Renal Replacement Therapy

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Patient-reported intra-dialytic symptoms and post-dialysis recovery times are influenced by psychological distress rather than dialysis prescription

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Abstract

Background: Dialysis is a life-sustaining treatment, but many patients suffer symptoms during dialysis and take time to recover. Previous reports have linked recovery time to intra-dialytic hypotension and rapid solute clearances, whereas others have reported an association with psychological factors. As such, we wished to investigate which factors were important in determining symptom self-reporting and delayed recovery times.

Methods: We recorded self-reported patient intra-dialytic symptoms, recovery times along with sessional dialysis prescriptions, blood pressure and urea clearance, and distress thermometer scores to assess psychological factors.

Findings: Six hundred twenty-three dialysis patients were studied; 621 treated by haemodiafiltration, 60.8% male, mean age 64.5 ± 16.2 years, and 46.1% diabetic. Almost half (49.6%) reported recovery within 1 h. On multivariate analysis, patient self-reported symptom scores were associated with longer post-dialysis recovery times (odds ratio (OR) 1.61, 95% confidence limits (CL) 1.33–1.95), higher distress thermometer scores (OR 1.3 CL (1.3–1.39), but lower hand grip strength (OR 0.85 CL (0.93–0.94), all $p < 0.001$, and younger rather than older patients (OR 0.98 CL (0.97–0.99) $p = 0.005$. We found no association with ultrafiltration rates or weight loss.

Discussion: Compared to earlier studies, our patients treated by haemodiafiltration reported fewer symptoms and shorter recovery times. Patients with higher self-reported distress thermometer scores had both longer post-dialysis recovery times and greater dialysis symptom scores. Younger patients reported more dialysis symptoms and longer recovery times than older patients. Future studies investigating patient self-reported recovery times and dialysis-associated symptoms should also consider interventions to reduce patient psychological factors as well as dialysis practices.

Keywords: Haemodialysis, Distress thermometer, Hand grip strength, Cramps, Headaches

Introduction

Haemodialysis is a life-sustaining treatment for patients with end-stage kidney disease. Despite the many technological developments in dialysis over the past 50 years [1], patients often feel tired after dialysis and may take time to recover [2]. In addition, patients may also complain of other symptoms that occur with dialysis including muscle cramps, headache, pruritus, dizziness and nausea [3, 4].

During dialysis, there are relatively rapid fluid and electrolyte shifts and changes in plasma osmolality [5]. Blood pressure may fall along with perfusion to internal organs, with hypotension being the most commonly reported complication of routine outpatient dialysis treatments [6]. Previous reports have linked various aspects of the dialysis prescription with intra-dialytic and post-dialysis symptom reporting, including the choice of dialysate sodium, potassium and temperature [7–9]. Whereas others have reported that the prevalence of intra-dialysis symptoms and post-dialysis fatigue is reduced by achieving greater urea clearance [10], or by changing from the standard thrice weekly dialysis schedule to shorter but more frequent

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daily dialysis sessions [11], or low-efficiency continuous dialysis [12]. Whether adding convective clearance or switching from haemodialysis to haemofiltration improves intra-dialytic symptoms and post-dialysis recovery times remains unclear, with some studies reporting a benefit and others no effect [9, 12, 13].

Although many reports have suggested that dialysis factors are the most important in determining intra-dialytic symptoms and post-dialysis fatigue [14], others have suggested that patient factors are equal if not more important in determining self-reported dialysis-associated symptoms [15, 16]. Due to the uncertainty [17, 18], we retrospectively investigated whether there was an association between intra-dialytic symptoms and time to recover post-dialysis and dialysis prescriptions, patient frailty and co-morbidity and patient psychological distress.

Patients and methods

As part of UK National Health Service guidelines to request patient feedback on treatment received, all patients attending for routine outpatient dialysis treatments under the care of a university hospital were asked to complete a questionnaire recording the frequency of dialysis-associated symptoms and time to recovery using a previously reported visual analogue scale [4, 14], and also a distress thermometer score, a screening tool for assessing psychological stress [19]. Hospital-computerised medical records were reviewed to obtain co-morbidity which had been recorded according to the Stoke-Davies grading [20] and frailty using the Canadian geriatric frailty score [21]. Hand grip strength (HGS) was measured using the grip-D strength dynamometer (Takei Scientific Instruments Co., Nigata, Japan) according to the manufacturer's instructions in the dominant arm, and the strongest of three measurements recorded [22].

