# Subclavian angioplasty during coronary interventions using radial approach

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## ABSTRACT

**Background:** In the past years, the percentage of percutaneous coronary angiography and coronary interventions using radial access had significantly increased due to its higher safety, lower risk of major bleeding, and hence lower cardiovascular mortality. Subclavian artery stenosis is one of the challenges that may be met during transradial coronary interventions, which may necessitate femoral access crossover or conversion.

**Aims:** To evaluate the feasibility and safety of performing subclavian angioplasty *via* radial access during complex coronary interventions using the forearm approach.

**Methods:** A series of patients with complex radial approach due to subclavian stenosis received subclavian angioplasty during the procedure. We included 48 patients out of 22 500 procedures performed from February 2009 to February 2020. All patients did not have alternative vascular access due to extensive peripheral arterial disease (previous history of iliac stenting or distal aortic occlusion, which makes femoral access crossover difficult; also the contralateral radial/ulnar artery was very faint or not detectable at all).

**Results:** Mean age was 72 (10) years and 67% of patients were males. Subclavian angioplasty was successfully done in all patients *via* ipsilateral radial access; 44 patients (91.7%) required subclavian stenting, and 4 patients were treated by subclavian angioplasty without stenting. Coronary angiography or intervention was perfectly achieved through the revascularized subclavian artery; coronary stenting was successfully done in 36 patients as indicated.

**Conclusions:** It can be concluded that percutaneous subclavian artery angioplasty can be done safely and effectively to facilitate complex transradial coronary procedures with an acceptable immediate technical success, especially in patients without alternative vascular access. Also, we may conclude that subclavian angioplasty may be successfully performed in patients with symptomatic upper limb ischemia, *via* the radial approach.

**Key words:** percutaneous coronary intervention, peripheral intervention, transradial approach

## INTRODUCTION

In the past years, the percentage of percutaneous diagnostic coronary angiography procedures and coronary interventions by radial or ulnar access had increased significantly. This increase is attributed to the reduction in mortality, major adverse cardiovascular events (MACE), and rate of major bleeding and vascular complications, hence the improved safety with the radial or ulnar approach [1, 2].

Diffuse atherosclerotic disease of the radial, ulnar or subclavian arteries, repeated procedures, iatrogenic dissection, and the need for intervention catheters with a larger diameter are the most encountered obstacles and the most frequent causes of femoral crossover or conversion [3–5].

Subclavian artery stenosis is associated with higher cardiovascular morbidity and mortality. It remains an important cause of

## WHAT'S NEW?

The transradial approach is the routine access for percutaneous coronary procedures in most centers. However, there are still complex cases in which radial access may not be successful due to the presence of severe atherosclerotic disease or stenosis in the radial or subclavian artery. We present a series of 48 patients with a complex forearm approach due to subclavian stenosis, for which subclavian angioplasty was performed during the procedure. All the included patients did not have alternative vascular access. According to our knowledge, this is the first series in which subclavian angioplasty is performed *via* the radial route. We have found that percutaneous subclavian artery angioplasty can be done safely to facilitate complex transradial coronary procedures, especially in patients without alternative vascular access. Also, we can postulate that subclavian angioplasty may be successfully performed in patients with symptomatic upper limb ischemia, *via* the radial approach.

upper limb, brain, and cardiac ischemia [6]. Subclavian artery angioplasty is an alternative to femoral crossover in complex radial or ulnar access. Subclavian angioplasty procedures have been performed with success in symptomatic patients with critical upper limb ischemia; however, their use in patients undergoing transradial coronary procedures is still not known [7, 8].

This study aimed to underline the safety and efficacy of performing subclavian angioplasty *via* the transradial approach during coronary intervention procedures.

