SUPPLEMENTAL MATERIAL

Data S1.

SUPPLEMENTAL METHODS
Study design and participants

Data collection
Clinical variables were abstracted from patient medical records. All clinical and laboratory data, including patient demographics, were collected and stored in a password-protected dataset.

Right heart catheterization (RHC)
All RHC measures were derived at end-expiration, and reported values represent the average of 5 to 10 cardiac cycles. Cardiac output (average of three cycles with <10% variation in patients in sinus rhythm and five cardiac cycles in patients with atrial fibrillation) was derived by both thermodilution and the Fick method using nomograms for oxygen uptake in conjunction with the Fick method. If patients did not have supplemental oxygen therapy, the direct Fick method was performed directly after oxygen uptake assessment. When a discrepancy was present between both methods, cardiac output was reported by direct Fick; if direct Fick measurement was not possible, thermodilution was used. Pulmonary vascular resistance and cardiac index were calculated as described previously (pulmonary vascular resistance=[mean pulmonary arterial pressure−pulmonary capillary wedge pressure]/cardiac output; cardiac index=[cardiac output/body surface area]).[1]

Bioimpedance spectroscopy
Bioimpedance is based on the principle that the body acts as a circuit with a given resistance (opposition of current flow through intracellular and extracellular solutions [Ri and Re]) and reactance (the capacitance of cells to store energy [Xc]).[2] The volume of the body fluid component is largely reflected in the resistance, whereas reactance might represent cell membrane integrity. The impedance is composed of the sum of resistance and reactance ($\sqrt{[R^2 + Xc^2]}$).[3] Another parameter that can be derived is the phase angle, which is the arc tangent of Xc/R. When a current passes through cells, a portion of the electrical current is stored and subsequently released in a different phase, termed "phase angle". The phase angle is related to the ability of cells to function as capacitors, which is dependent on the integrity of the cell membrane and cellular health. Bioimpedance data from the study population are provided in Table S4.
The three-compartment model of the BCM Body Composition Monitor has been validated against standard reference methods for assessment of fluid status and body composition in patients undergoing hemodialysis and peritoneal dialysis, albeit partly against gold standard techniques in healthy controls only.[4-7] BCM has been shown to be valid in different ethnicities[5], and measures impedance at 50 different frequencies between 5 kHz and 1 MHz. Reproducibility of BCM-derived parameters is high, with a coefficient of variation for the inter-observer variability for extracellular water and total body water around 1.2% in studies[8] performed in patients undergoing hemodialysis. Therefore, only one BCM measurement was performed in each individual patient. BCM results are normalized by sex and patient height. According to the manufacturer's recommendations we excluded patients if they had an unipolar pacemaker, while there were no limitations for patients with stents or bipolar pacemakers.[9] For measurement, the skin was cleansed with alcohol, then the electrodes were attached to one hand and one foot at the ipsilateral side, after the patient had been supine for at least 5 minutes and not touching any metal objects.
Hydration status (expressed in Liters) was derived from the impedance data based on a physiologic tissue model that separates the body into three compartments[4]: surplus water, normohydrated lean tissue, and fat tissue. Hydration status represents the difference between the measured amount of extracellular water and the amount of water expected in normohydrated tissue conditions. Patients are considered 'dehydrated' or 'overhydrated' when their absolute hydration status is below the 10th or above the 90th percentile of the normal, presumed healthy, reference population, respectively (corresponding to 1.1 L of negative or positive hydration status, respectively).[10, 11] Due to bio-physical reasons, bioimpedance spectroscopy does not measure sequestered fluid in the trunk, and presence of pleural effusion and ascites was documented by ultrasound.[12] Lean tissue mass represents the body mass without adipose tissue and excess extracellular water (fluid overload). Fat represents the mass of adipose lipids in the body. Lean tissue mass and fat are provided in kilograms as well as in relation to body weight (%). Lean tissue index is calculated as the quotient of lean tissue mass/height. Fat tissue index is defined as the quotient of adipose tissue mass/height. Adipose tissue mass is the mass of the adipose tissue, including the adipose water. Body cell mass represents the cellular, metabolically active body mass, excluding the extracellular fluid in the metabolically active tissue.[12]

Intra-abdominal pressure measurement
Intra-abdominal pressure was measured with a standard Foley catheter, which was connected to a pressure transducer placed in-line with the iliac crest at the midaxillary line. The Foley catheter was flushed with a maximal instillation volume of 50 mL sterile saline via the aspiration port of the Foley catheter with the drainage

tube clamped to allow a fluid-filled column to develop up into the bladder. A pressure transducer was then inserted in the aspiration port, and the pressure was measured. The intra-abdominal pressure was expressed in mm Hg and was measured at end-expiration in the supine position, ensuring that abdominal muscle contractions were absent.

Laboratory methods

Blood and urine samples were centrifuged for 10 minutes at 3000xg and 5 minutes at 500xg, respectively. Samples were processed within 30 minutes of collection.

B-type natriuretic peptide (BNP) and parathormone were measured by the chemiluminescence method on an Advia Centaur XPT analyzer (Siemens Healthcare GmbH, Erlangen, Germany). BNP >35 pg/mL was taken as the cut-off for diagnosing chronic heart failure.[13] Copeptin was measured by the Time-Resolve-Amplified Cryptate Emission method on a Brahms Kryptor Compact Plus (Thermo Fisher Scientific, MA, USA). The range of copeptin, a surrogate marker for proarginine vasopressin release and neurohormonal activation, in healthy individuals has been recently described as 4.2 [9.5] pmol/L.[14] Serum aldosterone was measured by the radioimmunological method on a Multi Crystal LB 2111 Gamma Counter (Berthold Technologies, Bad Wildbach, Germany). Urine sodium-to-potassium ratio <2 was considered as a marker of hyperaldosteronism. Urine fractional excretion of sodium <1% was considered as a marker of sodium retention. Cystatin C was measured by the immunoturbidimetric method on an AU5800 Chemistry Analyzer (Beckman Coulter, California, USA) with reference material ERM-DA471/IFCC (distributed by the European Joint Research Institute for Reference Materials and Measurements, Geil, Belgium).[15] Creatinine was measured by the photometric-enzymatic method on an Advia Centaur XPT analyzer, with calibration to isotope dilution mass spectrometry reference measurements. Blood urea nitrogen-to-creatinine ratio >20 was considered as a marker of neurohormonally mediated disproportionate reabsorption of urea compared with that of creatinine.[16] Creatinine clearance was calculated as: urine creatinine (mg/dL) x urine volume (mL) x1.73 (m^2)/1440 min x serum creatinine (mg/dL) x body surface area (m^2). For calculation of urea clearance, creatinine was substituted with urea.

Proteinuria was measured using a colorimetric method with pyrogallol red on an AU5800 Chemistry Analyzer. Albuminuria was measured by the immunoturbidimetric method on a Advia Centaur XPT, and alpha 1-microglobulin was measured by the immunonephelometric method on a BNII analyzer (Siemens Healthcare GmbH, Erlangen, Germany). Protein-to creatinine ratio, albumin-to-creatinine ratio, and alpha 1-microglobulin-to-creatinine ratio (all reported in units of mg/g creatinine) were then calculated. Microalbuminuria and increased tubular proteinuria (alpha 1 microglobulin) were defined as values $\geq$30mg/g and $\geq$20mg/g creatinine, respectively.[17, 18] Positive acanthocyturia, a diagnostic criterion of glomerulonephritis, was defined as $\geq$5% acanthocytes in centrifuged urinary sediment detected with a phase-contrast microscope Eclipse Ci-L (Nikon, Tokyo, Japan).[19] Sterile leukocyturia, associated with interstitial nephritis, nephrolithiasis, uroepithelial tumors, and infection with atypical organisms, was defined as a positive urinary dip stick test for leukocyte esterase in combination with a negative urine culture.[20]

Renal replacement therapy (RRT)

Patients with fluid overload received a stepped pharmacological diuretic therapy including adjustable doses of intravenous loop diuretic agents, thiazide diuretic agents, and aldosterone antagonists. Patients who fulfilled the criteria for diuretic resistance despite the stepped pharmacological therapy were transferred to RRT, as were patients who developed stage 3 acute kidney injury with fluid overload or a life-threatening complication (eg, pulmonary edema).[21] Modality of RRT was based on illness acuteness, patient preference, and co-morbidities (eg, presence of ascites). In general, peritoneal dialysis (conventional surgical technique; peritoneal dialysis catheter type Oreopoulous-Zellermann) was the preferred modality for patients with HF, except patients with life-threatening indications or cardiovascular instability, for whom slow extended daily hemodialysis with the GENIUS® dialysis system (Fresenius Medical Care, Bad Homburg, Germany) was preferred.

Table S1. ICC for RVSI measured by two independent nephrologists.

	Intraclass correlation*	95% confidence interval		F test with true value 0			
		Lower bound	Upper bound	Value	df1	df2	Significance
Inter-observer reliability							
Single measures	0.978†	0.973	0.982	178.709	204	612	0.000
Average measures	0.994‡	0.993	0.996	178.709	204	612	0.000
Intra-observer reliability							
TS – single measures	1.000†	1.000	1.000		204		
TS – average measures	1.000‡	1.000	1.000		204		
FH-S – single measures	1.000†	1.000	1.000	5302.258	204	204	0.000
FH-S – average measures	1.000‡	1.000	1.000	5302.258	204	204	0.000

Two-way mixed effects model where people effects are random and measures effects are fixed.

*Type A ICCs using an absolute agreement definition for inter-observer reliability; Type C ICCs using a consistency definition for intra-observer reliability.
†The estimator is the same, whether the interaction effect is present or not.
‡This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.
df=degrees of freedom; ICC=intraclass correlation coefficient; RVSI=renal venous stasis index.

Table S2. Classification of the RHC Cohort According to PH Subcategories.

	n (%)
No PH	40 (100)
Disease control	27 (67.5)
HF with preserved ejection fraction	13 (32.5)
Group 1 (PAH)	46 (100)
Idiopathic PAH	27 (58.7)
Connective tissue disease	8 (17.4)
Congenital systemic-to-pulmonary shunts	6 (13.0)
Porto-pulmonary PH	5 (10.9)
Group 2 (PH due to left heart disease)	30 (100)
PH-HF with preserved ejection fraction	30 (100)
Group 3 (PH due to lung disease and/or hypoxemia)	41 (100)
Chronic obstructive pulmonary disease	22 (53.7)
Interstitial lung disease	15 (36.6)
Sleep-disordered breathing	4 (9.8)
Group 4 (chronic thromboembolic PH)	34 (100)
Group 5 (PH with unclear multifactorial mechanisms)	14 (100)
Sarcoidosis	9 (64.3)
Churg-Strauss syndrome	1 (1.6)
Unknown mechanisms	4 (28.6)

HF denotes heart failure, PAH pulmonary arterial hypertension, PH pulmonary hypertension, and RHC right heart catheterization

Table S3. Clinical characteristics, invasive hemodynamics, echocardiographic data, renal function, and neurohormonal and hydration status stratified according to congestion stages as determined by intrarenal venous flow patterns.

