

Point-of-care ultrasound–guided early decongestion and 6-month outcomes in patients hospitalized with acute decompensated heart failure on an internal medicine ward: a comparative cohort study

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Research Article

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Abstract

Background

Residual congestion is a major driver of early events after hospitalization for acute decompensated heart failure (ADHF), and physical examination detects it poorly. We examined whether a point-of-care ultrasound (POCUS)–guided early decongestion strategy was associated with 6-month outcomes in patients with ADHF managed on an internal medicine ward.

Methods

In this single-center comparative cohort study, patients with ADHF managed with a POCUS-guided strategy were enrolled prospectively. In this strategy, an inferior vena cava (IVC) diameter > 2.1 cm with collapsibility < 50% triggered 200 mg of intravenous furosemide in the first 24 hours. Patients with ADHF who did not undergo POCUS in the clinic were retrospectively selected as controls. The primary outcome was a composite of all-cause death or heart failure (HF) readmission within 6 months after discharge, ascertained from hospital records and analyzed with Cox regression.

Results

Of 100 patients, 94 had verifiable follow-up (46 POCUS-guided, 48 controls; mean age 75.4 years; 55% women). The primary outcome occurred in 25 (54%) POCUS-guided patients and 19 (40%) controls (hazard ratio [HR] 1.49, 95% CI 0.82–2.71; adjusted HR 1.36, 95% CI 0.73–2.53). HF readmission (24% vs. 19%), death (37% vs. 31%), 30-day outcomes and length of stay did not differ significantly.

Conclusions

In this real-world cohort, POCUS-guided early intensified decongestion was not associated with improved 6-month outcomes. Adequately powered randomized trials that separate ultrasound assessment from diuretic intensity are needed before this strategy is adopted.

Background

Hospitalization for heart failure (HF) is a sentinel event with a substantial clinical and economic burden [1]. The months after discharge, often called the "vulnerable phase", carry a high risk of readmission and death [2, 3].

Congestion is the main reason for admission in acute decompensated heart failure (ADHF) and the main target of in-hospital treatment. Residual congestion at discharge is common and is associated with rehospitalization and mortality [4]. Persistent venous congestion is also linked to worsening renal

function [5]. Physical examination and symptoms have limited sensitivity for subclinical congestion, so many patients may leave hospital incompletely decongested [6].

Point-of-care ultrasound (POCUS) offers a rapid, repeatable bedside measure of congestion. Lung ultrasound B-lines reflect extravascular lung water and carry prognostic value in acute and chronic HF [7–9]. Inferior vena cava (IVC) diameter and collapsibility estimate right atrial pressure and systemic venous congestion [10], and IVC findings have been associated with readmission after ADHF [11]. Current guidelines support imaging alongside clinical and biomarker assessment [12].

Most of this evidence, however, shows that ultrasound findings predict outcomes, not that acting on them improves outcomes. Randomized trials of ultrasound-guided therapy are mixed. Pooled data suggest fewer HF readmissions without a survival benefit [13], whereas a multicenter IVC-guided decongestion trial in hospitalized patients [14] and an emergency department lung ultrasound–guided trial [15] were neutral. Whether intensifying early loop diuretic therapy improves outcomes is also uncertain [16, 17]. Moreover, a large share of patients hospitalized with HF are managed on internal medicine wards; they are older, more often women and more often have preserved ejection fraction than cardiology patients [18]. Data on internist-performed, POCUS-guided decongestion in this setting are scarce.

We therefore compared a POCUS-guided early decongestion strategy with standard clinical assessment in patients hospitalized with ADHF on internal medicine wards. The primary outcome was death or HF readmission within 6 months after discharge.

Methods

Study design and setting

This single-center comparative cohort study was conducted at Kartal Dr. Lütfi Kırdar City Hospital, Istanbul, Türkiye, and is reported according to the STROBE statement [19]. The POCUS-guided group comprised patients hospitalized with ADHF in the internal medicine clinic where POCUS-guided congestion assessment was performed; they were enrolled prospectively. The comparison group comprised consecutive patients hospitalized with ADHF in an internal medicine clinic of the same hospital where POCUS was not used; they were identified retrospectively from the hospital information system. Clinical trial number: not applicable.'

