Assessment of respiratory muscles' performance in patients with chronic renal failure immediately before and after hemodialysis

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Background Physiological abnormalities are frequent in the skeletal muscle structure of patients with chronic renal failure (CRF), and their main signs are fatigue, muscular weakness, and low exercise tolerance. Respiratory muscular weakness may lead to hemodialysis; maximum respiratory pressure measurements may help in early diagnosis and to decide on therapeutic interventions for these patients.

Objective To assess the respiratory muscle performance by measuring the maximum inspiratory pressure (PI_{max}) and the maximum expiratory pressure (PE_{max}) in patients with CRF immediately before and after hemodialysis (HD).

Patients and Methods Sixty patients with CRF were recruited and divided into two groups: group 1 included patients undergoing HD and group 2 included those receiving conservative treatment. All the patients were subjected to arterial blood gases, pulmonary function test, PI_{max}, and PE_{max}.

Results There was a significant difference between hemogasometric parameters (pH, $PaCO_2$), PI_{max}%, and spirometric parameters (FEV_1/FVC%, FEV_1%, and MMEFR) before and after dialysis. There was, moreover, a significant difference in hemogasometric parameters ($PaCO_2$, PaO_2), PI_{max}%, and spirometric parameters (FVC%, FEV_1%, and MMEFR) between CRF patients receiving conservative treatment and those under dialysis before the dialysis session. Furthermore, there was a significant difference in hemogasometric parameters (pH, PCO_2, PO_2), PI_{max}%, and spirometric parameters (FVC, FEV_1%, FVC, and MMEFR) between both groups. There was a significant inverse relationship between pH and PE_{max}% in group 2 and between PI_{max}% and MMEFR FEV_1 in group 1 before dialysis. In contrast, a significant direct relationship was found between PaO_2 and MMEFR in group 2, between PI_{max}% and FEV_1 in group 1 before dialysis as well as between PE_{max}% and FVC/FEV_1 in group 1 before dialysis.

Conclusion There was an obvious decrease in the respiratory muscle performance, arterial blood gases, and spirometric measurements in patients with CRF, both those who were receiving conservative treatment and those under HD, but this decrease was more apparent in those under HD. *Egypt J Broncho* 2014 8:100–107

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Keywords: chronic renal failure, hemodialysis, maximum expiratory pressure, maximum inspiratory pressure

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Introduction

Chronic renal failure (CRF) is characterized by progressive and irreversible destruction of renal structures. The respiratory system undergoes alterations in respiratory drive, pulmonary mechanics, muscle function, and gas exchange. This pulmonary dysfunction may be a direct result of the circulation of toxins or, indirectly, from the excess volume because of the increased quantities of circulating body fluids, anemia, immunological suppression, drugs, and deficient nutrition [1].

Among CRF patients undergoing dialysis, hemodialysis (HD) is the most frequently used modality (90.7%). This intervention is usually performed three times a week, 3–4 h/session. Although advances in HD have improved the survival of these patients, significant changes in their quality of life have been found. The physical functioning of such patients has been shown to be decreased, including a reduction in physical activity, muscle weakness, anemia, and several metabolic and hormonal alterations [2].

Physiological abnormalities are frequent in the skeletal muscle structure of patients with CRF, and their main signs are fatigue, muscular weakness, and low exercise tolerance. Respiratory muscular weakness may lead to hypoventilation; maximum respiratory pressure measurements may help in early diagnosis and therapeutic interventions for these patients [3].

Maximum inspiratory pressure (PI_{max}) and maximum expiratory pressure (PE_{max}) produced during static efforts are considered a reflex of the strength of the respiratory muscles. The relations of those maximum static pressures with general muscle development have been described by some authors [4].

The most widely used test for assessment of the overall strength of inspiratory and expiratory muscles consists

of measurement of maximum static mouth pressures. These tests have the advantage of being noninvasive and normal values have been well established in adults [4].

Aim of this work

The aim of this study is to assess the respiratory muscle performance by measuring the PI_{max} and the PE_{max} in patients with CRF immediately before and after HD.

Patients and methods

This study was carried out at the Pulmonary Function Unit Chest Department and the Renal Dialysis Unit in Ain Shams University Hospital in the period from January 2012 to January 2013.

