Disentangling the Ultrafiltration Rate–Mortality Association: The Respective Roles of Session Length and Weight Gain

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Summary

Background and objectives Rapid ultrafiltration rate is associated with increased mortality among hemodialysis patients. Ultrafiltration rates are determined by interdialytic weight gain and session length. Although both interdialytic weight gain and session length have been linked to mortality, the relationship of each to mortality, independent of the other, is not adequately defined. This study was designed to evaluate whether shorter session length independent of weight gain and larger weight gain independent of session length are associated with increased mortality.

Design, setting, participants, & measurements Data were taken from a national cohort of 14,643 prevalent, thrice-weekly, in-center hemodialysis patients dialyzing from 2005 to 2009 (median survival time, 25 months) at a single dialysis organization. Patients with adequate urea clearance and delivered dialysis session ≥240 and <240 minutes were pair-matched on interdialytic weight gain (n=1794), and patients with weight gain ≤3 and >3 kg were pair-matched on session length (n=2114); mortality associations were estimated separately.

Results Compared with delivered session length ≥240, session length <240 minutes was associated with increased all-cause mortality (adjusted hazard ratio [95% confidence interval], 1.32 [1.03 to 1.69]). Compared with weight gain ≤3, weight gain >3 kg was associated with increased mortality (1.29 [1.01 to 1.65]). The associations were consistent across strata of age, sex, weight, and weight gain and session length. Secondary analyses demonstrated dose-response relationships between both and mortality.

Conclusions Among patients with adequate urea clearance, shorter dialysis session length and greater interdialytic weight gain are associated with increased mortality; thus, both are viable targets for directed intervention.

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Introduction

Hemodialysis patients experience exceptionally poor survival compared with the general population (1,2). Available evidence indicates that rapid fluid removal during dialysis may contribute to all-cause and cardiovascular mortality in this population (3–6). Ultrafiltration rate (UFR) is determined by both the amount of fluid removed, which at steady state is equivalent to interdialytic weight gain (IDWG), and the time over which this fluid is removed (dialysis session length [DSL]). Prior studies have demonstrated that both shorter DSL and larger IDWG (both of which would increase UFR) are associated with increased mortality (3,7–14). However, because DSL and IDWG are highly inter-related, it is unclear whether the association of each with mortality is independent of the other. Although it is plausible that both DSL and IDWG influence mortality, it is also possible that only one is independently associated with mortality and the other only through implied relationship with the first.

Better delineating the independent associations of DSL and IDWG with survival bears important therapeutic consequence. For example, if DSL influences mortality independently of IDWG, extending the length of dialysis treatments would be advisable. Conversely, if DSL does not influence mortality independently of IDWG, extending treatment times would not add benefit, but merely add to cost and potential patient dissatisfaction. Prior studies have attempted to disentangle the independent associations of DSL and IDWG by multivariable adjustment (3,5,14). However, multivariable adjustment may incompletely control for confounding when the confounder (*e.g.*, IDWG) is highly imbalanced across exposure groups (*e.g.*, longer versus shorter DSL) such that limited overlap exists.

Dedicated analytic techniques such as matching, however, do enable disentanglement of independent associations even when exposures are highly correlated. For example, our group recently demonstrated that shorter DSL is associated with increased

mortality independently of body weight by matching patients with longer versus shorter prescribed DSL (<240 versus ≥240 minutes) on postdialysis weight (for which there was limited overlap) as well as on age, vascular access type, and sex (14).

We undertook this study to better delineate the association between greater UFR and mortality by testing the hypotheses that shorter DSL is associated with greater mortality independent of IDWG, and that greater IDWG is associated with greater mortality independent of DSL. We used data from a large, nationally representative cohort of prevalent patients who received in-center, thrice-weekly maintenance hemodialysis and who had adequate urea clearance by contemporary standards. To tightly control for confounding, participants were matched on IDWG in analyses of DSL, DSL in analyses of IDWG, and on other key covariates (sex, age, vascular access type, and postdialysis weight) in all analyses.

