ISSN 1949-8462 (online)

World Journal of *Cardiology*

World J Cardiol 2017 July 26; 9(7): 562-639

Published by Baishideng Publishing Group Inc

World Journal of Cardiology

Contents

Monthly Volume 9 Number 7 July 26, 2017

NAME OF JOURNAL
World Journal of Cardiology

ISSN
ISSN 1949-8462 (online)

LAUNCH DATE
December 31, 2009

FREQUENCY
Monthly

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PUBLICATION DATE
July 26, 2017

INSTRUCTIONS TO AUTHORS
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World Journal of Cardiology

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World J Cardiol 2017 July 26; 9(7): 609-619

DOI: 10.4330/wjc.v9.i7.609

ISSN 1949-8462 (online)

SYSTEMATIC REVIEWS

Hand dysfunction after transradial artery catheterization for coronary procedures

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Conflict-of-interest statement: None.

Data sharing statement: None.

Manuscript source: Invited manuscript

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Received: January 24, 2017
Peer-review started: February 1, 2017
First decision: May 11, 2017
Revised: May 24, 2017
Accepted: June 12, 2017
Article in press: June 13, 2017
Published online: July 26, 2017

Abstract

AIM

To sythesize the available literature on hand dysfunction after transradial catheterization.

METHODS

We searched MEDLINE and EMBASE. The search results were reviewed by two independent judicators for studies that met the inclusion criteria and relevant reviews. We included studies that evaluated any transradial procedure and evaluated hand function outcomes post transradial procedure. There were no restrictions based on sample size. There was no restriction on method of assessing hand function which included disability, nerve damage, motor or sensory loss. There was no restriction based on language of study. Data was extracted, these results were narratively synthesized.

RESULTS

Out of 555 total studies 13 studies were finally included in review. A total of 3815 participants with mean age of 62.5 years were included in this review. A variety of methods were used to assess sensory and motor dysfunction of hand. Out of 13 studies included, only 3 studies reported nerve damage with a combined incidence of 0.16%, 5 studies reported sensory loss, tingling and numbness with a pooled incidence of 1.52%. Pain after transradial access was the most common form of hand dysfunction (6.67%) reported in 3 studies. The incidence of hand dysfunction defined as disability, grip strength change, power loss or any other hand complication was incredibly low at 0.26%. Although radial artery occlusion was not our primary end point for

this review, it was observed in 2.41% of the participants in total of five studies included.

CONCLUSION

Hand dysfunction may occur post transradial catheterisation and majority of symptoms resolve without any clinical sequel.

Key words: Transradial access; Transfemoral access; Hand dysfunction

Core tip: Transradial access (TRA) is default access site in many countries to perform coronary procedures. Hand function may occur post TRA, however our review shows that its incidence is exceedingly low and most symptoms resolve without any clinical sequel.

Ul Haq MA, Rashid M, Kwok CS, Wong CW, Nolan J, Mamas MA. Hand dysfunction after transradial artery catheterization for coronary procedures. *World J Cardiol* 2017; 9(7): 609-619 Available from: URL: http://www.wjgnet.com/1949-8462/full/v9/i7/609.htm DOI: http://dx.doi.org/10.4330/wjc.v9.i7.609

INTRODUCTION

Coronary angiography is the current gold standard in providing anatomical information regarding the extent and severity of coronary artery disease[1,2]. Access site practice has changed in a number of European and Asian countries from mainly being transfemoral (TFA) to transradial (TRA)[3,4] in view of less access site related bleeding complications, mortality and shorter hospital stay associated with TRA[5-11]. For instance, in the United Kingdom use of radial access has increased from 14% to 80% between 2005 and 2014 in patients undergoing percutaneous coronary intervention (PCI) and it is estimated that this practice change has saved an estimated 450 lives nationally[12]. In the most recent European Society of Cardiology guidelines for management of non-ST elevation myocardial infarction (NSTEMI), TRA received class 1A indication for invasive management of NSTEMI with PCI[2]. Furthermore national bodies have formulated recommendations to prevent and minimize procedure related complications of TRA such as reducing the risk of radial artery occlusion (RAO), minimizing patient and operator radiation exposure and transitioning to TRA for primary PCI[13,14].

