Myocardial stunning και regional wall motion abnormalities: το κλειδί για την κατανόηση του αιφνίδιου θανάτου σε ασθενείς υπό αιμοκάθαρση;

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Επίκουρος Καθηγητής Καρδιολογίας ΑΠΘ

Α’ Καρδιολογική Κλινική ΠΓΝΘ ΑΧΕΠΑ

Sudden Cardiac Death in Hemodialysis Patients: An In-Depth Review

Darren Green, MBChB,[1] Paul R. Roberts, MD,[2] David I. New, PhD,[1] and Philip A. Kalra, MD[1]

Ά Καρδιολογική Κλινική ΑΧΕΠΑ

Sudden and unexpected death accounts for 1 in 4 deaths in patients with end-stage renal disease (ESRD)

Box 2. Current Indications for ICD Device Therapy in the General Population

- Survival of cardiac arrest due to VT or ventricular fibrillation
- Episode of sustained VT causing severe hemodynamic compromise
- Episode of sustained VT without hemodynamic compromise + EF <35%
- MI + EF <35% + nonsustained VT on 24-h ECG + inducible VT on electrophysiologic testing
- MI + EF <30% + QRS duration ≥120 ms on ECG

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ndt
Nephrology Dialysis Transplantation

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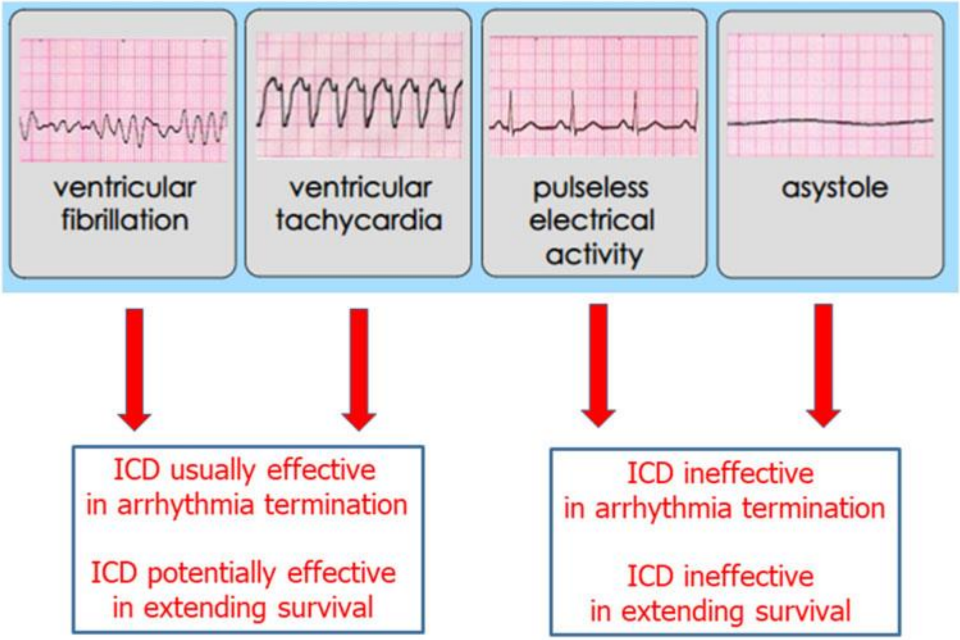
Sudden cardiac death in dialysis patients: different causes and management strategies

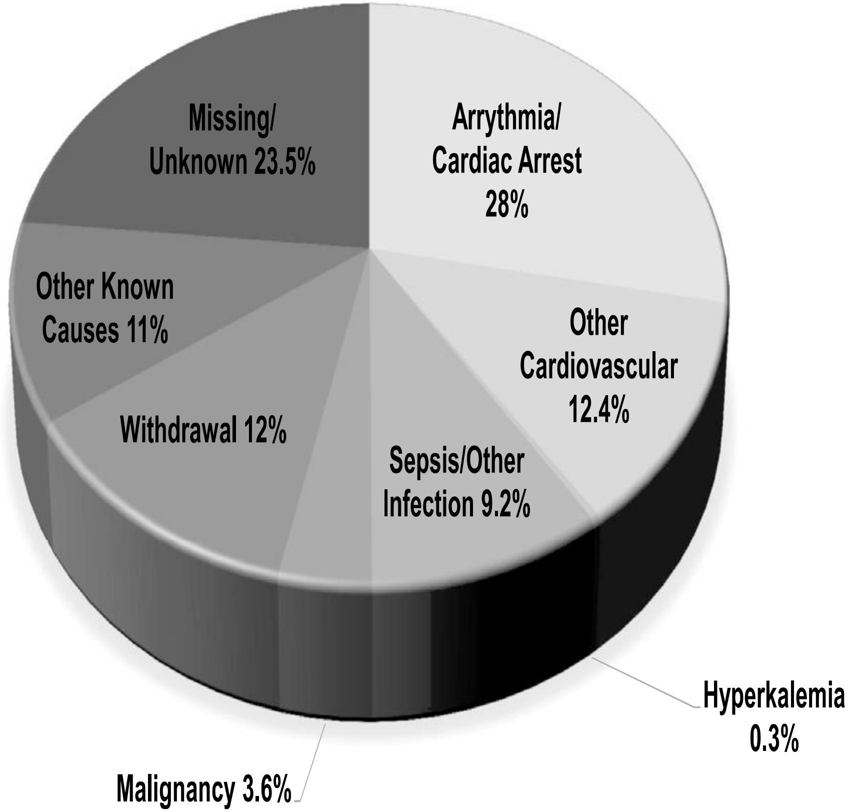
Simonetta Genovesi [1,2], Giuseppe Boriani [3], Adrian Covic[4,5], Robin W.M. Vernooij[6,7], Christian Combe [8,9], Alexandru Burlacu [5,10], Andrew Davenport[11], Mehmet Kanbay[12], Dimitrios Kirmizis[13], Daniel Schneditz[14], Frank van der Sande[15] and Carlo Basile[16,17] on behalf of the EUDIAL Working Group of ERA-EDTA



Sudden Cardiac Death Among Hemodialysis Patients

Melissa S. Makar, MD,[1,2] *and Patrick H. Pun, MD, MHS*[1,2]

Ά Καρδιολογική Κλινική ΑΧΕΠΑ



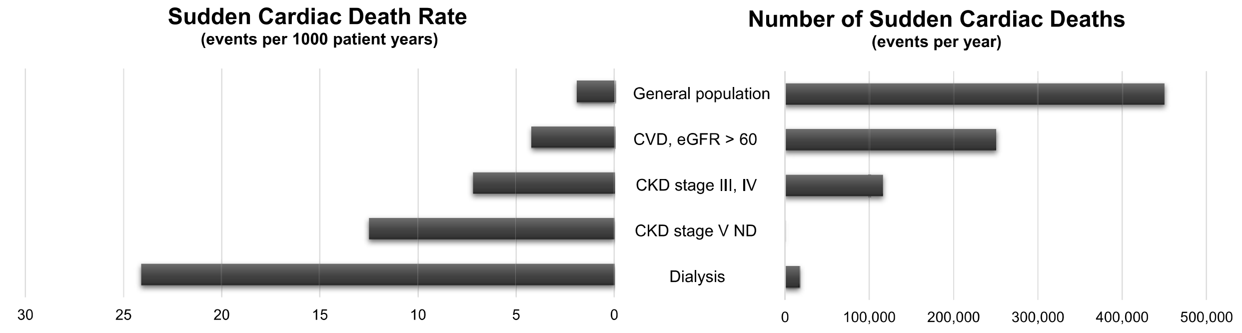
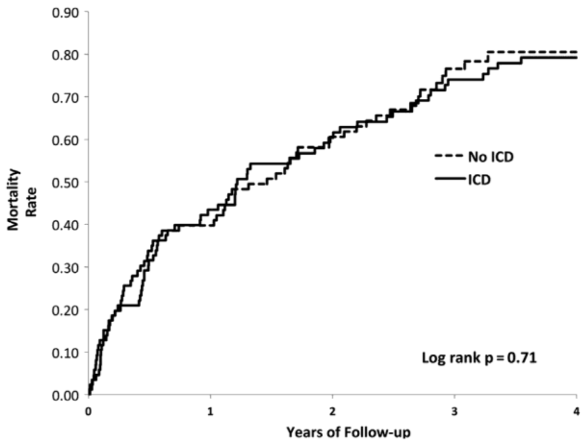


Figure 2. Rates of sudden cardiac death in (left) selected populations and (right) absolute numbers of affected individuals. Abbreviations: CKD, chronic kidney disease; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate; ND, nondialysis.[16,23]



AJKD 2017

Sudden Cardiac Death Among Hemodialysis Patients

Melissa S. Makar, MD,[1,2] *and Patrick H. Pun, MD, MHS*[1,2]

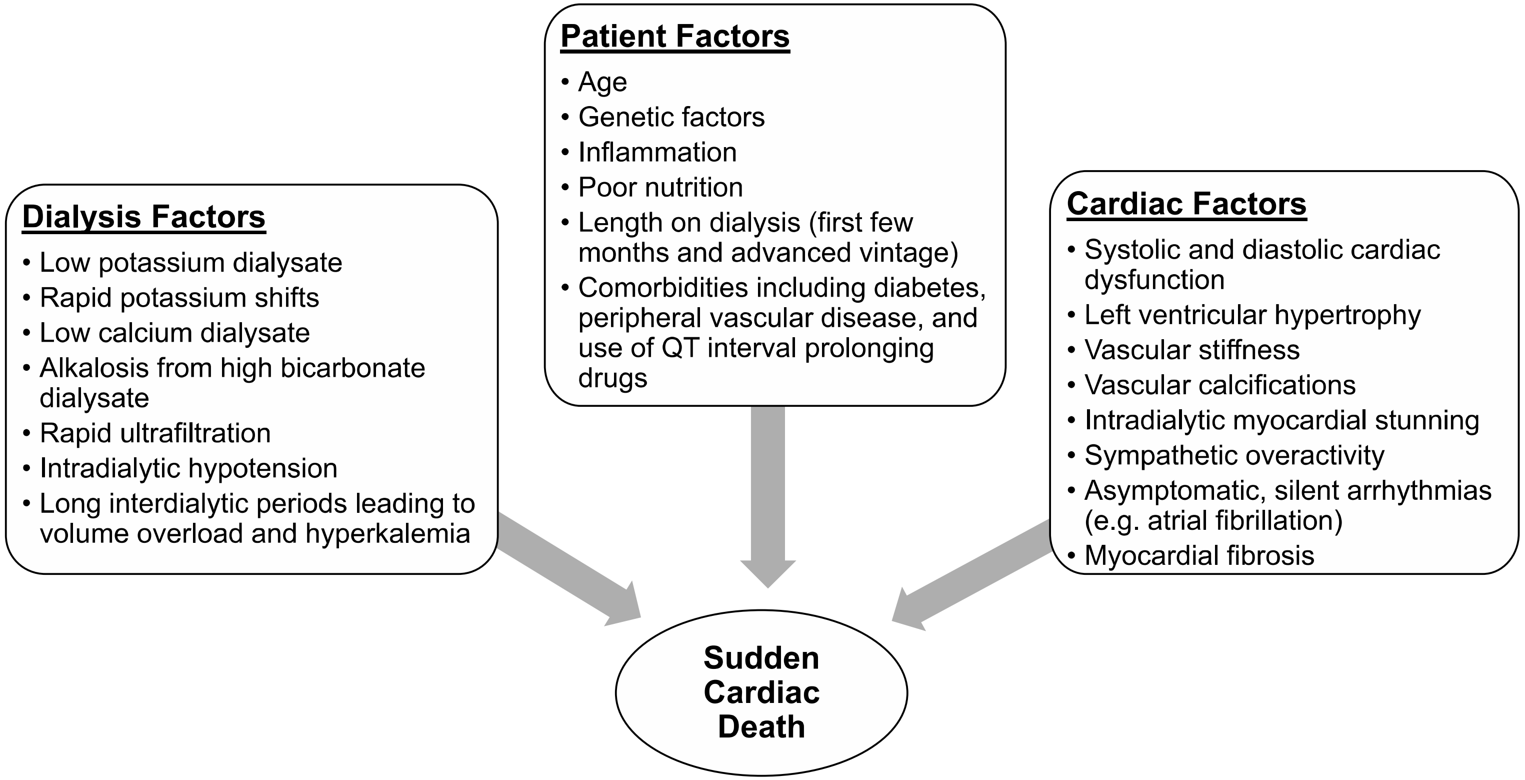


Figure 4. Major hypothesized risk factors for sudden cardiac death including postulated pathophysiology of sudden cardiac death. Based on information in Di Lullo et al.[78]

Risk Assessment for Sudden Cardiac Death in Dialysis Patients

Palaniappan Saravanan, MD, MRCP; Neil C. Davidson, MD, FRCP

Table 1. Factors Predisposing Dialysis Patients to Ventricular Arrhythmias and SCD

	Factors
Hemodynamic and biochemical factors	Volume overload
	Electrolyte abnormalities, particularly hyper- and hypokalemia
	Changes in calcium and phosphate metabolism and hyperparathyroidism
	Alterations in acid-base balance (blood pH and bicarbonate levels)
	Anemia
	Hypertension
Autonomic and endocrine factors	Loss of vagal tone due to uremia (uremic autonomic neuropathy)
	Reduced catabolism of circulating adrenergic hormones
	Diabetic autonomic neuropathy
	Activation of renin-angiotensin-aldosterone axis
Changes to the substrate	LVH/dilation
	LVSD
	Diffuse myocardial fibrosis altering conduction and repolarization
	Atrial dilation/stretch due to chronic fluid overload
	Scars of previous myocardial infarctions
Precipitating factors	Rapid fluctuations in volume status and blood pressure around dialysis
	Fluctuations in electrolytes, particularly potassium, around dialysis
	Acute coronary ischemia
	Hypoxia due to sleep apnea
	Acute changes in autonomic regulation during dialysis

ESC European Society of Cardiology
European Heart Journal (2019) **40**, 237–269
doi:10.1093/eurheartj/ehy462

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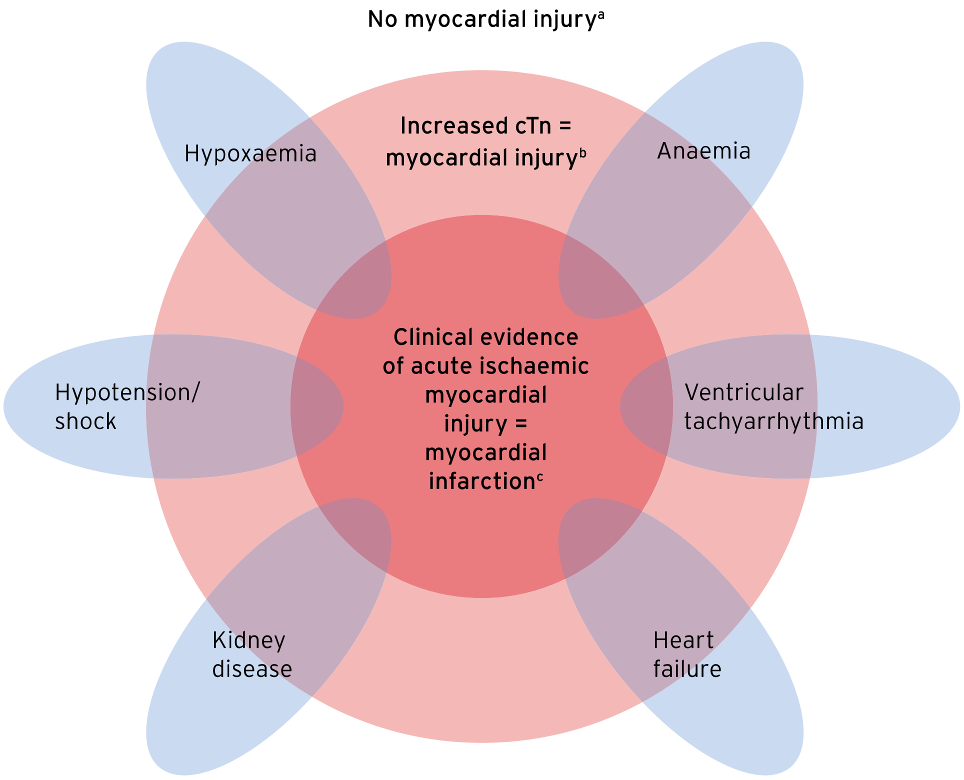
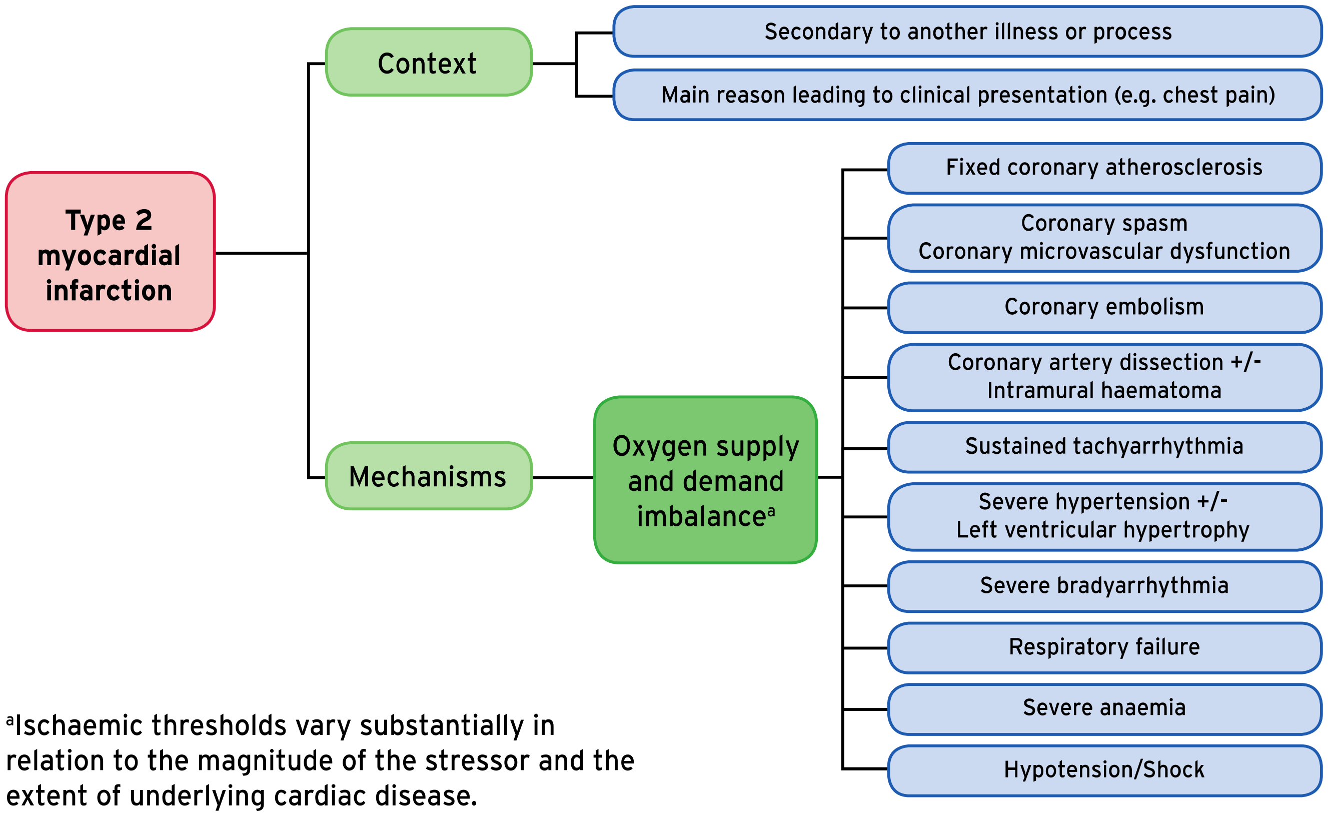
Fourth universal definition of myocardial infarction (2018)





[a]Ischaemic thresholds vary substantially in relation to the magnitude of the stressor and the extent of underlying cardiac disease.

