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ORIGINAL PAPER

IMPROV-ED study: outcomes after discharge for an episode of acute-decompensated heart failure and comparison between patients discharged from the emergency department and hospital wards

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Abstract
Objective To define the short- and mid-term outcomes of patients discharged after an episode of acute-decompensated heart failure (ADHF) and evaluate the differences between patients discharged directly from the emergency department (ED) and those discharged after hospitalization.
Methods We performed a prospective, multicenter, cohort-designed study, including consecutive patients diagnosed with ADHF in 27 Spanish EDs. Thirty-four variables on epidemiology, comorbidity, baseline status, vital signs, signs of congestion, laboratory tests, and treatment were collected in every patient. The primary outcome was a combined endpoint of ED revisit (without hospitalization) or hospitalization due to ADHF, or all-cause death. Secondary outcomes were each of these three events individually. Outcomes were obtained by survival analysis at different timepoints in the entire cohort, and crude and adjusted comparisons were carried out between patients discharged directly from the ED and after hospitalization.
Results Of the 3233 patients diagnosed with ADHF during a 2-month period, we analyzed 2986 patients discharged alive: 787 (26.4%) discharged from the ED and 2199 (73.6%) after hospitalization. The cumulative percentages of events for the whole cohort (at 7/30/180 days) for the combined endpoint were 7.8/24.7/57.8; for ED revisit 2.5/9.4/25.5; for hospitalization 4.6/15.3/40.7; and for death 0.9/4.3/16.8. After adjustment for patient profile and center, significant increases were found in the hazard ratios for ED- compared to hospital-discharged patients in the combined endpoint, ED revisit and hospitalization, being higher at short-term [at 7 days, 2.373 (1.678–3.355), 2.069 (1.188–3.602), and 3.071 (1.915–4.922), respectively] than at mid-term [at 180 days, 1.368 (1.160–1.614), 1.642 (1.265–2.132), and 1.302 (1.044–1.623), respectively]. No significant differences were found in death.
Conclusions Patients with ADHF discharged from the ED have worse outcomes, especially at short term, than those discharged after hospitalization. The definition and

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implementation of effective strategies to improve patient selection for direct ED discharge are needed.

Keywords Acute heart failure · Emergency department · Disposition · Hospital admission · Outcome

Introduction

Acute-decompensated heart failure (ADHF) is one of the most frequent diagnoses in patients who attend emergency departments (EDs) worldwide, especially in Western countries [1, 2]. In Spain, ADHF constitutes the leading cause of medical hospitalization through EDs [3]. Despite the substantial resource and economic implications of hospitalization, the final decision of emergency physicians to admit ADHF patients mainly relies on their subjective and personal clinical experience rather than on objective-supported evidence [4, 5]. This decision is complex and challenging, as a wide spectrum of clinical presentations ranging from minor forms of decompensation to life-threatening illness can be observed in ADHF, and these are often complicated by the presence of multiple co-morbid conditions, psychosocial, socio-economic, self-care, and health literacy issues [6]. As a result, some low-risk ADHF patients are hospitalized by emergency physicians (increasing the risk of hospital complications and health care costs) and some high-risk patients are discharged from the ED (enhancing the risk of clinical deterioration and death shortly after leaving the ED) [7]. In this respect, several groups have expressed concern about the potential harmful effects of ED discharge on patient outcome [8–12]. However, it is not well known whether patients discharged from the ED present increased adverse events compared to those discharged from the hospital. The different risk profiles of discharged and admitted patients, along with the confounding factors introduced by the hospitalization itself make it difficult to directly compare these two groups. Indeed, we only know of two previous studies assessing this hypothesis, with contradictory results [8, 9]. In view of these discrepancies, we designed the present study, the primary aim of which was to compare the outcomes of patients with an ADHF episode diagnosed in the ED according to whether they were discharged directly from the ED or after hospitalization.

Patients and methods

The IMPROV-ED study (Identifying areas of iMPROVment at Emergency Department for patients with acute-decompensated heart failure) is a prospective, multicenter, cohort-designed study, including consecutive patients diagnosed with ADHF in 27 Spanish EDs in both university and community hospitals from all the regions of our country. Patient inclusion was carried out from January 1st to February 28th, 2014, following the EAHFE Registry dynamics explained elsewhere [13, 14]. Briefly, patient inclusion is consecutively performed by the attending emergency physicians (all whom had received specific instructions about the protocol during a meeting held the week before the recruitment period), and all cases are double checked by the principal investigator of each center prior to the final patient inclusion into the database. The diagnosis of AHF is made based on clinical criteria, since, despite having some limitations, these are the criteria most commonly used on clinical grounds [15]. Although natriuretic peptide values are not available in the EDs of 16 out of the 27 participating centers, natriuretic peptide or echocardiographic confirmation is carried out in the ED or during hospitalization in more than 90% of patients following the ESC guidelines [16]. Interventions, treatments, and patient allocation (admission or discharge) are entirely based on the criteria of the attending emergency physician. Subsequent follow-up through telephone contact and consultation of medical reports is performed by the investigators. The only exclusion criteria for the IMPROV-ED study were: patients diagnosed with AHF during a myocardial infarction with ST elevation (because most of these patients are referred directly to angioplasty and do not stay in the ED) and patients who died before being discharged (because the main objective of the IMPROV-ED study was to compare outcomes after discharge, and therefore, patient had to be discharged to be included). The protocol was approved by the Ethical Committees of all the participating centers, and all patients gave informed consent to be contacted for follow-up.

