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Additional intermittent peritoneal dialysis in difficult-to-treat hemodialysis patients with severe heart disease

(Dialyse péritonéale intermittente supplémentaire chez les patients hémodialysés difficiles à traiter et souffrant d'une cardiopathie grave)

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Summary

Usually, patients treated by peritoneal dialysis are switched to full-time hemodialysis due to technique failure. Sometimes, hemodialysis can be added to peritoneal dialysis to improve dialysis delivery. It can be difficult to use hemodialysis on patients with significant heart disease (valvular disease or ischemic cardiomyopathy) and severe heart failure due to common immediate complications and intradialytic hypotension that may worsen cardiac function, thus closing the vicious cycle of cardiac dysfunction and ischemia. This can result in poor dialysis delivery along with volume overload despite regular hemodialysis sessions. Here, we describe a case series of difficult-to-treat hemodialysis patients (7 males aged 51–73) with significant cardiac comorbidities and heart failure in whom additional intermittent peritoneal dialysis was reintroduced on top of regular hemodialysis. They all were initially treated by peritoneal dialysis (median duration of peritoneal dialysis treatment was 16 months, range 2–44) and then switched to full-time hemodialysis due to insufficient ultrafiltration or reasons unrelated to ultrafiltration, but thereafter, they faced significant hemodialysis-related complications and volume overload despite regular weekly sessions. Peritoneal dialysis (one manual exchange) was reintroduced (2–4 months after switching to full-time HD) on 3 hemodialysis-free days, and patients were followed up. After 12 months, better volume management (regression of pleural effusion, a reduction in water body mass composition (median of 1 vs. 2.4 L), reduced serum NT-proBNP values (median of 13,030 vs. 45,384 pg/ml)), better cardiac functional status, and a reduction in the frequency and number of dialytic complications were achieved. Moreover, during the 12-month follow-up, such bimodal treatment resulted in improved health-related quality of life as assessed by the WHOQoL-BREF questionnaire (median of 74 vs 55). The addition of peritoneal dialysis in difficult-to-treat hemodialysis patients may result in benefits despite additional costs and burdens for patients.

Keywords : additional intermittent peritoneal dialysis, bimodal dialysis treatment, dialysis-related complications, heart failure, hemodialysis, peritoneal dialysis

Résumé

En général, les patients traités par dialyse péritonéale passent à l'hémodialyse à temps plein en raison de l'échec de la technique. Parfois, l'hémodialyse peut être ajoutée à la dialyse péritonéale pour améliorer sa gestion. Il peut être difficile d'utiliser l'hémodialyse chez les patients souffrant d'une maladie cardiaque sévère (maladie valvulaire ou cardiomyopathie ischémique) et d'une insuffisance cardiaque grave, en raison des complications immédiates fréquentes et de l'hypotension intra dialytique qui peut aggraver la fonction cardiaque, refermant ainsi un cercle vicieux. Il peut en résulter une mauvaise délivrance de la dialyse ainsi qu'une surcharge volumique malgré des séances d'hémodialyse régulières. Nous décrivons ici une série de cas de patients hémodialysés difficiles à traiter (7 hommes âgés de 51 à 73 ans) présentant d'importantes comorbidités cardiaques et une insuffisance cardiaque, chez lesquels une dialyse péritonéale intermittente supplémentaire a été réintroduite en plus de l'hémodialyse régulière. Ils ont tous été traités initialement par dialyse péritonéale (durée médiane du traitement par dialyse péritonéale : 16 mois, intervalle 2-44), puis sont passés à l'hémodialyse à temps plein en raison d'une ultrafiltration insuffisante ou pour des raisons non liées à l'ultrafiltration ; mais par la suite, ils ont été confrontés à des complications importantes liées à l'hémodialyse et à une surcharge volumique malgré des séances hebdomadaires régulières. La dialyse péritonéale (un échange manuel) a été réintroduite (2-4 mois après le passage à l'HD à temps plein) pendant 3 jours sans hémodialyse, et les patients ont été suivis. Après 12 mois, une meilleure gestion du volume (régression de l'épanchement pleural, réduction de la composition de la masse hydrique (médiane de 1 vs. 2,4 L), réduction des valeurs sériques de NT-proBNP (médiane de 13 030 vs. 45 384 pg/ml)), un meilleur état fonctionnel cardiaque et une réduction de la fréquence et du nombre de complications dialytiques ont été obtenus. De plus, au cours des 12 mois de suivi, ce traitement bimodal a permis d'améliorer la qualité de vie liée à la santé, telle qu'évaluée par le questionnaire WHOQoL-BREF (médiane de 74 vs 55). L'ajout de la dialyse péritonéale chez les patients hémodialysés difficiles à traiter peut s'avérer bénéfique malgré les coûts et les charges supplémentaires pour les patients.

