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RESEARCH ARTICLE

EFFICACY OF RESPIRATORY MUSCLE TRAINING ON ARTERIAL BLOOD GASES ON PATIENTS UNDER HEMODIALYSIS

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ABSTRACT

Background: Hemodialysis (HD) is a protein catabolic procedure. During dialysis the diaphragm as a skeletal muscle is affected by protein breakdown leading to its weakness and limitation of its movement and affecting the oxygenation.
Objective: to find out the efficacy of Respiratory Muscle training on arterial blood gases in patients undergoing hemodialysis.
Methods: This randomized clinical study was conducted *on* thirty patients of both genders undergoing hemodialysis, their age ranged from 35-45 years old. The 30 patients received respiratory muscle training. All patients in study attended the training program with 30% of maximum intensity by using incentive spirometer device followed by diaphragmatic and deep breathing exercises with 3 sets, each set had 3-5 repetitions for 3 times a week under therapist supervision and 5 times a day as home program for 12 week;. Blood gases were measured before and after the study.
Results: The results of this study showed a significant improvement (increase) inblood oxygenation (PaO2), SO2 by 1.21% and 1.53% respectively and a significant improvement (decrease) in PaCO2, , HCO3 and pHby 2.52%, 0.44% and 0.14% respectively.
Conclusion: It is recommended for patients undergoing hemodialysis to perform respiratory muscle training to enhance arterial blood gases.

INTRODUCTION

Renal or Kidney failure is commonly caused by high blood pressure or diabetes. Kidneys have many important roles such as regulating fluid & minerals in body. They also signal bone marrow to make RBCS, synthesize vitamin D, regulate acid base (balance) level problem in Kidneys will affect these capabilities and change level of calcium and phosphorus. In kidney failure, blood concentration of Ca^{+} and Phosphorus becomes abnormal. Ca^{+} level drop a condition called hypocalcemia that can cause skeletal muscle weakness and nerve problems. In contrast, phosphorus level rises. This condition called hyperphosphatemia which can cause bone problems and itching (Kumar, 2009). Patients undergoing hemodialysis (HD) suffer from energy-protein malnutrition, uremic myopathy and protein catabolism reducing their functional capacity (kaysen *et al*., 2012). In some cases, low calcium level in blood also should be to blame for muscle weakness. In cases of dialysis, low calcium level is closely related with high phosphorus level and it may cause various bone problems like bone pain, bone fracture and osteoporosis and hypokalemia is always seen which is accompanied by skeletal muscle weakness and cramps (Lee *et al*., 2009). The diaphragm is the major respiratory muscle, contributing up to 70% to resting lung ventilation (Jung *et al*., 2013). The inspiratory muscles are morphologically and functionally Skeletal muscles and therefore respond to training, just as any muscle of the locomotor system (Silva *et al*., 2013). Arterial blood gases are measured to determine the amount of oxygen dissolved in the blood (PaO2) the percentage of hemoglobin saturated with oxygen (SO2). The amount of carbon dioxide dissolved in the blood (PaCO2) and the amount of acid in the blood PH. The oxygen measure may be used to determine whether a patient needs oxygen therapy. The carbon dioxide measure gives some idea of lung function and is especially important to know when starting oxygen therapy. In chronic muscle weakness PaO2 and the alveolar-arterial PO2 difference mildly abnormal (Elbedewy, 2011).

In comparison to natural breathing deep DB was associated with a significant increase in *P*O2 and a significant decrease in *P*CO2, with a significant increase in tidal volume and a significant reduction in respiratory rate. During DB, dyspnoea worsened significantly and inspiratory muscle effort increased

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(Vitacca, 2000). Incentive spirometry (IS) is a breathing technique in which deep breathing exercises are performed through a device offering visual feedback in terms of inspired flow and volume. The addition of visual feedback is thought to improve breathing technique and increase patient motivation (Tyson *et al*., 2015). Diaphragmatic breathing technique is the pattern of breathing utilizing the diaphragm which is the chief inspiratory muscle. Diaphragmatic breathing increases relaxation, lymphatic flow & efficiency of gas exchange, most important to maintain proper health of tissues and muscles. Breathing has substantial effect on parameters of arterial blood gases and basal lung function (Tovar and Gums, 2014). Physiotherapists use breathing exercises to promote secretion removal, increase thorax mobility, enhance relaxation, control breathlessness, increase pulmonary ventilation, improve mobilization of the chest wall and oxygenation. There are many types of breathing exercises such as diaphragmatic breathing segmental breathing (Othman, 2016).

MATERIALS AND METHODS

Thirty patients of both sexes undergoing hemodialysis are involved in this study. Patients are clinically diagnosed. They were selected from Alouba Hemodialysis center- Alharam, Egypt. Their ages ranged from 35 to 45 years old. The study was conducted at Alouba Hemodialysis centerfromDecember 2015 to December 2016.

Inclusion Criteria

All Patients were

- Creatinine level from 4.8 to 7.8mg/dl
- Their age ranged from 35-45 years.