	All patients (n=205)	**No congestion (n=59)**	**Stage 1 congestion (n=77)**	**Stage 2 congestion (n=44)**	**Stage 3 congestion (n=25)**	**p value***
Baseline clinical data						
6MWD, m	277.23±136.05	309.76±118.16	296.83±142.97	224.55±127.15	232.80±137.57	0.0022
NYHA classification, n (%)						0.078
1–2	44 (21.5)	15 (25.4)	22 (28.6)	4 (9.1)	3 (12)	
3–4	161 (78.5)	44 (74.6)	45 (71.4)	40 (90.9)	22 (88)	
Oxygen supply, n (%)	118 (57.6)	28 (47.5)	45 (58.4)	33 (75.0)	12 (48.0)	0.0306
Maintenance therapy						
ACEi or ARB, n (%)	83 (40.5)	23 (39.0)	33 (42.9)	13 (29.5)	14 (56.0)	0.178
Loop diuretic dose, mg/day	40.0 [0.0–60.0]	20.0 [0.0–40.0]	20.0 [0.0–45.0]	40.0 [0.0–80.0]	80.0 [40.0–200.0]	<0.0001
Thiazide diuretic, n (%)	72 (35.1)	18 (30.5)	27 (35.1)	17 (38.6)	10 (40.0)	0.789
Aldosterone antagonist, n (%)	76 (37.1)	16 (27.1)	30 (39.0)	17 (38.6)	13 (52.0)	0.168
Triamterene, n (%)	5 (2.4)	0 (0)	3 (3.9)	2 (4.5)	0 (0)	0.307
PH-specific therapy, n (%)						0.433
Treatment-naïve	116 (56.6)	42 (71.2)	36 (46.8)	24 (54.5)	14 (56.0)	
Monotherapy	49 (23.9)	8 (13.6)	23 (29.9)	11 (25.0)	7 (28.0)	
Dual therapy	28 (13.7)	6 (10.2)	13 (16.9)	6 (13.6)	3 (12.0)	
Triple therapy	12 (5.9)	3 (5.1)	5 (6.5)	3 (6.8)	1 (4.0)	
Hemodynamics						
Mean PAP, mm Hg	34.84±14.63	24.10±9.62	37.14±15.02	42.84±12.33	39.00±13.11	<0.0001
PVR, dyn.s/cm^5	394 [214–604]	229 [110–420]	440 [277–600]	558 [293–829]	428 [245–750]	<0.0001
RAP, mm Hg	5.76±5.63	2.46±3.66	4.44±4.75	9.00±5.04	11.88±7.54	<0.0001
Cardiac index, L/min/m^2	2.73±0.98	2.98±1.01	2.76±1.00	2.47±0.70	2.48±1.13	0.0332
PCWP, mm Hg	9.0 [5.0–13.0]	7.0 [4.0–10.0]	9.0 [6.0–13.0]	10.5 [6.0–15.8]	12.0 [8.5–18.5]	<0.0001
Mixed venous oxygen saturation, %	63.76±8.35	66.70±6.42	65.11±6.59	59.83±9.70	59.60±10.63	<0.0001
Heart rate, beats/min	71.62±13.23	72.00±11.32	70.34±12.55	72.23±13.49	73.60±18.51	0.703
MAP, mm Hg†	84.25±11.57	85.22±10.28	83.71±12.18	85.69±13.06	81.09±9.48	0.375
Echocardiographic parameters						
Right heart						
TAPSE, mm	19.89±4.41	21.88±3.82	20.87±4.01	18.18±3.80	15.20±3.46	<0.0001
RV myocardial performance index (Tei index)	0.49±0.22	0.46±0.20	0.47±0.23	0.55±0.23	0.48±0.22	0.323
RV S', cm/s	11.60±3.52	12.95±3.31	12.18±3.20	10.17±3.23	9.08±3.43	<0.0001
TAPSE/Systolic PAP ratio	0.39±0.21	0.56±0.27	0.35±0.15	0.30±0.11	0.30±0.13	<0.0001
Tricuspid insufficiency, n (%)						0.0007
Mild	66 (32.2)	34 (57.6)	15 (19.5)	12 (27.3)	5 (20)	
Moderate	112 (54.6)	23 (39.0)	51 (66.2)	25 (56.8)	13 (52)	
Severe	25 (12.2)	1 (1.7)	10 (13.0)	7 (15.9)	7 (28)	
RA area, cm^2	18.89±6.72	14.14±6.30	18.87±5.70	20.99±6.24	24.16±6.60	<0.0001
RV diameter, mm	40.78±8.08	37.93±7.38	40.43±6.68	43.40±8.86	44.04±9.86	0.0009
IVC, cm	2.27±0.49	2.01±0.52	2.30±0.44	2.45±0.31	2.51±0.54	<0.0001
Left heart						
LVEF, %	60.0 [60.0–65.0]	60 [60.0–65.0]	60 [60.0–65.0]	60 [55.0–65.0]	60 [52.5–60.5]	0.0552

LA diameter, mm	41.98±6.86	39.78±6.35	40.65±6.51	43.17±6.12	48.56±5.85	<0.0001
LVEDD, mm	46.03±5.59	46.28±4.73	45.10±5.45	46.24±7.01	47.84±4.85	0.184
E/e' ratio	12.98±5.34	11.07±3.52	12.96±4.12	13.80±6.52	16.42±8.07	0.0007
Renal function						
Serum creatinine, mg/dL‡	1.01±0.45	0.92±0.40	0.86±0.26	1.13±0.53	1.44±0.52	<0.0001
Cystatin C, mg/L	1.10 [0.91–1.52]	0.98 [0.81–1.24]	1.06 [0.88–1.29]	1.33 [1.03–1.64]	1.83 [1.34–2.22]	<0.0001
Urea, mg/dL§	47.44±35.85	40.97±26.71	37.12±17.31	59.84±56.61	72.72±32.68	<0.0001
eGFR (CKD-EPI creatinine equation), mL/min/1.73 m^2‖	74.45±26.12	80.07±24.51	81.57±21.49	67.25±27.96	51.96±24.92	<0.0001
eGFR (CKD-EPI creatinine-cystatin C equation), mL/min/1.73 $m^{2\#}$	68.58±26.86	77.68±27.65	74.42±21.81	59.42±25.85	45.24±23.37	<0.0001
Renal filtration gradient, mm Hg**	69.30±12.46	73.70±10.60	70.36±12.08	67.64±13.00	58.61±10.42	<0.0001
Urine PCR, mg/g creatinine	58.8 [40.2–114.2]	51.5 [36.4–72.6]	55.3 [38.4–93.3]	70.3 [46.9–160.5]	116.2 [52.7–222.7]	0.0022
Urine ACR, mg/g creatinine	11.4 [6.3–29.7]	9.3 [5.2–16.0]	10.3 [6.2–22.2]	13.8 [8.1–45.8]	33.4 [11.3–223.7]	<0.0001
Urine α1MCR, mg/g creatinine	10.9 [6.0–19.1]	8.7 [5.1–16.5]	10.4 [5.9–19.0]	11.7 [7.0–25.3]	16.3 [8.3–40.1]	0.0283
Acanthocyturia, n (%)	7 (3.4)	2 (3.4)	3 (3.9)	2 (4.5)	0 (0)	0.775
Sterile leukocyturia, n (%)	2 (1.0)	1 (1.7)	0 (0)	1 (2.3)	0 (0)	0.555
Renal Doppler ultrasonography						
RVSI	0.11 [0.00–0.32]	0 [0.0–0.0]	0.10 [0.07–0.14]	0.33 [0.20–0.41]	0.56 [0.48–0.74]	<0.0001
Venous impedance index	0.84±0.26	0.44±0.12	1.00±0	1.00±0	1.00±0	<0.0001
RRI	0.71±0.07	0.69±0.08	0.70±0.07	0.74±0.06	0.75±0.06	<0.0001
Neurohormonal status						
BNP, pg/mL	138.0 [50.0–321.0]	46.0 [26.0–113.0]	150.0 [50.5–254.5]	303.0 [147.0–633.8]	534.0 [228.5–776.5]	<0.0001
Copeptin, pmol/L	11.1 [5.8–23.3]	9.1 [4.6–16.0]	7.9 [5.2–15.4]	18.8 [7.3–29.8]	27.7 [13.7–50.7]	<0.0001
Sodium, mmol/L	139.56±3.07	139.32±3.15	139.57±2.80	140.59±2.86	138.24±3.60	0.0206
Urine FeNa, %	0.6 [0.4–1.3]	0.7 [0.4–1.2]	0.6 [0.4–1.1]	0.5 [0.4–1.5]	1.3 [0.5–2.5]	0.073
BUN-to-creatinine ratio	21.15±7.53	20.48±7.14	20.16±6.52	20.35±9.39	23.63±7.22	0.131
Aldosterone, ng/dL	5.60 [3.1–11.8]	4.90 [3.0–8.6]	4.90 [3.0–13.4]	6.15 [3.0–11.7]	10.50 [4.2–19.1]	0.0531
Potassium, mmol/L	3.67±0.42	3.65±0.40	3.65±0.41	3.77±0.453	3.66±0.42	0.591
Urine Na/K ratio	3.23±2.24	3.84±2.58	3.20±2.28	2.68±1.47	2.88±2.17	0.0532
Hydration status						
Ascites, n (%)	7 (3.4)	0 (0)	1 (1.3)	0 (0)	6 (24.0)	<0.0001
Pleural effusion, n (%)	17 (8.3)	3 (5.1)	5 (6.5)	2 (4.5)	7 (28.0)	0.0021
Peripheral edema, n (%)	60 (29.3)	12 (22.0)	22 (28.6)	15 (34.1)	10 (40.0)	0.335
Hydration status (as measured by bioimpedance), L	0.71±2.12	-0.14±1.41	0.78±2.24	1.16±2.09	1.70±2.55	0.0006
Total body water, L	37.78±7.47	37.93±8.71	36.78±6.99	39.46±7.20	37.73±5.86	0.359
ECW, L	17.55±3.30	17.36±3.79	16.94±3.01	18.50±3.38	18.31±2.32	0.069
ICW, L	20.28±4.53	20.56±5.24	19.85±4.43	20.97±4.24	19.83±3.32	0.574
ECW/ICW ratio	0.95±0.15	0.86±0.11	0.86±0.11	0.89±0.11	0.94±0.14	0.0204
Intra-abdominal pressure measurement						
Intra-abdominal pressure, mm Hg	7.0 [6.0–9.0]	6.0 [5.0–6.0]	7.0 [6.0–7.0]	9.0 [8.0–10.0]	11.0 [10.0–13.0]	<0.0001
Abdominal perfusion pressure, mm Hg††	76.78±11.81	79.46±10.38	77.04±12.09	76.67±12.96	69.85±9.67	0.0078

Values are mean±SD, median [interquartile range], or n (%).

*After application of the Bonferroni correction, p<0.0008 was considered significant. †MAP was calculated as (systolic blood pressure+2x diastolic pressure)/3. ‡To convert the values for serum creatinine to μmol/L, multiply by 88.4. §eGFR was calculated with the CKD-EPI equation based on serum creatinine.[23] ||To convert the values for urea to BUN, multiply by 0.467. #eGFR was calculated with the CKD-EPI equation based on serum creatinine and cystatin C.[22] **The renal filtration gradient was calculated as: MAP–2x intra-abdominal pressure.[24] ††The abdominal perfusion pressure was calculated using the equation: MAP–intra-abdominal pressure.[24]
6MWD=6-min walk distance; ACEi=angiotensin-converting enzyme inhibitor; ACR=albumin-to-creatinine ratio; α1MCR=α1-microglobulin-to-creatinine ratio; ARB=angiotensin receptor blocker; BUN=blood urea nitrogen; BNP=b-type natriuretic peptide; CKD-EPI=Chronic Kidney Disease Epidemiology Collaboration; ECW=extracellular water; E/e' ratio=ratio of mitral inflow velocity to lateral annular relaxation velocity; eGFR=estimated glomerular filtration rate; FeNa=fractional excretion of sodium; ICW=intracellular water; IVC=inferior vena cava; LA=left atrial; LVEDD=left ventricular end-diastolic diameter; LVEF=left ventricular ejection fraction; MAP=mean arterial pressure; Na/K=sodium/potassium; NYHA=New York Heart Association; PAP=pulmonary arterial pressure; PCR= protein-to-creatinine ratio; PCWP=pulmonary capillary wedge pressure; PH=pulmonary hypertension; PVR=pulmonary vascular resistance; RA=right atrial; RAP=right atrial pressure; RRI=renal resistive index; RV=right ventricular; RV S'=systolic annular tissue velocity of the lateral tricuspid annulus; RVSI=renal venous stasis index; TAPSE=tricuspid annular plane systolic excursion.

