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Risk of brain injury during diagnostic coronary angiography: Comparison between right and left radial approach

Andrea Pacchioni [a,*], Francesco Versaci [a], Antonio Mugnolo [a,b], Carlo Penzo [a], Dimitrios Nikas [a], Salvatore Saccà [a], Luca Favero [a], Pier Francesco Agostoni [c], Zsolt Garami [d], Francesco Prati [e], Bernhard Reimers [a]

[a] Divisione di Cardiologia, Ospedale Civile, Mirano, Italy
[b] Divisione Clinicizzata di Cardiologia, Università di Verona, Verona, Italy
[c] Department of Cardiology, University Medical Center, Utrecht, Netherlands
[d] Department of Cardiovascular Surgery, Methodist DeBakey Heart and Vascular Center, The Methodist Hospital, Houston, USA
[e] Unità Operativa Complessa di Cardiologia II, Ospedale San Giovanni, CLI Foundation, Rome, Italy

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ABSTRACT

Objectives: To assess the incidence of silent cerebral embolization when using the transradial approach for diagnostic coronary angiography (DCA).

Background: Compared to other vascular access sites, the right transradial approach (RTA) could reduce the amount of brain emboli by avoiding mechanical trauma to the aortic wall caused by catheters and wire, whereas it increases manipulation of catheters in the ascending aorta and has a higher risk of direct embolization into the right common carotid artery. A recent study showed an increased incidence of microembolic signals (MES) in RTA compared to femoral. However, left transradial approach (LTA) has never been assessed.

Methods: 40 patients with suspected coronary artery disease were randomized to DCA via RTA (n = 20) or LTA (n = 20) with contemporaneous bilateral transcranial Doppler monitoring.

Results: MES were detected in all patients, with a significantly higher rate in the RTA group (median 61, interquartile range (IQR) 47–105, vs 48, IQR 31–60, $p = 0.035$). MES generated during procedures needing > 2 catheters (n = 8), are higher than those detected during procedures performed with 2 catheters (n = 32, 102, IQR 70–108, vs 48, IQR 33–60, $p = 0.001$). At multivariate analysis increasing number of catheters was the only independent predictor of high incidence of MES (OR 16.4, 95% CI 1.23–219.9, $p = 0.034$, $-2LL = 26.7$).

Conclusions: LTA has a lower risk of brain embolization because of the lower number of catheter exchange maneuvers. Since the degree of brain embolism depends on the magnitude of mechanical manipulation, catheter changes should be minimized to reduce the risk of cerebral embolization.

1. Introduction

Over the last ten years big efforts have been made to improve the outcome of percutaneous coronary intervention (PCI). The use of radial artery as an alternative vascular access site has been one of the most effective in reducing major access-site hemorrhagic and vascular complications [1,2] with a high procedural success rate, provided that there are adequate operator's skills [3,4]. Radial access has led to a reduction in mortality, especially in patients treated by experienced operators and needing high-dose antithrombotic drugs, such as those with acute coronary syndrome with ST segment elevation [5–7]. Moreover, it is generally well-tolerated by patients, making fast mobilization and short hospital stays possible. As another possible advantage, transradial access could reduce the peripheral atheroembolism due to mechanical trauma caused by the passage of wires and catheters along the aortic wall [8,9]. In particular, aortic arch atheroma is a well-known risk factor both for recurrent strokes

Abbreviations: PCI, percutaneous coronary intervention; RTA, right transradial approach; CCA, common carotid artery; DW-MRI, diffusion weighted magnetic resonance imaging; TCD, transcranial Doppler; MES, microembolic signal; LTA, left transradial approach; CAD, coronary artery disease; MCA, middle cerebral artery; MES_{man}, microembolic signal occurring during catheter manipulation; MES_{exch}, microembolic signal occurring during catheter exchange (advancement and retrieve of catheters, insertion of the wire); MES_{cor}, microembolic signal occurring during coronary examination (engagement of coronary ostium, manipulation of catheters in the ascending aorta); MES_{inj}, microembolic signal occurring during contrast medium injection and catheter flushing with saline solution; IQR, interquartile range.

* Corresponding author at: Cardiology Department, Mirano General Hospital, via Mariutto 13, Mirano, Venice, Italy. Tel.: +39 0415794241.
E-mail address: andreapacchioni@gmail.com (A. Pacchioni).

