Research Square

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Prognostic value of baseline global longitudinal strain and its changes after dialysis initiation in incident dialysis patients: a retrospective cohort study

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Abstract

Background

Left ventricular global longitudinal strain (GLS) detects myocardial dysfunction in end-stage kidney disease, but its prognostic value at the time of dialysis initiation and the significance of subsequent changes remain incompletely understood. We examined the association between baseline GLS and all-cause mortality and the course of GLS after dialysis initiation.

Methods

In this single-center retrospective cohort study, we included 654 adults who initiated dialysis between 2017 and 2023 and underwent speckle-tracking echocardiography within 3 months of dialysis initiation. All-cause mortality up to 1,000 days was analyzed using Cox regression adjusted for age, sex, diabetes mellitus, hypertension, and coronary artery disease. An exploratory GLS cutoff was derived using the Youden index. Serial changes in GLS and their associations with subsequent mortality were assessed in 364 patients who underwent repeat echocardiography approximately 1 year after dialysis initiation. GLS was expressed as an absolute value, with lower values indicating worse function.

Results

During follow-up, 54 patients (8.3%) died. After adjustment, higher baseline GLS was associated with lower mortality (hazard ratio [HR] per 1-percentage-point increase, 0.935; 95% confidence interval [CI], 0.878–0.996; P = 0.036). Patients with GLS > 12.1% had lower mortality than those with GLS ≤ 12.1% (adjusted HR, 0.492; 95% CI, 0.286–0.846; P = 0.010). In the longitudinal cohort, mean GLS decreased from 16.84% to 16.50% (mean difference, − 0.34 percentage points; 95% CI, − 0.61 to − 0.07; P = 0.013), and mean left ventricular ejection fraction decreased from 62.40% to 61.82% (mean difference, − 0.58 percentage points; P < 0.001). Twenty patients died after repeat imaging; neither follow-up GLS nor its change was significantly associated with subsequent mortality.

Conclusions

Lower baseline GLS at dialysis initiation was associated with higher all-cause mortality after adjustment for clinical covariates. Average changes in GLS during the first year of dialysis were small. Whether follow-up GLS or its change provides additional prognostic information remains uncertain because the longitudinal analysis involved a selected survivor cohort with few events.

Background

Cardiovascular disease is a leading cause of morbidity and mortality in patients with end-stage kidney disease (ESKD) [1]. The transition to dialysis is a period of heightened cardiovascular vulnerability [2], and accurate identification of patients at increased risk is important for prognostic assessment and the development of surveillance strategies [3]. Cardiac assessment around dialysis initiation therefore offers an opportunity to characterize myocardial dysfunction before longer-term outcomes are established.

Conventional echocardiographic assessment of systolic function relies primarily on left ventricular ejection fraction (LVEF) [4]. However, LVEF may remain preserved despite myocardial dysfunction and may not fully capture subclinical abnormalities in patients with chronic kidney disease or ESKD [5]. More sensitive markers of myocardial performance may therefore complement conventional risk assessment [6]. Global longitudinal strain (GLS), measured by two-dimensional speckle-tracking echocardiography, quantifies longitudinal myocardial deformation and has been associated with mortality in patients with kidney disease [7]. GLS can reveal myocardial impairment despite preserved LVEF, and prognostic associations have been reported in dialysis and heart failure populations [8, 9].

Most previous studies have relied on a single echocardiographic assessment, and data on longitudinal changes in GLS after dialysis initiation remain limited. Baseline GLS and its subsequent changes may capture different aspects of cardiac risk: the former reflects myocardial function around the transition to dialysis, whereas the latter may reflect evolving myocardial disease and changes in loading conditions. We therefore investigated the association between baseline GLS and all-cause mortality in incident dialysis patients. We also evaluated serial changes in GLS and the associations of follow-up GLS and its change with subsequent mortality in patients who underwent repeat echocardiography.

Methods

Study design and population

This single-center retrospective cohort study was approved by the Institutional Review Board of Incheon Sejong Hospital (IRB No. 2026-02-006), which waived the requirement for informed consent because of the retrospective design. The study population consisted of adult patients (≥ 18 years) with ESKD who initiated hemodialysis or peritoneal dialysis between 2017 and 2023. A total of 654 patients who underwent baseline echocardiography with strain analysis within 3 months before or after dialysis initiation were included. At our center, echocardiography is routinely recommended around the time of dialysis initiation and approximately 1 year thereafter. Demographic characteristics, comorbidities, dialysis modality, and laboratory data were extracted from electronic health records.