Nevertheless, despite of its clear advantages over TFA, TRA is not without limitations and is associated with longer operator learning curve[15,16], increased radiation exposure in individual operators at the start of their learning curves[17,18] and higher case radial proportion to translate the better results of randomized trials into clinical practice[11,19,20]. Moreover, vascular complications such as RAO[21] and radial artery spasm[22] are not uncommon and very recently concerns have been raised that patients undergoing TRA PCI may encounter hand dysfunction[23].

Whether access site related complications can lead to hand dysfunction is unclear and studies have reported inconsistence results. A study by van Leeuwen *et al*[24] investigated the impact of TRA on limb function at long term follow up, reported 9% and 11% of the patients develop temporary or permanent hand dysfunction respectively. Whereas Zwaan *et al*[25] reported a pooled incidence of 0.32% in 14 studies evaluating hand dysfunction post TRA.

Considering that the TRA is the predominant access site for cardiac catheterization procedures in many countries, there is little data around hand dysfunction post procedure. In view of the limited published data we conducted a systematic review to evaluate the hand dysfunction post TRA.

MATERIALS AND METHODS

We searched MEDLINE and EMBASE on 23 August 2016 using the search terms: [(radial or transradial or radial artery) AND (catheterisation or catheterization or angiography or angiogram or angioplasty or percutaneous coronary intervention or PCI)] AND (hand function or grip strength or disability or dysfunction or sensation or paraesthesia or paralysis). The search results were reviewed by two independent adjudicators (MAU, CWW) for studies that met the inclusion criteria and relevant reviews. The bibliographies of included studies and relevant reviewers were screened for additional studies.

We included studies with patients undergoing transradial procedure and evaluated hand function outcomes post procedure. No control group was required so studies could be single arm. There were no restrictions based on language, sample size or method of assessing hand function which included disability, nerve damage, motor or sensory loss. These results were then narratively synthesized.

RESULTS

Our search yielded 555 related studies out of which after screening and reviewing the full manuscripts, 13[24,26-38] studies were included in the final review. Detail process of inclusion and exclusion is illustrated in Figure 1.

Table 1 provides the description of studies, year of study, percentage of males and number of participants. A total of 3815 participants with mean age of 62.5 years were included in the studies. Table 2 describes the various methods of assessment employed to assess hand dysfunction, follow up time and results. We observed significant heterogeneity in the methods of assessment hand function and follow

Table 1 Study design and participant characteristics

Ref.	Study design/country/ year	No. of participants	Mean age	% male	Participant inclusion criteria and procedural details
Benit *et al*[26]	Randomized trial; Belgium; 1994-1995	50	57.7	100%	Participants had transradial coronary angioplasty with 6-Fr catheters and Palmaz-Schatz stent
Campeau *et al*[27]	Cohort study; Canada; Unclear	100	58 (median)	90%	Participants had transradial coronary angiogram with 5-Fr, 6-Fr and 7-Fr sheath
Chatelain *et al*[28]	Cohort study; Switzerland; 1995-1997	159	60	82%	Participants had transradial diagnostic and interventional cardiac procedures with 4-Fr, 5-Fr or 6-Fr introducer sheath and guide catheters with RadiStop radial compression system
De Belder *et al*[29]	Cohort study; United Kingdom; Unclear	75	Unclear	69%	Participants had transradial coronary angiography and intervention and severe peripheral vascular disease with 5-Fr or 6-Fr sheath and 6-Fr guide catheter
Kiemeneij *et al*[30]	Cohort study; The Netherlands; 1992-1993	100	62	77%	Participants had transradial coronary angiography with 6-Fr introducer and 6-Fr-guide catheters
Lotan *et al*[31]	Cohort study; Israel; 1994	100	61	79%	Participants had transradial coronary angiography and angioplasty with 6-Fr introducer and 6-Fr guide catheters
Prull *et al*[32]	Cohort study; Germany; Unclear	93	62.5	80.6%	Participants had transradial diagnostic cardiac catheterization with 5-Fr or 6-Fr sheath or transradial coronary intervention with 7-Fr sheath
Sciahbasi *et al*[33]	Prospective cohort study; Italy; Unclear	99	65	72%	Participants had transradial coronary angiography and angioplasty with 6-Fr introducer sheath
Tharmaratnam *et al*[35]	Retrospective case control study; United Kingdom; 2005-2006	1283	65.5	79%	Participants had transradial coronary angiography and angioplasty
Valgimigli *et al*[39]	Prospective cohort study; The Netherlands, Italy; 2014	942	70	73%	Participants had transradial coronary angiography and angioplasty
Van Leeuwen *et al*[24]	Prospective cohort study; The Netherlands; 2015	286	64	72%	Participants had transradial coronary angiography and angioplasty with 6-Fr introducer sheath
Wu *et al*[37]	Cohort study; United States; 1996-1998	40	65	88%	Participants underwent 6-Fr and 8-Fr transradial procedure
Zankl *et al*[34]	Prospective cohort study; Germany; 2010	488	Unclear	Unclear	Participants had transradial coronary angiography and angioplasty with 5- and 6-Fr introducer, 4-, 5- and 6-Fr catheters

