Indonesian Journal of Global Health Research
Volume 6 Number 1, Februari 2024
e-ISSN 2715-1972; p-ISSN 2714-9749
http://jurnal.globalhealthsciencegroup.com/index.php/IJGHR

THE EFFECTIVENESS OF HAND EXERCISE ON LIMB FUNCTION IN PATIENT CORONARY ARTERY DISEASE POSTTRANSRADIAL ARTERY CATHETERIZATION: SYSTEMATIC REVIEW

Dian Herdiana*, Tuti Herawati, Sri Yona
Faculty of Nursing, Universitas Indonesia, Jl. Saharjo No.161, South Manggarai, Tebet, South Jakarta City, Special Capital Region of Jakarta 12860 Depok, West Java, Indonesia
*mr.dianherdiana@gmail.com

ABSTRACT

Coronary Artery Disease (CAD) is leading cause of mortality worldwide. Catheterization using the transradial arterial (TRA) technique has been able to reduce morbidity and mortality rates from CAD, but this procedure also contributes to the occurrence of complications. The aim of this study was to search literature and analyse articles discussing the use of hand exercise on improving limb function in patients posttransradial cardiac catheterization. Methods: The design used was a systematic review with PRISMA adaptation. Articles were searched using databases: ScienceDirect, ProQuest, PubMed, Scopus and Hand Searching in Google Scholar. The keywords of article search were using "Coronary artery disease" AND "transradial artery catheterization" OR "Trans cardiac Catheterization" AND "hand exercise" AND "limb function. In the initial stage of information search on 5 October 2023, the total number of articles obtained before selection was carried out based on inclusion and exclusion criteria was 7273 articles. From the five databases used, selection was then carried out according to the inclusion and exclusion criteria. The inclusion criteria were research articles published in the last 10 years (2013-2023); use English; a journal article and open access; Involves adult respondents and full text articles. Exclusion criteria were encyclopedia articles, book chapters, conferences, correspondence, editorials, news, practice guidelines, protocols, systematic reviews, literature reviews and meta analysis. The results are discussing 7 articles published from 2013-2023. Conclusions Hand exercises are useful for restoring limb function within two hours after the procedure and over a long period of time.

Keywords: hand exercise; limb function; transradial artery catheterization

First Received	Revised	Accepted
10 December 2023	18 December 2023	30 December 2023
Final Proof Received		**Published**
18 February 2024		22 February 2024

How to cite (in APA style)
Herdiana, D., Herawati, T., & Yona, S. (2024). The Effectiveness of Hand Exercise on Limb Function in Patient Coronary Artery Disease Posttransradial Artery Catheterization: Systematic Review. *Indonesian Journal of Global Health Research*, *6*(1), 407-418. https://doi.org/10.37287/ijghr.v6i1.2797.

INTRODUCTION

Coronary Artery diseases (CAD) might result in unexpected mortality. CAD is the main cause of death worldwide, responsible for 17.8 million fatalities annually, or roughly 610,000 deaths annually (or 1 in 4 deaths) (Shahjehan & Bhutta, 2023). Heart disease is the main cause of death in Indonesia. According to the 2018 Riskesdas data, 15. out of 1000 Indonesians, or 1.5% of the population, had coronary heart disease. In Indonesia, coronary heart disease accounts for 12.9% of all causes of mortality (Kementrian Kesehatan RI, 2022). Coronary artery disease is characterized by an insufficient flow of blood and oxygen to the heart muscle. Oxygen demand and supply are out of balance as a result of coronary artery blockage. Usually, it is caused by plaques that obstruct blood flow in the coronary artery lumen (Shahjehan & Bhutta, 2023; Virani et al., 2020). Percutaneous Coronary Intervention (PCI) is one of the therapy treatments that must be used in addition to evaluation for treating obstruction in coronary heart disease (PERKI, 2022). PCI is the most common CAD

treatment and one of the most frequently performed medical procedures in the world with 97,376 PCI procedures reported in 2015 (Tryfonos et al., 2019). The European Society of Cardiology's recommendations for PCI in acute coronary syndrome advocate the transradial technique (TRA). Additionally, a compressive tool called the TR band (Anscare Medical, Jiangsu, China) helps maintain radial artery hemostasis following TRA. The rate of TRA complications is declining as coronary angiography becomes more experienced; however, new risks and complications are being reported, including artery occlusion, radial artery spasm, radial artery pseudoaneurysm, arterio-venous fistula, nerve damage, and complex regional pain syndrome with varying incidence(X. Zhang et al., 2023).

