jaa Just accepted article

EuroIntervention

Title: **Radial versus Femoral Approach for Left Ventricular Endomyocardial Biopsy.**

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DOI: 10.4244/EIJ-D-18-01061

Citation: Choudhury T, Lurz P, Schäufele TG, Nobre Menezes M, Lavi S, Tzemos N, Hartung P, Stiermaier T, Makino K, Bertrand OF, Gilchrist IC, Mamas MA, Bagur R. Radial versus Femoral Approach for Left Ventricular Endomyocardial Biopsy. *EuroIntervention* 2019; Jaa-522 2019, doi: 10.4244/EIJ-D-18-01061

Manuscript submission date: 07 November 2018

Revisions received: 23 January 2019

Accepted date: 06 February 2019

Online publication date: 12 February 2019

Radial versus Femoral Approach for Left Ventricular Endomyocardial Biopsy

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Short title: Radial versus femoral access for LV-EMB

Disclosures: Nothing to declare

Funding: None.

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ABSTRACT

Aims: Despite the widespread use of the radial approach in coronary interventions, left ventricular endomyocardial biopsy (LV-EMB) is most frequently performed via the femoral artery. We sought to assess the feasibility and safety of radial compared to femoral access in a large cohort of patients undergoing LV-EMB.

Methods and Results: Data from 264 patients who underwent LV-EMB in Germany, Portugal, Japan and Canada were collected. Clinical, procedural, safety and feasibility data were evaluated and compared between the two groups. LV-EMB was successfully performed by the radial approach in 129 (99%) of 130 and 134 (100%) patients by femoral access. Patients in the radial group were older (mean age 55.7 versus 44.3 years) and were more likely to have moderate-severe mitral regurgitation (27.7% versus TF 0%). Sheathless guides were used in 108 (83.1%) of radial and 2 (1.5%) of femoral patients, so the mean guiding catheter size (radial 7.0±1.0 French versus femoral 8.0±0.1 French, P<0.001) were significantly smaller in the radial group. Mild or moderate radial artery spasm occurred in 13 (10.0%) patients but only 1 (0.8%) patient required conversion to femoral access due to severe spasm. No access-site related complications were reported in the radial group while 11 (8.2%) patients in the femoral group had access-site hematomas (P=0.001). There were no major complications (mitral valve injury, pericardial tamponade requiring intervention, cerebrovascular accidents, persistent high-degree atrioventricular block, major bleeding or death) in either group.

Conclusions: Radial approach for LV-EMB appears to be safe and associated with a high-success rate while possibly leading to fewer access-site bleeding complications compared to the femoral access. The results of this international-multicentre study may support the radial approach for LV-EMB and further inspire the expansion of “radial-first” in the field of interventional cardiology.

Key words: radial, femoral, other, miscellaneous

Abbreviations

BARC: Bleeding Academic Research Consortium

EMB: Endomyocardial Biopsy

LV-EMB: Left Ventricular Endomyocardial Biopsy

PCI: Percutaneous Coronary Intervention

RAO: Radial Artery Occlusion

RHC: Right Heart Catheterization

RV-EMB: Right Ventricular Endomyocardial Biopsy

Condensed Abstract

Left ventricular endomyocardial biopsy (LV-EMB) is traditionally performed via transfemoral approach. Recent studies have shown the safety and feasibility of a transradial approach for LV-EMB. The results of this multicentre-international study show that transradial approach for LV-EMB is associated with high-success rate in patients undergoing native LV-EMB, while possibly leading to fewer access-site bleeding complications compared to femoral access. Transradial access is associated with the use of smaller sheaths, guiding catheters and bioptomes. These results further support the expansion of "radial-first" in the field of interventional cardiology.