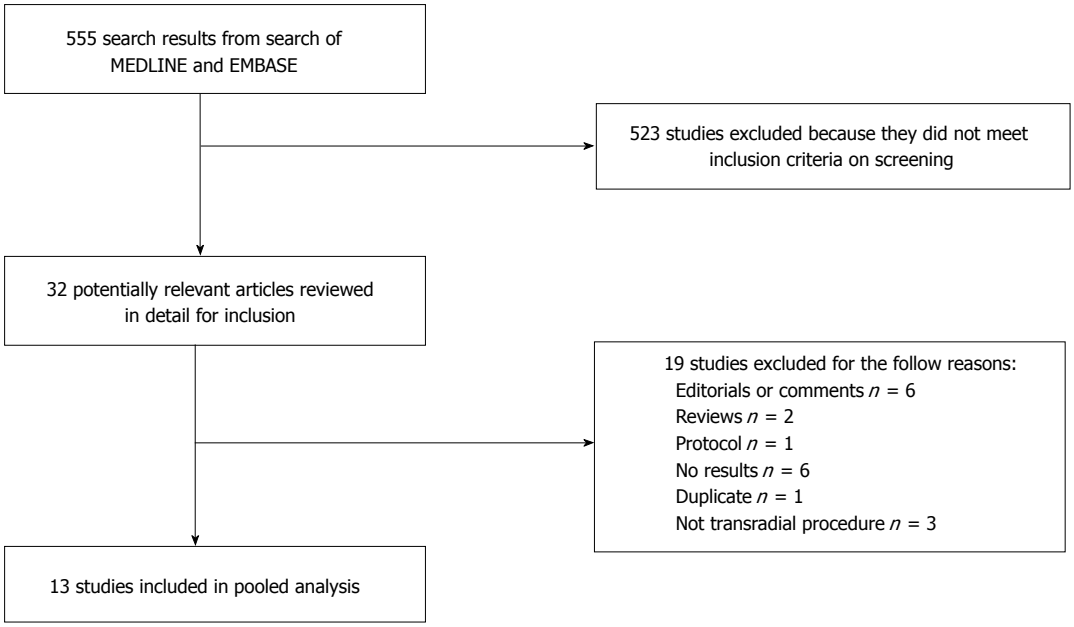

Figure 1 Flow diagram of study inclusion/ exclusion.

up time. For instance, the follow up of assessment varied from anytime between the day procedure was undertaken up to a year post TRA. Similarly, an array of methods were employed to assess the sensory and motor component of hand function such as questionnaire based surveys in the form of Disabilities

