

Transradial Artery Catheterization in the United States

A contemporary look at this procedure's history, evolution, and advantages.

BY CARLOS E. ALFONSO, MD, AND MAURICIO G. COHEN, MD

Transradial artery catheterization in the United States continues to develop, evolve, and grow. Multiple studies have now demonstrated the benefits of transradial artery access (TRA) for catheterization and percutaneous coronary intervention (PCI). In comparison to transfemoral PCI (f-PCI), transradial PCI (r-PCI) is associated with a lower risk of bleeding, reduced vascular complications, lower cost, and improved patient comfort.¹⁻³ In the largest randomized study, the RIVAL trial, the rates of procedural success were similar between radial and femoral approaches, with 7.6% versus 2% vascular access site crossover rates favoring f-PCI.⁴ Fueled by ample data and publications, and fed by eager radial enthusiasts across the United States, the use of TRA for catheterization and intervention has continued to consistently increase during the last decade.

HISTORICAL PERSPECTIVE

Radial artery catheterization is not new. Dr. Werner Forssman performed the first human cardiac catheterization via the brachial vein in 1929,⁵ and approximately 20 years later, the first transradial aortic cannulation was described.⁶ Although Dr. F. Mason Sones initially developed the technique of brachial artery cutdown for cardiac catheterization, Dr. Melvin Judkins further simplified the procedure in the 1960s with the development of the femoral approach, which could be performed percutaneously. With the advent of percutaneous coronary intervention in the late 1970s, when Dr. Andreas Gruentzig successfully performed the first coronary balloon angioplasty with a fixed wire and balloon system, coronary procedures were primarily performed via femo-

ral access. In those early years of coronary intervention, the procedure often involved large guiding catheters and consequently required larger arterial access; therefore, femoral access was the default strategy.

With the evolution of the field and the development of smaller devices and catheters, including steerable wires and lower-profile catheters, the possibility of access in smaller-caliber vessels became feasible. In 1989, Dr. Lucien Campeau reported the first series of transradial angiography.⁷ Four years later, Drs. Kiemeneij and Laarman reported the first transradial coronary stenting.⁸ Since it was first suggested and then demonstrated to be feasible, the use of TRA for catheterization and intervention quickly caught on in Europe and Asia. Although some countries in Europe (such as Germany) still lag behind in radial adoption rates, the majority of procedures in France, Scandinavian countries, the United Kingdom, Spain, and Italy are now performed via the radial approach. More recently, the European Society of Cardiology suggested in a consensus paper that a "radial-first" strategy should be the default approach.⁹

ADOPTION IN THE UNITED STATES

The United States has lagged behind Europe, Asia, and other developed nations in the adoption of TRA catheterization and intervention. By the mid-1990s, there was a first wave of radialists in the United States, but after the inception of vascular closure devices with important industry support and a sales force able to rapidly train practicing physicians, this initial enthusiasm rapidly dissipated. Most practicing interventional cardiologists in the United States are low-volume operators with busy daily