Participants

Adult patients hospitalized with a primary diagnosis of ADHF were eligible. Patients were excluded if they were aged < 18 years; had cardiogenic shock or severe hemodynamic instability requiring vasopressor or mechanical circulatory support; had acute coronary syndrome, acute pulmonary embolism, or another acute cardiovascular condition requiring a specific treatment strategy; had

dyspnea primarily attributable to a non-cardiac condition; had a left ventricular assist device or previous heart transplantation; had conditions precluding adequate lung ultrasound or inferior vena cava assessment; were unable to undergo POCUS within the predefined time window; or were unable or unwilling to provide informed consent. Fifty patients were included in each group.

Point-of-care ultrasound protocol

Point-of-care ultrasound protocol

All examinations were performed at admission by a single experienced internist. The IVC was imaged in the subcostal long-axis view during spontaneous breathing; maximum and minimum diameters were measured and the collapsibility index was calculated as $(IVC_{max} - IVC_{min}) / IVC_{max} \times 100$. An IVC diameter > 2.1 cm with collapsibility < 50% was considered to indicate elevated right atrial pressure [10].

Lung ultrasound used a six-zone protocol (three zones per hemithorax) [20]. A zone was considered positive when it contained more than three B-lines, and findings were classified as absent, unilateral or bilateral; pleural effusion was classified in the same way. Lung ultrasound findings were interpreted with the clinical picture but were not part of the dosing rule.

Decongestion strategy

In the POCUS-guided group, patients meeting the IVC criteria received 200 mg of intravenous furosemide in the first 24 hours; all patients in this group met the criteria. In the comparison group, initial therapy followed routine practice with 100 mg of intravenous furosemide in the first 24 hours. Thereafter, diuretic therapy in both groups was titrated by the treating physician. Because the POCUS pathway fully determined the initial dose, the intervention is analyzed as a combined strategy of ultrasound-confirmed congestion plus intensified early decongestion.

Data collection and definitions

Demographics, smoking and alcohol status, comorbidities, the age-adjusted Charlson Comorbidity Index [21], admission medications and admission laboratory values were obtained from medical records. Total furosemide dose and urine output were recorded during hospitalization. Left ventricular ejection fraction (LVEF) was obtained from transthoracic echocardiography performed by a cardiologist. According to the 2026 ESC Guidelines, patients were classified as having HF with reduced (HFrEF; LVEF < 50%) or preserved (HFpEF; LVEF $\geq$ 50%) ejection fraction [12].

Outcomes

The primary outcome was a composite of all-cause death or readmission to our hospital for HF within 6 months after discharge, analyzed as time to first event. Secondary outcomes were each component at 6

months, HF readmission and death within 30 days after discharge, and length of stay. Admission, discharge, readmission and death dates were ascertained from the hospital information system using the same procedure in both groups. Outcomes were re-ascertained from these records for the present analysis, and length of stay was calculated from the recorded dates.

Statistical analysis

Continuous variables are shown as mean $\pm$ standard deviation or median (interquartile range) according to the Shapiro–Wilk test, and categorical variables as number (%). Groups were compared with Student's t-test or the Mann–Whitney U test, and with the chi-square or Fisher's exact test.

Event-free survival was estimated with the Kaplan–Meier method and compared with the log-rank test. Hazard ratios (HRs) were estimated with Cox proportional hazards regression, unadjusted and adjusted for a prespecified set of covariates limited by the number of events: LVEF category, estimated glomerular filtration rate, age and age-adjusted Charlson index. HF readmission was analyzed with follow-up censored at death. The proportional hazards assumption was checked by comparing HRs for days 0–30 and 31–182.

Sensitivity analyses were (i) inverse probability of treatment weighting (IPTW) with stabilized weights, using propensity scores from age, sex, LVEF category, eGFR, log-transformed BNP, Charlson index, hemoglobin and smoking status, with balance assessed by standardized mean differences and outcomes compared by weighted logistic regression with robust standard errors (follow-up to 6 months was complete for all analyzed patients); and (ii) exclusion of POCUS-guided patients admitted before the ethics committee date. An exploratory analysis tested the interaction between strategy and LVEF category. Patients without verifiable follow-up records were excluded (complete-case analysis). Two-sided $p < 0.05$ was considered significant. Analyses were performed with Python 3.11 (statsmodels 0.15, SciPy 1.17).

