Associations between Hemodialysis Facility Practices to Manage Fluid Volume and Intradialytic Hypotension and Patient Outcomes

Indranil Dasgupta,[1,2] G. Neil Thomas,[2] Joanne Clarke,[2] Alice Sitch,[2,3] James Martin,[2] Brian Bieber,[4] Manfred Hecking,[5] Angelo Karaboyas,[4] Ronald Pisoni,[4] Friedrich Port,[4] Bruce Robinson,[4] and Hugh Rayner[1]

Abstract

Background and objectives Fluid overload and intradialytic hypotension are associated with cardiovascular events and mortality in patients on hemodialysis. We investigated associations between hemodialysis facility practices related to fluid volume and intradialytic hypotension and patient outcomes.

Design, setting, participants, & measurements Data were analyzed from 10,250 patients in 273 facilities across 12 countries, from phase 4 of the Dialysis Outcomes and Practice Patterns Study (DOPPS; 2009–2012). Cox regression models (shared frailty) were used to estimate associations between facility practices reported by medical directors in response to the DOPPS Medical Directors Survey and all-cause and cardiovascular mortality and hospitalization, and cardiovascular events, adjusting for country, age, sex, dialysis vintage, predialysis systolic BP, cardiovascular comorbidities, diabetes, body mass index, smoking, residual kidney function, dialysis adequacy, and vascular access type.

Results Of ten facility practices tested (chosen *a priori*), having a protocol that specifies how often to assess dry weight in most patients was associated with lower all-cause (hazard ratio [HR], 0.78; 99% confidence interval [99% CI], 0.64 to 0.94) and cardiovascular mortality (HR, 0.72; 99% CI, 0.55 to 0.95). Routine orthostatic BP measurement to assess dry weight was associated with lower all-cause hospitalization (HR, 0.86; 99% CI, 0.77 to 0.97) and cardiovascular events (HR, 0.85; 99% CI, 0.73 to 0.98). Routine use of lower dialysate temperature to limit or prevent intradialytic hypotension was associated with lower cardiovascular mortality (HR, 0.76; 99% CI, 0.58 to 0.98). Routine use of an online volume indicator to assess dry weight was associated with higher all-cause hospitalization (HR, 1.19; 99% CI, 1.02 to 1.38). Routine use of sodium modeling/profiling to limit or prevent intradialytic hypotension was associated with higher all-cause mortality (HR, 1.36; 99% CI, 1.14 to 1.63), cardiovascular mortality (HR, 1.34; 99% CI, 1.04 to 1.73), and cardiovascular events (HR, 1.21; 99% CI, 1.03 to 1.43).

Conclusions Hemodialysis facility practices relating to the management of fluid volume and intradialytic hypotension are associated with patient outcomes.

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[1]Department of Renal Medicine, Heartlands Hospital, Birmingham, UK; [2]Institute of Applied Health Research, University of Birmingham, Birmingham, UK; [3]National Institute for Health Research, Birmingham Biomedical Research Centre, University Hospitals Birmingham National Health Service Foundation Trust and University of Birmingham, Birmingham, UK; [4]Arbor Research Collaborative for Health, Ann Arbor, Michigan; and [5]Department of Internal Medicine III, Clinical Division of Nephrology and Dialysis, Medical University of Vienna, Vienna, Austria

Correspondence: Dr. Indranil Dasgupta, Heartlands Hospital, Bordesley Green East, Birmingham, B9 5SS, UK. Email: Indranil.Dasgupta@heartofengland.nhs.uk

Introduction

Adequate fluid volume management in patients on hemodialysis is important for both patient experience and outcomes. Volume overload can cause peripheral edema and breathlessness. In the long term it may lead to hypertension, left ventricular hypertrophy, and heart failure, and is associated with higher mortality (1–5). Volume depletion due to excessive fluid removal during dialysis can cause cramps, abdominal pain, vomiting, and dizziness. It can also cause intradialytic hypotension, which may result in impaired myocardial contractility and damage due to "stunning" (6). Repeated intradialytic hypotension is associated with higher mortality (7–9).

Interpreting associations between physiologic changes and outcomes at the patient level is problematic. Fluid overload may be associated with higher mortality through (*1*) cause and effect, as fluid overload may cause cardiac damage; (*2*) confounding, as sicker patients may develop fluid overload more easily; and (*3*) treatment bias, as sicker patients may be kept overloaded to maintain BP. Similarly, intradialytic hypotension may be associated with higher mortality through (*1*) cause and effect, as it may cause cardiac and brain damage; (*2*) confounding, as sicker patients may drop BP more often and to a greater extent; and (*3*) treatment bias, as sicker patients may be treated with more ultrafiltration to minimize symptoms.

Analyses of facility practices can help to distinguish between these possible interpretations. The majority of patients visit the hemodialysis facility that is geographically most convenient for them rather than for clinical reasons. Studying patient outcomes associated

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with treatment variables that operate at the facility level reduces the treatment-by-indication bias inherent in a patient-level analysis.

We hypothesized that patients in dialysis facilities that have a managed approach to fluid overload and intradialytic hypotension (where more attention is given to these potentially adverse factors) have better outcomes, after adjustment for differences between facilities in patient demographics and comorbidities.