Pre-midweek blood samples were taken for standard biochemical measurement of urea, creatinine, albumin, C-reactive protein (CRP) and N terminal pro-brain natriuretic peptide (NT-proBNP) (Roche Integra, Roche Diagnostics, Lewes, UK) [23], and haemoglobin along with the corresponding post-dialysis urea.

The dialysis prescription and dialysis session details were obtained from hospital computerised records. Patients were dialysed using either a Fresenius 4000H, or 5008H dialysis machines (Fresenius MC, Bad Homburg, Germany), or BBraun Dialogue^{+} (BBraun, Melsungen, Germany) with a polysulphone dialyzer (Fresenius MC, Bad Homburg, Germany) [24] and anticoagulated with a bolus of tinzaparin low molecular weight heparin (Leo Laboratories, Princes Risborough, UK) [25]. All dialysates had a set final concentration or 32 mmol/L of bicarbonate, 3.0 mmol/L acetate, magnesium 0.5 mmol/L and glucose 5.5 mmol/L. Conductivity modules were regularly calibrated and delivered dialysate sodium checked by both flame photometry and ion electrophoresis methods [26, 27].

Ethics

This retrospective audit complied with the UK National Health Service guidelines for clinical audit and service development and met with the approval from the Health Research Authority. In keeping with UK guidelines, all patient data were anonymised prior to analysis (www.hra.nhs.uk).

Statistical analysis

Data is presented as mean ± standard deviation, median (interquartile range) or as a percentage. Standard statistical tests were used to analyse data, (D'Agostino-Pearson normality test, ANOVA, Kruskal-Wallis, or chi-square test) with appropriate corrections made for multiple testing, where appropriate (Tukey or Gannet-Howell). Univariate correlation used Spearman analysis. Multivariable logistic regression analysis was performed using a step backward approach, using all variables with a $p < 0.1$ correlation, and then, variables were excluded if not statistically significant, unless they improved the model fit. Models were checked for collinearity between variables. Statistical analysis used Prism 8.0 (GraphPad, San Diego, USA) and Social and Political Sciences statistical package (SPSS 24.0, IBM, Armonk, USA). Statistical significance was taken as $p < 0.05$.

Results

Six hundred fifty-three adult outpatients attended for dialysis out of a possible 668, with 15 patients absent either admitted to hospital or on-holiday, and 623 (95.4%) completed the dialysis symptom and distress thermometer questionnaire. Ten patients were unable to understand the visual analogue scores due to their inability to understand English, 4 because of dementia or other mental illness and 16 either due to poor visual acuity or declined to participate.

Patient demographics are set out in Table 1. All but two patients were treated by post-dilutional haemodiafiltration. Patients were asked to record the frequency of dialysis-associated symptoms on a Likert visual analogue scale from zero to ten, and the most frequent symptom was tiredness followed by feeling cold, then cramps and symptoms associated with low blood pressure, pruritus and dizziness (Fig. 1). Patients were also asked to score their recovery time post-dialysis, with most patients reporting recovery with an hour (Fig. 2). Patients with higher intra-dialytic symptom scores had longer post-dialysis recovery times (Fig. 3).

On univariate analysis, greater symptom scores were associated with greater distress thermometer scores, longer time to recover, female gender, weaker hand grip strength, younger age, past medical history of hypertension, higher dialysis sessional urea reduction ratio, higher CRP, greater fall in systolic blood pressure during

Table 1 Patient demographics of 623 adult patients with chronic kidney disease attending for routine outpatient haemodiafiltration treatment. Patient demographics, dialysis prescription, co-morbidity and muscle strength. Results displayed as integers, percentage, mean ± standard deviation or median and interquartile range