Patients are diagnosed as chronic renal insufficiency on hemodialysis from 6 months to 2 years. They were medically stable and psychologically stable, their body mass index ranged from 25-29.9kg\m2

- Undergo Hemodialysis session 3 times per week
- All patients didn't participate in any physical activity prior the study by at least 6months.
- All patients signeda consent before the study.
- All patients are diagnosed with end stage kidney disease

Exclusion Criteria

- Patient with uncontrolled hypertension
- Patient with uncontrolled diabetes
- Patient with marked osteoporosis with a spontaneous rib fracture
- Evidence of any malignant diseases.
- Unstable metabolic disorders

Instrumentation

Evaluation tools and equipment

Acid-Base Analyzer

Blood-Gas Analyzer (GEM premier 3500). It is a omputerized device and it was used to measure arterial blood gases and to evaluate the level of oxygenation (PaO2), oxygen saturation (SO2) , Arterial carbon dioxide tension (PaCO2) , bicarbonate (HCO3) and acid base balance (pH). Disposable plastic syringe was used to draw arterial blood sample and polyproline tubes was used to keep blood sample.

Height and weight scale (SK-TZ 160, Made in China)

The measured height and weight was used to calculate body mass index (BMI) of each patient to fulfill the inclusion criteria of the study.

Training equipment

Incentivespirometer flow oriented (Respi·Flo· Three Ball Incentive Spirometer)

Procedures

The study protocol was explained in details for every patient before the initial assessment. A complete history and physical examination were taken for all patients with particular attention paid to identifying long-term complications of chronic renal failure. A written informed consent was signed by each patient before participation in the study as an agreement to be included in the present study. This study was reviewed and was approved by the Ethics Committee of Faculty of Physical therapy, Cairo University.

Evaluation procedure

Body mass index evaluation

A height and weight scale was used to measure height and weight to calculate body mass index: BMI = body weight in kilograms/height in meter squared .weight (kg) / [height (m)]^2 (Dhurandhar *et al*., 2017).

Test procedures

An arterial blood sample (2 to 3) ml was drawn a small bore needle attached to a (3-5) ml plastic airtight syringe. the syringe was prepacked and contained a small amount of heparin to prevent coagulation by drawing a small amount of heparin and squirting it out again. The sample was placed in acid-base analyzer device measures arterial blood gases and to evaluate the level of oxygenation (PaO2) , oxygen saturation (SO2) , Arterial carbon dioxide tension (PaCO2) , bicarbonate (HCO3) and acid base balance (pH).

Training procedure

Incentive spirometer

All subjects underwent training with triflow 5 times aday.thesession is applied once per day 3 times aweek under the therapist supervision and the rest are prescribed as home program exercise explained for each patient. The session is applied in form of; at first the patient sit upright with placing of incentive spirometer on a table at the same level of patient mouth, breathe out normally, put the mouthpiece in patient's mouth and tightly seal patient's lips around it, breathe in slowly and deeply, this would raise the balls to the top of the column, hold the breath as long as possible (at least five seconds), allowing the balls to came to the top of the column. patient takes rest for few seconds and repeated the procedure for at least 10 times per hour. All patients underwent treatment with breathing exercise program for 5 times per day for 12 weeks. The session is applied once per day 3 times per week with therapist supervision and the rest are as prescribed home program explained to each patient. (Tyson *et al*., 2015)

Breathing exercises

Sustained maximal inspiration technique

The subject was instructed to take deep breathing to total lung capacity and hold his breath for 2-3 seconds at the completion of inspiration then to exhale. This maneuver was repeated three successive times with rest for 2 seconds then repeated for 5 minutes .Thepatient was instructed to do the same exercise at home for 5 times per day (Borge, 2014).

Diaghragmatic breathing exercise

The subject lied inclined at 45° with his hips and knees flexed to relax the abdominal muscles. The subject's dominant hand was placed over midrectusabdominus area, while the other hand was placed over mid sternal area. Then the dominant hand was allowed to rise as inspiration continues while avoid excessive movement under the other hand. The previous instructions were repeated 3- 5 times. Thepatient was instructed to do the same exercise at home for 5 times per day. (Borge, 2014)

Statistical analysis

The data obtained from all thirty patients were statistically analyzed for comparison between before and after treatment results. The statistical package of social studies (SPSS, version 9) was used for data processing using the P-value≤ 0.05 as a level of significance.

RESULTS

The purpose of this study was to find out the effect of respiratory muscle training on patients undergoing hemodialysis, Data obtained from thirty patients before and after the study, regarding arterial blood gases (PaO2, SO2, PaCo2, HCO3 and pH) were statistically analyzed and compared.