Although PCI using the TRA technique has been able to reduce morbidity and mortality rates from CHD, this procedure also contributes to the occurrence of quite large complications, both minor problems with temporary sequelae that can cause irreversible damage to life-threatening ones if not carried out prevention and immediate treatment (Khairnar et al., 2021). Complications and risks have been reported, such as arterial occlusion, radial artery spasm, radial artery pseudoaneurysm, arteriovenous fistula, nerve damage, complex regional pain syndrome with The incidence of radial artery occlusion and radial artery spasm varies from 1% to 30% (n=102) and can occur within 24 hours after surgery (X. Zhang et al., 2023). From the incidence of these complications, complaints that often occur, especially pain that peaks 2 hours after the PCI procedure, are 79.40% (n = 133) accompanied by complaints of edema in 72.3% (n = 133) which can seriously affect patient comfort and can cause radial artery spasm. The next complication is bleeding, which occurred in 26% (n = 133), which can reduce patient safety after the procedure and affect the patient's prognosis (Brogiene et al., 2022a).

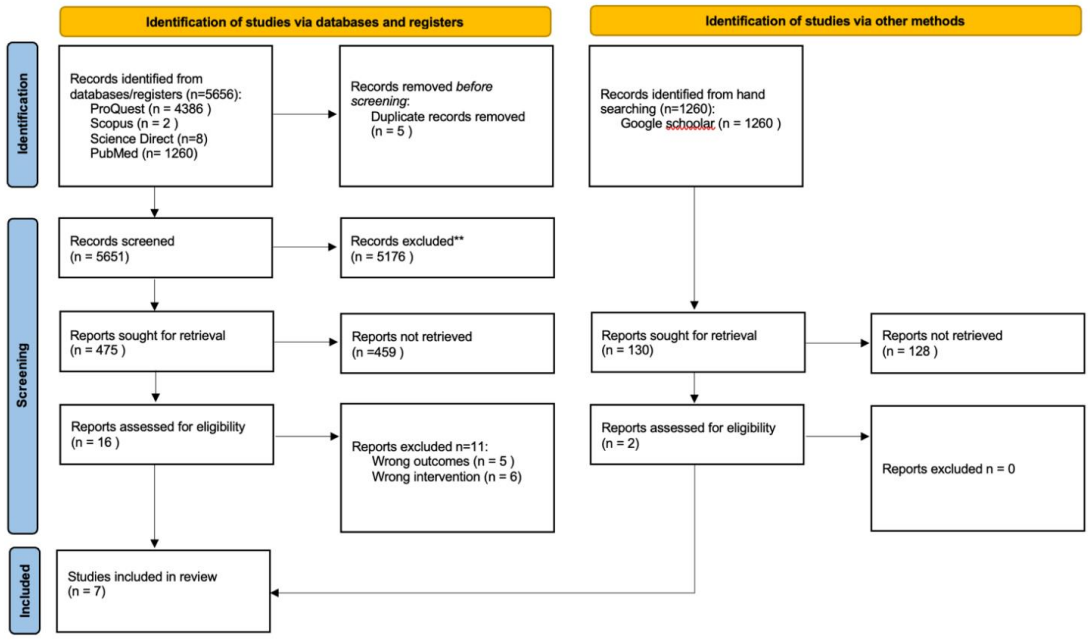
Complications and management after transradial cardiac catheterization have been of interest to cardiovascular scientists. From a clinical nursing point of view, to improve the experience of discomfort after transradial procedures, many methods have been tried to relieve discomfort in the arm for example elevation of the operated leg can promote better venous return and reduce swelling. However, this method is less effective because of the patient's compliance with immobilized movements which takes a long time and there is discomfort and reflex movements to carry out other activities (X. Zhang et al., 2023). This requires an intervention to prevent complications by searching for the best evidence base practice to overcome this problem. Research on reducing edema, pain and bleeding in post Transradial Cardiac Catheterization patients using hand exercises was carried out in China, namely on 102 randomly selected participants where the symptoms of edema and pain were defined as the main results, while skin temperature and degree of bleeding were the results. secondary, which is monitored and measured 1, 2, and 4 hours, after the intervention. The results of the study showed that the type of hand exercise in handgrip exercise was more effective in reducing edema and pain in the upper extremities compared to finger exercises and acupuncture point massage, but there was no significant difference in the skin temperature of the pierced limb and the degree of bleeding between the three groups (X. Zhang et al., 2023).

