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Hand exercise for arteriovenous fistula

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Abstract

Hand exercise is generally advised for patients with newly placed arteriovenous fistulae (AVF) because of its effects on vein diameter and fistula maturation. However, this practice is a point of controversy with inconsistent results. Any measure that can accelerate the maturation of AVF and reduce the interval between AVF creation and utilization would be beneficial. This paper will discuss measures adopted by doctors in improving the outcome of AVF surgery and review the available literature on the impact of hand exercise on AVF maturation and cephalic vein diameter.

Background

Regularly performed aerobic training has its beneficial effects on vascular function and thereby constitutes a preventative measure against cardiovascular disease [1,2]. However, aerobic training is insufficient to inhibit loss in muscular strength with advancing age; thus, resistance training is recommended to prevent sarcopenia. Recently, several lines of study have provided compelling data showing that exercise and training with blood flow restriction exercise (BFRE) leads to muscle hypertrophy and strength increase, while the influence of moderate-intensity resistance training on vascular function is still controversial. Although, there is no enough evidence to obtain consensus about impact of BFRE training on vascular function, available evidences suggested that BFRE training did not change coagulation factors and arterial compliance.

In patients with chronic renal failure (CRF) on haemodialysis (HD), long-term survival is related to adequate HD dosage. Therefore, a well-functioning arteriovenous fistula (AVF) is of utmost importance for the efficiency of the HD treatment. Commonly used form of vascular access for HD care are the AVF and the AV graft. AVFs are considered as the gold standard for HD because studies have shown that AV grafts have about 25–65% increased risk of failure and have two times increase in requirement of vascular intervention to maintain patency when compared to AVF [3,4].

There is an increase in the number of patients with suboptimal blood vessels attending access clinic, these include: patients in extremes of age group, failed previous attempts of AVF surgery, exhausted sites and atherosclerotic disease. Currently infection, thrombosis, late patient referral for AV surgery, switching from AVF to AV-grafts, and failure of AVF accounts for much of the morbidity [5,6]. Approximately 28–53% of fistulas fail to mature adequately and are not usable for dialysis [7]. AVF once created it typically needs time to mature. Therefore, it is important to construct the AVF early when renal failure is diagnosed in order to have sufficient time for its maturation. AVF maturity can be assessed both clinically and ultrasonographically. Depending on the maturity progression, initial cannulation of AVF could be performed between one to six months after the creation of AVF. Delay in maturation or failure of AVF is significantly associated with vascular access-related morbidity. Vascular access failure reduces the delivered dosage of HD, which increases the risk for morbidity and mortality. Given the need to have a safe and stable vascular access for HD and reduce the complications associated with using alternatives of AVF, it would be necessary to find ways which can increase the chance of clinically useful AVF. Few centers have adopted multidisciplinary approach, meticulous surgical technique and ipsilateral hand exercise to improve AVF outcome.

Multidisciplinary team approaches to vascular access management

Vascular access clinic provides optimal multidisciplinary approaches for access management. It provides a common platform for the patient, nephrologists, surgeon and dialysis nurse to work. The aim is to increase the success rates of AVF with the best possible outcome and low complication rates. Ideally all patients should have an access at the time of initiation of dialysis. Nephrologists play an important role in timely referral of patients requiring AVF for HD. Patients are educated to avoid indiscriminate peripheral venepuncture and preservation of veins. Access surgeon involves in preoperative assessment and post-operative surveillance of the patient. Duplex ultrasonography (DUS) is useful in determining vessels that are not visible on clinical examination (e.g. obesity, limb oedema), and in patients with abnormal vascular examination findings. DUS is useful in measurements of size and depth of the vessels. Venography is useful in localization of stricture and central venous stenosis.

Surgical technique

AVFs should be placed in the non-paralyzed functioning limb with the normal vessels. Success of AVF surgery depends primarily on the preoperative condition of artery and vein. Increased arterial flow is an important aspect associated with increase in the success rate AVF [8]. Veins with larger luminal diameter are associated with enhanced AVF maturation [9]. Overzealous lysing of too many valves can lead to injury and failure of AVF. Newly constructed AVF or AV grafts with low flow

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thrill experience early failure [10]. Selective obliteration of accessory veins using non-absorbable suture leads to higher success rates of AVF. Post-operative surveillance involves looking for abnormal findings such as absence of thrill or hyper pulsatile draining vein, and limb oedema distal to the fistula. Dialysis nurse play a vital role in maintaining a good quality of life in patients undergoing HD. They help in identifying patients with difficulty in cannulation of veins that are too small or too deep, inability to achieve the target dosage for HD, prolonged bleeding from the needle puncture sites or aspiration of clots.