ESC European Society of Cardiology
European Heart Journal (2019) **40**, 237–269
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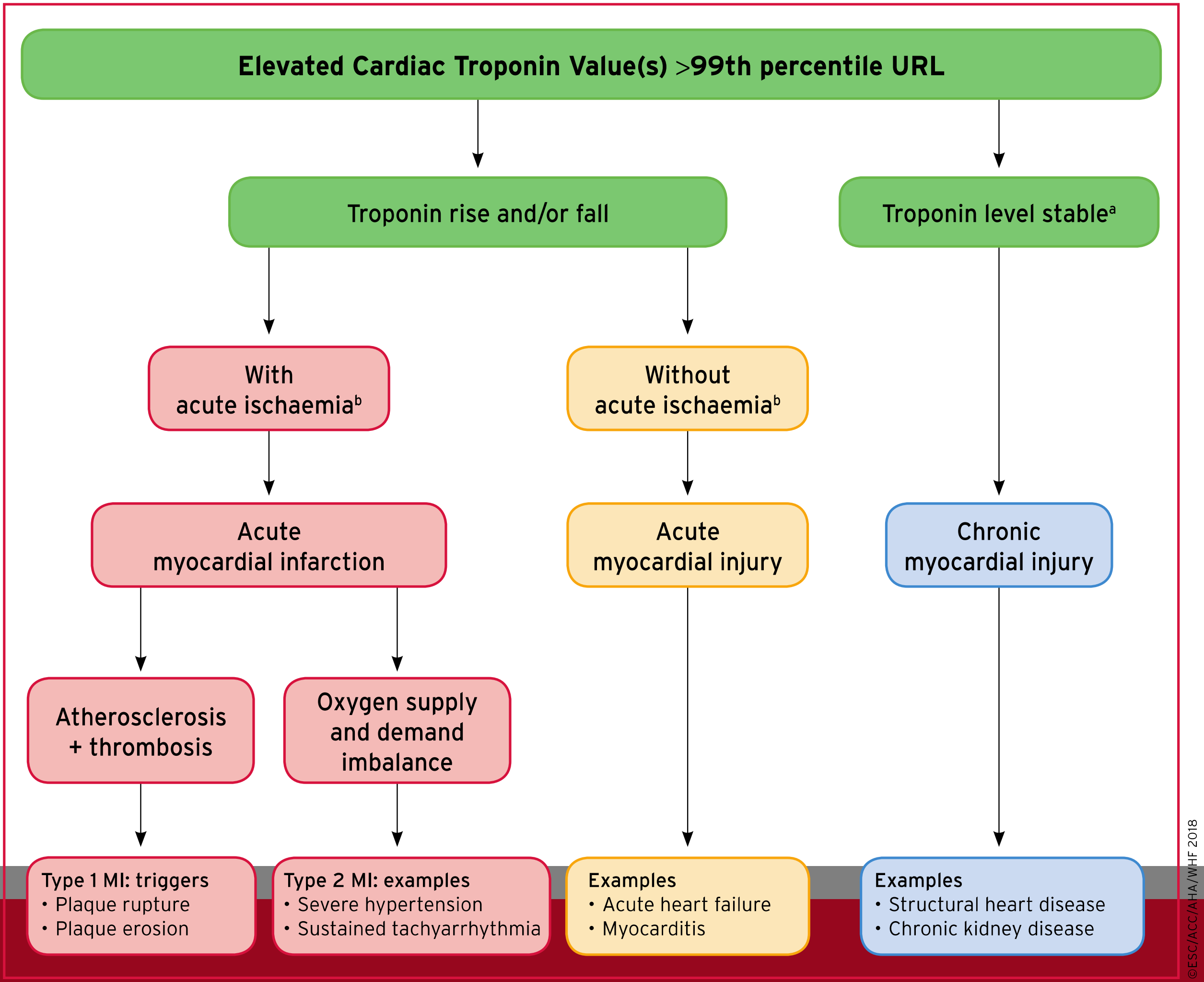


Table 1 Reasons for the elevation of cardiac troponin values because of myocardial injury

Myocardial injury related to acute myocardial ischaemia
Atherosclerotic plaque disruption with thrombosis.
Myocardial injury related to acute myocardial ischaemia because of oxygen supply/demand imbalance
Reduced myocardial perfusion, e.g. • Coronary artery spasm, microvascular dysfunction • Coronary embolism • Coronary artery dissection • Sustained bradyarrhythmia • Hypotension or shock • Respiratory failure • Severe anaemia
Increased myocardial oxygen demand, e.g. • Sustained tachyarrhythmia • Severe hypertension with or without left ventricular hypertrophy
Other causes of myocardial injury
Cardiac conditions, e.g. • Heart failure • Myocarditis • Cardiomyopathy (any type) • Takotsubo syndrome • Coronary revascularization procedure • Cardiac procedure other than revascularization • Catheter ablation • Defibrillator shocks • Cardiac contusion
Systemic conditions, e.g. • Sepsis, infectious disease • Chronic kidney disease • Stroke, subarachnoid haemorrhage • Pulmonary embolism, pulmonary hypertension • Infiltrative diseases, e.g. amyloidosis, sarcoidosis • Chemotherapeutic agents • Critically ill patients • Strenuous exercise

Myocardial Stunning with Hemodialysis: Clinical Challenges of the Cardiorenal Patient

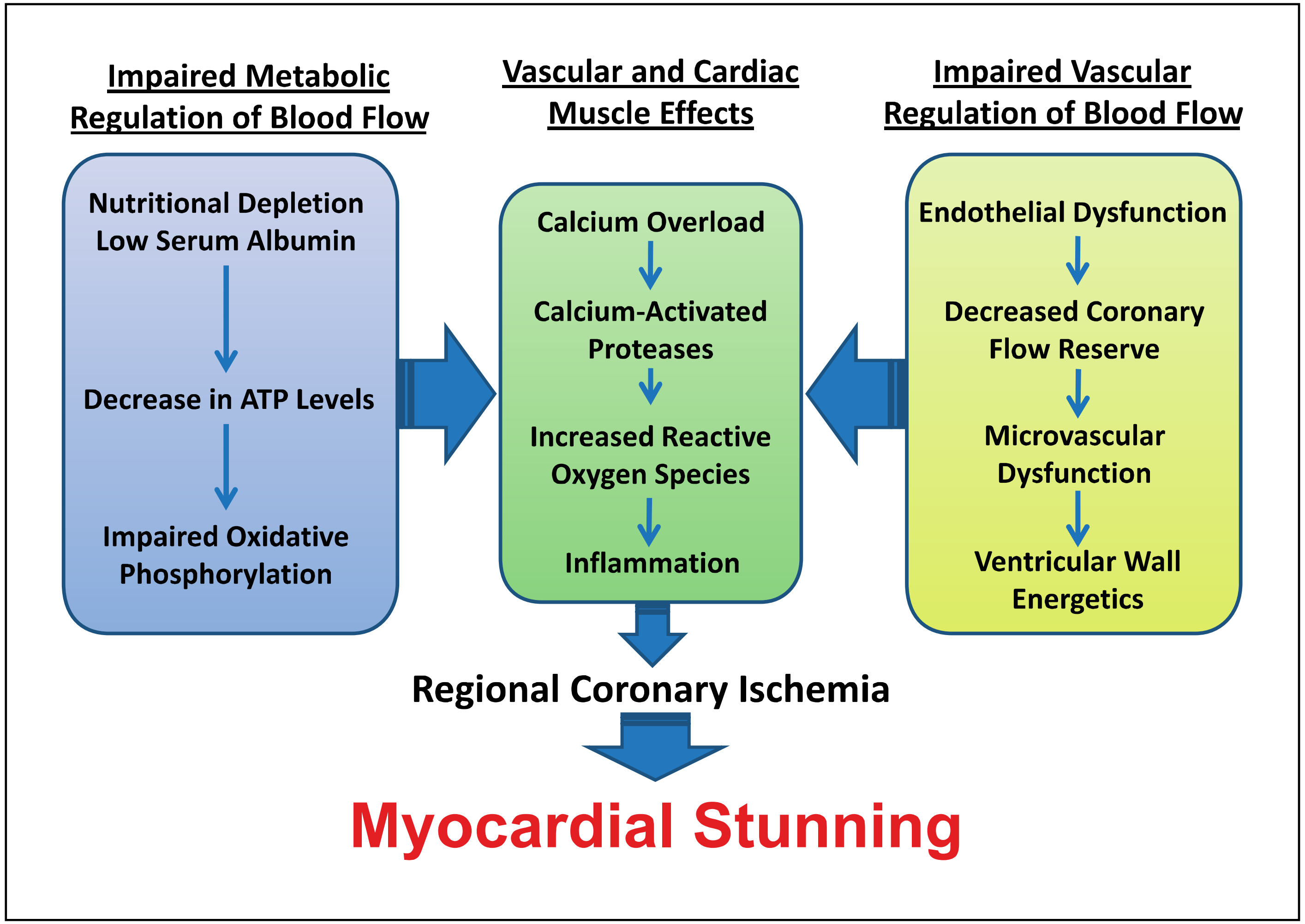
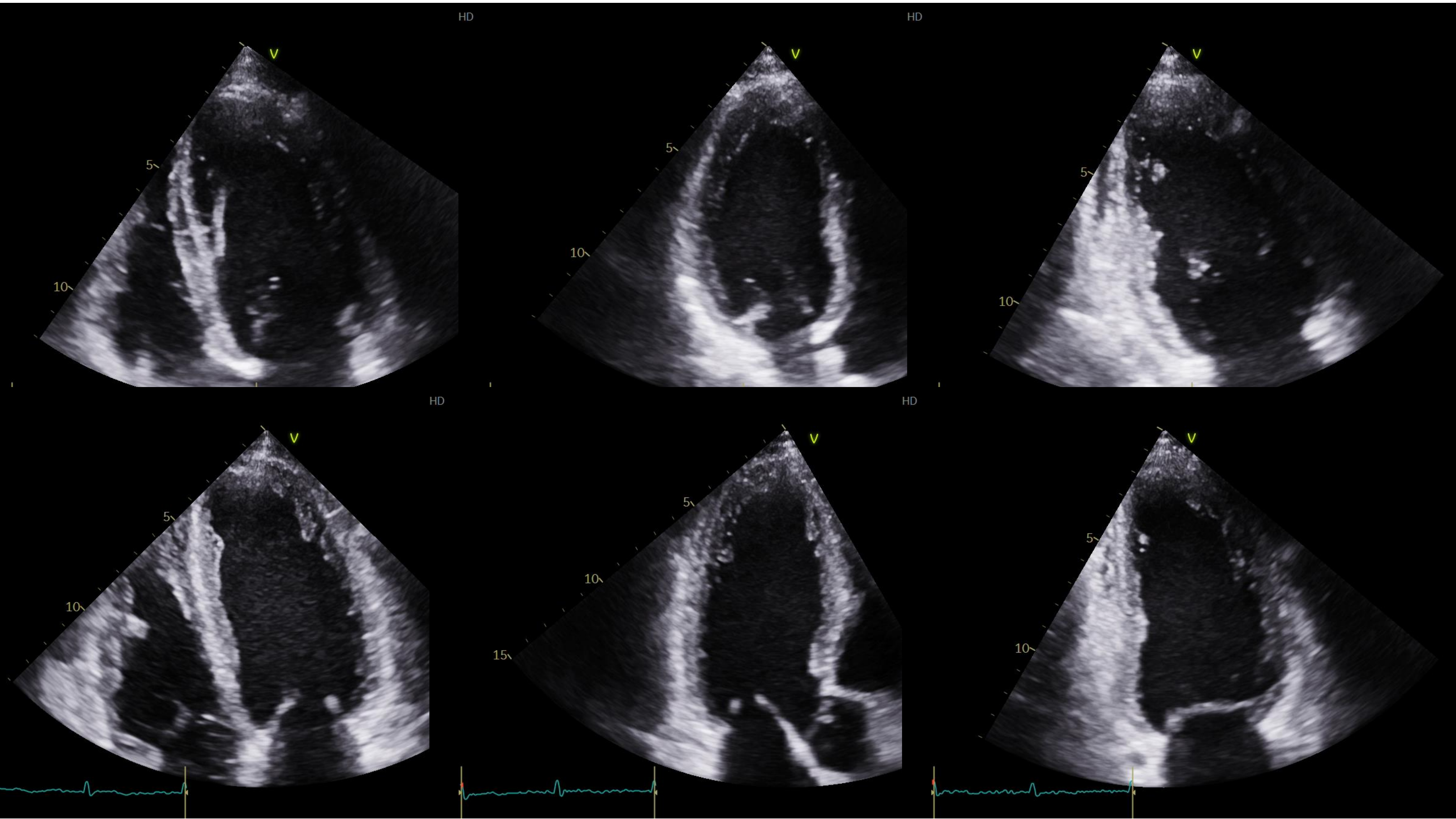


Table 1. Directions for future investigation and clinical implementation

Peritoneal dialysis versus HD
Antioxidants/anti-inflammatory agents
Remote preconditioning
HD protocol
Dialysate temperature (37°C vs. cooled)
Dialysis frequency (daily vs. thrice/week)
Volume removed per session (i.e. decreasing ultrafiltration)
Session duration of dialysis (long vs. short)
Location/vessel of AFV/catheter
Central venous catheter versus AVF versus arteriovenous graft
Flow rate during HD (lower flow rate vs. higher flow rate)


HD
V
5
10
HD
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5
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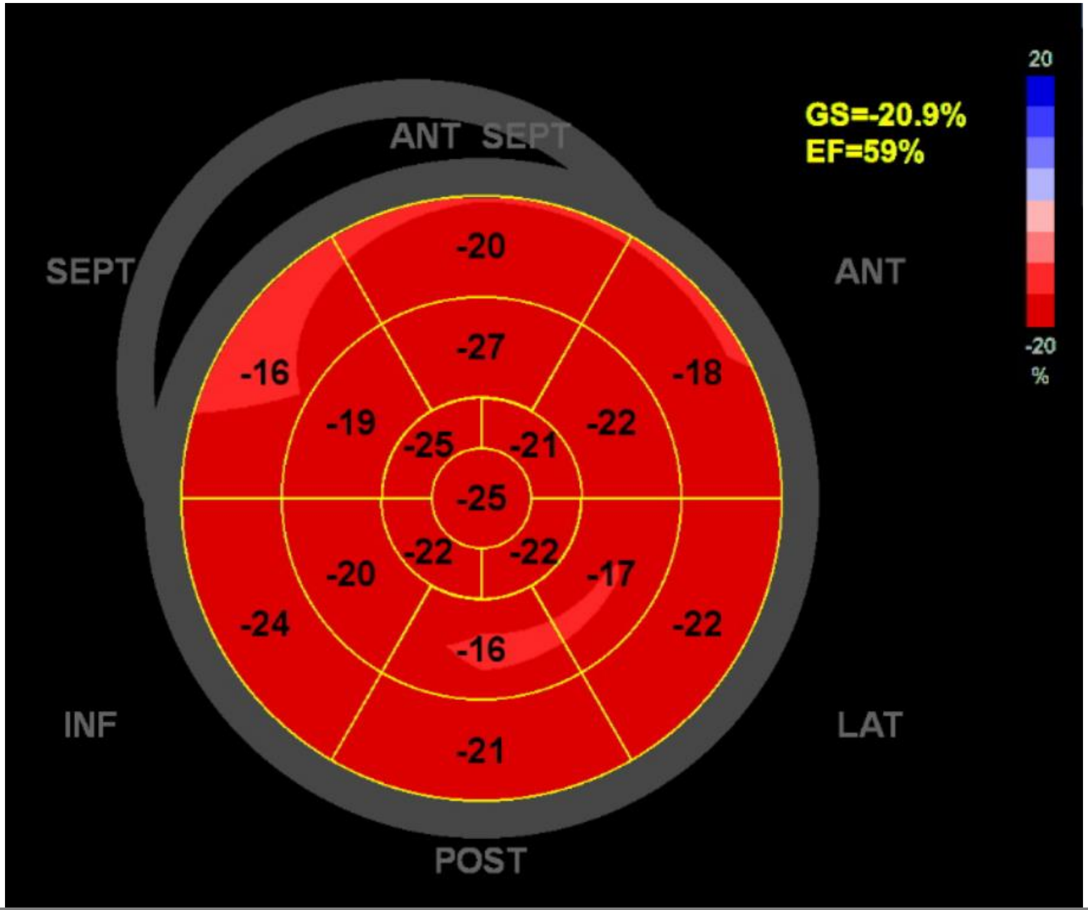
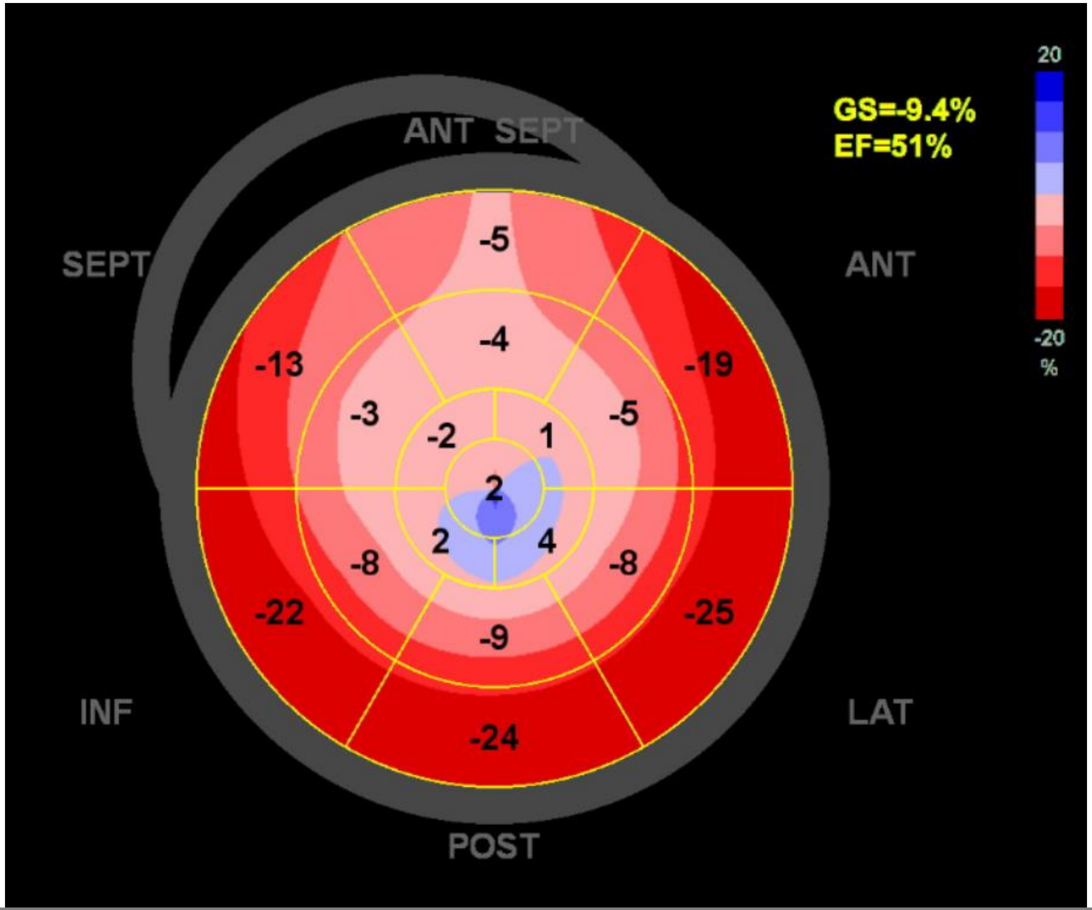
15
V
5
10

Speckle Tracking Left Ventricular Global Longitudinal Strain





Baseline : 2-ch
T1: 0:23
Low : 2-ch
T1: 2:58
Peak : 2-ch
T1: 8:11
Baseline : 2-ch
T1: 0:23
5
10
15
151
5:22HR
60
5:42HR

Myocardial stunning in hemodialysis: What is the overall message?