Previous research shows that hand exercises can guide patients to perform functional exercises that can improve blood circulation in the upper limbs and increase blood flow in the radial artery and cephalic vein (Lewandowski et al., 2021). In the hand grip test after transradial study (HANGAR), a hand dynamometer applied to patients undergoing transradial PCI improved the recovery of hand strength and helped improve blood circulation in the limbs. In addition, other hand exercises such as acupoint massage and finger exercises with low intensity and short duration produce significant reductions in blood pressure and can improve cardiovascular stress in patients diagnosed with coronary artery disease (Sciahbasi et

al., 2016). The aim of this systematic review is to review and determine the effect of hand exercise on limb function in CAD patients post transradial cardiac catheterization.

METHOD

The method used in this research is a Literature Review with a Systematic Review type. The source of information in this research uses secondary data. The databases used in this research are ScienceDirect, ProQuest, PubMed, Scopus and Hand Searching on Google Scholar. The author conducted a literature search through databases using English and a systematic literature search between 2013 and 2023. In the search for related literature using several keywords such as: "Coronary artery disease" AND "transradial artery catheterization" OR "Trans cardiac Catheterization" AND " hand exercise" AND "limb function". In the initial stage of searching for information on October 5 2023, the online data base from ProQuest got 4386, using Science Direct 8 articles, Scopus got 2 articles, then PubMed got 1617 articles. Next, hand searching using Google Scholar got 1260 articles. The total number of articles obtained before selection was carried out based on inclusion and exclusion criteria was 7273 articles. The systematic review used in this study used the Preferred Reporting Item for Systematic Reviews and Meta-Analytics (PRISMA) search strategy. From the five databases used, selection was then carried out according to the inclusion and exclusion criteria. The inclusion criteria are research articles published in the last 10 years (2013-2023); use English; is a journal article and open access; Involves adult respondents and full text articles. Exclusion criteria are encyclopaedia articles, book chapters, conferences, correspondence, editorials, news, practice guidelines, protocols, systematic reviews, literature reviews and meta analysis. The journal selection process in the PRISMA adaptation literature review research is shown in Figure 1.



Gambar 1. Table PRISMA

RESULTS

This literature review includes seven studies that used hand exercises to treat limb function. Of these, discussing limb function outcomes: pain, edema, bleeding, blood circulation, arm and finger muscle strength. Three articles discuss the immediate effects after two hours of action, namely: pain, edema and bleeding. The other four articles discuss the long-term

effects, namely blood circulation, muscle strength and fingers. The study was conducted in five countries, namely China, America, England, Italy, Lithuania and Colombia. From the results of 3 studies that had an immediate effect after the procedure, among the three hand exercise groups, there was no reduction in the circumference of the middle finger and palm within 1 hour. However, the middle finger edema of patients in the handgrip exercise group decreased gradually at 2 hours and 4 hours after intervention compared with finger exercise and acupoint massage. Likewise, the palm edema of patients in the handgrip exercise group was gradually reduced at 2 hours and 4 hours after the intervention compared with the other two groups. The pain score at the 4th hour decreased in the handgrip exercise group and was lower than in the acupoint massage group and finger exercise group. whereas in the other 2 groups there was no difference. In terms of safety, hand skin temperature gradually recovered in all three groups, which showed no significant difference. In addition, bleeding from the puncture site after surgery was seen in all patients, and there was no significant difference in the bleeding rate between the three groups (Brogiene et al., 2022a; X. Zhang et al., 2022, 2023).