A large language model–based tool (Claude, Anthropic) was used to assist with statistical analysis code, reference verification and language editing. The authors reviewed and verified all analyses, results and text and take full responsibility for the content of the manuscript.

Ethics

The study was approved by the Clinical Research Ethics Committee of Koşuyolu High Specialization Training and Research Hospital (2025.06.10/ 2025-KAEK-43). Written informed consent was obtained from all patients in the POCUS-guided group. The study was conducted in accordance with the Declaration of Helsinki.

Results

Study population

Of 100 patients (50 per group), 94 were analyzed: follow-up records could not be found for 3 POCUS-guided patients, and the outcome records of 1 POCUS-guided and 2 control patients could not be verified. Mean age was 75.4 ± 10.9 years and 52 patients (55%) were women (Table 1). Comorbidities, admission medications, renal function, natriuretic peptide levels and most laboratory values were similar between groups. HFrEF was less frequent in the POCUS-guided group (43% vs. 69%; $p = 0.014$), and former smokers were less frequent (11% vs. 31%; $p = 0.045$ for smoking status).

Table 1
Baseline characteristics of the analyzed cohort

Variable	POCUS-guided (n = 46)	Standard care (n = 48)	p
Age, years	75.7 ± 9.8	75.0 ± 11.9	0.737
Female sex	28 (61)	24 (50)	0.289
Age-adjusted Charlson index [‡]	7 (5–7)	6 (5–7)	0.243
Diabetes mellitus	31 (67)	27 (56)	0.267
Hypertension	36 (78)	36 (75)	0.709
Atrial fibrillation	13 (28)	14 (29)	0.923
Coronary artery disease	29 (63)	31 (65)	0.877
Chronic kidney disease	22 (48)	18 (38)	0.311
Smoking: never / current / former	27 / 14 / 5	24 / 9 / 15	0.045
LVEF, %	50 (40–50)	45 (35–50)	0.227
HFrEF (LVEF < 50%)	20 (43)	33 (69)	0.014
ACEi/ARB	32 (70)	31 (65)	0.608
Beta-blocker	37 (80)	40 (83)	0.715
MRA	11 (24)	7 (15)	0.250
Loop diuretic	39 (85)	43 (90)	0.486
SGLT2 inhibitor	11 (24)	14 (29)	0.564
eGFR, mL/min/1.73 m ²	34 (19–48)	39 (23–52)	0.344
Creatinine, mg/dL	1.50 (1.16–2.68)	1.35 (1.10–2.40)	0.580
Sodium, mmol/L	137.4 ± 3.7	136.2 ± 5.6	0.245
Hemoglobin, g/dL	10.2 ± 2.0	10.5 ± 2.3	0.498
Albumin, g/dL	3.4 ± 0.4	3.4 ± 0.4	0.947
CRP, mg/L	13.5 (9.0–31.5)	14.0 (8.0–25.2)	0.575
BNP, pg/mL	656 (378–1001)	708 (310–1374)	0.967
Values are mean ± SD, median (IQR) or n (%). [‡] Missing for 1 control patient. ACEi/ARB, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker; MRA, mineralocorticoid receptor antagonist; SGLT2, sodium–glucose cotransporter 2.			

Ultrasound findings and treatment

All POCUS-guided patients met the IVC congestion criteria; 96% had bilateral pleural effusion and 93% had B-lines (Table 2). Total in-hospital furosemide dose was numerically higher in the POCUS-guided group (median 590 vs. 520 mg; $p = 0.083$), whereas urine output in the first 24 hours (3500 vs. 3050 mL; $p = 0.285$) and during hospitalization (9600 vs. 9225 mL; $p = 0.765$) did not differ.