Smrita DORAIRAJAN,[1,2] Anand CHOCKALINGAM,[1,3] Madhukar MISRA[2]

Table 1 Possible mechanisms/contributors of cardiac dysfunction in hemodialysis (HD) patients

Renal replacement predictors
1. Ultrafiltration rate
2. HD-related hypotension
3. Dialysate temperature
4. Rapid HD performed infrequently
Cardiac predictors
1. Small cardiac chamber size
2. Chamber hypertrophy
3. Epicardial coronary disease with typical ischemia
4. Microvascular endothelial dysfunction
5. Frequent ventricular ectopy and tachycardias
General medical issues
1. Overmedication with antihypertensive agents
2. Reduced fluid intake
3. Volume loss related to sweating, bleeding, etc.
4. Reduced exercise and muscle tone

Chronic Kidney Disease and Coronary Artery Disease

JACC State-of-the-Art Review

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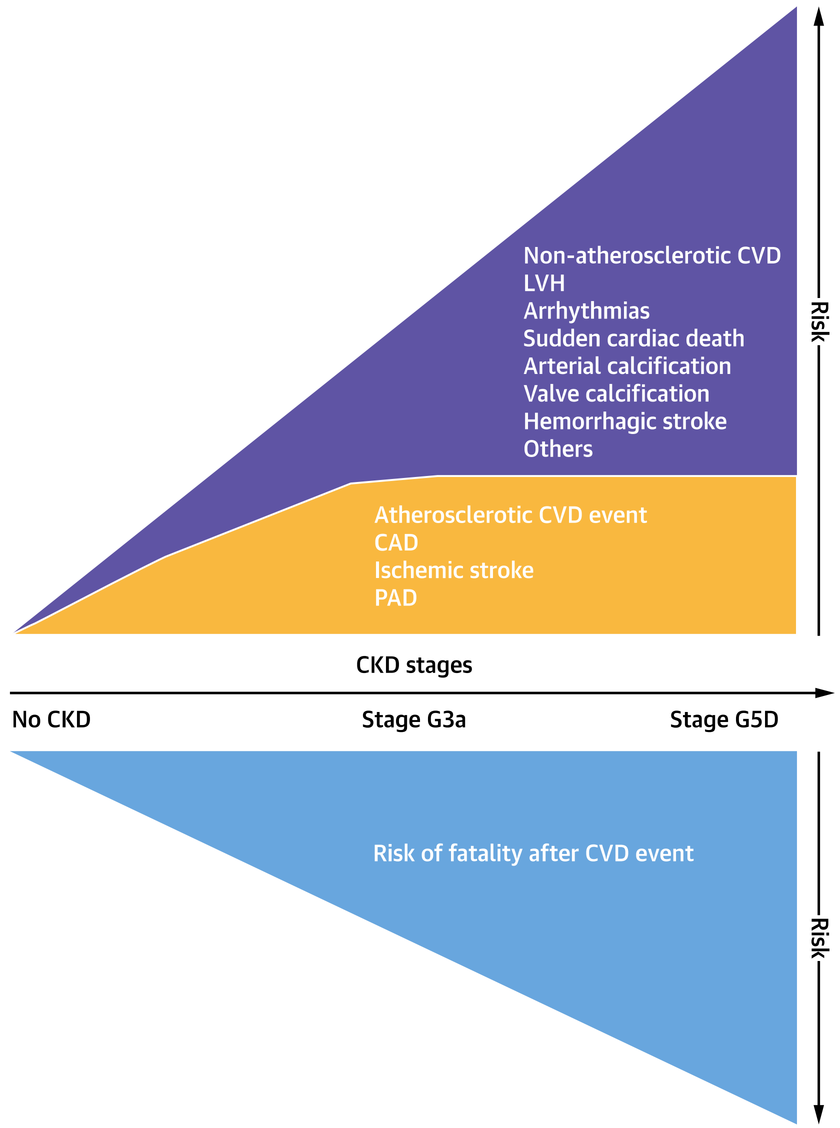
CENTRAL ILLUSTRATION Changes in Cardiovascular Disease Risk During Chronic Kidney Disease Progression



Sarnak, M.J. et al. J Am Coll Cardiol. 2019;74(14):1823-38.

Cardiovascular disease (CVD) event **(upper triangle)**; contributions of atherosclerotic CVD **(yellow)**; nonatherosclerotic CVD **(purple)**, and risk of fatality after CVD event **(blue)**. Reproduced with permission from Wanner et al. (10). CAD = coronary artery disease; LVH = left ventricular hypertrophy.

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Coronary computed tomography angiography in dialysis patients undergoing pre-renal transplantation cardiac risk stratification

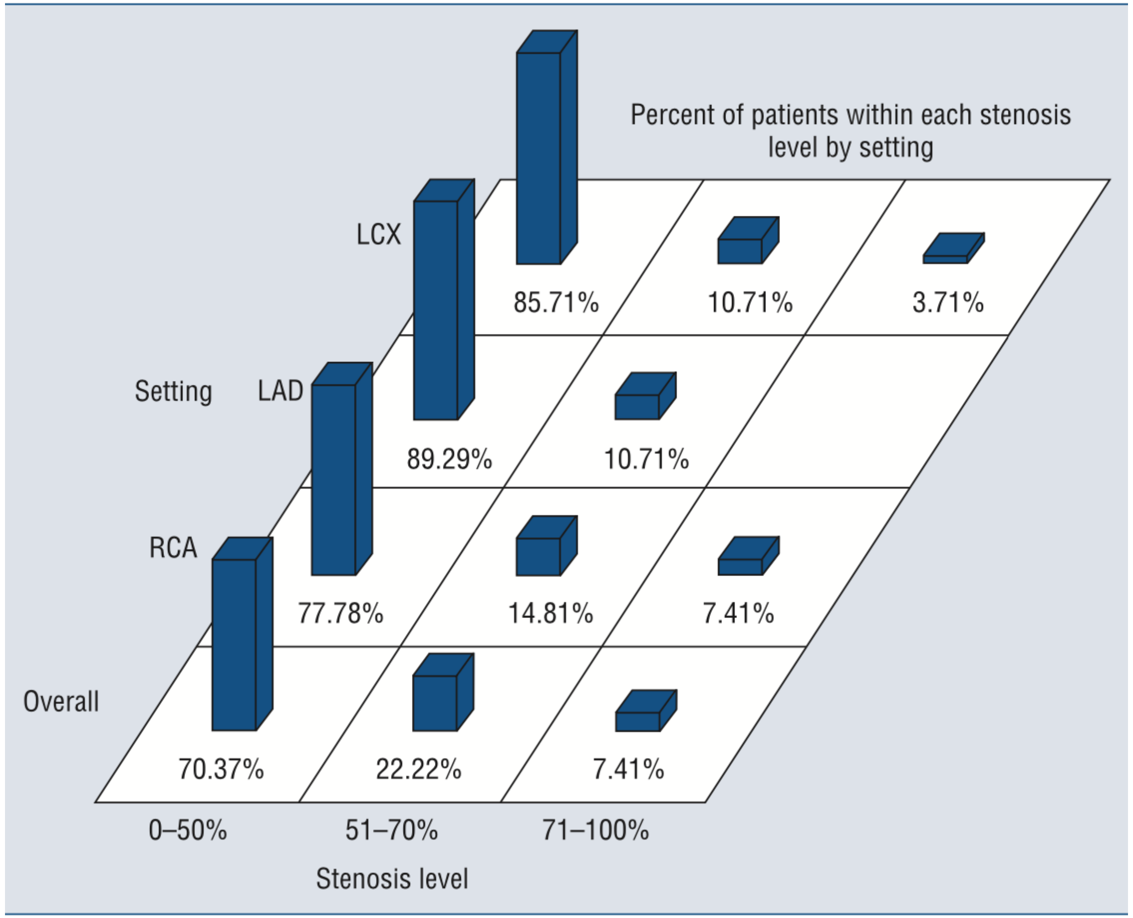
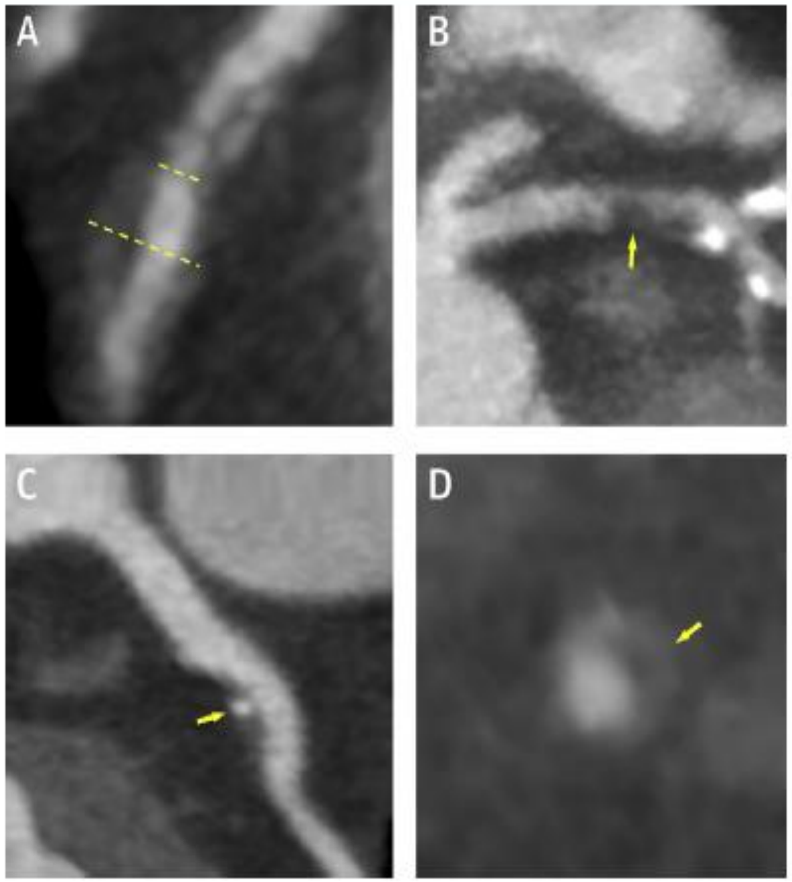
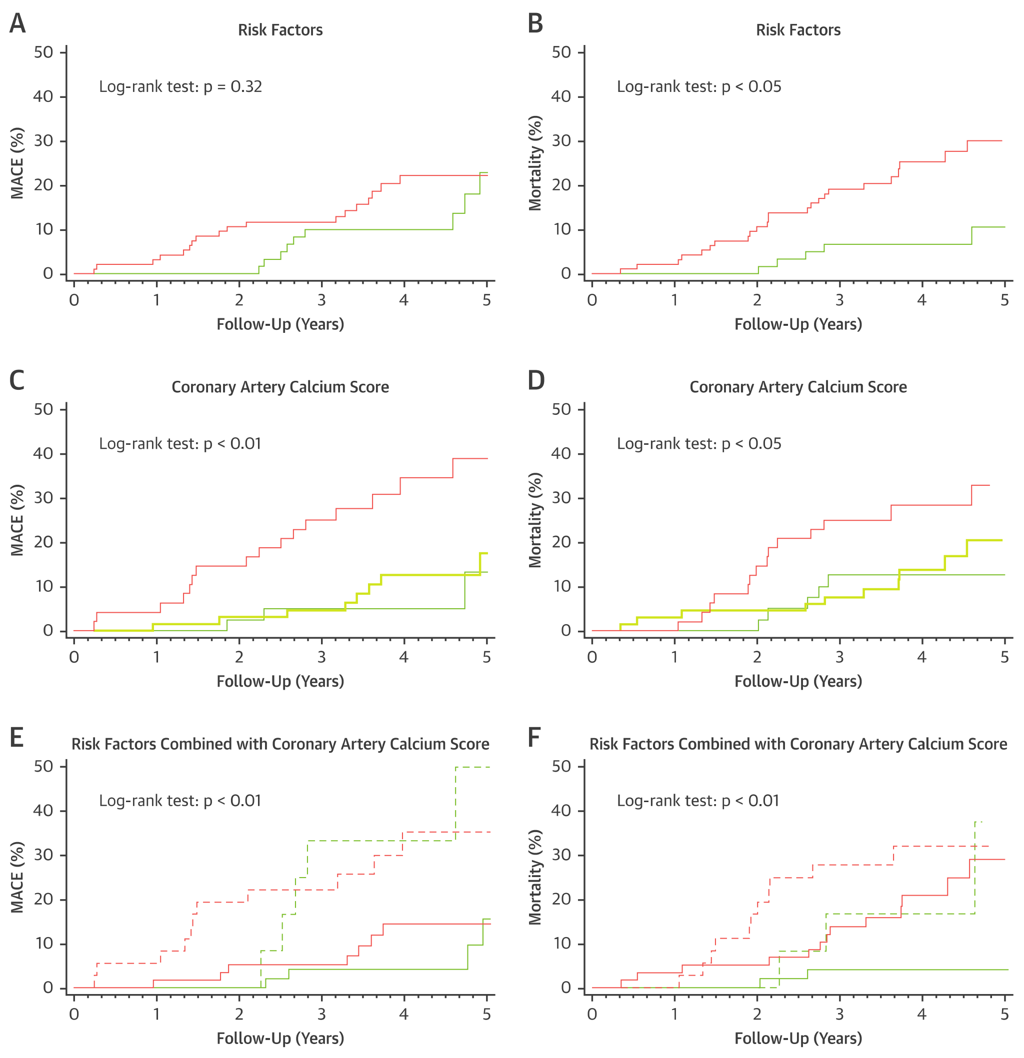


FIGURE 1 Coronary Plaque Characteristics Identified on Computed Tomography Coronary Angiography



Prognostic Value of Risk Factors, Calcium Score, Coronary CTA, Myocardial Perfusion Imaging, and Invasive Coronary Angiography in Kidney Transplantation Candidates

FIGURE 3 Time-to-Event Analysis



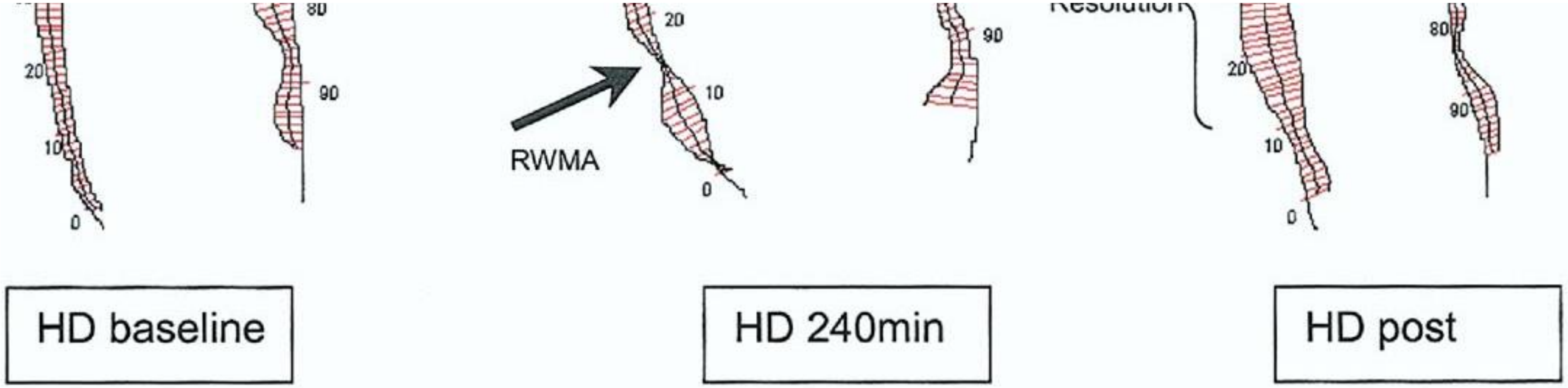
Number of risk factors by **(A)** major adverse cardiac events (MACE) and **(B)** mortality. The **green and pink lines** represent patients with <3 versus ≥3 risk factors, respectively. Coronary artery calcium score group by **(C)** major adverse cardiac events and **(D)** mortality. The **green, yellow, and pink lines** represent patients with coronary artery calcium scores of 0, 1 to 399 versus ≥400. Number of risk factors combined with coronary artery calcium scores by **(E)** major adverse cardiac events and **(F)** mortality. The **green solid and dashed lines** represent patients with <3 risk factors and coronary artery calcium scores <400 versus ≥400, respectively. The **pink solid and dashed lines** represent patients with ≥3 risk factors and coronary artery calcium scores <400 versus ≥400, respectively.

Occurrence of Regional Left Ventricular Dysfunction in Patients Undergoing Standard and Biofeedback Dialysis

Nicholas M. Selby, MD, Stewart H. Lambie, MD, Paolo G. Camici, MD, Christopher S. Baker, MD, and Christopher W. McIntyre, MD

Table 4. Global (EF) and Regional (SF) LV Function During Standard (HD) and Biofeedback Dialysis

	EF (%)	$SF_{(mean)}$ (%)	$SF_{(WMA)}$ (%)
HD			
Baseline	50.1 ± 10.7	2.64 ± 1.5	2.98 ± 1.7
Peak	48.7 ± 12.3	**2.26 ± 1.4***	**1.69 ± 1.0†**
Recovery	53.4 ± 13.3	2.64 ± 1.3	**2.38 ± 1.3†‡**



Hemodialysis-Induced Cardiac Injury: Determinants and Associated Outcomes

James O. Burton,* Helen J. Jefferies,* Nicholas M. Selby,* and Christopher W. McIntyre*†

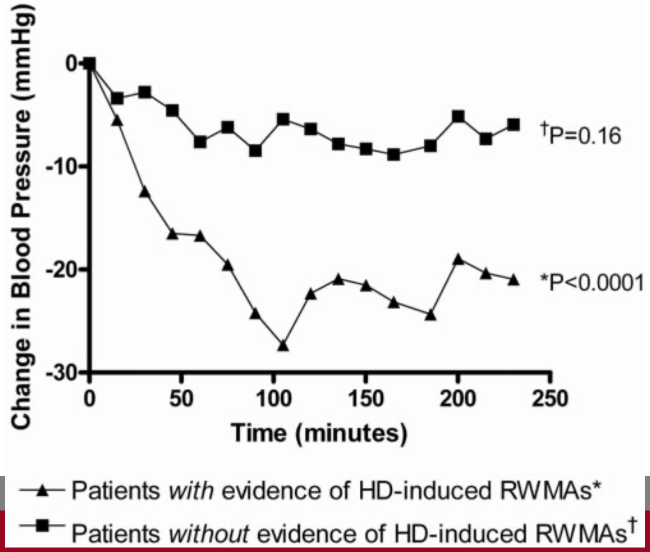
Ά Καρδιολογική Κλινική ΑΧΕΠΑ

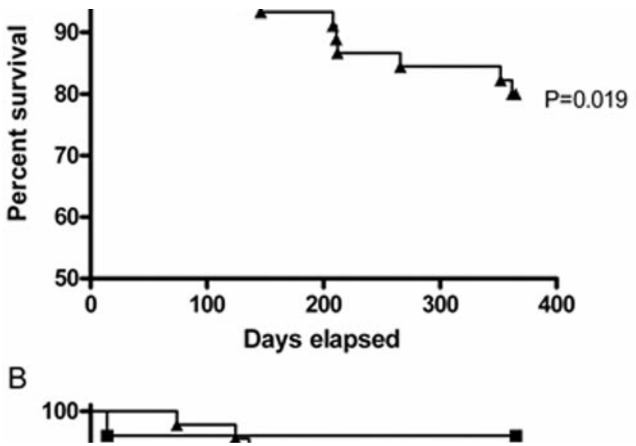
All Patients (n = 70) | Patients *with* RWMAs (n = 45) | Patients *without* RWMAs (n = 25)

