Impact of Peritoneal Dialysis on Pulmonary Function Test in a Patient With Diaphragm Paralysis

The infusion of intra-peritoneal fluid for dialysis increases intra-peritoneal pressure (IPP). The rise in IPP is reported to be proportional to the volume infused (1). It has been documented that IPP is about equal to intra-abdominal pressure (IAP) (2). It was also shown that increased IAP has an impact on pulmonary function tests and that these can be improved, for example, by reducing the size of polycystic kidneys by transcatheter renal artery embolization (3). This impact of increased intra-peritoneal fluid on pulmonary function has been demonstrated in several studies. For example, patients after ascites paracentesis show improvement in dyspnea through an increase in total lung capacity (TLC) and residual volume (RV) (4,5). It has been described that with the infusion of 2 L of dialysis fluid in the peritoneal space patients can feel dyspnea, which is most prominent in the sitting position

(6). Several studies have looked at the impact of peritoneal dialysis (PD) on respiratory function. They found that with the infusion of 2 L of dialysis fluid, there was a significant decrease in TLC and RV. Forced expiratory volume in 1 second (FEV1), ratio of forced expiratory volume in 1 second to forced vital capacity (FEV1/FVC) and carbon monoxide diffusing capacity (DLCO) were unchanged (7). This restrictive effect seems to be compensated by an increase in the strength of the respiratory muscles, probably due to increased diaphragmatic contractility. This was shown by an increase in inspiratory capacity (IC) following the infusion of 2 L of dialysis fluid (8–10).

Very few studies looked at the clinical impact of these changes in patients with pulmonary disease. One study, published in 1986, showed no clinically significant deterioration after initiation of PD in 9 patients with chronic pulmonary obstructive disease (COPD) and 3 patients with kyphoscoliosis (10). This was also described in an additional patient with severe COPD (11).

Patients with unilateral diaphragm paralysis are usually asymptomatic but may have dyspnea on exertion (12). It is known that diaphragm paralysis has an impact on pulmonary function tests by decreasing FVC to 70–80% of the predicted value, which is further decreased by 15–25% in the supine position. Maximal inspiratory pressure (MIP) is usually decreased to 60% of predicted. Interestingly, MIP has been shown to be reduced in uremic patients as well (9). To date, there have been no studies showing the impact of PD on patients with diaphragmatic paralysis who lack a possible means of compensating for the restrictive effect of the intra-peritoneal fluid volume.

CASE REPORT

A 70-year-old female patient with end stage renal disease on a solitary kidney and diabetic nephropathy was in hemodialysis

for over 20 years. She had refused kidney transplant in 2007. She had a native arterio-venous fistula on the right arm which became non-functional in 2009, a thrombosed left arm graft in 2010 and subsequently developed thrombosis of both subclavian veins. Her past medical history also revealed type 2 diabetes, coronary artery disease for which she had a coronary artery bypass in 2006, peripheral vascular disease, cerebrovascular disease with a previous stroke and obesity. Chest X-ray showed a raised left diaphragm and paralysis was confirmed by fluoroscopy. No cause was identified for this paralysis and it preceded her coronary artery bypass surgery. She was followed in pneumology for dyspnea, and a mild restrictive syndrome diagnosed by pulmonary function tests was attributed to the diaphragm paralysis and her obesity. With the lack of any access to hemodialysis, PD became an interesting option, but there was concern about deteriorating her respiratory status with the addition of intra-abdominal fluid. Pulmonary function tests were done 1 month prior to start of PD and showed a FEV1 1.12 L (62%), FEV1/FVC 0.86, FVC 1.30 L (55%), TLC 3.15 L (74%), RV 1.58 L (82%), DLCO 44%. A PD catheter was installed and she began continuous ambulatory PD (CAPD) with 2-L exchanges 4 times per day. The patient noted no increase in her dyspnea and tolerated PD. Pulmonary function tests were repeated 1 month later, with the peritoneal cavity full and showed FEV1 1.12 L (62%), FEV1/FVC 0.81, FVC 1.38 L (58%), TLC 2.98 L (70%), RV 1.50 L (78%), DLCO 50% (Table 1).