Materials and Methods

Data Source

The Dialysis Outcomes and Practice Patterns Study (DOPPS) is a large international prospective cohort study of patients aged ≥18 years, treated with in-center hemodialysis. Detailed information regarding the study design has been reported previously (10,11). Patients on maintenance hemodialysis were randomly selected from representative national samples of randomly selected hemodialysis facilities in each country. Study approval and patient consent were obtained as required by national and local ethical regulations in each country. In this analysis, DOPPS phase 4 (2009–2012) data from 273 hemodialysis facilities in 12 countries in three regions were used: North America (Canada, United States), Europe/ANZ (Belgium, France, Germany, Italy, Spain, Sweden, United Kingdom, Australia, New Zealand), and Japan. Data on demographics and comorbid conditions (Table 1) were abstracted from medical records at study entry using uniform and standardized data collection tools. Practice patterns in relation to the management of fluid volume and intradialytic hypotension were extracted from responses to the Medical Directors Survey. Using the 29 items related to fluid management in the questionnaire (Supplemental Table 1), ten questions (Table 2) were chosen *a priori* for testing in this analysis on the basis of the investigators' judgement of the most important and commonly used practices that might affect patient outcomes. Outcome data were collected prospectively over 3 years. One exposure variable was defined from each of the ten questions as a binary variable, comparing "Yes, routinely" with "Yes, but infrequently" and "No" combined.

Table 1. Demographic details of available patients (*n*=10,898)

Patient Demographics	All Patients, *n*=10,898
Age[a], yr, median (IQR)	67 (56–76)
Sex[a]	
Women	4323 (40%)
Men	6565 (60%)
Body mass index[a], kg/m^2, median (IQR)	25 (21–29)
Smoking status[a]	
Never	3990 (49%)
Ever	4209 (51%)
Region[a]	
Australia/New Zealand	596 (6%)
Canada	645 (6%)
Europe	5701 (52%)
Japan	2260 (21%)
United States	1696 (16%)
Predialysis systolic BP[a], mm Hg, mean (SD)	142 (22)
Postdialysis systolic BP, mm Hg, mean (SD)	135 (23)
Antihypertensive prescription	8609 (79%)
Number of antihypertensive drugs, mean (SD)	2.3 (1.2)
Interdialytic weight gain, kg, median (IQR)	1.8 (1.2–2.5)
Ultrafiltration rate, L, median (IQR)	2.1 (1.4–2.9)
Kt/V[a], mean (SD)	1.46 (0.33)
Vascular access type[a]	
Native arteriovenous fistula	6831 (66%)
Synthetic graft	716 (7%)
Dialysis catheter	2766 (27%)
Dialysis vintage,[a] yr, median (IQR)	1.9 (0.4–5.4)
Comorbidities[a]	
Coronary heart disease	4168 (39%)
Congestive heart failure	2581 (24%)
Diabetes	4477 (42%)
Other cardiovascular	3364 (31%)
Cerebrovascular disease	1807 (17%)
Hyperlipidemia	5056 (47%)
Peripheral vascular disease	3236 (30%)

Values are numbers (percentages) unless specified. IQR, interquartile range.
[a]Indicates factors adjusted for in the analyses.

Statistical Analyses

We used multilevel Cox regression (shared frailty) models, which allow for the correlation of observations from patients within facilities, to estimate associations (hazard ratio [HR]) between facility practices relating to management of fluid volume and intradialytic hypotension and five outcomes: patient all-cause and cardiovascular mortality, cardiovascular events, and all-cause and cardiovascular hospitalization. Cardiovascular events comprised angina, acute myocardial infarction, cardiac arrest/sudden death, congestive heart failure, coronary angioplasty, coronary bypass graft, transient ischemic attack, stroke, and carotid endarterectomy. Cardiovascular causes of death and hospitalization were acute myocardial infarction, atherosclerotic heart disease, cardiac arrhythmia, cardiac arrest, congestive heart failure, ischemic stroke, hemorrhagic stroke, and ischemic/anoxic encephalopathy. Follow-up started at study enrollment and continued until the event of interest, death, study phase end, loss to follow-up, transplantation, switch to home dialysis, or 7 days after leaving the facility (whichever occurred first).

To acknowledge the potential for type 1 error because of multiple comparisons, 99% confidence intervals (99% CIs) were used rather than the standard 95% confidence intervals. All facility practices listed in Table 2 were included as covariates in each of the models and analyses were further adjusted for country and individual-level characteristics reported at study enrollment: age, sex, country, mean predialysis systolic BP (from three readings over 1 week), dialysis vintage, smoking status, body mass index, residual kidney function (assessed by urine volume >200 ml/d recorded in the patient record), vascular access type in use, single-pool Kt/V, and comorbidities (coronary heart disease, congestive heart failure, cerebrovascular disease, other cardiovascular disease, hyperlipidemia, peripheral vascular disease, and diabetes). Adjustment for

Table 2. Dialysis facility characteristics and practices related to fluid volume management and intradialytic hypotension (IDH) by region