Mots-clés : dialyse péritonéale intermittente supplémentaire, traitement de dialyse bimodale, complications liées à la dialyse, insuffisance cardiaque, hémodialyse, dialyse péritonéale

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Introduction

Kidney failure (KF), defined by a permanent decline in glomerular filtration rate of less than 15 ml/min/1.73m^2, requires renal replacement therapy (RRT), i.e. kidney transplantation or dialysis, or sometimes supportive care when RRT is not an option [1]. Maintenance dialysis is a blood purification method which aims to remove metabolic waste, water excess and rebalance electrolytes thus mimicking exocrine kidney function. For patients with chronic KF requiring maintenance dialysis, there are two options, hemodialysis (HD) and peritoneal dialysis (PD), both of which can be applied at the same time (bimodal dialysis treatment). In HD, extracorporal circulation is used to remove water and solutes from blood, and remains the most common form of RRT, counting for more than 80% of patients receiving RRT in near all countries, followed by PD and kidney transplantation [2]. Standard HD can be performed in a dialysis clinic (in-centre HD) or at home (home HD). In-centre HD typically occurs 3 times weekly for 4 hours per treatment. In some centers shorter or longer overnight HD treatments can be provided and in developed countries home-HD became important modality of individualized HD treatment [1]. In PD, peritoneal membrane is used for the water and solute exchange after instillation of dialysis solution in the abdomen. This can be performed manually, typically with 4-6 manual exchanges daily (CAPD, continuous ambulatory PD), or via machine-automated exchanges (APD, automated PD) which is often performed at night [3]. Although PD is more cost-effective than in-center HD, it is still used less frequent than HD, only in approximately 11% of patients receiving dialysis (3). In long-term PD patients, loss of residual renal function and deterioration of peritoneal membrane function may cause toxin accumulation and ultrafiltration (UF) insufficiency, with volume overload leading to technique failure and switch to HD [4,5]. This conversion can be direct from PD to HD or, sometimes, combination of PD and HD (bridge therapy) is used for some time (e.g. two HD sessions per month or one weekly session) before switching to full-time HD. Such bimodal regimen seems to be not redundant, but a rational and cost-effective modality of RRT with comparable admission and mortality rate as in patients directly switched to HD [6]. Several studies showed that bimodal dialysis therapy could increase dialysis adequacy, decrease fluid overload and improve health-related quality of life (HRQoL) in patients requiring dialysis [7,8].

Patients receiving maintenance dialysis as RRT have high mortality rate with a 5-year survival of less than 50% in some countries[1]. Cardiovascular diseases are the major cause of morbidity and mortality in dialysis patients and the primary leading cause of death in both HD and PD patients, accounting for around 50% of deaths in dialysis patients [1,9]. In incident patients with KF, the prevalence of heart failure (HF) is around 30% and atherosclerotic coronary artery disease (CAD) around 18%. Even in dialysis patients without significant cardiovascular risk, a risk of cardiovascular events including admission due to HF increases significantly after dialysis initiation [9]. Before reaching KF, HF and chronic kidney disease (CKD) frequently co-exist and probably bidirectional causality is present with one system dysfunction predating the other [10]. Mechanisms involved in myocardial decline during dialysis include atherosclerosis, aldosterone-induced cardiac fibrosis, left-ventricular hypertrophy, vascular stiffening and medial vascular calcifications upon bone-mineral disorder in KF [10]. In circumstances of the cardiac disease and HF in dialysis patients, volume overload can be frequent and more severe, and its management more difficult. This may be particularly seen in patients without residual kidney function receiving HD where diuretics have no any effect. During the conventional three-times weekly in-center HD, aggressive UF is often needed in response to interdialytic weight gain, thereby