Echocardiography and strain analysis

Echocardiographic images were reviewed using GE Healthcare offline analysis software. Left ventricular dimensions were measured in the parasternal long-axis view, and LVEF was calculated using the biplane modified Simpson method. Apical two-chamber, four-chamber, and long-axis views were used for strain

analysis. The left ventricular endocardial border was traced manually at end-diastole, defined as the first frame of mitral valve coaptation, and the region of interest was adjusted to encompass the myocardial thickness. Segmental longitudinal strain was computed automatically using an 18-segment model, and segments with inadequate speckle tracking were excluded. Patients with two or more non-analyzable segments in a single view or more than three non-analyzable segments overall were considered ineligible for strain analysis. GLS was calculated by averaging the available segmental values at peak systolic strain [4]. All GLS values were expressed as absolute values; lower absolute GLS therefore indicates worse longitudinal systolic function. Changes in GLS and LVEF were defined as follow-up minus baseline values and are reported in percentage points.

Outcome and follow-up

Outcome and follow-up
The primary outcome was all-cause mortality. Survival time was calculated from the date of dialysis initiation to the date of death or last follow-up. Patients who did not die were censored at kidney transplantation, the last date they were known to be alive, or day 1,000, whichever occurred first.

Longitudinal echocardiography cohort

In a secondary analysis, patients who underwent follow-up echocardiography within ± 6 months of the 1-year time point after dialysis initiation were evaluated. Patients who died before follow-up echocardiography, lacked follow-up echocardiographic data, or were transferred to other hospitals were excluded. In these analyses, only deaths occurring after follow-up echocardiography and within 1,000 days of dialysis initiation were counted as events.

Statistical analysis

Continuous variables are presented as mean ± standard deviation (SD) or median (interquartile range [IQR]), as appropriate, and categorical variables as frequencies and percentages. Comparisons between groups were performed using the independent t-test or Mann–Whitney U test for continuous variables and the chi-square test or Fisher’s exact test for categorical variables.

Receiver operating characteristic (ROC) analysis was used to derive a baseline GLS cutoff for all-cause mortality using the Youden index. Because this cutoff was derived in the same cohort in which its association with mortality was assessed, analyses using the cutoff were considered exploratory.

In the overall cohort, Cox proportional hazards regression was used to evaluate associations between echocardiographic parameters and all-cause mortality, and hazard ratios (HRs) with 95% confidence intervals (CIs) were calculated. GLS was analyzed as a continuous variable and as a categorical variable using the data-derived cutoff. Multivariable models included age, sex, diabetes mellitus, hypertension, and coronary artery disease. Given the limited number of events, covariates were restricted to these

prespecified clinical variables, and LVEF and GLS were assessed in separate models; the incremental prognostic value of GLS beyond LVEF was therefore not evaluated. Survival curves were estimated using the Kaplan–Meier method and compared using the log-rank test.

Changes in echocardiographic parameters between baseline and follow-up examinations were evaluated using paired t-tests, and correlations between baseline and follow-up GLS were assessed using Pearson correlation analysis. In the longitudinal cohort, associations of follow-up echocardiographic parameters and their changes with subsequent mortality were assessed using separate univariable logistic regression models, and odds ratios (ORs) with 95% CIs were reported. These exploratory analyses did not account for differences in the duration of observation after repeat imaging.

All statistical analyses were performed using IBM SPSS Statistics version 32.0 (IBM Corp., Armonk, NY, USA) and MedCalc Statistical Software (MedCalc Software Ltd, Ostend, Belgium). A two-sided P value < 0.05 was considered statistically significant.

Results

Study population and baseline characteristics

The study cohort comprised 654 incident dialysis patients, of whom 364 underwent follow-up echocardiography (Fig. 1). The baseline GLS cutoff derived using the Youden index was 12.1%. Baseline characteristics according to this cutoff are shown in Table 1. Patients with baseline GLS ≤ 12.1% had more pronounced cardiac remodeling and dysfunction than those with GLS > 12.1%, including lower LVEF (53.6% vs. 60.9%, P < 0.001), a higher E/e' ratio (22.5 vs. 16.4, P < 0.001), a larger left atrial volume index (51.4 vs. 43.6 mL/m², P < 0.001), and greater left ventricular dimensions. Heart failure was also more prevalent in patients with GLS ≤ 12.1% (45.1% vs. 25.7%, P < 0.001).

