ORIGINAL RESEARCH

Comparing strength and range of motion of the upper limb with AV fistula access with the contralateral upper limb among patients treated with hemodialysis

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Abstract

Introduction: The arteriovenous (AV) fistula is a gold standard method for safe and effective repeated vascular access for patients on hemodialysis (HD). The patients, with AV-fistula access in their upper limb, have some limitations in using the involved limb both in daily living and during the dialysis process. The aim of this study was to compare range of motion (ROM), muscle strength and arm circumference of fistula created limb with the contralateral upper limb.

Material and Methods: 23 patients (50-85 year), receiving HD through AV fistula in one of their upper limbs, at least for 3 months, were enrolled. ROM, muscle strength, and arm circumference of both upper limbs were measured using goniometer, dynamometer and tape-measure, respectively. Then the values of the both sides were compared together.

Results: In ROM tests shoulder forward flexion, backward extension, internal rotation, external rotation, horizontal extension, and horizontal adduction, and in muscle strength tests shoulder abduction and hand grip were significantly ($p<0.05$) more limited or weaker at the fistula side. Arm circumference was significantly greater at the fistula created limb.

Conclusion: The upper limb, which is involved during HD process, is weaker and has more limited ROM in comparison with the contralateral limb. We suggest more attention to develop specific exercise programs for maintaining the abilities of the limb with AV-fistula access.

Keywords: Hemodialysis, Arteriovenous fistula, Range of motion, Muscle strength

Introduction

Hemodialysis (HD) is a life-saving treatment for patients with end stage renal disease (ESRD) [1]. The arteriovenous (AV) fistula is a gold standard method for safe and effective repeated vascular access for patients on hemodialysis [2, 3]. Vascular access consists of AV fistula in the upper limbs or central vascular access in subclavian or jugular veins [4].

Musculoskeletal impairment of upper extremities including muscle weakness and reduction of muscle strength in HD patients can occur due to the disease course such as abnormal electrolyte level and metabolic conditions or be directly related to vascular access devices [4]. sedentary life style, proteinuria, mitochondrial dysfunction, low capillary density, atrophic muscle fibers and increased inflammatory mediators are among the factors, which have been suggested as the results of muscular weakness in these patients [5].Vascular access related complications, regardless of the area and type of vascular intervention, include peripheral neuropathies, limited use of upper limb having the vascular access, upper limb edema as a result of vascular insufficiency, swelling and functional impairment in upper extremity [6]. In addition, AV fistula can deteriorate the upper limbs disability due to the obligate position necessary during HD sessions and limited use of upper limb because of the presence of vascular access [7]. The upper extremities disability and impaired physical functioning widely compromise daily living activities and quality of life in HD patients [2, 7].

Intradialytic exercise [8], and training programs between dialysis sessions are being used for improving physical fitness [9-11], psychological condition, and quality of life [12] of HD patients. However, the patient has to rest the limb with vascular access with minimum movement during the dialysis process, for several hours often three times a week. Therefore, training the involved limb with intradialytic exercise is limited. Although there are some cautions for using the limb with AV fistula during daily routines, but some people may have excessive fear from using or exercising the limb. Usually these patients are advised not to lift heavy objects with the access limb [13].

The purpose of this study was to evaluate range of motion (ROM), muscle strength and arm circumference of fistula created limb and compare to contralateral limb in order to provide information, which may contribute to improvement of rehabilitation programs to maintain upper limb function in HD patients.

Materials and Methods

In this cross-sectional study, patients with ESRD receiving dialysis through AV fistula between 2012 and 2013 in dialysis department of Taleghani hospital of Tehran were enrolled. Inclusion criteria consisted of patients receiving HD, via AV fistula in their upper limbs as vascular access, 3 times a week, at least for three months. 26 patients met the inclusion criteria. Exclusion criteria included declined participation (1 case), impaired of movement of upper limb due to primary musculoskeletal problems, or medical conditions associated with impaired mobility like CVA (2 cases). Finally, 23 patients entered to the study. All subjects provided informed consent for study participation.