Sixty patients with CRF were recruited in this study and an informed consent was signed by every patient. This study was approved by the ethical committee.

The study was carried out on two groups:

(1) Group 1 included 30 patients with CRF undergoing regular HD for at least 6 months to study the effect of CRF and HD on respiratory muscle function.
(2) Group 2 included 30 patients with CRF under conservative treatment to study the effect of CRF on respiratory muscle function; this was the control group.

All patients were subjected to the following:

(1) Full assessment of history and thorough clinical examination.
(2) Chest radiograph posteroanterior view.
(3) Arterial blood gas analysis (for group 1, this was carried out 1 h before and 1 h after HD).
(4) PI_{max} and PE_{max} (for group 1, these were determined 1 h before and 1 h after HD).
(5) Spirometry (for group 1, this was measured 1 h before and 1 h after HD).
(6) Serum electrolytes (Na, K, Ca, P, Mg, and total protein, albumin).

Exclusion criteria

(1) Ischemic heart disease (recent myocardial infarction, unstable angina).
(2) Cardiac arrhythmias (recent) – mental confusion.
(3) Neuromuscular diseases – chronic liver disease.
(4) Associated pulmonary diseases such aschronic obstructive pulmonary disease and obese hypoventilation syndrome (OHVS).
(5) Pregnant women – patients who refused to sign the consent.

The results are analyzed in terms of descriptions, differences, and comparisons between the two groups.

Results

All tests were well tolerated in all 60 patients.

In this study, there was a statistical difference between the spirometry values, PI_{max}, and PE_{max} between group 1 and group 2; this difference is shown in (Fig. 1).

In this study, comparison of arterial blood gases (ABG), pulmonary function test (PFT), PI_{max}, and PE_{max} between patients in group 1 before dialysis and those in group 2 was carried out, and there was a significant difference in pH, $PaCO_2$, PaO_2, PI_{max}, FVC%, FEV_1%, and MMEFR between CRF patients receiving conservative treatment and those under dialysis before the dialysis session using an independent Student *t*-test data analysis of age, gender, duration of dialysis of chronic renal failure patients in this study was shown in table 1. This is shown in (Table 2).

In addition, this study found that there was a difference in the pH, $PaCO_2$, and PaO_2 immediately before and after HD (P = 0.242) using a paired *t*-test, and this difference is shown in (Figs 2–4).

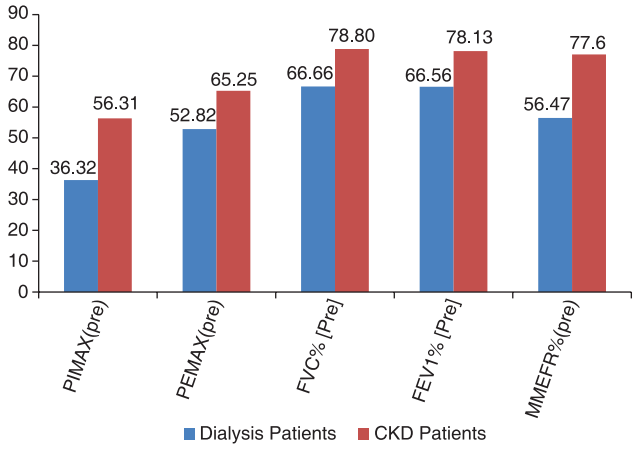
In the present study, there was a statistically significant difference in PI_{max} and MMEFR before and after

Table 1 Age and BMI, sex, and duration of dialysis of CRF patients in the study

Data analysis	Mean ± SD	
	Group 1	Group 2
Age (years)	43.1000 ± 17.26737	48.3448 ± 15.48565
Sex		
Male	21	18
Female	9	12
BMI (m^2/kg)	24.1067 ± 8.28787	25.4744 ± 6.48635
Dialysis duration (years)	4.5172 ± 2.92917	—

CRF, chronic renal failure.

