Effect of exercise during hemodialysis: result of a 3-month pilot study

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ABSTRACT

Exercise is a cornerstone to overcome the reduced exercise capacity of dialysis patients in the course of rehabilitation. We designed an exercise program using stationary cycling during hemodialysis (HD) treatment. Patients cycled while sitting on their HD chair during the second or third hour of every HD treatment for 30 to 45 minutes in a semisupervised manner. In this pilot study, nine patients joined the program and eight patients completed a 3-months’ exercise. All were on twice-a-week HD except one was on thrice-a-week treatment. There was a significant improvement of 15.3% in the walking distance of the 6-minute walk (from 307 ± 44 m to 352 ± 54 m, p = 0.001). A trend toward an improvement (16.9%) in peak metabolic equivalent (MET) and duration on treadmill exercise (12.3%). There was no significant change in blood pressure and lipid profile but there was a downward trend of high-density lipoprotein cholesterol (HDL-C) (p = 0.066). There were no significant symptoms or complications during exercise except one patient who did not complete the 3-month course because of knee pain due to osteoarthritis of knees. We concluded that exercise can be conducted during HD to increase exercise capacity for rehabilitation purpose. Long-term maintenance exercise may be needed to effect any modification of cardiovascular risk factors.

Key words: Hemodialysis, Rehabilitation, Renal failure

中文摘要

在透析病人的康复過程中，運動是一項能克服病人運動能力減退的重要措施。我們設計了一項在血液透析治療時原地踩腳車的運動方案。病人在每次接受血液透析治療的第2或第3小時時，以半仰臥的姿勢坐在椅上踩車30至45分鐘，九例病人參加了此項試驗性的研究，其中八例完成了3個月的運動計劃。除一例每週接受血液透析治療三次外，其餘均為每週兩次。在6分鐘步行距離測試中有顯著進步的佔15.3%(自307 m ± 44 m 到 352 m ± 54 m，p = 0.001)，最大代謝當量(MET)及踩車運動週期趨向改善的分別佔16.9%及12.3%。血壓、血脂無顯著改變，但HDL-膽固醇有下降的趨勢(p = 0.066)。除一例因膝關節骨關節炎引起骨痛未能完成3個月的運動療程外，其餘病人在做運動時均無明顯症狀和併發症發生。我們的結論是在血液透析治療時做運動可能能提升病人的運動能力，從而促進其康復過程，長期維持運動是否能改善心血管危險因素仍需觀察。

INTRODUCTION

Rehabilitation of dialysis patients, in terms of physical, social and vocational, is an important but difficult task. An obstacle to rehabilitation is reduced exercise capacity, as measured by the maximal aerobic capacity (VO₂ max) which can be reduced by up to 50% in chronic dialysis patients compared with healthy individuals (1,2). The Life Options Rehabilitation Advisory Council identified five core objectives or bridges that are essential to rehabilitation of end stage renal failure patients:
Exercise during hemodialysis

Encouragement, Education, Exercise, Employment and Evaluation (3). It advised that exercise should be incorporated into the standard plan of care.

The beneficial effects of aerobic exercise on physical capacity of HD patients had been documented with patient’s VO₂ max increased by 23% to 42% after training (4-7). We have also shown that VO₂ max can be improved by 16% in continuous ambulatory peritoneal dialysis (CAPD) patients after a 3-month exercise program (8). Exercise was usually conducted in form of bicycle ergometry, upper limb ergometry, walk-jogging on treadmill three times a week. For HD patients, it is usually conducted between HD treatments. However this sort of program is very inconvenient to patient as it requires frequent visits for both HD treatment and exercise training. Painter et al had experimented an exercise program using stationary exercycle during the second or third hour of HD treatment, three times a week and showed a 17% and 23% increase in VO₂ max in the first 3 months and by the end of 6 months, respectively (4).

In Hong Kong, most HD patients are receiving HD treatments twice a week and therefore exercise training during HD would only be conducted twice a week. We adopted the method of Painter et al in our HD patients who are mostly dialyzed two times a week. The purpose of this pilot study is to study the effectiveness and to identify the difficulties of conducting such program.

METHODS

Patients

Stable patients in the maintenance HD program at Tung Wah Hospital were invited to participate in the exercise training. They had been stable on HD for more than 6 months and were not suffering from active cardiac diseases or major musculoskeletal problems limiting lower limb exercise. Written informed consent was obtained from all patients before the study.