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placing stress on the heart and peripheral vasculature. Such stress is aggravated in patients with co-existing HF whose hemodynamic is already vulnerable, thus episodes of hypotension may occur [9]. Even in HD patients without known heart disease, episodes of myocardial stunning due to hemodynamic changes during the HD treatment may occur, leading to higher morbidity and mortality and development of HF [11]. Taken all together, volume management in HD patients with HF and other heart conditions can be challenging. On the other hand, adjustment of blood volume, predominately by removal of excess salt and water by UF, is necessary for cardiac function optimization [10]. Due to much lower UF rate, PD is not associated with such hemodynamic changes like HD, neurohumoral activation is less intense and myocardial stunning is absent [12]. PD, usually prescribed as intermittent treatment (IPD) can be used for severe and drug-resistant HF treatment in patients with cardiorenal syndrome, even before reaching KF [10,13]. While there is plenty of data on additional HD treatment in PD patients encountering technique failure (bimodal PD and HD treatment), there is little data on the additional use of PD in patients switched to full-time HD in order to improve volume status management.

Here, we describe a series of the patients switched from PD to full-time HD, in whom significant HF was present and volume overload was treated by reintroduction of intermittent PD (aIPD) on the top of conventional three-times weekly HD.

Methods

Patients included in this retrospective case series were treated and followed up at Division of Dialysis, General Hospital Zadar, Croatia. All included patients were switched directly from PD as an initial RRT modality to full-time HD and suffered from HF with consequent difficult-to-treat volume overload. In order to improve dialysis delivery in this difficult-to-treat dialysis population, aIPD was commenced based on individualized approach guided by last available 4-h peritoneal equilibration test (PET) results and patient's characteristics and comorbidities (e.g. abdominal hernia). Peritoneal ultrafiltration (UF) insufficiency was defined as a net UF from 4-h PET <400 ml and/or daily UF is insufficient to maintain adequate fluid status [14]. During every HD session before and after aIPD commencement, all relevant data were recorded (blood pressure measurement, saturation of peripheral blood by oxygen) and later analyzed as well as frequency of intradialytic and interdialytic HD related complications (cramps, intradialytic hypotension, headache, cardiac arrythmia). Hypoxemia was defined as saturation of peripheral blood with oxygen (SpO^2) < 92% measured by pulse oximetry. Hypotension was defined as systolic blood pressure < 90 mmHg before starting HD session. Intradialytic hypotension was defined as any symptomatic intradialytic drop in blood pressure or a nadir intradialytic systolic blood pressure < 90 mmHg [1,15]. Every patient had full cardiological evaluation before the additional IPD treatment was started, including electrocardiography, cardiac ultrasound with left ventricle ejection fraction (LVEF) estimation and coronary angiography. Diagnosis of HF was made by consultant cardiologist based on symptoms and cardiac ultrasound. HF was further classified as HF with reduced ejection fraction (HFrEF; EF <40%), HF with mildly-reduced EF (HFmrEF; EF 40-55%) or HF with preserved EF (HFpEF, EF in men ≥55%) [16]. The New York Heart Association (NYHA) functional classification was employed by cardiologist to stratify patients according to HF-related symptoms. In order to assess volume status, following elements were used: "dry" body mass, X-ray of thoracic organs and bioelectrical impedance analyzer (BIA, Fresenius Medical Care, Germany) employed for body composition mass overhydration estimation (BCM-OH, expressed in liters). After aIPD commencement, patients