Variable	Results
Male gender	379 (60.8)
Age, years	64.5 ± 16.2
Diabetic	287 (46.1)
Ethnicity, White	269 (43.2)
Ethnicity, Black	202 (32.4)
Ethnicity, Asian	149 (23.9)
Age, years	64.5 ± 16.2
Venous catheter, access	147 (23.6)
Arterio-venous fistula/graft access	445 (71.4)/31 (5.0)
Pre-dialysis weight, kg	71.5 (61.8–83.9)
Post-dialysis weight, kg	70.0 (60.7–82.1)
Ultrafiltration rate, mL/kg.h	6.0 (3.9–8.0)
Convection volume, L	19.1 (16.0–23.0)
Urea reduction ratio, %	74.6 (69.3–78.9)
Dialysis session time, h	4.0 (3.5–4.0)
Dialysate sodium, mmol/L	136 (136–138)
Dialysate potassium, mmol/L	2.0 (1.0–2.0)
Dialysate calcium, mmol/L	1.0 (1.0–1.25)
Dialysate temperature, °C	35.5 ± 0.7
Dialyzer surface area, m^2	2.10 (1.8–2.2)
Tinzaparin, IU	2500 (2500–2500)
Serum sodium, mmol/L	139 ± 3.6
Serum urea, mmol/L	18.2 ± 5.8
Serum creatinine, umol/L	690 (547–861)
C-reactive protein, mg/L	6.0 (2.0–11.0)
Serum albumin, g/L	39 (36–41)
Haemoglobin, g/L	108.0 ± 14.3
Serum pro-brain natriuretic peptide, ng/L	5635 (1566–11,953)
Glycated haemoglobin, mmol/mol	47.5 (37.7–61.7)
Blood sugar, mmol/L	6.5 (5.4–8.2)
Prescribed antihypertensives	375 (60.2)
Myocardial infarction	115 (18.5)
Coronary artery bypass, surgery/stenting	43 (6.9)/58 (9.3)
Peripheral vascular disease	90 (16.4)
Renal artery stenosis/aortic aneurysm	24 (3.9)
Transient ischaemic attack	19 (3.1)
Cerebrovascular accident	65 (10.4)
Cancer	104 (16.7)
Frailty	4 (3–5)
Distress thermometer	3 (0–6)
Hand grip strength, kg	20.4 ± 10.5

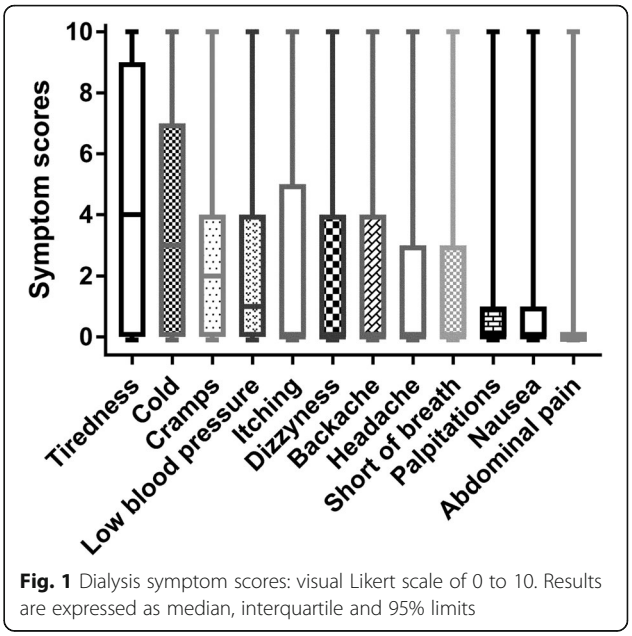

Fig. 1 Dialysis symptom scores: visual Likert scale of 0 to 10. Results are expressed as median, interquartile and 95% limits

the dialysis session, but lower in those with a past medical history of aortic aneurysm or atheromatous reno-vascular disease and cancer (Table 3).

We performed univariate analysis and found that patient age was negatively associated with headache ($r = -0.21$, $p < 0.001$), cramps ($r = -0.14$, $p < 0.001$), nausea ($r = -0.123$, $p < 0.001$), dizziness ($r = -0.13$, $p = 0.001$) and tiredness ($r = -0.11$, $p = 0.007$) (Table 2). Hand grip strength was negatively associated with backache ($r = -0.20$, $p < 0.001$), tiredness ($r = -0.19$, $p < 0.001$), feeling cold ($r = -0.16$, $p < 0.001$), short of breath ($r = -0.15$, $p < 0.001$), abdominal pain ($r = -0.14$, $p < 0.001$), itching ($r = -0.11$, $p = 0.006$), nausea ($r = -0.11$, $p = 0.014$), and dizziness ($r = -0.09$, $p = 0.027$). Distress thermometer scores were positively associated with all symptoms as follows: tiredness ($r = 0.35$), backache ($r = 0.32$), dizziness ($r = 0.28$), cramps ($r = 0.26$), headache ($r = 0.26$), short of breath ($r = 0.26$), feeling cold ($r = 0.24$), abdominal pain ($r = 0.24$), itching ($r = 0.91$), palpitations ($r = 0.22$), nausea ($r = 0.21$) and low blood pressure ($r = 0.18$); all $p < 0.001$.