Arm exercise training and mechanism of action

AVF failure to mature remains a barrier to its successful usage for HD treatment. Few studies have demonstrated the beneficial effects of hand exercise on maturation of the blood vessels and reduction in the complications after AVF surgery. Hand exercise was proved to be effective in increasing the diameter of artery and vein around the AVF, and it improved the capacity for vasodilatation and maturation of the fistula. The effect of exercise on venous size was evaluated by Leaf DA et al. [11] in 5 patients with CRF. They underwent 6-weeks of ipsilateral isometric hand-grip exercise lasting for 3 minutes and repetitive squeezing of soft ball. The size of the cephalic vein in both the groups [absence of exercise arm (048 ± 0.016 cm) and the presence of a tourniquet of the exercised arm (0.056 ± 0.022 cm)] increased significantly (< 0.05) when compared to the control arm. Wendelhag I et al. [12], included 12 men aged 60 years, using DUS, recorded the luminal diameter and blood flow velocity of the brachial artery before and after reactive hyperaemia. Occlusion of the artery was done by two different ways: first by occlusion only and then by adding ischaemic hand exercise during the occlusion. It was observed that luminal diameter [4.63 ± 0.35 versus 4.45 ± 0.34] and blood flow velocity [2.24 ± 2.00% versus 7.42 ± 3.32%] was significantly higher [$P < 0.01$] after ischaemic hand work.

Exercise is thought to increase the rate of fistula maturation. It is hypothesized that exercise increases the blood flow and hence, the diameter of the outflow vein. Therefore, repetitive exercise tends to dilate the vein, increase AVF function, reduce AVF related morbidity and mortality in adults on HD. During BFRE, the cuff pressure occludes venous return and causes arterial blood flow to become turbulent, resulting in the enhanced metabolic stress and fast-twitch fiber recruitment in skeletal muscle. Further, turbulent flow in the vessel increases shear stress, followed by increase in the deposition of endothelium produce nitric oxide resulting in increase in the diameter of the vessels due to wall dilatation [13]. At the end of exercise, cuff deflation causes ischemic reperfusion, greater vasodilatation and enhanced blood flow [13]. Barbosa JB et al. [14] performed a randomized clinical trial involving 26 CRF patients. Twelve were recruited in each arm and blood flow restriction was performed at 50% of systolic blood pressure and using 40% of handgrip strength as load for the isometric exercises in both groups. The diameter of the radial artery increased in all segments in BFRE group, while there was a significant increase in the diameter of the cephalic vein (2 cm: $p = 0.008$) observed in the control group. BFRE was effective in increasing radial artery diameter before surgical intervention.

Studies on maturation of AV fistula

Uy AL et al. [15] enrolled 17 patients and concluded that mean cephalic vein diameter increased in both the exercise and non-exercise arm from 1.66 to 2.13 mm and from 2.22 to 2.81 mm, respectively. There was no significant difference noted between the groups. The study performed by Uy AL et al. [15] concluded that isometric hand exercise was an effective way to enhance AVF maturation, improve blood flow in the A-V fistula and decrease morbidity associated with vascular access. Oder TF et al. [16] studied effect of exercise on newly placed AVF maturation in 23 patients using duplex ultrasound. The diameter of the fistula was examined three times before and after five minutes of squeezing a rubber ball. Fistula diameter increased in 86% of the patients; it was observed that exercise performed after AVF surgery was associated with increase in mean fistula diameter by 9.3%. Therefore, the study recommended hand exercise for better maturation. Rus et al. [17] studied the effect of handgrip exercise and noted that radial artery diameters, vein diameters, and endothelium-dependent vasodilatation significantly increased after 4 and 8 weeks of handgrip exercise training. Kumar S et al. [18] studied effect of simple exercise on one arm and has shown that brachial artery diameter, radial artery diameter and cephalic vein diameter increased significantly in exercise arm when compared to non-exercise arm. Salimi F et al. [19] recruited fifty patients and they were randomly allocated to 2 groups [structured isometric exercise program versus simple hand exercise (opening and closing the fingers)] with 25 patients in each group. A significant difference in the draining vein diameter, vein wall thickness, vein area and blood flow rate were seen in cases. There were a greater number of patients with clinically mature AVF in isometric exercise group than in control. Thus, it was concluded that isometric exercise has effect on most of the sonographic parameters that could be beneficial for acceleration of AVF maturation. Turmel-Rodrigues et al. [20] used ultrasonography at two and four months in 40 uremic patients after the operation and compared to 20 healthy volunteers. This study noted significant increase in radial artery blood flow rate exercise group. However, there was no demonstrable increase in flow rate in the exercise group. Therefore, they did not recommend exercise in uremic patients. The Study by Moran et al. [21] found similar findings, and they concluded that exercising an arm with an AVF was not helpful because it did not increase the blood flow significantly. Most of the research studies involved variable design and differences in their findings could be because of small sample size; therefore, it is not possible to draw conclusion based on these studies.

