Transradial approach for coronary procedures in the elderly population

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Abstract
Transradial cardiac catheterisation has been reported to be more beneficial compared to other approaches with easier and safer post-procedural haemostasis, better patient comfort, earlier ambulation and possibility of performing procedure and discharge on the same day. There is only limited data examining transradial access in the elderly population. In this review we looked at the available literature to give an insight into how the transradial approach compared to the transfemoral and other approaches in the elderly population. Elderly population is at higher risk of vascular access site bleeding and the transradial approach has shown equal efficacy to transfemoral approach. However, transradial approach significantly reduces vascular complications, hospital stay, mobilization times and adverse cardiac events. Therefore, transradial approach should be considered as the preferred vascular access site in the elderly population.


Keywords: Percutaneous coronary intervention; The elderly; Transradial cardiac catheterisation

1 Introduction

Ever since the German physician Forssmann performed a right heart catheterisation on himself in 1929, coronary angiography has revolutionised interventional cardiology and investigating coronary artery disease.[1] Traditionally the procedures have been performed via the femoral artery as an access point but in 1964, The Montreal Heart Institute performed cardiac catheterisation utilising the proximal radial artery given the benefits of collateral circulation to the hand.[2] However due to a longer procedural time, it was not until 1989 when Campeau performed the first transradial (TR) diagnostic cardiac catheterisation and in 1992, Kiemeneij the first coronary angioplasty.[3]

With all approaches, cardiac catheterisation brings with it the risks of bleeding, acute vessel thrombosis, restenosis and pseudoaneurysm.[4] And although less than 1% of cases undergo these complication, much research has been devoted to determining the access site that has the best outcome for patients.[4]

Transradial cardiac catheterisation has been reported to be more beneficial compared to other approaches with easier and safer post-procedural haemostasis, better patient comfort, earlier ambulation and possibility of performing procedure and discharge on the same day.[5] Interest in the TR approach has spread worldwide, aided by radial training and specific radial equipment, and over the recent years, the change from femoral to radial access has risen in popularity. In 2009, Europe performed 719,094 percutaneous coronary intervention (PCI) procedures with 47.5% using the TR approach and in 2013, UK performed 71.2% of their PCIs via the radial artery.[3,6]

The median age of people in UK is rising with those aged 65 or over making up 16% of the population in 2010 and projected to reach 23% by 2030.[7] This increase in an elderly population has ramifications on both the incidence and prevalence of cardiovascular disease but also the health system’s resources. As individuals get older, they are naturally more predisposed to atherosclerosis with their risk of harm progressing significantly if also associated with cardiovascular risk factors that will accumulate over time.[8,9]

Ageing will also effect the management of ischaemic heart disease. Elderly patients tend to have complex comorbidities affecting many systems and therefore outcomes will differ, the care delivered will not have the same impact on each patient due to possibility of poor compliance and discharge delay due to social circumstances and the intrinsic cardiac pathology is more advanced which all contributes to increased difficulty in treatment and management.[10,11]

In 2012, the British Heart Foundation stated that for those aged 65 and over, 11% of deaths were caused by coronary artery disease, the biggest single cause of death in
UK.[12] In the same year there were 1.6 million episodes related to cardiovascular disease within NHS hospitals accounting for 10% of all inpatient episodes for men and 6.2% among women.[12] The prevalence of myocardial infarction in those aged 65 and over in UK is at nearly 27% with nearly 42% suffering from angina.[12] The NHS spent more than £6.8 billion treating cardiovascular disease in 2012/3 in England alone.[11]

Despite this burden of coronary artery disease in the elderly population, there are significant gaps in research for appropriate therapies and clinical needs for this patient group.[13] Coronary artery disease is the most common cause of death in older adults yet there is little data on the various interventional management options for the elderly as they tend to be excluded from randomized controlled trials. To make matters worse, the complications of comorbidities and polypharmacy leads to hesitation by clinicians to offer evidence-based pharmacological therapies that would be beneficial to their condition.[14]

The number of elderly patients receiving cardiac interventional procedures is increasing. Revascularisation may improve mortality and morbidity as well as quality of life, an important endpoint for patient of that age.[13] However, although cardiac catheterisation has shown great benefit in elderly patients, even more so than younger patients, they also have a higher rate of complications.[10] It is important to analyze the therapy options available in order to benefit patient management in the elderly with coronary artery disease. The purpose of this article is to review the transradial approach for cardiac catheterisation in the elderly.

