Orthostatic hypoxaemia in dialysed adult polycystic kidney disease patients

Z. Korzets1, E. Golan1, S. Ben-Chitrit1, Y. Smorjik2, P. Os1 and J. Bernheim1

Departments of 1Nephrology and 2Pulmonology, Meir Hospital, Kfar Saba and the Sackler School of Medicine, Tel Aviv University, Tel Aviv, Israel

Abstract

Background. Recently we observed a unique clinical phenomenon, namely, orthostatic or postural hypoxaemia in a 72-year-old female adult polycystic kidney disease (APKD) patient, maintained on CAPD. Extensive investigations failed to yield a satisfactory explanation for her ambulatory hypoxaemia.

Methods. To validate our observation, 15 dialysed patients underwent blood gases analyses in both the supine and ambulatory positions (SpO2 and ApO2 respectively). Patients were divided into two groups: group 1 (n=7) whose end-stage renal failure (ESRF) was due to APKD and group 2 (n=8) in whom ESRF was due to other causes.

Both haemodialysed (HD) and CAPD patients were included. ApO2 was determined as the pO2 immediately upon standing up. Readings in HD patients were taken at the end of the dialysis session, that is, at the patients’ dry weight.

Results. Respective SpO2 and ApO2 of the two groups were 85±17.1 and 78±20.5 vs 85.8±19 and 91±21 mmHg. Delta change in pO2 defined as the mean decrease (negative value) or mean increase (positive value) of ApO2 in relation to SpO2 was −7.85 (group 1) vs +5.2 mmHg (group 2), P<0.005. In group 1, six of seven patients demonstrated a negative delta. In group 2, four of eight showed a positive delta whilst the remaining four had no change in the delta value.

Conclusion. Orthostatic hypoxaemia may occur in dialysed patients whose ESRF is due to APKD.

Key words: adult polycystic kidney disease; dialysis; orthostatic hypoxaemia

Introduction

Hypoxaemia in patients with ESRF is frequently encountered and is most commonly due to pulmonary congestion as a result of fluid overload. Haemodialysis-associated hypoxaemia is also a well-recognized occurrence, thought to be due mainly to hypoventilation incurred as a result of a decreased pCO2 particularly when dialysing against an acetate base [1]. Peritoneal dialysis, on the other hand, is rarely associated with ventilatory impairment in patients without overt lung disease [2]. APKD has not been reported to cause a decline in pO2. Based on a clinical observation (case report detailed below) documenting orthostatic hypoxaemia in a CAPD patient (ESRF due to APKD), this study was conducted in order to confirm the existence of this unique phenomenon.

Case report

A 72-year-old Caucasian female with ESRF due to APKD had been maintained on CAPD for 24 months. She presented with shortness of breath markedly exacerbated by standing up and alleviated by lying down. There was no history of any previous lung disease. On physical examination the patient was obviously dyspnoeic on standing, with a respiratory rate of 24/min, which was reduced to 16/min when supine. Blood pressure when erect was 90/60, and was 120/80 mmHg in the supine position. The only other physical finding of note was the presence of huge bilateral palpable kidneys. There were no signs of heart failure. Supine pO2 (SpO2) was 64 versus an ambulatory pO2 (ApO2) of 44.2 mmHg. The decrease in ApO2 occurred irrespective of the presence of fluid in the peritoneal cavity. Pulmonary function tests revealed no restrictive or obstructive component. There were no ventilation/perfusion defects on a lung scan. Computerized tomography (CT) of the chest was without abnormality. CT of the abdomen demonstrated only huge bilateral polycystic kidneys. Pulmonary angiography showed no major arteriovenous shunt. On echocardiography, normal sized chambers were visualized, with good left ventricular contractility. An electromyographic study revealed evidence of peripheral neuropathy.