## METHODS

We present a series of procedures with a complex radial approach due to subclavian stenosis, for which subclavian angioplasty was performed during the procedure. All patients had manifestations of ipsilateral upper limb ischemia in the form of claudication and difficult alternative vascular access due to diffuse and advanced atherosclerotic peripheral vascular disease. In all the included patients, the ipsilateral radial artery was palpated, but the contralateral side was faint or not palpable. We set goals of efficacy and safety that included the success rate of the procedure and the existence of radial/ulnar pulse at follow-up. Before performing the subclavian angioplasty, other strategies like sheathless catheters, 4–5 F catheters, and balloon-assisted tracking over angioplasty wire were tried without success [9]. All patients were on antiplatelet therapy, and immediately after the cannulation of the ipsilateral radial artery, the cocktail was administered through the introducer with 5000 IU of unfractionated heparin and 200 µg of nitroglycerin. In cases of suspicion of vasospasm, boluses with nitroglycerin or verapamil and sedatives were administered.

There were 48 cases of subclavian angioplasty, out of 22 500 coronary procedures, from February 2009 to February 2020. Patients presenting with the acute coronary syndrome (ACS) were excluded.

These were the steps of the procedure (Figure 1):

- Access through the radial route and advancing the 6 F introducer sufficiently to progress the catheters through the artery.
- Proceeding with a hydrophilic 0.035"guidewire or, if not possible, a 0.014"or 0.018"angioplasty guidewire trying to negotiate the stenosed subclavian artery.
- Progressing the peripheral over-the-wire (OTW) balloons and dilating the diseased segment.
- Proceeding with the coronary procedure and intervention as needed.
- Performing control injection at the end of the procedure to assess for residual stenosis or possible complications resulting from subclavian angioplasty and stenting of the diseased segment if needed.

The following data were collected: patients' demographics and risk factors, coronary angiographic data, subclavian angioplasty procedure details (wires used, balloons for predilatation or postdilatation, and subclavian stenting), and outcomes (success of subclavian angioplasty and success of coronary interventions).

Follow-up was performed at 1, 3, 6, and 12 months postprocedure. Clinical follow-up included recording of vital signs and palpation of the radial and ulnar pulses in all visits. An arterial duplex was performed at 6 and 12 months after the angioplasty procedure. Follow-up echocardiography was performed 1 month and 1 year after the coronary intervention.

### *Statistical analysis*

Statistical analysis was conducted using Statistical Package for Social Sciences (SPSS version 25.0). Categorical variables are expressed as absolute values and percentages. Continuous variables were expressed as mean (standard deviation [SD]).

## RESULTS

### *Patients' characteristics (Table 1)*

Most of the patients were male (67%) with multiple cardiovascular risk factors (83% hypertensive, 75% dyslipidemic [low-density lipoprotein cholesterol, LDL-C, >160 mg/dl or triglycerides, TGs, >200 mg/dl], and 83% diabetic). Peripheral arterial disease (PAD) was previously documented in all patients; 36 patients had a previous history of iliac stenting,