Table S4. Additional data on clinical characteristics, invasive hemodynamics, echocardiographic data, renal function, neurohormonal and hydration status according to congestion stages as determined by renal venous stasis index.

			RVSI tertiles			
	All patients (n=205)	**RVSI=0 (n=59)**	**First 0<RVSI≤0.12 (n=49)**	**Second >0.12<RVSI≤0.32 (n=48)**	**Third RVSI>0.32 (n=49)**	**p value***
Maintenance therapy, n (%)						
Calcium channel blocker	46 (22.4)	10 (16.9)	11 (22.4)	14 (29.2)	11 (22.4)	0.518
Thiazide diuretic	72 (35.1)	18 (30.5)	18 (36.7)	17 (35.4)	19 (38.8)	0.826
Aldosterone antagonist	76 (37.1)	16 (27.1)	24 (49.0)	12 (25.0)	24 (49.0)	0.0095
Triamterene	5 (2.4)	0 (0)	2 (4.1)	3 (6.3)	0 (0)	0.103
Renal function, n (%)						
Acanthocyturia	7 (3.4)	2 (3.4)	2 (4.1)	1 (2.1)	2 (4.1)	0.942
Sterile leukocyturia	2 (1.0)	1 (1.7)	0 (0)	0 (0)	1 (2.0)	0.605
Neurohormonal status						
BUN-to-creatinine ratio	21.15±7.53	20.48±7.14	20.38±6.60	20.78±6.93	23.06±9.14	0.236
Aldosterone, ng/dL	5.60 [3.1–11.8]	4.9 [3.0–8.6]	5.9 [3.0–13.5]	4.7 [3.0–11.8]	7.2 [4.1–16.7]	0.0292
Urine Na/K ratio	3.23±2.24	3.84±2.58	3.34±2.35	2.87±1.76	2.76±1.98	0.0470
Hydration status, n (%)						
Total body water, L	37.78±7.47	37.93±8.71	36.50±7.30	37.82±6.19	38.92±7.11	0.495
Extracellular water, L	17.55±3.30	17.36±3.79	16.62±2.95	17.80±3.17	18.54±2.87	0.0450
Intracellular water, L	20.28±4.53	20.56±5.24	19.88±4.66	20.03±3.64	20.62±4.27	0.812

Values are mean±SD, median [interquartile range], or n (%).

*After application of the Bonferroni correction, $p<0.004$ was considered significant.

BUN=blood urea nitrogen; Na/K=sodium/potassium; PH=pulmonary hypertension; RVSI=renal venous stasis index.

Table S5. Correlation of RVSI with relevant parameters*.

	RVSI Correlation coefficient	**p value†**
Demographics		
Age	0.238	0.0006
Body mass index	– 0.025	0.720
Clinical variables		
6MWD	– 0.239	0.0006
Loop diuretic dose	0.369	<0.0001
Hemodynamics		
Mean PAP	0.472	<0.0001
PVR	0.321	<0.0001
RAP	0.584	<0.0001
Cardiac index	– 0.321	<0.0001
PCWP	0.404	<0.0001
Mixed venous oxygen saturation	– 0.391	<0.0001
Echocardiographic parameters		
Right heart		
TAPSE	– 0.456	<0.0001
RV myocardial performance index (Tei index)	0.037	0.672
RV S'	– 0.357	<0.0001
TAPSE/Systolic PAP ratio	– 0.332	<0.0001
RA area	0.471	<0.0001
RV diameter	0.272	<0.0001
IVC	0.355	<0.0001
Left heart		
LVEF	– 0.163	0.0201
LA diameter	0.404	<0.0001
E/e' ratio	0.250	0.0006
Renal function		
Serum creatinine	0.394	<0.0001
Urea	0.427	<0.0001
Cystatin C	0.462	<0.0001
eGFR (MDRD equation) ‡	– 0.365	<0.0001
eGFR (CKD-EPI creatinine equation)§	– 0.365	<0.0001
eGFR (CKD-EPI creatinine-cystatin C equation)‖	– 0.433	<0.0001
Renal filtration gradient#	– 0.327	<0.0001
Urine PCR	0.315	<0.0001
Urine ACR	0.341	<0.0001
Urine α1MCR	0.233	0.0008
RRI	0.323	<0.0001
Neurohormonal status		
BNP	0.623	<0.0001
Copeptin	0.350	<0.0001
Hydration status		
Hydration status (as measured by bioimpedance)	0.301	<0.0001
ECW/ICW ratio	0.178	0.0141
Intra-abdominal pressure measurement		
Intra-abdominal pressure	0.772	<0.0001
Abdominal perfusion pressure**	– 0.214	0.0021

Pearson or Spearman correlation was considered as appropriate. *Relevant parameters were chosen based on their clinical role; in addition, parameters that showed a significant difference across RVSI tertiles (table 2) were included. †After application of the Bonferroni correction, $p<0.0014$ was considered significant. ‡eGFR was calculated with the MDRD equation based on serum creatinine.[25] §eGFR was calculated with the CKD-EPI equation based on serum creatinine.[23] ‖eGFR was calculated with the CKD-EPI equation based on serum creatinine and cystatin C.[22] #The renal filtration gradient was calculated as: MAP–2x intra-abdominal pressure.[24] **The abdominal perfusion pressure was calculated using the equation: MAP–intra-abdominal pressure.[24]

6MWD=6-min walk distance; ACR=albumin-to-creatinine ratio; α1MCR=α1-microglobulin-to-creatinine ratio; CKD-EPI=Chronic Kidney Disease Epidemiology Collaboration; BNP=b-type natriuretic peptide; ECW=extracellular water; E/e' ratio=ratio of mitral inflow velocity to lateral annular relaxation velocity; eGFR=estimated glomerular filtration rate; ICW=intracellular water; IVC=inferior vena cava; LA=left atrial; LVEF=left ventricular ejection fraction; MAP=mean arterial pressure; MDRD=Modification of Diet in Renal Disease; PAP=pulmonary arterial pressure; PCR=protein-to-creatinine ratio; PCWP=pulmonary capillary wedge pressure; PVR=pulmonary vascular resistance; RA=right atrial; RAP=right atrial pressure; RRI=renal resistive index; RV=right ventricular; RV S'=systolic annular tissue velocity of the lateral tricuspid annulus; RVSI=renal venous stasis index; TAPSE=tricuspid annular plane systolic excursion.

Table S6. Correlation of renal function with relevant parameters*.

	Serum creatinine Correlation coefficient	p value†	eGFR (CKD-EPI creatinine-cystatin C equation) Correlation coefficient	p value†
Demographics				
Age, yrs	0.342	<0.0001	–0.542	<0.0001
Baseline clinical data				
PaO_2‡	–0.021	0.764	0.028	0.685
$PaCO_2$‡	0.005	0.944	0.053	0.451
6MWD	–0.211	0.0023	0.350	<0.0001
Laboratory data				
Hemoglobin	–0.166	0.0173	0.258	0.0002
Uric acid	0.479	<0.0001	–0.510	<0.0001
C-reactive protein	0.213	0.0022	–0.282	<0.0001
Maintenance therapy				
Loop diuretic dose	0.482	<0.0001	–0.389	<0.0001
Hemodynamics				
RAP	0.293	<0.0001	–0.323	<0.0001
PCWP	0.265	<0.0001	–0.270	<0.0001
Mixed venous oxygen saturation	–0.249	<0.0001	0.312	<0.0001
Echocardiographic parameters				
TAPSE	–0.315	<0.0001	0.300	<0.0001
RV myocardial performance index (Tei index)	–0.011	0.901	0.062	0.092
RV S’	–0.176	0.012	0.126	0.073
TAPSE/Systolic PAP ratio	–0.168	0.016	0.258	<0.0001
RA area	0.342	<0.0001	–0.333	<0.0001
LA diameter	0.310	<0.0001	0.310	<0.0001
Renal function				
Renal filtration gradient	–0.279	<0.0001	0.283	<0.0001
Urine PCR	0.180	0.0099	–0.240	0.0005
Urine ACR	0.179	0.0104	–0.238	0.0006
Urine α1MCR	0.397	<0.0001	–0.523	<0.0001
Renal Doppler Ultrasonography				
RRI	0.237	<0.0001	–0.430	<0.0001
RVSI	0.486	<0.0001	–0.433	<0.0001
Neurohormonal status				
BNP	0.343	<0.0001	–0.416	<0.0001
Copeptin	0.554	<0.0001	–0.599	<0.0001
Urine FeNa	0.447	<0.0001	–0.492	<0.0001
Hydration status				
ECW/ICW ratio	0.085	0.246	–0.261	0.0003
Intra-abdominal pressure measurement				
Intra-abdominal pressure	0.333	<0.0001	–0.327	<0.0001

Pearson or Spearman correlation was considered as appropriate. *All available study variables were included in the analysis, but only variables that were significant in the analysis are presented here; in addition, paO_2 and $paCO_2$ are presented based on their clinical role. †After application of the Bonferroni correction, $p<0.0006$ was considered significant. ‡Blood gas measurements were taken from arterialized capillary ear lobe blood during right heart catheterization. In patients with long-term oxygen treatment, oxygen was applied via nasal cannula at the previously prescribed flow rate.

6MWD=6-min walk distance; ACR=albumin-to-creatinine ratio; α1MCR=α1-microglobulin-to-creatinine ratio; BNP=b-type natriuretic peptide; CKD-EPI=Chronic Kidney Disease Epidemiology Collaboration; ECW=extracellular water; E/e’ ratio=ratio of mitral inflow velocity to lateral annular relaxation velocity; eGFR=estimated glomerular filtration rate; FeNa=fractional excretion of sodium; ICW=intracellular water; LA=left atrial; LVEF=left ventricular ejection fraction; MAP=mean arterial pressure; $PaCO_2$=arterial carbon dioxide pressure; PaO_2=arterial oxygen pressure; PAP=pulmonary arterial pressure; PCR=protein-to-creatinine

ratio; PCWP=pulmonary capillary wedge pressure; RA=right atrial; RAP=right atrial pressure; RV=right ventricular; RV S'=systolic annular tissue velocity of the lateral tricuspid annulus; RVSI=renal venous stasis index; TAPSE=tricuspid annular plane systolic excursion.