Of 654 incident dialysis patients with baseline GLS, 364 underwent repeat echocardiography. Among the 290 patients without repeat imaging, 34 died before reassessment and 256 had no follow-up echocardiographic data. Twenty deaths occurred after repeat imaging in the longitudinal cohort. GLS, global longitudinal strain

Table 1
Baseline characteristics according to baseline GLS (n = 654)

Variable	GLS > 12.1% (n = 459)	GLS ≤ 12.1% (n = 195)	P value
Age, years	63.7 ± 13.9	65.1 ± 13.2	0.249
Male sex	267 (58.2)	123 (63.1)	0.279
Dialysis modality			0.329
Hemodialysis	444 (96.7)	192 (98.5)	
Peritoneal dialysis	15 (3.3)	3 (1.5)	
Hypertension	161 (35.1)	65 (33.3)	0.735
Diabetes mellitus	171 (37.3)	80 (41.0)	0.413
Coronary artery disease	145 (31.6)	73 (37.4)	0.174
Myocardial infarction	29 (6.3)	22 (11.3)	0.045
Stroke	40 (8.7)	24 (12.3)	0.204
Peripheral arterial disease	26 (5.7)	15 (7.7)	0.422
Atrial fibrillation	26 (5.7)	24 (12.3)	0.006
COPD	7 (1.5)	3 (1.5)	1.000
Heart failure	118 (25.7)	88 (45.1)	< 0.001
Echocardiographic parameters			
LVEF, %	60.9 ± 6.8	53.6 ± 6.1	< 0.001
E/e'	16.4 ± 6.9	22.5 ± 9.1	< 0.001
LAVI, mL/m²	43.6 ± 18.7	51.4 ± 19.8	< 0.001
LVESD, mm	33.7 ± 5.5	43.3 ± 9.1	< 0.001
LVEDD, mm	50.7 ± 5.4	55.6 ± 7.8	< 0.001

Values are mean ± SD or n (%). Continuous variables were compared using independent-samples t-tests and categorical variables using chi-square tests with continuity correction. GLS is expressed as an absolute value. COPD, chronic obstructive pulmonary disease; E/e', ratio of early transmitral inflow velocity to early diastolic mitral annular velocity; GLS, global longitudinal strain; LAVI, left atrial volume index; LVEDD, left ventricular end-diastolic diameter; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic diameter; SD, standard deviation

Baseline GLS and all-cause mortality

During follow-up of up to 1,000 days after dialysis initiation, 54 patients (8.3%) died. Kaplan–Meier analysis showed lower survival in patients with baseline GLS ≤ 12.1% than in those with GLS > 12.1% (log-rank P = 0.012) (Fig. 2). In univariable Cox analysis, baseline GLS (HR per 1-percentage-point increase, 0.937; 95% CI, 0.881–0.997; P = 0.039) and baseline LVEF (HR per 1-percentage-point increase, 0.95; 95% CI, 0.92–0.99; P = 0.006) were associated with mortality. Baseline GLS and LVEF were moderately correlated (r = 0.546, P < 0.001).

Patients were grouped using the data-derived baseline absolute GLS cutoff of 12.1%. Shaded areas indicate 95% confidence intervals. Numbers at risk are shown beneath the curves. Log-rank P = 0.012. GLS, global longitudinal strain

After adjustment for age, sex, hypertension, diabetes mellitus, and coronary artery disease, baseline GLS remained associated with all-cause mortality (HR per 1-percentage-point increase, 0.935; 95% CI, 0.878–0.996; P = 0.036) (Table 2). Patients with GLS > 12.1% had lower mortality than those with GLS ≤ 12.1% (adjusted HR, 0.492; 95% CI, 0.286–0.846; P = 0.010). Older age was also associated with mortality (HR per 1-year increase, 1.10; 95% CI, 1.07–1.13; P < 0.001), whereas the other clinical covariates were not statistically significant.