Evaluation

A simple questionnaire was designed. Demographic data were obtained along with medical records, details of HD (frequency, duration, site of vascular access), AV fistula placement and hand dominancy. In addition, assessment of 10 variables related to range of motion, 5 variables related to muscle strength and one variable related to arm circumference were recorded. All measurements were performed on both upper limbs by the same investigator. Each test was performed twice, and the better result was considered. If the difference between the two measurements was more than 10 percent, a third attempt was performed. Then the mean value of the measures was recorded.

Upper limb range of motion measurement

ROM was measured with goniometer device. The measurement unit was degree. In this study, 2 types of goniometers were applied; manual and wall goniometers. The maximum range of shoulder abduction, internal rotation, external rotation, horizontal adduction, horizontal extension (horizontal abduction), forward flexion, backward extension, elbow flexion, and extension were recorded. Additionally, minimum distance of thumb to bony prominence of C7 vertebra, while the

subject attempted to reach the hand as above as possible on the back, was measured. This was the only test related to ROM that was

measured with tape and the unit was centimeter (cm).

Muscle strength measurement

Muscular strengths were examined, using a digital pulling dynamometer and a digital handgrip dynamometer, both made by Danesh Salar Iranian Company, with accuracy of ±20 grams. The measurement unit was kilogram (kg). The pulling dynamometer was used to measure strength of movements including elbow flexion, shoulder external rotation, internal rotation, and abduction. The handgrip dynamometer was applied for handgrip strength test. The subject was asked to hold the base of dynamometer on the heel of palm while grasping the handle with the middle of the four fingers. Then he/she was ask to squeeze the device with maximum isometric effort. The dynamometer records the maximum force during 5 seconds of squeeze.

Arm circumference measurement

Arm circumference of both arms was measured with a tape at the mid-point between the acromion process and head of radius bone. The measurement unit was centimeter (cm).

Statistical analysis

Data were analyzed using SPSS statistical software version 19 (SPSS Inc. Chicago, USA). The paired t-Test was used to compare the both sides. A p-value <0.05 was considered statistically significant.

Results

23 patients including 14 (60.9%) male and 9 (39.1%) female who had underwent HD through AV fistula at the upper limb, during the study period, were enrolled. The mean age was 66 (range 50 to 85) years old. All individuals were right handed. The majority of AV fistula accesses (19 cases, 82.6%) were located at the non-dominant side and the rest of them, were at the dominant side. Five (21.7%) patients had a history of previous AV fistula placement.

As illustrated in table 1, six variables, among those related to ROM, had significant differences, between both sides. Shoulder forward flexion, backward extension, internal rotation, external rotation, horizontal extension, and horizontal adduction were significantly more limited at the fistula side. Range of motion at elbow joints was similar at both sides.

As illustrated in table 2, among the five variables related to muscle strength, two of them including shoulder abduction and hand grip, were significantly lower at the fistula side. There was no significant difference, in shoulder internal and external rotation and elbow flexion forces, between both sides.

There was not any ROM or strength variable showing more flexible or stronger values at fistula side than the non-fistula side (table1, 2).

Arm circumference of the fistula created limb was greater than the contralateral arm (31.8±4.4 vs 29.5±5.1 cm, p<0.01).

Discussion

This study revealed that some parameters related to muscle strength in fistula created upper limb is significantly weaker than contralateral limb. This observation is in agreement with Capitanini et al. [7] who found that HD patients had lower values in hand grip strength test and shoulder mobility in both arms in comparison to control group. The researchers also found that fistula created limb had greater limitation of shoulder extra-rotation than the other shoulder in active and passive movements. These results showed that beside metabolic abnormalities as a part of musculoskeletal dysfunction in HD patients, presence of vascular access can deteriorate the upper limb disability possibly due to the obligate position during the HD sessions and limited use of upper limb because of the presence of the vascular access. In another study, Hurton et al. [4] reported that upper extremity complications, including motor strength, develop more common in HD patients, regardless of type or location of vascular access.

Tuna et al. [6], demonstrated that patients with advanced CKD receiving HD treatment through AV fistula in the upper extremity have a significant impairment in muscle strength and functional level of hand. However, they had found no difference between two hands. It may indicate that hand dysfunction is secondary to the nature of disease or HD treatment, and not from the vascular access. This is not in agreement with our findings in handgrip test. However, it seems that shoulder movement is more limited than finger and hands movements during long hours of HD sessions, and their study was focused on hand level.