Table S7. Clinical characteristics, invasive hemodynamics, echocardiographic data, renal function, and neurohormonal and hydration status according to PH groups

	No PH (n=40)	Group 1 PH (pulmonary arterial hypertension) (n=46)	Group 2 PH (PH due to left heart disease) (n=30)	Group 3 PH (PH due to lung disease and/or hypoxemia) (n=41)	Group 4 PH (chronic thromboembolic PH) (n=34)	Group 5 PH (PH with unclear multifactorial mechanisms) (n=14)	p value*
Baseline clinical data							
Oxygen supply, n (%)		27 (58.7)	13 (43.3)	35 (85.4)	17 (50.0)	14 (100)	<0.0001
6MWD, m	313.15±126.56	309.07±153.40	269.60±115.46	199.12±105.30	308.38±147.46	239.43±104.40	<0.0001
NYHA classification, n (%)							0.0054
1–2	10 (25)	17 (37.0)	5 (16.7)	3 (7.3)	8 (23.5)	1 (7.1)	
3–4	30 (75)	29 (63.0)	25 (83.3)	38 (92.7)	26 (76.5)	13 (92.9)	
Comorbidities, n (%)							
Hypertension	23 (57.5)	21 (45.7)	27 (90.0)	32 (78.0)	18 (52.9)	7 (50.0)	<0.0001
Diabetes mellitus	8 (20.0)	8 (17.4)	11 (36.7)	11 (26.8)	6 (17.6)	4 (28.6)	0.388
Atrial fibrillation	10 (25.0)	7 (15.2)	24 (80.0)	6 (14.6)	7 (20.6)	2 (14.3)	<0.0001
Maintenance therapy							
ACEi or ARB, n (%)	18 (45.0)	12 (26.1)	21 (70.0)	18 (43.9)	9 (26.5)	5 (35.7)	0.0027
Loop diuretic dose, mg/day	0.0 [0.0–35.0]	40.0 [0.0–65.0]	50.0 [20.0–90.0]	40.0 [0.0–50.0]	40.0 [0.0–80.0]	40.0 [0.0–80.0]	0.0017
Thiazide diuretic, n (%)	9 (22.5)	18 (39.1)	11 (36.7)	17 (41.5)	12 (35.3)	5 (35.7)	0.567
Aldosterone antagonist, n (%)	8 (20.0)	22 (47.8)	12 (40.0)	13 (31.7)	17 (50.0)	4 (28.6)	0.0562
Triamterene, n (%)	0 (0)	3 (6.5)	0 (0)	0 (0)	1 (2.9)	1 (7.1)	0.197
PH-specific therapy, n (%)							<0.0001
Treatment-naive	40 (100)	10 (21.7)	21 (70.0)	22 (53.7)	18 (52.9)	5 (35.7)	
Monotherapy	0 (0)	14 (30.4)	9 (30)	11 (26.8)	10 (29.4)	5 (35.7)	
Dual therapy	0 (0)	14 (30.4)	0 (0)	6 (14.6)	4 (11.7)	4 (28.6)	
≥Triple therapy	0 (0)	8 (17.4)	0 (0)	2 (4.9)	2 (5.9)	0 (0)	
Hemodynamics							
Mean PAP, mm Hg	17.68±4.60	42.13±18.07	37.90±12.03	35.63±9.31	36.91±8.25	46.00±11.75	<0.0001
PVR, dyn.s/cm^5	151.5 [89.5–223.8]	547.5 [343.8–786.5]	315.5 [166.3–478.5]	486.0 [344.5–707.5]	454.5 [334.0–632.5]	519.5 [475.0–613.5]	<0.0001
RAP, mm Hg	2.75±4.74	5.24±5.61	9.97±6.08	5.29±5.55	5.53±5.05	8.93±5.44	<0.0001
Cardiac index, L/min/m^2	3.10±1.41	2.69±0.80	2.68±0.92	2.47±0.67	2.56±0.64	2.99±1.31	0.0533
PCWP, mm Hg	7.0 [4.0–10.0]	8.5 [5.0–11.3]	19.0 [12.8–24.3]	7.0 [4.5–10.0]	8.0 [5.0–11.3]	12.0 [8.5–15.3]	<0.0001
Mixed venous oxygen saturation, %	67.65±7.01	64.69±8.81	61.91±8.81	62.69±7.05	60.73±8.72	64.05±8.51	0.0083
Heart rate, beats/min	71.45±11.11	70.39±11.46	66.13±12.01	73.98±12.91	72.15±13.56	97.71±21.30	0.0306
MAP, mm Hg†	86.28±10.54	81.28±10.42	82.94±10.16	84.91±13.16	82.58±13.07	84.52±10.88	0.191

Echocardiographic parameters							
Right heart							
TAPSE, mm	21.45±4.83	20.22±4.25	18.07±4.09	19.07±4.02	19.82±3.55	20.86±2.77	0.0269
RV myocardial performance index (Tei index)	0.40±0.19	0.52±0.22	0.43±0.19	0.54±0.22	0.52±0.25	0.49±0.27	0.237
RV S', cm/s	12.40±3.88	11.76 ±3.71	10.62±3.37	10.71±3.13	11.91±3.27	12.79±3.30	0.112
TAPSE/Systolic PAP ratio	0.67±0.24	0.31±0.15	0.32±0.11	0.33±0.16	0.35±0.15	0.32±0.10	<0.0001
Tricuspid insufficiency							0.159
Mild	23 (57.5)	14 (30.4)	6 (20.0)	14 (34.1)	8 (23.5)	3 (21.4)	
Moderate	12 (30.0)	22 (47.8)	14 (46.7)	15 (36.6)	16 (47.1)	4 (28.6)	
Severe	5 (12.5)	10 (21.7)	10 (33.3)	12 (29.2)	10 (29.4)	7 (50)	
RA area, m^2	15.15±6.47	18.42±6.56	20.70±6.93	19.25±6.62	20.78±6.00	21.85±5.58	0.0009
RV diameter, mm	36.43±7.88	42.13±8.29	40.31±8.02	42.20±8.24	41.21±6.16	44.57±7.86	0.0031
IVC, cm	2.15±0.47	2.25±0.59	2.37±0.41	2.30±0.46	2.27±0.43	2.45±0.50	0.317
Left heart							
LVEF, %	60.0 [58.1–65.0]	60.5 [60.0–65.0]	60.0 [55.0–65.0]	60.0 [60.0–65.0]	60.0 [60.0–65.0]	60.0 [60.0–65.0]	0.161
LA diameter, mm	40.87±7.60	40.70±6.90	47.47±6.40	40.89±6.08	40.44±5.40	43.69±5.22	<0.0001
LVEDD, mm	47.78±5.09	44.40±5.96	49.20±4.81	44.39±5.48	45.79±5.60	44.00±3.49	<0.0001
E/e' ratio	11.69±4.64	11.03±2.83	20.44±6.03	13.30±4.91	11.57±4.48	11.68±3.61	<0.0001
Renal function							
Serum creatinine, mg/dL‡	0.91±0.45	1.04±0.43	1.23±0.50	0.99±0.43	0.99±0.42	0.78±0.25	0.0175
Cystatin C, mg/L	0.97 [0.76–1.21]	1.19 [0.93–1.50]	1.36 [1.10–1.98]	1.09 [0.94–1.73]	1.07 [0.88–1.52]	1.06 [0.98–1.22]	0.0032
Urea, mg/dL§	39.98±29.56	45.67±42.10	61.57±34.11	49.05±29.86	49.15±44.64	35.50±14.40	0.143
eGFR (CKD-EPI creatinine equation), mL/min/1.73 m^2‖	83.28±23.76	73.30±27.87	56.57±21.63	77.15±25.32	71.97±25.05	89.50±21.14	<0.0001
eGFR (CKD-EPI creatinine-cystatin C equation), mL/min/1.73 m^2#	80.60±27.39	67.46±27.24	50.77±20.19	69.30±26.56	66.91±26.29	78.07±19.50	<0.0001
Renal filtration gradient, mm Hg**	73.88±10.66	66.19±10.32	65.01±11.71	70.03±14.57	68.05±13.88	68.45±11.52	0.0288
Urine PCR, mg/g creatinine	54.3 [44.9–82.9]	57.0 [35.9–106.3]	57.7 [35.6–131.7]	70.5 [46.7–146.2]	50.2 [36.4–121.9]	64.1 [44.8–111.9]	0.443
Urine ACR, mg/g creatinine	11.6 [6.1–17.0]	9.2 [5.3–27.1]	12.1 [7.9–39.7]	11.5 [6.6–66.2]	11.7 [7.5–29.3]	16.0 [6.5–55.3]	0.442
Urine α1MCR, mg/g creatinine	9.8 [15.9–18.6]	8.7 [4.9–17.6]	15.3 [9.3–27.9]	13.1 [5.6–34.5]	11.2 [4.7–22.0]	7.6 [6.2–11.5]	0.071
Acanthocyturia, n (%)	1 (2.5)	5 (10.9)	0 (0)	1 (2.4)	0 (0)	0 (0)	0.057
Sterile leukocyturia, n (%)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.9)	1 (7.1)	0.135

Intrarenal Doppler Ultrasonography							
Congestion stage							<0.0001
0	27 (67.5)	10 (21.7)	1 (3.3)	1 (24.4)	9 (26.5)	2 (14.3)	
1	13 (32.5)	20 (43.5)	12 (40)	16 (39.0)	14 (41.2)	6 (42.9)	
2	0 (0)	11 (23.9)	7 (23.3)	10 (24.4)	9 (26.5)	4 (28.6)	
3	0 (0)	5 (10.9)	10 (33.3)	5 (12.2)	2 (5.9)	2 (14.3)	
Venous impedance index of 1.0	13 (32.5)	36 (78.3)	29 (96.7)	31 (75.6)	25 (73.5)	12 (85.7)	0.482
RVSI	0.0 [0.00–0.09]	0.13 [0.04–0.34]	0.27 [0.11–0.46]	0.09 [0.02–0.29]	0.12 [0.00–0.29]	0.15 [0.06–0.36]	<0.0001
RRI	0.67±0.05	0.71±0.07	0.76±0.06	0.71±0.08	0.73±0.07	0.71±0.07	<0.0001
Neurohormonal status							
BNP, pg/mL	51.00 [22.5–175.5]	134.00 [375.5–324.8]	232.50 [157.5–590.0]	114.00 [55.0–538.5]	160.00 [98.5–314.5]	196.00 [45.8–531.0]	<0.0001
Copeptin, pmol/L	6.95 [4.2–13.5]	7.95 [5.2–18.9]	15.45 [6.4–39.2]	14.15 [8.0–27.7]	16.30 [6.8–23.1]	11.35 [6.1–20.1]	0.0063
Urine FeNa, %	0.60 [0.4–1.1]	0.65 [0.3–1.4]	1.20 [0.6–1.9]	0.80 [0.4–1.3]	0.50 [0.3–1.4]	0.4 [0.3–0.5]	0.0162
Sodium, mmol/L	139.33±3.24	139.24±3.14	139.90±2.90	139.66±3.03	139.47±3.52	140.50±1.51	0.783
BUN-to-creatinine ratio	20.28±8.18	19.09±6.80	23.05±7.86	22.58±7.22	21.47±7.84	21.29±6.46	0.189
Aldosterone, ng/dL	4.70 [3.00–8.45]	8.85 [3.90–19.88]	5.75 [3.00–10.90]	4.70 [3.00–12.30]	6.30 [3.00–11.83]	4.65 [3.00–6.95]	0.079
Potassium, mmol/L	3.75±0.45	3.61±0.39	3.78±0.45	3.60±0.43	3.62±0.40	3.67±0.25	0.271
Urine Na/K ratio	3.52±2.31	2.80±1.70	3.61±2.65	3.45±2.54	3.04±2.16	2.90±1.94	0.53
Hydration status							
Ascites, n (%)	0 (0)	2 (4.3)	3 (10.0)	1 (2.4)	1 (2.9)	0 (0)	0.588
Peripheral edema, n (%)	9 (22.5)	14 (30.4)	9 (30.0)	12 (29.3)	11 (32.4)	5 (35.7)	0.929
Pleural effusion, n (%)	0 (0)	5 (10.9)	3 (10.0)	3 (7.3)	2 (5.9)	4 (28.6)	0.0346
Hydration status (as measured by bioimpedance), L	0.11±1.64	0.97±2.02	1.05±2.53	0.54±2.21	0.71±2.28	1.35±1.91	0.282
Total body water, L	38.46±7.26	36.13±7.81	37.73±6.31	38.85±8.35	37.76±7.91	38.16±5.58	0.679
ECW, L	17.57±3.30	16.88±3.28	17.74±2.84	17.82±3.75	17.54±3.45	18.39±2.68	0.710
ICW, L	20.88±4.31	19.51±4.53	19.97±4.01	20.03±5.12	20.22±4.93	19.76±3.37	0.669
ECW/ICW ratio	0.85±0.09	0.87±0.12	0.90±0.12	0.86±0.13	0.88±0.13	0.94±0.11	0.132
Intra-abdominal pressure measurement							
Intra-abdominal pressure, mm Hg	6.0 [5.0–7.0]	7.0 [6.0–9.0]	8.5 [7.0–10.0]	7.0 [6.0–9.0]	7.0 [6.0–8.3]	8.0 [6.8–10.3]	<0.0001
Abdominal perfusion pressure, mm Hg††	80.08±10.50	73.73±10.11	75.99±10.66	79.47±13.70	75.31±13.35	74.74±10.95	0.092

Values are mean±SD, median [interquartile range], or n (%).