We also evaluated her MIP and IC on the same day with and without fluid in the peritoneal cavity (Table 2). The impact of the decubitus position, as described in diaphragm paralysis, was also evaluated. As expected, her MIP dropped from 32 cmH₂O in the sitting position to 28 cmH₂O in dorsal decubitus. The same results were obtained whether or not the patient had 2 L of fluid in her peritoneal cavity. As was

TABLE 1
Pulmonary Function Tests Before and After the Start of Peritoneal Dialysis

Date	Peritoneal fluid (yes/no)	FEV1 (L; % of predicted)	FEV1/FVC	FVC (L; % of predicted)	TLC (L; % of predicted)	RV (L; % of predicted)
2012/11/16 before PD	no	1.12; 62	0.86	1.30; 55	3.15; 74	1.58; 82
2013/01/24	yes	1.12; 58	0.81	1.38; 58	2.98; 70	1.50; 78

FEV1 = forced expiratory volume in 1 s; FVC = forced vital capacity; TLC = total lung capacity; RV = residual volume; PD = peritoneal dialysis.

TABLE 2
Evaluation of the Impact of Peritoneal Fluid on Inspiratory Capacity

Date	Peritoneal fluid (yes/no)	IC sitting (L; % of predicted)	IC DD (L; % of predicted)	MIP sitting (cmH ₂ O)	MIP DD (cmH ₂ O)	SVC sitting (L; % of predicted)	SVC DD (L; % of predicted)
2013/10/18 12:13 pm	no	1.08; 60	1.12; 62	32	28	1.24; 54	1.31; 57
2013/10/18 8:32 am	yes	1.26; 70	1.16; 64	32	28	1.30; 57	1.20; 53

IC = inspiratory capacity; DD = dorsal decubitus; MIP = maximal inspiratory pressure; SVC = slow vital capacity.

described previously, her inspiratory capacity increased 19% when peritoneal fluid was added, from 1.08 L to 1.26 L in the sitting position but not in dorsal decubitus (from 1.12 L to 1.16 L).

DISCUSSION

Previous literature has revealed the impact of intra-peritoneal fluid on pulmonary function tests and the presence of dyspnea in certain circumstances. The restrictive effect caused by this fluid is in part compensated by an increase in inspiratory capacity in the normal individual. This is expected as IC is equal to the TLC minus the functional residual capacity (FRC), which is in fact decreased with the addition of dialysis fluid in the intra-peritoneal space (i.e. $IC = TLC - FRC$, Figure 1). In the presence of unilateral diaphragm paralysis, this ability to recruit inspiratory function after the infusion of dialysate in the intra-peritoneal space is preserved in the sitting position. However, this increase in inspiratory capacity is not found in dorsal decubitus due to the incapacity of developing a strong enough inspiratory force to achieve the initial TLC.

When there are no longer any vascular accesses available for hemodialysis, PD can be an interesting option. In the presence of unilateral diaphragm paralysis and a pre-existing restrictive syndrome, one can worry about the feasibility of PD. Interestingly, this case, like the previous literature, reveals that there was a mild decrease in TLC and RV after the infusion of 2 L of intra-change to PD fluid. There were no significant changes in FEV, FEV1/FVC and FVC. There was also an increase in inspiratory capacity, as previously described. This increase likely compensates for the restrictive effect of the addition of intra-peritoneal fluid.

In this patient with diaphragm paralysis and a baseline restrictive syndrome, the ability to increase inspiratory capacity with intra-peritoneal fluid was preserved in the sitting position. Most importantly, the fluid was well tolerated and the patient did not find an increase in dyspnea. It must be noted that this patient presented left diaphragm paralysis. It is known that the right diaphragm plays a more important role in respiratory function. It could thus be questioned whether

Figure 1— Schematic representation of pulmonary function test lung volumes.

the outcomes would have been the same in the case of right and, more importantly, in the presence of bilateral diaphragm paralysis or in a patient with more significant reduction in lung capacity. It is nonetheless reassuring that no problems were noted in this patient. Peritoneal dialysis is therefore a viable option in patients with left diaphragm paralysis.

DISCLOSURES

The authors have no financial conflicts of interest to declare.

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