Fig. 1



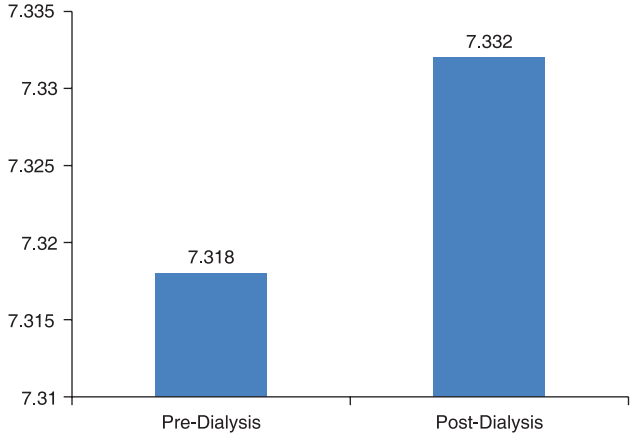
PI_{max}, PE_{max}, and spirometry of the participants in the study. PE_{max}, maximum expiratory pressure; PI_{max}, maximum inspiratory pressure.

Table 2 Comparison of ABG, PFT, PI_{max}, and PE_{max} between patients in group 1 before dialysis and those in group 2

Data analysis	Group				Value	
	1		2			
	Mean	SD	Mean	SD	*t* value	*P* value
Age	43.10	17.27	48.34	15.49	−1.227	0.225
BMI	24.11	8.29	25.47	6.49	−0.704	0.484
pH (Pre)	7.32	0.02	7.33	0.03	−2.082	0.042
$PaCO_2$ (Pre)	32.13	2.54	25.80	7.41	4.427	0.000
PaO_2 (Pre)	88.63	7.42	77.40	6.86	6.088	0.000
PI_{max}% (Pre)	36.33	28.57	56.31	24.87	−2.890	0.005
PE_{max}% (Pre)	52.82	36.29	65.26	29.88	−1.449	0.153
FVC% (Pre)	66.67	17.65	78.80	17.67	−2.661	0.010
FEV_1% (Pre)	66.59	14.22	78.13	21.01	−2.492	0.016
FEV_1/FVC%	82.833	8.17	84.830	8.84	−0.909	0.182
MMEFR% (Pre)	56.47	20.74	77.06	20.20	−3.897	0.000

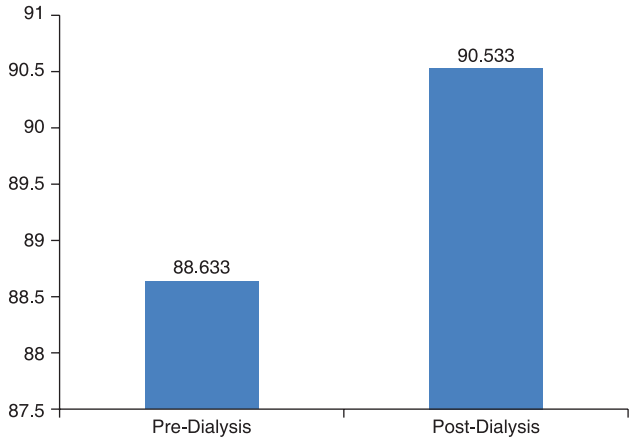
A significant difference in PI_{max}, hemogasometric [pH, $PaCO_2$, PaO_2], and spirometric parameters [FVC%, FEV_1%, and MMEFR] was observed between CRF patients receiving conservative treatment and those under dialysis before the dialysis session; ABG, arterial blood gases; CRF, chronic renal failure; PE_{max}, maximum expiratory pressure; PFT, pulmonary function test; PI_{max}, maximum inspiratory pressure.

Fig. 2



Difference in pH immediately before and after hemodialysis.

Fig. 4



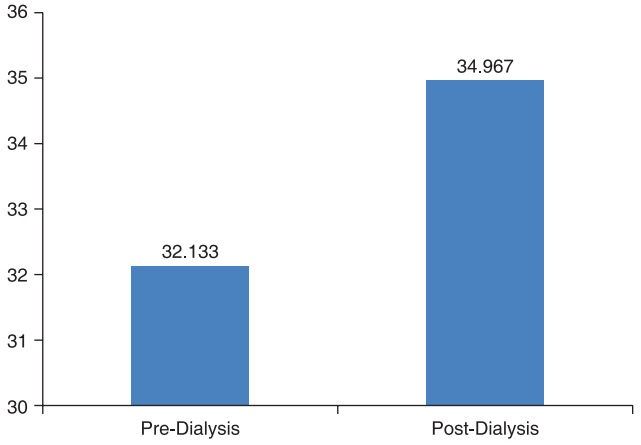
Difference in PaO_2 immediately before and after hemodialysis.

dialysis ($P \leq 0.000$, $P \leq 0.003$), whereas there was no statistically significant difference between PE_{max} before and after dialysis ($P = 0.648$). This is shown in (Fig. 5).