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were systematically followed-up including: levels of serum albumin and N-terminal pro-brain natriuretic peptide (NT-proBNP), frequency of the complications related to HD, volume status (thoracic X-rays and BCM-OH) and health-related quality of life (HRQoL) assessment. For HRQoL assessment WHOQoL-BREF questionnaire was used [17,18]. It assesses QoL through four domains (physical health, psychological, social relationships and environment) and it is accepted as a tool for QoL assessment in population of patients with KF and those receiving RRT [19,20]. All patients provided both written and oral consent for aIPD treatment and follow up. Numerical variables are expressed as medians with a range. The Wilcoxon test for paired samples was used for comparison of medians of numerical variables at the beginning of the aIPD and 12 months later (W and z values shown).

Description of case series

A total of 7 male patients (age 51–73 years) with aIPD treatment on top of the three-times weekly in-center HD were followed up for at least 12 months. All relevant demographic and baseline clinical data are summarized in *Table 1, 2 and 3* and details on aIPD treatment as well as dialysis outcomes in *Table 5*. Initially, all patients were treated by PD (median duration of PD treatment 16 months, range 2–44 months), but later they were switched to full-time HD due to PD UF insufficiency, major surgical procedures or other reasons (details provided in *Table 2*). After transfer to full-time HD (via tunneled venous catheters), peritoneal catheter was kept in peritoneal cavity with appropriate regular maintenance (peritoneal lavage once weekly). At the moment of aIPD commencement, all patients were oligoanuric and had significant HF (NYHA class III-IV) on the top of ischemic cardiomyopathy (ISC)/coronary artery disease (CAD) and/or severe valvular disease *(Table 3)*. In five patients coronary angiography showed significant calcifications of coronary arteries (arteriosclerosis) and significant coronary atherosclerosis with consequent chronic heart ischemia. Patient 4 had hypertrophic cardiomyopathy and coronary arteries calcifications with consequent HFpEF. Patient 5 had HFpEF due to severe left ventricular hypertrophy (LVH), pacemaker implantation due to complete atrioventricular block and artificial aortic valve due to severe stenosis and endocarditis of artificial aortic valve. Six patients had systemic hypotension before HD session and other complications related to HD like headache, cramps, intradialytic hypotension and hypoxemia (at least one complication per HD session). Arrhythmic disorders appeared commonly during the HD session *(Table 2)*. At the beginning of aIPD, all patients had signs of inadequate volume status management (pleural effusions, elevated BCM-OH) and significantly elevated values of serum NT-proBNP. In our series of patients baseline assessment showed generally reduced HRQoL. In 6 patients aIPD regimen included one manual exchange of glucose solution or icodextrin per day three times weekly (in days without HD) and in one patient system for APD was used for glucose solution exchange *(Table 4)*. In all patients, the same HD regimen was kept (three times weekly, 4–4.5 hours), and aIPD was commenced soon after switch to HD (2–4 months). Average daily net UF achieved by aIPD ranged from 400-850 ml. Such bimodal RRT was continued between 12–38 months and was stopped due to patient's death (six patients) or complete loss of UF by IPD (Patient 3) *(Table 4)*. In all patients, values of NT-proBNP decreased (median of 13,030 vs 45,384 pg/ml; W=0, z= -2.366) and serum albumin increased (median of 41.8 vs 37.8 g/L; W=0, z= -2.366) after 12 months of aIPD commencement. Complete regression of pleural effusion and reduction of BCM-OH (median of 1 vs 2.4 L; W=0, z= -2.366) was achieved in all patients as well as reduction in number and frequency of complications related to HD. Systemic hypoxia disappeared in all patients, cramps became less frequent (< 1x weekly) as well as arythmic disorders. Those being

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hypotensive prior to HD session remained hypotensive after aIPD introduction, but additional intradialytic falls in blood pressure became less frequent (< 1x weekly). In five patients improvement in NYHA grade was achieved over 12 months of bimodal dialysis *(Table 5)*. In patient 3 significant improvement of LVEF was noticed after aIPD was introduced. Significant increase in HRQoL scores was observed in all patients after 12 months of follow-up (median of 74 vs 55; W=0, z= -2.366) *(Table 5)*.