From the results of 4 studies with long-term effects, for analysis of hand grip strength, loss of hand grip strength was found in hand access after catheterization. This study monitored hand grip strength for at least 30 days after the procedure. The results showed no significant difference in hand exercise compared to the control group. Arterial diameter and blood flow velocity did not change after 6 weeks of intervention in all three groups. The impact of catheterization on the response to hand exercise on radial artery (RA) diameter, with an increase in RA diameter in response to hand exercise. Significant findings show that the RA diameter is wider 1 week after catheterization (Dawson et al., 2012; Gaviria et al., 2021; Sciahbasi et al., 2016; Tryfonos et al., 2020).

Table 1.
Summary Results of Review Articles

Database	Authors, country of origin, year of published	Article title	Journal title	Aim	Design	Sample	Results (can be expanded)	Notes
ProQuest	(X. Zhang et al., 2023) China	Comparison of the effects of three kinds of hand exercises on improving limb function in patients after transradial cardiac catheterization	International Journal of Nursing Sciences	this study aimed to explore the effectiveness of this method and determine which is more conducive to alleviating patients' discomfort while ensuring its safety.	RCT	99 participant	Among the 99 participants who completed the process, the palm edema was gradually relieved in the handgrip exercise group at 2 h (H 1⁄4 6.710, P 1⁄4 0.035) and 4 h (H 1⁄4 10.060, P < 0.001) following the intervention. The edema of fingers in the handgrip exercise group was obviously relieved at 2 h (H 1⁄4 9.353, P < 0.01) and 4 h (H 1⁄4 10.699, P < 0.001) following the intervention compared with the other two groups. In addition, the pain	We discovered that handgrip exercise, compared to finger exercise and acupoint massage, is more successful in reducing limb edema.

Database	Authors, country of origin, year of published	Article title	Journal title	Aim	Design	Sample	Results (can be expanded)	Notes
							score at 4 h (H 1⁄4 7.048, P 1⁄4 0.029) was clearly decreased in the handgrip exercise group. However, there was no significant difference in the punctured limb's skin temperature (H 1⁄4 0.922, P 1⁄4 0.631) and the degree of bleeding (H 1⁄4 0.123, P 1⁄4 0.940) among the three groups.	
Scopus	(Tryfonos et al., 2020) Amerika	Exercise-induced vasodilation is not impaired following radial artery catheterization in coronary artery disease patients	the America n Physiolo gical Society	This study aimed to examine arterial re-sponses to acute exercise followin g catheteri zation.	Quasi Experime ntal	33 participant	Thirty-three CAD patients (65.87.3 yr, 31.56.3 kg/m^2, 82% men) undergoing transradial catheterization were assessed before and 1 wk postcath-eterization. Radial artery (RA) diameter and shear rate were assessed during handgrip exercise (HE), in both the catheterized (CATH) and control (CON) arms. Endothelial function was also assessed via simultaneous bilateral radial flow-mediated dilation (FMD) at both time points. We found that the increase in RA diameter and shear stress in response to HE (*P* 0.0001) was maintained postcatheter- ization in both the CATH and CON arms, whereas FMD following catheterization was impaired in the CATH [6.5 3.3 to 4.7 3.5% (*P* 0.005)] but not in the CON [6.22.6 to 6.43.5% (*P* 0.797)] limb. While endothelial	In summary, this work offers valuable insights into artery function in humans after catheterizati on. Our findings demonstrate d that, despite localized FMD impairment brought on by catheterizati on, the RA's capacity to dilate in response to exercise after damage from the procedure was mostly unchanged. This emphasizes the possibility that stimulus-specific vascular reactions to catheterizati on exist. Exercise-based rehabilitatio

