Effect of Hand Exercise Program on AV-Shunt Maturation in Chronic Kidney Disease Patients: A Literature Review

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Abstract

An important aspect in the management of chronic kidney disease is the establishment of adequate vascular access for hemodialysis. Arteriovenous fistula (AV-shunt) is the main and most ideal option for vascular access in the hemodialysis process. This study collected research on the assessment of the effectiveness of hand training programs on arteriovenous shunt (AV-Shunt) maturation in patients with chronic kidney disease (CKD). Searches were conducted on ScienceDirect and Google Scholar. Only experimental studies examining the effects of hand exercises after surgery were reviewed. Data that has been filtered and reviewed by researchers. This study aims to summarize the effects of various hand training programs in the process of AV-Shunt/AVF maturation in CKD patients through a literature review. This study uses the literature review method by analyzing articles from trusted electronic databases such as ScienceDirect and Google Scholar with the keywords maturation AV-Shunt, hand exercises and CKD. The selected articles met the inclusion criteria, namely focusing on hand training interventions analyzed with the PICOT approach. The results of the study show that regular exercise can increase blood diameter and flow, resulting in the patentability of vascular access for the hemodialysis process, which ultimately improves the quality of life. A structured exercise program is an effective intervention in the maturation process of AV-Shunt in CKD patients.

***Keywords**: AV-Shunt Maturation, Hand Exercises, CKD.*

A. INTRODUCTION

Chronic Kidney Disease (CKD) is a health condition characterized by a gradual decline in kidney function, one of the treatments of which is hemodialysis. To improve the quality of life of hemodialysis patients, adequate hemodialysis adequacy is required, where in achieving hemodialysis adequacy, adequate and patent vascular access is required. Arteriovenous Fistula (AVF) is the most recommended type of vascular access or the main choice recommended by the National Kidney Foundation (NKF-KDOQI), because it has the lowest rates of infection, stenosis, and thrombosis compared to other types of vascular access. In addition, AVF is considered to have superior patency and lower complications. Although AVF is arguably the most ideal vascular access, and is usually made long before dialysis begins, many of them fail, so patients must start hemodialysis (HD) using a catheter, which increases the risk of catheter-related complications.

Globally, AVF maturation failure remains a clinical problem for patients and has been reported in observational studies ranging from 20% to 60% (KDOQI Clinical Practice Guideline for Vascular Access, 2020). After AVF creation, it will take time to mature. AVF maturity can be evaluated clinically or using ultrasound. Depending on

the level of maturity, early AVF cannulation can be performed between one and six months after creation. Delays in AVF maturation or failure are closely associated with morbidity related to vascular access (Maruti, 2019).

In a systematic review conducted by Nantakool et al. (2020) stated that arm exercise programs carried out after AVF surgery provide a superior effect on the level of maturation compared to usual care or unstructured exercise. Various training efforts are made to support AV-shunt maturation, one of which is by using a simple aid, namely a handgrip with a certain load setting. This study aims to summarize the effects of various hand exercise programs on the AV-Shunt maturation process in CKD patients through a literature review.

B. METHOD

This article is a literature review that summarizes and analyzes the results of related studies. Literature searches were conducted using electronic databases, namely ScienceDirect and Google Scholar using the keywords AV-Shunt maturation, hand exercises, and CKD. The search was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol and involved selecting articles based on predetermined inclusion criteria. The article search period lasted from November to December 2024. The next step is to identify the problem or research topic to be solved. By setting research parameters and limitations, researchers can narrow the scope of the literature study to support research objectives in a more focused manner.

Finally, the researchers determined the inclusion criteria in the literature search were freely accessible English-language articles published in the last five years (2019-2024), articles using quantitative research methods with experimental designs, and original and relevant research articles in full text and open access. The exclusion criteria were articles where hand exercise interventions were carried out before the AV-Shunt was created and unpublished research. From the search, a total of 2074 ScienceDirect and Google Scholar articles were found. After initial screening of articles based on the inclusion criteria of stage 1, 603 articles were obtained. Further screening related to duplicate articles, qualitative research and original articles obtained 92 articles, then articles with experiments and hand exercises performed after AV-Shunt surgery, found 8 articles, then completeness of text and open access produced 8 articles, 8 articles were taken for analysis.