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in the general population and embolism during invasive procedures [10,11]. The right transradial approach (RTA), which avoids the manipulation of catheters in the abdominal and descending aorta and in the longest part of the aortic arch, could decrease the embolic risk [12], although a counterbalance effect is possible by the increased catheter manipulation in the ascending aorta and by the risk of direct embolization into the right common carotid artery (CCA).

Although the rate of acute stroke after left heart catheterization or PCI is lower than 0.5% [13], silent cerebral embolization is a common event [14,15]. Postprocedural diffusion-weighted magnetic resonance (DW-MRI) imaging has shown an unexpectedly high rate of new brain infarcts [16,17]. Moreover, intraprocedural transcranial Doppler (TCD) scan revealed the systematic occurrence of microembolic signals (MES), related to air embolism, blood clots, platelet aggregates or dislodged atheromatous debris [18]. MES can be detected in almost every surgical and percutaneous cardiovascular procedure [19–25] and are related to new DW-MRI lesions [15].

In the only randomized study directly comparing right radial versus femoral artery approach, however, MES have been higher in the right radial group. This was explained, at least in part, by navigation through tortuous and atheromatous innominate artery and direct debris embolization into the right CCA [26]. The left radial artery is another access site for performing invasive procedures. The left transradial approach (LTA) is as safe and effective as the right radial [27–30] and, having a straighter route to the left heart, could reduce the risk of brain injury. We sought to test this hypothesis by a comparison between the right and left transradial approaches.

2. Methods

2.1. Patients

In June 2011, 40 consecutive patients with suspected coronary artery disease (CAD), admitted for stable angina, unstable angina or acute myocardial infarction without ST-segment elevation underwent coronary angiography after randomization to RTA or LTA using sealed envelopes, with contemporaneous bilateral TCD monitoring of middle cerebral arteries (MCAs). Exclusion criteria were previous by-pass coronary surgery, hemodynamic instability, atrial fibrillation, positive Allen test, need for left ventricle catheterization, hemodialysis patients with an arteriovenous fistula, insufficient acoustic temporal bone window and severe carotid stenosis (excluded by echo-Doppler examination before catheterization). Primary endpoint was the overall amount of MES generated during the procedure, secondary endpoints were the numbers of MES generated at different stages of coronary angiography (see below) and separately in right and left MCA. The study was approved by our local Ethical Committee and all patients gave written consent. The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology.

2.2. Catheterization

For both RTA and LTA, the patient's arm was secured to an arm board on the homolateral side of the catheterization table. All the coronary diagnostic angiographies were performed by experienced interventional cardiologists trained in transradial procedures from both accesses (>150 procedures/year for each access). Access was obtained using the Seldinger technique, with a 20-gauge needle and a 6 Fr radial glide sheath (Radifocus Introducer II, Terumo Europe, Leuven, Belgium). After sheath insertion, a cocktail containing 2500 U of unfractioned heparin, nitroglycerine 200 mcg and verapamil 2.5 mg was injected intra-arterially. The heparin effect was not reversed after the procedure. 6 Fr Judkins diagnostic catheters (Cordis Corporation, Miami, FL, USA) were used as first-choice. A different catheter type (Amplatz, Cordis Corporation, Miami, FL, USA) was used when needed. A standard 0.035 inch wide × 260 cm long J-tip Emerald wire (Cordis Corporation, Miami, FL, USA) was used to bring the catheter to the aortic cusps. Alternatively, hydrophilic 0.035 inch glidewire (Terumo Europe, Leuven, Belgium) was used when needed to overcome supraaortic vessel tortuosity. The wire was advanced in the ascending aorta followed by the diagnostic catheter and, after performing selective coronary angiography, the catheter was exchanged over the wire after adequate back-flow. Catheter exchange was considered both over-the-wire retrieval and advancement of catheters and wire insertion to overcome tortuosity or redirect catheter tip. Selective catheterization of the right and left coronary arteries was carried out connecting the catheter to a closed automatic injection system (Acist CVi, Acist Medical Systems, Eiden Prairie, MN, USA) to allow pressure monitoring and injection. A water-soluble, non-ionic, dimeric contrast medium iodixanol (Visipaque 320 mg I/ml, GE Healthcare, Chalfont St Giles, UK) was used in all procedures. The time needed for every step of the diagnostic procedure was recorded. If indicated, PCI was performed immediately after the diagnostic angiography or deferred according to clinical status and indication. After completion of coronary angiography or intervention, the sheath was removed, and a compression device (Radistop, St Jude Medical, Saint Paul, MN, USA) was applied for hemostasis. Patients were monitored for at least 24 h and any neurologic complications were recorded.