Database	Authors, country of origin, year of published	Article title	Journal title	Aim	Design	Sample	Results (can be expanded)	Notes
							dysfunction, assessed by FMD, was apparent 1 wk postcatheterization, the ability of the RA to dilate in response to exercise was not impaired. The impact of catheterization and consequent endothelial denudation on vascular dys/function in humans may therefore be stimulus specific, and a highly level of redundancy appears to exist that preserves exercise-mediated vasodilator responses.	n may be safe to begin shortly after catheterizati on operations because vascular responses to exercise were largely retained after the procedure; however, this needs to be validated in larger samples and with different cohorts.
PubMed	(Sciahbasi et al., 2016) Italy	Radial Artery Occlusion and Hand Strength After Percutaneous Coronary Procedures: Results of the HANGAR Study	Catheterization and Cardiovascular Intervention	The aim of this prospective study was to evaluate muscle force of the hand, thumb, and forefinger in patients with prolonged radial occlusion after transradial percutaneous coronary procedures.	a single-centre prospective study designed/ cohort	99 participant	The day before their percutaneous coronary procedures, elective patients with chronic stable angina underwent evaluations for radial artery patency, hand grip, Allen test, and thumb and forefinger pinch tests. Both at the follow-up and the day following the procedure, the identical actions were taken. Patients were split into two groups at follow-up based on whether they had radial patency (group 1) or occlusion (group 2). Findings: Of the 99 individuals in the study, nine (9.1%) had an occluded artery (group 2) and 90 patients had a patent radial artery (group 1). At baseline, there were no significant differences in hand grip test between the two groups (42611	Radial artery occlusion after percutaneous coronary procedures was not associated with a reduction in hand and finger strength.

Database	Authors, country of origin, year of published	Article title	Journal title	Aim	Design	Sample	Results (can be expanded)	Notes
							kg in group 1 and 41617 kg in group 2, P50.74). In both groups, after the procedure, the hand grip test values was significantly reduced com- pared with baseline values (40 6 11 kg in group 1, P < 0.0001 and 37 6 17 kg in group 2, P50.007).	
Hand searching google scoolar	(X. Zhang et al., 2022) China	Effects of Acupoint Massage, Finger and Handgrip Exercise on Edema and Hand Pain After Transradial Approach for Coronary Procedure	International Journal Of Nursing Sciences	To explore the effectiveness of acupoint massage, finger and handgrip exercise methods and determine which method is more conducive to reducing patient discomfort while ensuring safety.	RCT	95 participant	In the second, fourth, and sixth hours following the intervention, the edema of the patients' middle finger in the handgrip exercise group (consisting of 33 patients, 34 in the acupoint massage group, and 28 in the finger exercise group) decreased gradually in comparison to the other two groups. Furthermore, in the fourth and sixth hours following the injection, the patient's palm edema during handgrip activity progressively subsided. In the handgrip exercise, there was a noticeable decrease in the fourth hour's pain score. However, there was not a significant difference in the level of bleeding or the operating limb's skin temperature.	Compared with finger exercise and acupoint massage, handgrip exercise would promote the blood circulation and relieve the edema of operative limb.
Pub Med	(Dawson et al., 2013) United Kingdom	Low-Flow Mediated Constriction is Endothelium-Dependent Effects of Exercise Training After Radial	Circ Cardiovasculer Interv	The aim of this study was therefore 2-fold: to examine the impact of catheteri	RCT	32 participant	Thirty-two subjects undergoing transradial catheterization underwent assessment of L-FMC and FMD in the catheterized and contralateral radial artery before, and the day after, catheterization. A	L-FMC in the radial artery is reduced by catheterization and the ensuing endothelial denudation, indicating that it is endothelium

Database	Authors, country of origin, year of published	Article title	Journal title	Aim	Design	Sample	Results (can be expanded)	Notes
		Artery Catheterization		zation on radial artery vasoconstrictor function (L-FMC) in the catheterized (Cath) and noncath-eterized arms, and to examine the impact of localized handgrip exercise training on radial artery FMD and L-FMC after catheterization.			further 18 patients were recruited and randomly assigned to either a 6-week handgrip exercise training program (N=9) or a nonexercise control period (N=9). L-FMC was attenuated 1 day postcatheterization in the catheterized arm (−2.07±0.84 to 0.35±0.83), but unchanged in the noncatheterized arm (−0.93±0.86 to −0.90±0.92; *P*<0.05). In the training study, both FMD and L-FMC of the catheterized arm were preserved in the exercise group 7 weeks after catheterization (FMD-pre, 6.84±0.79; FMD-post, 6.85±1.16; L-FMC-pre, −2.14±1.42; L-FMC-post, −3.58±1.04%), but reduced in the control group (FMD-pre, 8.27±1.52; FMD-post, 4.66±0.70; *P*=0.06; L-FMC-pre, −3.26±1.19; L-FMC-post, −1.34±1.27%; *P*<0.05).	-dependent. Furthermore, we show for the first time that exercise training improves the function of the vasodilators and constrictors in the radial artery.
Hand searching google scoolar	(Gaviria et al., 2021) Colombia	Coronary arteriography with radial access in coronary acute disease and its relation with handgrip strength and radial artery permeability (CARHA	Cardiovasc Metab Sci.	examined the frequency of problems following coronary artery bypass grafting with radial access. With a focus on grip	Prospective observational longitudinal cohort study	77 participant	Proportion according to gender was 48.1% women and 51.9% men, the median age of 66 years (58-72). In the handgrip strength of patients with radial access, we found a statistically significant difference between the initial and final measurement p < 0.001 (IC 95%: 1.59-4.07).	Future research is necessary to fully understand the sort of intervention that resulted in the considerable loss of handgrip strength in both genders, as well as the force values for IADL