2 Advantages of transradial

As the radial artery is not an end artery and other vessels contribute towards the blood supply to the hand, in the event of an occlusion, ischaemia to its distribution territory will be prevented by collateral arteries, such as the ulnar artery. Bleeding complications that arise with transfemoral access can lead to an increase in morbidity and delay discharge, worsened by the aggressive anticoagulant and antiplatelet therapy routinely used in interventional procedures.[16,17] Whereas clinical trials have consistently shown radial access for acute coronary syndrome reduces adverse clinical events mainly through a reduction in bleeding as compared to the femoral artery.[18,19] This is because the radial artery is more compressible, not positioned around major vessels and not as wide as the femoral, allowing sheath removal to have less complications, which makes it more preferable to the brachial artery too. The decrease in vascular complications was even more significant in women who classically have a greater risk of complications when using the femoral for access.[20] A study showed that using the radial artery had significantly lower access site and bleeding complications in comparison to the brachial and thus it is the favored upper limb arterial access.[21] This is particularly important in the elderly population, as there is already an increased risk of bleeding in those aged 65 or over and those aged 75 or over are at a higher rate of peri-procedural vascular complications than others.[22] Furthermore as the elderly are more likely to have other co-morbidities such as liver disease, renal failure and resistant hypertension, with the antithrombotic therapy they receive, their bleeding risk will increase accordingly post percutaneous coronary intervention.[23] With major adverse cardiovascular events, notably in-hospital mortality, associated with bleeding for those with acute coronary syndrome, the transradial approach should theoretically lower this risk for the elderly as compared to other access points.[19,24]

The elderly also present with more vascular problems. Abdominal aortic aneurysms, lower limb arteriopathy and tortuosity of the iliac arteries may prove to be relative or absolute contraindications to using the femoral artery for coronary intervention thus making radial more favorable.[25] But transradial access also brings with it its own difficulties, especially in the elderly with aortic root dilatation, increased tortuosity of the subclavian artery and aortic arch, atherosclerosis and calcification of the great vessels.[25] However, the transradial approach has been shown to compatible with a wide range of coronary lesions including high complexity cases with failings attributed to access issues rather than guide catheter handling and support.[26]

As the radial artery is not immediately associated with a nerve like the femoral artery, there are reduced neurological complications too.[4] Other studies have also noted patient preference due to less discomfort and increased mobility, a shorter recovery period, earlier ambulation and discharge associated with the transradial approach.[27,28] This is a likely consequence of the reduction in complications during the procedure and also results in a better clinical outcome.[29] Alongside its benefits, transradial access has also been noted to be more cost effective and more financially appealing.[30] With the increase in demand for procedures due to more patients suffering from ischaemic heart disease, transradial access for coronary artery intervention has become more attractive being the safest and most effective option available that allows same day or outpatient procedures.

Despite concerns the transradial approach may increase the risk of stroke due to its anatomy, increased frequency of catheter exchange and associated longer procedural times,
data has shown that the risk of neurological complications is the same as when using the femoral artery for vascular access.[31]

### 3 Complications

Alongside its advantages, the transradial approach brings with it complications like any vascular access procedure. Puncture, sheath insertion and catheter use can damage the artery itself or the surrounding tissue, with severity of complications differing among person to person.