Dialysis Facility Characteristics and Practices	All Facilities, *n*=273	Australia/ New Zealand, *n*=14	Canada, *n*=18	Europe, *n*=120	Japan, *n*=58	United States, *n*=63
Number of patients per facility	67 [45–96]	52 [36–64]	87 [44–160]	72 [52–91]	77 [47–127]	46 [29–76]
Patient-to-doctor ratio	19 [11–27]	8 [5–18]	22 [9–29]	21 [14–27]	25 [12–34]	15 [9–22]
Patient-to-nurse ratio	4 [3–6]	4 [3–4]	3 [3–3]	4 [3–5]	6 [4–7]	6 [4–10]
For-profit facility	76 (28%)	10 (7%)	0 (0%)	36 (30%)	17 (30%)	23 (37%)
Fluid volume management						
Protocol that specifies how often to assess dry weight in most patients	67 (25%)	4 (29%)	1 (6%)	28 (23%)	26 (46%)	8 (13%)
Routine orthostatic BP measurement to assess dry weight	157 (58%)	11 (79%)	14 (78%)	55 (46%)	29 (51%)	48 (76%)
Routine online volume indicator to assess dry weight	57 (21%)	2 (15%)	6 (33%)	35 (30%)	3 (5%)	11 (18%)
Routine bioimpedance study to assess dry weight	13 (5%)	0 (0%)	0 (0%)	11 (9%)	1 (2%)	1 (2%)
Routine online volume indicator AND bioimpedance study	6 (2%)	0 (0%)	0 (0%)	5 (4%)	0 (0%)	1 (2%)
Policy that limits fluid removal during dialysis session	93 (35%)	6 (43%)	5 (28%)	44 (37%)	20 (36%)	18 (29%)
Performs isolated ultrafiltration	192 (73%)	9 (69%)	14 (82%)	95 (80%)	32 (56%)	42 (71%)
Management of intradialytic hypotension						
Protocol for managing IDH	128 (50%)	8 (57%)	10 (56%)	48 (45%)	23 (40%)	39 (66%)
Routine sodium modeling/profiling to limit or prevent IDH	118 (43%)	1 (7%)	16 (89%)	53 (44%)	5 (9%)	43 (68%)
Routine lower dialysate temperature to limit or prevent IDH	128 (47%)	6 (46%)	14 (78%)	73 (61%)	6 (11%)	29 (46%)

Values are median [interquartile range] and numbers (percentages).

interdialytic weight gain was not considered appropriate because it is a potential mediator of the practice patterns of interest on patient outcomes.

Multiple imputation was performed using chained equations with five multiple imputed data sets generated. This method was used to replace missing covariate data, assuming data were missing at random. Outcome data were not imputed. The proportion of missing data imputed was 28% for Kt/V, 25% for smoking status, and <9% for all other covariates. All analyses were conducted using Stata version 15.

Results

Data from 10,898 patients were available (Table 1) and between 10,086 and 10,250 patients were included in the modeling analyses after excluding patients with missing data for each analysis. Table 2 shows the dialysis facility characteristics. Supplemental Table 2 compares characteristics and facility practices between those facilities that answered "Yes" to the question "Is there a protocol in your unit that specifies how often to assess dry weight in most patients?" and those that answered "No, done as clinically indicated." Median (interquartile range) follow-up time was 1.4 (0.7–2.5) years for all-cause and cardiovascular mortality, 1.2 (0.5–2.2) years for cardiovascular events, and 0.62 (0.3–1.4) years for all-cause hospitalization.

Twenty-five percent of medical directors reported having a protocol in their dialysis unit that specified how often to assess dry weight in most patients. In the others, dry weight was assessed only as clinically indicated. Orthostatic BP measurement was routinely used in assessing dry weight in 58% of units. An online volume indicator and bioimpedance study were routinely used in 21% and 5% of units, respectively.

Sodium modeling/profiling and lower dialysate temperature were routinely used to limit or prevent intradialytic hypotension for patients prone to intradialytic hypotension in 43% and 47% of units, respectively.

Associations were found between patient outcomes and a number of the facility practices tested, following adjustment as described in the "Materials and Methods" section (Figures 1–5). Having a protocol that specifies how often to assess dry weight in most patients in the facility, as against assessing dry weight only when clinically indicated, was associated with lower risk of all-cause mortality (HR, 0.78; 99% CI, 0.64 to 0.94). Routine use of sodium modeling/profiling to limit or prevent intradialytic hypotension was associated with higher risk of all-cause mortality (HR, 1.36; 99% CI, 1.14 to 1.63).

Having a protocol that specifies how often to assess dry weight in most patients in the facility and the routine use of lower dialysate temperature to limit or prevent intradialytic hypotension were both associated with lower risk of cardiovascular mortality (HR, 0.72; 99% CI, 0.55 to 0.95 and HR, 0.76; 99% CI, 0.58 to 0.98 respectively). Routine use of sodium modeling/profiling to limit or prevent