*After application of the Bonferroni correction, p<0.0008 was considered significant. †MAP was calculated as (systolic blood pressure+2x diastolic pressure)/3. ‡To convert the values for serum creatinine to µmol/L, multiply by 88.4. §To convert the values for urea to BUN, multiply by 0.467. ||eGFR was calculated with the CKD-EPI equation based on serum creatinine.[23] #eGFR was calculated with the CKD-EPI equation based on serum creatinine and cystatin C.[22] **The renal filtration gradient was calculated as: MAP–2x intra-abdominal pressure.[24] ††The abdominal perfusion pressure was calculated using the equation: MAP–intra-abdominal pressure.[24]

6MWD=6-min walk distance; ACEi=angiotensin-converting enzyme inhibitor; ACR=albumin-to-creatinine ratio; α1MCR=α1-microglobulin-to-creatinine ratio; ARB=angiotensin receptor blocker; BNP=b-type natriuretic peptide; BUN=blood urea nitrogen; CKD-EPI=Chronic Kidney Disease Epidemiology Collaboration; ECW=extracellular water; E/e' ratio=ratio of mitral inflow velocity to lateral annular relaxation velocity; eGFR=estimated glomerular filtration rate; FeNa=fractional excretion of sodium; ICW=intracellular water; IVC=inferior vena cava; LA=left atrial; LVEDD=left ventricular end-diastolic diameter; LVEF=left ventricular ejection fraction; MAP=mean arterial pressure; Na/K=sodium/potassium; NYHA=New York Heart Association; PAP=pulmonary arterial pressure; PCR=protein-to-creatinine ratio; PCWP=pulmonary capillary wedge pressure; PH=pulmonary hypertension; PVR=pulmonary vascular resistance; RA=right atrial; RAP=right atrial pressure; RRI=renal resistive index; RV=right ventricular; RV S'=systolic annular tissue velocity of the lateral tricuspid annulus; RVSI=renal venous stasis index; TAPSE=tricuspid annular plane systolic excursion.

Table S8. Outcomes in the RHC cohort.

Outcome, n (%)	RHC cohort (n=205)
PH-related morbidity and death from any cause	91 (44.4%)
Unscheduled hospitalizations for fluid overload	64 (31.2%)
Escalations of PH-specific therapy	71 (34.6%)
Death from any cause	21 (10.2%)

Five patients underwent pulmonary thrombendarterectomy, and one patient underwent lung transplantation.

RHC=right heart catheterization; PH=pulmonary hypertension.

Table S9. Predictors of morbidity and mortality by the univariate Cox proportional hazard model.

	Univariate	
Predictor	**HR (95% CI)**	**p value**
Baseline clinical data		
Age	1.02 (1.00–1.03)	0.0439
Sex	0.63 (0.42–0.95)	0.0265
6MWD	0.997 (0.996–0.999)	0.0006
NYHA classification	1.62 (1.19–2.20)	0.0024
Pulmonary hypertension group	0.81 (0.72–0.91)	<0.0001
Diabetes mellitus	1.88 (1.21–2.91)	0.0048
Atrial fibrillation	2.56 (1.68–3.88)	<0.0001
Uric acid	1.25 (1.16–1.34)	<0.0001
Hemodynamics		
Mean PAP	1.03 (1.02–1.04)	<0.0001
PVR	1.00 (1.00–1.00)	<0.0001
RAP	1.12 (1.07–1.14)	<0.0001
Cardiac index	0.54 (0.39–0.74)	<0.0001
PCWP	1.06 (1.03–1.09)	<0.0001
Mixed venous oxygen saturation	0.93 (0.91–0.96)	<0.0001
Echocardiographic parameters		
TAPSE	0.90 (0.86–0.94)	<0.0001
RV S’	0.86 (0.80–0.93)	<0.0001
TAPSE/Systolic PAP ratio	0.05 (0.01–0.19)	<0.0001
Tricuspid insufficiency	1.76 (1.32–2.35)	<0.0001
RA area	1.07 (1.04–1.09)	<0.0001
RV diameter	1.05 (1.02–1.07)	<0.0001
IVC diameter	2.08 (1.38–3.13)	<0.0001
LVEF	0.98 (0.95–1.00)	0.0477
LA diameter	1.07 (1.04–1.10)	<0.0001
E/e’ ratio	1.07 (1.03–1.11)	<0.0001
Renal function		
Serum creatinine	2.59 (1.83–3.66)	<0.0001
Cystatin C	2.18 (1.69–2.82)	<0.0001
Urea	1.01 (1.01–1.02)	<0.0001
eGFR (MDRD equation)*	0.99 (0.98–0.99)	<0.0001
eGFR (CKD-EPI creatinine equation) †	0.98 (0.97–0.98)	<0.0001
eGFR (CKD-EPI creatinine-cystatin C equation)‡	0.98 (0.97–0.99)	<0.0001
Renal filtration gradient	0.97 (0.95–0.99)	0.0007
Urine α1MCR	1.01 (1.01–1.02)	<0.0001
Urine FeNa	1.21 (1.09–1.34)	<0.0001
Renal Doppler ultrasonography		
RVSI tertiles	20.57 (9.03–46.87)	<0.0001
1st tertile RVSI group vs RVSI=0	2.31 (1.06–5.05)	0.0363
2nd tertile RVSI group vs RVSI=0	3.63 (1.71–7.65)	0.0007
3rd tertile RVSI group vs RVSI=0	8.70 (4.33–17.48)	<0.0001
Congestion stages	2.00 (1.63–2.44)	<0.0001
Stage 1 congestion vs stage 0	2.65 (1.29–5.44)	0.0078
Stage 2 congestion vs stage 0	6.35 (3.08–13.09)	<0.0001
Stage 3 congestion vs stage 0	8.45 (3.98–17.96)	<0.0001
Venous impedance index	14.61 (4.31–49.55)	<0.0001
Neurohormonal status		
BNP	1.00 (1.00–1.00)	<0.0001
Copeptin	1.02 (1.02–1.03)	<0.0001
Aldosterone	1.01 (1.00–1.02)	0.0184
Hydration status		
Hydration status (as measured by bioimpedance)	1.14 (1.03–1.25)	0.0081
Extracellular/intracellular water	8.42 (1.31–54.25)	0.0251
Ascites	2.85 (1.30–6.23)	0.0089
Pleural effusion	2.27 (1.26–4.10)	0.0064
Intra-abdominal pressure measurement		
Intra-abdominal pressure	1.25 (1.17–1.34)	<0.0001
Abdominal perfusion pressure§	0.98 (0.96–1.00)	0.0226

All available study variables were included in the univariate analysis, but only variables that were significant in the univariate analysis are presented here. *eGFR was calculated with the MDRD equation based on serum creatinine.[25] †eGFR was calculated with the CKD-EPI equation based on serum creatinine.[23] ‡eGFR was calculated with the CKD-EPI equation based on serum creatinine and cystatin C.[22] §The abdominal perfusion pressure was calculated using the equation: MAP–intra-abdominal pressure, while MAP was calculated as (systolic blood pressure+2x diastolic pressure)/3.[24]

6MWD=6-min walk distance; α1MCR=α1-microglobulin-to-creatinine ratio; BNP=b-type natriuretic peptide; CKD-EPI=Chronic Kidney Disease Epidemiology Collaboration; CI=confidence interval; E/e’ ratio=ratio of

mitral inflow velocity to lateral annular relaxation velocity; eGFR=estimated glomerular filtration rate; FeNa=fractional excretion of sodium; HR=hazard ratio; IVC=inferior vena cava; LA=left atrial; LVEF=left ventricular ejection fraction; MAP=mean arterial pressure; MDRD=Modification of Diet in Renal Disease; NYHA=New York Heart Association; PAP=pulmonary arterial pressure; PCWP=pulmonary capillary wedge pressure; PVR=pulmonary vascular resistance; RA=right atrial; RAP=right atrial pressure; RV=right ventricular; RV S'=systolic annular tissue velocity of the lateral tricuspid annulus; RVSI=renal venous stasis index; TAPSE=tricuspid annular plane systolic excursion.

Table S10. Predictors of unscheduled hospitalization due to fluid overload by the univariate Cox proportional hazard model.