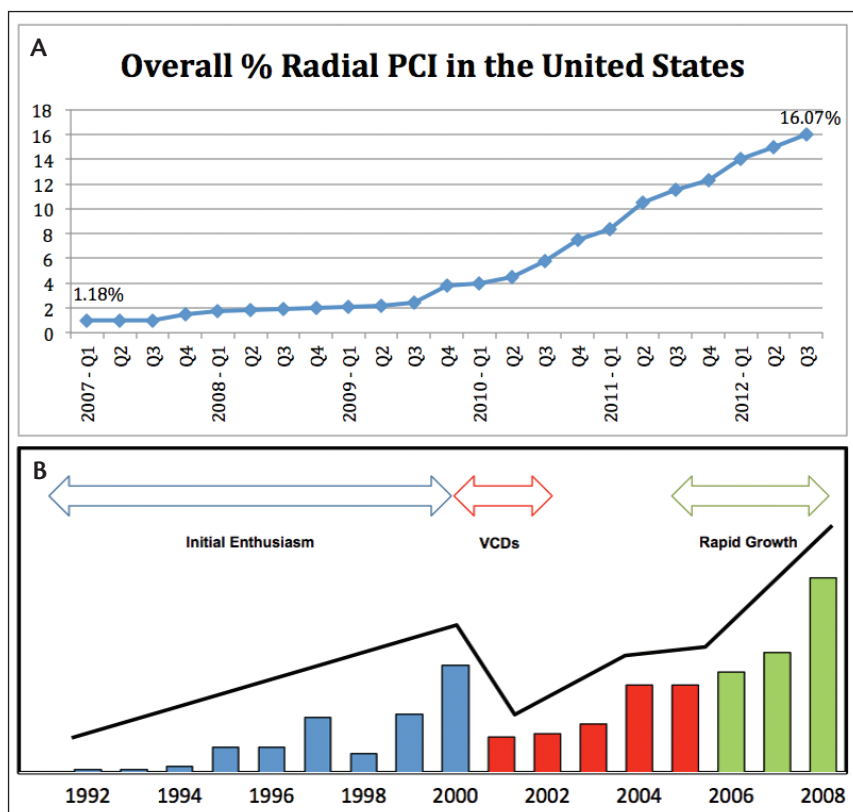


Figure 1. Overall percentage of transradial PCI procedures between 2007 and 2012 and PubMed search results on TRA between 1991 and 2008. The overall percentage of r-PCI performed in the United States began to demonstrate an upswing around 2009 (A).¹³ There has been an increased number of hits in literature searches on radial access (B), demonstrating the initial enthusiasm period that lasted until the introduction of vascular closure devices, followed by a period of renewed enthusiasm and rapid growth from 2004 to 2008.

schedules of seeing outpatients and reading noninvasive studies and do not have enough time to learn new techniques. In this context, transfemoral access with the use of vascular closure devices was a more appealing choice than transradial catheterization, which is associated with a steep initial learning curve.¹⁰ Early adopters, who for various reasons decided to pursue TRA, were the exception rather than the norm and became islands in a sea of primarily transfemoral operators.

As recently as 2007, fewer than 3% of cases were performed via TRA in the United States.¹¹ With better understanding of the unfavorable impact of bleeding on cardiovascular outcomes, the cardiology community changed its perception of TRA and slowly started to embrace this technique as a strategy to avoid bleeding and prevent vascular complications. More than 20 years after its inception, TRA was finally included in the 2011 ACC/AHA/SCAI PCI guidelines with a class IIa recom-

mendation for the prevention of access site complications.¹² A more recent analysis of the Cath-PCI National Cardiovascular Data Registry (NCDR), which included nearly 3 million cases performed at 1,400 hospitals between January 2007 and September 2012, demonstrated that over that time course, the use of TRA catheterization dramatically increased. In the first quarter of 2007, r-PCI accounted for 1.18% of all PCI performed, but this increased to 16.1% by the third quarter of 2012, or approximately one of six PCIs (Figure 1). It is likely that these numbers will continue to grow over the next decade.

However, the adoption of TRA for PCI has not occurred uniformly. Use of r-PCI by region is more prevalent in the Northeast, where approximately one-quarter of all procedures were performed transradially in the third quarter of 2012. Rates of r-PCI lag behind in other regions, such as the West, with <10% of all PCI procedures being performed radially.¹³ However, it is expected that with increased offerings of training courses and proctorships, the West and other regions will

eventually catch up with the Northeast. Newly trained interventional cardiologists proficient in TRA settling in low-use regions will spur the continued growth of this procedure. The preferential blooming of r-PCI within regions concentrated in the Northeast was likely driven by the early adopters, who were seeds of change.

REASONS FOR GROWTH

Did the increased use of radial artery catheterization arise because of positive studies and publications showing its merits over femoral artery catheterization, or is the increasing number of publications the result of increasing use in the community? The number of manuscripts published demonstrating the benefits of radial artery catheterization over the past 10 years in major United States cardiology journals has reflected increased use and popularity (Figure 2) and predated the increase in clinical use by a few years.