Table 2
Admission ultrasound findings in the POCUS-guided group (n = 46)

Parameter	Value
IVC maximal diameter, cm	2.40 ± 0.08 (range 2.3–2.6)
IVC minimal diameter, cm	1.69 ± 0.17 (range 1.3–1.9)
IVC collapsibility index, %	29.3 ± 7.5 (range 17–46)
B-lines: bilateral / unilateral / absent	29 (63) / 14 (30) / 3 (7)
Pleural effusion: bilateral / unilateral	44 (96) / 2 (4)

Outcomes after discharge

The primary outcome occurred in 25 POCUS-guided patients (54%) and 19 controls (40%) (log-rank $p = 0.19$; Fig. 1). The strategy was not associated with the primary outcome in unadjusted (HR 1.49, 95% CI 0.82–2.71) or adjusted analysis (HR 1.36, 95% CI 0.73–2.53). HF readmission and death at 6 months, outcomes at 30 days and length of stay were also similar (Table 3). HRs were comparable for days 0–30 (1.42) and 31–182 (1.56), supporting proportional hazards.

Table 3
Outcomes after discharge

Outcome	POCUS-guided (n = 46)	Standard care (n = 48)	Unadjusted HR (95% CI)	Adjusted HR (95% CI)⊠	IPTW OR (95% CI)⊠
Death or HF readmission, 6 months (primary)	25 (54)	19 (40)	1.49 (0.82–2.71)	1.36 (0.73–2.53)	2.05 (0.83–5.02)
HF readmission, 6 months	11 (24)	9 (19)	1.40 (0.58–3.39)	1.36 (0.53–3.51)	1.86 (0.62–5.53)
Death, 6 months	17 (37)	15 (31)	1.20 (0.60–2.41)	1.21 (0.59–2.46)	1.48 (0.58–3.78)
HF readmission, 30 days	4 (9)	4 (8)	—	—	—
Death, 30 days	8 (17)	8 (17)	—	—	—
Length of stay, days	6 (3–9)	6.5 (4–9)	—	—	—
Values are n (%) or median (IQR). HR > 1 indicates more events with the POCUS-guided strategy. ⊠Adjusted for LVEF category, eGFR, age and age-adjusted Charlson index (n = 93). ⊠Inverse probability of treatment weighting. p-values: primary 0.152, HF readmission 0.541, death 0.559, 30-day readmission 1.000, 30-day death 0.926, length of stay 0.635.					

IPTW achieved balance (maximum standardized mean difference 0.52 before and 0.07 after weighting) and gave consistent results. In the exploratory subgroup analysis, the primary outcome occurred in 9/20 vs. 15/33 patients with HFrEF and in 16/26 vs. 4/15 patients with HFpEF (p for interaction = 0.11).

Discussion

In this cohort of patients hospitalized with ADHF on internal medicine wards, a strategy of POCUS-confirmed congestion followed by doubled early intravenous furosemide was not associated with fewer deaths or HF readmissions within 6 months. Point estimates were numerically unfavorable, but confidence intervals were wide; the adjusted HR of 1.36 (0.73–2.53) is compatible with a modest benefit as well as substantial harm. Results were consistent across adjusted, weighted and sensitivity analyses.

Comparison with previous studies

Our findings agree with the neutral results of the largest randomized trial of IVC-guided decongestion in hospitalized patients. In CAVA-ADHF (n = 327), adding daily IVC ultrasound to clinical assessment did not improve NT-proBNP reduction or secondary endpoints [14]. In the emergency department, lung ultrasound-guided therapy in BLUSHED-AHF did not reduce congestion at 6 hours or improve days alive and out of hospital at 30 days [15]. A 2026 meta-analysis of seven randomized trials (824 patients)

found fewer HF readmissions with ultrasound-guided management (RR 0.61, 95% CI 0.38–0.96) but no effect on mortality (RR 0.96, 95% CI 0.58–1.58) [13]. The largest benefit came from small trials combining lung and IVC ultrasound, such as CAVAL US-AHF, in which daily ultrasound-guided therapy reduced subclinical congestion at discharge and 90-day events in 60 patients [22]. Those trials used ultrasound repeatedly to titrate therapy toward a decongestion target; our strategy used a single admission scan to trigger one fixed dose increase, which may explain the difference.