© 1997 European Renal Association–European Dialysis and Transplant Association
Subjects and methods

Following the above case report, blood gases analyses (room air) were performed in 15 dialysed patients (maintained on both HD and CAPD), in the supine and ambulatory position. Haemodialysis was performed thrice weekly for 4–5 h using hollow-fibre dialysers (either polysulphone or cellulose triacetate) at a blood flow of 300 ml/min and dialysate flow of 500 ml/min. All HD patients were on bicarbonate dialysis. CAPD was performed using the double-bag system and Dialine (Travenol, Israel) peritoneal dialysis solutions. Either four or five exchanges per day of between 2 and 2.5 litres were carried out as appropriate for the patient.

Patients were divided into two groups: group 1, those in whom ESRF was due to APKD; and group 2, those in whom ESRF was due to other causes. Supine readings were taken after a 10-min period of lying down. Immediately upon standing up from the reclining position and at 5 min thereafter, blood was drawn for ambulatory values. In HD patients, blood gases were always assessed after a dialysis session, at the patient’s optimal dry weight. Results were compared using the Mann–Whitney test.

Results

Results are shown in Table 1. As can be seen, there were seven patients in group 1, this being the total number of dialysed APKD patients in our unit, and eight patients in group 2. Although the two groups were well matched with regard to age and dialysis mode, there were fewer males in group 1 (3M/4F vs 6M/2F).

Supine pO₂ (SpO₂) was similar between groups. Ambulatory pO₂ immediately upon standing and at 5 min in the erect posture were identical (results not shown). In contrast to SpO₂, ambulatory pO₂ was markedly divergent between the groups, decreasing to 78 ± 20.5 mmHg in group 1 and increasing to 91 ± 21 mmHg in group 2. Delta change in pO₂, defined as the mean decrease (negative value) or the mean increase (positive value) was 7.85 vs +5.2 in groups 1 and 2 respectively (P < 0.005). A negative delta was seen in six of seven patients of group 1. In group 2, four of eight patients demonstrated a positive delta while the four remaining patients had no demonstrable change. There were no differences in pCO₂ values (range 30–35 mmHg) in the supine or erect position in either group.

Discussion

Dialysis patients frequently present with shortness of breath due, in the majority of instances, to fluid overload. The resultant hypoxaemia is rapidly reversible upon ultrafiltration. Haemodialysis-associated hypoxaemia occurs within 15–30 min of the onset of dialysis when dialysing against an acetate buffer. Its two major determinants have generally been considered to be: (a) acetate load and consequent metabolism leading to increased oxygen consumption and decreased carbon dioxide (CO₂) production, with a resultant reduction of the respiratory quotient, and (b) CO₂ losses through the dialysate, leading to hypventilation [1].

Haemodialysis-associated hypoxaemia has also been observed in bicarbonate dialysis, probably dependent on the bicarbonate concentration in the dialysate. A greater than 37 mmol/l dialysate bicarbonate might result in rapid alkalization of the patient, with a consequent compensatory hypoventilation. With the current use of bicarbonate dialysis usually at a concentration of 35 mmol/l (at least in Western countries as well as in our unit), dialysis hypoxaemia is less often seen. Peritoneal dialysis is rarely associated with ventilatory impairment in patients without overt lung disease [2]. Most studies of pulmonary function in CAPD have measured lung volumes. Data, however, is controversial in as much as volumes were reported to be unchanged or undergo a significant decline immediately upon the institution or during the early course of CAPD [2–4]. Changes in lung volume were compensated for after a period varying from 2 weeks to several months. Hypoxaemia, when determined, was only a short-lived event undergoing a rapid adaptive process: a fortnight after the commencement of CAPD [5] or within approximately 610 min in IPD [6]. The hypoxaemia seen in these circumstances was attributed to ventilation/perfusion inequality in areas of microatelectasis. Its rapid adaptation is, in the main, thought to be due to localized vasoconstriction of the affected atelectatic areas [7].