Materials and Methods

Study Design

This study was approved by the Partners Health Care Institutional Review Board. All study data were obtained from a cohort of 14,643 randomly selected prevalent adult patients receiving thrice-weekly, in-center hemodialysis at one large dialysis organization. Patients entered the cohort between January 1, 2005 and January 16, 2009 and dialyzed at one of 1247 outpatient facilities located in diverse geographic regions across the United States.

We sought to estimate the influence of DSL and IDWG on survival in the context where there was no compelling indication to extend DSL on the basis of urea removal; therefore, we excluded patients with urea reduction ratio (URR) <65%. (URR was chosen over Kt/V for this purpose to limit collinearity with DSL.) Delivered DSL was selected over prescribed DSL as the exposure of interest because it is more directly germane to UFR. To bear greatest relevance to the broader US dialysis population, we excluded patients with delivered DSL <150 or >270 minutes. In analyses of the delivered DSL–mortality association, we further excluded patients dialyzing at facilities without at least one participant in each DSL category, so as to avoid center effect bias derived through deterministic DSL. In analyses of the IDWG–mortality association, we excluded patients with mean IDWG <0 kg, because such patients are not representative of the broader population.

Data Collection

All study data were obtained from the large dialysis organization's comprehensive electronic medical record and collected according to the organization's standard clinical protocols. Demographic details were recorded by unit personnel upon admission to one of the organization's facilities. Treating nephrologists ascertained comorbidity data through patient interview, examination, and medical record review and updated data based on clinical course. Laboratory parameters were measured upon large dialysis organization entry and then on a biweekly or monthly basis. Dialytic session data, including delivered DSL and predialysis and postdialysis weights, were recorded on a session-by-session basis per the organization's standard clinical protocol. Predialysis and postdialysis weights and BP were measured immediately preceding and after each dialysis treatment; BP was measured in the seated position. IDWG was defined as predialysis weight (in kilograms) – postdialysis weight from the previous session (in kilograms). Date of death and attributed cause of death were recorded in the medical record by dialysis unit staff.

Time Sequence and Designation of Exposures and Outcome

The exposures of interest, delivered DSL and IDWG, were considered as the means of (typically 12) values over the 30-day period after cohort entry. Thirty-day mean delivered DSL demonstrated excellent correlation with 60-day (r=0.95) and 90-day means (r=0.93), and 30-day mean IDWG demonstrated strong correlation with 60-day (r=0.70) and 90-day means (r=0.60). Therefore, a 30-day exposure assessment period was chosen to minimize survivor bias.

Covariate data for demographic characteristics (age, sex, race, vascular access type, and dialytic vintage) and comorbidities (diabetes, coronary artery disease, and congestive heart failure) were considered as of cohort entry. Biochemical covariates (URR, albumin, creatinine, and phosphate) were considered as the last value measured during the 30-day exposure assessment period. Predialysis systolic BP was considered as the mean value over the 30-day exposure window.

The outcome of interest was death from any cause. Cause-specific mortality was not considered due to missingness and untested validity of attributed cause of death data. Patients were considered at-risk for outcome on day 31 after cohort entry (*i.e.*, immediately after the exposure/covariate assessment period) and remained at-risk until death or censoring for the following: transfer of care, transplant, change in dialytic modality, renal function recovery, or end of study (February 21, 2009). Patients failing to maintain large dialysis organization enrollment during the 30-day exposure period were excluded. Given varying cohort entry times, maximal potential follow-up time was 48.7 months.

Statistical Analyses

The delivered DSL–mortality and IDWG–mortality associations were considered in parallel analyses. In the primary analysis, DSL and IDWG were considered as dichotomous variables (<240 versus ≥240 minutes and ≤3 versus >3 kg), because we considered these clinically relevant cut-points. In secondary analyses, IDWG dichotomization cut-points were varied (≤2.5 versus >2.5 kg, ≤3.5 versus >3.5 kg, and ≤4.0 versus >4.0 kg). Baseline participant characteristics were described across exposure groups as counts and proportions for categorical variables and as means and SDs for continuous variables. Bivariable comparisons were made using contingency table methods and chi-squared testing, t tests, or ANOVA, as dictated by data type.