General characteristics of the subjects: Table (1)

Table 1. Descriptive statistics for the mean age, weight, height, and BMI of the thirty patients

Items	Age (Year)	Weight (kg)	Height (cm)	BMI (kg/m^2)
Mean	40.67	74.24	165.93	26.97
Standard deviation	±3.62	±6.09	±9.15	±1.04
Minimum	35.00	58.40	148.00	25.20
Maximum	45.00	95.20	183.00	29.10

Results of Arterial blood gases pre and post the study

Table 2. Descriptive statistics for the mean age, weight, height, and BMI of the thirty patients

	Pre- treatment Mean± SD	Post-treatment Mean± SD	p-value	t-value	of improvement %
PaO2	79.27 ±13.89	80.23 ±13.75	0.001	3.846	1.21%
SO2	86.70 ±8.28	88.03 ±7.80	0.0001	4.382	1.53%
PaCo2	35.70 ±3.94	34.80 ±3.52	0.001	4.382	2.52%
HCO3	15.84 ±2.80	15.77 ±2.79	0.008	2.855	0.44%
Ph	7.33 ±0.07	7.31±0.05	0.01	2.370	0.14%

SD: Standard Deviation, P- value: Probability Level, *: significant

DISCUSSION

This study was conducted to find out the effect of respiratory musclestraining onarterial blood gases in patients undergoing hemodialysis, Thirty elderly subjects were participated in this study, Each subject of this study had participated in respiratory muscle training included incentive spirometer triflow meter followed by diaphragmatic and Sustained maximal inspiration technique This program were applied 3 times per week under physical therapist supervision, 5 times a days as home program for 12 weeks. The results of this study revealed that 12 weeks of respiratory muscles training produced a significant increase in arterial blood gases For PaO2 with a percentage of improvement equal to (1.21%), for SO2 with a percentage of improvement equal to (1.53%). for PaCO2 with a percentage of improvement equal to (2.52%). for HCO3 with a percentage of improvement equal to (0.44%). For pH with percentage of improvement equal to (0.14%). Significant muscle weakness and associated atrophy is seen in both dialysis patients and in patients with chronickidney disease (CKD) stages 3–4. This is associated with increased morbidity and mortality **(**John *et al*., 2013**).** There is evidence that muscle training administered to patients respiratory muscle weakness can change this scenario, promoting a significant improvement intheir physical and functional capacity (Hassan, 2016). Breathing exercises are the most potent factor capable of increasing the pulmonary ventilation and improving mobilization of the chest wall, drainage of tracheo-bronchial secretions, promote relaxations as well as to maintain and improve chest wall mobility and to regain the most efficient breathing pattern. There are many types of breathing exercise and the exercise connected with breathing is more beneficial to improve ventilation, oxygenation, increase the number of muscles used and increase chest mobility (Illis, 2012). This study included Thirty patients (15 women, 15 men) with age ranging from (35-45) years oldand was conducted to determine the efficacy ofrespiratory Muscles training on arterial blood gases in patients undergoing hemodialysis.

The incentive spirometer has been used for improvement in exchange of gases and oxygenation, depending on the cooperation of the patient and easy fulfillment (Renault *et al*., 2009). A systematic review was conducted of seven studies about incentive spirometer after thorax surgery. Three studies reported that incentive spirometer can improve gas exchange and others stated that incentive spirometer is ineffective after thorax surgery. Finally, they concluded that IS can promote oxygenation and gas exchange after thorax surgery (Agostini and Singh, 2009). Mordian*et al*., 2012, showed that planned breathing exercise (IS and deep breathing together) significantly improved PaO2 and SaO2 on the postoperative day of coronary artery bypass surgery. Another study stated that improvement in blood oxygenation by respiratory exercises is temporary and is reversible after a short time; so, for improvement in oxygenation repetitive exercises are needed (Brage *et al*., 2009). Marchesan, Krug, Moreira *et al*., 2008 carried out a study with respiratory muscle strength training inchronic kidney disease patients on hemodialysis by use of pressure vacuum meter reading. After 15 weeks of training, a statistically significant ($p < 0.05$) improvement was observed in aerobic resistance, and maximum inspiratory and expiratory pressures (PImax and PEmax, respectively) in the experimental group. The prescription of exercise for Chronic kidney disease patients is less usual than for other chronic diseases.

This is noteworthy, considering that physical activity levels among CKD patients are significantly lower than among healthy individuals (Johansen and Painter, 2009). Moreover, low aerobic capacity, a physical fitness marker that can be improved by exercise, has been pointed to as the strongest predictor of mortality among end stage renal diseases (Cheema, 2008). Assuming that the benefits of exercise could also apply to CKD patients, physical activity deserves to be considered as a major component of treatment in all stages of the disease (Johansen and Painter, 2006). Itwas foundthat there is a significant beneficial effect of various exercise interventions on physical fitness, muscular functioning, walking capacity, cardiovascular function andquality of life inchronic kidney disease patients, with stronger evidence for dialysis patients and aerobic exercise programs (Heiwe and Jacobson, 2014). In the study by Chawla *et al*., 2013, it was shown that the level of arterial oxygen saturation had a significant increase after inspiratory muscle training.

On the other side, there are controversial results reported by the studies conducted by Afrasiabi *et al*., 2007 indicated that the IS does not have significant effect on improvement of arterial blood gases.

Conclusion

Respiratory muscle training is an effective rehabilitative method that improves arterialblood gases in hemodialysis patients prior the session.

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