Table 2 Results of studies

Ref.	Measure of hand function and vascular complications	Follow up post procedure	Results
Benit *et al*[26]	Local complications assessed in clinic by history and EMG	1 mo	Nerve damage documented by EMG: 0/50 Local pain: 0/50
Campeau *et al*[27]	Patients were re-examined or questioned over telephone about local complications	1 to 3 mo	No nerve injury: 0/100
Chatelain *et al*[28]	Physicians assessed for any clinical events	Assessment prior to discharge	Paraesthesia of right thumb during exercise: 1/159
De Belder *et al*[29]	Clinical evaluation	4-6 wk	Haematoma and paraethesia post procedure: 1/75 Hand sensation and function at 4-6 wk: 0/75
Kiemeneij *et al*[30]	Examination and ultrasound study performed if radial artery pulsations or flow were absent	1 to 3 mo	Functional disability of the hand: 0/100
Lotan *et al*[31]	Assessment methods unclear	1 mo follow up	Small hematoma in wrist: 3/100 Small pseudoaneurysm: 2/100 Numbness of the thumb and index finger: 1/100 No flow on Doppler: 2/100
Prull *et al*[32]	Clinical evaluation with ultrasound	Post-procedure assessment	Vascular complication: 9/93 Motor skills, coordination or force reduction of hand after procedure: 0/93 No pseudoaneurysm: 0/93
Sciahbasi *et al*[33]	Radial artery occlusion by ultrasound test. Handgrip strength by Jamar Plus dynamometer. Thumb and forefinger pinch test by Jamar Plus electronic pinch gauge	Day of procedure and at least 30 d follow up	Radial artery occlusion: 9/99 Hand grip strength change at follow up: 0/99 Thumb and forefinger pinch test change at follow up: 0/99
Tharmaratnam *et al*[35]	Questionnaire posted to address and clinical notes for significant clinical events	Unclear	Problem with radial access site: 166/1283 (12.9%) Pain at puncture site: 95/1283 (7.4%) Swelling: 46/1283 (3.6%) Bruising: 30/1283 (2.3%) Non-specific sensory abnormalities either pain or paraesthesia in hand: 22/1283 (1.71%)
Valgimigli *et al*[39]	Radial artery occlusion by duplex echocardiographic examination. Hand grip strength test with dynanometer	Just after procedure, 1 d, 30 d and 1 yr	Radial artery occlusions at day 1: 5/942 Radial artery occlusions at 1 year: 3/942 Change in handgrip strength test: 0/942 Ischemic vascular or bleeding complications: 0/942
Van Leeuwen *et al*[24]	Quick DASH questionnaire and CISS questionnaire. Patients were asked to describe any procedure-related extremity complaints or loss of function at 1 mo	Pre, 30 d and 1 yr post procedure	Temporary upper limb complaint (< 30 d): 26/286 (9%) Persisting upper limb complaint (> 30 d): 31/286 (11%) Pain: 13/286 Numbness: 2/286 Tingling: 3/286 Stiffness: 2/286 Less power: 2/286 Upper limb function by QuickDASH at 30 d: No change over time, baseline 4.55 (IQR 0-13.64), follow up 2.27 (IQR 0-9.32) Upper limb function by CISS at 30 d: No change over time Upper limb function by QuickDASH at 1 yr: no change over time, baseline 2.39 (IQR 0-13.64), follow up 0 (0-11.02) Cold intolerance was not associated with access route at 1 yr
Wu *et al*[37]	Ultrasound assessment for radial artery occlusion, aneurysm or dissection. Grip strength based on dynamometer results. Palmar pinch, key pinch and tip pinch strength tests were assessed by dynamic endurance test	Late follow up 315 d	Hand complication in hospital: 0/40 Radial occlusion: 1/40 Late radial occlusions: 5/34 Radial artery aneurysm: 0/40 Radial artery dissection 0/40 Grip strength: Baseline 68 ± 34, post-catheterization 69 ± 35 Palmar pinch: Baseline 18 ± 10, post-catheterization 17 ± 6 Key pinch: Baseline 19 ± 7, post-catheterization 19 ± 6 Tip pinch: Baseline 14 ± 6, post-catheterization 14 ± 4 Endurance: Median for 6 Fr and 8 Fr is 78 (IQR 53, 108) and 58 (IQR 32, 68) respectively, post-catheterization 58 (IQR 47, 84) and 56 (IQR 38, 80), respectively
Zankl *et al*[34]	Assessment with ultrasound	4 wk follow up	Radial artery occlusion at 1 d: 51/488 Persistent radial artery occlusion at 4 wk: 21/488 Radial nerve paralysis: 1/488

CISS: Cold intolerance symptom severity; EMG: Electromyography.