A comparison was performed in ABG, PFT, PI_{max}, and PE_{max} between patients in group 1 after dialysis and those in group 2 in the following (Table 3), and there was a significant difference in $PaCO_2$, PaO_2, PI_{max}, FVC%, and MMEFR between CRF patients receiving conservative treatment and those under dialysis after the dialysis session using an independent Student *t*-test.

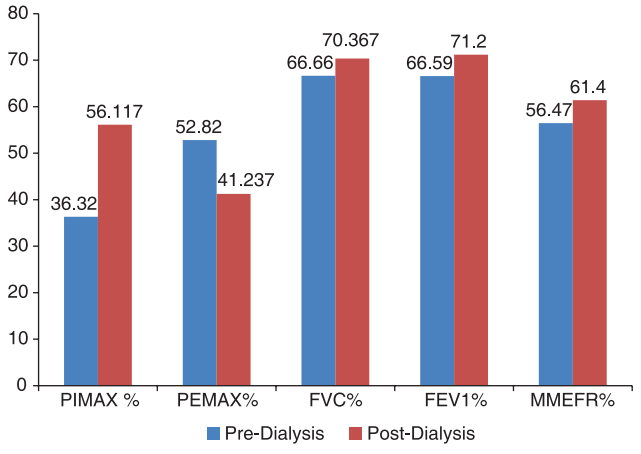
In addition, this study performed a comparison of ABG, PFT, PI_{max}, and PE_{max} immediately before and after HD in group 1 patients and observed that there was a significant difference between pH, $PaCO_2$, PI_{max}%, FEV_1/FVC%, FEV_1%, and MMEFR before and after dialysis ($P \leq 0.05$) using a paired *t*-test, and this is shown in (Table 4).

Fig. 3



Difference in $PaCO_2$ immediately before and after hemodialysis.

Fig. 5



Difference in PFT, PI_{max}, and PE_{max} immediately before and after hemodialysis. PE_{max}, maximum expiratory pressure; PFT, pulmonary function test; PI_{max}, maximum inspiratory pressure.

Moreover, in this study, there was a correlation between ABG and PFT, PI_{max}, and PE_{max} in CRF patients receiving conservative treatment, and it was found that there was a significant direct relationship between pH and PE_{max}, and a significant direct relationship between PaO_2 and MMEFR using the Pearson correlation coefficient, but no significant relationship between $PaCO_2$ and PI_{max}, PE_{max}, FVC, FEV_1, and MMEFR; all these results are shown in (Table 5).

Table 3 Comparison of ABG, PFT, PI_{max}, and PE_{max} between patients in group 1 after dialysis and those in group 2

Data analysis	Group				Value	
	1		2			
	Mean	SD	Mean	SD	*t* value	*P* value
Age	43.10	17.27	48.34	15.49	−1.227	0.225
BMI	24.11	8.29	25.47	6.49	−0.704	0.484
pH (Post)	7.33	0.02	7.33	0.03	0.902	0.350
$PaCO_2$ (Post)	34.97	2.79	25.80	7.41	6.340	0.000
PaO_2 (Post)	90.53	6.53	77.40	6.86	7.600	0.000
PI_{max}% (Post)	56.12	35.65	56.31	24.87	−2.690	0.035
PE_{max} (Post)	41.24	29.01	65.26	29.88	−0.09	0.360
FVC% (Post)	70.37	15.18	78.80	17.67	−1.91	0.050
FEV_1% (Post)	71.20	10.93	78.13	21.01	−1.620	0.110
FEV_1/FVC% (Post)	87.08	7.1	84.833	8.48	1.087	0.860
MMEFR% (Post)	61.40	20.47	77.06	20.20	−2.97	0.004

A significant difference in PI_{max}, $PaCO_2$, PaO_2, FVC%, and MMEFR was detected between CRF patients receiving conservative treatment and those under dialysis after the dialysis session; ABG, arterial blood gases; CRF, chronic renal failure; PE_{max}, maximum expiratory pressure; PFT, pulmonary function test; PI_{max}, maximum inspiratory pressure.