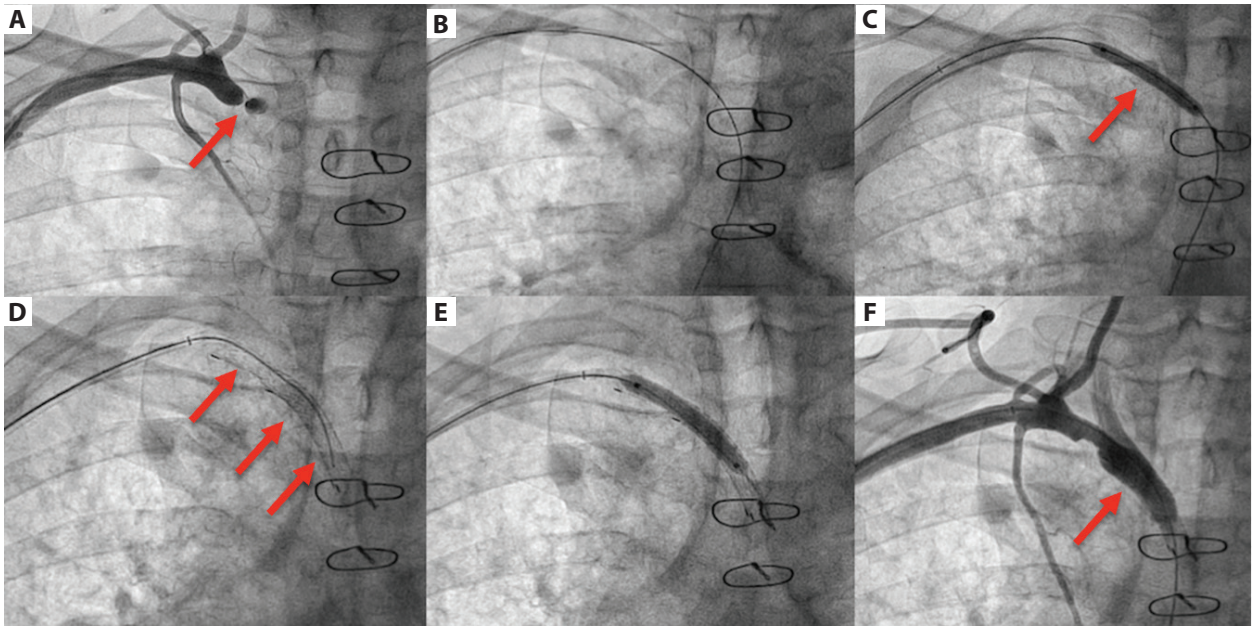


**Figure 1.** Angiogram showing: **A.** Severe stenosis in the right subclavian artery (the arrow). **B.** Crossing with a 0.018″ guide wire. **C.** Dilatation with a balloon 5 × 40 mm (the arrow). **D.** Two self-expandable stents 6 × 40 mm and 6 × 60 mm were deployed. **E.** Postdilatation with a 7 × 40 mm balloon. **F.** Good angiographic result (the arrow)

**Table 1.** Demographics and patients' characteristics

| | |
|---|---|
| Age, years, mean (SD) | 72 (10) |
| Male sex, n (%) | 32 (67) |
| Active smoker, n (%) | 24 (50) |
| Hypertensive, n (%) | 40 (83) |
| Diabetes mellitus, n (%) | 40 (83) |
| Atrial fibrillation, n (%) | 5 (10.4) |
| Hyperlipidemic (LDL-C >160 mg/dl or TGs >200 mg/dl), n (%) | 36 (75) |
| Peripheral artery disease, n (%) | 48 (100) |
| Previous peripheral (iliac) stenting, n (%) | 36 (75) |
| Prior ischemic heart disease (stable anginal symptoms or previous ACS or coronary revascularization), n (%) | 32 (67) |
| Previous coronary intervention by the same approach, n (%) | 8 (17) |
| BMI, kg/m$^2$ | |
| Overweight, BMI, 25–29.9 kg/m$^2$, n (%) | 26 (54.2) |
| Obese, BMI >30 kg/m$^2$, n (%) | 5 (10.4) |
| Chronic kidney disease, eGFR <30 ml/min/1.73m$^2$, n (%) | 4 (8) |
| Hemoglobin level, g/dl, mean (SD) | 13.5 (2.1) |
| Serum creatinine, mg/dl, mean (SD) | 1.0 (0.9) |
| Medications, n (%) | |
| Antiplatelets | 44 (91.7) |
| NOAC | 5 (10.4) |
| Statins | 48 (100) |

Abbreviations: BMI, body mass index; eGFR, estimated glomerular filtration rate; LDL-C, low-density lipoprotein cholesterol; NOAC, non-vitamin K antagonist oral anticoagulants; TGs, triglycerides

4 patients had occluded distal aorta and 67% of patients had a previous history of coronary artery disease (CAD; stable anginal symptoms, or previous history of ACS, or coronary revascularization). Five patients (10.4%) had atrial fibrillation and were taking anticoagulation (non-vitamin K antagonist oral anticoagulants [NOAC], 3 patients were taking apixaban, and 2 patients were taking rivaroxaban). Statins were used in all patients, and 44 patients (91.7%) were taking antiplatelets. Mean hemoglobin concentration was 13.5 (2.1) g/dl, serum creatinine level was 1.0 (0.9) mg/dl. Twenty six patients were overweight (body mass index [BMI], 25–29.9 kg/m$^2$), and five patients (10.4%) were obese (BMI >30 kg/m$^2$).