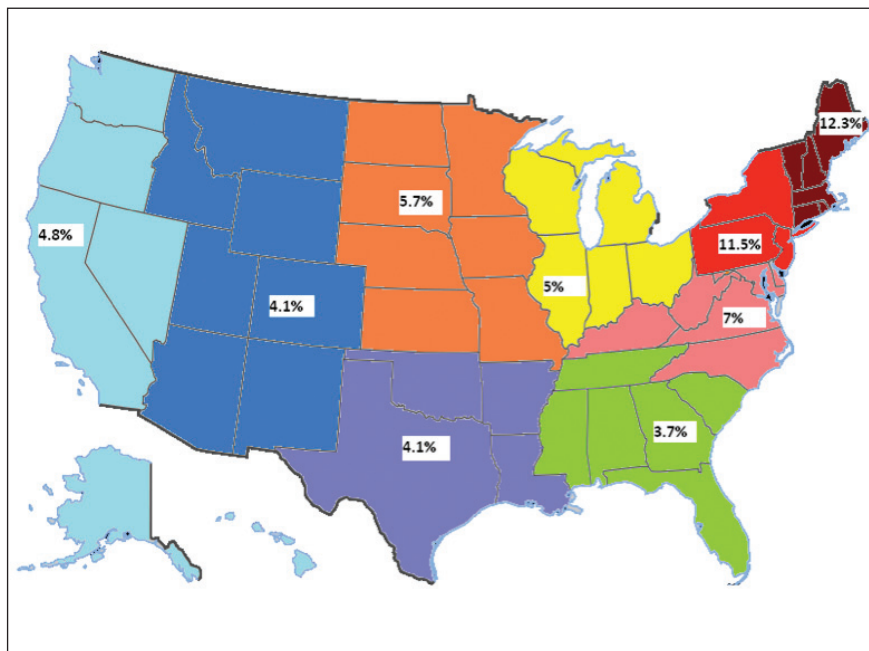


Figure 2. Geographical variation in the adoption of transradial PCI between 2007 and 2012. An analysis from the NCDR-Cath PCI registry demonstrated significant regional variability in transradial PCI procedures, with more use in the Northeast and Mid-Atlantic states. These numbers increased during the course of the study. By the third quarter of 2012, r-PCI accounted for approximately 25% of cases performed in the Northeast region.¹³

Is TRA catheterization a product of academic training or of the Generation X and Millennial users? In other words, does the use of TRA differ among cardiologists depending on their age or years removed from fellowship training? The NCDR-Cath PCI registry demonstrated that from 2007 to 2012, r-PCI was more prevalent in university hospitals and institutions with fellowship/residency programs.¹³

Cardiology fellowship training programs have an important and crucial role in the dissemination and education of the future cardiovascular physician workforce. Fellows will learn TRA catheterization during fellowship if they are taught by mentors who are themselves proficient. An anecdotal poll of recently graduated interventional cardiology fellows from the University of Miami over the past 5 years demonstrates that the majority have incorporated TRA catheterization to varying degrees in their clinical practice, ranging from 40% to 90% of their current cardiac catheterization cases. Although the role of fellowship training cannot be overlooked, the bulk of invasive and interventional cardiologists are years removed from fellowship training, and more than half perform 40 or fewer procedures per year in the United States.¹⁴

It is apparent that the rate of growth and incorporation of TRA catheterization is faster than can be accounted for by just the yearly influx of new trainees into the interventional workforce who are proficient with radial artery catheterization. Many cardiologists removed from the auspices of fellowship training have adopted a self-help approach to acquire the skills necessary for radial artery catheterization.

The skill set needed for TRA catheterization is not intrinsically different from the skill set for transfemoral catheterization, but is only a modification. Although there is a ramp-up early learning period for beginners (as there is with any procedure), the suggested number of cases to develop proficiency hovers around 50 to 100, which is an easily attainable number for any busy interventional cardiologist in < 1 year.¹⁵

The development of various courses, simulators, and proctorships supported by industry and professional associations, such as the Society for Cardiovascular Angiography and Interventions (SCAI), has helped to get the word out and provide training. These courses will likely continue to have a crucial role in supporting the continued adoption of r-PCI and will help in shortening the learning curve for new operators.