There is a significant correlation between PI_{max} and FEV_1 (r = 0.36, P = 0.04); also, there was a significant correlation between PE_{max} and FVC (r = 0.523, P = 0.002) using the Pearson correlation coefficient. These results are shown in (Figs 6 and 7). In addition, there was a significant positive correlation between PI_{max} and MMEFR (r = 0.500, P = 0.005).

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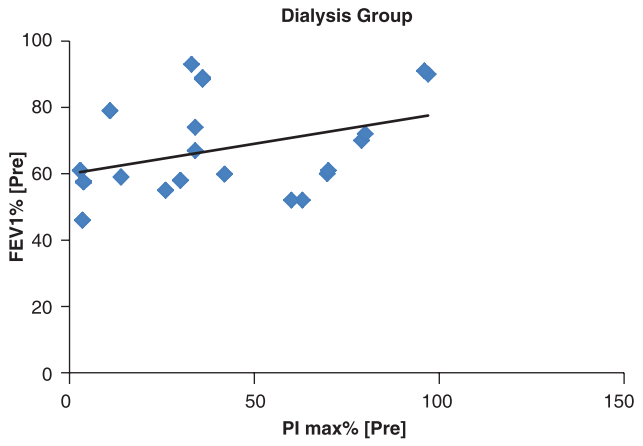
Table 4 Comparison of ABG, PFT, PI_{max}, and PE_{max} immediately before and after hemodialysis in the patients in group 1

Data analysis	Paired differences		*t*	*P* value
	Mean	SD		
pH (Pre)–pH (Post)	−0.01400	0.02541	−3.018	0.005
$PaCO_2$ (Pre)–$PaCO_2$ (Post)	−2.83333	3.14131	−4.940	0.000
PaO_2 (Pre)–PaO_2 (Post)	−1.90000	8.71918	−1.194	0.242
PI_{max}% (Pre)–PI_{max}% (Post)	−4.91000	6.08969	−4.416	0.000
PE_{max}% (Pre)–PE_{max}% (Post)	−3.29333	39.14974	−0.461	0.648
FVC% (Pre)-FVC% (Post)	−3.70000	17.37844	−1.166	0.253
FEV_1% (Pre)-FEV_1% (Post)	−4.60667	12.86186	−1.962	0.059
FEV_1/FVC% (Pre)-FEV_1/FVC% (Post)	−4.247	14.907	−2.149	0.0178
MMEFR% (Pre)-MMEFR% (Post)	−4.93333	8.43201	−3.205	0.003

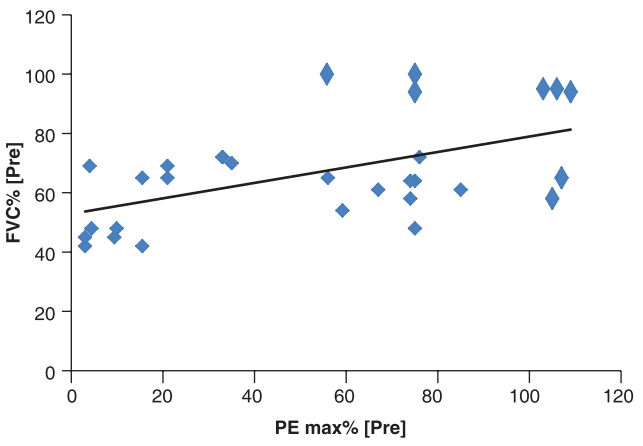
A significant difference was observed between pH, $PaCO_2$, PI_{max}%, FEV_1/FVC%, FEV_1%, and MMEFR before and after dialysis; ABG, arterial blood gases; PE_{max}, maximum expiratory pressure; PFT, pulmonary function test; PI_{max}, maximum inspiratory pressure.

Fig. 6



Correlation between PI_{max} and FEV_1% (pred). PI_{max}, maximum inspiratory pressure.

Fig. 7



Correlation between PE_{max} and FVC% (pred). PE_{max}, maximum expiratory pressure.