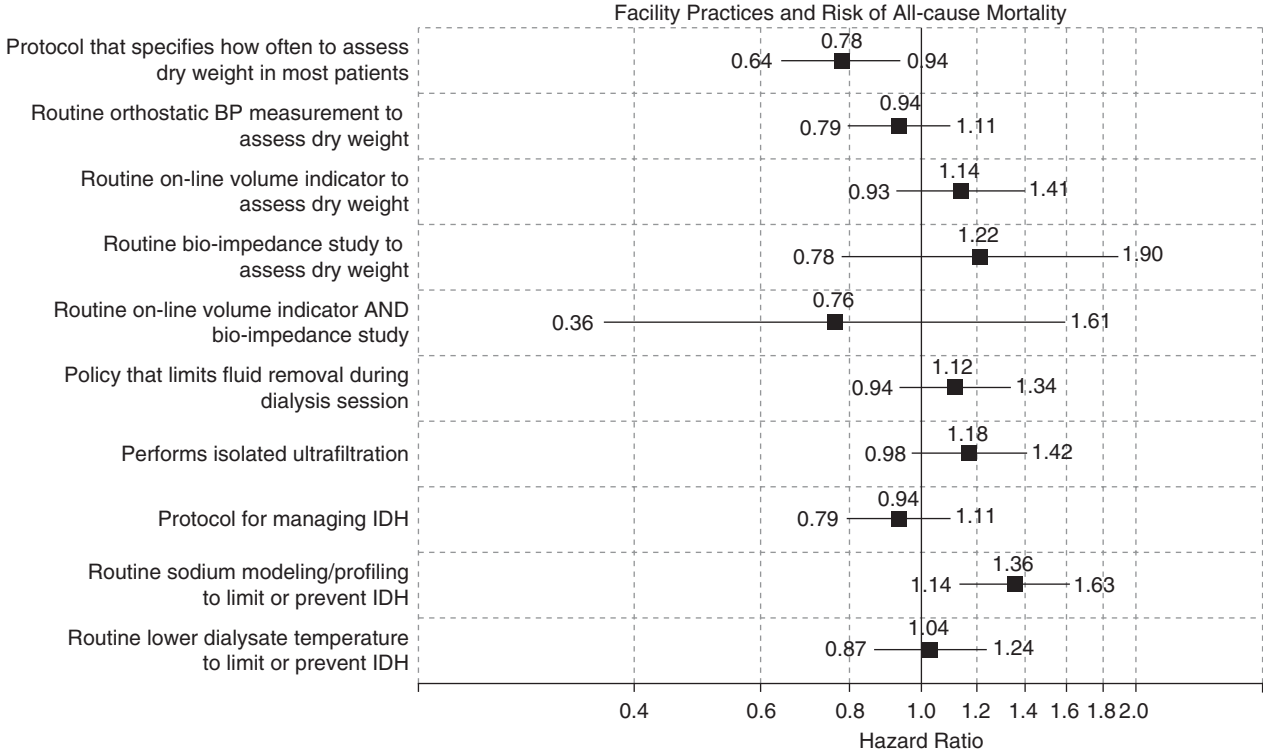

Figure 1. | **Associations between facility practices and risk of all-cause mortality (HR and 99% CI, *n*=10,250).** Data from patients after multiple imputation for missing data, adjusted for age, sex, country, mean predialysis systolic BP, vintage, smoking status, body mass index, kidney function, vascular access type, and single-pool Kt/V, comorbidities (coronary heart disease, congestive heart failure, other cardiovascular, cerebrovascular disease, hyperlipidemia, peripheral vascular disease, and diabetes). IDH, intradialytic hypotension.

intradialytic hypotension was associated with higher risk of cardiovascular mortality (HR, 1.34; 99% CI, 1.04 to 1.73).

Routine use of orthostatic BP measurement to assess dry weight was associated with lower risk of cardiovascular events (HR, 0.85; 99% CI, 0.73 to 0.98). Routine use of sodium modeling/profiling to limit or prevent intradialytic hypotension was associated with higher risk of cardiovascular events (HR, 1.21; 99% CI, 1.03 to 1.43).

Routine use of orthostatic BP measurement to assess dry weight was associated with lower risk of all-cause hospitalization (HR, 0.86; 99% CI, 0.77 to 0.97) and cardiovascular hospitalization (HR, 0.86; 99% CI, 0.71 to 1.03; *P*=0.03). Routine use of an online volume indicator to assess dry weight was associated with higher risk of all-cause hospitalization (HR, 1.19; 99% CI, 1.02 to 1.38).

The practices of using bioimpedance spectroscopy, a limit to fluid removal during dialysis, isolated ultrafiltration, and having a protocol for managing intradialytic hypotension were not associated with patient outcomes. A sensitivity analysis without adjusting for urine volume provided similar results.

Discussion

This analysis of international DOPPS data shows that certain practices relating to the management of fluid volume and intradialytic hypotension are associated with both better and worse patient outcomes. Having a protocol that specifies how often to assess dry weight in most patients in the facility was associated with lower risk of all-cause and cardiovascular mortality; routine use of orthostatic BP measurement to assess dry weight was associated with lower risk of hospitalization and cardiovascular events; and the routine use of lower dialysate temperature to limit or prevent intradialytic hypotension was associated with lower risk of cardiovascular mortality. Conversely, routine use of an online volume indicator to assess dry weight was associated with higher risk of hospitalization and routine use of sodium modeling/profiling to limit or prevent intradialytic hypotension was associated with higher risk of cardiovascular events and mortality.

Patients on hemodialysis have a high risk of cardiovascular disease and mortality that is not explained fully by traditional and nontraditional risk factors, nor mitigated significantly by their treatment (12–19). Hence attention has shifted to fluid volume management (20,21) and there is a body of mostly observational evidence suggesting that inadequate management of fluid volume is associated with higher mortality (1–5,22,23), substantiated by two small randomized trials (24,25).

The management of fluid volume varies widely between dialysis facilities. A survey of hemodialysis centers in the United Kingdom found that only 22% of centers had a policy for fluid volume management and 56% routinely assessed patients' fluid status (26). There was no significant association between having a written fluid management policy, regular fluid status assessment, or using a blood volume monitor or bioimpedance device, and outcomes.