In the DSL–mortality analysis, patients delivered DSL <240 versus ≥240 minutes were matched 1:1 on the basis of age (±2.5 years), sex (identical), vascular access type (identical), postdialysis weight (nearest neighbor with

caliper width not exceeding +1.5 kg), and IDWG (+0.25 kg). Similarly, in the IDWG–mortality analysis, patients with IDWG ≤3 versus >3 kg were matched 1:1 on the basis of age (+2.5 years), sex (identical), vascular access type (identical), postdialysis weight (nearest neighbor with caliper width not exceeding +1.5 kg), and delivered DSL (rounded to the nearest 5-minute increment). The postdialysis weight caliper width of 1.5 kg was empirically selected based on a balance of minimizing weight differences between matched pair members and achieving adequate successful pair matches for power considerations; this was done without consideration of outcome. All survival analyses were then stratified on matched pair assignment. Adjusted associations were estimated using multivariable Cox proportional hazards models with inclusion of covariate terms for other variables plausibly associated with both exposure and outcome; this included terms for age and postdialysis weight (and in DSL–mortality analyses, IDWG) to account for residual imbalance despite matching. Kt/V was excluded from the primary DSL–mortality analysis because it represented a plausible pathway intermediate, and because it introduced collinearity into the model. Sensitivity analyses with its inclusion yielded near identical estimates (data not shown). Specification of continuous covariates (linear versus categorical) was guided by each covariate's observed association with outcome as assessed by regression coefficient graphical evaluation, Akaike's information criterion, and Martingale residual plots. The proportionality assumption for each model was tested graphically and by Schoenfeld residual testing (no variables were in violation).

Effect modification of the DSL–mortality and IDWG–mortality associations on the basis of age, sex, and postdialysis weight and IDWG and delivered DSL was explored through restriction subgroup analysis; for these analyses, age, postdialysis weight, IDWG, and DSL were dichotomized at their medians. Significance of interaction was assessed by likelihood ratio testing of nested models that did and did not include two-way cross product terms (factor by exposure). All analyses were performed using Stata/MP software (release 10; StataCorp LP, College Station, TX).

Results

Baseline Characteristics of Cohorts

Characteristics of patients in the source cohort are presented in Table 1. Compared with patients with DSL ≥240 minutes, those with DSL <240 minutes were older, had lower mean IDWGs and postdialysis weights, were more likely to be women, and were less likely to have diabetes, coronary artery disease, and congestive heart failure. Compared with patients with IDWG ≤3 kg, those with IDWG >3 kg were younger, had higher mean DSLs, postdialysis weights, and predialysis systolic BPs, and were more likely to be men, black, and have diabetes and congestive heart failure.

Primary Analyses

In the primary analysis of delivered DSL–mortality, 897 patients with DSL <240 minutes were pair-matched to 1 control with DSL ≥240 minutes (38.5% of eligible patients with DSL ≥240 minutes were successfully matched). The matched pairs demonstrated excellent balance across all matching factors including IDWG (Table 2 and Supplemental Figure 1).

Overall, 567 deaths occurred during 4362 patient-years of at-risk time. The median survival time was 25.0 months. Compared with delivered DSL ≥240 minutes, DSL <240 minutes was significantly associated with increased mortality (adjusted hazard ratio [HR], 1.32; 95% confidence interval [95% CI], 1.03 to 1.69; P=0.03) (Figure 1). The estimates were consistent across strata of age (interaction P=0.92 for <65 versus ≥65 years), sex (interaction P=0.46), postdialysis weight (interaction P=0.28 for <75 versus ≥75 kg), IDWG (interaction P=0.56 for ≤2.8 versus >2.8 kg), and among patients who did and did not miss ≥1 dialysis sessions during the exposure assessment period (interaction P=0.15).