Parameter	Predialysis blood testing		
	Patients *with* RWMAs	Patients *without* RWMAs	*P* value
Haemoglobin (g/dl)	11 ± 1.3	11.5 ± 1	0.15
Haematocrit (%)	36 ± 4	36 ± 2	0.35
Na^+ (mEq/L)	138 ± 3	139 ± 4	0.18
K^+ (mEq/L)	4.8 ± 0.8	4.7 ± 0.9	0.89
Urea nitrogen (mg/dl)	59.1 ± 15.1	55.5 ± 14.0	0.33
Creatinine (mgl/dl)	8.8 ± 2.5	9.8 ± 2.9	0.13
Phosphorus (mg/dl)	5.3 ± 1.2	5.0 ± 1.9	0.42
Bicarbonate (mEq/L)	22.7 ± 3.0	22.8 ± 3.2	0.87
Calcium (mg/dl)	9.68 ± 0.6	9.6 ± 0.6	0.58
Albumin (g/dl)	3.5 ± 0.4	3.7 ± 0.3	0.02
hsCRP (mg/L)	1.2 ± 1.0	0.8 ± 0.7	0.13
cTnT (ng/ml)	0.098 ± 0.08	0.036 ± 0.04	0.001

Table 3. The effect of increasing ultrafiltration (UF) volume and worsening intradialytic haemodynamics on the development of HD-induced RWMAs

Factor associated with presence of myocardial stunning	Odds Ratio	*P* value
UF volume during HD of 1L	5.1	0.007
UF volume during HD of 1.5L	11.6	
UF volume during HD of 2L	26.2	
Maximum SBP reduction during HD of 10 mmHg	1.8	0.002
Maximum SBP reduction during HD of 20 mmHg	3.3	
Maximum SBP reduction during HD of 30 mmHg	6.0	





Hemodialysis-Induced Cardiac Dysfunction Is Associated with an Acute Reduction in Global and Segmental Myocardial Blood Flow

Christopher W. McIntyre,*† James O. Burton,* Nicholas M. Selby,* Lucia Leccisotti,‡ Shvan Korsheed,* Christopher S.R. Baker,‡ and Paolo G. Camici‡

PET and ECHO

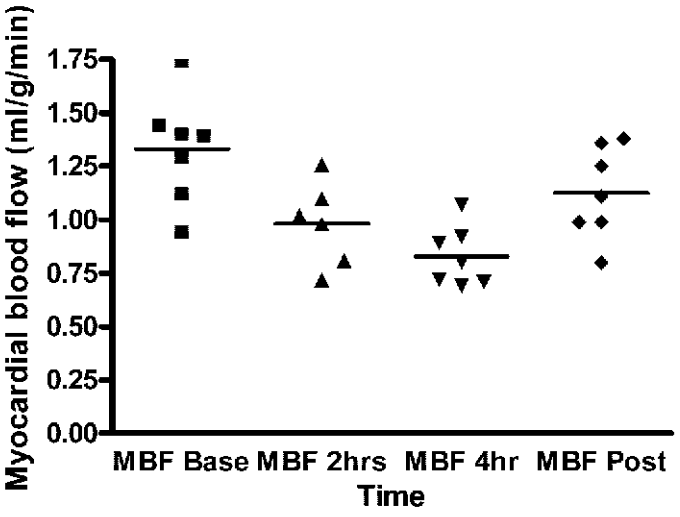
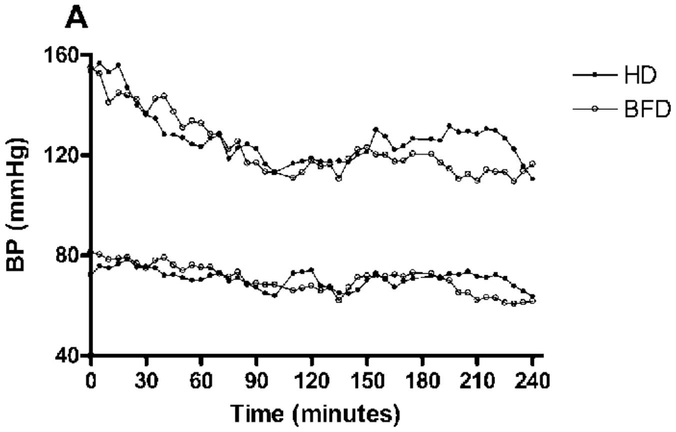


Figure 1. Mean global myocardial blood flow (MBF) reduced significantly during dialysis from baseline with partial restoration in the recovery period.



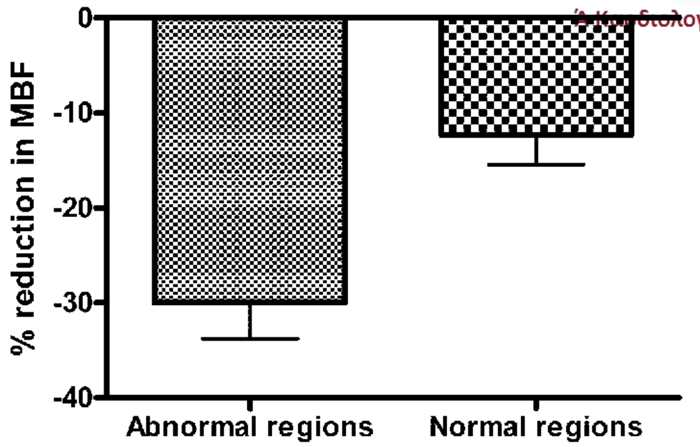


Figure 3. The development of regional ventricular dysfunction as measured by regional wall motion abnormalities (RWMA; abnormal regions) was associated with a greater reduction in MBF from baseline than areas that maintained normal movement (normal regions; $P = 0.001$).

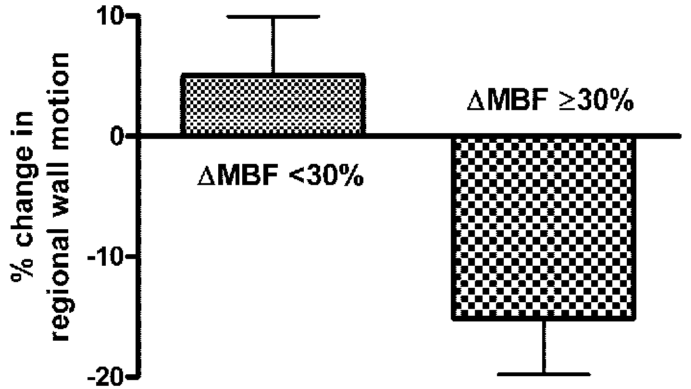
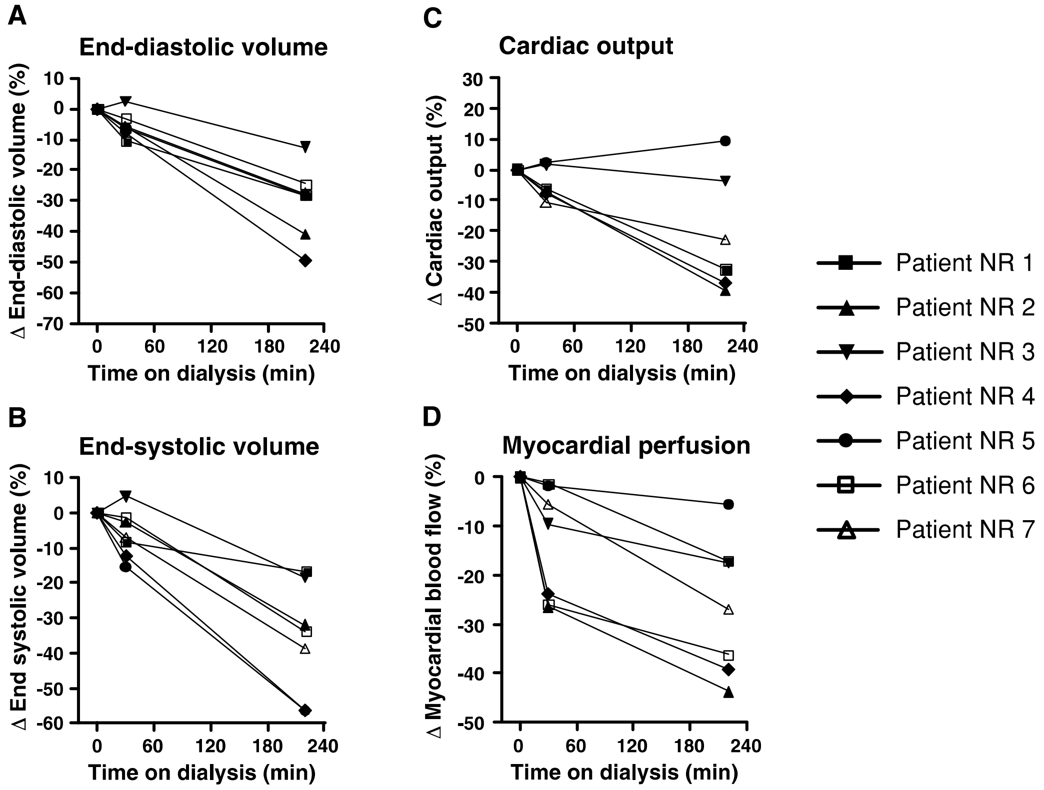


Figure 4. An MBF reduction of ≥30% was associated with a mean reduction in wall motion of −15.2%; however, an MBF reduction of <30% was associated with a mean increase in wall motion of 5% ($P < 0.01$).

Clin JASN 2008

Haemodialysis is associated with a pronounced fall in myocardial perfusion

Judith J. Dasselaar[1,2], Riemer H. J. A. Slart[3], Martine Knip[2], Jan Pruim[3], René A. Tio[4], Christopher W. McIntyre[5], Paul E. de Jong[2] and Casper F. M. Franssen[1,2]



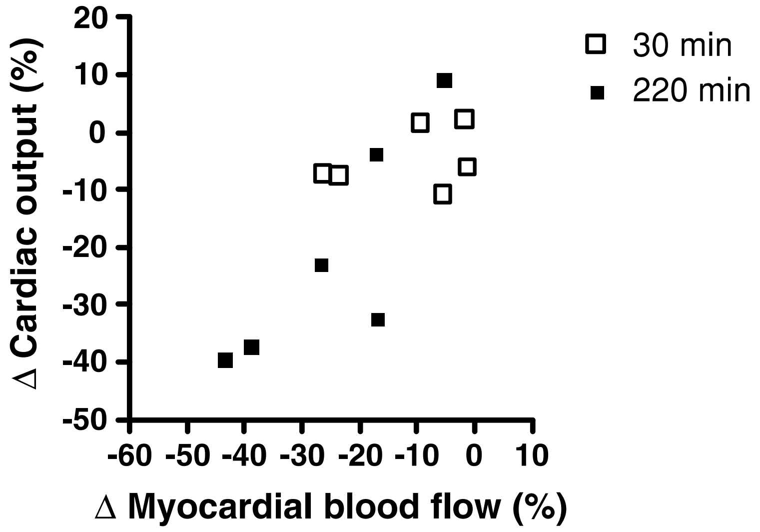


Fig. 3. Relationship between the relative change in myocardial blood flow and the relative change in cardiac output (both from baseline). The open squares represent the correlation at 30 min of HD (not significant). The closed squares represent the correlation at 220 min of HD ($r = 0.84$; $P = 0.03$).

Association of segmental wall motion abnormalities occurring during hemodialysis with post-dialysis fatigue

Table 2. Adjusted relative risk for severe PDF

	Model 1			Model 2		
	RR	(95% CI)	P-value	RR	(95% CI)	P-value
Change in the wall motion abnormality score (point)	1.2	(1.1, 1.3)	<0.001	1.9	(1.4, 2.6)	<0.001
Depression	3.4	(1.3, 9.0)	0.01	2.0	(0.6, 6.8)	0.3
Decrease in SBP during dialysis (mmHg)[a,b]	—	—	—	1.6	(0.8, 3.1)	0.15
Increase in SBP during dialysis (mmHg)[a,b]	—	—	—	1.1	(0.6, 2.2)	0.7
Ultrafiltration (L)[b]	—	—	—	1.0	(0.7, 1.4)	0.9

Table 1. Cohort characteristics and univariate relative risks for PDF

	Absent or mild fatigue[a] ($n = 32$)	Severe fatigue[a] ($n = 8$)	Univariate relative risk for severe PDF		
			RR	95% CI	P-value
Demographics					
Age (years)	61 (±15)	61 (±15)	0.99	(0.97, 1.0)	0.9
Dialysis vintage (years)	5 (±6)	3.3 (±2)	0.92	(0.8, 1.0)	0.16
Male gender	25 (78%)	8 (100%)	1.3	(0.4, 5.1)	0.7
Caucasian race	6 (19%)	3 (38%)	2.5	(0.95, 6.6)	0.06
Clinical factors					
History of depression	5 (18%)	3 (30%)	4.6	(1.8, 12)	0.002
Diabetes	15 (47%)	3 (38%)	0.6	(0.2, 1.9)	0.4
Atherosclerosis[b]	14 (44%)	4 (50%)	1.6	(0.5, 4.7)	0.4
Myocardial infarction	8 (26%)	1 (13%)	0.7	(0.2, 1.9)	0.4
Congestive heart failure	6 (19%)	0 (0%)	0.3	(0.05, 1.4)	0.1
Pre-dialysis SBP (mmHg)[c,d]	140 (±18)	143 (±7)	1.1	(0.9, 1.5)	0.4
Hemoglobin (g/dL)	11 (±1)	11 (±2)	0.9	(0.6, 1.2)	0.4
Albumin (g/dL)	3.7 (±0.4)	3.6 (±0.5)	0.6	(0.2, 1.3)	0.19
Phosphorus (mg/dL)	5.3 (±2)	5.6 (±1)	1.1	(0.9, 1.4)	0.5
Parathyroid hormone (mg/dL)	286 (7, 2800)	331 (97, 2800)	1.0	(0.99, 1.0)	0.4
Dialysis-related factors					
Symptomatic hypotension[e]	6 (19%)	2 (25%)	1.5	(0.7, 3.6)	0.3
Decrease in SBP during dialysis (mmHg)[c,d]	25 (±15)	32 (±8)	1.3	(0.96, 1.8)	0.09
Increase in SBP during dialysis (mmHg)[c,d]	13 (±9)	9 (±5)	0.5	(0.3, 1.1)	0.1
Ultrafiltration[c] (l)	2.5 (±1)	3 (±1)	1.4	(0.9, 2.1)	0.19
Kt/*v*	1.6 (±0.3)	1.6 (±0.3)	0.8	(0.18, 3.4)	0.8
Echocardiographic factors					
Left ventricular mass index (g/m^2)	99 (59, 172)	87 (61, 170)	0.3	(0.07, 1.3)	0.1
Baseline abnormal diastolic function	22 (69%)	5 (63%)	0.7	(0.3, 1.5)	0.4
Baseline ejection fraction[d]	57% (±7%)	56% (±5%)	<0.001	(<0.001, >1000)	0.5
Baseline WMA	8 (25%)	2 (25%)	0.6	(0.13, 2.4)	0.4
Worsened WMA (dichotomous)	5 (16%)	4 (50%)	1.7	(1.1, 1.9)	0.04
Average change in the WMA score (point)	0 (−1.5, 2.7)	0 (0, 8)	1.1	(1.1, 1.2)	<0.001

AJKD
In Practice

Ά Καρδιολογική Κλινική ΑΧΕΠΑ

Echocardiography in Hemodialysis Patients: Uses and Challenges

Diana Y.Y. Chiu, MBChB,[1,2] Darren Green, PhD,[1,2] Nik Abidin, MBBS,[3]
Smeeta Sinha, PhD,[1,2] and Philip A. Kalra, MD[1,2]

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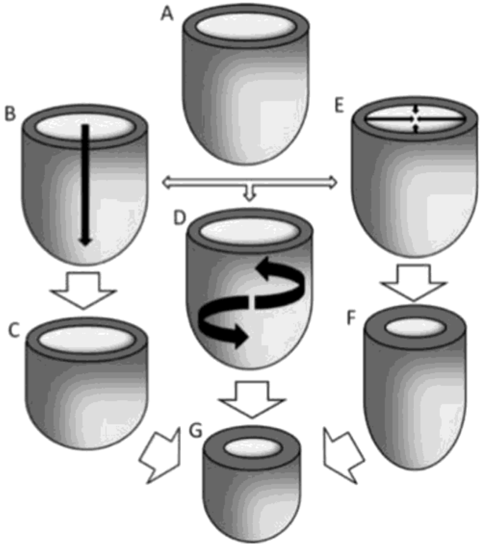
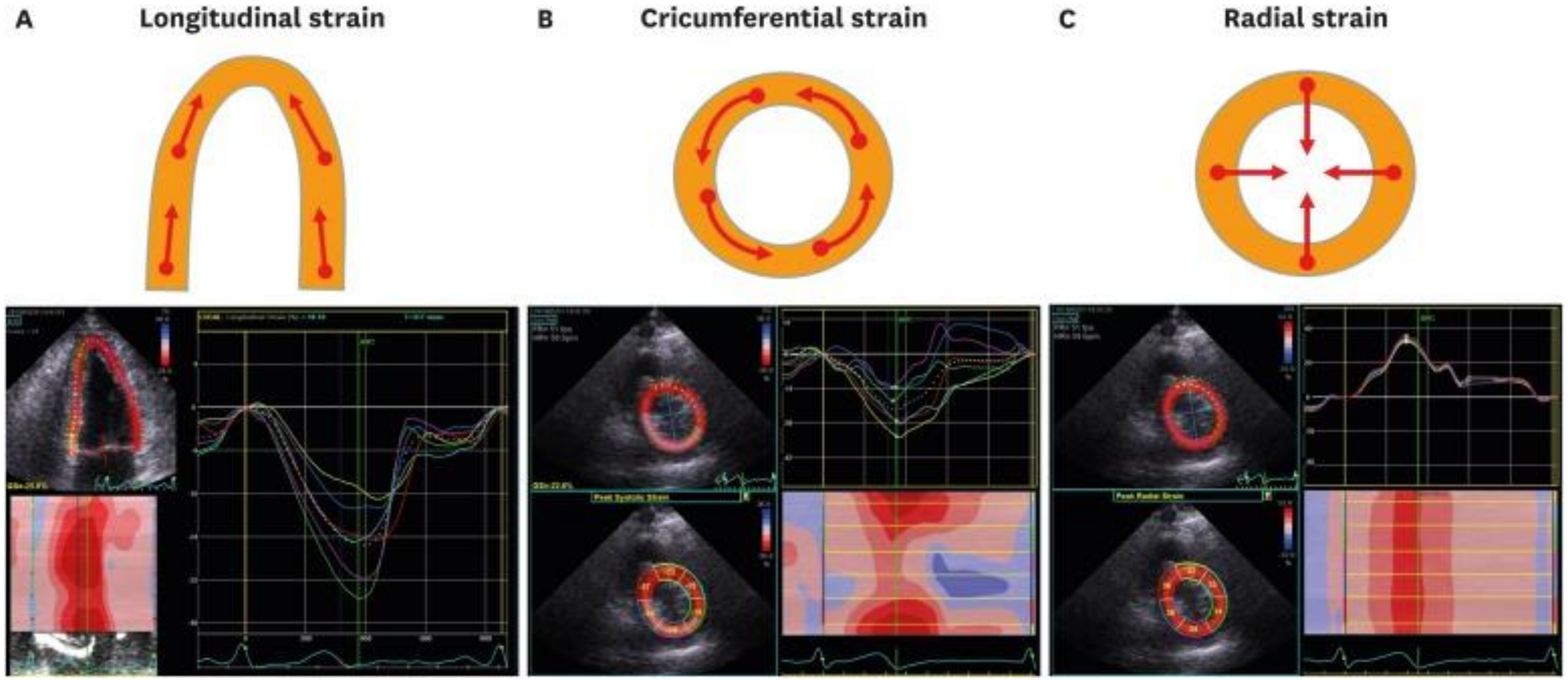
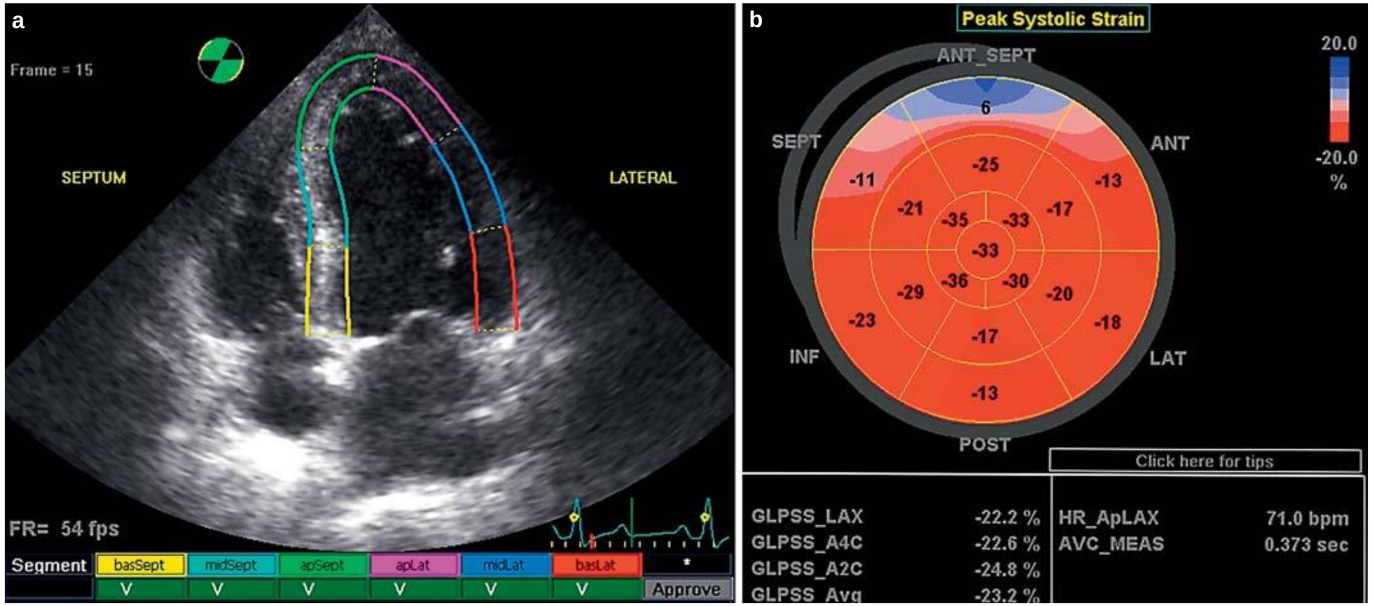


Figure 4. Schematic representation of the 3 components of left ventricular (LV) contraction. From the end-diastolic position of maximum volume (A), the ventricle will shorten longitudinally from the base to the apex (B to C), undergo torsion/twisting around its longitudinal axis (D) and radial strain that causes a thickening of the myocardial wall and a narrowing of the perpendicular radius (E to F). The resultant change in LV cavity volume (A to G) represents ejection fraction. Reproduced from Green et al[50] with permission of Oxford University Press.