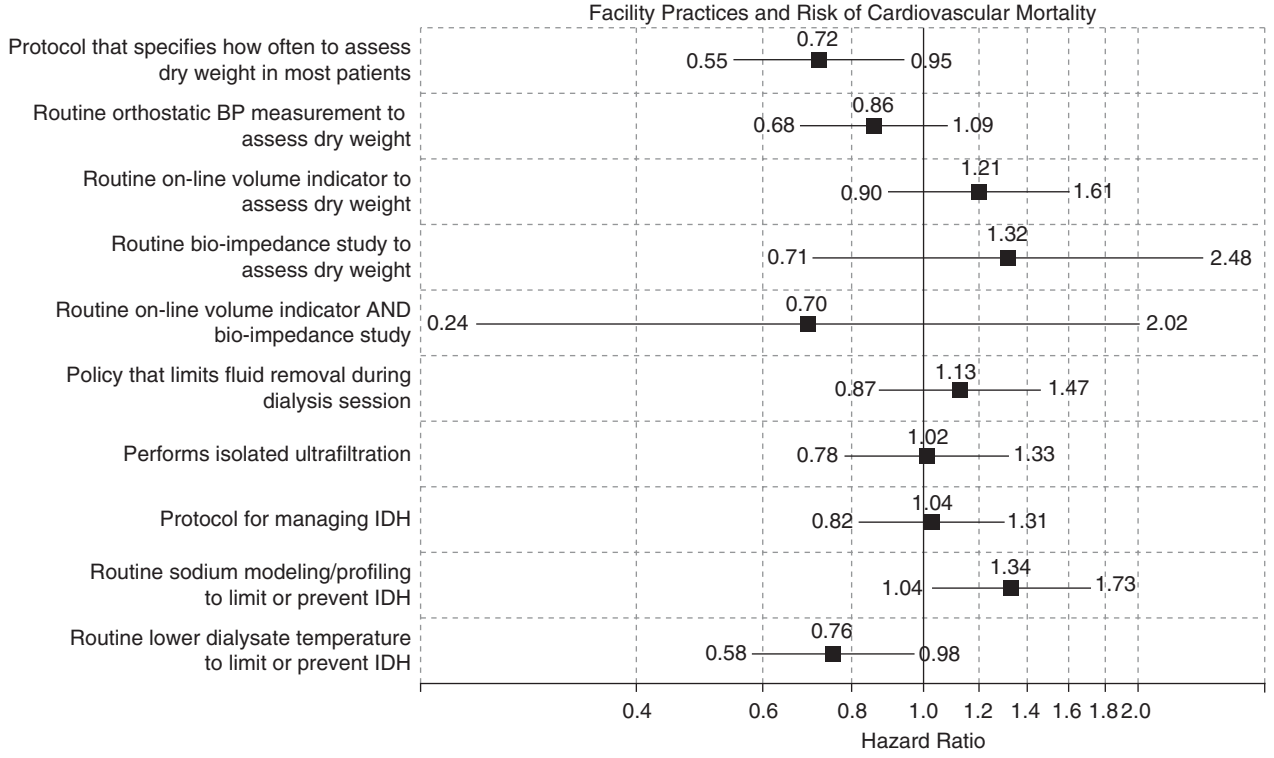

Figure 2. | **Associations between facility practices and risk of cardiovascular mortality (HR and 99% CI, *n*=10,250).** Data from patients after multiple imputation for missing data, adjusted for age, sex, country, mean predialysis systolic BP, vintage, smoking status, body mass index, kidney function, vascular access type, single-pool Kt/V, and comorbidities (coronary heart disease, congestive heart failure, other cardiovascular, cerebrovascular disease, hyperlipidemia, peripheral vascular disease, and diabetes). IDH, intradialytic hypotension.

However, the 22% of centers that measured residual kidney function or interdialytic urine volume had significantly higher 1-year survival in both incident and prevalent patients on hemodialysis. This prior study was not able to adjust for differences in patient demographics or comorbidities.

Our results emphasize the importance of clinical assessment of dry or target weight. A recent study showed that patients who repeatedly failed to achieve their prescribed target weight (>1 kg, ≥30% dialysis sessions versus <30%) had 47% higher risk of all-cause hospitalization over 30 days (27). Two small, randomized trials have demonstrated a benefit of strict fluid volume management. Hur *et al.* (24) found reduction in left ventricular mass, left atrial volume, BP, and arterial stiffness in patients randomized to strict fluid management. Onofriescu *et al.* (25) found lower all-cause mortality in patients randomized to bioimpedance-guided fluid removal (HR, 0.1; 95% confidence interval, 0.01 to 0.81). After 2.5 years, there was a greater reduction in arterial stiffness, relative fluid overload, and systolic BP.

Intradialytic hypotension is present in 20%–30% of hemodialysis sessions (28). As well as affecting patient's experience, it is associated with a higher risk of vascular access thrombosis, mesenteric ischemia, cardiovascular events, hospital admission, and mortality (29–33). Although a number of interventions reduce the number and severity of episodes of hypotension, evidence of beneficial effects on long-term outcomes is lacking (28,34). In this study, use of lower temperature dialysate to limit or prevent intradialytic hypotension was associated with a 24% lower risk of cardiovascular mortality. Lower temperature hemodialysis abrogates poor coronary perfusion associated with intradialytic hypotension and reduces myocardial stunning (35,36). Furthermore, in a randomized trial, lower temperature dialysis reduced white matter changes in the brain (37).

