3 to 9) per 1000 patients in favor of transradial PCI instead of transfemoral PCI [4]. This can be rationally explained by the anatomical difference of the wrist (radial) versus the groin (femoral) which makes achieving access site hemostasis much easier for the radial approach compared to the transfemoral approach. In spite of similar conclusion drawn from numerous other studies [5] radial access has lagged behind in the US. The reasons are many and include operators' perceptions of an apparent increase in fluoroscopic time as well as reluctance to gain additional skills needed to

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traverse the occasional tortuous subclavian and aortic arch systems (common in octogenarians), structural variants (e.g. an ulnar loop and kinks) and the dreaded radial artery spasm. But there is plenty of published and anecdotal data suggesting that the learning curve for radial artery access is relatively short and more importantly, the younger generation of Interventionalists and fellows-in-training in radial-heavy programs becomes adept quite early on in their training [6,7]. The failure rate during early training of the beginner is small (5%) and this improves rapidly [7] over time. Lower profile and improved deliverability of angiographic equipment and technical improvements (fine access needles, customized hydrophilic sheaths, dedicated radial catheters and hemostatic devices) have also contributed heavily in the greater adoption of TRC in the last decade.

1.1.1. Is it really necessary to do a modified Allen's or Barbeau test prior to RAC if there is a palpable radial artery pulse?

According to recent prospective data [11] there is little additional safety introduced in radial catheterizations by performing preprocedural Allens' or Barbeau test. In an elaborate mechanistic trial, the ipsilateral thumb capillary lactate was used as the primary physiological surrogate for distal ischemia after radial artery catheterization immediately after catheterization, at 30 days, and at 1 year. Valgimigli M et al. prospectively looked at 83 patients with normal and 120 patients with abnormal Allen's test (and Barbeau test) before the cannulation and found no difference in the incidence of the primary endpoint in the "normal" as well as the "abnormal" Allen's groups immediately after catheterization and at 30 days and 1 year. Only 5 patients out of 203 had a (asymptomatic) loss of radial pulse (day 1) and only one of whom had had an abnormal Allen test (radial pulsation returned in two of these patients at the scheduled 30 day follow up). Contemporary labs are adopting an inclusive strategy of doing radial catheterizations *without* Allen's or Barbeau's [12]. There have been surgical reports of radial artery harvest for coronary bypass in those with abnormal Allen's with no deleterious after-effects most likely due to extensive routes of collaterization throughout the ulnar and radial systems in the forearm [13]. Currently, there are weak clinical evidence of the utility of these testing for collateral hand circulation [14] and *no proof that a normal Allen's test is warranted for safety reasons.* Radial artery access should not be denied just based on an abnormal Allen's test; this is especially imperative in those with lower extremity peripheral artery disease in whom femoral artery access could be difficult, dangerous or impossible [15]. Many experienced radial operators worldwide have performed hundreds of thousands of radial catheterizations based solely on a palpable radial artery in those with abnormal Allen's test without any increase in the rate of hand ischemia — the hand has a tremendous collateral circulation. However, overt concerns about medico-legal implications and public reporting have continued to plague many US operators in accessing the palpable RA with abnormal Allen's test despite modern data to the contrary.

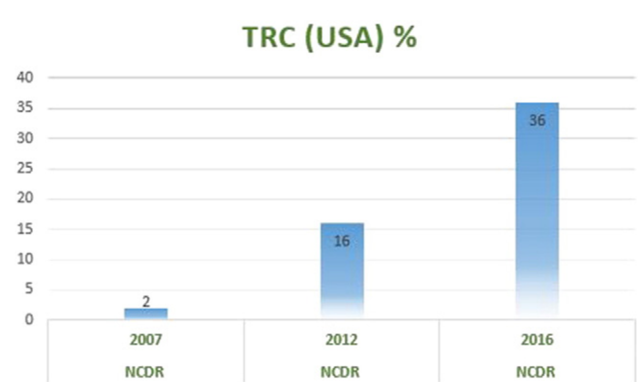

Fig. 1. Rates of transradial catheterization (TRC) in the United States as a percentage (%) of the total coronary angiographies and interventions performed in 2007, 2012 and 2016. Data obtained from the Cath-PCI National Cardiovascular Data Registry (NCDR) of the American College of Cardiology.