INTRODUCTION

Endomyocardial biopsy (EMB) is most frequently undertaken from the right ventricle (RV). Left ventricular EMB (LV-EMB) is less often performed, possibly due to anecdotal concerns regarding safety. However, observational data showed that LV-EMB is equally safe as compared to RV-EMB.[1, 2] Furthermore, in conditions where the non-invasive investigations show a predominant pathological involvement of the LV, LV-EMB provides a higher diagnostic yield compared to RV-EMB.[2, 3]

LV-EMB has traditionally been performed via the femoral approach, but recent small observational studies[4-6] have shown that transradial LV-EMB is feasible and safe. Lower profile bioptomes along with the advent of sheathless guide catheters have allowed the performance of transradial LV-EMB. It is known that the transradial approach for percutaneous coronary interventions (PCI) improves bleeding outcomes that further translates in mortality benefit as compared to transfemoral approach and across a broad spectrum of presentations.[7-10] However, whether the benefits seen in coronary interventions translates to LV-EMB is, at present, unknown. Albeit LV-EMB can be performed using similar equipment to that used for PCI, there are certain differences between the two procedures. These include the use of larger sheaths and guides with transfemoral LV-EMB, whereas performing transradial LV-EMB usually requires smaller outer-diameter sheaths or sheathless guide catheters as compared to patients undergoing routine PCI. Therefore, we sought to assess the safety, feasibility and procedural outcomes of radial compared to femoral approaches for LV-EMB in a multicentre study.

METHODS

Study population and outcomes definitions

This is a multicenter, international registry of patients undergoing LV-EMB via radial or femoral access in Canada, Germany, Japan, and Portugal. Data was gathered prospectively in local databases and then analyzed centrally (TC and RB). Data were collected using electronic and paper health records on multiple variables including, but not limited to, demographics and baseline clinical data, access route, and procedural characteristics (including sheath, guiding catheter and bioptome size along with hemostasis management). Procedure-related complications occurring in the peri-procedural period were recorded. Major complications were defined as pericardial tamponade requiring intervention, cerebrovascular accidents, persistent high-degree atrioventricular block, mitral valve injury, major bleeding defined as per Bleeding Academic Research Consortium (BARC) definitions[11] or death. All access-site related complications were recorded. The Early Discharge After Transradial Stenting of Coronary Arteries (EASY) scale was used to grade wrist hematomas: grade I (up to 5 cm), grade II (up to 10 cm), and grade III (>10 cm).[12] Femoral hematomas were likewise graded using the EASY scale. Incidence of pseudoaneurysms and retroperitoneal hemorrhage was also recorded. Procedural success was defined as the completion of the EMB via the intended access route along with obtainment of number and quality of samples deemed satisfactory for pathological analysis. The study was in accordance with local ethics standards at each participating institution and informed consent was obtained for the procedure.

Left ventricular endomyocardial biopsy: Technical aspects

All procedures were performed by experienced radial and femoral operators who were well versed in performing both RV-EMB and LV-EMB. The choice of access site was not influenced by the indication for LV-EMB but rather by the overall centre experience, expertise and access route of preference by the operator. The decision to perform LV-EMB, instead of RV-EMB was based on clinical and non-invasive assessment. LV-EMB was preferred where the pathological involvement predominantly involved or was suspected to involve the LV on non-invasive studies and/or clinical assessment. The radial LV-EMB procedure has been previously described.[4, 5, 13]

Briefly, transradial LV-EMB can be performed using a standard sheath or a sheathless guide (Eaucath, Asahi Intecc, Japan). The sheath (if used) and guide catheter size depends on the outer diameter of the bioptome. The bioptome is the same type and length required for femoral RV-EMB. For transradial LV-EMB, it is preferred the use of sheathless guides in view of the smaller outer diameter for the same inner diameter as compared to sheaths. For instance, a 6.5-French or 7.5-French sheathless Judkins Right or Multipurpose guides are most commonly used due to their shape that follows the long axis of the LV cavity. After radial access is gained, the sheathless guide mounted on its dilator is advanced over a 0.035" guidewire under fluoroscopy guidance up to the ascending aorta, where the dilator is then removed. Intravenous heparin is recommended to reduce the risk of systemic embolization and also administered as per standard practices to prevent radial artery occlusion (RAO), and doses were left to the operator's discretion.