Conversely, use of sodium modeling or profiling to limit or prevent intradialytic hypotension was associated with a 36% higher risk of all-cause mortality, 34% higher risk of cardiovascular death, and 21% higher risk of cardiovascular events. Sodium profiling involves sodium loading at the start of the dialysis treatment and a net gain in sodium overall, leading to hypertension and increased interdialytic weight gain (38). High interdialytic weight gain is associated with fluid overload-related hospitalization, cardiovascular events, and mortality (39).

The finding that patients in facilities that routinely used an online volume indicator to assess dry weight had an 18% higher risk of hospitalization is consistent with the results of a randomized trial of the Crit-Line device (40). In this trial, as well as an increase in mortality, nonvascular access–related hospitalization was increased by 61%, although the authors point to an abnormally low rate of hospitalization in the conventionally treated group. Another randomized controlled trial (41) showed that relative blood volume control did not reduce the frequency of symptomatic intradialytic hypotension in a selected group

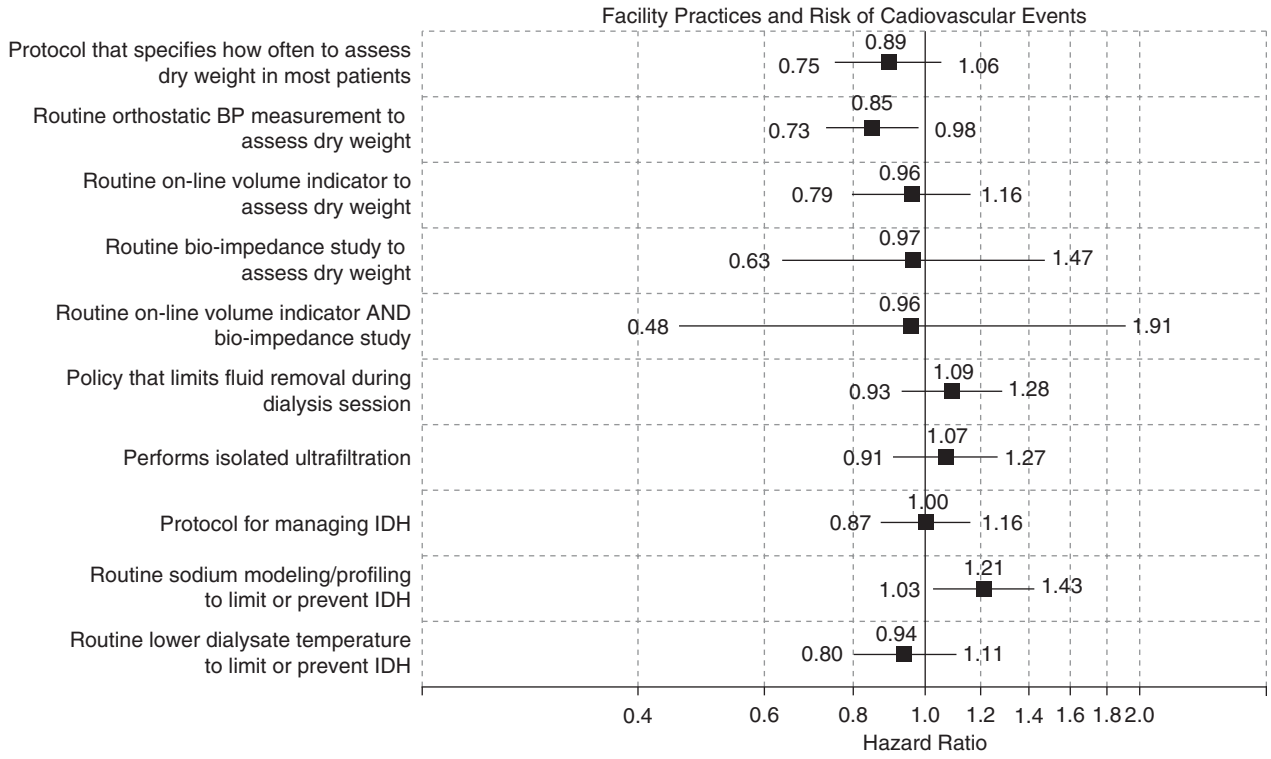

Figure 3. | **Associations between facility practices and risk of cardiovascular events (HR and 99% CI, *n*=10,110).** Data from patients after multiple imputation for missing data, adjusted for age, sex, country, mean predialysis systolic BP, vintage, smoking status, body mass index, kidney function, vascular access type, single-pool Kt/V, and comorbidities (coronary heart disease, congestive heart failure, other cardiovascular, cerebrovascular disease, hyperlipidemia, peripheral vascular disease, and diabetes). IDH, intradialytic hypotension.

of extremely hypotension-prone patients. A recent observational study found that specific hourly intradialytic relative blood volume ranges are associated with lower all-cause mortality (42). It is unclear whether the DOPPS facilities that used an online volume indicator did so as a diagnostic tool for fluid overload or in relative blood volume–controlled feedback of the ultrafiltration rate, so-called "blood volume monitoring" (43).