Database	Authors, country of origin, year of published	Article title	Journal title	Aim	Design	Sample	Results (can be expanded)	Notes
		NG)		strength in particular and how it relates to radial flow in order to lay the theoretical groundwork for future modifications to the standards and protocols now in use for coronary arteriography.				that were below ideal levels.
Proquest	(Brogiene et al., 2022) Lithuania	Procedure-Related Access Site Pain Multimodal Management following Percutaneous Cardiac Intervention: A Randomized Control Trial	*Pain Research and Management*	Multimodal pain management (MPM) models can reduce the intensity and prevalence of pain and this approach has not been researched in the field of postprocedural pain management.	RCT	137 participant	Results showed that A-S pain prevalence during the 3-month follow-up period was decreasing. Statistically significant difference between the groups (CG versus IG) was after 24 h (41.2% versus 18.5, $p = 0.005$), 48 h (30.9% versus 1.5%, $p \leq 0.001$), 1 week (25% versus 10.8%, p 0.042), 1 month (23.5% versus 7.7%, $p = 0.017$) after the procedure. The mean of the highest pain intensity was after 2 h (IG-2.17 ± 2.07; CG-3.53 ± 2.69) and the lowest 3 months (IG-0.02 ± 0.12; CG-0.09 ± 0.45) after the procedure. A-S pain intensity mean scores were statistically significantly higher in CG during the follow-up period	In conclusion, MPM approach can reduce A-S pain prevalence and pain intensity after PCI. More randomized control studies are needed.

Database	Authors, country of origin, year of published	Article title	Journal title	Aim	Design	Sample	Results (can be expanded)	Notes
							(Wilks' λ 0.84 F (7,125) 3.37, p = 0.002).	

DISCUSSION

This review was conducted to identify hand exercise interventions to recharge limb function in CAD patients posttransradial artery catheterization. There are several types of hand exercise intervention, including handgrip exercise, finger exercise, acupoint massage. This review revealed that hand exercise intervention was effective in improving arm function immediately after 2 hours of the procedure and in the long term after transradial artery catheterization. In this study, there was an effect of general arm training on leg comfort. In addition, it was found that handgrip exercises were more effective in reducing edema in the arms compared to finger exercises and acupoint massage. Handgrip exercise significantly reduced palm circumference and finger circumference starting from 2 hours post-intervention; the edema of the middle finger and even other fingers in the handgrip training group was obviously reduced compared with the other groups. This is caused by peripheral blood circulation starting from the fingers and gradually but in this study at 6 hours after the procedure and found that the degree of extremity edema in the three groups of patients gradually stabilized, which may be caused by gradual relaxation of the patient's wounds. pressure at the sixth hour, allowing the targeted limb to return to normal blood flow (X. Zhang et al., 2022, 2023).