Radial artery occlusion, although insignificant if the ulnar artery has good flow, is undesirable and the most common complication with estimated figures ranging from 2%–10%.[32] The likely causes of this complication are insufficient use of antiplatelet therapy, usage of mismatched and large catheter sizes, diabetes and occlusive haemostasis.[33,34] Prolonged radial artery compression may also be associated with occlusion.[35] In patients with radial artery occlusion, around half recanalize their artery spontaneously and so the incidence of occlusion decreases with time post procedure.[33] Moreover, radial artery occlusion is asymptomatic due to collateral circulation. Due to the risk of emboli and digital ischaemia, retrograde canalization of a radial occlusion should be avoided if possible.[32]

Inability to gain access to the radial artery due to calcification or tortuosity can result in a failed procedure. Similarly, anatomical variations of the internal arteries will not allow proper engagement of the coronary arteries.[36] Pseudo-aneurysms and arterio-venous fistulas that arise from trauma are rare due to the radial artery being a small calibre vessel compared to the femoral and generally managed without difficulty using compression.[3] Bleeding can cause haematomas and when involving the radial artery, are generally well controlled with manual pressure. Mediastinal and neck haematomas, although a complication, are very rare.[37] When passage of wire or catheter is difficult it is advised to use fluoroscopy in order to guide to the ascending aorta and exchange the catheters over the wire.

When bleeding occurs internally, pressure within the arm can increase eventually leading to compartment syndrome, an emergency that must be managed immediately otherwise the limb will be at risk of ischaemia and irreversible damage. Discontinuing anticoagulant and antiplatelet therapy, external pressure, analgesia and monitoring of haemodynamics and distal refill pressure can prevent surgical intervention.[3]

The radial artery is also prone to spasm during transradial procedures and exchange of catheters. Using nitrates and calcium channel blockers through the catheter aid relaxation of the arterial walls.[38] Antispasmodics, untraditional vaso-dilators, such as molsidomine, and sedation have also been suggested for prophylaxis against spasm.[39,40] Partial or complete radial evulsion is very rare and has only been seen where operators have forcefully removed appliances that were entrapped in severe radial artery spasm.[3]

### 4 Transradial in the elderly

Obtaining vascular access in the elderly can be complicated with calcification and tortuosity of the arteries.[10] Similarly, coronary intervention in this age population can be challenging due to advanced atherosclerosis. As discussed above, the transradial approach has numerous benefits, which have been seen in multiple studies, but there have only been a few small studies examining transradial access in the elderly population.[41] In this review we looked at these studies to give an insight into how the transradial approach compared to the transfemoral and other approaches in the prevalence of adverse clinical events, complications, procedural time and length of stay as well as other important criteria.

The OCTOPLUS study conducted in 2004 looked at 377 patients who underwent coronary angiography or angioplasty in octogenarians. The efficacy of PCI remained the same between the transradial and transfemoral approaches with only a slight increase in procedural time and X-ray exposure for those who had angiography via the radial.[42] However, the activated coagulation times, contrast medium volume and number of guiding catheters used was similar. The need for blood transfusions and incidence of false aneurysms was not significant between the two groups. There was a significant decrease in access related vascular complications, such as haematomas, in the 192 patients belonging to this group in this randomized trial.

Klinke, et al.[43] compared the treatment outcomes of patients aged 80 or over undergoing transradial and transfemoral coronary intervention. Angiographic success rates were 96% in patients who underwent transradial access versus 88% in the transfemoral group and clinical success rates 94% versus 83% respectively. Once matched to adjust for baseline differences, the outcomes of cardiac and all-cause death at 6 and 12 months between 225 patients were the same in both transradial and transfemoral groups. In-hospital complications were also similar but in-hospital death rate was drastically lower for transradial approach patients. Post-procedural length of stay was also lower for this group. Therefore short-term outcomes were better for those that had transradial access.

An observational study of 155 patients that underwent primary or rescue PCI for acute myocardial infarction in
patients aged 70 or more showed that door to balloon time was equivalent in both groups of patient that either underwent coronary intervention via the femoral or radial artery.\cite{44} The total procedure time, however, was shorter in transradial group. Major adverse clinical events such as myocardial infarction or death, angiographic success and length of hospital stay was comparable in both groups but there were no major access site complications when using the radial artery. Angiographic success was also comparable between both groups as was fluoroscopy time, heparin and contrast volume used.