Left Ventricular Systolic Strain in Chronic Kidney Disease and Hemodialysis Patients

Yen-Wen Liu[a, b] Chi-Ting Su[c] Yao-Yi Huang[b] Chun-Shin Yang[e]
Jenq-Wen Huang[d] Mao-Ting Yang[e] Jyh-Hong Chen[a] Wei-Chuan Tsai[a]



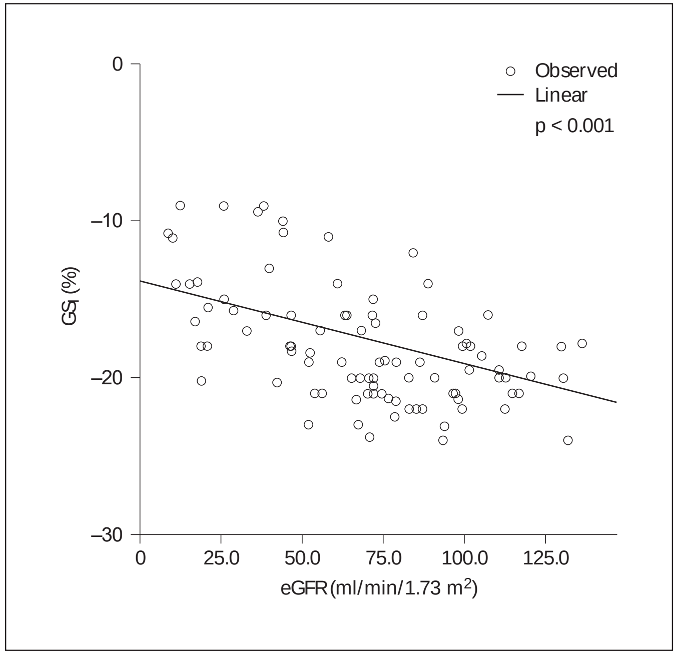


Fig. 3. Using linear regression analysis, left ventricular GS decreased significantly with deteriorating renal function (eGFR) in the controls and the moderate-advanced CKD group.

Ά Καρδιολογική Κλινική ΑΧΕΠΑ

Acute Stunning Effect of Hemodialysis on Myocardial Performance: a Three Dimensional Speckle Tracking Echocardiographic Study

Ά Καρδιολογική Κλινική ΑΧΕΠΑ

Table-2. Left ventricle analysis before and after HD.

Left ventricle (LV) (n:38)	Pre-hemodialysis	Post-hemodialysis	*p* value
End diastolic volume index (EDVi) (ml/m²)	69 ± 23	57 ± 23	**<0.001**
End systolic volume index (ESVi) (ml/m²)	32 ± 18	28 ± 16	**0.010**
Stroke volume index (SVi) (ml/m²)	37 ± 10	28 ± 10	**<0.001**
LV mass index (LVMi) (g/m²)	72 ± 10	68 ± 8	**0.022**
Ejection fraction (EF) (%)	55 ± 9	52 ± 9	**0.001**
Cardiac output (CO) (lt/min)	4.9 ± 1.6	3.9 ± 1.4	**<0.001**
Global longitudinal strain (GLS) (%)	-14.2 ± 5.2	-11.1 ± 4.6	**<0.001**
Global circumferential strain (GCS) (%)	-14.8 ± 4.2	-12.4 ± 5.2	**0.009**
Global radial strain (GRS) (%)	41.5 ± 16	33.3 ± 16.5	**0.003**
Global area strain (GAS) (%)	-24.7 ± 7.2	-20.1 ± 7.6	**0.001**
TWIST (degree)	4.7 ± 4.2	5.6 ± 4.9	0.413
TORSION (degree/cm)	0.87 ± 0.61	1.25 ± 1.34	0.285

p< 0,05

Table-4. Relationship between changes in strain parameters and blood pressure.

	Systolic tension		Diastolic tension		Pulse	
Left ventricle	r	*p*	r	*p*	r	*p*
GLS	**0.527**	**0.002**	**0.435**	**0.015**	**0.368**	**0.042**
GCS	**0.410**	**0.022**	0.310	0.089	0.287	0.117
GRS	**0.411**	**0.022**	**0.411**	**0.022**	**0.380**	**0.035**
AREA	**0.446**	**0.012**	**0.385**	**0.032**	**0.425**	**0.017**

Table-6. The effect of beta blocker treatment on strain parameters before and after HD.

	Beta Blocker					
	Before	After	*p*	Before	After	*p*
	User (n:19)			**Non user** (n:19)		
GLS (%)	-12.9 ± 5.3	-11.9 ± 5.1	0.243	-15.5 ± 5.1	-10.3 ± 4.1	**<0.001**
GCS (%)	-14.1 ± 4.4	-14.1 ± 5.8	0.953	-15.4 ± 4	-10.9 ± 4.2	**0.001**
GRS (%)	38.3 ± 16.4	37.9 ± 19.4	0.909	44.5 ± 15.6	29.1 ± 12.6	**<0.001**
AREA (%)	-23 ± 7.6	-22.3 ± 8.4	0.683	-26.3 ± 6.6	-18.1 ± 6.5	**<0.001**

Table-7. The effect of calcium channel blocker treatment on strain parameters before and after HD.

	Calcium channel blocker					
	Before	After	*p*	Before	After	*p*
	User (n:18)			**Non user** (n:20)		
GLS (%)	-14 (-18, -4)	-11 (-18, -3)	0.090	-16.2 ± 5.1	-10.8 ± 5.1	**<0.001**
GCS (%)	-13.7 ± 4	-13 ± 5.6	0.536	-15.9 ± 4.2	-11.9 ± 5	**0.006**
GRS (%)	35.5 ± 13.6	34.8 ± 15.4	0.763	52.5 (21, 68)	27.5 (10, 80)	**0.002**
AREA (%)	-22 ± 6.8	-21.2 ± 7.7	0.565	-30 (-35, -16)	-18 (-33, -8)	**0.001**

The Impact of Hemodialysis on Segmental and Global Longitudinal Myocardial Strain

Shih-Han S. Huang, MD,[a,b,c] Lisa E. Crowley, MD,[a] Helen J. Jefferies, MD,[a]
Mohamad T. Eldehni, MD,[a] Aghogho Odudu, MD,[a] and Chris W. McIntyre, MD[a,b]

Healthy vs HD

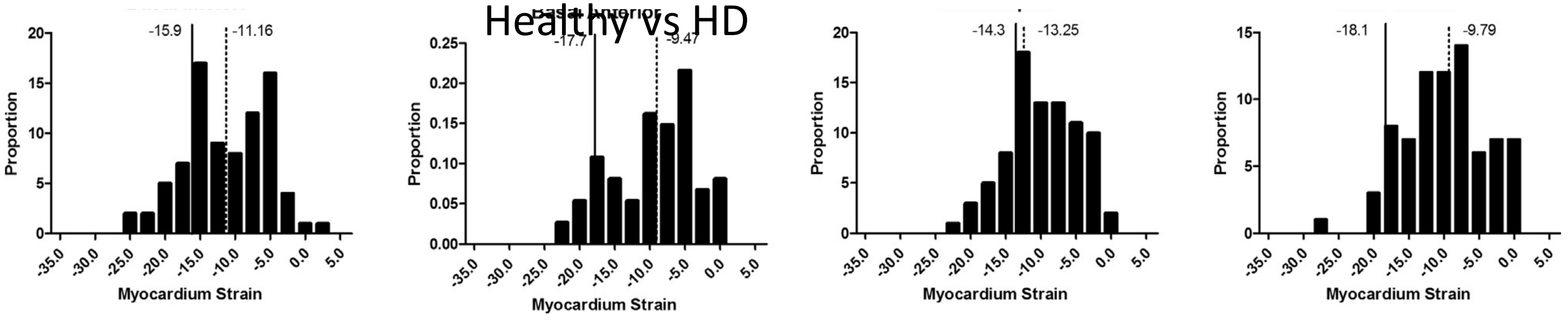


Table 1. The segmental longitudinal strain values: before dialysis and at peak dialysis

	Before dialysis		Peak dialysis		
Segment	Mean (%)	SD	Mean (%)	SD	*P*
Basal inferior	−10.1	7.46	−9.8	7.66	0.73
Midinferior	−14.7	6.64	−13.7	7.14	0.20
Apical inferior	−16.7	8.23	−15.3	8.69	0.10
Apical anterior	−10.3	8.95	−10.0	8.67	0.77
Midanterior	−8.3	7.15	−6.8	7.27	0.10
Basal anterior	−8.2	7.86	−6.4	7.69	0.06
Basal septal	−9.4	6.59	−8.3	6.80	0.18
Midseptal	−13.7	6.23	−12.5	6.20	0.13
Apical septal	−15.16	8.64	−13.7	8.55	0.09
Apical lateral	−10.1	10.03	−10.0	8.78	0.96
Midlateral	−9.6	8.25	−8.3	7.56	0.14
Basal lateral	−9.3	8.13	−6.8	7.13	0.01

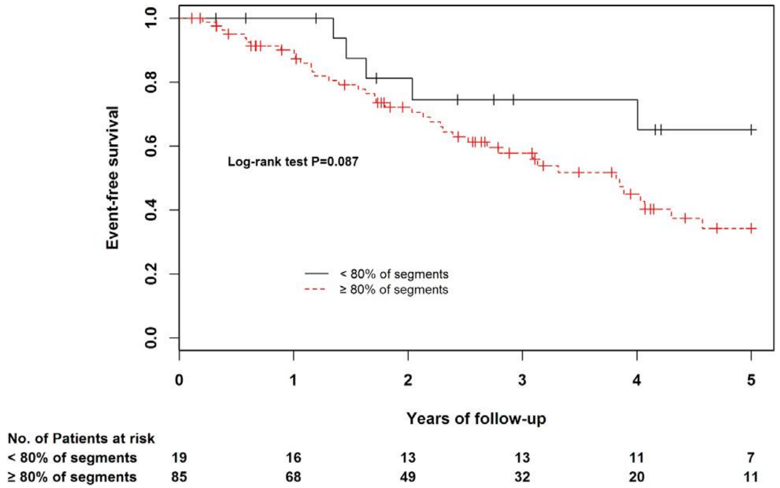


Figure 3. Kaplan-Meier Analysis comparing survival time between the groups that had > 80% of segments above the mean segmental longitudinal strain, and ≤ 80% of segments above the mean segmental longitudinal strain.

Ά Καρδιολογική Κλινική ΑΧΕΠΑ

Estimated left ventricular pressure-myocardial strain loop as an index of cardiac work predicts all-cause mortality in patients receiving regular hemodialysis

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Hsin-Yueh Liang [b,g,*], Guei-Jane Wang [a,d,e,h,**]

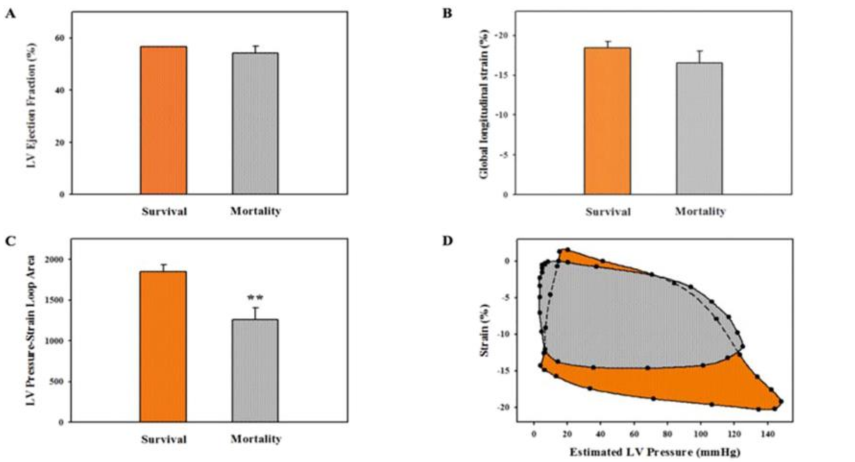


Fig. 2. The prediction potential of left ventricular ejection fraction (LVEF), global longitudinal strain (GLS) and cardiac work index (CWI) on prognosis of end-stage kidney disease (ESRD) patients receiving regular hemodialysis. (a) LVEF; (b) GLS; (c) CWI used to predict all-cause mortality. (d) Comparison of CWI from survival (orange) vs. mortality (grey) groups. The CWI of these two cases are close to mean values of survival and mortality groups, respectively (1880.86%-mmHg vs. 1377.51%-mmHg).

Table 2
Univariate and multivariable Cox regression analyses of all-cause mortality.

	Univariate Cox analysis		Multivariate Cox analysis			
			Model 1		Model 2	
	HR (95% CI)	p value	HR (95% CI)	p value	HR (95% CI)	p value
Age (≥70 yrs)	3.28 (1.61–6.69)	0.001	2.91 (1.40–6.07)	0.004	2.66 (1.29–5.49)	0.008
CWI (<1271 mmHg%)	5.11 (2.40–10.91)	<0.001	2.97 (1.26–7.01)	0.013	4.30 (2.00–9.25)	<0.001
GLS (>−18.15%)	2.82 (1.26–6.34)	0.012	1.82 (0.71–4.65)	0.211		

Abbreviations: CWI = cardiac work index. GLS = global longitudinal strain. HR = hazard ratio. 95% CI = 95% confidence interval. ROC = receiver operating characteristic. The cut-off values of CWI and GLS were determined by ROC curve analysis with optimal sensitivity and specificity.

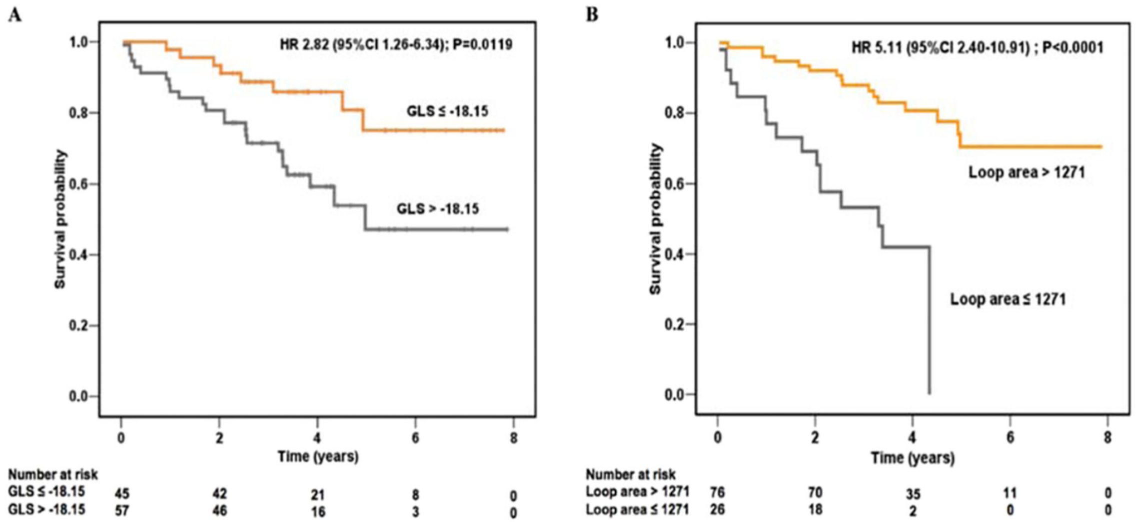


Fig. 4. All-cause mortality dichotomized according to GLS (≤−18.15 and >−18.15) and CWI (≤1271 mmHg-% and >1271 mmHg-%).

The impact of volume overload on right heart function in end-stage renal disease patients on hemodialysis

Serkan Ünlü MD, MSc[1,2,3] | Asife Şahinarslan MD[1] | Gökhan Gökalp MD[1] | Özden Seçkin MD[1] | Selim Turgay Arınsoy MD[4] | Nuri Bülent Boyacı MD[1] | Atiye Çengel MD[1]

TABLE 4 2D speckle tracking strain measurements of right ventricle and right atrium before and after hemodialysis

Parameters	Before HD	After HD	*P*
Right ventricle			
RV GLS (%)	−24.1 ± 3.7	−19.9 ± 4.2	<.001
RV SR (s^{-1})	−1.3 ± 0.3	−1.2 ± 0.3	.084
RV early diastolic SR (s^{-1})	1.3 ± 0.4	1.1 ± 0.4	<.001
RV late diastolic SR (s^{-1})	1.1 ± 0.5	1.1 ± 0.4	.941
RVFW LS (%)	−28.8 ± 4.7	−23.7 ± 5.5	<.001
RVFW SR (s^{-1})	−1.8 ± 0.4	−1.7 ± 0.4	.089
RVFW early diastolic SR (s^{-1})	1.8 ± 0.5	1.4 ± 0.6	<.001
RVFW late diastolic SR (s^{-1})	1.5 ± 0.6	1.5 ± 0.6	.928
Right atrium			
RA reservoir LS (%)	45.6 ± 10.8	38.2 ± 8.1	<.001
RA contraction LS (%)	−16.7 ± 6.8	−16.4 ± 7.1	.835
RA reservoir SR (s^{-1})	2.3 ± 0.7	2.5 ± 0.5	.090
RA conduit phase SR (s^{-1})	−1.5 ± 0.8	−1.2 ± 0.6	<.001
RA contraction SR (s^{-1})	−2.2 ± 0.9	−2.2 ± 0.7	.596

The high ultrafiltration volumes are shown to be associated with myocardial stunning.