	Univariate	
Predictor	**HR (95% CI)**	**p value**
Baseline clinical data		
Age	1.04 (1.01–1.06)	0.0013
Sex	0.48 (0.29–0.79)	0.0039
6MWD	0.996 (0.994–0.998)	<0.0001
NYHA classification	1.81 (1.24–2.64)	0.0022
Pulmonary hypertension group	0.83 (0.72–0.95)	0.0083
Diabetes mellitus	2.58 (1.56–4.27)	<0.0001
Atrial fibrillation	4.05 (2.47–6.63)	<0.0001
Sodium	0.93 (0.86–0.99)	0.0286
Uric acid	1.29 (1.19–1.41)	<0.0001
Hemodynamics		
Mean PAP	1.02 (1.01–1.04)	0.0008
PVR	1.00 (1.00–1.00)	0.0246
RAP	1.15 (1.11–1.20)	<0.0001
Cardiac index	0.46 (0.31–0.68)	<0.0001
PCWP	1.08 (1.05–1.11)	<0.0001
Mixed venous oxygen saturation	0.92 (0.90–0.95)	<0.0001
Echocardiographic parameters		
TAPSE	0.86 (0.81–0.91)	<0.0001
RV S’	0.77 (0.70–0.85)	<0.0001
TAPSE/Systolic PAP ratio	0.02 (0.00–0.18)	<0.0001
Tricuspid insufficiency	2.22 (1.55–3.18)	<0.0001
RA area	1.11 (1.07–1.14)	<0.0001
RV diameter	1.06 (1.03–1.10)	<0.0001
IVC diameter	2.60 (1.59–4.16)	<0.0001
LVEF	0.96 (0.94–0.99)	0.0037
LA diameter	1.07 (1.04–1.11)	<0.0001
E/e’ ratio	1.08 (1.03–1.12)	<0.0001
Renal function		
Serum creatinine	3.40 (2.33–4.94)	<0.0001
Cystatin C	2.62 (1.99–3.45)	<0.0001
Urea	1.01 (1.01–1.02)	<0.0001
eGFR (MDRD equation)*	0.98 (0.97–0.99)	<0.0001
eGFR (CKD-EPI creatinine equation) †	0.97 (0.96–0.98)	<0.0001
eGFR (CKD-EPI creatinine-cystatin C equation)‡	0.97 (0.96–0.98)	<0.0001
BUN-to-creatinine ratio	1.04 (1.01–1.07)	0.0117
Renal filtration gradient	0.96 (0.94–0.98)	<0.0001
Urine α1MCR	1.01 (1.01–1.02)	<0.0001
Urine FeNa	1.21 (1.07–1.36)	0.0017
Renal Doppler ultrasonography		
RVSI tertiles	1.71 (1.48–1.98)	<0.0001
1st tertile RVSI group vs RVSI=0	6.49 (1.42–29.64)	0.0157
2nd tertile RVSI group vs RVSI=0	10.98 (2.52–47.76)	0.0014
3rd tertile RVSI group vs RVSI=0	35.60 (8.54–148.38)	<0.0001
Congestion stages	2.49 (1.94–3.20)	<0.0001
Stage 1 congestion vs stage 0	7.36 (1.71–31.72)	0.0074
Stage 2 congestion vs stage 0	25.51 (6.05–107.67)	<0.0001
Stage 3 congestion vs stage 0	32.17 (7.44–139.09)	<0.0001
Venous impedance index	121.10 (9.45–1552.61)	<0.0001
Neurohormonal status		
BNP	1.00 (1.00–1.00)	<0.0001
Copeptin	1.03 (1.02–1.04)	<0.0001
Aldosterone	1.02 (1.00–1.03)	0.0122
Hydration status		
Hydration status (as measured by bioimpedance)	1.16 (1.04–1.29)	0.0089
Extracellular/intracellular water	14.97 (1.66–135.09)	0.0159
Extracellular water	1.09 (1.01–1.18)	0.0280
Ascites	3.11 (1.24–7.77)	0.0153
Pleural effusion	2.42 (1.19–4.90)	0.0142
Peripheral edema	2.09 (1.28–3.44)	0.0034
Intra-abdominal pressure measurement		
Intra-abdominal pressure	1.36 (1.26–1.47)	<0.0001
Abdominal perfusion pressure§	0.97 (0.95–1.00)	0.0210

All available study variables were included in the univariate analysis, but only variables that were significant in the univariate analysis are presented here. *eGFR was calculated with the MDRD equation based on serum creatinine.[25] †eGFR was calculated with the CKD-EPI equation based on serum creatinine.[23] ‡eGFR was calculated with the CKD-EPI equation based on serum creatinine and cystatin C.[22] §The abdominal perfusion

pressure was calculated using the equation: MAP–intra-abdominal pressure, while MAP was calculated as (systolic blood pressure+2x diastolic pressure)/3.[24]

6MWD=6-min walk distance; α1MCR=α1-microglobulin-to-creatinine ratio; BNP=b-type natriuretic peptide; BUN=blood urea nitrogen; CKD-EPI=Chronic Kidney Disease Epidemiology Collaboration; CI=confidence interval; E/e' ratio=ratio of mitral inflow velocity to lateral annular relaxation velocity; eGFR=estimated glomerular filtration rate; FeNa=fractional excretion of sodium; IVC=inferior vena cava; HR=hazard ratio; LA=left atrial; LVEF=left ventricular ejection fraction; MAP=mean arterial pressure; MDRD=Modification of Diet in Renal Disease; NYHA=New York Heart Association; PAP=pulmonary arterial pressure; PCR=protein-to-creatinine ratio; PCWP=pulmonary capillary wedge pressure; PVR=pulmonary vascular resistance; RA=right atrial; RAP = right atrial pressure; RV=right ventricular; RV S'=systolic annular tissue velocity of the lateral tricuspid annulus; RVSI=renal venous stasis index; TAPSE=tricuspid annular plane systolic excursion.

Table S11. Predictors of escalation of PH-specific therapy by the univariate Cox proportional hazard model.

	Univariate	
Predictor	**HR (95% CI)**	**p value**
Baseline clinical data		
6MWD	0.997 (0.995–0.999)	0.0013
NYHA classification	1.59 (1.11–2.27)	0.0110
Pulmonary hypertension group	0.79 (0.69–0.91)	0.0008
Diabetes mellitus	1.90 (1.16–3.12)	0.0105
Atrial fibrillation	1.79 (1.11–2.89)	0.0177
Potassium	0.49 (0.28–0.88)	0.0162
Uric acid	1.26 (1.16–1.36)	<0.0001
Hemodynamics		
Mean PAP	1.03 (1.02–1.04)	<0.0001
PVR	1.00 (1.00–1.00)	<0.0001
RAP	1.08 (1.04–1.12)	<0.0001
Cardiac index	0.41 (0.28–0.60)	<0.0001
PCWP	1.04 (1.01–1.07)	0.0072
Mixed venous oxygen saturation	0.92 (0.90–0.95)	<0.0001
Echocardiographic parameters		
TAPSE	0.89 (0.85–0.94)	<0.0001
RV S’	0.84 (0.77–0.91)	<0.0001
TAPSE/Systolic PAP ratio	0.04 (0.01–0.21)	<0.0001
Tricuspid insufficiency	1.54 (1.12–2.12)	0.0079
RA area	1.05 (1.02–1.09)	0.0013
RV diameter	1.05 (1.02–1.08)	0.0005
IVC diameter	2.00 (1.25–3.19)	0.0037
LA diameter	1.05 (1.01–1.08)	0.0072
LVEDD	0.95 (0.91–0.99)	0.0221
E/e’ ratio	1.07 (1.03–1.12)	0.0006
Renal function		
Serum creatinine	2.55 (1.74–3.73)	<0.0001
Urea	1.01 (1.00–1.01)	<0.0001
Cystatin C	1.95 (1.50–2.55)	<0.0001
eGFR (MDRD equation)*	0.99 (0.98–0.99)	<0.0001
eGFR (CKD-EPI creatinine equation) †	0.98 (0.97–0.99)	<0.0001
eGFR (CKD-EPI creatinine-cystatin C equation)‡	0.98 (0.97–0.99)	<0.0001
Renal filtration gradient	0.96 (0.94–0.99)	0.0007
Urine α1MCR	1.01 (1.01–1.02)	<0.0001
Urine FeNa	1.24 (1.10–1.39)	<0.0001
Renal Doppler ultrasonography		
RVSI tertiles	1.43 (1.26–1.63)	<0.0001
1st tertile RVSI group vs RVSI=0	2.16 (0.89–5.24)	0.0872
2nd tertile RVSI group vs RVSI=0	3.52 (1.53–8.07)	0.0030
3rd tertile RVSI group vs RVSI=0	7.03 (3.22–15.35)	<0.0001
Congestion stages	1.86 (1.49–2.33)	<0.0001
Stage 1 congestion vs stage 0	2.37 (1.05–5.35)	0.0373
Stage 2 congestion vs stage 0	6.22 (2.79–13.87)	<0.0001
Stage 3 congestion vs stage 0	6.39 (2.73–14.97)	<0.0001
Venous impedance index	12.59 (3.20–49.45)	<0.0001
Neurohormonal status		
BNP	1.00 (1.00–1.00)	<0.0001
Copeptin	1.03 (1.02–1.04)	<0.0001
Hydration status		
Pleural effusion	2.15 (1.10–4.21)	0.0256
Intra-abdominal pressure measurement		
Intra-abdominal pressure	1.22 (1.13–1.32)	<0.0001
Abdominal perfusion pressure§	0.97 (0.95–0.99)	0.0098

All available study variables were included in the univariate analysis, but only variables that were significant in the univariate analysis are presented here. *eGFR was calculated with the MDRD equation based on serum creatinine.[25] †eGFR was calculated with the CKD-EPI equation based on serum creatinine.[23] ‡eGFR was calculated with the CKD-EPI equation based on serum creatinine and cystatin C.[22] §The abdominal perfusion pressure was calculated using the equation: MAP–intra-abdominal pressure, while MAP was calculated as (systolic blood pressure+2x diastolic pressure)/3.[24]

6MWD=6-min walk distance; α1MCR=α1-microglobulin-to-creatinine ratio; BNP=b-type natriuretic peptide; CKD-EPI=Chronic Kidney Disease Epidemiology Collaboration; CI=confidence interval; E/e’ ratio=ratio of mitral inflow velocity to lateral annular relaxation velocity; eGFR=estimated glomerular filtration rate; FeNa=fractional excretion of sodium; HR=hazard ratio; IVC=inferior vena cava; LA=left atrial; LVEDD=left ventricular end-diastolic diameter; MAP=mean arterial pressure; MDRD=Modification of Diet in Renal Disease;

NYHA=New York Heart Association; PAP=pulmonary arterial pressure; PCWP=pulmonary capillary wedge pressure; PH=pulmonary hypertension; PVR=pulmonary vascular resistance; RA=right atrial; RAP=right atrial pressure; RV=right ventricular; RV S'=systolic annular tissue velocity of the lateral tricuspid annulus; RVSI=renal venous stasis index; TAPSE=tricuspid annular plane systolic excursion.

Table S12. Predictors of death from any cause by the univariate Cox proportional hazard model.

	Univariate	
Predictor	**HR (95% CI)**	**p value**
Baseline clinical data		
Sex	0.30 (0.12–0.77)	0.0127
6MWD	1.0 (0.99–1.00)	0.0239
NYHA classification	2.65 (1.30–5.41)	0.0074
Uric acid	1.25 (1.09–1.43)	0.0018
Hemodynamics		
RAP	1.08 (1.02–1.15)	0.0149
Mixed venous oxygen saturation	0.92 (0.88–0.96)	<0.0001
Echocardiographic parameters		
TAPSE	0.88 (0.80–0.96)	0.0045
RV S'	0.74 (0.64–0.87)	<0.0001
TAPSE/Systolic PAP ratio	0.01 (0.00–0.17)	0.011
RA area	1.10 (1.04–1.17)	0.0018
RV diameter	1.07 (1.02–1.12)	0.0076
Renal function		
Serum creatinine	2.14 (1.05–4.40)	0.0376
Urea	1.01 (1.00–1.02)	0.0262
Renal Doppler ultrasonography		
RVSI tertiles		0.065
1st tertile RVSI group vs RVSI=0	2.00 (0.48–8.38)	0.342
2nd tertile RVSI group vs RVSI=0	1.25 (0.25–6.17)	0.788
3rd tertile RVSI group vs RVSI=0	4.33 (1.19–15.72)	0.026
Congestion stages	1.39 (1.10–1.77)	0.0066
Stage 1 congestion vs stage 0	1.29 (0.31–5.38)	0.732
Stage 2 congestion vs stage 0	3.84 (1.02–14.48)	0.0469
Stage 3 congestion vs stage 0	4.03 (0.96–16.86)	0.0564
Neurohormonal status		
BNP	1.00 (1.00–1.00)	0.0012
Copeptin	1.02 (1.00–1.04)	0.0193
Intra-abdominal pressure measurement		
Intra-abdominal pressure	1.22 (1.06–1.41)	0.0069

All available study variables were included in the univariate analysis, but only variables that were significant in the univariate analysis are presented here.

6MWD=6-min walk distance; BNP=b-type natriuretic peptide; CI=confidence interval; HR=hazard ratio; NYHA=New York Heart Association; PAP=pulmonary arterial pressure; RA=right atrial; RAP=right atrial pressure; RV=right ventricular; RV S'=systolic annular tissue velocity of the lateral tricuspid annulus; RVSI=renal venous stasis index; TAPSE=tricuspid annular plane systolic excursion.