Applying handgrip exercise also has another advantage of significantly accelerating hemostasis following transradial access. Regularly reducing pressure at the puncture site in conjunction with physical exercise can assist in the better relief of extremity edema. According to research, the pulmonary pump and muscle are the two main components that propel the peripheral venous return to the heart. Without impacting systemic circulation, hand workouts like empty hand holds and hand muscle expanders can raise venous return. Due to the minimal degree of muscle contraction, merely performing finger exercises or acupoint massage as a venous return approach may not have a major intervention effect. Handgrip exercises, on the other hand, are meant to take advantage of the motor effect that muscle pumps have on the velocity of peripheral venous flow. In addition, the use of handgrip exercises for resistance training can help stretch the forearm muscles, contract the flexor muscles of the hands, and effectively encourage the return of blood, lymph and can help increase fibrinolytic activity and reduce plasminogen activator-1, thereby increasing tissue-type plasminogen activator (t-RA) and increasing plasmin dissolution, which increases blood flow velocity and improves blood circulation. Different from other resistance exercises such as holding a bouncy ball, handgrip exercises can restore grip strength by avoiding excessive or insufficient grip strength which affects grip training. Regarding the procedure, handgrip exercises give patients the feeling of grasping an object to increase their compliance, distract the patient's attention and eliminate the perception of pain (Brogiene et al., 2022a; X. Zhang et al., 2022, 2023).

Handgrip exercise, which has a long-term effect, increases the vasodilator response 1 week after catheterization. This suggests that it can maintain its ability to dilate in response to exercise after catheterization. This may have implications for recommendations regarding safe timing for cardiac rehabilitation. This also has an effect on improving endothelial function which restores Nitrous oxide to carry out vasodilation and vasoconstriction when the patient exercises (Tryfonos et al., 2020). In other studies, catheterization can result in denudation of the

endothelium, with handgrip exercise being able to weaken the peripheral vasoactive effects of the endothelin-114 pathway and that this exercise increases (flow mediated dilatation) FMD which functions to dilate blood vessels. The mechanisms responsible for the impact of handgrip exercise on FMD involve mobilization of progenitor cells 15 – 17 and early return of functional integrity of the endothelial layer. This handgrip exercise can protect against the effects of oxidation or inflammation on artery walls and also on endothelial function (Dawson et al., 2013). The effects of catheterization can also cause loss of hand grip function due to procedural factors: in some patients, there is a local hematoma, and most patients experience symptoms of radial puncture. With this handgrip exercise, you can restore hand grip function by improving circulation to the peripheral areas of the hand so that the hand muscles are able to move again (Gaviria et al., 2021; Sciahbasi et al., 2016). This study showed that blood flow velocity increased significantly compared to the resting state by using various frequencies and durations of hand grip training in patients. These results are consistent with previous research which states that clinical handgrip exercise with moderate frequency and duration can improve blood circulation in the upper extremities in patients (M. Zhang et al., 2014).

CONCLUSION

Hand exercises are useful for returning limb function both within two hours after the procedure and over a long period of time. Using an electronic handgrip exercise to perform grip exercises is the most effective type of hand exercise among other hand exercise exercises to improve blood circulation and relieve edema, pain and bleeding in the extremities for CAD patients after transradial access. In the handgrip exercise group, edema on the fingers was reduced, and hand circumference decreased after the intervention compared to the other two groups. In addition, the results showed that this approach had a positive impact on the patient's pain perception, which disappeared within 4 hours after the intervention and could also guarantee the safety of hand grip training. The three types of hand exercise can jointly prevent bleeding or hematoma within 24 hours.

REFERENCES

Brogiene, L., Urbonaite, A., Baksyte, G., & Macas, A. (2022). Procedure-Related Access Site Pain Multimodal Management following Percutaneous Cardiac Intervention: A Randomized Control Trial. Pain Research and Management, 2022. https://doi.org/10.1155/2022/6102793

Dawson, E. A., Alkarmi, A., Thijssen, D. H. J., Rathore, S., Marsman, D. E., Timothy Cable, N., Jay Wright, D., & Green, D. J. (2013). Low-flow mediated constriction is endothelium-dependent: Effects of exercise training after radial artery catheterization. Circulation: Cardiovascular Interventions, 5(5), 713–719. https://doi.org/10.1161/CIRCINTERVENTIONS.112.971556

Gaviria, S., Alzate, M., Ramírez, A., Villegas, J., Restrepo, A., Ospina, J. J., Jaramillo, N., Moreno-Bedoya, S., & Contreras, H. (2021). Coronary arteriography with radial access in coronary acute disease and its relation with handgrip strength and radial artery permeability (CARHANG). Cardiovascular and Metabolic Science, 32(2), 94–100. https://doi.org/10.35366/99746