Table 2
Cox regression analyses of baseline GLS and all-cause mortality (n = 654)

GLS parameter and model	HR (95% CI)	P value
GLS as a continuous variable (per 1-percentage-point increase)		
Unadjusted	0.937 (0.881–0.997)	0.039
Age- and sex-adjusted	0.936 (0.879–0.997)	0.039
Fully adjusted[a]	0.935 (0.878–0.996)	0.036
GLS > 12.1% versus ≤ 12.1%		
Unadjusted	0.510 (0.298–0.872)	0.014
Age- and sex-adjusted	0.496 (0.289–0.850)	0.011
Fully adjusted[a]	0.492 (0.286–0.846)	0.010

[a]Adjusted for age, sex, diabetes mellitus, hypertension, and coronary artery disease. Each GLS specification was analyzed in a separate model. GLS is expressed as an absolute value. CI, confidence interval; GLS, global longitudinal strain; HR, hazard ratio

Serial changes in GLS and LVEF

Of the 654 patients, 34 (5.2%) died before follow-up echocardiography, all within the first year after dialysis initiation, and were excluded from the longitudinal analysis. Of the remaining 620 patients, 256

(41.3%) did not undergo follow-up echocardiography and were also excluded. The longitudinal cohort therefore comprised 364 patients. The median interval between baseline and follow-up echocardiography was 392 days (IQR, 147–590 days), and 20 patients (5.5%) died after follow-up echocardiography.

Baseline and follow-up GLS values were strongly correlated (r = 0.705, P < 0.001) (Fig. 3A). Mean GLS decreased from 16.84 ± 3.33% to 16.50 ± 3.48% (mean difference, − 0.34 percentage points; 95% CI, − 0.61 to − 0.07; P = 0.013), and mean LVEF decreased from 62.40 ± 7.27% to 61.82 ± 7.30% (mean difference, − 0.58 percentage points; 95% CI, − 0.91 to − 0.25; P < 0.001) (Table 3; Fig. 3B). Although both changes were statistically significant, their average magnitudes were small, and these mean changes do not describe the full range of individual trajectories.

Table 3
Changes in echocardiographic parameters from baseline to follow-up (n = 364)

Variable	Baseline	Follow-up	Mean difference (95% CI)	P value
LVEF, %	62.40 ± 7.27	61.82 ± 7.30	−0.58 (− 0.91 to − 0.25)	< 0.001
GLS, %	16.84 ± 3.33	16.50 ± 3.48	−0.34 (− 0.61 to − 0.07)	0.013

Values are mean ± SD. Mean differences are follow-up minus baseline values, expressed in percentage points, and were compared using paired t-tests. GLS is expressed as an absolute value. CI, confidence interval; GLS, global longitudinal strain; LVEF, left ventricular ejection fraction; SD, standard deviation

A Relationship between baseline and follow-up absolute GLS in 364 patients. The dashed line indicates the line of identity and the solid line the linear fit. B Paired baseline and follow-up measurements; black circles and error bars indicate means and 95% confidence intervals. The mean change was − 0.34 percentage points (95% CI, − 0.61 to − 0.07; paired P = 0.013). CI, confidence interval; GLS, global longitudinal strain

Follow-up GLS and subsequent mortality

In the longitudinal cohort, neither follow-up LVEF nor follow-up GLS was significantly associated with subsequent all-cause mortality in univariable logistic regression. Changes in LVEF and GLS were also not significantly associated with mortality (Table 4).

Table 4
Follow-up echocardiographic parameters, their changes, and subsequent all-cause mortality (n = 364)

Variable (per 1-percentage-point increase)	OR (95% CI)	P value
Follow-up LVEF	0.976 (0.925–1.029)	0.371
Follow-up GLS	0.985 (0.866–1.120)	0.822
ΔLVEF	1.059 (0.917–1.222)	0.436
ΔGLS	1.113 (0.921–1.345)	0.266

Odds ratios were estimated using separate univariable logistic regression models for deaths occurring after follow-up echocardiography (20 events). Changes (Δ) were calculated as follow-up minus baseline values. GLS is expressed as an absolute value. These exploratory models did not account for variable follow-up time. CI, confidence interval; GLS, global longitudinal strain; LVEF, left ventricular ejection fraction; OR, odds ratio

Characteristics according to availability of follow-up echocardiography

To characterize potential selection and survivor bias, baseline characteristics were compared according to the availability of follow-up echocardiography (Additional file 1: Table S1). Patients without repeat imaging were more often male and had more coronary artery disease, myocardial infarction, atrial fibrillation, and heart failure, as well as lower baseline LVEF and GLS. Mortality was higher among patients without repeat imaging (11.7% vs. 5.5%, P = 0.006), although these groups were defined partly by survival to repeat assessment.