Jaffe, et al\cite{45} in 2007 performed an analysis of radial versus femoral approach for PCI in 228 octogenarians that identified similar procedural success rates in both approaches. However, more contrast was used and cannulation and fluoroscopy times were longer with the radial approach. It also showed a higher crossover rate to alternate access sites compared to the femoral approach. The rates of peri-procedural infarction and repeat procedure were the same in both groups. Similarly, the length of hospital stay was equivalent for transradial and transfemoral access. Nevertheless, both vascular site complications, including bleeding and haematoma, as well as ambulation time were reduced in this group. Other vascular complications, such as the need for blood transfusion and vascular surgery, were not significant between the two approaches. There were no deaths or emergency coronary artery bypass grafting (CABG) procedures required in either study arm. Multivariate regression analysis of both approaches showed that the transradial approach was a negative predictor for post-procedural vascular complications.

A trial of 307 patients that were randomized to either transradial or transfemoral coronary angiography and intervention in patients aged 75 or over showed a reduction in both minor and major complications, including bleeding requiring surgery or transfusion and stroke, for those in the transradial group. Although there was no difference between fluoroscopy time, number of catheters used and amount of contrast agent, total examination time was significantly longer for the transradial approach as was the time to first cine angiographic acquisition.\cite{46}

Safety and feasibility of the transradial approach for primary percutaneous coronary intervention in those with acute myocardial infarction was explored in a study of 103 patients aged over 65.\cite{47} Success rates for both approaches were alike. Similarly, the difference between puncture success, puncture time, cannulation, reperfusion and procedure time were not significant. Like other studies, the length of in-hospital stay and vascular complications, including pseudo-aneurysm, haematoma and bleeding, was increased in the transfemoral group but there was no difference in major adverse clinical events including death and re-infarction over a period of a month post procedure. The study also showed that the usage of temporary pacemakers or inter-arterial balloon pumps as complications was not any greater in one group over the other.

Another observational study of 354 patients aged between 80 and 89 who underwent primary PCI showed no difference in angiographic success or findings, contrast volume used or stent deployment between treatment through the radial or femoral artery.\cite{48} Needle to balloon, radiation and total procedure time were also equivalent. Major adverse cardiac and cerebral event rates in-hospital were not significant between transradial or transfemoral and neither was vascular complications but no patients suffered access site bleeding with the transradial approach compared to 12 in the transfemoral approach. In-hospital, 30-day and 1-year mortality were also similar between the two treatment arms. The transradial approach was also noted to have significantly higher conversion rate to another approach.

Jinnouchi et al\cite{49} in 2012 showed that transradial PCI for acute myocardial infarction reduced CCU stay in patients 80 or older, with nearly 1.5 days extra being spent in those with non-transradial interventions, and also facilitated earlier ambulation, including being quicker to sit and stand post procedure. Equally, the duration of hospital stay for the 116 patients investigated was reduced in the transradial approach as compared to the non-transradial approach which was nearly 6 days longer. Using multivariate logistic regression analysis, transradial approach for coronary intervention was recognized as an independent predictor of short CCU stay of 3 days or less. Inter-arterial balloon pumps and closure devices were not used for patients undergoing transradial intervention but significantly increased in comparison for those with other approaches. Fluoroscopy time and contrast amount was also less for the transradial approach patients. However, procedural time and success rates were comparable between transradial and non-transradial intervention. There was also no statistical significance between stroke and re-infarction rated between the two intervention arms. In-hospital mortality was not different between the two groups but there was significantly less bleeding complications for patients undergoing transradial intervention.