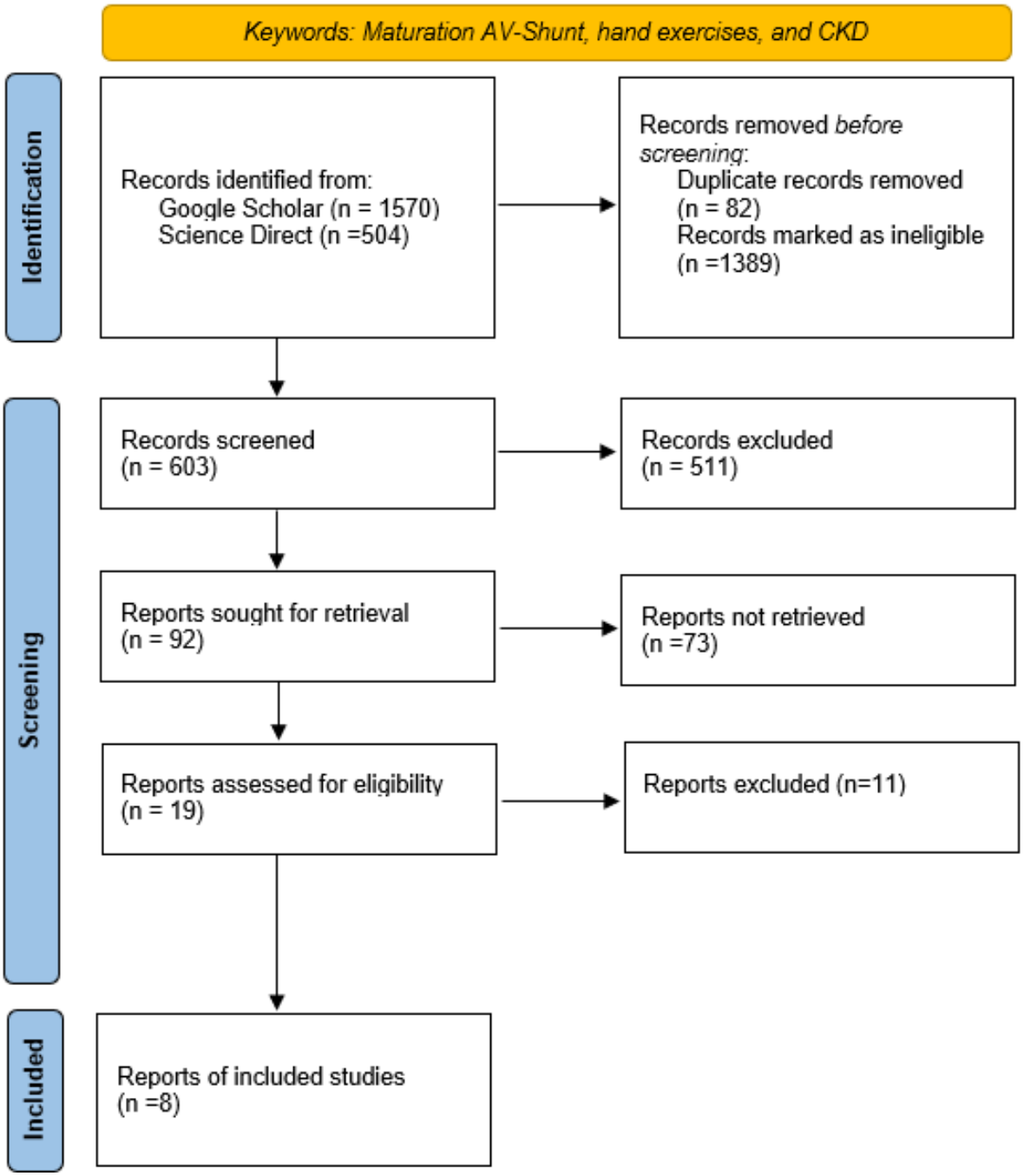

Figure 1 PRISMA Diagram

The characteristics of the included articles can be seen in table 1 below:

Table 1. Characteristics of Articles

Title	Population/Sample	Intervension	Comparation	Results	Time
Chen, J. W., Fu, H. Y., Hii, H., Tseng, H. W., Chang, P. Y., Chang, C. H., ... & Chan, C. Y. (2023). A randomized trial of postoperative handgrip exercises for fistula maturation in patients with newly created wrist radiocephalic arteriovenous fistulas. *Kidney International Reports*, *8*(3), 566-574.	Post-AV-fistula surgery patients with a sample of 119 patients aged 20 to 80 years with newly created radiocephalic AVF.	Postoperative handgrip exercises program consisting of three groups: 1. Group A: Basic program (2 sessions per day). 2. Group B: Advanced program (6 sessions per day) 3. Group C: Advanced program plus upper arm tourniquet (6 sessions per day)	Group A was compared with group B and group C to determine the benefits of hand exercises on AVF maturity.	1. No significant differences were found in the three groups at each period of 14-90 days post AVF surgery 2. A slight decrease in group B on the 60th day but still not significant.	3 months after AV fistula creation.
Kumar A/LS Katheraveloo, K., Suryani Safri, L., Guo Hou, L., Hafiz Maliki, A., Md Idris, M. A., & Harunarashid, H. (2020). Effect of isometric handgrip exercise on the size of cephalic veins in patients with stage 3 and 4 chronic kidney disease: A randomized controlled trial. *The Journal of Vascular Access*, *21*(3), 372-378.	34 patients with chronic kidney disease requiring vascular access for hemodialysis.	8-week handgrip isometric exercise to increase cephalic vein diameter in the non-dominant arm. Method: squeeze a standard squeeze ball for 2x15 min/day, 20 x/min for 8 weeks	The control group did not do handgrip training.	1. After 8 weeks, the mean cephalic vein diameter in the intervention group increased from 1.77 to 2.15 without a tourniquet and from 1.97 mm to 2.43 mm with a tourniquet ($p < 0.05$). 2. There was also a significant change in the mean diameter of the distal forearm cephalic vein ($p < 0.05$) in the intervention group when measured both with and without a tourniquet.	The duration of the intervention was 8 weeks, with measurements taken at weeks 0, 4, and 8.

Li, Y., Huang, L. J., Hou, J. W., & Hu, D. D. (2024). Impact of stage-specific limb function exercises guided by a self-management education model on arteriovenous fistula maturation status. *World Journal of Clinical Cases*, *12*(14), 2316.	Patients with arteriovenous fistula (AVF) in a hospital in Sichuan, China, undergoing hemodialysis and aged 18 years and above, with a sample of 74 patients	Gradual leg training based on self-management that includes 3 phases, namely 1. Phase of forming self-management awareness, starting 2 weeks before surgery, namely training with mnemonic techniques with instructional video media. 2. Physician-led training phase, starting from the first post-operative day to the 7th day, then the 8th to 14th day the training is the same as in the first phase. 3. Patient-led training phase, starting from the 15th day to the 8th week, by gradually expanding the variety and frequency of training.	The control group received standard limb function training without self-management-based stages.	4. The results showed that the intervention group had higher scores in symptom recognition, symptom prevention, and self-management than the control group after 8 weeks ($P < 0.05$). 5. In addition, the intervention group showed better blood vessel diameter and depth of the skin than the control group at 4 weeks and 8 weeks postoperatively ($P < 0.05$).	Evaluations were performed at 4 and 8 weeks after surgery.
Nantakool, S., Srisuwan, T., Reanpang, T., Rerkasem, K., & Prasannarong, M. (2022). A randomized controlled trial of the effect of postoperative hand exercise training on arteriovenous fistula maturation in patients	Patients with chronic kidney disease (CKD) stages 4-5 who will undergo arteriovenous fistula (AV fistula) creation with a sample of 25 respondents.	Isometric (ISM) hand exercise program with an intensity of 30% MVC (maximum voluntary contraction) for 25 respondents. The program consists of: 1. Warm-up: static stretching of the flexor and extensor muscles of the forearm and hand 2. Exercise: Squeezing and	Isotonic exercise (IST) on the hands of 25 respondents as a control group	1. ISM is better at increasing cephalic vein diameter than IST 2. Both programs increase brachial artery diameter and brachial artery blood flow 3. ISM provides more patients who meet ultrasound and clinical maturity criteria	10 weeks