Table I. Demographic data and features of renal replacement therapy

Patient	Sex	Year of birth	RRT (PD)				
			Start date (YYYY-MM)	Patient's age (years)	Last 4 hour D/P Cr	Residual diuresis (ml)	PD duration (mo)
1	M	1947	2016-03	69	0.72	<100	44
2	M	1955	2021-01	66	0.65	300	2
3	M	1958	2019-06	61	0.69	<100	16
4	M	1946	2016-12	70	0.80	<100	31
5	M	1969	2019-04	50	0.87	<100	10
6	M	1955	2011-02	56	0.81	300	2
7	M	1938	2007-10	69	0.94	<100	23

Abbreviations: RRT, renal replacement therapy; D/P Cr, dialysate-to-plasma creatinine ratio; PD, peritoneal dialysis

Table II. Hemodialysis-related complications

Patient	Switch to full-time HD								
	Reason for switch to HD	Start date (YYYY-MM)	Patient's age (years)	Cramps	Headache	Hypotension	Arrhythmia	Hypoxia	Intradialytic hypotension
1	UF insufficiency	2020-01	73	•		•	•		•
2	Severy pulmonary embolism; UF insufficiency	2021-03	66	•	•	•	•	•	•
3	Cardiac valve surgery	2020-10	62	•	•	•			•
4	UF insufficiency; Abdominal surgery	2019-06	73	•	•				•
5	UF insufficiency; Cardiac valve surgery	2020-02	51	•	•	•	•	•	•
6	Poor cooperation due to psychiatric condition	2011-04	56	•	•	•	•	•	•
7	UF insufficiency	2009-09	71	•	•	•	•		•

Abbreviations: HD, hemodialysis

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Table III. Clinical data on heart disease in reported case series

Patient	Cardiac disease						
	CAD	ISC	VD	LVH	LVEF (%)	Heart failure	Additional heart condition
1	•	•	•	•	30	HFrEF	LBBB
2		•	•	•	30	HFrEF	AF, LV aneurysm
3	•	•	•	•	15-30	HFrEF	Artificial aortic valve; Stenosis of artificial aortic valve (TAVI procedure)
4	•		•	•	55	HFpEF	Hypertrophic cardiomyopathy
5			•	•	55	HFpEF	PM (complete AV block); Artificial aortic valve; Endocarditis of artificial aortic valve
6	•	•		•	30	HFrEF	LBBB, ICD (after episode of VT)
7	•	•	•	•	40-45	HFmrEF	AF, LV aneurysm

Abbreviations: CAD, coronary artery disease; ISC, ischemic cardiomyopathy; VD, valvular disease (e.g. aortic valve stenosis or calcifications, mitral annulus calcification, etc); LVH, left ventricular hypertrophy; LVEF, left ventricle ejection fraction; HFrEF, heart failure with reduced EF; HFpEF, heart failure with preserved EF; HFmrEF, heart failure with mildly reduced EF; LBBB, left bundle branch block; TAVI, transcatheter aortic valve implantation; AF, atrial fibrillation; LV, left ventricle; PM, pacemaker; ICD, implantable cardioverter defibrillator

Table IV. Characteristics and regimen of additional intermittent peritoneal dialysis (aIPD)

Patient	Initiation of aIPD (YYYY-MM)	Additional intermittent PD (aIPD) prescription				
		HD rythm (times per week x h)	aIPD solution and volume (ml)	aIPD (times per week)	Dwell (h)	Daily UF (range, ml)
1	2020-05	3 × 4.5	IC × 2000	3	8	400-600
2	2021-05	3 × 4.5	G1 × 1500	4	2	650-850
3	2021-01	3 × 4	APD*	4	1.5	450-650
4	2019-08	3 × 4	G3 × 1000	3	3	480-680
5	2020-05	3 × 4	G3 × 2000	4	2	550-750
6	2011-07	3 × 4	G1 × 1000	3	3	550-750
7	2009-12	3 × 4	G2 × 2000	4	2.5	500-700