1.1.2. What about the additional radiation exposure when we trade in radial for femoral approach?

There are some published data which show that radial access procedure increases the average radiation exposure – may be up to double – but this varies enormously by operator experience and center experience. Standard radiation protection protocols are adequate for most TRCs with the exception of the left radial approach (in coronary artery bypass graft cases, for example). Commercially available radiation protection drapes over the patient can dramatically reduce scatter radiation by up to 12-fold for the eyes and 29-fold for the hands [16]. Unfortunately, in spite of being relatively cheap, their acceptance has considerably lagged behind in most hospitals in the US. Most disposable commercially available radiation protection drapes (RADPAD; Worldwide Innovations & Technologies, Overland Park, KS; X-Drape®, AADCO Medical Inc., Randolph, VT) range from approximately $20 to $30 per drape, adding little to the cost of the procedure but potentially contributing a great deal to the safety of the operator(s). Other specific, but often underutilized ways to decrease scatter radiation during TRC include (1) Placing the arm *close* to the body, and not extending it out (2) using lower frames (7 fps) with diluted (50%) contrast, navigating in "fluoroscopy-save" (FS) versus cinematography mode to traverse a difficult radial anatomy — applying lessons learned from peripheral angiography. In pilot randomized trials, FS mode during elective TRC exposed the operator to a third of the radiation dose (240 μR versus 605 μR, $p = 0.046$) and the patient received less than half of the radiation (151 ± 69 vs. 260 ± 125 mGy, $p = 0.001$) when compared to routine cine mode angiography [17]. Ultimately, as operators and centers get more experienced at TRC, they get more efficient in reducing radiation exposure and eventually this difference will likely be eliminated when the transradial and transfemoral approaches are used with at least equal frequency [18]. The estimated annual effective radiation dose received by catheterization lab operators is comparable to the natural background exposure of about 2.4 mSv/year [36]. Even with a (potential) doubling of radiation exposure by virtue of TRC, the cumulative annual exposure of an average operator is likely to be less than the World Health Organization recommended 0.5 mSv/month limit. In the global context however, the lifetime radiation risk is probably better measured against the National Council on Radiation Protection and Measurements (NCRP, United States) limit of whole body effective dose of 10 mSv $\times$ age/lifetime.

1.1.3. Acute radial artery injury after instrumentation: are instrumented radial artery conduits ideal for coronary artery bypass grafting (CABG)?

TRC leads to local puncture damage at the minimum but potentially can cause more extensive trauma to the radial artery including acute intimal tears (67.1% and more frequent in the distal rather than in the proximal RA), medial dissections (35.6%) and eventually chronic intimal thickening after repeated TRC procedures [19]. However, there are only scant objective data on the impact of these effects on long-term radial artery graft patency and on clinical outcomes after bypass surgery. It is such fear of a theoretical risk of (radial artery) graft compromise which had initially caused much hesitancy among US cardiac surgeons in harvesting an instrumented radial artery and pushed back early US interventionalists from adopting a radial approach. Although, cumulative clinical experience has proven otherwise, it might be prudent to avoid TRC in elective cases going for possible CABG until this issue is definitively settled. When TRC is performed in such cases, routinely using smaller bore (4F) catheters and meticulously exchanging catheters over a wire should help to minimize trauma. Long-term randomized data are needed to looks for signals of earlier graft failure and adverse clinical outcomes after CABG in patients with instrumented radial artery grafts compared to "fresh" arterial grafts. However, proven strategies for preventing radial artery occlusion like use of standard hydrophilic

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