Procedural success rate was above 95% for both transradial and transfemoral approach for PCI in a study of 268 patients aged 80 or over. Like other studies, vascular complications including access site bleeding, pseudo-aneurysm and haematoma were significantly lower for the transradial group but conversely, a longer cannulation and fluoroscopy time as well as higher chance of crossover to another site
was more associated with this group. Major adverse complications including the need to have blood transfusions and myocardial infarction were not significant between transradial and transfemoral approaches. There were no emergency CABG procedures or mortalities post procedure in either group. Ambulation time was much faster in patients receiving transradial intervention but length stayed in hospital was similar for all patients as was overall success rate of the intervention. Multivariate regression also identified transradial access as negative predictor for post-procedural vascular complications in this study too.\[50\]

Secco, et al.\[51\] looked at reperfusion times in 283 patients aged 75 or more without cardiogenic shock who underwent primary PCI via the radial or femoral artery. They showed that although the door to balloon time was not significant between the two, the arterial puncture and balloon inflation time itself was actually reduced in the transradial group by just under 2 and 5 min, respectively. Haematoma of the access site was significantly more common in the transfemoral access patients but post procedural access site bleeding was similar in both groups.

A prospective cohort study of 293 patients aged over 75 that presented with STEMI were shown to have decreased in-hospital mortality, 1-year mortality and major adverse clinical events if the procedure was done through the radial artery as compared to patients with similar clinical characteristics who had the procedure done via the femoral artery.\[52\]

In 2015, a study recruited 1098 patients aged 75 or over who had undergone percutaneous coronary intervention via either the transradial or transfemoral approach. Once a propensity score analysis was used to match bias, it showed that the rates of major adverse cardiovascular events such as myocardial infarction, target vessel revascularisation and death were significantly lower for those patients whose radial artery was used for catheter insertion. Similarly the transfemoral approach was associated with higher rates of in-hospital myocardial infarction, access site complications and major bleeding. They concluded that the transradial approach should be the preferred route in the elderly due to its greater safety.\[53\]

There is currently no comparative date between transradial and other approaches for coronary intervention in nonagenarians. A retrospective study of 107 patients who had PCI showed, however, that success rate of the procedure was 90% and severe complications were 19%, 11% of which were directly related to the procedure in this age group.\[53\]

Multiple studies of various sizes and looking at various populations over the age of 65 have shown that the transradial approach to coronary intervention is just as successful to the transfemoral approach with equal rates of major adverse clinical events. Overall procedural time, including fluoroscopy and cannulation time, has shown to be increased in a few studies but there has been strong evidence to suggest a reduction in complications, most notably vascular complications, reduction in length of stay post procedure, earlier ambulation time and reduced mortality when using the transradial approach. This has also been shown by a meta-analysis of 11 studies that included 2188 patients looking at the transradial approach.\[41\]

5 Optimizing transradial procedures in the elderly

The data strongly suggests that the transradial approach significantly reduces vascular complications including the incidence of haematoma, access site bleeding and pseudoaneurysms in comparison to other access sites, most notably the transfemoral approach which is traditionally the most popular, for the elderly. Furthermore using the radial artery reduces major adverse cardiovascular events such as myocardial infarction and death. It has also been noted that transradial interventions speed up ambulation time and reduced hospital stay too and have shown similar efficacy levels as the transfemoral approach.

Nevertheless, along with its advantages, the transradial approach has some problems during the learning curve in the elderly with higher rates of crossover site usage, increased fluoroscopy and therefore radiation time and longer procedure time.

In transradial interventions, the arterial sheath should be removed immediately after the procedure and with mechanical pressure over the access site, bleeding can be prevented and haemostasis achieved. Various haemostatic devices are available but the two most widely used are the TR Band and Radistop. A study that compared the efficacy of both devices in 790 patients showed that both devices were effective in achieving haemostasis. However, patients receiving the TR Band expressed less discomfort and pain. Small and large haematoma incidence rates were similar in both groups but the Radistop took a significantly shorter time to achieve haemostasis.\[54\] Therefore the operator can opt for a TR Band in those elderly patients who are generally weaker and will experience more discomfort or a Radistop in those with a higher risk of bleeding.