### *Procedural data (Table 2)*

Regarding angiographic data, severe arteriosclerotic stenosis of the subclavian artery was found in most of the included patients, and only four patients (8.3%) had a totally occluded subclavian artery which was successfully crossed with a steerable stiff 0.014-inch wire (e.g., ASAHI Confianza [Abbott Vascular, Santa Clara, CA, US]). Angioplasty was performed with different types of OTW peripheral balloons, the most commonly used balloon diameter was 6 mm. All cases were done with 6 F guiding catheters. Subclavian stenting was performed in 44 patients (91.7%), and 4 patients did not require stenting due to good luminal gain on control angiography performed at the end of the procedure. Balloon expandable stents were used in 50% of patients. Eight patients required 2 stents for treating subclavian stenosis. Destination introducer, to correct radial/brachial tortuosity, with a 6 F therapeutic catheter was used in eight patients. 75% of patients had significant CAD that was treated by coronary stenting, and 25% had non-significant CAD. For closure of the radial artery, a pneumatic brace system was used for 4–6 hours. Aspirin 75–100 mg was given to all patients, clopidogrel was used in 38 patients (79.2%), and ticagrelor in 5 patients (10.4%).

**Table 2.** Procedural data and follow-up

| | |
|---|---|
| Multivessel coronary disease, n (%) | 32 (67) |
| Angiographic severe coronary calcification, n (%) | 16 (33) |
| Totally occluded subclavian artery, n (%) | 4 (8) |
| Right subclavian artery disease, n (%) | 32 (67) |
| Wires used, n (%) | |
| 0.014″ | 32 (67) |
| 0.018″ | 16 (33) |
| Exchange to 0.035″ wire (after predilatation) | 24 (50) |
| Balloon predilatation, n (%) | 48 (100) |
| Predilatation balloon diameter, mm, mean (SD) | 4.8 (1.5) |
| Predilatation balloon length, mm, mean (SD) | 60 (34) |
| Subclavian stenting, n (%) | 44 (91.7) |
| Patients requiring two stents, n (%) | 8 (17) |
| Subclavian stent diameter, mm, mean (SD) | 6.25 (0.9) |
| Subclavian stent length, mm, mean (SD) | 59.7 (19.5) |
| Balloon postdilatation, n (%) | 16 (33) |
| Postdilatation balloon diameter, mm, mean (SD) | 7.0 (0.9) |
| Postdilatation balloon length, mm, mean (SD) | 50 (11.5) |
| Vascular complications, n (%) | 0 |
| Coronary PCI, n (%) | 36 (75) |
| Long sheath 90 cm, n (%) | 8 (17) |
| Successful coronary intervention, n (%) | 48 (100) |
| Medications, n (%) | |
| Aspirin | 48 (100) |
| Clopidogrel | 38 (79.2) |
| Ticagrelor | 5 (10.4) |
| NOAC | 5 (10.4) |
| Follow-up, n (%) | |
| Patency of ipsilateral forearm pulsations | 48 (100) |
| MACE | 0 |

Abbreviations: MACE, major adverse cardiovascular events; PCI, percutaneous coronary interventions; other — see Table 1

### *Follow-up (*Table 2*)*

With follow-up at 1, 3, 6 months, and 1 year, ipsilateral radial and ulnar pulse were clearly felt in all patients. Arterial duplex showed patent ipsilateral peripheral circulation in all treated patients. Four patients required repeat coronary angiography, and the subclavian stent was found to be widely patent in all of them. Patients with atrial fibrillation were maintained on aspirin and anticoagulants for 6 months, then aspirin was stopped. No MACE (myocardial infarction, stroke, arrhythmia, or mortality) was recorded in any of the included patients.