Our analyses included adjustment for mean predialysis systolic BP, suggesting that improved outcomes associated with practices related to the assessment of dry weight may not be mediated through improved BP control.

Having a protocol that specifies how often to assess dry weight in most patients and using orthostatic BP to assess dry weight might be indicators of more careful attention being paid to patients' fluid status, over and above the delivery of routine dialysis care. Lower temperature dialysate and sodium profiling may both be used in units that pay particular attention to the management of intradialytic hypotension (Supplemental Table 2). The fact that these two practices are associated with beneficial and adverse outcomes respectively suggests that the associations we have found are not nonspecific center effects that relate to generally more attentive care.

Practices related to the management of interdialytic weight gain, such as a policy to limit the volume of fluid removed during a dialysis session (suggesting an ultrafiltration rate threshold) and the use of isolated ultrafiltration, were not found to be associated with patient outcomes. A recent analysis has found that lower rather than higher interdialytic weight gain is associated with worse patient outcomes when adjusted for fluid overload measured by bioimpedance spectroscopy (5). Only 5% of facilities in this study used a bioimpedance device to assess dry weight, limiting the statistical power of this analysis.

There are some limitations of this study. Practices surveyed, *i.e.*, the covariates used in the analysis, were on the basis of the medical director's response to a questionnaire and it was not possible to establish the extent to which these practices were followed or their detailed design. For example, the routine and individualized temperature of dialysate used in facilities was not collected. Fluid-related hospitalization data were not available. There was no definition of intradialytic hypotension in the questionnaire. This study uses DOPPS phase 4 (2009–2012) data; the definition of intradialytic hypotension has become clearer since then (8). Confounding by other practices that were not studied cannot be excluded and causation cannot be implied from the associations.

The analysis was adjusted extensively for patient risk factors that may affect the comparisons of patient outcomes between facilities. We performed sensitivity analyses without adjusting for urine volume and found that results were consistent. We were not able to account for any effect of changes in practice patterns over time. We used the first hospitalization as an outcome rather than total hospitalization burden. Because first hospitalization increases the likelihood of a second hospital admission, the

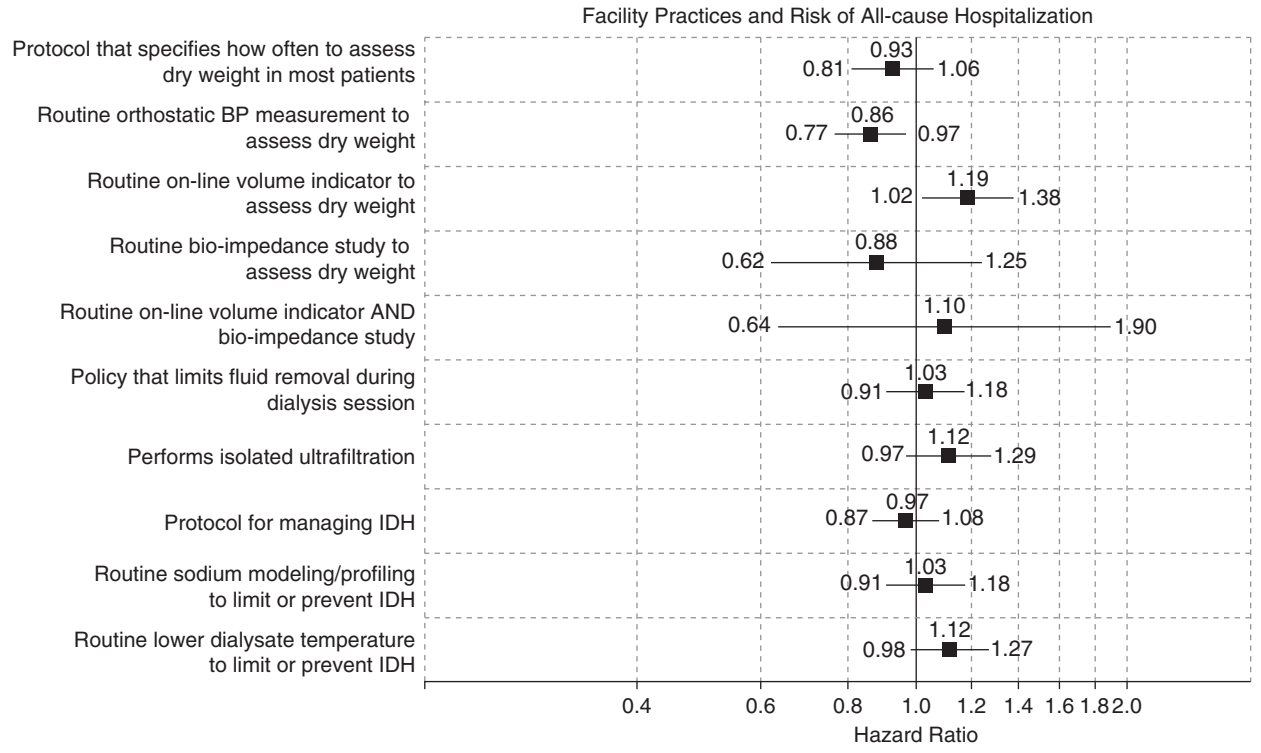

Figure 4. | **Associations between facility practices and risk of all-cause hospitalization (HR and 99% CI, *n*=10,086).** Data from patients after multiple imputation for missing data, adjusted for age, sex, country, mean predialysis systolic BP, vintage, smoking status, body mass index, kidney function, vascular access type, single-pool Kt/V, and comorbidities (coronary heart disease, congestive heart failure, other cardiovascular, cerebrovascular disease, hyperlipidemia, peripheral vascular disease, and diabetes). IDH, intradialytic hypotension.

second admission may have a different likelihood and be somewhat biased.