Why have the numbers continued to increase, and is TRA a fad or here to stay? Various procedural improvements and transradial technologies have helped some of the obstacles associated with TRA catheterization over the past decade. Some of the improvements involve fine access needles, dedicated hydrophilic sheaths, new catheter shapes, and hemostatic devices. The profile and deliverability of intravascular devices have also continued to improve. Currently, most coronary procedures can be completed by using 5- or 6-F systems. Therefore, radial artery catheterization does not limit the ability to complete the vast majority of coronary interventional procedures, regardless of complexity. Operator experience with the radial approach also continues to grow. This is evident in the decreased incidence of access site fail-

ure, increased procedural success, and reduced radiation exposure that occur over time.^{16,17}

COST SAVINGS

In the current era of cost containment, national and local health care policy is also an important driver of change and innovation. Health care payers and systems are increasingly pushing an improvement in quality of care, and providers are increasingly measured on quality-of-care benchmarks. Based on current data, the continued migration toward TRA procedures is inevitable and makes sense. In addition to data suggesting it is safer, TRA outperforms its femoral-approach counterpart on various quality-of-life measures, including pain, discomfort, and earlier ambulation.² In addition, it has been shown to be more cost efficient and is estimated to save \$300 to \$400 per case.¹⁹

Prevention of vascular complications is another major benefit of TRA over femoral access. In addition to improved outcomes, the decreased rate of vascular complications also has a major financial benefit, as it decreases the need for subsequent prolonged hospital stay and further diagnostic and other potential interventions. Overall, the cost savings continue to improve after the first year of initiating a radial program as the operators continue to become more efficient. Radial artery procedures are associated with shorter length of hospital stay and are ideally suited for early discharge after diagnostic procedures.³ Same-day home discharge after uncomplicated r-PCI may lead to significant cost savings compared to an overnight stay.²⁰ It should be noted that most payers, including Medicare, consider PCI an outpatient procedure, and hospitals receive a single payment regardless of whether the patients are sent home after a few hours or kept overnight in regular wards or observation units.

FUTURE APPLICATIONS

Although the use of r-PCI has incrementally increased over the past few years, it may still be relatively underused in the United States, where there is room for continued growth. The greatest benefits of r-PCI may be observed in the population of patients at highest risk

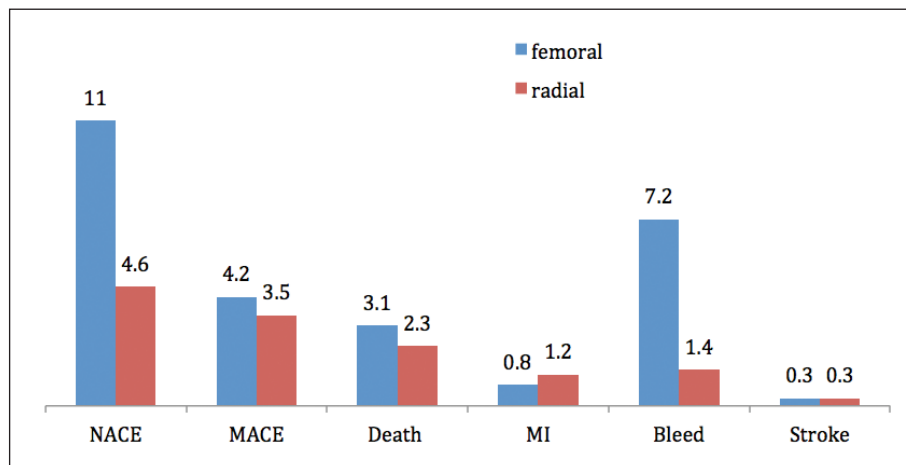


Figure 3. Event rates from the STEMI RADIAL trial, which compared radial to femoral access for STEMI interventions and demonstrated r-PCI compared with f-PCI was associated with a nonsignificant decrease in MACE and a statistically significant decrease in net adverse cardiac events (NACE; $P = .0028$) driven by an important reduction in bleeding rates ($P = .0001$).¹⁸

for bleeding, which includes the elderly, women, and patients presenting with acute coronary syndromes and ST-elevation myocardial infarction (STEMI). However, r-PCI is underutilized in these populations.

Elderly patients and women may pose more of a technical challenge in various respects, including smaller-caliber vessels, tortuosity, and calcifications. The use of r-PCI for primary percutaneous intervention in the setting of STEMI remains a hot topic for debate, despite evidence to support its use.²¹⁻²³ Many have argued against the use of r-PCI for STEMI. Primarily, there is a concern that r-PCI may delay time to reperfusion if there is increased vascular access time or difficult anatomy requiring multiple catheter manipulations or catheter exchanges. In addition, in the hemodynamically unstable patient requiring hemodynamic support, r-PCI would require a second arterial access, which can potentially delay implementation of a hemodynamic support device.