We then analysed our data to determine the effect of gender. Time to recover was not different between men and women ($p = 0.057$), but distress thermometer scores were higher for women (median 4 (1–6) vs 3 (0–6), $p = 0.041$), but after adjusting for multiple testing, this was then not significant. We analysed individual symptom scores, and again, after adjusting for multiple testing, the following symptoms were reported more frequently by female patients: headache median 1 (0–3) vs 0. (0–2), nausea 0 (0–2) vs 0 (0–0), backache 1 (0–6) vs 0 (0–3), dizziness 2 (0–4) vs 0 (0–3), tiredness 5.5 (1.5–10) vs 3 (0–7), feeling cold 5 (0–10) vs 2 (0–5) and low blood pressure 0 (0–5) vs 0 (0–3); all $p < 0.05$.

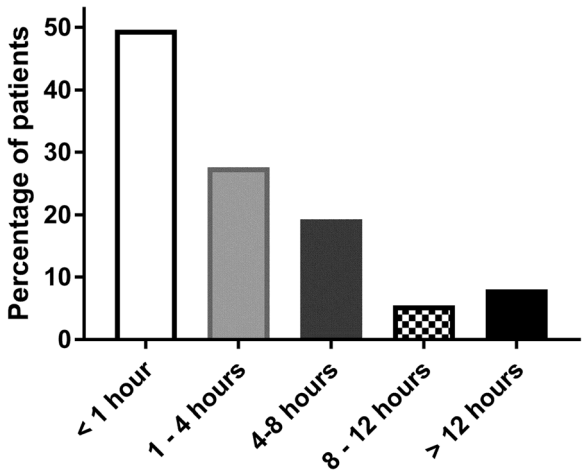

Fig. 2 Percentage of patients reporting time to recover after their haemodialysis session between less than an hour to more than 12 h

We then divided the patient cohort according to dialysis symptom scores (Table 3). Ultrafiltration rates were calculated as the weight loss achieved with the dialysis session divided by the session time or by session time and pre-dialysis weight. Patients with symptomatic hypotension, when ultrafiltration rate was changed (21 patients), or had intravenous fluids (11 patients), were excluded from the analysis of ultrafiltration rates. We found that those patients who reported more dialysis-associated symptoms also reported taking a longer time to recover post-dialysis, and were more likely to be female, of younger age and of Asian ethnicity. Although Asian patients were older than Black patients, median age 70 (59–78) vs 60.5 (51–75) years, there was no difference with White patients 68 (56–79) years, but Asians had lower weight than Black patients (66.8 (55.8–76) vs 72.8 (65–87) kg) but not different from White patients (69.3 (59.8–82.5) kg). However, urea reduction ratio was greater for Asian patients (76.1 (71.5–80)) compared to Whites (74.4 (68–78.8)) and Blacks (73.5 (68.4–77)), $p < 0.05$. HGS was lower for Asians (16.0 (11.4–22.5) kg) vs White (18.8 (13.6–26.1) kg) vs Black (21.2 (14.2–29.7) kg), $p < 0.05$.

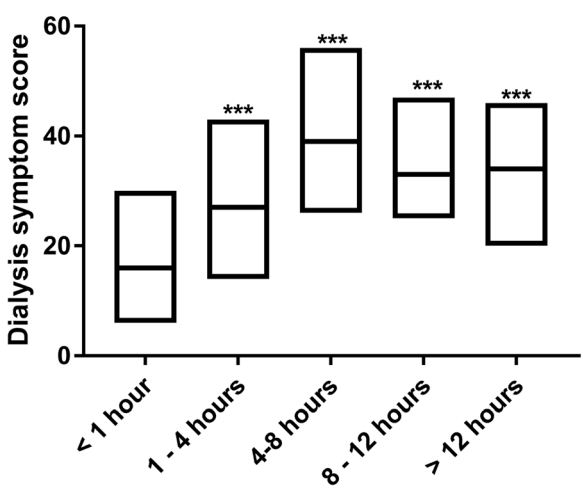

Fig. 3 Post-dialysis recovery times and dialysis symptom scores. Median and interquartile ranges