We herein report on a hitherto undescribed phenomenon, namely the occurrence of orthostatic hypoxaemia in dialysed APKD patients. This clinical observation was initially made in a female APKD patient maintained on CAPD. Despite being thoroughly investigated, no satisfactory explanation for the ambulatory decline in pO₂ was forthcoming. The presence of uraemic polyneuropathy could be implicated, possibly giving rise to respiratory muscle dysfunction. However, if this had been the case, lung function tests should have shown a restrictive component. This patient’s pulmonary function tests were entirely within normal limits. Of note is the fact that orthostatic hypoxaemia was a constant finding, irrespective of the presence of fluid in the peritoneal cavity. Our follow-up study

---

Table 1. Results of the blood gas analyses

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Men age (years)</td>
<td>59.6</td>
<td>53.3</td>
</tr>
<tr>
<td>Dialysis mode</td>
<td>Haemodialysis</td>
<td>CAPD</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>SpO₂ (mmHg)</td>
<td>85.0 ± 17.1</td>
<td>85.5 ± 19.0</td>
</tr>
<tr>
<td>ApO₂ (mmHg)</td>
<td>78.0 ± 20.5</td>
<td>91.0 ± 21.0</td>
</tr>
<tr>
<td>Delta (mmHg)</td>
<td>−7.85</td>
<td>+5.2*</td>
</tr>
</tbody>
</table>

*P < 0.005 vs group 1.
confirmed the existence of this phenomenon in dialysed APKD patients. Apart from our test case, pulmonary function tests were not performed in any other patient. As both HD and CAPD patients demonstrated the ambulatory drop in pO\textsubscript{2}, mode of dialysis does not seem to be a contributing factor. Particularly impressive is the fact that a negative delta value, denoting a decline of pO\textsubscript{2} in the erect position, was found in six of the seven APKD patients tested. All these patients had markedly enlarged polycystic kidneys with no noticeable difference in kidney size among them. Our test case had a significant postural drop in blood pressure, but this was not evidenced in the other APKD patients. Thus, although we cannot exclude the presence of a subclinical degree of uraemic neuropathy in these patients the ambulatory hypoxia appears to be independent of lowered blood pressure values in the erect position.

In contrast to the APKD group, group 2 patients demonstrated either no change or a positive delta value. APKD per se has not been reported to cause hypoxaemia. Theoretically, extensive cystic involvement of the lung could lead to decreased oxygenation. However, the mere presence of even multiple cysts cannot explain the postural drop in pO\textsubscript{2}, nor its occurrence in the dialysis setting. None of our APKD patients had pulmonary cysts. The absence of any difference in pCO\textsubscript{2} between the supine and erect positions does not support hypoventilation as playing a causative role.

The best plausible explanation for the observed phenomenon we can offer is the existence of intrapulmonary shunting associated with intrapulmonary vascular dilatation. Such intrapulmonary shunting appears to be the major reason for the severe hypoxaemia (pO\textsubscript{2} < 50 mmHg) occasionally seen in patients with chronic liver disorders [8]. It is caused by intrapulmonary vascular dilatation at the precapillary level, or direct arteriovenous communications. It has been postulated that some type of circulating factor or metabolite not cleared by the diseased liver is responsible for the diffuse dilatation in the pulmonary parenchyma and the pleural surfaces. Possibly this postulate also applies to dialysed patients. The end result would be a stream of venous blood that does not receive diffused oxygen from the normally functioning alveoli. Interestingly, in some chronic liver-disease patients, this process is worsened when the patient assumes a standing position from the supine. Because of gravity, increased blood flow through the lung bases may indeed increase the flow through dilated precapillary beds, thus aggravating the hypoxaemia. This situation which we have termed orthostatic hypoxaemia is also known as orthodeoxia. The associated increase in dyspnoea with positional change is called platypnoea. Ours is but a preliminary study in a small number of patients. Although some of them had liver cysts, none showed any disturbance of liver function. Whether orthodeoxia is unique to dialysed APKD patients or a certain subsection of them, or perhaps is also seen in APKD patients with advanced chronic renal failure requires further studies.

References


Received for publication: 29.7.96
Accepted in revised form: 15.11.96