Diuretic intensity

Because all POCUS-guided patients received 200 mg of furosemide in the first 24 hours, our study mainly tested early diuretic intensification in patients with ultrasound-confirmed congestion. Randomized data suggest that intensification alone does not improve outcomes. In DOSE, a high-intensity strategy increased fluid loss and relieved dyspnea but did not change 60-day death, rehospitalization or emergency visits [16]. In PUSH-AHF, natriuresis-guided intensification increased natriuresis without affecting 180-day death or HF hospitalization [17]. Consistent with this, urine output in our study did not differ between groups despite the higher initial dose. Because decongestion at discharge was not assessed, we cannot tell whether the strategy changed congestion status; recurrence of congestion after discharge is itself associated with worse outcomes [23].

Ejection fraction phenotype

In the exploratory subgroup analysis, event rates were similar with both strategies in HFrEF (45% vs. 45%) but higher with the POCUS-guided strategy in HFpEF (62% vs. 27%), without significant interaction ($p = 0.11$). This finding rests on few events and may reflect chance or residual confounding. It nevertheless raises a hypothesis worth testing: that aggressive early decongestion driven by IVC criteria may be less suitable in HFpEF [Güncel kaynak gerekli: HFpEF'te agresif dekonjesyon ve preload bağımlılığı]. Patients with HFpEF, who predominate on internal medicine wards [18], are underrepresented in trials of ultrasound-guided therapy [13].

Clinical implications

Our results do not support routine intensification of early diuretic therapy on the basis of a single admission IVC scan. POCUS remains a useful bedside tool for assessing congestion, but whether acting on it improves outcomes depends on how it is used; strategies that reassess congestion repeatedly and define a decongestion target before discharge appear more promising [13, 22].

Strengths and limitations

Strengths include a real-world internal medicine population, a simple and reproducible IVC decision rule, echocardiographic LVEF by a cardiologist, outcome dates ascertained from hospital records in the same way for both groups, and consistent results across adjusted, weighted and sensitivity analyses.

This study has several limitations. Six patients (6%) were excluded because follow-up data were missing or could not be verified, which may have introduced selection bias. Ultrasound guidance and diuretic

dose were fully collinear, precluding assessment of their independent effects. Ultrasound examinations were performed only in the intervention group and at admission; therefore, changes in congestion during hospitalization and residual congestion at discharge could not be evaluated. In addition, urinary sodium and daily body weight were not systematically recorded. All ultrasound examinations were performed by a single operator, and interobserver reproducibility was not assessed. Finally, the relatively small sample size, absence of an a priori power calculation, and wide confidence intervals limit the precision of the effect estimates and warrant cautious interpretation of the findings.

Implications for research

A randomized trial on internal medicine wards should separate imaging from dose intensification, use repeated ultrasound with a predefined decongestion target, assess congestion at discharge in both arms, and be powered for clinical outcomes, with prespecified analysis by LVEF phenotype.

Conclusions

In patients hospitalized with ADHF on internal medicine wards, a strategy of POCUS-confirmed congestion followed by intensified early intravenous diuretic therapy was not associated with fewer deaths or HF readmissions within 6 months after discharge. These real-world data add to neutral randomized evidence from other settings and do not support intensifying diuretics on the basis of a single admission IVC scan. Randomized trials that separate ultrasound assessment from diuretic intensity, reassess congestion before discharge and examine LVEF phenotypes are needed.

Abbreviations

ACEi/ARB

angiotensin-converting enzyme inhibitor/angiotensin receptor blocker

ADHF

acute decompensated heart failure

BNP

B-type natriuretic peptide

CI

confidence interval

CRP

C-reactive protein

eGFR

estimated glomerular filtration rate

HF

heart failure

HFpEF

heart failure with preserved ejection fraction

HFrEF

heart failure with reduced ejection fraction
HR
hazard ratio
IPTW
inverse probability of treatment weighting
IQR
interquartile range
IVC
inferior vena cava
LVEF
left ventricular ejection fraction
MRA
mineralocorticoid receptor antagonist
OR
odds ratio
POCUS
point-of-care ultrasound
RR
relative risk
SD
standard deviation
SGLT2
sodium–glucose cotransporter 2
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology.