Table 2 Spearman univariate correlation with dialysis symptom scores

Variable	Univariate correlation *r*	*p* value
Distress thermometer score	0.46	< 0.001
Time to recover post-dialysis	0.38	< 0.001
Female gender	0.29	< 0.001
Hand grip strength	− 0.26	< 0.001
Age	− 0.31	0.001
History of hypertension	0.11	0.005
Renal artery stenosis/aortic aneurysm	− 0.11	0.008
Urea reduction ratio	0.10	0.012
Fall in systolic blood pressure	0.10	0.013
History of cancer	− 0.09	0.019
C-reactive protein	0.09	0.020

Multivariable logistic regression models were compared to those with dialysis symptom scores above and below the median. When recovery time was excluded, the total dialysis symptom score was associated with younger age, higher distress thermometer score and hand grip strength (Table 4). Including recovery time, the same variables remained independently statistically significant as did a past history of a transient ischaemic attack. We found no association between the dialysate temperature and patients reporting feeling cold during dialysis ($r = -0.08$, $p = 0.06$), and similarly, prescription of hydroxy-3-methyl-glutaryl-coenzyme A 3 reductase inhibitors (statins) did not increase reporting of muscle cramps during dialysis (median score 2 (0–4) vs 2 (0–4)).

Discussion

Although dialysis is a life-sustaining treatment for patients with end-stage kidney disease, dialysis imposes many restrictions both in terms of diet and also lifestyles, and as such, there is a relatively high prevalence of self-reported depression [28]. In addition to the perturbation of dialysis on normal daily activities, patients may experience a variety of symptoms during the dialysis session and then take time to recover from the dialysis treatment [2, 3]. Dialysis symptoms have variously been ascribed to the rapid reduction in plasma osmolality [3, 5] and the reduction in effective circulating plasma volume [7, 9, 15]. However, with technological improvements in the dialysis machines and dialysis water quality [1], more recently, reports have suggested that other factors, in terms of patient demographics and co-morbidity, and in

Table 3 Patients divided into quartiles according to dialysis symptom scores. Months of dialysis treatment (vintage), ultrafiltration rate mL/kg.h (UFR), change in pre- vs post-systolic blood pressure in mmHg (SBP), dialysate temperature (Temp), dialysate sodium mmol/L (Dial Sodium), sodium gradient between serum and dialysate mmol/L (Na gradient), urea reduction (URR), % patients with recovery post-dialysis < 1 h (recovery < 1 h), C-reactive protein, glycated haemoglobin mmol/mol (HbA1c), pro N terminal brain natriuretic peptide (BNP), hand grip strength (HGS), distress thermometer (DT) and prescribed antihypertensive medications (BP meds)

Variable	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Symptom score	5 (3–7)	17 (14–21)***	31 (28–35)***	51 (43–61)***
Male	79.1	68.2	49.0	44.8***
Age, years	68 ± 14	65 ± 16	65 ± 17	61 ± 17***
Diabetic, %	44.3	44.3	46.2	50.0
White, %	43.9	50.9	45.5	31.8
Black, %	37.3	28.1	27.6	36.8
Asian, %	18.9	21.0	22.5	30.5*
Vintage months	30.6 (12.5–68.8)	33.4 (10.1–70.4)	32.9 (13.6–65.7)	38.7 (18.5–71.7)
Weight, kg	73.0 ± 15.8	76.3 ± 16.0	74.3 ± 20.8	71.0 ± 20.6
% weight loss	2.2 (1.4–3.0)	2.1 (1.3–2.9)	2.2 (1.6–3.1)	2.4 (1.2–3.0)
UFR, mL/kg.h	4.2 (4.0–4.8)	4.1 (4.1–4.7)	4.1 (4.0–4.7)	4.1 (4.1–4.7)
Session hours	4.0 (3.5–4.0)	4.0 (3.5–4.0)	4.0 (3.5–4.0)	4.0 (3.5–4.0)
Temp., °C	35.9 ± 0.7	35.8 ± 0.7	35.9 ± 0.7	35.9 ± 0.7
Dial, sodium	137 ± 1.0	137 ± 1.0	137 ± 1.0	137 ± 1.0
Na, gradient	2 (0 to 4)	2 (0 to 4)	2 (− 1 to 4)	2 (− 1 to 4)
Qb, mL/min	322 ± 31	323 ± 31	320 ± 29	322 ± 39
Dialyzer, m^2	1.9 ± 0.3	2.0 ± 0.3	2.0 ± 3.0	1.9 ± 0.3
URR, %	73.8 ± 8.9	71.5 ± 9.9	73.4 ± 8.5	74.5 ± 9.3
%SBP > 20 down	26.1	29.8	39	29.5
%SBP > 10 up	25.5	22.4	12.8*	14.8*
Haemoglobin, g/L	108.5 ± 14.5	108.9 ± 14.8	109.4 ± 14.5	105.5 ± 13.4
Recovery < 1 h	18.5	15.2	8.7***	7.2***
Albumin, g/L	38.4 ± 4.5	38.5 ± 4.6	38.2 ± 4.1	38.2 ± 4.7
CRP, mg/L	5.0 (2.0–10.0)	6.0 (3.0–11.0)	7.0 (3.0–11.0)	6.0 (2.0–11.0)
HbA1c	48 (38–56)	46 (38–61)	50 (41–66)	47 (36–60)
Glucose, mmol/L	6.5 (5.1–8.0)	6.2 (5.5–8.1)	6.2 (5.2–8.4)	6.8 (5.5–8.1)
BNP, ng/L	3130 (1678–9943)	3385 (1357–8944)	4253 (1483–15,112)	4072 (1443–14,744)
Frailty	4 (3–5)	4 (3–5)	4 (3–5)	5 (4–8)
HGS, kg	23 ± 10	22 ± 11	19 ± 10**	17 ± 9***
DT, score	1.0 (0–3.0)	2.5 (0–5.0)**	4.0 (1.5–6.0)*	5.0 (4.0–8.0)***
BP meds, %	67.4	50.3*	64.1	62.3