Transfemoral access for LV-EMB was performed under fluoroscopic guidance, in an antero-posterior view, and using a radiopaque marker placed at the femoral head level as landmark. Once access is gained, the guiding catheter is advanced over a 0.035" wire under fluoroscopy guidance up to the ascending aorta. The remainder of the procedure is as described below.

A pigtail catheter can be inserted into the guide catheter for additional safety and used to cross the aortic valve, thereby positioning the guide catheter in the mid-LV cavity, then, the pigtail catheter is removed. The position of the guide catheter is confirmed in orthogonal views (i.e. right anterior oblique 30-45º and left anterior oblique 30-45º). A Y-type hemostatic valve is connected to the guide catheter, and thorough flushing with saline is performed after connection to a conventional manifold. A bioptome is advanced into the LV through the hemostatic valve and guide catheter. Bioptome size is usually 5.5-French, although smaller sized bioptomes (3-French) are also available. Samples are then obtained. Importantly, repetitive bleed-back and manual flushing are strongly advised to avoid air embolization during each sample extraction and bioptome re-insertion. Following completion of a transradial LV-EMB, a radial hemostatic band is positioned over the radial access site, the guide catheter is removed over the 0.035" guidewire, and at this point, the hemostatic band is adjusted to the wrist.[4, 5, 13] For transfemoral LV-EMB, manual pressure or a vascular closure device was employed to achieve hemostasis.

Statistical analyses

Continuous variables are expressed as mean ± standard deviation, and categorical variables are expressed as n (%). Comparison of continuous variables was performed using the Student *t*-test, and categorical variables were compared using the Chi-square test. All statistical tests were 2-tailed, and differences were considered statistically significant when a P-value was <0.05. Data analyses were performed using the Statistical Package for Social Sciences (SPSS) version 24 (IBM, Inc. in Chicago, Illinois, USA).

RESULTS

Population and pre-procedural characteristics

A total of 264 patients underwent LV-EMB; of those, 130 (49.2%) were performed through the radial and 134 (50.8%) through the femoral access. Patients in the radial group were significantly older (55.7±14.3 versus 44.3±15.4 years, P<0.001) and had a lower mean left ventricular ejection fraction (33.7±15.4% versus 38.4±16.9%, P=0.02) compared to the femoral group. More patients in the radial group presented with New York Heart Association classification III/IV (43.8% versus 30.6%, P<0.001). All patients had LV-EMB for the first time (except 1 patient in the transradial group). In the transradial group, the most common indications for LV-EMB were dilated cardiomyopathy (30.5%), infiltrative cardiomyopathy (21.1%) and myocarditis (14.1%), whereas in the transfemoral group it was myocarditis. Relevant patients' demographics and baseline clinical characteristics are detailed in **Table 1**.

Access, sheath and guide catheters

Intravenous heparin was administered in 124 (95.4%, mean 4252±1104 IU) patients in the radial group and none in the femoral group. Mild or moderate radial artery spasm occurred in 13 (10.0%) patients and 1 (0.8%) patient required crossover to femoral access due to severe spasm.

In the radial group, 22 (16.9%) patients had sheaths inserted while the remainder (n=108; 83.1%) underwent LV-EMB via a sheathless guide. In the femoral group, 132 (98.5%) of patients had sheaths inserted (all 8-French) while 2 patients had LV-EMB via a sheathless guide (both 7.5-French). Sheath size was significantly smaller in the radial group (radial 5.1±0.2 French versus TF 8.0±0.0 French, P<0.001). The majority of sheathless guide catheters were 7.5-French (n=93/110; 84.5%), therefore, the mean guide catheter size was significantly smaller in the radial group (radial 7.0±1.0 French versus femoral 8.0±0.1 French, P<0.001). **Table 2** illustrates the procedural data.

Left ventricular endomyocardial biopsy

The procedural success rate was 99% (129 of 130 patients) in the transradial group and 100% in the transfemoral group (P=0.31). In radial patients, 5.5-French (84%) and 3-French (16%) bioptomes were used whereas all femoral patients had 5.4-French bioptomes. The radial group had a higher number of samples obtained per LV-EMB as compared to the femoral group (6.8±2.6 versus 6.1±0.8, P=0.005). Samples obtained were quantitatively and qualitatively suitable for pathological analysis in all patients and in both groups. The fluoroscopy times were similar in the two groups (TR 8.0±3.7 versus TF 8.3±3.1 minutes, P=0.44).