Table 3 Summary of pooled results for hand dysfunction or vascular complications post transradial procedure

Hand dysfunction or vascular complication	No. of studies	No of events	No of participants	Percentage of events
Nerve damage	3[26,27,34]	1	638	0.16%
Sensory loss, tingling and numbness	5[24,28,29,31,35]	29	1903	1.52%
Pain	3[24,26,35]	108	1619	6.67%
Hand function, disability, grip strength change, stiffness, power loss and hand complications	6[24,30,32,33,37,39]	4	1560	0.26%
Vascular complications including occlusions, hematoma, pseudoaneurysm and dissection	6[29,31,32,35,37,39]	54	1762	3.06%
Radial artery occlusion	5[31,33,34,37,39]	40	1663	2.41%

Table 4 Disabilities of Arm, Shoulder and Hand (QuickDASH) Questionnaire

	No difficulty	Mild difficulty	Moderate difficulty	Severe difficulty	Unable
1 Open a tight or new jar	1	2	3	4	5
2 Do heavy house hold chores eg. Wash walls, floors	1	2	3	4	5
3 Carry a shopping bag or briefcase	1	2	3	4	5
4 Wash your back	1	2	3	4	5
5 Use a knife to cut food	1	2	3	4	5
6 Recreational activities in which you take some force or impact through your arm shoulder or hand	1	2	3	4	5
7 During the past week to what extent has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbors or groups?	1	2	3	4	5
8 During the past week, were you limited in your work or other daily activities as a result of your arm, shoulder or hand problem?	1	2	3	4	5
9 Arm, shoulder or hand pain	1	2	3	4	5
10 Tingling	1	2	3	4	5
11 Sleep	1	2	3	4	5

of Arm, Shoulder and Hand (Quick DASH) or Cold Intolerance and Symptom Severity (CISS) or postal surveys, electromyography (EMG), dynamometer and forefinger pinch grip tests.

Table 3 presents pooled results of various form of limb dysfunction described by the studies. Out of 13 studies included, only 3 studies reported nerve damage[26,27,34] with a combined incidence of 0.16%, 5 studies reported sensory loss, tingling and numbness[24,28,29,31,35] with a pooled incidence of 1.52%. Pain after TRA was the most common form of hand dysfunction (6.67%) reported in 3 studies[24,26,35]. The incidence of hand dysfunction defined as disability, grip strength change, power loss or any other hand complication was incredibly low at 0.26%[24,30,32,33,37,39]. Although RAO was not our primary end point for this review, it was observed in 2.41% of the participants in total of five studies included[31,33,34,37,39].

In one the very early studies from pre-stent era, Campeau *et al*[27] assessed the neurological damage to hand following TRA using 5 Fr, 6 Fr or 7 Fr sheath. Patients were assessed at 1 and 3 mo either clinically or *via* telephone reported no nerve injury. It is not clear how the nerve damage was assessed in patients reviewed by telephone. Another study employing a more subjective assessment of nerve function using EMG in 150 patients receiving TRA using a 6 Fr sheath reported no damage to the median nerve at 1 mo follow up. In a large retrospective analysis of 1283 patients undergoing TRA using hydrophilic sheaths, 13.2% patients reported non-specific sensory symptoms post procedure[35]. However, the results were dependent on a questionnaire based postal survey and no objective method was used to assess for the sensory loss. Similarly two other studies[28,29] assessing the neurological dysfunction post TRA, reported only 1 case of paraesthesia of right thumb and 1 case of forearm haematoma resulting in some sensory disturbance of hand but no loss of function. More importantly, both cases made full recovery without any clinical sequel.