Purpose of an RCT

Published research papers [11,16,17] have studied the effect of Handgrip exercise for fistula surgery, but the numbers of patients enrolled were too small to draw conclusion. Though this practice of hand exercise is recommended in the Kidney Disease Outcomes Quality Initiative (DOQI) guide-lines for fistula maturation; however, there has never been any objective quality evidence shown to support this manoeuvre. No research has been performed for determining which type of hand exercise (number of repetitions, duration and frequency etc.) is more effective for facilitating the maturation of the vessels and for improving the functioning of the fistula. Variations in the outcome in studies could be because of different study design. Hence, interventions aimed at enhancing fistula maturation are warranted. Therefore, there is a need for a randomized clinical trial to study the effect of exercise on A-V fistula maturation and function.

There is an ongoing clinical trial to study the effect of handgrip exercise on the outcome of arteriovenous fistula surgery. Trial is registered prospectively [CTRI/2017/04/008283 (Registered on: 03/04/2017)]. It is a single institution, in-hospital two arms prospective randomized control trial study, comparing the two groups (Group "A"- control, Group "B"- cases). Primary aim is to study the efficacy of hand grip exercise on the outcome of AVF surgery. Efficacy means maturation and success of AV fistula surgery. AVF is considered to be

mature if the cross-sectional luminal diameter of draining vein is more than 4 mm and Intra-access flow rate in draining vein > 500 ml/hr. Intra-access flow rate and vascular diameters will be measured using DUS at 0, 4, and 8 weeks from the date of AVF. Measurements will be taken about 5 - 20 cm proximal to the AVF incision mark. Success of AVF surgery is defined as a fistula that has the potential for being used clinically as a dialysis vascular access.

This study is being carried out in the Department of Surgical Disciplines, All India Institute of Medical Sciences, New Delhi. A total of 200 chronic kidney disease patients attending vascular access clinic for creation of arteriovenous fistula for HD will be recruited under the study protocol. After assessing the inclusion and exclusion criteria and taking consent, patients will be divided into two groups. Group "A" involves no handgrip exercise after AVF surgery, and group "B" involves handgrip exercise using handgrip equipment provided for 10 min per hour or till the patient experiences lethargy of fingers (whichever is earlier) for 12 times a day for 2 months after AVF surgery. Patients recruited in the study group begin to perform hand grip exercise immediately after the surgery using handgrip exercise equipment tool. Routine pre-operative teaching and care of AVF will be taught for both the groups. Distribution of groups will be via computer generated randomization sequence with variable block size, randomization sequence will be implemented via sealed envelope at the time of patient allocation to study arm. Depending on the site most suitable for creation of AVF either radiocephalic or brachiocephalic or brachiobasilic fistula will be created. Post-operatively patient will be started on antibiotic and analgesics for 3 to 5 days. All the patients under the treatment trial will be followed in the postoperative period.

Conclusion

- AVF is gold standard form of vascular access for HD.
- AVF failure causes morbidity and reduces patients' quality of life. Thus, any manoeuvre that may increase the chance that a fistula will develop enough to be of clinical use becomes extremely important.
- Studies that have shown positive effects of handgrip exercise on AVF functioning consisted of small numbers of patients enrolled that are too small to draw the conclusion
- There is a need for further studies with adequate numbers to evaluate the effect of exercise on the outcome of AVF surgery.

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