There was a correlation between duration of dialysis and PI_{max}, PE_{max}, ABG, and PFT in CRF patients before HD, and there was a significant direct correlation between duration of dialysis and PI_{max} and $PaCO_2$ in predialysis patients using the Pearson correlation coefficient, as shown in (Table 6).

Discussion

In the current study, the mean age of the patients in group 2 was 48.3 years, whereas it was 43.1 years in group 1, with no statistically significance difference between both groups. Similarly, there was no statistical significance in the mean BMI in both groups: 25.4 kg/m^2 for the patients in group 2 and 24.1 kg/m^2 for the patients in group 1. However, in the study carried out by Rocha and Araújo [4] that included 35 CRF patients to evaluate the maximum respiratory pressure in CRF patients before and after HD, the mean age was 51.7 years and the mean weight was 62.0 kg. In the study of Cury *et al.* [5], who assessed the negative effect of CRF on lung function, the mean age of those under dialysis was 43.91 ± 2.32 years and the mean BMI was 23.67 ± 0.69.

This study found that the mean duration of dialysis was 4.5 ± 2.9 years, and there was a significant direct correlation between duration of dialysis and PI_{max} and $PaCO_2$ in predialysis patients using the Pearson correlation coefficient, which is higher than the mean of dialysis duration in the study of Cury *et al.* [5], which was 2.77 ± 0.32 years, but there was no correlation between this and the PI_{max} values in dialysis patients.

This current study found that the mean PI_{max}% was 36.3 ± 28.5 just before dialysis and the mean PE_{max}% before dialysis was 52.8 ± 36.3, and these were 56.1 and 41.2, respectively, after the dialysis session, which are lower than the results of the study of Rocha and Araújo [4] as the mean PI_{max}% and PE_{max}% immediately before dialysis were 67.5 and 67.9, respectively, and the mean PI_{max}% and PE_{max} immediately after dialysis were 79.0 ± 36.7 and 59.0 ± 10.7.

The current study confirmed that there was a statistically significant improvement in PI_{max} after dialysis ($P < 0.0001$), although there was no statistically significant difference in PE_{max} before and after dialysis ($P = 0.648$).

In addition, this study found that there was a statistically significant difference in PI_{max} between both groups ($P < 0.05$), whereas there was no statistically significant difference between the included groups in PE_{max} ($P = 0.153$).

The current study found that there was an improvement in PI_{max} after dialysis, although the results of the study of Rocha and Araújo [4] indicated that patients with CRF on HD treatment showed reductions in PI_{max} and PE_{max}. Patients showed a decrease in the mean PI_{max} and PE_{max} in relation to the values predicted before and after HD. Both PI_{max} and PE_{max} before and after HD had significantly lower mean values than the predicted ones ($P < 0.0001$), showing a significant impairment in respiratory muscle strength in that group of patients.

The current study found that the pulmonary function values were reduced, and PI_{max} and PE_{max} values were below those predicted. These results are in agreement with the study of Karacan *et al.* [6], which reported that CRF patients have significantly decreased respiratory muscle strength, and also Schardong *et al.* [7], who assessed the pulmonary function, respiratory muscle strength, and quality of life of 30 CRF patients undergoing HD. These authors reported that pulmonary function values were reduced, and PI_{max} and PE_{max} values were below those predicted.

In the CRF patients under dialysis, in the current study, there was no statistically significant difference before and after HD as FVC was 66.6% before

Table 5 Correlation between ABG and PFT, PI_{max}, and PE_{max} in CRF patients receiving conservative treatment

Value	PI_{max}	PE_{max}	FVC	FEV_1	MMEFR
pH					
r value	−0.334	−0.572	−0.206	−0.019	−0.084
P value	0.071	0.001	0.275	0.921	0.660
$PaCO_2$					
r value	−0.012	−0.260	−0.169	0.111	−0.276
P value	0.951	0.165	0.372	0.558	0.140
PaO_2					
r value	0.123	0.203	−0.226	0.165	0.493
P value	0.518	0.283	0.230	0.383	0.006

A significant correlation was observed between ABG and PFT, PI_{max}, and PE_{max} in CRF patients receiving conservative treatment. Moreover, a significant direct relationship was observed between pH and PE_{max}, and between PaO_2 and MMEFR. In contrast, there was no significant relationship between $PaCO_2$ and PI_{max}, PE_{max}, FVC, FEV_1, and MMEFR; ABG, arterial blood gases; CRF, chronic renal failure; PE_{max}, maximum expiratory pressure; PFT, pulmonary function test; PI_{max}, maximum inspiratory pressure.