In a prospective study of 203 patients after TRA, Valgimigli *et al*[39] assessed the motor component of hand function by performing handgrip strength tests using a dynaomometer at 30 d and 1 year, maximal isometric strength on handgrip test did not change over time. Van Leeuwen *et al*[24] conducted a randomised study of 338 patients to evaluate motor component of upper limb function using self-reported shortened version of Disabilities of Arm, Shoulder and Hand (Quick DASH, Table 4) and sensory component using Cold Intolerance and Symptom Severity (CISS, Table 5) questionnaires at baseline and 30 d. There was no statistically significant change in Quick DASH score at baseline to follow up in patients undergoing

Table 5 Cold Intolerance symptoms severity Questionnaire

Questions	Score
Which of the following symptoms of cold intolerance do you experience in your injured limb on exposure to cold?	
Pain, numbness, stiffness, weakness, aching, skin colour change (white/bluish white/blue)	
How often do you experience these symptoms? (Please tick)	
Continuously/all the time	
Several times a day	
Once a day	
Once a week	
Once a month or less	
Never	
When you develop cold induced symptoms, on your return to a warm environment are the symptoms relieved? (Please tick)	
Not applicably	
Within a few minutes	
Within 30 min	
After more than 30 min	
What do you do to ease or prevent your symptoms occurring? (Please tick)	
Take no special action	
Keep hand in pocket	
Wear gloves in cold weather	
Wear gloves all the time	
Avoid cold weather/stay indoors	
Other (please specify)	
How much does cold bother your injured hand in the following situations? (Please score 0-10)	
Holding a glass of ice water	
Holding a frozen package from the freezer	
Washing in cold water	
When you get out of a hot bath/shower with air room temperature	
During cold wintry weather	
Please state how each of the following activities have been affected as a consequence of cold induced symptoms in your injured hand and score each (please score 0-4)	
Domestic chores	
Hobbies and interests	
Dressing and undressing	
Tying your	

TRA (baseline 4.55; IQR: 0.00 to 13.64; follow-up 2.27 IQR: 0.00 to 9.32, P = 0.06). Similarly there was no change in the CISS score over time. An important feature of the study was they included patients undergoing TFA to make a comparison between the two access sites. More recently, HANGAR (HANd Grip test After tRansradial percutaneous coronary procedures) study investigated 108 patients with stable angina undergoing PCI using 6Fr sheath with a primary endpoint of variation in hand grip strength measured with the Jamar Plus dynamometer after the procedure[33]. The secondary endpoints of interest were thumb and forefinger pinch measured using key pinch and electronic pinch gauge respectively. Out of 99 patients, 9 patients developed radial artery occlusion after the procedure, the patients were then divided in two groups according to the radial patency (group 1) or occlusion (group 2) The hand grip test values were significantly reduced compared with baseline values (40 ± 11 kg in group 1, P < 0.0001 and 37 ± 17 kg in group 2, P = 0.007) after the procedure but returned back to baseline at follow up. Interestingly thumb and finger pinch function was unaffected at baseline, after the procedure and follow up. Finally ARCUS (Effects of transradial percutaneous coronary intervention on upper extremity function) is an ongoing trial assessing the effects of TRA on hand function by taking various measurement such as Echo Doppler for radial artery occlusion, Questionnaires testing including Quick DASH (Table 4), Boston Carpal Tunnel Questionnaire (BCTQ, Table 6) and Visual Analogue Scale (VAS), volumetry of hand and forearm, sensibility of fingertips, key and palmar grips and isometric strength of wrist and elbow[40]. The interim results were published recently suggesting that 143 of 191 (74.9%) patients had some form of upper limb dysfunction defined as a complied binary score of various measurements taken[38]. Furthermore, RAO was 9.8% in upper limb dysfunction group as compared to 0% RAO in non-upper limb dysfunction group.

DISCUSSION

In the current review, we synthesize the evidence on the incidence and clinical impact of hand dysfunction after TRA. We observe a very low incidence of hand dysfunction in limited literature and importantly, we observe significant heterogeneity in the definition and method of assessment of hand dysfunction amongst the studies, with no internationally accepted measure of hand dysfunction that can be used as the gold standard for such studies. Many of these studies are