Data expressed as number, percentage, mean ± standard deviation, or median (interquartile range). *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ vs quartile 1

particular psychosocial well-being have a greater influence on self-reported dialysis symptoms [17].

To determine the relative influence of individual components of the dialysis prescription and patient demographics and psychosocial factors on self-reported dialysis symptoms, we reviewed the responses over 600 patients. Some years ago, we introduced the distress thermometer score into our clinical practice [29]. This is a simple visual analogue scale which was initially developed as a rapid screening tool for assessing adjustment disorders and major depression in patients with cancer and then expanded to other conditions [30]. Compared to previous studies in haemodialysis patients, our haemodiafiltration cohort generally reported fewer dialysis symptoms and quicker post-treatment recovery times [5, 31]. However, in keeping with recent reports, we found that fatigue was the most commonly reported symptom by our haemodialysis patients [32]. The next most commonly reported dialysis-associated symptom was one of feeling the cold. Our dialysis centres performed post-dilution

Table 4 Backward logistic regression models of above and below dialysis symptom scores. Model 1 without and model 2 with time to recover post-dialysis. Adjusted Nagelkerke r^2 values 0.311 and 0.371, respectively. Standard error of β (StE β), odds ratio (OR), 95% confidence limits of odds ratio 95% CL. Hand grip strength (HGS), distress thermometer score (DT), history of transient ischaemic attack (TIA)

Variable	Beta (β)	StE β	Wald	OR	95% CL	*p* value
Model 1						
Age, years	− 0.26	0.01	13.3	0.98	0.96–0.98	< 0.001
HGS, kg	− 0.05	0.01	18.8	0.95	0.93–0.97	< 0.001
DT	0.28	0.04	62.6	1.33	1.24–1.42	< 0.001
Model 2						
HGS, kg	− 0.05	0.01	16.7	0.95	− .93–0.94	< 0.001
DT	0.26	0.04	46	1.30	1.30–1.39	< 0.001
Time to recover	0.48	0.01	23.7	1.61	1.33–1.95	< 0.001
Age, years	− 0.02	0.01	7.9	0.98	0.97–0.99	0.005
TIA	1.51	0.72	4.4	4.54	1.1–18.7	0.036

haemodiafiltration, and haemodiafiltration is recognised to reduce the risk of intra-dialytic hypotension, by increasing thermal losses, which may explain the relatively high prevalence of feeling cold compared to reports from patients treated by haemodialysis [33], although there was no statistical association between the dialysate temperature and patient reports of feeling cold. Cramps were the third most common symptom reported. Previous studies have suggested that the choice of lower dialysate sodium concentrations may increase the prevalence of cramps [7]. However, we found no difference in the prescription of dialysate sodium or the gradient between serum sodium and dialysate sodium and self-reported symptoms. An earlier dialysis outcomes study reported an association between dialysate sodium selection and post-dialysis recovery times; however, in more than 50% of cases, patient data was not available for the analysis, and there was no data collected on dialysate temperature [33].