Table 6 Correlation between duration of dialysis and PI_{max}, PE_{max}, and PFT in CRF patients under hemodialysis

	pH	$PaCO_2$	PaO_2	PI_{max}%	PE_{max}%	FVC%	FEV_1%	MMEFR%
Dialysis duration (years)								
r	0.222	0.415	0.016	0.417	0.184	0.217	−0.061	−0.249
P	0.248	0.025	0.936	0.024	0.339	0.257	0.752	0.193

A significant positive correlation was detected between PI_{max} and MMEFR [$r = 0.500$, $P = 0.005$]; CRF, chronic renal failure; PE_{max}, maximum expiratory pressure; PFT, pulmonary function test; PI_{max}, maximum inspiratory pressure.

dialysis and 70.3% just after the session. Also, FEV_1 was 66.5% before dialysis and increased to 71.2% just after the dialysis; there was no statistically significant difference between both values. FVC for those under conservative treatment was 78.8%, whereas FEV_1 was 78.1%. These results are lower than those found in the study carried out by Coelho *et al.* [8] on 30 chronic kidney disease (CKD) patients to assess the effects of CRF on exercise capacity, nutritional status, pulmonary function, and respiratory musculature; in their study, FVC was 94% and FEV_1 was 86%.

The present study observed that the mean FEVI% was 78.13, which is not in agreement with the result of the study carried out by Coelho *et al.* [8], which showed that there was a statistically significant decrease in the PFTs among the volunteers in the CRF group, although the values remained within clinically normal parameters; also, Siafakas *et al*. [9] showed that patients with CRF may have limitations in their airflow. According to these authors, the reduction in FEV_1 may be associated with reduced muscular strength, which is responsible for the delays in muscle fiber contraction.

This exciting study showed that the FVC% was 78.80, FEV_1% was 78.13, and MMEFR% was 77.0 in CRF patients on conservative treatment; this is in agreement with the results of Bush and Gabriel [10], who reported that patients with CRF undergoing conservative treatments might have spirometry values within the normal range because of greater preservation of pulmonary functions. However, Dujic *et al.* [11] reported that there was a decrease in all spirometric variables, including FVC, and attributed this decrease to reversible obstructions in the airways and to trapped air caused by the accumulation of liquid near the airways.

Our study found that there was a decrease in all spirometric values, PI_{max}, and PE_{max} in patients undergoing HD in comparison with CRF patients under conservative treatment; these results are in agreement with those of Cury *et al.* [5], who assessed the negative effect of CRF on lung function, and reported that patients under dialysis showed the worst results for lung function (FVC, FEV1, maximum voluntary ventilation (MVV), maximum inspiratory pressure (MIP), and maximum E xpiratory pressure (MEP)) and functional capacity (6MWT) in comparison with those under conservative treatment. Positive correlation results were observed between respiratory muscle strength (MIP and MEP) and the volumetric parameters (FVC) and overall functioning of the respiratory system (MVV) in the study groups, thus suggesting that the muscle strength parameter was the main component with the greatest influence on impairment of lung function in patients undergoing dialysis and in kidney transplant patients.

This study reported that there was a statistically significant difference between PI_{max} and MMEFR before and after dialysis.($P \leq 0.000$, $P \leq 0.003$), whereas there was no statistically significant difference between PE_{max} before and after dialysis ($P = 0.648$) using a paired *t*-test; these results are in agreement with those of Paltiel *et al.* [12], who investigated the inspiratory muscle strength of 21 patients (13 men and eight women, age range 27–78 years) with CRF undergoing chronic HD. The authors reported that PI_{max} was significantly reduced in all patients, except one, before the HD session, compared with the predicted reference values. After HD, a significant increase in PI_{max} (from 52.9 ± 3.5 to 60.7 ± 3.7% of the predicted value: $P < 0.0001$) was observed.