Table 6 Boston Carpal Tunnel Syndrome Questionnaire

	1	2	3	4	5
A: Symptom severity scale (11 items)					
1 How severe is the hand or wrist pain that you have at night?	Normal	Slight	Medium	Serious	Very serious
2 How often did hand or wrist pain wake you up during a typical night in the past two weeks?	Normal	Once	2-3	4-5	> 5
3 Do you typically have pain in your hand or wrist during the daytime?	No Pain	Slight	Medium	Serious	Very Serious
4 How often do you have hand or wrist pain during daytime?	Normal	1-2 times/d	1 times/d	> 5 times/d	Continued
5 How long on average does an episode of pain last during the daytime?	Normal	< 10 min	10-60 continued	> 60 min	Continued
6 Do you have numbness (loss of sensation) in your hand?	Normal	Slight	Medium	Severe	Very Serious
7 Do you have weakness in your hand or wrist?	Normal	Slight	Medium	Severe	Very Serious
8 Do you have tingling sensations in your hand?	Normal	Slight	Medium	Severe	Very Serious
9 How severe is numbness (loss of sensation) or tingling at night?	Normal	Slight	Medium	Severe	Very Serious
10 How often did hand numbness or tingling wake you up during a typical night during the past two weeks?	Normal	Once	2-3 times	4-5 times	> 5
11 Do you have difficulty with the grasping and use of small objects such as keys or pens?	Without difficulty	Little difficulty	Moderate difficulty	Very difficulty	Very difficult
B: Functional status scale (8 items)					
Writing					
Buttoning of cloths					
Holding a book while reading					
Gripping of a telephone handle					
Opening of jars					
House hold chores					
Carrying of grocery basket					
Bathing and dressing					

poorly conducted and subjective reports of sensory/hand dysfunction with only few studies quantifying any changes in a robust manner. Finally, we find no evidence of widespread clinically significant hand dysfunction post TRA and the potential benefits of TRA in reducing major bleeding, access site related complications and mortality outweigh such rare events.

The majority of studies that reported cases of neurological deficits following TRA were underpowered[26,29,37]. In most circumstances, studies relied on subjective reporting of symptoms by patients, rather than quantifying the neurologic deficit with proper neurophysiological or other robust objective testing[24,27-31,34,35]. Benit *et al*[26] assessed nerve damage clinically and quantified this using EMG. Valgimigli *et al*[39] and Sciahbasi *et al*[33] used dynamometer to assess hand grip function whereas only Sciahbasi *et al*[33] used electronic pinch gauge to check for thumb and finger pinch tests. Van Leeuwen *et al*[24] used QuickDASH questionnaire and Cold Intolerance Symptom Severity (CISS) questionnaire based assessment of hand function post TRA.

The clinical significance of neurological and motor injuries leading to hand dysfunction must be considered. Many neurological injuries are known to be transient and resolve over time. For instance, van Leeuwen *et al*[24] reported that almost 20% patients developed subjective neurological complications in the form of numbness, tingling, stiffness and less power, more importantly nearly 50% resolved by 30 d at follow up. Similarly, pain is commonly reported by patients regardless of the access site practice but long term sequel of such symptoms is unclear. In addition, there is no consensus on the optimal method of assessing hand function and studies so far have used various methods such VAS, BCTQ, Disabilities of Arm, Shoulder and Hand (QuickDASH) and CISS (Tables 4-6).

Visual analogue scale is measure of pain intensity on a continuous scale anchored by pain descriptor ranging from "no pain (0 score)" to worst pain (score 10)[41]. BCTQ questionnaire comprises of a symptom severity scale and a functional status scale (Table 6). The symptom severity scale has 11 questions scored from 1 point (mildest) to 5 points (most severe). Likewise, functional status scale has eight questions scored from 1 point (no difficulty with activity) to 5 points (cannot perform the activity at all)[42]. Similarly,

CISS score is usually employed to detect cold intolerance. It consists of 6 questions and based on response, patient with a score of 30 or higher is said to have pathological CISS score[43,44]. There is a need of internationally agreed, sensitive method of assessing hand function amongst the radial community to evaluate and monitor for such complications.