In the primary analysis of IDWG–mortality, 1057 patients with IDWG >3 kg (25.9% of those eligible) were successfully pair-matched to one control with IDWG ≤3 kg. The matched pairs were well balanced across all matching factors including delivered DSL (Table 2 and Supplemental Figure 2).

Overall, 646 deaths occurred during 5087 patient-years of at-risk time. The median survival time was 25.0 months. Compared with IDWG ≤3 kg, IDWG >3 kg was significantly associated with increased mortality (adjusted HR, 1.29; 95% CI, 1.01 to 1.65; P=0.04) (Figure 1). Similar estimates were observed across strata of age (interaction P=0.33 for <65 versus ≥65 years), sex (interaction P=0.24), postdialysis weight (interaction P=0.86 <75 versus ≥75 kg), delivered DSL (interaction P=0.17 for ≤215 versus >215 minutes), and among patients who did and did not miss ≥1 dialysis sessions during the exposure assessment period (interaction P=0.42).

Secondary Analyses

To examine for a dose-response relationship in the delivered DSL–mortality association, we calculated the difference in DSL between matched pair members and categorized pairs by tertile of DSL difference. The association between DSL ≥240 and <240 minutes and mortality was then estimated within each tertile. The magnitude of the association between delivered DSL <240 minutes (referent to DSL ≥240) and mortality was incrementally larger when DSL differences between matched pair members were greater (Figure 2).

An analogous secondary analysis was performed stratifying matched IDWG pairs on the difference in IDWG between pair members. The magnitude of the association between higher (versus lower) IDWG was incrementally larger when differences in IDWG were greater (Figure 2). To further evaluate for a dose-response trend in the IDWG–mortality association, we compared the association between high (versus low) IDWG varying the threshold value used to distinguish low and high IDWG (≤2.5 and >2.5 kg, ≤3.5 and >3.5 kg, and ≤4.0 and >4.0 kg). As the threshold for categorization was increased, the magnitude of the association between high IDWG and mortality was larger (Table 3).

Table 1. Comparison of baseline characteristics between delivered DSL <240 versus □240 minutes and IDWG □3 versus >3 kg within respective (unmatched) source cohorts