For some inexperienced users or hospitals, these may present true obstacles. However, a recent analysis of the NCDR Cath-PCI registry demonstrated steady growth in TRA use for primary PCI from 0.9% to 6.4% of cases over a 5-year period extending from 2007 to 2011.²⁴ Many of the perceived obstacles in the implementation of TRA for primary PCI will be dispelled with dedication, championing of transradial programs, and increased use and experience at the operator, staff, and site levels. Indeed, the recent STEMI RADIAL trial (Figure 3) showed a trend toward decreased major adverse cardiac events (MACE) and death rates, with a substantial difference in MACE primarily driven by a statistically significant 80% reduction in bleeding events.¹⁸



Figure 4. Massive attendance at a transradial session at the Transcatheter Cardiovascular Therapeutics conference in 2011.

SUMMARY

Given the recognized benefits that TRA can offer at many levels, primarily to the patient, TRA catheterization is here to stay. The United States will likely continue to experience a shift toward a radial-first paradigm because this is the most sensible approach. However, there will still be a subset of patients for whom transfemoral access will still be preferred. Sooner rather than later, the landscape in the United States will mirror that of Europe and Asia, and TRA procedures will represent an increasing majority of the cases performed in our catheterization laboratories. This evolution continues to be supported by professional societies, which are voices for change and provide various resources to enact this change.

Major cardiology meetings have sessions dedicated to teaching and promoting TRA for catheterization and interventions. Attendance of these sessions has grown substantially over the years; Figure 4 shows massive participation in a transradial session at a Transcatheter Cardiovascular Therapeutics conference. SCAI offers various transradial courses yearly,²⁵ and the AimRADIAL master class²⁶ provides advanced TRA training and a forum for discussion of the most recent scientific and technological advances in the field. Cardiology fellowship training programs and various organized courses will continue to support and provide the needed training and education. Ultimately, the continued migration toward a radial-first mentality will signify better care for our patients through minimizing risks, decreasing discomfort, and shortening recovery time. ■

Carlos E. Alfonso, MD, is Assistant Professor of Medicine and Cardiology Fellowship Program Director,

Cardiovascular Division, Department of Medicine at the Elaine and Sydney Sussman Cardiac Catheterization Laboratory, University of Miami Hospital and Miller School of Medicine in Miami, Florida. He stated that he has no financial interests related to this article.

Mauricio G. Cohen, MD, is Associate Professor of Medicine, Cardiovascular Division, Department of Medicine, and Director of the Elaine and Sydney Sussman Cardiac Catheterization Laboratory at the University of Miami Hospital and Miller School of Medicine in Miami, Florida. He has disclosed that he is on the Speakers' Bureau for Medtronic and Terumo Medical, and is a consultant to Terumo Medical. Dr. Cohen may be reached at (305) 243-5050; mgcohen@med.miami.edu.