The mechanisms that may underlie hand dysfunction after TRA remains unclear though there are several possible explanations. For instance, Flexor Carpi Radialis, Flexor Pollices Longus tendons and Median nerve lies next to radial artery at wrist from lateral to medial respectively. Neurological deficits may occur from direct damage to these structures during cannulation of the radial artery. There also may be indirect extrinsic compression of these structures due to haematomas which may result in motor or sensory deficit of the hand. Endothelial dysfunction, intimal hyperplasia and medial dissections resulting in radial artery stenosis and occlusion are well known complications associated with TRA[45,46]. Haematoma or pseudoaneurysm is another relatively rare complications encountered after TRA. There is a possibility that such vascular complications may lead to transient or permanent ischemia of the nervous supply of hand leading to sensory deficit or directly cause motor dysfunction of small muscles of hand. Additionally, there are anatomic variations of neurovascular bundles of hand[47] which might be injured during the puncture leading to hand dysfunction such as sensory or motor symptoms. There are isolated case reports that describe this mechanism of nerve damage[48-50]. RAO may occur post TRA[21], however it is usually asymptomatic and rarely causes ischemia due to the excellent collateral supply of hand from ulnar and intermediate artery[45,51]. Notably, recent results of ACRUS trial suggested that hand dysfunction was very common in patients developing RAO compared to the ones with a patent radial artery post procedure[38]. However, in the study conducted by Valgimigli *et al*[39] across whole spectrum of Allen test, there were no differences in serial lactate measurement after the procedure suggesting that it is unlikely such mechanism can lead to clinically significant hand dysfunction.

It is unclear what factors are associated with hand dysfunction after TRA. It could very well be that certain patient factors, such as baseline hand muscle strength, history of musculoskeletal disorders, gender, atypical anatomy may be a risk factor but no studies have evaluated such predictors. Another important point how minor changes in hand function may impact on a patient's life. For example individuals that require very fine manual dexterity for their profession such as watchmakers, pianists, and surgeons may notice very minor changes in hand function whilst in other patient groups this may be less relevant. Finally, the way in which complications are managed may also affect hand function such as how quickly a haematoma is identified and compressed. Future studies should be focused in assessing both patient and procedure related factors which may lead to development of hand dysfunction with clinically relevant end points. Finally, current literature does not provide an insight around the prevalence and significance of lower limb function in patients undergoing transfemoral access. Adequately powered randomized trial with a control group is required to better understand the incidence and mechanisms involved in the development of hand dysfunction post TRA.

In conclusion, hand dysfunction is an exceedingly rare complication post TRA. There is significant heterogeneity in the methodology and reporting of the studies investigating hand function after TRA. Patients may develop non-specific sensory symptoms or muscle weakness but majority of these symptoms resolve over time. Future studies should be focused around assessing such complications using robust methodology and more importantly reporting on the clinical relevance of hand function. Given the reductions in mortality, MACE and major bleeding complications associated with use of TRA in high risk groups undergoing PCI, TRA should remain the default access site for PCI in such high risk groups of patients at risk of bleeding complications, in line with international guidelines and consensus statements.

COMMENTS

Background

The uptake of transradial access (TRA) for cardiac procedures is growing with both observational and randomized controlled trial data showing decreases in mortality and access site related bleeding complications across the whole spectrum of acute coronary syndromes compared to procedures undertaken through the femoral approach.

Research frontiers

Recently, concerns have been raised around hand dysfunction following transradial procedures.

Innovations and breakthroughs

The review of the literature suggests that hand dysfunction after TRA has been reported in several studies and case reports. The quality of the evidence describing these complications is poor as many studies are underpowered and do not report any events. These complications appear to be rare and of uncertain clinical impact in most cases. Isolated case reports have reported rare complications such as compartment syndrome requiring emergency surgery or complex regional pain syndrome which can be disabling due to chronic pain.

Applications

The current literature is limited as there is no standardized method of assessment of hand function with very few studies that provide mechanistic insight. Higher quality studies with clinically relevant endpoints are needed to better understand the incidence and clinical significance of the hand dysfunction following TRA.

Terminology

TRA: Transradial access; TFA: Transfemoral access; PCI: Percutaneous coronary intervention; UED: Upper Extremity dysfunction.

Peer-review

It is an excellent review.

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P- Reviewer: Falconi M, Gong KZ **S- Editor**: Ji FF
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