Characteristics	Delivered DSL <240 min (*n*=7098)	Delivered DSL ≥240 min (*n*=2327)	*P*	IDWG ≤3 kg (*n*=7758)	IDWG >3 kg (*n*=4076)	*P*
Delivered DSL (min)			—			<0.001
Mean + SD	206.9+20.4	246.9+8.3		208.4+24.3	224.2+22.8	
Median	210.0	243.3		210.0	227.4	
IQR	[190.0, 223.4]	[240.6, 250.8]		[185.5, 228.0]	[209.7, 240.6]	
IDWG (kg)			<0.001			—
Mean + SD	2.5+1.0	3.2+1.2		2.0+0.6	3.8+0.7	
Median	2.4	3.1		2.1	3.7	
IQR	[1.8, 3.1]	[2.3, 4.0]		[1.6, 2.5]	[3.3, 4.2]	
IDWG (% of body weight)[a]			<0.001			<0.001
Mean + SD	3.6+1.5	3.8+1.4		3.0+1.1	4.8+1.2	
Median	3.5	3.7		3.0	4.7	
IQR	[2.6, 4.5]	[2.8, 4.6]		[2.2, 3.7]	[4.0, 5.5]	
Age (yr)	62.9+15.3	60.1+13.5	<0.001	65.4+14.8	57.2+13.9	<0.001
Female sex	3822 (53.9)	719 (30.9)	<0.001	4325 (55.7)	1465 (35.9)	<0.001
Access			0.002			<0.001
Fistula	2634 (37.1)	933 (40.1)		2544 (32.8)	1827 (44.8)	
Graft	2323 (32.7)	668 (28.7)		2391 (30.8)	1390 (34.1)	
Catheter	2074 (29.2)	708 (30.4)		2761 (35.6)	819 (20.1)	
Missing	67 (0.9)	18 (0.8)		64 (0.8)	40 (1.0)	
Postdialysis weight (kg)	71.4+17.3	86.2+20.9	<0.001	69.8+16.6	83.6+20.3	<0.001
Race			<0.001			<0.001
White	4343 (61.2)	1275 (54.8)		4857 (62.6)	2405 (59.0)	
Black	2714 (38.2)	1037 (44.6)		2852 (36.8)	1656 (40.6)	
Missing	42 (0.6)	15 (0.6)		51 (0.7)	15 (0.4)	
Diabetes	3635 (51.2)	1355 (58.2)	<0.001	3870 (49.9)	2334 (57.3)	<0.001
Coronary artery disease	825 (11.6)	332 (14.3)	0.001	907 (11.7)	532 (13.1)	0.03
Congestive heart failure	2589 (36.5)	978 (42.0)	<0.001	2597 (33.5)	1833 (45.0)	<0.001
Vintage (yr)			0.003			<0.001
<1	1787 (25.2)	531 (22.8)		2340 (30.2)	621 (15.2)	
[1–2)	1046 (14.7)	324 (13.9)		1106 (14.3)	628 (15.4)	
[2–4)	1780 (25.1)	589 (25.3)		1811 (23.3)	1147 (28.1)	
≥4	2463 (34.7)	871 (37.4)		2465 (31.8)	1672 (41.0)	
Missing	22 (0.3)	12 (0.5)		38 (0.5)	8 (0.2)	
Predialysis SBP (mmHg)			0.01			<0.001
≤130	982 (13.8)	361 (15.5)		1240 (16.0)	491 (12.1)	
131–150	2247 (31.7)	784 (33.7)		2604 (33.6)	1244 (30.5)	
151–170	2550 (35.9)	749 (32.2)		2578 (33.2)	1485 (36.4)	
>170	1319 (18.6)	433 (18.6)		1338 (17.3)	856 (21.0)	
Urea reduction ratio (%)	74.7+5.2	74.3+5.2	<0.001	75.1+5.2	73.4+5.0	<0.001
eKt/V	1.4+0.3	1.5+0.3	<0.001	1.4+0.3	1.4+0.3	0.09
n	6582	2168		7190	3757	
Missed sessions[b]			<0.001			<0.001
0	4929 (69.4)	1751 (75.3)		5386 (69.4)	2987 (73.3)	
1	733 (10.3)	205 (8.8)		771 (9.9)	404 (9.9)	
2	620 (8.7)	184 (7.9)		725 (9.3)	311 (7.6)	
3	233 (3.3)	50 (2.2)		253 (3.3)	93 (2.3)	
≥4	583 (8.2)	137 (5.9)		625 (8.1)	281 (6.9)	

Table 1. (Continued)

Characteristics	Delivered DSL <240 min (*n*=7098)	Delivered DSL ≥240 min (*n*=2327)	*P*	IDWG ≤3 kg (*n*=7758)	IDWG >3 kg (*n*=4076)	*P*
Albumin (g/dl)			0.03			<0.001
≤3.0	488 (6.9)	152 (6.5)		1587 (20.5)	546 (13.4)	
3.1–3.5	1298 (18.3)	375 (16.1)		3424 (44.1)	1933 (47.4)	
3.6–4.0	3177 (44.8)	1066 (45.8)		2060 (26.6)	1428 (35.0)	
>4.0	2106 (29.7)	716 (30.8)		33 (0.4)	26 (0.6)	
Missing	29 (0.4)	18 (0.8)				
Creatinine (quartile)			<0.001			<0.001
1	1804 (25.4)	487 (20.9)		2384 (30.7)	552 (13.5)	
2	1780 (25.1)	518 (22.3)		2046 (26.4)	857 (21.0)	
3	1708 (24.1)	588 (25.3)		1766 (22.8)	1087 (26.7)	
4	1606 (22.6)	648 (27.9)		1331 (17.2)	1460 (35.8)	
Missing	200 (2.8)	86 (3.7)		233 (3.0)	120 (2.9)	
Phosphorus (mg/dl)			0.01			<0.001
≤4.0	1518 (21.4)	447 (19.2)		1937 (25.0)	517 (12.7)	
4.1–5.0	1861 (26.2)	598 (25.7)		2202 (28.4)	930 (22.8)	
5.1–6.0	1670 (23.5)	586 (25.2)		1796 (23.1)	1008 (24.7)	
>6.0	2033 (28.6)	682 (29.3)		1801 (23.2)	1608 (39.5)	
Missing	16 (0.2)	14 (0.6)		24 (0.3)	13 (0.3)	