Assessment

All patients underwent a thorough clinical examination. An exercise electrocardiogram (ECG) on a treadmill machine using modified Bruce protocol was conducted at baseline. The test was stopped when patient developed symptoms or could not continue due to fatigue. Patients with abnormal exercise ECG were eliminated from the exercise program. The following data were obtained during the exercise-stress test: 1. The duration of exercise; 2. the peak heart rate; and 3. the peak metabolic equivalent (MET). The maximal aerobic capacity (VO₂ max) was not measured because in our past experience, many patients felt uncomfortable with wearing the O₂ analysis mask during exercise and MET is defined as a direct reflection of VO₂ with one MET equivalent to 3.5 mL/kg/minute of O₂ consumed (9). A 6-minute walk test was conducted under supervision of a physiotherapist. The distance that the patients walked to-and-fro within a 10-meter linear distance within 6 minutes was recorded. The exercise-stress test and 6-minute walk test were repeated at 3-month.

Other Investigations

The average pre- and postdialysis body weight, blood pressure over a week before and 3 months after the exercise program was recorded. Hemoglobin levels, total cholesterol, HDLC, low-density lipoprotein cholesterol (LDL-C) and triglyceride levels were measured at baseline and at 3 months after exercise.

The Exercise

We purchased three stationary exercise bike (exercycle) with back support type and modified them by removing the seat portion. Cycling was conducted with patients sitting on the HD chair (Lazboy Inc., Michigan, USA) as shown in figure 1. Forward pushing of the exercycle was frequently encountered and was overcome by anchoring the exercycle to the HD chair with a removable band (Fig. 2). Cycling was conducted at the second or third hour on HD two or three times a week according to the frequency of HD treatment. The cycling was initially closely supervised by a physiotherapist until patients were well acquainted with the exercise. The resistance of the cycling was self-adjusted to achieve the 10 to 13 scores of the Borg’s scale (i.e. mildly difficult as felt subjectively by patients). The cycling lasted initially 15 minutes and was gradually increased to 30 to 45 minutes according to the endurance of the patients. The assimilated cycling distance as generated by the machine

Figure 1. Picture showing the original scene with a patient sitting on the HD chair to perform cycling exercise during HD treatment.
was recorded each time. Symptoms occurring during exercise were recorded.

**Statistics**

Values were expressed as mean ± standard deviation. Data analysis was performed using SPSS for Windows version 6.0. Paired t-test was used to compare data before and after exercise.

**RESULTS**

Twelve patients voluntarily joined the study. Three were eliminated for active coronary artery disease, back pain and gross fluid overload. All were using arteriovenous fistula on forearm for HD except one who used PermCath®. Nine patients commenced on the program. There were two patients with mild osteoarthritis of knees and one patient developed exacerbation of symptoms after exercise commenced and exercise was stopped. Only eight patients completed the 3 months’ course of exercise. All were on HD twice weekly except one on HD thrice weekly. As for underlying diseases, two have polycystic kidney disease, two have presumed chronic glomerulopathy, one has systemic lupus erythematosus, and three have unknown ones. The mean age was 48.3 ±13.2 years and they were on HD for 48.3 ±34.5 months, and on dialysis for 108.6 ±54.2 months. The baseline and 3-month results were shown in table 1 and figure 2.

There was a 15.3% increase in the walking distance from the 6-minute walk test ($p = 0.001$) (Fig. 3). There was also an improvement in peak MET (16.9%) and duration on treadmill (12.3%) though the differences were not statistically significant. However, there was no significant correlation between the total assimilated
Exercise during hemodialysis

There was no statistical differences in the body weight, blood pressure, hemoglobin level and lipid profile. However, a trend toward an increase of HDLC (baseline 1.05 mmol/L, 3 months 1.13 mmol/L, 95% confidence interval for difference -0.007 to +0.177, \(p = 0.066\)) was observed.

Most patients were symptom-free during the exercise. One experienced several episodes of mild chest discomfort during cycling, but this symptom also occurred during HD without cycling. Cardiologist was consulted and there was no evidence of coronary artery disease. There was no change in ST segments in baseline and the 3-month exercise ECG. A patient with mild osteoarthritis did not experience knee pain during cycling. Exercise had to be moved to the fourth hour of HD in one patient as he used to sleep for 2 to 3 hours on HD treatment.

One patient elected not to continue the exercise after 3 months as he thought he could achieve the same effect by exercising on his own. All other patients elected to continue the exercise program beyond 3 months.