with chronic kidney disease. *Journal of Vascular Surgery*, *75*(1), 230-237.		holding a hand grip exercise device at 30% MVC for 1 minute, 6 times a day, increased by 1 minute each week to a maximum of 6 minutes and then maintained until the 10th week. 3. Cool-down: the procedure is the same as the first week's warm-up.			
Manjunath, P. M., Gurpremjit, S., Devender, S., Surabhi, V., Ramana, A. P., Sreenivas, V., & Aggarwal, S. K. (2021). The effect of post-operative handgrip exercise on the maturation of arteriovenous fistula: a randomized controlled trial. *Indian Journal of Surgery*, *83*, 920-925.	A total of 200 patients with chronic renal failure were randomly allocated to a handgrip exercise group or a control group.	Grip exercises were performed for 8 weeks after AVF surgery. Clinical and ultrasonographic success of AVF was assessed at 8 weeks, exercises were performed 10 min/h or until fatigue. With n = 98	Control group that did not do hand exercises with n = 96	1. In the radiocephalic FAV group, the clinical success rate was higher in the handgrip training group than in the control group (p = 0.043). 2. There was no significant difference in ultrasonographic success between the two groups. There was no difference in outcomes between the groups for brachiocephalic FAV.	8 weeks (2017-2018)
González, I. T., Simó, V. E., Pallares, S. I., Guzman, F. M., Nicolás, M. F, Gallego, V. D, ... & Serna, M. R. D. A. (2021). Upper limb isometric exercise protocolled programme	Patients with chronic kidney failure stage 5-5D who will undergo FAV creation in the upper arm	The intervention group will perform an isometric exercise program.	The control group only received routine education	1. Vein size, brachial blood flow, and arm muscle strength were significantly improved only in the intervention group. 2. The clinical and ultrasonographic	November 2015 and December 2017, respondents were observed for 4 weeks and 8 weeks post-surgery

and arteriovenous fistula maturation process. *Clinical Kidney Journal*, *14*(2), 688-695.				maturation rates of FAV were higher in the intervention group at 4 weeks (70% vs 33%) and 8 weeks (77% vs 33%) postoperatively. 3. These results apply to both the distal and proximal regions of FAV.	respectively.
Poetra, J. F., Andriati, D. P., & Poerwandari, D. (2019). The Effect Of Hand Exercise On Grip Strength, Forearm Circumference, Diameter Of Vein, Blood Flow Volume And Velocity In Patient Who Underwent Arteriovenous Fistula Surgery And On Routine Haemodialysis. *Sura Phys Med Rehab J*, *1*(1), 14-24.	Patients with routine HD who underwent arteriovenous fistula (AVF) surgery with a sample of 14 respondents.	Hand exercises using hand grips for 5 weeks. Hand exercise technique: Performed in morning and evening sessions Each session 3x10 grips at a speed of 10 x/min.	Control group that received routine care without the introduction of the hand gripper.	1. Grip strength and forearm circumference significantly increased in the intervention group before and after exercise intervention ($p < .001$, $p = .001$). 2. Cephalic vein diameter and blood flow also significantly increased in this group ($p = .027$, $p = .033$). 3. Blood flow velocity showed no difference before and after exercise intervention. 4. Significant results were found in the increase in grip strength, forearm circumference, cephalic vein diameter, and blood flow volume compared between treatment groups ($p < .001$; ES = .94,	July and November 2015, observations were conducted for 5 weeks on each participant.