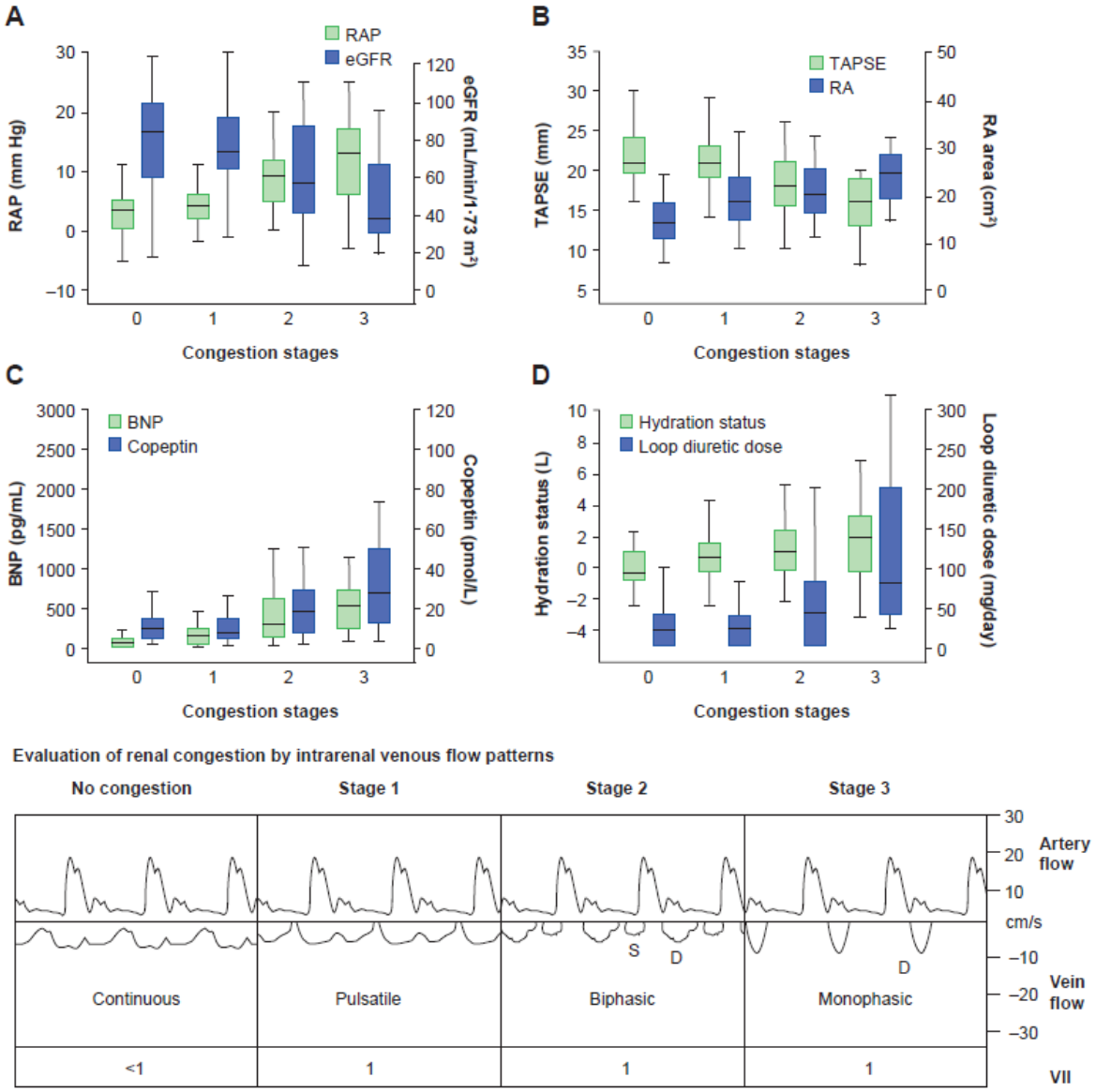
Table S13. Performance of RVSI versus IRVF patterns in models including both variables for prediction of secondary endpoints.

	Wald statistic		
Secondary endpoint	Unplanned hospitalization due to fluid overload	Escalation of PH-specific therapy	All-cause mortality
RVSI	6.163	0.721	0.611
IRVF patterns	0.996	2.675	0.204

Higher Wald statistic indicates superiority for prediction of endpoint. RVSI was superior to IRVF patterns in models including both RVSI and IRVF patterns as predictor variables for all component endpoints except need for escalation of PH-specific therapy.

IRVF=intrarenal venous flow; PH=pulmonary hypertension; RVSI=renal venous stasis index.

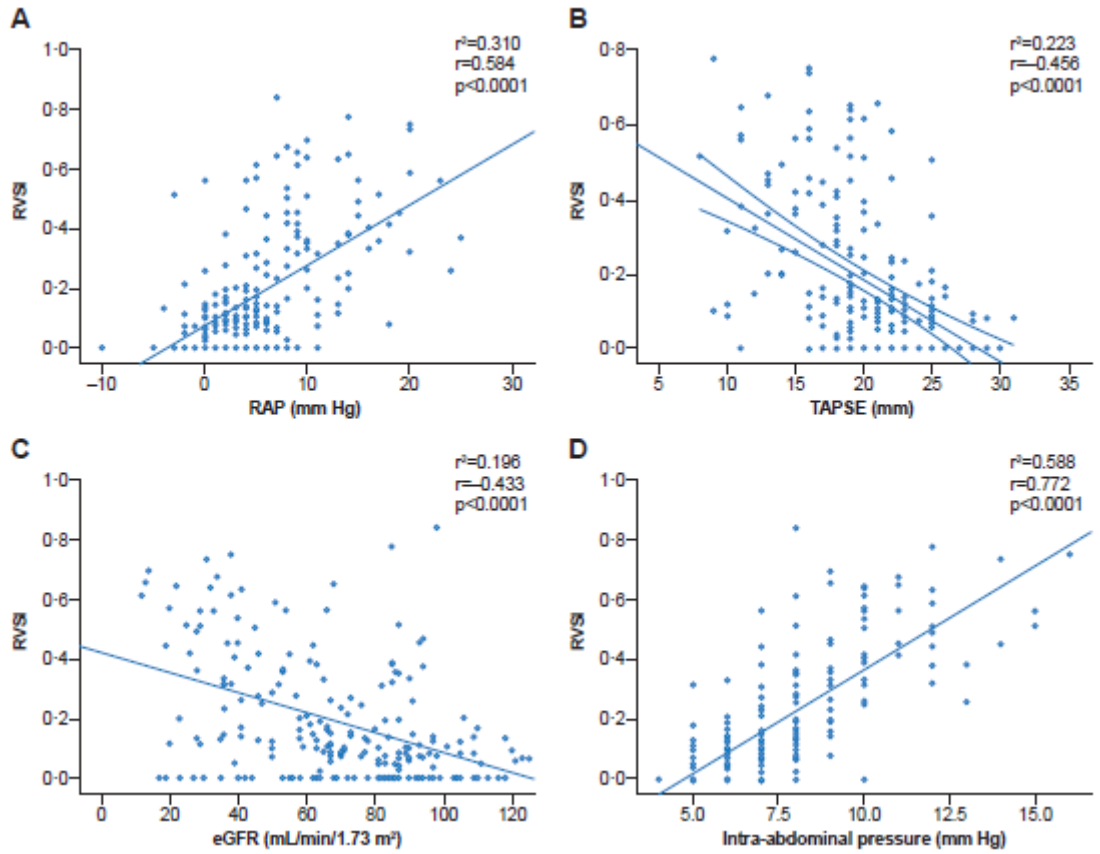
Figure S1. IRVF patterns and associated clinical parameters.



Severity of renal congestion can be evaluated by identifying four distinct IRVF patterns using renal Doppler ultrasonography. The figure illustrates the associations of these IRVF patterns with RAP and renal function **(a)**, right ventricular systolic function and right atrial area **(b)**, neurohormonal **(c)**, and hydration status **(d)**. Fluid overload as measured by bioimpedance is likely to occur as a result of hemodynamic alterations and neurohormonal activation leading to a deterioration of renal function and fluid retention.

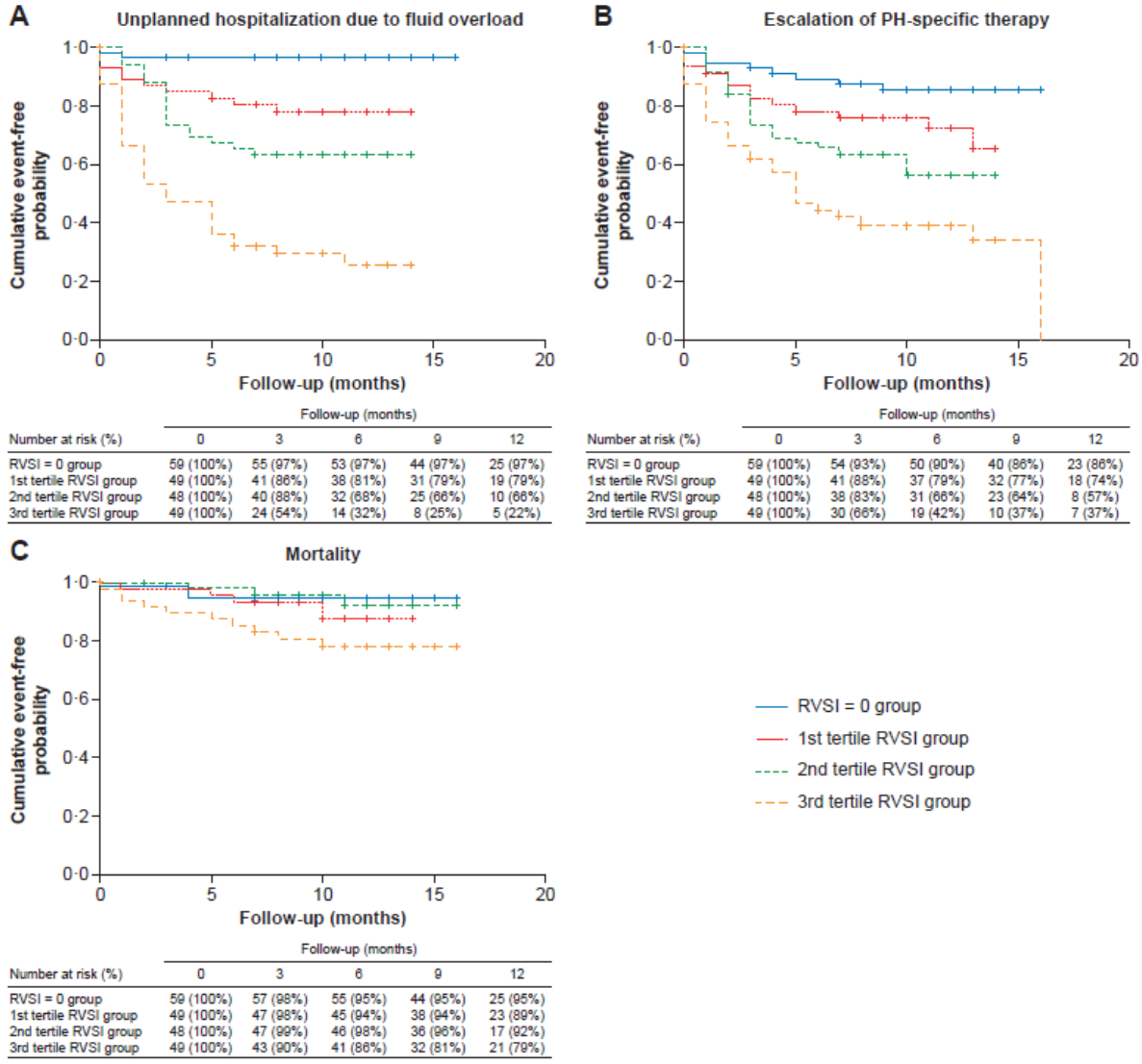
BNP=b-type natriuretic peptide; D=diastole; eGFR=estimated glomerular filtration rate (based on Chronic Kidney Disease Epidemiology Collaboration creatinine-cystatin C equation[22]); IRVF=intrarenal venous flow; RA=right atrial; RAP=right atrial pressure; S=systole; TAPSE=tricuspid annular plane systolic excursion; VII=venous impedance index.