This study has a number of strengths. The nationally representative sample makes the results generalisable to the population of patients on in-center hemodialysis in each country. Multiple imputation was used to replace missing data and the large sample size provides sufficient statistical power to detect weak-to-moderate associations (44).

The associations we have found are consistent with interventional studies using surrogate patient outcomes. That the worse outcomes associated with blood volume monitoring have also been found in a randomized, clinical trial (41) supports the suggestion that the associations may be causal.

In summary, some hemodialysis facility practices related to the management of fluid volume overload and intradialytic hypotension are associated with patient outcomes. The results emphasize the importance of regular and careful clinical assessment of target weight and fluid balance. Those practices that are associated with improved outcomes merit further investigation to define the features that are likely to be beneficial and then study in adequately powered, randomized, clinical trials.

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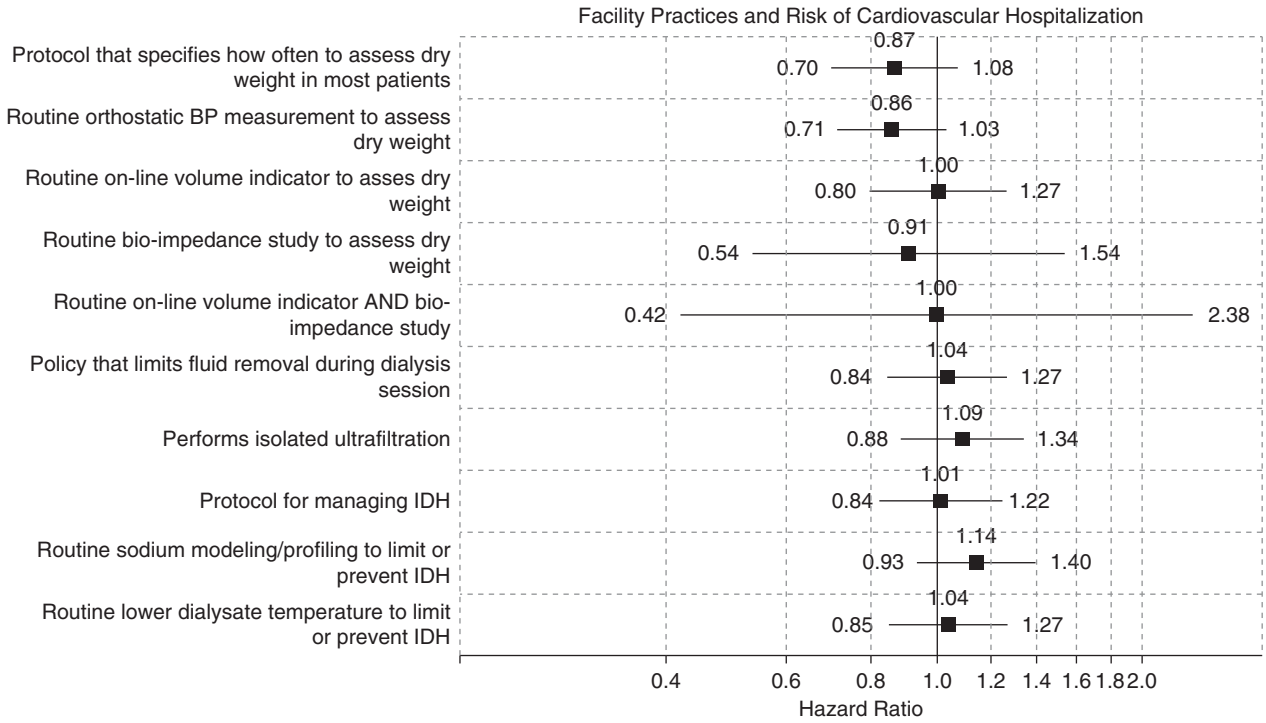

Figure 5. | **Associations between facility practices and risk of cardiovascular hospitalization (HR and 99% CI, *n*=10,086).** Data from patients after multiple imputation for missing data, adjusted for age, sex, country, mean predialysis systolic BP, vintage, smoking status, body mass index, kidney function, vascular access type, single-pool Kt/V, and comorbidities (coronary heart disease, congestive heart failure, other cardiovascular, cerebrovascular disease, hyperlipidemia, peripheral vascular disease, and diabetes). IDH, intradialytic hypotension.

The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

Disclosures

M.H. received financial remuneration for two lectures and chairing a symposium from Fresenius Medical Care during the years 2017–2018. All other authors have nothing to declare.

Supplemental Material

This article contains the following supplemental material online at http://cjasn.asnjournals.org/lookup/suppl/doi:10.2215/CJN.08240718/-/DCSupplemental.

Supplemental Table 1. List of questions related to volume management included in the Medical Director Survey.

Supplemental Table 2. Comparison of characteristics and facility practices between those facilities that answered "Yes" to the question "Is there a protocol in your unit that specifies how often to assess dry weight in most patients?" and those that answered "No, done as clinically indicated."

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