Declarations

Ethics approval and consent to participate

The study was approved by the Clinical Research Ethics Committee of Koşuyolu High Specialization Training and Research Hospital (decision no. 2025-KAEK-43; date.2025.06.10) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients in the POCUS-guided group. Clinical trial number: not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

HE: Conceptualization, Investigation, Data curation, Writing – original draft. AG: Investigation, Data curation, Validation. BB: Formal analysis, Visualization, Writing – review & editing. All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Availability of data and materials

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

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Figures

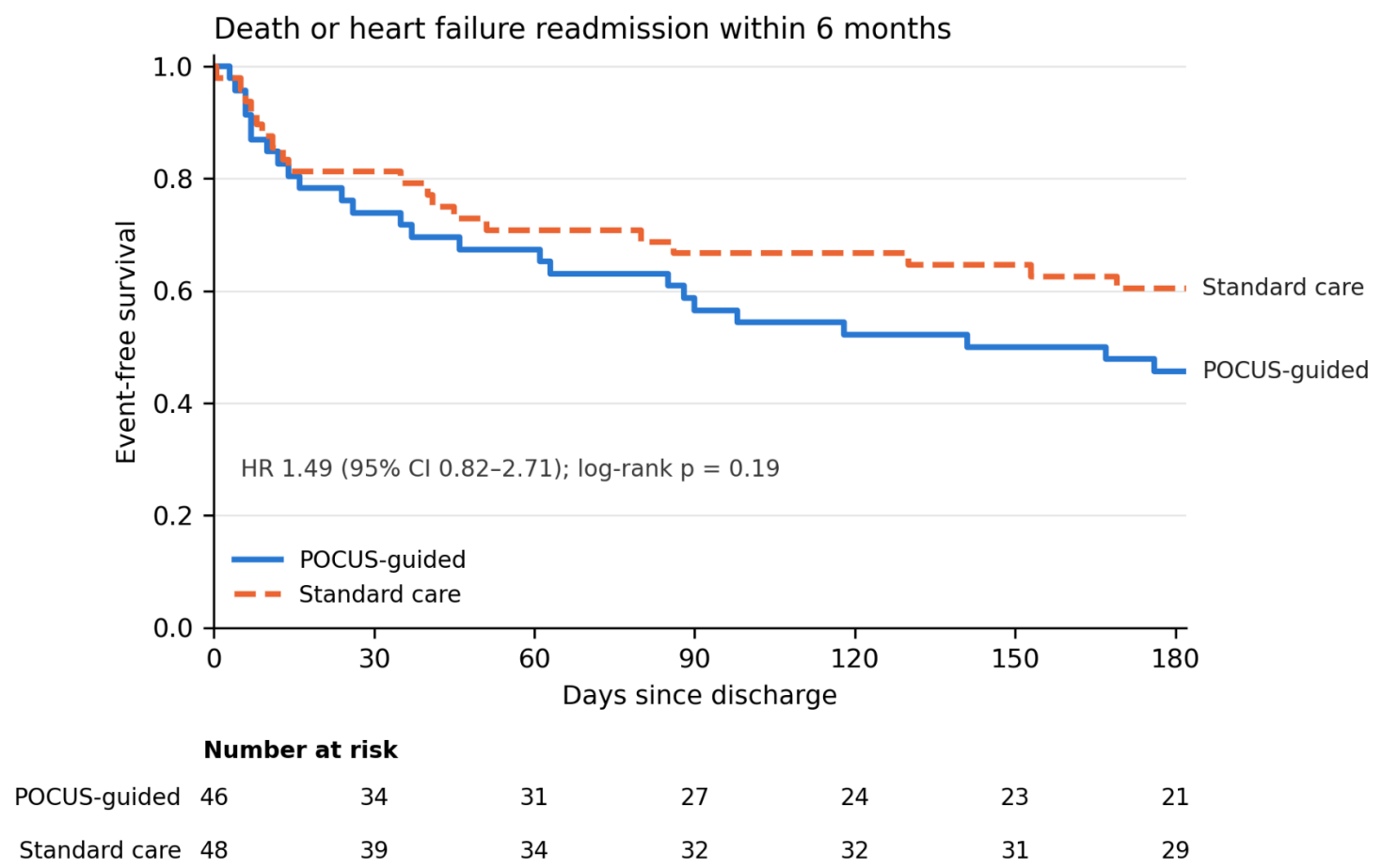


Figure 1

Kaplan–Meier estimates of freedom from death or HF readmission within 6 months after discharge, by management strategy, with numbers at risk.