Kementrian Kesehatan RI. (2022, September 29). Penyakit Jantung Penyebab Utama Kematian. https://sehatnegeriku.kemkes.go.id/baca/rilis-media/20220929/0541166/penyakit-jantung-penyebab-utama-kematian-kemenkes-perkuat-layanan-primer/

Khairnar, S. V., Nath, R. K., Yadav, B., Bhosale, K., & Chandraker, S. (2021). Prevalence of abnormal upper limb arterial anatomy and its correlation with access failure during transradial coronary angiography. Indian Heart Journal, 73(1), 44–48. https://doi.org/10.1016/j.ihj.2020.11.146

Lewandowski, P., Budaj, A., Zuk, A., Slomski, T., Maciejewski, P., & Ramotowski, B. (2021). The impact of using a larger forearm artery for percutaneous coronary interventions on hand strength: A randomized controlled trial. Journal of Clinical Medicine, 10(5), 1–11. https://doi.org/10.3390/jcm10051099

PERKI. (2022). Panduan pravensi arterosklerosis (Vol. 1).

Sciahbasi, A., Rigattieri, S., Sarandrea, A., Cera, M., Di Russo, C., Fedele, S., Romano, S., Penco, M., & Rocco Pugliese, F. (2016). Radial artery occlusion and hand strength after percutaneous coronary procedures: Results of the HANGAR study. Catheterization and Cardiovascular Interventions, 87(5), 868–874. https://doi.org/10.1002/ccd.26142

Shahjehan, R. D., & Bhutta, B. S. (2023, February 9). Coronary Artery Disease. NIH. https://www.ncbi.nlm.nih.gov/books/NBK564304/

Tryfonos, A., Cocks, X. M., Mills, J., Daniel, X., Green, J., & Dawson, E. A. (2020). Exercise-induced vasodilation is not impaired following radial artery catheterization in coronary artery disease patients. J Appl Physiol, 128, 422–428. https://doi.org/10.1152/japplphysiol

Tryfonos, A., Green, D. J., & Dawson, E. A. (2019). Effects of Catheterization on Artery Function and Health: When Should Patients Start Exercising Following Their Coronary Intervention? In Sports Medicine (Vol. 49, Issue 3, pp. 397–416). Springer International Publishing. https://doi.org/10.1007/s40279-019-01055-3

Virani, S. S., Alonso, A., Benjamin, E. J., Bittencourt, M. S., Callaway, C. W., Carson, A. P., Chamberlain, A. M., Chang, A. R., Cheng, S., Delling, F. N., Djousse, L., Elkind, M. S. V., Ferguson, J. F., Fornage, M., Khan, S. S., Kissela, B. M., Knutson, K. L., Kwan, T. W., Lackland, D. T., … Tsao, C. W. (2020). Heart disease and stroke statistics—2020 update a report from the American Heart Association. Circulation, 141(9), E139–E596. https://doi.org/10.1161/CIR.0000000000000757

Zhang, M., Fang, X. X., Li, M. E., Zheng, C. H., Zhou, X. H., & Lyu, X. Q. (2014). Handgrip exercise elevates basilic venous hemodynamic parameters in healthy subjects. International Journal of Nursing Sciences, 1(4), 389–393. https://doi.org/10.1016/j.ijnss.2014.10.014

Zhang, X., Bao, Z., Wei, L., Zhang, Z., Hu, Y., Xu, D., Sun, W., & Xu, D. (2023). Comparison of the effects of three kinds of hand exercises on improving limb function in patients after transradial cardiac catheterization. International Journal of Nursing Sciences, 10(2), 182–188. https://doi.org/10.1016/j.ijnss.2023.03.011

Zhang, X., Bao, Z., Wei, L., Zhang, Z., Hu, Y., Xu, D., & Xu, D. (2022). Effects of Acupoint Massage, Finger and Handgrip Exercise on Edema and Hand Pain After Transradial Approach for Coronary Procedure. International Journal of Nursing Sciences. https://doi.org/10.21203/rs.3.rs-1351907/v1