*Abbreviations: PD, peritoneal dialysis; aIPD, additional intermittent peritoneal dialysis; HD, hemodialysis; UF, ultrafiltration; APD, automated peritoneal dialysis; IC, icodextrin; G1, glucose solution 1.5%; G2, glucose solution 2.3%; G3, glucose solution 4.25%; *four overnight cycles (G1 x 1700 ml, dwell 80 minutes) and IC x 1000 ml during the day (dwell 8h)*

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Table V. Follow-up data (after 12 months)

Patient	Follow-up after aIPD initiation												Duration of bimodal treatment (months)
	Pleural effusion		Serum albumin (g/L)		NT-pro-BNP (pg/ml)		WHOQoL-BREF score		BCM-OH (L)		NYHA status		
	0	12 mo	0	12 mo	0	12 mo	0	12 mo	0	12 mo	0	12 mo	
1	Yes	No	39.4	↑ 41.8	45,384	↓ 1,384	57	↑ 80	2.8	1.2	IV	III	36
2	Yes	No	33.9	↑ 34.9	54,470	↓ 4,016	59	↑ 77	3.3	-0.5	IV	III	14
3	Yes	No	37.8	↑ 42.4	38,695	↓ 12,990	46	↑ 71	2.0	1.1	IV	III	38
4	Yes	No	39.2	↑ 41.8	23,230	↓ 13,030	55	↑ 81	3.6	1.7	III	II	29
5	Yes	No	35.4	↑ 37.5	46,379	↓ 39,990	51	↑ 62	1.9	0.7	IV	III	28
6	Yes	No	25.6	↑ 40.0	58,100	↓ 25,100	48	↑ 53	1.7	1.0	IV	III-IV	12
7	Yes	No	38.8	↑ 56.5	42,789	↓ 21,000	57	↑ 74	1.3	0.8	III	III	32
Median value:			37.8	41.8	45,384	13,030	55	74	2.4	1			29 (12-38)

Abbreviations: NT-proBNP, N-terminal probrain natriuretic peptide; WHOQoL-BREF, World Health Organization Quality of Life BREF questionnaire; BCM-OH, body composition mass; NYHA, New York Heart Association

Discussion

Here, we described a case series of patients on maintenance HD with significant HF and inadequate dialysis delivery whose volume management and HD-related complications were improved by reintroducing aIPD. All patients were initially treated by PD but, due to technique failure or change in RRT modality choice, they were switched to full-time HD. Soon after switching to HD, and despite regular weekly sessions, numerous HD-related complications appeared along with signs of volume overload. Usually, after direct switching from full-time PD to full-time HD, dialysis delivery is improved in terms of better volume management, blood pressure regulation and solute clearance [2]. However, patients in our series had significant heart disease underlying HF, the majority of them were hypotensive before HD sessions and experienced additional intradialytic blood pressure fall. Intradialytic hypotension and HD-related complications which appeared (cramps, cardiac arrythmias, systemic hypoxia) significantly limited HD delivery due to frequent HD interruptions which also resulted in substantial fear of continuing HD. In-center HD is limited by duration and number of sessions per week. Long interdialytic intervals and aggressive ultrafiltration in response to interdialytic weight gain collectively engender large and potentially rapid changes in fluid and solutes, thereby placing stress on the heart and peripheral vasculature. Intensive HD, including short daily and nocturnal treatment, lessens the "unphysiology" of the usual schedule and may substantially improve cardiovascular outcomes (9). However, patients are not always prone to undergo these more intensive HD regimens. Additionally, other HD modalities which could improve HD quality like nocturnal HD with longer overnight sessions, are not yet available or in routine use in Croatia. Of note, intensifying diuretic therapy is a possible option for volume overload management in patients with preserved residual diuresis which was not a case in our anuric patients. Reintroducing aIPD seemed to be a rational option in our difficult-to-treat HD patients with overall good results despite additional costs and burden for the patient. It seems that aIPD (one manual exchange three-times weekly in HD free days) was an acceptable and less demanding option for our patients then intensifying HD regimen. When compared to HD, PD achieves water and solutes removal more slowly allowing adequate time for vascular refilling from extravascular spaces thereby avoiding hypotension in patients with