**DISCUSSIONS**

This pilot study confirmed the usefulness of exercise training during HD with a definite improvement of walking distance on the 6-minute walk test and a trend toward improvement in MET and duration on treadmill. Control group was not employed in this pilot study because of the small number of patients. Without a control group, one may argue that the improvement might be related to adaptation with the exercise tests. We think this is unlikely as the assessment tests were separated 3 months apart and the form of exercise training is completely different from the assessment. A control group will help to better delineate the benefit when a full scale study is to be conducted.

We did not measure VO\(_2\) max directly because most patients dislike the mask employed during the test in our past experience. MET from treadmill exercise is a direct reflection of the VO\(_2\) max, and more importantly, the 6-minute walk test represents a functional exercise capacity assessment related to daily activities. The 6-minute walk test was also demonstrated to be highly correlated with VO\(_2\) max as well as highly predictive of mortality and morbidity in heart failure and cardiopulmonary illness (10-14). The baseline 6-minute walk test mean walking distance was only 307 m. It was substantially lower than the mean value of 635 m (range 515 m - 742 m) of normal individuals of the age group 40 to 59 as measured by the Physiotherapy Department, Kowloon Hospital, Hong Kong (unpublished data) and the median distance of 576 m for men and 494 m for women in a group of healthy adults aged 40 to 80 (15). After 3 months of exercise during HD, there was a mean of 15.3% improvement in the walking distance (\(p = 0.001\)). The degree of improvement of peak MET at 3 months (16.9%) was similar to the 17% improvement in 13 patients (\(p < 0.05\)) as reported by Painter et al. We did not achieve any statistical difference because we involved a smaller number of patients in our pilot study. Interestingly, although most patients were receiving twice weekly exercise, we still achieved a similar degree of improvement over that obtained with thrice weekly exercise which is considered to be the optimal regime in most exercise training program for normal individuals (16,17). However, we did not observe similar significant changes in other clinical parameters including lipid profile and blood pressure reduction as reported by Painter et al (4). Yet the trend toward a reduction in HDLC levels in our pilot study is quite encouraging. As the improvement of cardiovascular features in HD patients may occur over a period of 6 to 9 months after exercise on off-HD days, it is possible that similar cardiovascular risk factors improvement may be achieved with longer duration on exercise during HD (5,18). The lack of correlation between the total assimilated cycling distance and the degree of improvement in exercise parameters might be due to the small sample size and/or variation in the cycling intensity which was self-adjusted by patients.

The cost for each exercycle was HKD4350. Three

<table>
<thead>
<tr>
<th>Exercise parameters before and 3 months after exercise during HD.</th>
<th>Baseline</th>
<th>3 months</th>
<th>(95% C.I. of the difference)</th>
<th>(p) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-minutes walk distance, m</td>
<td>307 ±44</td>
<td>352 ±54</td>
<td>(+25 to +64)</td>
<td>0.001</td>
</tr>
<tr>
<td>Treadmill:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak MET</td>
<td>6.63 ±2.62</td>
<td>7.75 ±2.71</td>
<td>(-0.89 to +3.15)</td>
<td>NS</td>
</tr>
<tr>
<td>Duration, minutes</td>
<td>10.78 ±4.33</td>
<td>12.11 ±3.96</td>
<td>(-1.04 to +3.72)</td>
<td>NS</td>
</tr>
<tr>
<td>Peak pulse, m/minutes</td>
<td>119 ±22.2</td>
<td>121 ±13</td>
<td>(-13 to +16)</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS = Not significant
machines allow six patients to conduct the exercise in one HD session, or a total of maximum 36 patients per week if all are on twice weekly HD. The design of the program is to minimize supervision from physiotherapists or nurses except in the initial phase. Once patients are acquainted with the exercise, they should be able to conduct the exercise in a semisupervised manner in the sense that they can report any symptoms during exercise to HD nurses immediately and can immediately slow down or stop the cycling. No extra manpower from staff is required in the maintenance phase. These features make this exercise program cost-effective and safe. In this pilot study, no patients developed significant symptoms during the exercise including muscle cramps, hypotension nor hypertension. The only exception might have been one who had non-specific chest discomfort during exercise without ECG abnormalities.

CONCLUSION

In conclusion, we demonstrated that exercise during HD is beneficial to patients in terms of improvement in walking distance in 6 minutes and peak MET (and hence VO₂ max) even with twice weekly frequency. We also identified some patient problems that may interfere the exercise including osteoarthritis of knees and habit of sleeping during HD. Long-term maintenance exercise may show more definite results in cardiovascular risk factors modification and a possible subsequent improvement in cardiovascular morbidity. However, we may need to look into ways to maintain patients' incentive in committing to long-term regular exercise.

REFERENCES