TABLE 3 Conventional echocardiographic measurements before and after hemodialysis

Parameters	Before HD	After HD	*P*
Dimensions, areas, and volumes of right heart chambers			
RV basal diameter (cm)	3.4 ± 0.6	2.7 ± 0.5	<.001
RV mid-cavity diameter (cm)	2.1 ± 0.5	1.8 ± 0.4	<.001
RV longitudinal diameter (cm)	6.4 ± 0.8	5.8 ± 0.8	<.001
RA longitudinal axis (cm)	4.7 ± 0.6	4.5 ± 0.5	<.001
RA short axis (cm)	3.5 ± 0.6	3.0 ± 0.5	<.001
RA end-systolic area (cm^2)	13.8 ± 3.0	10.6 ± 2.8	<.001
RV diastolic area (cm^2)	13.7 ± 3.0	10.1 ± 2.8	<.001
RV end-systolic area (cm^2)	7.05 ± 2.0	5.9 ± 3.0	<.001
RV FAC (%)	48.3 ± 9.8	46.9 ± 9.2	.389
TAPSE (cm)	2.1 ± 0.4	1.7 ± 0.3	<.001
Doppler measurements of right ventricle			
E (cm/s)	71 ± 23	50 ± 15	<.001
A (cm/s)	58 ± 17	48 ± 16	<.001
E/A	1.3 ± 0.5	1.1 ± 0.3	.004
MPI	0.3 ± 0.2	0.5 ± 0.2	<.001
sPAP	43 ± 17	25 ± 12	<.001
Deceleration time (ms)	219.5 ± 77.8	250 ± 96.4	.032
Tissue Doppler measurements of right ventricle			
E′ (cm/s)	14 ± 3	10 ± 3.0	<.001
A′ (cm/s)	16.0 ± 4.0	15.0 ± 4.0	.147
E′/A′	0.9 ± 0.4	0.7 ± 0.3	<.001
S′ (cm/s)	15.0 ± 3.0	12.0 ± 3.0	<.001
E/E′	5.4 ± 2.3	5.5 ± 2.1	.648
MPI	0.5 ± 0.1	0.6 ± 0.2	.002
IVA (m/s^2)	35.4 ± 11.7	37.9 ± 14.1	.066

AJKD
In Practice

Echocardiography in Hemodialysis Patients: Uses and Challenges

Diana Y.Y. Chiu, MBChB,[1,2] *Darren Green, PhD,*[1,2] *Nik Abidin, MBBS,*[3] *Smeeta Sinha, PhD,*[1,2] *and Philip A. Kalra, MD*[1,2]

Box 1. Causes of an Enlarged Left Atrium in Hemodialysis Patients

Increased preload to left atrium

- Volume overload
- Mitral valve regurgitation
- Arteriovenous fistula
- High-output states: chronic anemia

Increased afterload to left atrium

- Left ventricular systolic dysfunction
- Mitral stenosis
- Hypertension
- Left ventricular hypertrophy

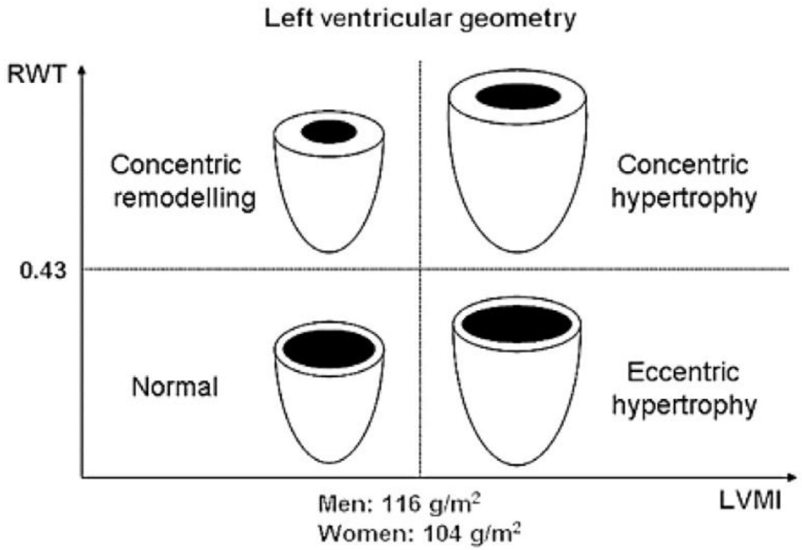
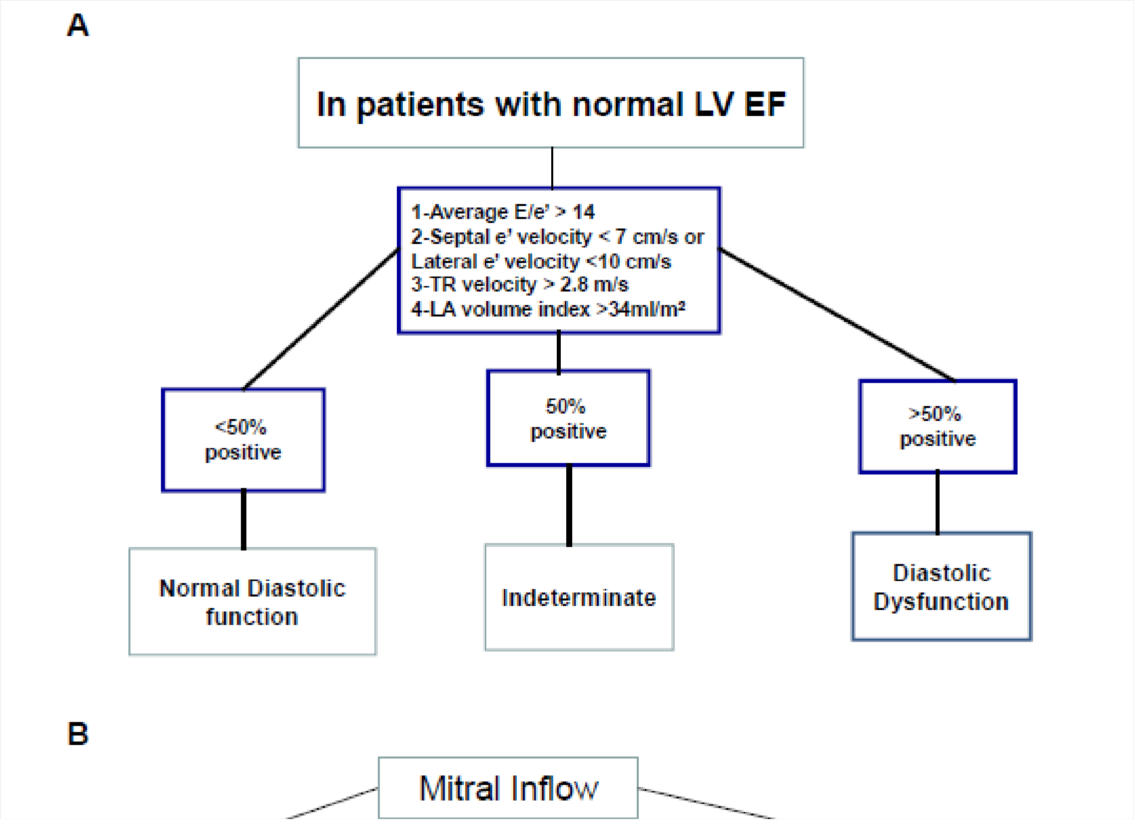
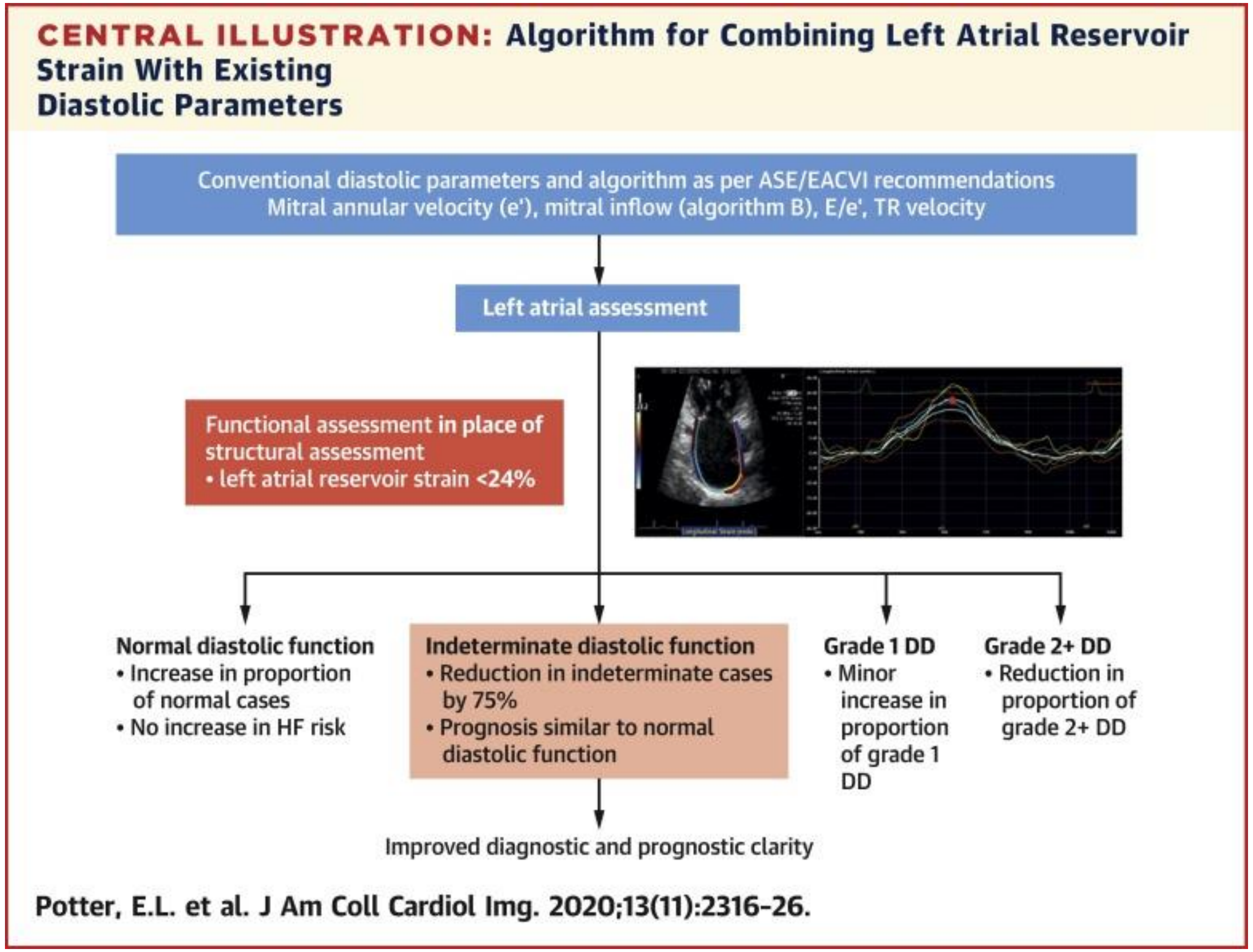


Figure 1. Classification of left ventricular (LV) geometry. Note: Relative wall thickness (RWT) is calculated from echocardiographic parameters by (2 × posterior wall thickness)/Left ventricular diastolic diameter or septal wall thickness + (posterior wall thickness/Left ventricular diastolic diameter). Because LV mass end-diastolic volume (M/V) is directly proportional to RWT (RWT of 0.32-0.42 corresponds to M/V of 1.0-1.5), RWT may be replaced by M/V whereby an enlarged M/V with increased LV mass index is classified as concentric hypertrophy. In concentric remodeling and hypertrophy, end-diastolic volume is reduced, whereas in eccentric hypertrophy, end-diastolic volume is enlarged. Abbreviation: LVMI, left ventricular mass index. Figure reproduced from Gerdts[15] with permission of Oxford Uni-

LV Diastolic Dysfunction





The Ebb and Flow of Echocardiographic Cardiac Function Parameters in Relationship to Hemodialysis Treatment in Patients with ESRD

Ά Καρδιολογική Κλινική ΑΧΕΠΑ

Charalampos Loutradis,[1] Pantelis A. Sarafidis,[1] Christodoulos E. Papadopoulos,[2]
Aikaterini Papagianni,[1] and Carmine Zoccali[3]

Table 2. Overview of studies evaluating changes in LV diastolic function echocardiographic indices during hemodialysis and association with intradialytic volume changes

Author	Year	*N*	Time of Evaluation	Main Finding	Diastolic Function Change	Association between Changes in Indices and Volume	Volume Marker
Drighil *et al.*[30]	2008	17	Before and after hemodialysis	LV E and E/A ratio, and RV E decrease	Deterioration	Yes (+)	Intradialytic weight loss
Sadler *et al.*[31]	1992	24	Before, at 2 h, and after hemodialysis	LV and RV E and E/A ratio decrease	Deterioration	Yes (+)	Intradialytic weight loss
Dubin *et al.*[32]	2014	35	Before and during the last hour of hemodialysis	LV E/Em ratio decrease	Deterioration	Yes (+)	NT-proBNP
Fijalkowski *et al.*[33]	2006	25	Before and after hemodialysis	LV E and E/Em decrease	Deterioration	Yes (+)	Intradialytic weight loss
Graham *et al.*[35]	2003	17	Before and after hemodialysis	LV E and E/A ratio decrease	Deterioration	No	Intradialytic weight loss
Assa *et al.*[36]	2013	109	Before, at 60 and 180 intradialytic minutes, and after hemodialysis	LV E and Em decrease	Deterioration	No	BNP
Sarafidis *et al.*[29]	2016	41	Before and after two separate hemodialysis sessions	LV and RV E decrease	Deterioration	Yes (+)	Intradialytic weight loss

Studies are presented in chronologic order ("+" is used to present a positive correlation). E and Em, early non–tissue-Doppler and tissue-Doppler diastolic velocities (accordingly); A, late diastolic velocity; NT-proBNP, N-terminal pro b-type natriuretic peptide; BNP, brain natriuretic peptide.

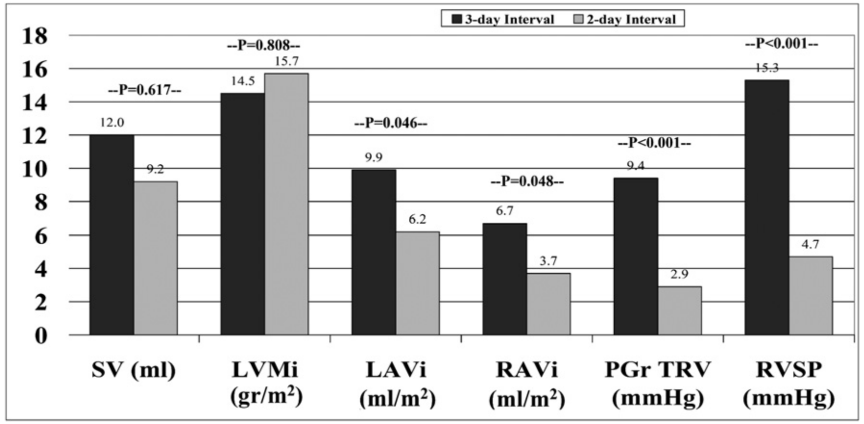


Figure 2. Changes in echocardiographic indices of LV and RV remodeling and function during the 3-day and 2-day interdialytic intervals. Interdialytic changes in stroke volume (SV) and LVMi were similar, but interdialytic changes in left atrial volume index (LAVi), right atrial volume index (RAVi), tricuspid regurgitation peak gradient (PGr TVR), and RVSP were greater during the 3-day compared with the 2-day interval, suggesting increased pulmonary circulation and right ventricle loading over the 3-day period. (Illustration based on results from Tsilonis *et al.*[47])

Haemodialysis acutely deteriorates left and right diastolic function and myocardial performance: an effect related to high ultrafiltration volumes?

Ά Καρδιολογική Κλινική ΑΧΕΠΑ

Pantelis A. Sarafidis[1], Vasilios Kamperidis[2], Charalampos Loutradis[1], Konstantinos Tsilonis[2], Fani Mpoutsiouki[2], Athanasios Saratzis[3], Georgios Giannakoulas[2], Georgios Sianos[2] and Haralambos Karvounis[2]

Table 2. Comparisons between pre- and post-haemodialysis body weight, BP, HR and LV echocardiographic indices on the first and a standard weekly haemodialysis session

Parameter	First weekly haemodialysis session (Monday or Tuesday)			Standard haemodialysis session (Wednesday/Thursday or Friday/Saturday)		
	Start	End	P-value	Start	End	P-value
Body weight (kg)	72.2 ± 12.5	69.3 ± 12.5	< 0.001	71.7 ± 12.5	69.0 ± 12.6	<0.001
SBP (mmHg)	145.5 ± 21.6	135.9 ± 23.5	0.009	143.1 ± 19.8	135.1 ± 19.6	0.022
DBP (mmHg)	77.9 ± 13.4	76.8 ± 11.2	0.547	78.2 ± 11.2	76.1 ± 13.1	0.224
HR (bpm)	70.1 ± 10.9	73.6 ± 13.5	0.004	69.0 ± 10.3	75.2 ± 11.9	<0.001
LVMi (g/m^2)	139.2 ± 66.2	121.2 ± 62.7	< 0.001	139.6 ± 63.4	127.7 ± 66.7	0.006
LAVi (mL/m^2)	44.6 ± 16.0	35.7 ± 14.3	< 0.001	43.0 ± 16.4	36.8 ± 17.1	<0.001
LVESVi (mL/m^2)	26.2 ± 12.9	24.1 ± 12.8	0.126	28.2 ± 13.3	25.8 ± 12.7	0.039
LVEDVi (mL/m^2)	58.3 ± 19.9	54.8 ± 23.3	0.138	61.8 ± 20.6	58.3 ± 22.0	0.053
LVEF (%)	55.7 ± 12.4	56.2 ± 11.1	0.798	56.1 ± 10.7	56.2 ± 12.3	0.901
SV (mL)	80.4 ± 18.2	72.9 ± 26.8	0.083	83.2 ± 30.1	73.7 ± 21.1	0.022
CO (L/min)	5.68 ± 1.50	5.35 ± 2.18	0.308	5.71 ± 2.09	5.46 ± 1.44	0.388
S'_{mean} LV (m/s)	0.077 ± 0.017	0.080 ± 0.020	0.324	0.074 ± 0.015	0.077 ± 0.016	0.153
LVOT (cm)	1.98 ± 0.24	1.97 ± 0.25	0.561	1.97 ± 0.23	1.98 ± 0.21	0.743
LVOT VTI (cm)	26.6 ± 5.9	24.1 ± 7.2	0.036	27.3 ± 8.6	24.1 ± 5.9	0.010
E wave (m/s)	0.96 ± 0.28	0.75 ± 0.27	< 0.001	0.89 ± 0.24	0.78 ± 0.29	<0.001
E/A	1.17 ± 0.44	0.94 ± 0.46	0.001	1.14 ± 0.49	0.92 ± 0.42	<0.001
DT (ms)	232.13 ± 62.87	242.99 ± 63.27	0.281	224.73 ± 53.28	225.02 ± 53.41	0.972
E'_{mean} wave (m/s)	0.19 ± 0.03	0.17 ± 0.03	<0.001	0.19 ± 0.04	0.18 ± 0.05	0.336
E/E'_{mean}	5.11 ± 1.42	4.60 ± 1.64	0.025	4.95 ± 1.76	4.56 ± 2.05	0.056
$IVRT_{mean}$	0.076 ± 0.019	0.079 ± 0.024	0.355	0.076 ± 0.020	0.077 ± 0.023	0.668
TEI_{mean}	0.50 ± 0.14	0.55 ± 0.17	0.021	0.52 ± 0.23	0.56 ± 0.16	0.399

Table 4. Univariate and multivariate linear regression analyses of parameters possibly affecting the change in *E* index, reflecting LV diastolic function, during a standard haemodialysis session

Parameter	Univariate analysis				Multivariate analysis			
	Estimate	SEM	95% CI	P-value	Estimate	SEM	95% CI	P-value
Age (per year increase)	0.004	0.001	0.001–0.006	0.003	0.003	0.001	0.001–0.005	0.023
Sex (female versus male)	0.009	0.040	−0.072–0.090	0.824				
IDWL (per L increase)	0.046	0.013	0.019–0.073	0.001	0.042	0.012	0.018–0.066	0.001
SBP change (per mmHg increase)	0.001	0.001	−0.002–0.001	0.684				
HR change (per bpm increase)	−0.004	0.003	−0.009–0.002	0.166	−0.003	0.002	−0.007–0.001	0.119
LVMi change (per g/m^2 increase)	0.001	0.001	−0.002–0.002	0.891				
CO change (per L/min increase)	0.014	0.011	−0.009–0.037	0.236				
TEI_{mean} change (per unit increase)	−0.122	0.081	−0.286–0.042	0.140	−0.067	0.066	−0.202–0.069	0.323

Haemodialysis acutely deteriorates left and right diastolic function and myocardial performance: an effect related to high ultrafiltration volumes?