## DISCUSSION

Nowadays, the transradial approach in coronary angiography and percutaneous coronary interventions (PCI) is an attractive alternative to the femoral approach. The expanded use of the transradial approach originates from its high procedural success, reduced risk of major access site-related bleeding, lower mortality, increased patient comfort, and cost reduction [1, 2].

However, there are still complex cases in which radial access may not be successful due to the presence of severe atherosclerotic disease or stenosis in the subclavian artery [3–5].

The evolution of the transradial approach over the last few years brought about new procedural difficulties that should be overcome by evolving techniques. As in the above-described cases, atherosclerotic disease or stenosis of the subclavian artery is a major obstacle to a successful radial approach and may result in complications or conversion to a transfemoral approach. Radial access is routinely used in our center, and we try to overcome any difficulties in the access site before shifting to alternative access without causing harm to the patients. Subclavian artery angioplasty represents a useful technique to overcome this obstacle in symptomatic patients undergoing coronary angiography or PCI.

We included 48 cases of symptomatic subclavian artery stenosis, all patients had 1 or more risk factors for atherosclerosis and had a documented history of extensive PAD; which ruled out the possibility of using other vascular accesses or shifting to femoral access. In the included patients, the ipsilateral radial artery was palpated, but the contralateral side was faint or not palpable, which made shifting to the contralateral side impractical. Also shifting to femoral access was not feasible as all of the included patients had extensive lower limb arteriopathy and history of iliac intervention or distal aortic occlusion. When thoroughly analyzing the patients' history, we found that most of the patients had symptomatic upper extremity ischemic symptoms. All patients underwent successful subclavian angioplasty through the radial approach, with or without stent implantation.

In most published series [8], left subclavian artery angioplasty predominates over right, perhaps because of some reservations about angioplasty at a site near the right common carotid origin. However, in our series, most of the cases (32 out of 48) had right subclavian artery disease which was successfully treated percutaneously without complications.

For the treatment of symptomatic hand ischemia, endovascular treatment with percutaneous angioplasty is now considered the first-line therapy for above elbow arterial diseases. Surgical revascularization is reserved for difficult cases with anatomy unfavorable to the percutaneous approach. The risk of new neurological or ischemic sequelae following subclavian angioplasty is very low [7, 8, 10].

Although the primary aim of our procedure was to open the subclavian artery to continue the percutaneous coronary procedure, this may raise the possibility of adopting radial access or a route for performing ipsilateral subclavian angioplasty while percutaneously treating symptomatic subclavian stenosis. According to our knowledge, this is the largest series in which subclavian angioplasty was performed *via* the radial route using single ipsilateral access, unlike most of the published series [10–13], in which the femoral route was the standard access.

## CONCLUSION

Percutaneous subclavian artery angioplasty through the radial route is a safe and effective tool in symptomatic patients during complex transradial coronary procedures. It has an acceptable immediate technical success, leading to a reduction in the need for femoral crossover which may not be feasible in all patients especially those at high cardiovascular risk or having extensive PAD. Also, we may conclude that subclavian angioplasty may be successfully performed in patients with symptomatic upper limb ischemia, *via* the radial approach.

### *Study limitations*

The main limitation is the design of the study, which is retrospective and non-comparative. Further studies may be needed to validate and confirm the findings in our study.

Screening for subclavian stenosis was not routinely performed in all patients, it was only diagnosed when the percutaneous catheters or guidewires could not advance into the aorta; this may underestimate the prevalence of subclavian stenosis in the studied population.

The contralateral subclavian artery was not injected to look for contralateral subclavian disease.

### *Article information*

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