Similarly, we found no difference in the prescription of dialysate potassium and dialysis-associated symptoms [8]. Symptoms associated with low blood pressure were then next most commonly reported, and several previous studies have reported a strong association between ultrafiltration rates and post-dialysis fatigue [15, 34, 35]. However, these studies were typically reporting much high ultrafiltration rates of > 9 mL/kg.h compared to our patients, and we found no association with changes in systolic blood pressure or pre-dialysis NT-proBNP. Compared to previous studies, our patients reported relatively fewer symptoms [15, 16, 35]. This may have been due to the use of convective clearance with haemodiafiltration rather than conventional haemodialysis [13], or the colder dialysates [9], or lower ultrafiltration rates used in our study cohort [15, 33–35].

However, there was a significant association between the distress thermometer scores and both dialysis symptom scores and the time taken to recover post-dialysis. Other studies have also observed an effect of patient psychological distress on self-reported depression and the time to recovery after dialysis [15–17]. Previous studies have reported an association between longer post-dialysis recovery times and a history of psychiatric disorders, in particular depression [33].

Although women reported an increased number of symptoms with dialysis, particularly headache, nausea, abdominal pain, dizziness, fatigue and feeling the cold, in keeping with other studies [33], on multivariable testing, gender was not statistically significant.

Interestingly, we found no effect of previous myocardial infarction, coronary artery bypass surgery or cardiac stenting and patient-reported symptoms, whereas patients with a history of cancer and aortic aneurysm and reno-vascular disease who had undergone stenting reported fewer symptoms. Whether this represents that those patients who may have had more potentially stressful experiences report fewer symptoms remains to be determined. In keeping with previous studies, our older patients reported fewer symptoms and it has been suggested that older patients are more accepting treatments which restrict life-style than younger patients [17].

We did not observe an effect of ultrafiltration rates and dialysis-associated symptoms; however, our ultrafiltration rates were much lower than those previously reported with increased post-dialysis recovery times [15, 33, 35]. However, patients with a history of the transient ischaemic attack reported more intra-dialytic symptoms, and these may have been more susceptible to changes in brain blood flow and osmolality [3, 5]. In addition, both female and Asian patients reported more symptoms than patients from other ethnicities, and Asian patients had lower body weight but had higher urea reduction ratios, which may have predisposed to greater relative changes in serum osmolality [3, 5].

We found that younger patients and those with greater HGS reported more dialysis-associated symptoms. This would suggest that younger healthier patients suffered more symptoms. This apparent paradox has been previously reported and may be due to younger patients having greater difficulty in adapting to dialysis in terms of changes in social and financial circumstances and in comparison to friends and peers, whereas older patients are more acceptable to chronic ill health [36]. This is supported by the association between distress thermometer scores and patient-reported symptoms [37]. Thus, underlying psychological distress is a major factor in patient self-reported symptoms.

Compared to previous studies, our patients treated by haemodiafiltration reported fewer intra-dialytic symptoms and shorter post-treatment recovery times. Haemodiafiltration may offer advantages in terms of intra-dialytic blood pressure stability due to the additional cooling effect and also the use of ultra-pure dialysate water [38]. However, both patients with greater psychological distress as assessed by the distress thermometer and also those smaller female and Asian patients reported more symptoms, suggesting that in addition to psychological factors, the greater reduction in urea contributed to dialysis-associated symptoms and delayed post-dialysis recovery.

Abbreviations
CRP: C-reactive protein; NT-proBNP: N terminal pro-brain natriuretic peptide

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Availability of data and materials
Data is with Royal Free Hospital audit.

Authors' contributions
AD registered the audit. SY and KT handed out and collected the questionnaires. AD analyzed the data. All authors contributed to the first draft and approved the final draft of the manuscript.

Ethics approval and consent to participate
This retrospective audit was approved by the Royal Free Hospital and complied with the UK National Health Service (NHS) guidelines for clinical audit and service development and met with the approval from the Health Research Authority (HRA). In keeping with the UK guidelines, all patient data were anonymised prior to analysis (https://www.hra.nhs.uk).

Consent for publication
All authors agreed on the publication of this study.

Competing interests
The authors declare that they have no competing interests.

Publisher's Note

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