Ά Καρδιολογική Κλινική ΑΧΕΠΑ

Pantelis A. Sarafidis[1], Vasilios Kamperidis[2], Charalampos Loutradis[1], Konstantinos Tsilonis[2], Fani Mpoutsiouki[2], Athanasios Saratzis[3], Georgios Giannakoulas[2], Georgios Sianos[2] and Haralambos Karvounis[2]

Table 3. Comparisons between pre- and post-haemodialysis values of RV echocardiographic indices and IVC diameter on the first and a standard weekly haemodialysis session

Parameter	First weekly haemodialysis session (Monday or Tuesday)			Standard haemodialysis session (Wednesday/Thursday or Friday/Saturday)		
	Start	End	P-value	Start	End	P-value
RAV (mL)	27.30 ± 10.58	21.34 ± 10.05	<0.001	26.05 ± 13.46	22.54 ± 12.21	<0.001
RVEDD (cm)	3.61 ± 0.87	3.12 ± 0.75	<0.001	3.49 ± 0.75	3.18 ± 0.69	<0.001
IVC diameter (cm)	1.93 ± 0.41	1.54 ± 0.45	<0.001	1.79 ± 0.39	1.37 ± 0.40	<0.001
RAP (mmHg)	9.76 ± 3.82	7.88 ± 4.34	<0.001	9.32 ± 3.96	6.24 ± 4.10	<0.001
RVSP (mmHg)	44.64 ± 16.25	33.14 ± 12.43	<0.001	37.87 ± 13.74	30.16 ± 12.78	<0.001
RVOT VTI (cm)	19.97 ± 3.44	18.24 ± 4.72	0.006	19.61 ± 4.92	17.67 ± 4.19	0.006
TRV max (m/s)	2.87 ± 0.54	2.54 ± 0.54	<0.001	2.68 ± 0.55	2.46 ± 0.54	<0.001
S′ RV (m/s)	0.15 ± 0.04	0.15 ± 0.04	0.575	0.14 ± 0.03	0.15 ± 0.04	0.149
PVR (dyn s/cm^5)	1.63 ± 0.37	1.72 ± 1.02	0.541	1.59 ± 0.40	1.60 ± 0.37	0.806
E RV wave (m/s)	0.89 ± 0.26	0.67 ± 0.25	<0.001	0.86 ± 0.24	0.77 ± 0.31	<0.001
E′ RV wave (m/s)	0.123 ± 0.042	0.113 ± 0.038	0.183	0.117 ± 0.036	0.110 ± 0.042	0.313
E′/A′ RV	0.94 ± 0.67	0.80 ± 0.49	0.069	0.94 ± 0.67	0.75 ± 0.46	0.028
E/E′ RV	8.55 ± 3.28	7.10 ± 2.54	0.008	7.97 ± 2.19	7.45 ± 2.88	0.308
TEI RV	0.52 ± 0.20	0.59 ± 0.20	0.021	0.50 ± 0.14	0.52 ± 0.17	0.145

Table 5. Univariate and multivariate linear regression analyses of parameters possibly affecting the change in *E* RV index, reflecting RV diastolic function, during a standard haemodialysis session

Parameter	Univariate analysis				Multivariate analysis			
	Estimate	SEM	95% CI	P-value	Estimate	SEM	95% CI	P-value
Age (per year increase)	0.003	0.002	0.001–0.006	0.095	0.001	0.001	−0.001–0.004	0.286
Sex (female versus male)	0.009	0.048	−0.089–0.107	0.850				
IDWL (per L increase)	0.080	0.013	0.053–0.106	<0.001	0.084	0.013	0.057–0.110	<0.001
SBP change (per mmHg increase)	0.002	0.001	−0.001–0.004	0.153	0.001	0.001	−0.001–0.003	0.199
HR change (per bpm increase)	−0.008	0.003	−0.014–−0.002	0.013	−0.006	0.002	−0.010–−0.001	0.018
RVEDD change (per cm increase)	−0.009	0.069	−0.150–0.131	0.896				
RAP change (per mmHg increase)	0.007	0.006	−0.006–0.020	0.292				
TEI RV change (per unit increase)	−0.239	0.138	−0.519–0.040	0.091	−0.052	0.095	−0.246–0.142	0.588

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Original Investigation

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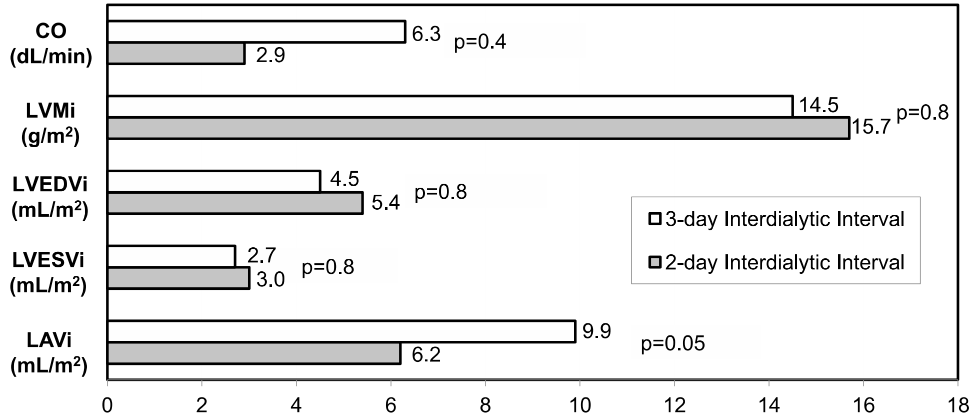
Echocardiographic Parameters During Long and Short Interdialytic Intervals in Hemodialysis Patients

Konstantinos Tsilonis, MD,[1] Pantelis A. Sarafidis, MD, MSc, PhD,[2,3] Vasilios Kamperidis, MD, MSc, PhD,[1] Charalampos Loutradis, MD, MSc,[2] Panagiotis I. Georgianos, MD, PhD,[3] Konstantinos Imprialos, MD,[2] Antonios Ziakas, MD, PhD,[1] Georgios Sianos, MD, PhD,[1] Pavlos Nikolaidis, MD, PhD,[3] Anastasios N. Lasaridis, MD, PhD,[3] and Haralambos Karvounis, MD, PhD[1]



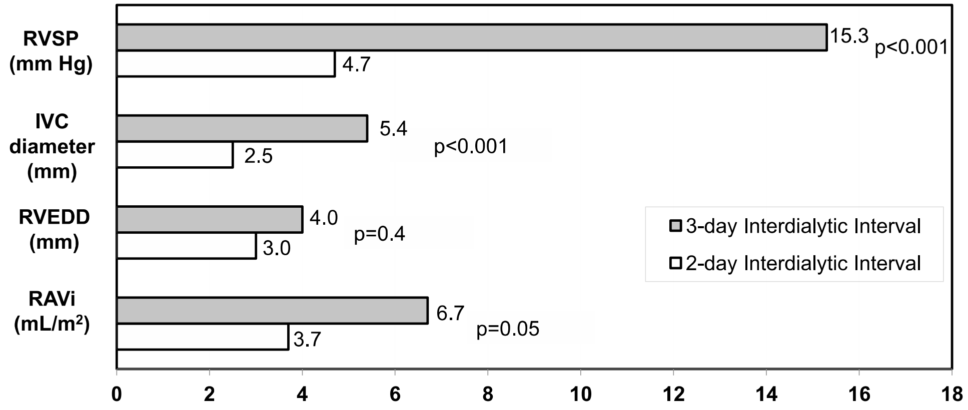


Table 4. Univariate and Multivariate Linear Regression Analysis of Parameters Possibly Affecting the Change in RVSP During Interdialytic Intervals

	Univariate Analysis		Multivariate Analysis	
Parameter	Estimate ± SE (95% CI)	*P*	Estimate ± SE (95% CI)	*P*
IDWG	1.512 ± 0.707 (0.104 to 2.920)	0.04	1.645 ± 0.659 (0.332 to 2.958)	0.02
SBP change	0.171 ± 0.144 (−0.114 to 0.457)	0.2		
Heart rate change	−0.028 ± 0.128 (−0.283 to 0.227)	0.8		
Sm RV change	−2.246 ± 26.880 (−55.740 to 51.248)	0.9		
E/Em RV change	0.820 ± 0.419 (−0.012 to 1.653)	0.05	1.142 ± 0.426 (0.293 to 1.990)	0.009
PVR change	6.177 ± 2.786 (0.633 to 11.721)	0.03	7.034 ± 2.644 (1.766 to 12.303)	0.01

Changes in right ventricular dimensions, function, and pulmonary circulation loading according to the degree of interdialytic weight gain in maintenance hemodialysis patients

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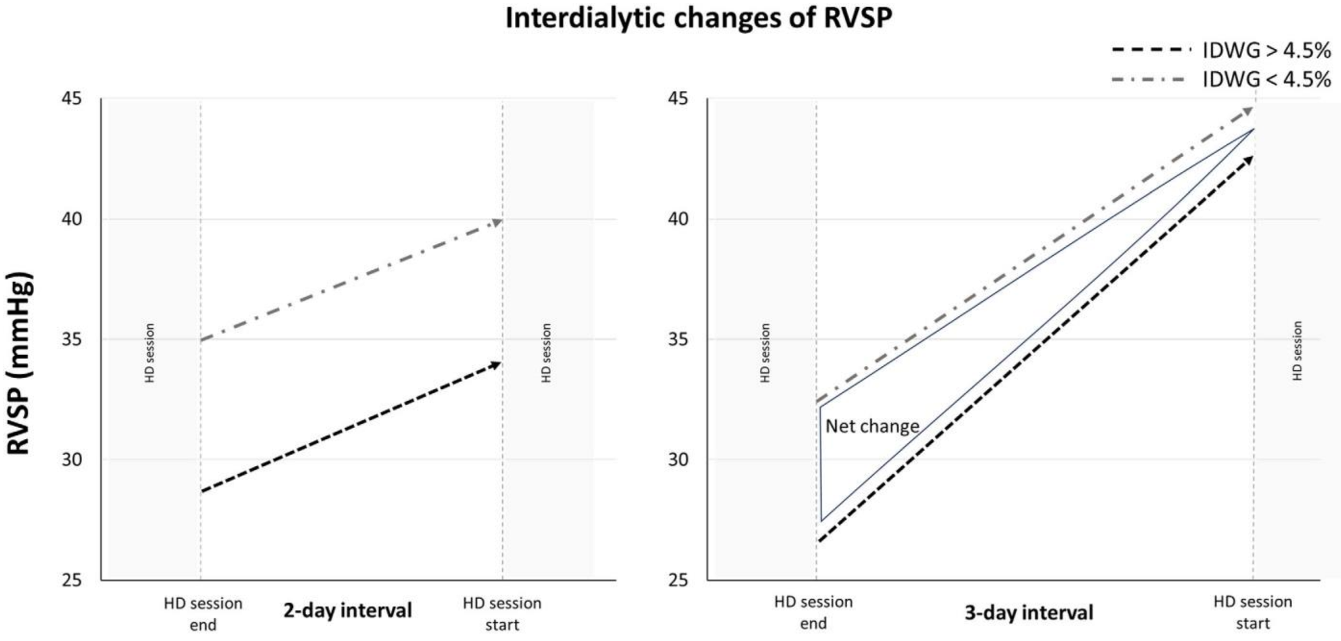
Vasileios Anastasiou[1] | Marieta P. Theodorakopoulou[2] | Vasileios Kamperidis[1] | Stylianos Daios[1] | Konstantinos Tsilonis[1] | Maria-Eleni Alexandrou[2] | Dimitrios V. Moysidis[1] | Afroditi Boutou[3] | George Giannakoulas[1] | Antonios Ziakas[1] | Pantelis Sarafidis[2]

TABLE 2 Comparison of the echocardiographic indices of right ventricular performance and volume status at the start and end of the 3-d Interdialytic Interval depending on the IDWG corrected for dry weight.

	IDWG>4.5% ($n = 21$)			IDWG <4.5% ($n = 20$)			Net changes of high vs. low IDWG% groups		
Parameters	3-day start	3-day end	*p*-value	3-day start	3-day end	*p*-value	>4.5%	<4.5%	*p*-value
RV Sm (cm/s)	14 ± 3.31	15.21 ± 3.91	0.197	14.35 ± 3.77	14.65 ± 4.83	0.77	1.21 ± 3.9	0.3 ± 4.5	0.49
RVOT VTI	17.2 ± 3.54	20.34 ± 3.38	<0.001	18.34 ± 4.72	20.34 ± 2.62	0.042	3.14 ± 2.65	1.99 ± 3.96	0.45
RV Tei index	0.48 (0.43–0.66)	0.50 (0.36–0.67)	0.594	0.53 (0.43–0.76)	0.52 (0.35–0.62)	0.13	−0.2 (−0.12–0.12)	−0.06 (−0.17–0.04)	0.13
RV E/Em	6.93 ± 2.54	8.46 ± 3.39	<0.001	7.16 ± 2.1	8.85 ± 3.33	0.028	1.53 ± 1.40	1.69 ± 3.07	0.84
TR Vmax (m/s)	2.26 ± 0.42	2.83 ± 0.49	<0.001	2.56 ± 0.57	2.78 ± 0.59	0.013	0.57 ± 0.33	0.30 ± 0.50	0.15
PGr TRV (mm Hg)	21.15 ± 8.38	33.17 ± 11	<0.001	27.52 ± 12.5	33.72 ± 14.6	0.026	12.02 ± 7.57	6.19 ± 11.43	0.11
RVSP (mm Hg)	26.43 ± 11.17	42.86 ± 11.9	<0.001	32.52 ± 13.7	46.63 ± 19.2	<0.001	16.43 ± 5.37	14.11 ± 13.38	0.015
PVR (dyn*s*cm^{-5})	1.44 (1.25–1.72)	1.53 (1.36–1.77)	0.59	1.49 (1.28–1.75)	1.51 (1.32–1.98)	0.9	0.05 (−0.13–0.18)	0.06 (−0.42–0.35)	0.036
RVEDD (mm)	3.28 ± 0.58	3.71 ± 0.66	<0.001	3.09 ± 0.73	3.33 ± 0.79	0.015	0.43 ± 0.47	0.24 ± 0.39	0.47
RAVi (mL/m^2)	19.38 (15.97–30.77)	30.89 (20.63–35.00)	<0.001	17.47 (15.24–20.55)	24.97 (18.81–31.23)	<0.001	4.74 (3.23–13.50)	5.38 (1.28–11.51)	0.22
IVCd (cm)	1.29 ± 0.32	1.85 ± 0.4	<0.001	1.5 ± 0.46	2 ± 0.44	<0.001	0.55 ± 0.27	0.50 ± 0.39	0.29



Intradialytic Cardiac Magnetic Resonance Imaging to Assess Cardiovascular Responses in a Short-Term Trial of Hemodiafiltration and Hemodialysis

Charlotte Buchanan,* Azharuddin Mohammed,† Eleanor Cox,* Katrin Köhler,‡ Bernard Canaud,‡ Maarten W. Taal,† Nicholas M. Selby,† Susan Francis,* and Chris W. McIntyre§‖

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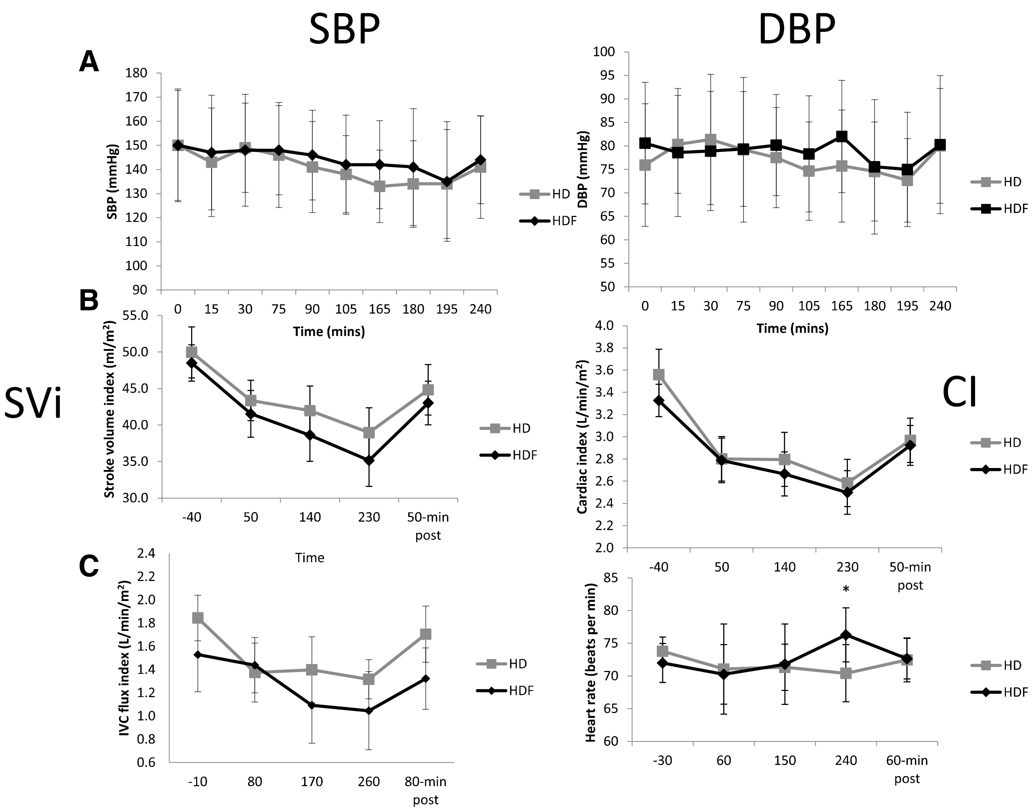
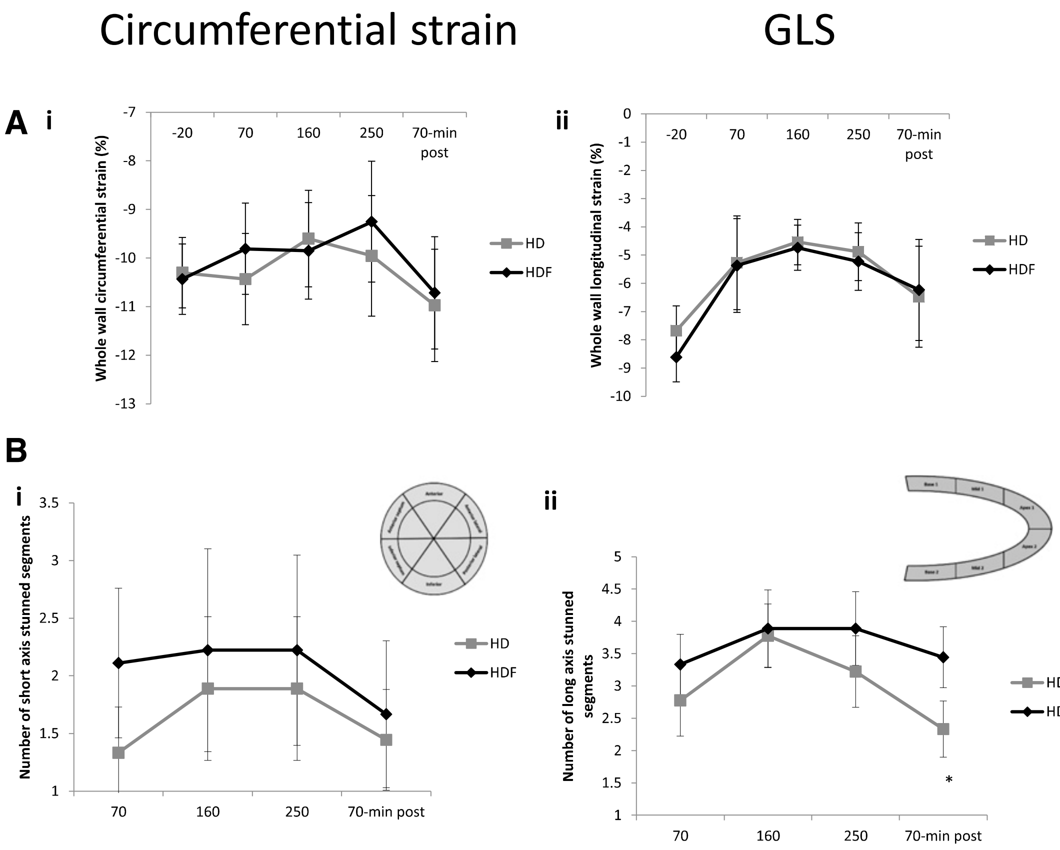
1st CMR study intradialytic