In our study, ROM tests revealed that shoulder internal rotation, external rotation, horizontal adduction, horizontal extension, forward flexion and backward extension were significantly more limited in fistula created limb than the other side.

In the study conducted by El-Najjar et al. [14], musculoskeletal disorders in HD patients were reviewed. Their results revealed that among 144 HD patients, 87 patients (60.4%) had musculoskeletal manifestations and the most common presenting symptom was joint pain and the shoulder was the most common site, after knee joint and back.

Although, our study had not been focused on etiology of upper limb functional impairment in HD patients, but our findings revealed that there are some more limitations in ROM of shoulder, and weaker muscle forces in some planes of shoulder movement and hand grip, at the side of vascular access. The patients who are being treated with HD, spend several hours each session in dialysis unit, usually three times a week. Various intradialytic exercise programs have been introduced for helping these patients [8]. However, involvement of the limb with vascular access during HD process makes it difficult to efficiently incorporate such trainings for this part of body. Therefore, paying more attention to develop specific exercise programs, between the dialysis sessions, may be helpful for maintaining the abilities of the limb with AV-fistula access.

Generally, a stronger arm has a greater size because of muscles with larger diameter. Nonetheless, we found that arm circumference of the fistula created limb (the weaker limb) was greater than contralateral limb. This finding can be contributed to upper limb edema as a result of vascular insufficiency. On the other hand, the flexion and extension forces of elbow, which are produced by arm muscles, were similar at both sides. However, more precise anthropometric measurements may be needed for better understanding of this finding.

Conclusion

Tis study revealed that patients with ESRD receiving HD treatment through AV fistula have more limited shoulder joint, and weaker shoulder and hand grip muscle force, at the side of vascular access. In addition, arm circumference of fistula created limb was significantly greater than contralateral side.

Although significant results were gained in this study, but the number of participants was limited. We suggest similar studies with greater sample size with multicentral design. Musculoskeletal system involvement in HD patients remains a major problem and requires more attention in its prevention and treatment. Developing specific exercise programs and rehabilitation approaches in order to maintain mobility and strength of the fistula created limb can be beneficial in the routine treatment program of ESRD patients receiving HD.

Conflict of interests

Authors declare no conflict of interests.

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Tables

Table 1. Upper limb ROM in HD patients.

Variable	Number of cases	Missing data	Mean of non-fistula side	Mean of fistula side	p-value	
Shoulder abduction	22	1	113.8 ± 31.7	117.4 ± 21.4	.541	not sig
Shoulder internal rotation*	22	1	53.9 ± 17.6	40.7 ± 13.6	.008	sig
Shoulder external rotation*	22	1	120.5 ± 36.1	105.6 ± 31	.023	sig
Shoulder horizontal adduction	22	1	33.6 ± 21.2	28.1 ± 22.6	.036	sig
Shoulder horizontal extension	22	1	87.2 ± 42.7	80.8 ± 37.5	.005	sig
Shoulder forward flexion	22	1	162.5 ± 31.9	150.7 ± 34.1	.001	sig
Shoulder backward extension	22	1	40.8 ± 13.6	30.9 ± 12.5	.000	sig
Elbow extension	23	0	12.7 ± 3.71	13.9 ± 3.9	.320	not sig
Elbow flexion	23	0	134.8 ± 18.5	134.2 ± 19.6	.727	not sig
Thumb to C7 distance	22	1	33.4 ± 7.4	32.7 ± 7.8	.524	not sig

Sig: Significant
* Stating position: 90 degree shoulder abduction & elbow flexion

Table 2. Upper limb muscle strength in HD patients.

Variable	Number of cases	Missing data	Mean of non-fistula side	Mean of fistula side	p-value	
Shoulder abduction	22	1	6.1 ± 5.5	5.2 ± 4.7	.038	sig
Shoulder external rotation*	22	1	7.1 ± 4.5	6.7 ± 3.8	.128	not sig
Shoulder internal rotation*	22	1	7.3 ± 4.1	6.8 ± 3	.133	not sig
Elbow flexion	23	0	6.2 ± 3.4	6 ± 3.7	.487	not sig
Hand grip	23	0	17.2 ± 7.1	14.3 ± 6	.004	sig

* Starting position: Arms beside the body and 90 degree elbow flexion

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