Discussion

In this cohort of incident dialysis patients, lower baseline GLS was associated with higher all-cause mortality after adjustment for selected clinical covariates. In patients with repeat echocardiography, GLS and LVEF showed small average declines after dialysis initiation, and neither follow-up GLS nor its change was significantly associated with subsequent mortality. These findings distinguish the prognostic association of baseline GLS in the overall cohort from the more uncertain interpretation of serial measurements in a selected survivor subgroup.

Conventional measures of systolic function, including LVEF, may incompletely characterize myocardial dysfunction in patients with advanced kidney disease [10]. Studies using echocardiographic and cardiovascular magnetic resonance strain measurements have reported associations between impaired myocardial deformation and mortality in ESKD [11, 12], and similar associations have been described in chronic kidney disease and heart failure populations [13, 14]. Our findings extend this literature to assessment around dialysis initiation. However, the current models establish an association

independent of the included clinical covariates rather than incremental prognostic value beyond LVEF, which should be tested in larger cohorts with more events.

The mean decline in GLS was less than 1 percentage point. Statistical significance of such a small average change does not establish clinically meaningful deterioration, particularly in the absence of reproducibility data or a prespecified threshold for meaningful change [15]. Strain measurements are influenced by loading conditions, and changes in cardiac mechanics have been observed before and after individual hemodialysis sessions [16]. Structural abnormalities associated with chronic kidney disease, including hypertrophy and fibrosis, may persist despite dialysis treatment [17, 18]. Nevertheless, our observational findings cannot distinguish persistent myocardial injury from variation in loading conditions or measurement. Kim et al. reported improvement in GLS after kidney transplantation [19], but differences in patient selection and treatment context limit direct comparison. The present study therefore does not establish whether dialysis reverses, stabilizes, or worsens underlying myocardial disease.

The difference between the baseline and longitudinal findings warrants cautious interpretation. Repeat imaging was available only for patients who survived to reassessment, and these patients had less comorbidity and better baseline cardiac function than those without repeat imaging. Their narrower range of risk and the occurrence of only 20 subsequent deaths may have limited the ability to detect associations. In addition, logistic regression did not account for the timing of death, censoring, or variable observation periods after repeat imaging; a time-to-event analysis with a clearly defined landmark at repeat echocardiography would better address these temporal differences. The null longitudinal findings should therefore not be interpreted as evidence that serial GLS assessment lacks prognostic value.

Assessment at dialysis initiation is clinically relevant because adverse outcomes are concentrated in the early dialysis period [20]. GLS may characterize myocardial dysfunction that is not fully apparent from LVEF alone [21, 22]. Al-Chalabi et al. reported differing prognostic associations of GLS in maintenance hemodialysis patients with and without diabetes [23]. Our study included both groups at dialysis initiation and additionally examined repeat measurements, but it did not test an interaction between diabetes and GLS; the baseline association should therefore not be assumed to be identical across diabetes subgroups. Clinically, baseline GLS may complement a broader cardiac assessment at dialysis initiation, but the present data do not establish that GLS-guided management improves outcomes or that the 12.1% cutoff should be used as a treatment threshold.

Limitations

Several limitations should be acknowledged. First, this retrospective, single-center study is susceptible to residual confounding and selection bias, including selection for analyzable baseline strain imaging. Because of the limited number of deaths, the multivariable models did not include heart failure history, LVEF, laboratory markers, or indices of volume status, which differed between GLS groups. Second,

baseline imaging was obtained within 3 months before or after dialysis initiation, introducing variation in clinical state and possible time-origin bias when imaging occurred after cohort entry. Third, follow-up imaging was unavailable for many patients, and the longitudinal cohort was conditioned on survival and repeat assessment; the small number of deaths and unadjusted logistic models limit interpretation of the longitudinal associations. Fourth, the data-derived GLS cutoff was not externally validated and may overestimate risk separation. Fifth, variation in loading conditions relative to dialysis sessions and measurement reproducibility may influence the interpretation of small serial changes. Finally, all-cause mortality does not distinguish cardiovascular from noncardiovascular mechanisms, and the predominantly hemodialysis population limits generalizability to peritoneal dialysis.