In the radial group, the common pathology diagnoses were myocarditis (20.8%), idiopathic dilated cardiomyopathy (19.2%), and amyloidosis (13.1%). In the femoral group, the commonest pathology diagnoses were myocarditis (70.9%), idiopathic dilated cardiomyopathy (14.2%) and persistent of chronic viral infection (9.7%).

Concomitant coronary angiography and right heart catheterization

A total of 110 (84.6%) patients in the radial group and 132 (98.5%) patients in the femoral group underwent concomitant coronary angiography (**Table 2**). Thirty (23.1%) patients in the radial group underwent concomitant right heart catheterization (RHC), 19 (63%) of them through a forearm vein. In the femoral group, 129 (96.3%) patients underwent concomitant RHC, and 3 (2.3%) of these had RHC through a forearm vein.

Post-procedural management

Patent hemostasis was achieved in 120 patients (92.3%) in the transradial group (**Table 2**). The TR Band (Terumo) was used in 80 (61.5%) patients and the Bengal Radial Compression Band (Ates Group, Benrikal) in 29 (22.3%) patients. In the transfemoral group, hemostasis was achieved using manual pressure and compression bandage in all patients except for 1, who had a suture-mediated vascular closure device (ProGlide, Abbott Vascular, Illinois, USA).

Periprocedural complications

There were no major complications in either group. Access-site related hematoma occurred in 11 (8.2%) patients in the transfemoral group while none in the transradial group (P=0.001). Of these 11 patients, 9 had grade 2, and 2 had grade 1 hematomas. No retroperitoneal bleeds or pseudoaneurysms were reported. Pericardial effusion was noted in 4 transradial and 14 transfemoral patients. None of the pericardial effusions were hemodynamically significant to require any form of intervention. Two patients in the femoral group developed transient high-degree atrioventricular block, but no pacing was required. Non-sustained ventricular tachycardia was observed in 1 (0.8%) patient in the transradial group and 3 (2.3%) patients in the transfemoral group (P=0.33). **Table 3** shows detailed procedure-related complications.

DISCUSSION

The results of this study including 264 patients undergoing LV-EMB show that the radial approach is feasible and safe, achieving similar high procedural success rates whilst appears to be associated with less access-site related bleeding complications as compared to the femoral route.

The safety of LV-EMB has already been demonstrated in reports comparing LV-EMB versus RV-EMB[1-3] using the femoral artery and vein routes. Yilmaz et al.[1] showed a higher rate of minor complications in the LV-EMB group as compared to the RV-EMB group; however, the authors found similar, low rates, of major complications including hemopericardium requiring pericardiocentesis and stroke (0.32%, each, respectively). Chimenti et al.[2] reported data on patients undergoing transfemoral LV-EMB and noted a 0.08% rate of cardiac perforation and tamponade, a 0.22% rate of transient cerebral ischemia and no deaths. The authors also reported more frequent local complications (access site hematoma) or vasovagal reaction during LV-EMB compared to RV-EMB.[2] Conversely, Stiermaier et al.[3] showed one major complication, a pericardial tamponade requiring surgical revision during RV-EMB, whereas no severe complications occurred during LV-EMB.

Notably, data on transradial LV-EMB is still scant, and previous case series have shown absence of major complications during the procedures,[5, 6] and very low rate of minor complications, yet with small sample sizes. In the present study, we show a very low rate of complications using either transradial or transfemoral accesses and, to best of our knowledge, we are the first to compare the transradial and transfemoral approaches for LV-EMB, and further confirm the safety profile of the transradial approach in terms of lowering access-site related bleeding complications.