Values presented as mean ± SD or *n* (%) except where indicated. Across delivered session length groups and IDWG groups; determined by *t* test for continuous variables and chi-squared testing for categorical variables. DSL, dialysis session length; IDWG, interdialytic weight gain; IQR, interquartile range; SBP, systolic BP.
[a]Calculated as IDWG (kg)/postweight (kg).
[b]Number of dialysis sessions missed during the 30-day exposure period.

Discussion

Prior observational studies have demonstrated positive associations between UFRs and mortality, but no study has fully evaluated the independent roles of DSL and IDWG in mediating this relationship. In this analysis, we demonstrate that among patients receiving thrice-weekly in-center hemodialysis with adequate urea clearance, both DSL and IDWG play important roles in the UFR–mortality relationship, and that these associations are independent of one another. Specifically, shorter delivered DSL is associated with increased mortality independent of IDWG, and larger IDWG is associated with increased mortality independent of delivered DSL. In addition, the data suggest dose-response relationships in both associations, adding evidence in favor of causality. These observations indicate that both DSL extension and IDWG reduction are potentially viable targets for directed clinical intervention.

Prior epidemiologic studies have demonstrated associations between DSL and IDWG and mortality. Four such studies showed an association between shorter session length and decreased survival (3,11,12,14). Of these studies, only two adjusted for a measure of IDWG—one by using ultrafiltration volume as a proxy (3)—and did so through inclusion of a covariate term in the multivariable survival model (3,14). In at least two of these studies, limited overlap of IDWG across DSL groups was observed (3,14), implicitly limiting multivariable modeling's ability to adequately adjust for confounding.

Despite uncertainty in the empirical clinical data, it remains highly plausible that shorter DSL increases the risk of death. By necessitating more rapid fluid removal in a compressed timeframe, shorter dialysis sessions expose patients to greater fluid shifts with attendant myocardial stunning and ischemia (15), intradialytic hypotension, hemodynamic destabilization (16), and resultant interruptions of end-organ perfusion. The cumulative consequences of these cardiac stresses have been linked to maladaptive changes in left ventricular geometry such as hypertrophy and fibrosis with derivative heart failure and conduction system abnormalities (15,17–22). Shorter dialysis sessions may also detrimentally affect survival through limiting removal of phosphorus, b2-microglobulin, and other middle molecules (23–25).

Prior studies have also demonstrated an association between greater IDWG and increased mortality (7–10). Kalantar-Zadeh *et al.*, for example, demonstrated an adjusted HR of 1.25 (95% CI, 1.12 to 1.39) for IDWG ≥4.0 kg versus referent 1.5–2.0 kg (8). However, none of the prior studies adjusted IDWG–mortality associations for DSL, making it impossible to ascertain whether the associations observed were truly independent of DSL differences. As with the DSL–mortality association, strong biologic basis for deleterious consequences of greater IDWG does exist. Chronic volume overload promotes maladaptive cardiac structural changes (*e.g.*, left ventricular hypertrophy and fibrosis) through direct activation of the mammalian target of rapamycin pathway (26–28) and through upregulation of the sympathetic nervous system and renin-angiotensin-aldosterone pathways (29,30). This, in turn, distorts cardiac conduction