In addition, this study found that there was a significant direct correlation between duration of dialysis and PI_{max} ($P = 0.024$) and $PaCO_2$ ($P = 0.025$) in predialysis patients using the Pearson correlation coefficient, but these results were not in agreement with those of Paltiel *et al.* [12], who investigated the inspiratory muscle strength of 21 patients (13 men and eight women, age range 27–78 years) with CKD undergoing chronic HD. The authors reported that on analyzing the individual data, the results showed no significant correlation between inspiratory muscle strength before HD and the duration of HD treatment.

The current study found that there was a greater decrease in respiratory muscle strength and pulmonary function in CRF patients undergoing HD; this was in agreement with the main results of Kovelis *et al.* [13], who included 20 patients to evaluate pulmonary function and respiratory muscle strength in CRF patients on HD. There was a decrease in the PI_{max} and PE_{max} and spirometric results in CRF patients.

Furthermore, in the current study, there was a significant direct relation between duration of dialysis and PI_{max}, whereas there was no statistically significant correlation with the spirometric variables and duration of dialysis; this result was in agreement with that of Kovelis *et al.* [13] as the duration of HD showed no statistically significant correlation with the spirometric variables.

Kovelis *et al.* [13] reported that the patients in their study showed an increase in FVC ($P = 0.02$) at the end of the first HD session of the week. There were no statistically significant alterations in MIP or MEP

before and after the HD session. Moreover, Rahgoshai *et al.* [14] recruited 26 CRF patients under HD and found that only the FVC of patients improved significantly after the HD session ($P = 0.02$), and the other factors, including vital capacity (VC), FEV_1, and FEV_1/FVC ratio, showed no significant changes in comparison with those before HD. However, in the current study, for pulmonary function and respiratory muscle performance, there was a significant difference between PH, $PaCO_2$, PI_{max}%, FEV_1/FVC%, and MMEFR before and after dialysis ($P \leq 0.05$) using a paired *t*-test; also, there was a significant difference in PI_{max} in CKD patients under dialysis immediately before and after the session.

In the current study, there was an improvement in MMEFR% and FEV1/FVC% after dialysis, which is in agreement with the result of Navari *et al.* [15], who evaluated spirometry parameters in 41 patients on HD. They reported that the improvement in spirometry parameters was significant in patients undergoing dialysis with bicarbonate dialysate.

This current study found that there was a significant improvement in pH, $PaCO_2$, PI_{max}, FEV_1/FVC, and MMEFR after dialysis, and there was also an improvement in FEV_1 and FVC, but this was statistically insignificant; these results were not in agreement with the results of the study of Kovacevic *et al.* [16], who evaluated 39 patients with chronic kidney failure, but without cardiac and pulmonary diseases, and showed that ventilator function indicators, especially the VC and FEV1, improved significantly after HD.

In the current study, for ABG, there was a significant difference in pH, PCO_2, and PO_2 between CRF patients receiving conservative treatment and those under dialysis. Furthermore, there was a significant difference in pH in CKD patients under dialysis immediately before and after the session ($P = 0.005$), which was in agreement with the study of Noh *et al.* [17], who recruited 53 chronic kidney diseases patients to evaluate pH before and after HD (0.001).

The current study found that there was no significant decrease in PaO_2 in CRF patients, with no significant difference between the value before and after dialysis (0.24); this can be attributed to pulmonary artery microembolization from the dialyzer membrane, alveolar hypoventilation because of loss of $PaCO_2$ across the dialyzer membrane, ventilation perfusion mismatch because of change in pulmonary vascular volume, and reversible lung damage because of intrapulmonary leukostasis from contact of blood with the dialyzer membrane. This result is in agreement with the results of a study carried out by Coelho *et al.* [8], in which there was no significant difference between the value of PaO_2 before and after dialysis.

In the current study, in terms of spirometry, there was a significant difference in FVC%, FEV_1%, and MMEFR% between both groups, whereas a study by Herrero *et al.* [18] compared a group of patients on HD with another group on conservative treatment and concluded that there was no difference between the groups in terms of FVC or FEV_1.

Conclusion

It was concluded from this study that there was an obvious decrease in the respiratory muscle performance, ABG, and spirometric measurements in patients with CRF, both those receiving conservative treatment and those under HD, but this decrease was more apparent in those under HD. Moreover, there was an improvement in PI_{max} after the dialysis session, whereas there was no significant change in PE_{max}.

Acknowledgements

Conflicts of interest

None declared.

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