Conclusions

Lower baseline absolute GLS was associated with higher all-cause mortality in incident dialysis patients after adjustment for selected clinical covariates. Small average declines in GLS were observed in patients with repeat imaging, but the prognostic significance of follow-up GLS and its change remains uncertain because of survivor selection, few events, and the limitations of the longitudinal analysis. These findings support further evaluation of baseline GLS for risk assessment at dialysis initiation and of serial GLS using standardized imaging and appropriately timed outcome analyses.

Abbreviations

CI: Confidence interval

COPD: Chronic obstructive pulmonary disease

E/e': Ratio of early transmitral inflow velocity to early diastolic mitral annular velocity

ESKD: End-stage kidney disease

GLS: Global longitudinal strain

HR: Hazard ratio

IQR: Interquartile range

LAVI: Left atrial volume index

LVEDD: Left ventricular end-diastolic diameter

LVEF: Left ventricular ejection fraction

LVESD: Left ventricular end-systolic diameter

OR: Odds ratio

ROC: Receiver operating characteristic

SD: Standard deviation

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Incheon Sejong Hospital (IRB No. 2026-02-006). The requirement for informed consent was waived by the Institutional Review Board because of the retrospective design of the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

SDB collected the data and drafted the manuscript. SJ and SJJ contributed to data interpretation and critically revised the manuscript. SL contributed to data collection. KHK supervised the study, interpreted the data, and wrote and critically revised the manuscript. All authors read and approved the final manuscript.