- Bertrand OF, Belisle P, Joyal D, et al. Comparison of transradial and femoral approaches for percutaneous coronary interventions: a systematic review and hierarchical Bayesian meta-analysis. *Am Heart J*. 2012;163:632-648.
- Cooper CJ, El-Shiekh RA, Cohen DJ, et al. Effect of transradial access on quality of life and cost of cardiac catheterization: a randomized comparison. *Am Heart J*. 1999;138:430-436.
- Safley DM, Amin AP, House JA, et al. Comparison of costs between transradial and transfemoral percutaneous coronary intervention: a cohort analysis from the Premier research database. *Am Heart J*. 2013;165:303-309.e2.
- Jolly SS, Yusuf S, Cairns J, et al. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. *Lancet*. 2011;377:1409-1420.
- Forsmann-Falk R, Werner Forsmann: a pioneer of cardiology. *Am J Cardiol*. 1997;79:651-660.
- Radner S. Thoracic aortography by catheterization from the radial artery; preliminary report of a new technique. *Acta Radiol*. 1948;29:178-80.
- Campeau L. Percutaneous radial artery approach for coronary angiography. *Cathet Cardiovasc Diagn*. 1989;16:3-7.
- Kiemeneij F, Laaman GJ. Percutaneous transradial artery approach for coronary stent implantation. *Cathet Cardiovasc Diagn*. 1993;30:173-178.
- Hamon M, Pristipino C, Di Mario C, et al. Consensus document on the radial approach in percutaneous cardiovascular interventions: position paper by the European Association of Percutaneous Cardiovascular Interventions and Working Groups on Acute Cardiac Care and Thrombosis of the European Society of Cardiology. *EuroIntervention*. 2013;8:1242-1251.
- Spaulding C, Lefevre T, Funck F, et al. Left radial approach for coronary angiography: results of a prospective study. *Cathet Cardiovasc Diagn*. 1996;39:365-370.
- Rao SV, Ou FS, Wang TY, et al. Trends in the prevalence and outcomes of radial and femoral approaches to percutaneous coronary intervention: a report from the National Cardiovascular Data Registry. *JACC Cardiovasc Interv*. 2008;1:379-386.
- Levine GN, Bates ER, Blankenship JC, et al. 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. *Catheter Cardiovasc Interv*. 2012;79:453-495.
- Feldman DN, Swaminathan RV, Kaltenbach LA, et al. Adoption of radial access and comparison of outcomes to femoral access in percutaneous coronary intervention: an updated report from the national cardiovascular data registry (2007-2012). *Circulation*. 2013;127:2295-2306.
- Maroney J, Khan S, Powell W, Klein LW. Current operator volumes of invasive coronary procedures in Medicare patients: implications for future manpower needs in the catheterization laboratory. *Catheter Cardiovasc Interv*. 2013;81:34-39.
- Ball WT, Shariff W, Jolly SS, et al. Characterization of operator learning curve for transradial coronary interventions. *Circ Cardiovasc Interv*. 2011;4:336-341.
- Turner S, Sacinty M, Manogue M, et al. Transitioning to the radial artery as the preferred access site for cardiac catheterization: an academic medical center experience. *Catheter Cardiovasc Interv*. 2012;80:247-257.
- Jolly SS, Cairns J, Yusuf S, et al. Procedural volume and outcomes with radial or femoral access for coronary angiography and intervention. *J Am Coll Cardiol*. 2014;63:954-963.
- Bernat I, Horak D, Stasek J, et al. ST elevation myocardial infarction treated by radial or femoral approach in a multicenter randomized clinical trial: the STEMI-RADIAL trial. *J Am Coll Cardiol*. 2014;63:964-972.
- Roussinov O, Wilson SJ, Henley K, et al. Cost-effectiveness of the radial versus femoral artery approach to diagnostic cardiac catheterization. *J Invasive Cardiol*. 2007;19:349-353.
- Rinfret S, Kennedy WA, Lachaine J, et al. Economic impact of same-day home discharge after uncomplicated transradial percutaneous coronary intervention and bolus-only abiximab regimen. *JACC Cardiovasc Interv*. 2010;3:1011-1019.
- Mehta SR, Jolly SS, Cairns J, et al. Effects of radial versus femoral artery access in patients with acute coronary syndromes with or without ST-segment elevation. *J Am Coll Cardiol*. 2012;60:2490-2499.
- Romagnoli E, Biondi-Zoccai G, Sciahbasi A, et al. Radial versus femoral randomized investigation in ST-segment elevation acute coronary syndrome: the RIFLE-STEACS (Radial Versus Femoral Randomized Investigation in ST-Elevation Acute Coronary Syndrome) study. *J Am Coll Cardiol*. 2012;60:2481-2489.
- Bernat I, Abdelal E, Plourde G, et al. Early and late outcomes after primary percutaneous coronary intervention by radial or femoral approach in patients presenting in acute ST-elevation myocardial infarction and cardiogenic shock. *Am Heart J*. 2013;165:338-343.
- Baklanov DV, Kaltenbach LA, Marso SP, et al. The prevalence and outcomes of transradial percutaneous coronary intervention for ST-segment elevation myocardial infarction: analysis from the National Cardiovascular Data Registry (2007 to 2011). *J Am Coll Cardiol*. 2013;61:420-426.
- SCAI announces the perfect educational pairing. The Society for Cardiovascular Angiography and Interventions website. <http://www.scai.org/TRIP-CTO/Default.aspx>. Accessed April 16, 2014.
- Third Advanced International Masterclass. AimRADIAL 2014 website. <http://www.aimradial.org>. Accessed April 16, 2014.