Figure S2. Correlation of RVSI with RAP (a), TAPSE (b), eGFR (c), and intra-abdominal pressure (d).



eGFR=estimated glomerular filtration rate (based on Chronic Kidney Disease Epidemiology Collaboration creatinine-cystatin C equation[22]); RAP=right atrial pressure; RVSI=renal venous stasis index; TAPSE=tricuspid annular plane systolic excursion.

Figure S3. Kaplan-Meier estimate curves according to RVSI tertiles.



Number at risk (%)	Follow-up (months) 0	3	6	9	12
RVSI = 0 group	59 (100%)	55 (97%)	53 (97%)	44 (97%)	25 (97%)
1st tertile RVSI group	49 (100%)	41 (86%)	38 (81%)	31 (79%)	19 (79%)
2nd tertile RVSI group	48 (100%)	40 (88%)	32 (68%)	25 (66%)	10 (66%)
3rd tertile RVSI group	49 (100%)	24 (54%)	14 (32%)	8 (25%)	5 (22%)

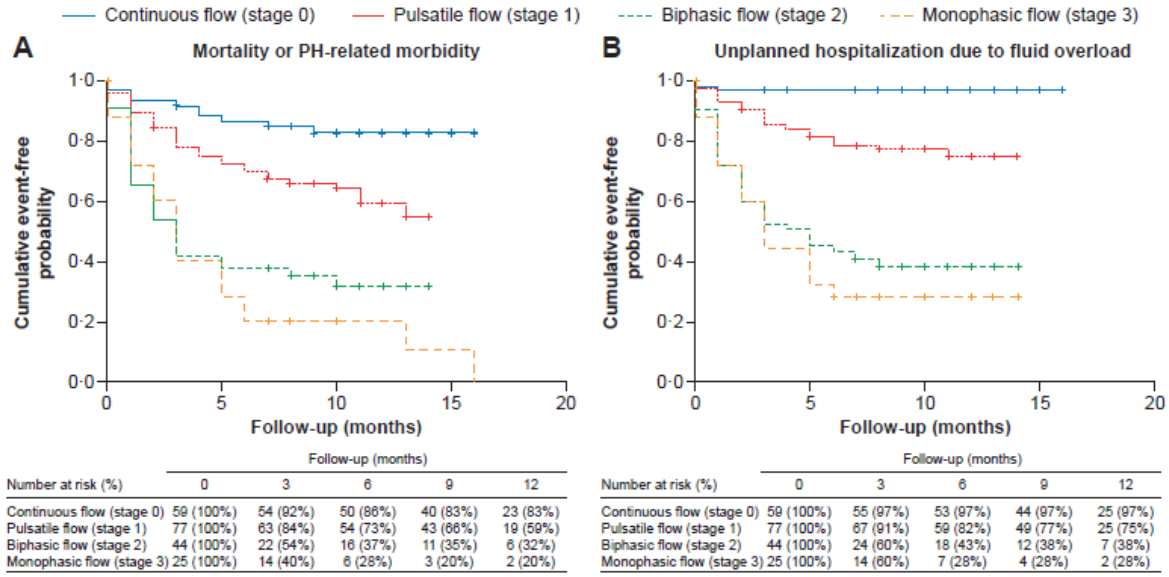
Number at risk (%)	Follow-up (months) 0	3	6	9	12
RVSI = 0 group	59 (100%)	54 (93%)	50 (90%)	40 (86%)	23 (86%)
1st tertile RVSI group	49 (100%)	41 (88%)	37 (79%)	32 (77%)	18 (74%)
2nd tertile RVSI group	48 (100%)	38 (83%)	31 (66%)	23 (64%)	8 (57%)
3rd tertile RVSI group	49 (100%)	30 (66%)	19 (42%)	10 (37%)	7 (37%)

Number at risk (%)	Follow-up (months) 0	3	6	9	12
RVSI = 0 group	59 (100%)	57 (98%)	55 (95%)	44 (95%)	25 (95%)
1st tertile RVSI group	49 (100%)	47 (98%)	45 (94%)	38 (94%)	23 (89%)
2nd tertile RVSI group	48 (100%)	47 (99%)	46 (98%)	36 (96%)	17 (92%)
3rd tertile RVSI group	49 (100%)	43 (90%)	41 (86%)	32 (81%)	21 (79%)

Patients in the 3rd tertile RVSI group had a significantly higher probability than other patients of the following individual components of the composite endpoint: unscheduled hospitalization for fluid overload ($p<0.0001$) **(a)** and escalation of PH-specific therapy ($p<0.0001$) **(b)**. After Bonferroni correction, death from any cause did not show a significant difference between patients in the 3rd tertile RVSI group and other patients ($p=0.0412$) **(c)**.

PH=pulmonary hypertension; RVSI = renal venous stasis index.

Figure S4. Kaplan-Meier estimate curves according to IRVF patterns.



A	Follow-up (months)				
Number at risk (%)	0	3	6	9	12
Continuous flow (stage 0)	59 (100%)	54 (92%)	50 (86%)	40 (83%)	23 (83%)
Pulsatile flow (stage 1)	77 (100%)	63 (84%)	54 (73%)	43 (66%)	19 (59%)
Biphasic flow (stage 2)	44 (100%)	22 (54%)	16 (37%)	11 (35%)	6 (32%)
Monophasic flow (stage 3)	25 (100%)	14 (40%)	6 (28%)	3 (20%)	2 (20%)

B	Follow-up (months)				
Number at risk (%)	0	3	6	9	12
Continuous flow (stage 0)	59 (100%)	55 (97%)	53 (97%)	44 (97%)	25 (97%)
Pulsatile flow (stage 1)	77 (100%)	67 (91%)	59 (82%)	49 (77%)	25 (75%)
Biphasic flow (stage 2)	44 (100%)	24 (60%)	18 (43%)	12 (38%)	7 (38%)
Monophasic flow (stage 3)	25 (100%)	14 (60%)	7 (28%)	4 (28%)	2 (28%)

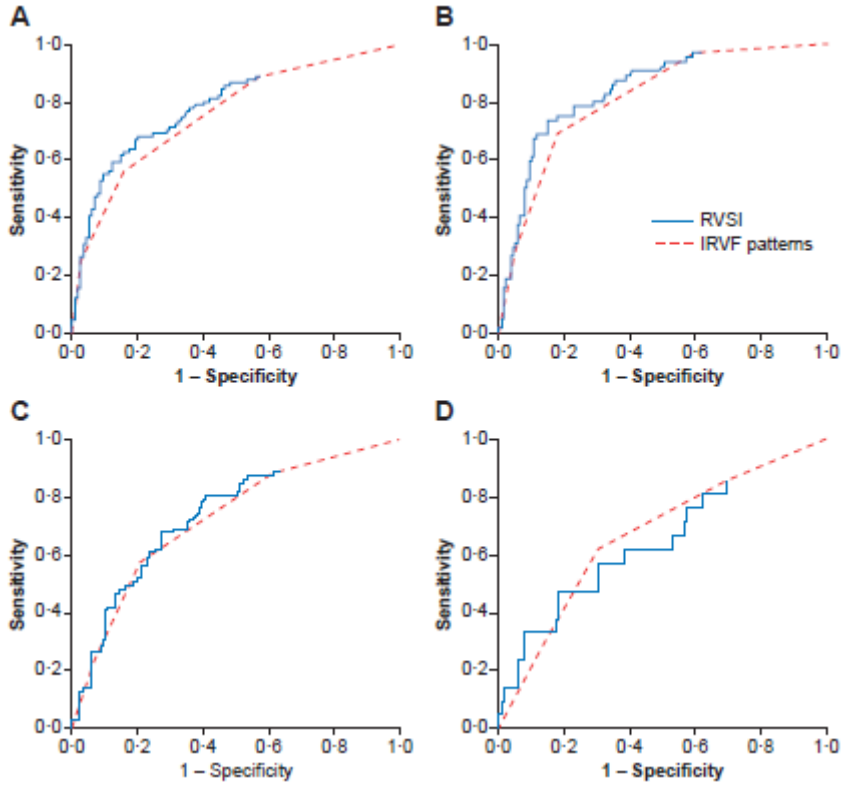
C	Follow-up (months)				
Number at risk (%)	0	3	6	9	12
Continuous flow (stage 0)	59 (100%)	54 (93%)	50 (90%)	40 (86%)	23 (86%)
Pulsatile flow (stage 1)	77 (100%)	64 (87%)	57 (78%)	47 (75%)	23 (71%)
Biphasic flow (stage 2)	44 (100%)	28 (69%)	19 (45%)	13 (43%)	7 (39%)
Monophasic flow (stage 3)	25 (100%)	17 (68%)	11 (47%)	5 (42%)	4 (42%)

D	Follow-up (months)				
Number at risk (%)	0	3	6	9	12
Continuous flow (stage 0)	59 (100%)	57 (98%)	55 (95%)	44 (95%)	25 (95%)
Pulsatile flow (stage 1)	77 (100%)	74 (99%)	72 (96%)	60 (96%)	33 (92%)
Biphasic flow (stage 2)	44 (100%)	39 (91%)	38 (88%)	29 (84%)	20 (8%)
Monophasic flow (stage 3)	25 (100%)	24 (96%)	22 (88%)	17 (84%)	8 (79%)

Patients in the highest IRVF pattern group had a significantly higher probability than other patients of the composite endpoint of PH-related morbidity or death from any cause (p<0.0001) **(a)** and the following individual components of the composite endpoint: unscheduled hospitalization for fluid overload (p<0.0001) **(b)** and escalation of PH-specific therapy (p<0.0001) **(c)**. After Bonferroni correction, death from any cause did not show a significant difference between patients in the highest IRVF pattern group and other patients (p=0.0387) **(d)**.

IRVF=intrarenal venous flow; PH=pulmonary hypertension.

Figure S5. Comparison of RVSI and IRVF patterns as predictors of the primary and secondary clinical endpoints.



Receiver operating characteristic analyses indicate that RVSI was superior to the four IRVF patterns as a predictor of the composite primary endpoint (AUC: 0.789 and 0.761, respectively; p=0.038) **(a)**, and for the prediction of unplanned hospitalization due to fluid overload (AUC: 0.843 and 0.813, respectively; p=0.045) **(b)** but not escalation of pulmonary hypertension-specific therapy (AUC: 0.737 and 0.724, respectively; p=0.36) **(c)**, nor all-cause mortality (AUC: 0.650 and 0.668, respectively; p=0.37) **(d)**. Diagonal segments are produced by ties.

AUC=area under the curve; IRVF=intrarenal venous flow; RVSI=renal venous stasis index.

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