Table 2. Comparison of age, sex, vascular access type, postdialysis weights, IDWG, and DSL and other covariates between patients delivered DSL <240 versus □240 minutes and IDWG □3 versus >3 kg in the matched analytical cohorts

Characteristics	Delivered DSL <240 min (*n*=897)	Delivered DSL ≥240 min (*n*=897)	*P*	IDWG ≤3 kg (*n*=1057)	IDWG >3 kg (*n*=1057)	*P*
Matching factors and variables derived from these						
Age (yr)			—			—
Mean ± SD	63.6±11.7	63.6±11.8		62.4±11.7	62.4±11.7	
Median [IQR]	64.0 [56.0, 72.0]	64.0 [56.0, 73.0]		63.0 [55.0, 71.0]	63.0 [54.0, 71.0]	
Min, max	(24, 91)	(24, 90)		(23, 90)	(24, 89)	
Female	307 (34.2)	307 (34.2)	—	404 (38.2)	404 (38.2)	—
Access			—			—
Fistula	406 (45.3)	406 (45.3)		500 (47.3)	500 (47.3)	
Graft	239 (26.6)	239 (26.6)		345 (32.6)	345 (32.6)	
Catheter	250 (27.9)	250 (27.9)		212 (20.1)	212 (20.1)	
Missing	2 (0.2)	2 (0.2)		0	0	
Postdialysis weight (kg)			—			—
Mean ± SD	76.5±13.7	76.5±13.8		75.5±13.3	75.5±13.4	
Median [IQR]	75.6 [66.3, 85.7]	75.6 [66.2, 85.6]		74.0 [66.1, 83.9]	73.9 [66.0, 84.2]	
Min, max	(45.3, 130.2)	(44.4, 129.4)		(39.5, 129.2)	(40.1, 130.4)	
IDWG (kg)			—			—
Mean ± SD	2.8±0.9	2.8±0.9		2.1±0.6	3.7±0.6	
Median [IQR]	2.8 [2.2, 3.4]	2.8 [2.2, 3.4]		2.3 [1.8, 2.6]	3.6 [3.2, 4.1]	
Min, max	(0.4, 5.9)	(0.3, 5.9)		(1.1, 3.0)	(3.0, 6.8)	
IDWG (% of body weight)[a]			—			—
Mean ± SD	3.7±1.1	3.7±1.1		2.9±1.0	5.1±1.1	
Median [IQR]	3.6 [3.0, 4.1]	3.7 [3.1, 4.3]		3.0 [2.3, 3.6]	4.9 [4.3, 5.6]	
Min, max	(0.5, 6.9)	(0.5, 7.1)		(0.0, 5.8)	(2.8, 9.8)	
Delivered DSL (min)						—
Mean ± SD	211.2±19.6	244.8±6.8		218.1±20.5	218.1±20.5	
Median [IQR]	211.4 [197.4, 227.1]	242 [240.3, 245.8]		215.0 [210.0, 240.0]	215.0 [210.0, 240.0]	
Min, max	(150, 240)	(240, 270)		(165, 270)	(165, 270)	
Other covariates						
Race			0.005			0.03
Nonblack	567 (63.2)	506 (56.4)		630 (59.6)	690 (65.3)	
Black	328 (36.6)	384 (42.8)		419 (39.6)	361 (34.2)	
Missing	2 (0.2)	7 (0.8)		8 (0.8)	6 (0.5)	
Diabetes	494 (55.1)	529 (59.0)	0.10	545 (51.6)	657 (62.2)	<0.001
Coronary artery disease	101 (11.3)	137 (15.3)	0.01	131 (12.4)	150 (14.2)	0.22
Congestive heart failure	341 (38.0)	341 (38.0)	0.99	376 (35.6)	456 (43.1)	<0.001