JASN 2017

Troponin T for the Detection of Dialysis-Induced Myocardial Stunning in Hemodialysis Patients

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Tobias Breidthardt, James O. Burton, Aghogho Odudu, Mohamed Tarek Eldehni, Helen J. Jefferies, and Christopher W. McIntyre

All Patients (n=70)	Patients Not Developing HD-Induced Stunning	Patients Developing HD-Induced Stunning

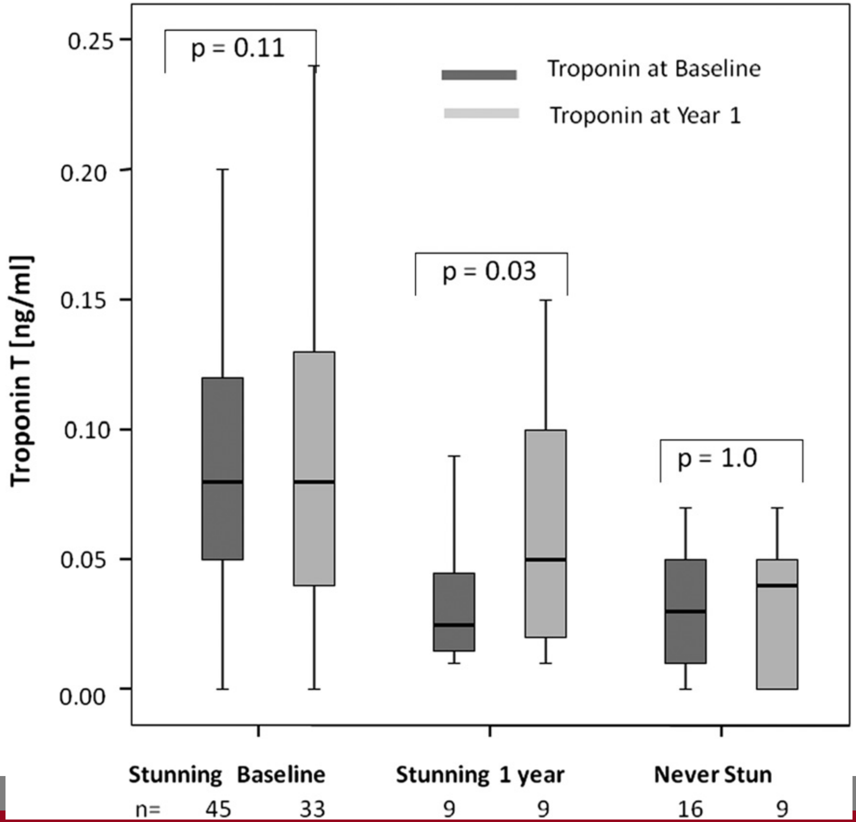

Table 2. Detection of hemodialysis-induced myocardial stunning in univariate and multivariable regression analyses

Predictor	Odds Ratio (95% CI)	P Value
Univariate analysis		
age	1.05 (1.01–1.09)	0.02
male sex	1.93 (0.64–5.76)	0.24
history of coronary artery disease	2.11 (0.71–6.31)	0.18
history of diabetes mellitus	4.38 (1.40–13.76)	0.01
history of arterial hypertension	1.38 (0.51–3.74)	0.53
left ventricular ejection fraction	0.98 (0.93–1.03)	0.42
dialysis vintage	0.99 (0.98–1.01)	0.57
interdialytic hypotension (per every additional episode)	1.97 (1.05–3.69)	0.04
ultrafiltration volume (for every additional liter)	2.54 (1.22–5.31)	0.01
troponin T (for every 0.1-ng/ ml increase)	16.38 (2.84–94.43)	, 0.01
troponin T level . 0.06 ng/ ml	10.96 (3.11–38.62)	, 0.01
Multivariable analysis		
age	1.05 (0.99–1.11)	0.08
history of diabetes mellitus	2.95 (0.59–14.53)	0.18
interdialytic hypotension (per every additional episode)	1.95 (0.80–4.80)	0.14
ultrafiltration volume (for every additional liter)	4.38 (1.01–18.24)	0.04
troponin T (for every 0.1-ng/ ml increase)	9.33 (1.63–53.43)	0.01

Clin JASN 2012

High-sensitive troponin T increase after hemodialysis is associated with left ventricular global longitudinal strain and ultrafiltration rate

Serkan Ünlü[1, 2, 3], Asife Şahinarslan[1], Burak Sezenöz[1], Orhan Mecit Uludağ[3], Gökhan Gökalp[1], Özden Seçkin[1], Selim Turgay Arınsoy[4], Özlem Gülbahar[5], Nuri Bülent Boyacı[1]

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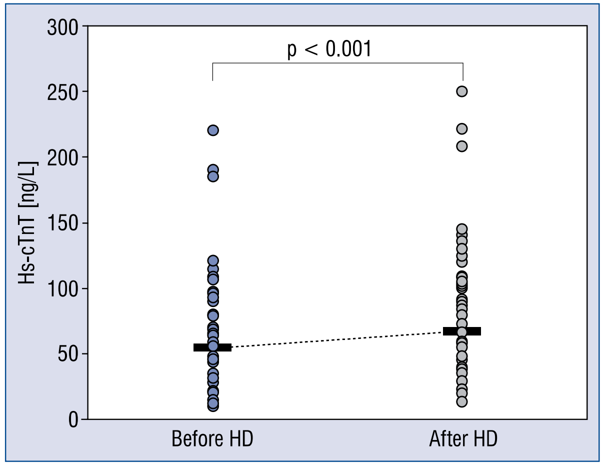

Figure 1. High-sensitive cardiac troponin T (hs-cTnT) levels before and after hemodialysis (HD). Comparison between mean values before and after HD is presented. Significance is indicated on the graph.

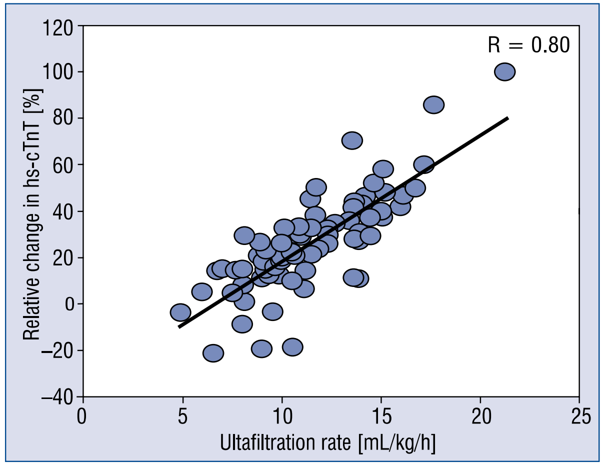

Figure 2. Comparison between relative change of high-sensitive cardiac troponin T (hs-cTnT) (y-axis) and the ultrafiltration rate (x-axis). The correlation coefficient (R) is indicated. P value is < 0.001.

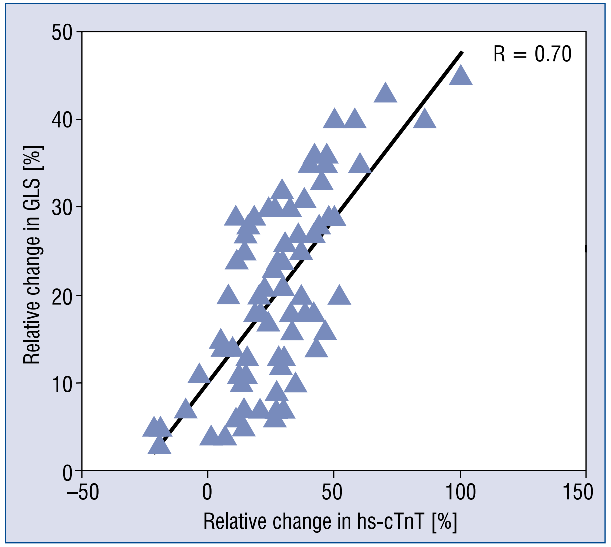

Figure 3. Comparison between relative change of global longitudinal strain (GLS) measurements (y-axis) and relative change in high-sensitive cardiac troponin T (hs-cTnT) (x-axis). The correlation coefficient (R) is indicated. P value is < 0.001.

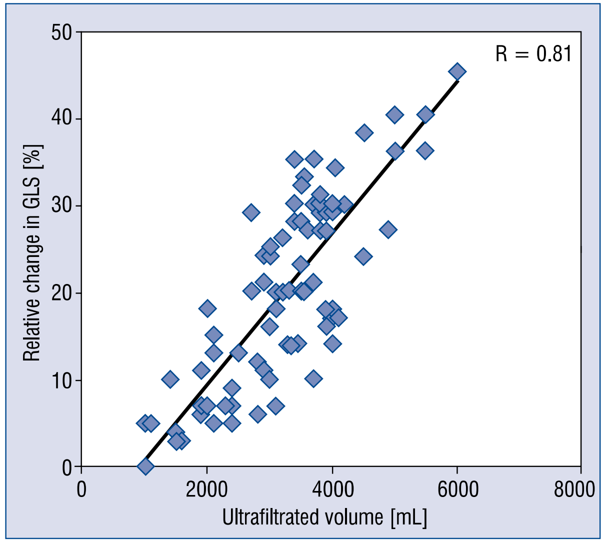

Figure 4. Comparison between relative change of global longitudinal strain (GLS) measurements (y-axis) and the ultrafiltrated volume (x-axis). The correlation coefficient (R) is indicated. P value is < 0.001.

Hemodialysis-Induced Regional Left Ventricular Systolic Dysfunction and Inflammation: A Cross-sectional Study

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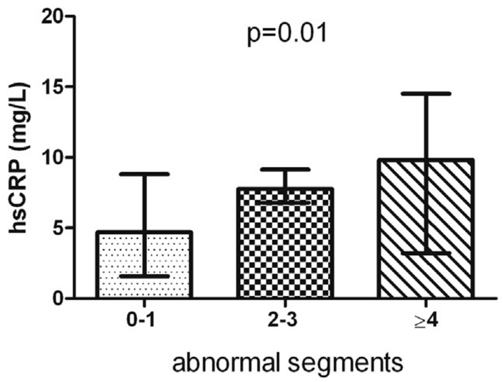
All Patients (N = 105)	No HD-Induced Regional LVSD (n = 76)	HD-Induced Regional LVSD (n = 29)

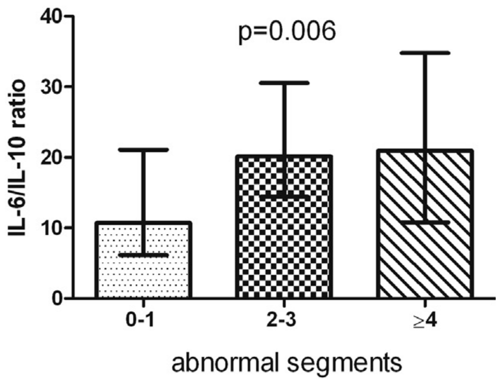
Table 3. Regression Models for the Relationship Between Predialysis Concentration of Markers and Hemodialysis-Induced Regional LV Systolic Dysfunction

	Univariate		Multivariate[a]	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Inflammatory markers				
Log(hs-CRP)	2.82 (1.10-7.25)	0.03	3.38 (1.02-11.20)	0.05
Log(PTX3)	6.27 (1.08-36.47)	0.04	2.41 (0.28-21.00)	0.4
Log(TNF-α)	0.72 (0.05-10.92)	0.8	1.18 (0.05-30.15)	0.9
Log(IL-6)	3.30 (0.86-12.70)	0.08	2.13 (0.44-10.31)	0.4
Log(IL-10)	0.34 (0.10-1.16)	0.09	0.21 (0.04-0.97)	0.05
Log(IL-6:IL-10 ratio)	4.14 (1.42-12.03)	0.009	3.92 (1.20-12.75)	0.02
Bioincompatibility markers				
Leukocytes	1.03 (0.83-1.27)	0.8	1.06 (0.85-1.33)	0.6
Neutrophils	1.03 (0.76-1.41)	0.8	1.05 (0.76-1.46)	0.8
Myeloperoxidase	0.08 (0.003-2.02)	0.1	0.28 (0.01-15.41)	0.5
Complement C3	4.15 (0.65-26.74)	0.1	8.26 (0.85-79.99)	0.07
Endothelial markers				
sICAM-1	0.53 (0.04-7.56)	0.6	0.44 (0.01-15.0)	0.7
vWF	1.01 (0.99-1.01)	0.08	1.01 (0.99-1.02)	0.4
Proendothelin	0.73 (0.01-46.1)	0.9	0.22 (0.001-36.25)	0.6
Endothelin 1	0.33 (0.10-1.11)	0.07	0.28 (0.06-1.27)	0.1

hcCRP



IL6 / IL10 ratio



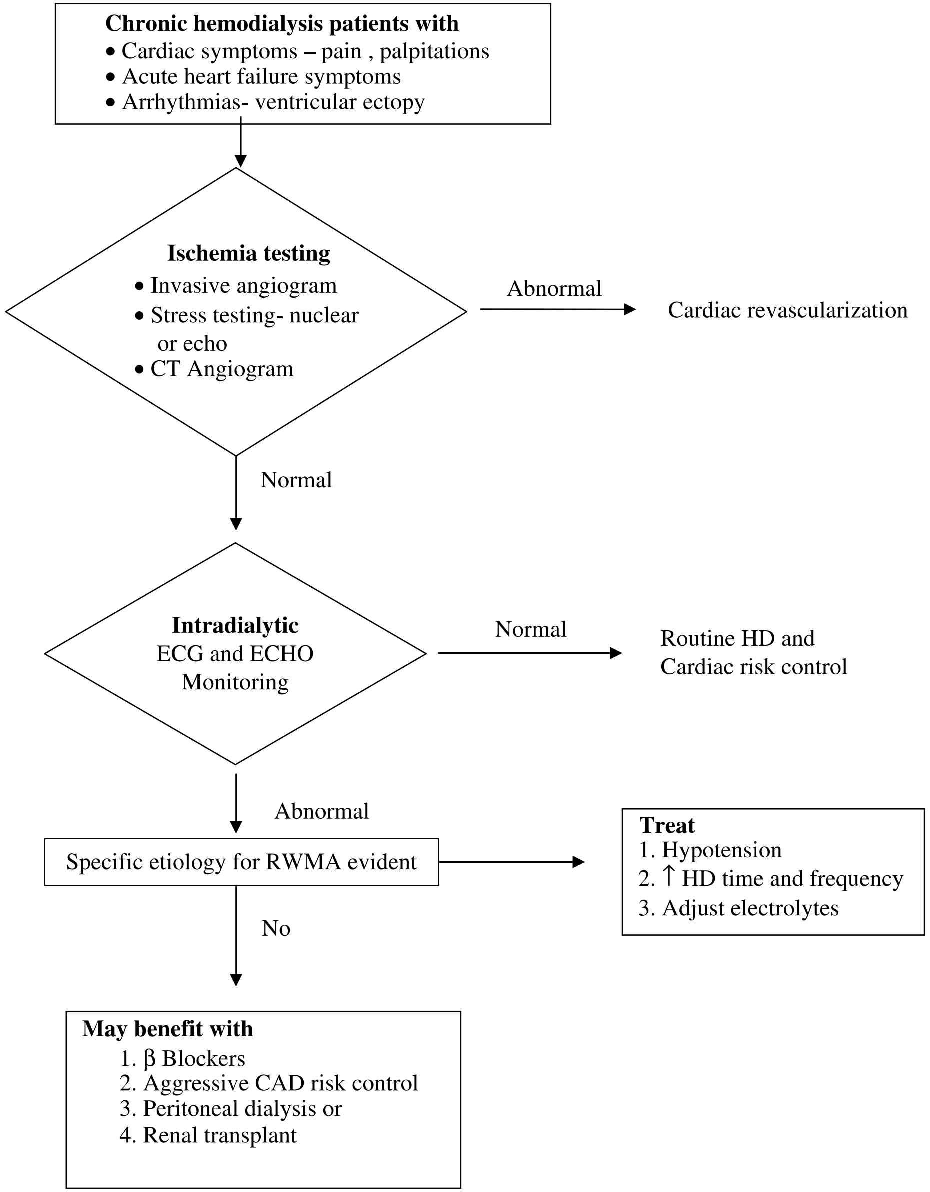


Figure 1 Algorithm for evaluating and managing symptomatic cardiac dysfunction in hemodialysis patients.

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Sudden Cardiac Death Among Hemodialysis Patients

Melissa S. Makar, MD,[1,2] and Patrick H. Pun, MD, MHS[1,2]

Table 1. Possible Strategies for SCD Prevention in HD Patients

General Strategy	Specific Intervention
Manage cardiomyopathy	
Systolic dysfunction	Use carvedilol in patients with dilated cardiomyopathy
Diastolic dysfunction/LVH	Consider more frequent HD to reduce left ventricular mass; consider use of spironolactone, ACE inhibitors, or ARBs
Minimize arrhythmic triggers	
Potassium shifts	Monitor predialysis potassium frequently, especially after hospitalization, and change dialysate bath accordingly; avoid low (<2 mEq/L) potassium baths; consider potassium modeling and potassium-binding agents to reduce interdialytic hyperkalemia
Calcium shifts	Avoid low (<2.5 mEq/L) calcium baths, especially with concurrent use of QT interval–prolonging medications
Metabolic alkalosis	Avoid high dialysate bicarbonate concentrations in alkalotic patients; account for all sources of base in dialysate, including acetate
Rapid ultrafiltration	Encourage patient adherence to salt and fluid restrictions; avoid sodium ramping and large dialysate/serum sodium gradients; extend dialysis time so that ultrafiltration rates do not exceed 10 mL/kg/h
Dialysis-induced myocardial ischemia	Lower dialysate temperature to 0.5°C-2°C below patient temperature to reduce intradialytic hypotension
Medications	Avoid QT interval–prolonging medications when possible and reconcile medication list regularly
Weigh risks and benefits of ICDs	Consider ICDs for secondary prevention; increase communication between nephrologists and cardiologists to consider risks and benefits of primary prevention ICDs; consider leadless defibrillators to reduce vascular and infectious risks
Improve response to cardiac arrest	Increase dialysis clinic staff awareness of cardiac arrest risk and readiness to provide basic life support; encourage awareness and CPR training among patients and families

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