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Figures

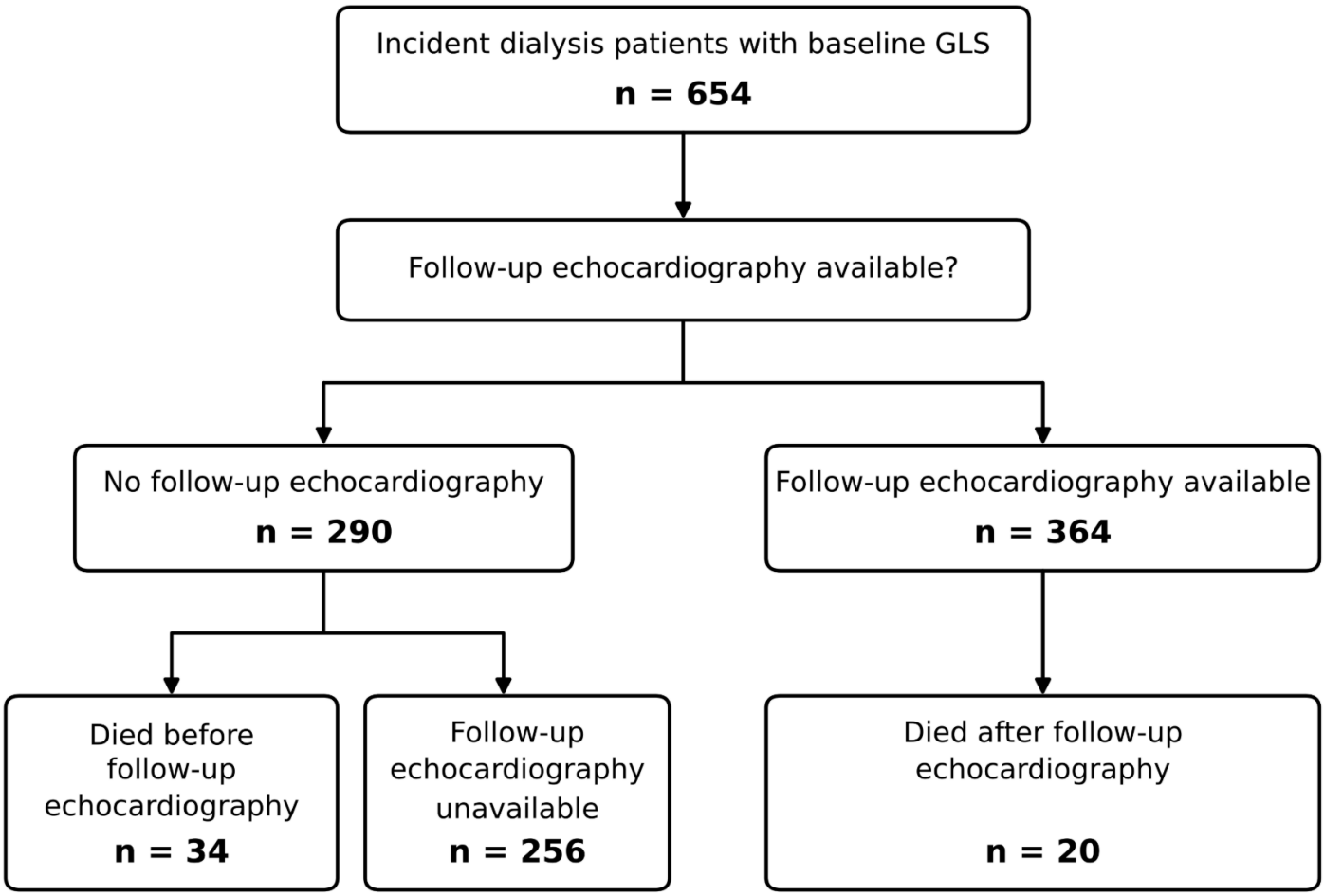
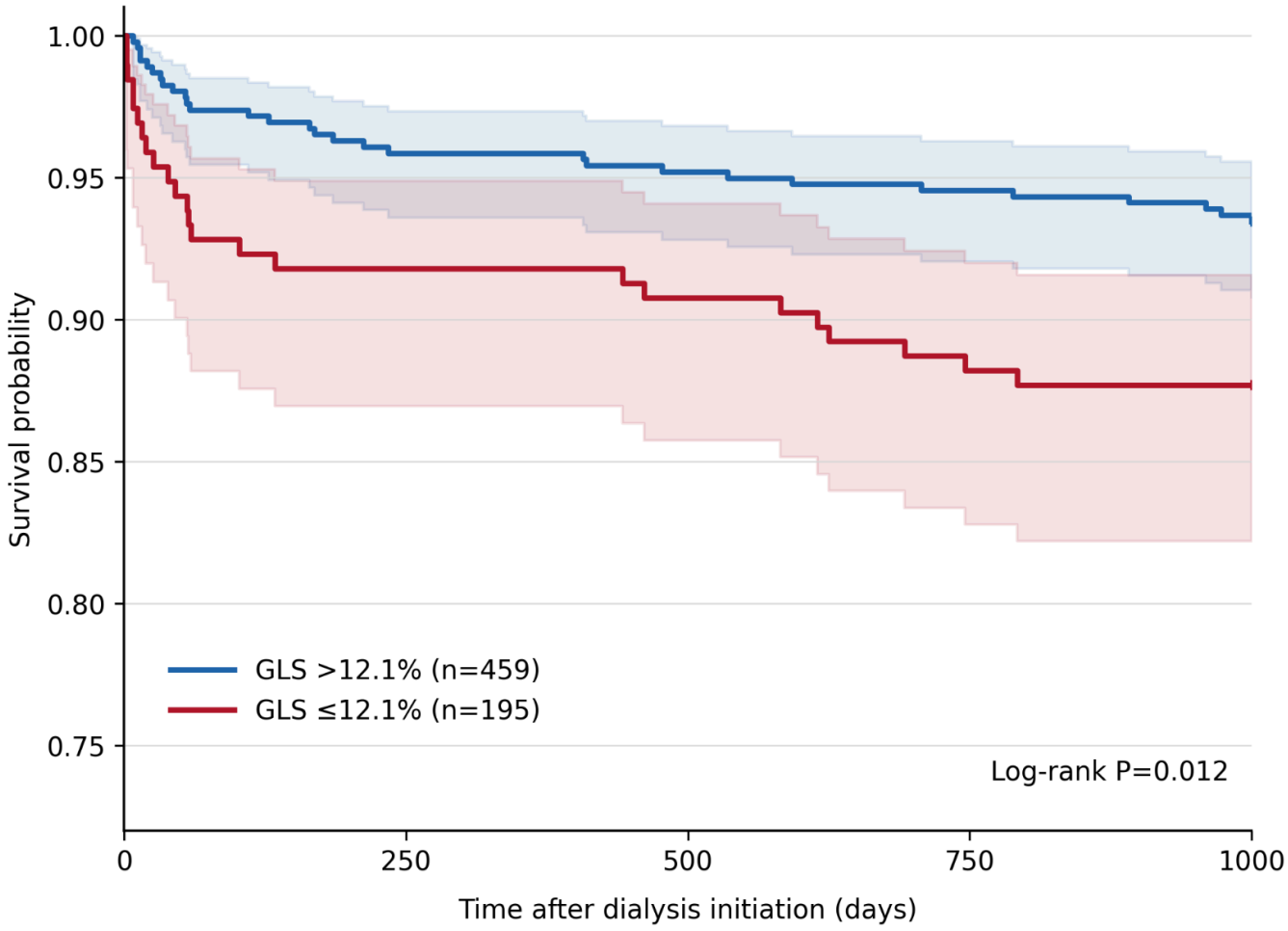