2.3. TCD monitoring

Transtemporal insonation of both MCAs was performed with a power M-Mode Doppler system (ST3, Spencer Technologies, Seattle, WA, USA), using two 2-MHz pulse wave probes (TCD100M, Spencer Technologies, Seattle, WA) fixed bilaterally with a headframe (Marc 600, Spencer Technologies, Seattle, WA) and configured to display Doppler signal power colored red and blue for directionality, in an M-mode format [31]. The single-gate spectrogram from a user-selected depth was displayed simultaneously. MES appeared as characteristic sloping high-power tracks in the image, which facilitates exclusion of potential artifacts. Artifacts tend to show significant power track at all gates simultaneously, whereas true embolic signals have a progression across depth as time changes (Fig. 1) [32]. TCD monitoring was performed and recorded continuously from incision of the artery until withdrawal of the intra-arterial introducer; reported data refer to coronary diagnostic angiography, i.e. until removal of the last diagnostic catheter used. The insonation depth for MCA was from 40 to 60 mm, the sample volume was 9 mm, pulse repetition scale settings were 5 kHz, gain of 40 dB, minimum dynamic range of 80 dB and filter setting was 200 Hz. During the procedure MES were automatically identified and counted while the time of their occurrence was recorded. An examiner reviewed the blinded, recorded exams off-line, assigning MES to different stages of coronary angiography: [1] catheter manipulation (MES_{man}), further distinguished in: manipulation in aortic arch and coronary ostia engagement (MES_{cor}) and catheter exchange, including advancement and over-the wire removal of catheters and insertion of the wire to overcome tortuosity (MES_{exch}); [2] injection of contrast medium and catheter flushing (MES_{inj}).

2.4. Statistics

Previous data [15,28] showed that transfemoral procedures generated 40% fewer particulate MES in comparison to RTA. In our pilot evaluation of MES during RTA procedure we found a total amount of 750 MES in 10 cases (mean 75, standard deviation ± 28) and we hypothesized that LTA, compared to RTA, reduced MES in a similar amount as the transfemoral. Therefore, a minimum of 40 patients had to be enrolled to detect a difference of at least 35% between the two radial access sites with 80% power at $p<0.05$. Distribution of variables was assessed with skewness test. Data were expressed as mean ± standard deviation and as median with interquartile range (IQR), according to distribution, and compared using the Student's T-test (two tailed) for parametric data and the Mann–Whitney U test (two tailed) for non-parametric data. Categorical variables were expressed as proportion and compared with the chi^2 test and Fisher's exact test. Simple and multiple logistic regression analysis (enter method) was performed to evaluate independent predictors of high incidence of MES (cut-off value >66th percentile). The statistical analyses were performed using SPSS 11.0 (IBM, Armonk, NY, USA).

3. Results

No significant differences in baseline characteristics of patients are present between RTA and LTA groups (Table 1). Procedural success was achieved in all cases and characteristics are shown in Table 2. A significant difference was only observed for the higher amount of contrast medium in RTA group (49.2 ± 17.8 ml vs 33.6 ± 5.8 ml, $p=0.001$). Although it was not significant, a trend towards more catheter exchanges in RTA group was also observed. No clinical events were reported; however, MES were detected in all patients with a significantly higher rate in the RTA group (median 61, IQR 47–105, vs 48, IQR 31–60, $p=0.035$; Fig. 2), which also generated more MES_{man} (37, IQR 30–78, vs 22, IQR 17–30, $p=0.001$) and especially MES_{exch} (30, IQR 23–41, vs 13, IQR 8–19, $p<0.001$). A similar rate of MES_{cor} (6, IQR 3–20, vs 7, IQR 2–14, $p=0.718$) and MES_{inj} was detected (23, IQR 9–30, vs 21, IQR 3–34, $p=0.776$) (Table 3). In addition, an individual analysis of each MCA indicated that more MES_{man} entered the right MCA during RTA procedure (22, IQR 16–54, vs 10, IQR 5–31, $p=0.002$), while left MCA has been equally affected by both RTA and LTA (16, IQR 8–19, vs 11, IQR 6–15, $p=0.085$; Fig. 3).

Interestingly, when the whole study population is considered independently of vascular access used, more MES were generated during procedures needing more than 2 catheters ($n=8$) than during