A recent study[14] showed that over a 12-year period, more than 70000 EMB were performed in the United States and thus, this number is certainly much larger worldwide. While the vast majority of these procedures are likely to be RV-EMB (site of EMB not specified in study), the already known equivalent safety of RV-EMB and transfemoral LV-EMB[1, 2] may potentially increase the adoption of LV-EMB into clinical practice. Hence, extrapolating these findings to a larger population, it suggests a fairly sizeable composite risk of major and minor complications with the femoral access for LV-EMB, therefore, raises the question of whether the radial approach would contribute to further minimise this risk.

Access-site, catheters and concomitant procedures

The choice for initial access-site directly influences the cases for concomitant coronary angiography and/or RHC as seen in the present study. Previous studies in the coronary setting have evaluated the frequency of access-site cross-overs. Importantly, the main reasons for conversion from radial to femoral are usually failure to obtain access/significant radial artery spasm, or forearm and subclavian tortuosity. Our cross-over rate from transradial to transfemoral was only 0.8%, and this was secondary to severe radial spasm. We observed mild or moderate radial spasm in 10% patients, but this can be easily overcome in most cases with intra-arterial vasodilators. Furthermore, sizing of the radial artery using ultrasound guidance might help further reduce the chances of radial spasm.

The sheath (when used) and guiding catheter sizes were significantly smaller in the radial group compared to the femoral group, thus allowing the procedure to be performed via smaller sized arteries. Smaller sheath size has been shown to be an independent predictor of access-site related bleeding and RAO complications in transradial coronary interventions.[15] Importantly, sheath and guiding catheter size are not a limiting factor for transradial LV-EMB with the advent of smaller profile bioptomes and sheathless guides. Indeed, 84% of the transradial LV-EMBs were performed with a 5.5-French bioptome, therefore, slightly larger size compared to the femoral group (5.4-French). Sheathless guides have overcome the “working space advantage” of femoral access, for instance, a 7.5-French sheathless guide has a 2.49 mm external-diameter and 2.05 mm internal-diameter allowing the passage of a 5.5-French (1.85 mm shaft outer-diameter) biopsy forceps. Moreover, the outer-diameter of a 7.5-French sheathless guide is smaller than a standard 6-French sheath (2.70 mm). In addition, smaller-sized (3-French) bioptomes have allowed LV-EMB via 5-French sheaths in 16% of our radial patients.

This data is also relevant for those patients undergoing concomitant coronary angiogram, RHC, and EMB since the three procedures can be performed via the radial artery and forearm vein, respectively, providing a “one-stop shop” to do these procedures through the arm at a lower bleeding risk. Patients undergoing coronary angiogram can have their angiography done using 5-French catheters, and then exchange the radial sheath with a 6.5-French or 7.5-French sheathless guide catheter to perform LV-EMB. Even though we found that transfemoral patients had more concomitant RHCs and angiograms, transradial patients had more samples taken, therefore, obtaining comparable fluoroscopy times between the groups.

Bleeding risk, hemostasis, and post-procedural care

The radial artery is a superficial artery that can be easily compressed, and liberal compression can be applied along the distal forearm to achieve hemostasis. In our study, the transfemoral group had a significant number of patients with access-site hematoma (EASY Grade 1 and 2, 8.2%), whereas none of the transradial patients had any access-site bleeding complications. Notably, although 98.5% patients undergoing transfemoral LV-EMB received 8-French sheaths, they did not systematically receive IV heparin, while all transradial patients did. Although manual compression was used in the majority of patients in the femoral group, and a vascular closure device was used in one patient only, this is unlikely to influence the rate of access site-related complications in the femoral group as manual compression and closure devices have been shown to be comparable in terms of safety.[16] Our findings build upon the evidence base for the well-known reduction in access-related risk of bleeding using the transradial approach, now applied to the setting of LV-EMB. Moreover, elective patients undergoing transradial LV-EMB can mobilize earlier and thus, potentially discharged quicker.[17]

Importantly, one of the limitations of the transradial route would be the need for repeat EMB (i.e. heart transplant patients needing surveillance EMB). Repeat procedures via the same radial artery are both feasible and safe. However, the rate of RAO may increase with successive procedures.[18, 19] Intravenous heparin 50 U/Kg along with patent hemostasis and shortened compression times (i.e. 60 minutes) protocols significantly reduce the incidence of RAO.[20, 21] In our series, intravenous heparin was administered in 95% of the patients and patent hemostasis was achieved in the majority (92%) of them. Notably, although the risk of ventricular perforation is rare, and even more with LV-EMB as compared to RV-EMB,[2, 3] heparin can be rapidly reversed with protamine.