Figure 1

Flow diagram of the study cohort and availability of follow-up echocardiography



Number at risk

GLS >12.1%	459	440	437	434	430
GLS ≤12.1%	195	179	177	172	171

Figure 2

Kaplan–Meier curves for all-cause mortality according to baseline GLS

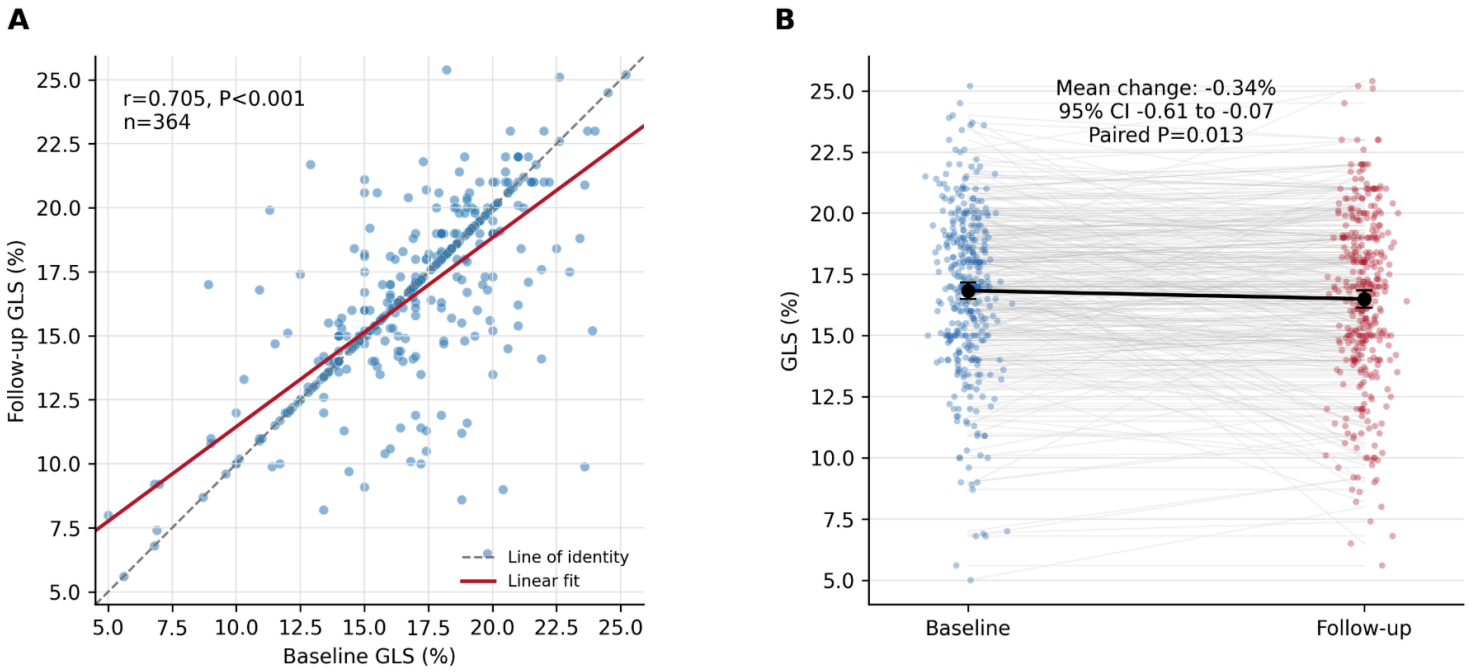


Figure 3

Correlation and longitudinal changes in GLS

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- 04Additionalfile1TableS1.docx