The study also noted that patients with smaller wrist circumference, patients who did not receive heparin during the procedure and patients who experienced arterial spasm during the intervention were more likely to develop radial ar-
tery occlusion. Two of the important risk factors for developing radial artery occlusion are large sheaths and a small radial artery. The GRASP study looked at the predictors for a small radial artery found that body surface area, weight, height and body mass index were not correlated with radial artery diameter but women, smaller wrist circumference and South Asian patients were more likely to have smaller radial arteries.\textsuperscript{[55]} Downsizing and miniaturising coronary interventional material and equipment, such as thin-walled catheters, sheathless catheters, anchor wire and balloon-assisted tracking, to be used in smaller arteries, or “Slender Transradial Intervention” has been suggested to reduce bleeding complications, contrast used, haemostasis time and rates of radial occlusion thereby refining the already advantageous transradial approach.\textsuperscript{[56]} The Glidesheath Slender is a thin-walled catheter showed a procedural success rate of 99.1\%, spasm in 4.4\% and radial artery occlusion in only 1 out of 114 patients.\textsuperscript{[57]} However, the use of “Slender TRI” needs more training and currently not commercially attractive due to low demand.

Another study of 790 patients that underwent transradial intervention found that radial artery occlusion, local large haematoma or arterial dissection was not affected by length or type of sheath. However, they did discover that radial spasm, another complication of the transradial approach, is reduced if using a hydrophilic coated sheath and that younger age, female sex, diabetes and lower body mass index were predictors for radial artery spasm.\textsuperscript{[58]}

Studies have shown that there is less subclavian tortuosity encountered with left radial approach and therefore making catheter manipulation easier and with less cross over rates.\textsuperscript{[59,60]}

The PREVAIL study showed that the left radial route was associated with shorter procedural times and fluoroscopy time than the right radial approach and the TALENT study showed that in diagnostic procedures, the left radial approach had significantly lower fluoroscopy time and less radiographic exposure and these differences were confined to the elderly population aged 70 and over as well as to the operators in training.\textsuperscript{[61,62]} A single centre study of 1032 coronary angiograms also showed reduced fluoroscopy time and fewer catheters used for left transradial access and evidence also suggests that this route is associated with fewer cerebrovascular accidents.\textsuperscript{[63]} Fu, et al.\textsuperscript{[64]} had shown similar decreased fluoroscopy time and shorter needle to balloon time in 100 patients undergoing left transradial coronary intervention for STEMI compared to 100 patients who had right transradial access. Another study interestingly showed that the although there was more discomfort reported for the operator if using the left radial artery for access, this route was not more uncomfortable during the procedure itself and was associated with less radiation exposure for the operators.\textsuperscript{[65]} These observations could be helpful in choosing vascular access site especially in elderly population.

6 Remaining challenges

However there is still room for further exploration of decreasing its complications, refining technique and balancing the risk of delaying reperfusion with this approach as compared to the transfemoral. With the limited number of studies present focusing on those aged 65 or more, especially octogenarians and nonagenarians, more data is also needed. Furthermore, from a pharmacological perspective, the use of anticoagulant therapy before and during the procedure, namely heparin, low molecular weight heparin and bivalirudin, and the optimal time of administration is not yet fully understood.\textsuperscript{[4]}

7 Summary

With the increasing ageing population, cardiovascular disease is becoming ever more prevalent and thus percutaneous coronary interventions are increasing in demand. The benefits to the transradial approach to coronary intervention have been well documented. Its reduction of vascular complications makes it an attractive modern alternative, especially in those that present with STEMI as they have the highest risk of bleeding and adverse events. This review summarizes the overall benefits and potential complications encountered when using the transradial approach in those aged 65 or more. Elderly population is at higher risk of vascular access site bleeding and the transradial approach has shown equal efficacy to transfemoral approach. However, transradial approach significantly reduces vascular complications, hospital stay, mobilization times and adverse cardiac events. Therefore, transradial approach should be considered as the preferred vascular access site in the elderly population.

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