Limitations

The main limitation of this study lies in its non-randomized nature and inherent risks of selection bias encountered in these study populations. Another limitation of this study is that ultrasound guidance was no systematically used to identify the bifurcation of the common femoral artery while obtaining femoral access. As above-mentioned, almost all patients in the transfemoral group had 8-French sheaths and guides, precluding therefore, a head-to-head comparison in terms of sheath size. Despite this limitation, the risk of access site complications is likely to be influenced by a balance of factors such as sheath size, arterial access and hemostasis techniques but also the use of heparin. Nonetheless, our study shows a real-world population comparing current practices of radial and femoral access for LV-EMB. A potential limitation with the use of 3-French bioptomes is the likelihood of obtaining smaller sample sizes and hence non-diagnostic EMB. However, this was not the case in any of the 21 patients undergoing LV-EMB using 3-French bioptomes, highlighting the importance of the technique rather than the actual bioptome size.

Radial artery patency was not systematically assessed using the reverse Barbeau test and/or Doppler ultrasound, however, this data reflects daily real-world practice and is not dissimilar to the coronary practice where radial artery patency is not routinely assessed prior to hospital discharge. Although randomized-controlled trials may help determine the superiority or non-inferiority of either access for LV-EMB, these might be difficult to undertake. Certainly, these results should indeed be validated and supported by future, larger-scale studies. Meanwhile, in the absence of definitive evidence, the well-established benefits of the radial access in minimizing vascular and bleeding complications may also apply for patients undergoing LV-EMB.

CONCLUSION

Radial approach for LV-EMB appears to be safe and associated with high-success rate while possibly leading to fewer access-site bleeding complications compared to femoral access. The results of this multicentre-international study may support the radial approach for LV-EMB and further inspire its expansion in the field of interventional cardiology. Moreover, the conversion to a "radial-first" access strategy could also be encouraged for invasive cardiologists, without interventional-training, performing diagnostic procedures and EMB.

Impact on daily practice

Left ventricular endomyocardial biopsy (LV-EMB) appears to be as safe as right ventricular endomyocardial biopsy. The transradial approach for LV-EMB is associated with high-success rate in patients undergoing native LV-EMB, while possibly leading to fewer access-site bleeding complications compared to femoral access. Transradial access is associated with the use of smaller sheaths, guiding catheters and bioptomes. The results of this multicentre-international study further inspire the expansion of "radial-first" in the field of interventional cardiology."

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Table 1: Baseline clinical characteristics of patients undergoing left ventricle endomyocardial biopsy

Variables	Transradial n=130	Transfemoral n=134	P-value
Age	55.7±14.3	44.3±15.4	<0.001
Male	81 (62)	98 (73)	0.060
Weight (Kg)	76.1±21.5	84.9±18.8	0.001
Body mass index	26.4±6.5	27.3±6.4	0.31
Hypertension	42 (32)	69 (52)	0.001
Dyslipidemia	28 (22)	40 (30)	0.11
Diabetes	14 (11)	15 (11)	0.90
New York Heart Association III/IV	57 (43)	41 (31)	<0.001
Coronary artery disease	17 (13)	6 (4.5)	0.013
Atrial fibrillation/flutter	19 (15)	17 (13)	0.72
Cerebrovascular disease	1 (0.8)	1 (0.7)	0.97
Peripheral vascular disease	2 (1.5)	1 (0.7)	0.54
Chronic kidney disease*	20 (15)	37 (28)	0.11
Chronic obstructive pulmonary disease	4 (3.1)	1 (0.7)	0.17
Smoker (current or previous)	34 (26)	65 (49)	<0.001
Previous heart transplant	0 (0)	0 (0)	-
Left ventricular ejection fraction (%)	33.7±15.4	38.4±16.9	0.022
Moderate or severe mitral regurgitation	36 (28)	0 (0)	<0.001
Left ventricular hypertrophy	51 (39)	28 (21)	<0.001
First endomyocardial biopsy	129 (99)	134 (100)	0.31

Values are expressed as n (%) or mean ± standard deviation. Some percentages may not add up to 100 because of rounding. *Estimated glomerular filtration rate <60 mL/min/1.72m^2.