				$p < .001$; ES = .4, $p = .046$; ES = .84, $p = .035$; ES = .53). 5. There was no difference in cephalic vein blood flow velocity between these two groups.	
Silva, I. B., Barbosa, J. B., Araújo, A. X. P., & Marinho, P. E. (2021). Effect of an exercise program with blood flow restriction on the muscular strength of patients with chronic kidney disease: a randomized clinical trial. *Journal of Bodywork and Movement Therapies*, *28*, 187-192.	Patients with chronic kidney disease (CKD) who require arteriovenous fistula (AVF) before undergoing hemodialysis with a sample of 26 patients.	A partial blood flow restriction (BFR) exercise program in the arm, involving isometric exercises for the finger and elbow flexor muscles.	The control group performed the exercise without blood flow restriction.	The results showed that there was no significant difference between the intervention and control groups in terms of handgrip strength and arm circumference at the end of the program. However, both groups showed an increase in muscle strength and arm circumference from baseline.	The duration of the intervention was eight weeks, with exercises performed five times a week.

C. RESULTS AND DISCUSSION

The results of the article findings in the table above show various exercise program interventions aimed at arteriovenous shunt (AVF) maturation in CKD patients. Various studies reviewed emphasize the importance of hand exercises in improving the size and function of blood vessels, as well as quality of life in CKD patients. In the findings of Munjanath et al. (2020) handgrip exercises after AV-Shunt Radiocephalica (RCAVF) surgery not only help improve grip strength but also contribute to postoperative clinical success.

Kumar et al. (2019) who studied the impact of isometric exercises using handgrips to increase the diameter of the cephalic vein in CKD patients where the effect of this hand exercise can be increased by applying a tourniquet, although the duration of exercise in this study was not comparable to the increase in vein diameter. Physical activity in this case hand exercises physiologically increases blood flow and stimulates nitric oxide substances that cause vasodilation. In accordance with this study which showed a significant increase after eight weeks of exercise, and supports that this type of exercise is effective in improving vascular access.

Similar results were also found by Chen et al. (2022), hand exercise program using handgrip showed positive results in the AV-Shunt maturation process. This exercise was performed on patients with different exercise frequencies where higher exercise frequencies could increase the diameter and blood flow of the veins although no significant differences were found in all groups studied. The results of AVF maturation that were not significant in the difference in hand exercise frequency found by Chen et al, provide the assumption that the exercise program is sufficient to be carried out only 2 sessions per day.

In the hand exercise program in the study of Li et al. (2024) which discussed self-management, gradual exercise showed good results in improving AV-Shunt maturation and patient quality of life. This approach emphasizes the importance of patient education in doing exercises independently to maintain health. However, the interventions carried out in this study are quite complex and are very likely to confuse patients with the stages of exercise. Simplification of education may be very necessary to make it easier for patients to exercise their hands. In the study of Gonzalez et al. (2021) highlighted the importance of an education program for patients in understanding and doing exercises correctly. By following a good education program, patients can significantly improve their health outcomes. From the results of this study, it can be concluded that a structured exercise program is an effective intervention in the AV-Shunt maturation process in CKD patients.

In the study of Febrianto et al. (2019), showed significant results between the control group and the intervention group in terms of grip strength, forearm circumference ($p = 0.001$), cephalic vein diameter ($p = 0.027$), blood flow ($p = 0.033$), which means that hand exercises increase AVF maturity. Theoretically, the relationship between blood flow volume, velocity, and blood vessel radius shows that in conditions with a constant blood vessel radius, changes in flow volume are proportional to changes in velocity.

D. CONCLUSION

Adequate AVF maturation is needed to improve the quality of life of CKD patients. Based on the summary of the articles that have been analyzed, it can be concluded that hand exercise interventions, both isometric and isotonic, have an important role in improving AVF maturation in patients with CKD. Routine exercise implementation can increase the diameter and blood flow, resulting in patency of vascular access for hemodialysis, which ultimately improves quality of life. Therefore, the implementation of a structured and directed exercise program that is easy for patients to understand should be an important part of the care of patients with AVF to achieve optimal results. Current clinical guidelines recommend isometric exercises as a strategy to improve AVF maturation, but the evidence available to date regarding postoperative hand exercises to improve AVF maturation is still very limited.

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