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vulnerable hemodynamic [10]. Additional UF achieved by aIPD allowed reduction in UF rate during HD sessions leading to less common occurrence of HD-related complications, especially intradialytic hypotension which aggravates already existing chronic ischemic heart injury. Moreover, over time, volume management was improved with regression of pleural effusion, BCM-OH and NT-proBNP values in all patients. By introducing aIPD, overall performance of the cardiovascular system improved in patients in our series with improvement in NYHA grade in five of them and substantial improvement in LVEF in patient 3.

In patients encountering PD failure, so called bimodal therapy with introduction of the HD session once per week or even per month, may be sufficient in restoring dialysis adequacy [6,8]. However, such bimodal approach is rarely used in Croatia and direct switch to full-time HD is far more common. Such approach works well for the majority of PD patients, but here we showed that for some patients with significant cardiac comorbidities and volume management issues, this may not be sufficient and significant complications related to HD may appear. PD seems to be a rationale option in treatment of the drug-resistant or difficult-to-treat HF in patients with cardiorenal syndrome even without need for RRT [10,13,21]. Although there was no difference in mortality rates between PD and extracorporal methods of UF in the treatment of a diuretic-resistant HF, PD seems to be effective in symptom relief along with improvement in NYHA grade and positive effect on LVEF [13]. For patients suffering from HF, independently of kidney function and need for RRT, the symptom relief is very important outcome influencing directly HRQoL. Here, we showed that adding PD in form of aIPD as described is a rationale option for HF treatment in HD patients. By introducing aIPD, not only volume management was improved, but HRQoL increased over the period of 12 months. HRQoL is one of the most important dialysis outcomes and any improvement in its values is valuable for dialysis patients whose HRQoL is generally decreased [2,20]. Even though aIPD seems to be demanding for patients already undergoing in-center HD because they have to perform it in HD-free days, HRQoL has increased anyway. An important aspect of PD when compared to HD is its performance in a home setting. Probably one of the most important results of introducing aIPD was reduction in number and frequency of immediate HD-related complications. This resulted not only in better HD delivery, but also in overcoming the fear of HD session which improved dialysis-related QoL and feeling of better “health-being”. This may be emphasized as one of the strong benefits of aIPD in our case series.

Interestingly, all patients in our series had PD as initial mode of RRT with subsequent switch to HD due to UF insufficiency in some of them (failure and loss of UF because of peritoneal solute transport rate or insufficient daily UF to maintain adequate fluid status). However, not negligible UF was achieved after PD was reintroduced in form of aIPD. It is known that even a short period of “peritoneal rest” may lead to a significant decrease in peritoneal solute transport rate and subsequent recovery of UF [22]. Recently, a small clinical trial showed the benefit of switching from CAPD to IPD during one month in terms of decrease in transport rate and recovery of UF [23]). In our cohort, there was a longer period of peritoneal rest (2-4 months) until aIPD was reintroduced and, of no less importance, aIPD was used only three times weekly with short dwells that might have contributed to UF reappearance.

In conclusion, adding IPD in difficult-to-treat HD patients with significant heart comorbidities and HF may be a reasonable option for improvement of the dialysis delivery, reduction of HD-related immediate complications and dialysis outcomes including HRQoL. Further investigations,

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desirable randomized clinical trials, are needed to show real value and all aspects of aIPD and such bimodal treatment in that specific dialysis population.

Limitations

The main limitation of this study is the small number of patients included, the possible selection bias and, due to what was mentioned previously, the low generalizability of the data.

Authors' Contributions

Conceptualization: NZ and DK; methodology, DK, MK and NZ; formal analysis, DK, MK, JN and NZ; investigation, DK, MK and NZ; writing – original draft preparation, NZ; writing – review and editing, DK, MK, JN and NZ; visualization, JN and NZ; supervision: DK and NZ. All authors have read and agreed to the publisced version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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