Table 2. Procedural characteristics of patients undergoing left ventricle endomyocardial biopsy

Variables	Transradial n=130	Transfemoral n=134	P-value
First endomyocardial biopsy	129 (99)	134 (100)	0.31
Procedural Success	129 (99)	134 (100)	0.31
Right radial access	129 (99)	-	-
Left radial access	2 (1.5)	-	-
Crossover	1 (0.8)	0 (0)	-
Allen's test	86 (66)	-	-
Plethysmography test	15 (12)	-	-
Intra-arterial verapamil	104 (80)	-	-
Heparin given	124 (95)	0 (0)	<0.001
Heparin dose (IU)	4252±1104	-	-
Sheath used	22 (17)	132 (99)	<0.001
Sheathless	108 (83)	2 (1.5)	<0.001
Sheath size (if sheath used)	5.1±0.2	8.0±0.0	<0.001
5-French	21 (16)	0 (0)	<0.001
6-French	1 (0.8)	0 (0)	
8-French	0 (0)	132 (98.5)	
Guiding catheter size (including sheathless)	7.0±1.0	8.0±0.1	<0.001
5-French	21 (16)	0 (0)	<0.001
6-French	1 (0.8)	0 (0)	
6.5-French	14 (11)	0 (0)	
7.5-Fr	91 (70)	2 (1.5)	
8-French	0 (0)	132 (98.5)	
8.5-French	3 (2.3)	0 (0)	
Guide shape used			
Judkins Right 3.5/4	20 (15)	133 (99)	-
Multipurpose	99 (76)	1 (0.7)	
Power Backup	1 (0.8)	0 (0)	
Mild or moderate radial spasm	13 (10)	-	-
Bioptome size	5.1±0.9	5.4±0.0	<0.001
3-French	21 (16)	-	-
5.4/5.5-French	109 (84)	134 (100)	
Number of samples taken	6.8±2.6	6.1±0.8	0.005
Concomitant RHC	30 (23)	129 (96)	<0.001

RHC via forearm vein	19 (15)	3 (2.2)	<0.001
Concomitant coronary angiography	110 (85)	132 (99)	<0.001
Fluoroscopy time (minutes)	8.0±3.7	8.3±3.1	0.44
Patent haemostasis	120 (92)	-	-
Hemostatic wrist band			
Bengal	29 (23)	-	
TR band	80 (62)	-	
ProGlide	0 (0)	1 (0.7)	-
Other	21 (16)	-	

Values are expressed as n (%) or mean ± standard deviation, unless otherwise stated. RHC: right heart catheterization. IU: international units. Some percentages may not add up to 100 because of rounding.

Table 3. Periprocedural complication rates

Complication	Transradial n=130	Transfemoral n=134	P-value
Pericardial effusion	4 (3.1)	14 (10)	0.018
Pericardial tamponade	0 (0)	0 (0)	-
Arteriovenous fistula	0 (0)	0 (0)	-
Transient atrioventricular block	0 (0)	2 (1.5)	0.16
Persistent atrioventricular block	0 (0)	0 (0)	-
Non-sustained ventricular tachycardia	1 (0.8)	3 (2.3)	0.33
Transient or persistent hypotension	0 (0)	0 (0)	-
Mitral valve/apparatus injury	0 (0)	0 (0)	-
Stroke or TIA	0 (0)	0 (0)	-
Access-site hematoma (Grade 1 and 2)	0 (0)	11 (8.2)	0.001
Death	0 (0)	0 (0)	-

Values are expressed as n (%) or mean ± standard deviation, unless otherwise stated. TIA: transient ischemic attack.