In every patient included in the IMPROV-ED study, we collected the following 34 variables usually recorded in all ADHF patients attending the ED: epidemiological data (age and sex), comorbidities (hypertension, diabetes mellitus, dyslipemia, ischemic heart disease, heart valve disease, atrial fibrillation, chronic renal disease, cerebrovascular disease, chronic obstructive pulmonary disease, dementia, and previous episodes of ADHF), baseline status (assessed by the NYHA class and Barthel Index estimated 1 month prior to decompensation, and echocardiography data—preserved or reduced systolic function, left ventricular ejection fraction—if performed during the index episode or in the previous 6 months), vital signs [systolic blood pressure (SBP), heart rate and room-air pulsioxymetry], clinical data of congestion at ED arrival (legs oedema, increased jugular venous pressure, and hepatomegaly), and results of blood tests (hemoglobin, creatinine, sodium, and potassium) performed at ED, as well as treatment at discharge [loop diuretics, thiazide

diuretics, aldosterone-receptor blockers (ARB), angiotensin-converting-enzyme inhibitor (ACEI) or angiotensin-II receptor antagonist (ARA-II), betablockers, and digoxin].

The primary outcome of the IMPROV-ED study was a combined endpoint, constituted by ED revisit due to heart failure not requiring hospital admission, need for hospitalization due to heart failure, or all-cause death, whatever occurred first. Secondary outcomes were each of these three events considered individually: ED revisit (without hospital admission), hospitalization, and death. We defined the 7-, 30-, and 180-day outcomes for the whole cohort of patients for every primary and secondary endpoints. The patients were divided into two groups depending on whether they were discharged directly home from the ED (without hospitalization) or after hospitalization to investigate possible differences in outcomes between the two groups. In addition, a multivariable analysis on the independent predictors of the primary endpoint at 180 days was carried out separately for patients directly discharged from ED and for patients discharged after hospitalization.

The results are presented as mean and standard deviation (SD) for the quantitative variables (or as median and percentile 25–75 (p25–75) for those without a normal distribution and as absolute values and percentages for the qualitative variables. Comparisons between groups were made using the Student's *t* test (or non-parametric Mann–Whitney *U* test if not distributed normally) for quantitative variables and the Chi-square test for qualitative variables. Survival tables and curves for the primary and secondary outcomes were obtained with the Kaplan–Meier method for the entire cohort. Thereafter, we repeated the same analysis for the two subgroups of patients (discharged from ED and from hospital), and comparisons between the two subgroups were performed using the log-rank test. Unadjusted hazard ratios (HR) with a 95% confidence interval (95% CI) were calculated for patients discharged from the ED compared to those discharged from hospital and adjusted for the differences found between the two groups. Finally, a further HR adjustment by center was also performed. All these calculations were repeated using survival curves truncated at 7, 30, and 180 days. The independent variables associated with the primary endpoint at 180 days for each of the two groups (discharged from ED or after hospitalization) were investigated separately by multivariable analysis using logistic regression. Sample size calculation was made to detect an absolute change of 6% in the probability of presenting a combined endpoint at 180 days in patients discharged from ED compared to those discharged after hospitalization, for which a 60% of cumulative event was estimated. Assuming an alpha error of 0.05 and a beta-error of 0.20, patients lost at follow-up of 2%, and a distribution of 25/75% of patients discharged from ED/hospital, a sample size of 637/1931 patients was determined for each respective group. Differences were considered as statistically significant with a *p* value less than 0.05, or when the 95% CI of the HR excluded the value of 1. All calculations were performed using the SPSS 19.0 software and Epidat 3.1.

Results

Of 3233 patients diagnosed with AHF at 27 Spanish EDs during the study period, we included 2986 patients discharged alive and whose follow-up was available in the final analysis (Fig. 1): 787 (26.3%) were discharged directly from the ED [median ED stay: 0 (0–1) days; median follow-up: 43 (5–61) days], and 2199 (73.6%) were discharged after hospitalization [median ED stay: 7 (5–11) days; median follow-up: 37 (24–55) days].

Table 1 presents the epidemiological and clinical data of the patients studied. Patients were of advanced age [79.8 (10.0) years], predominantly women (55.1%), with several comorbidities and some limitations in baseline status: 24.4% had NYHA class III–IV and 17.8% had severe or complete dependence (Barthel index of 60 or less). Patients discharged directly from the ED differed in 13 out of 34 variables compared to patients discharged after hospitalization: they were younger, had a lower frequency of peripheral vascular disease, dementia and previous episodes of ADHF as comorbidities, were in a better baseline functional status (either assessed by NYHA class or Barthel Index), at ED arrival the heart rate was lower, pulsioxymetry higher, hemoglobin higher, and creatinine, sodium and potassium values were lower, and, when discharged, they were less frequently on treatment with ARB.

Among the entire cohort, 381 patients revisited the ED, 646 were hospitalized, and 196 died (65 died at home, with no further ED revisit or hospitalization after the index event discharge, Fig. 1). Survival curves for the primary and secondary endpoints in the entire cohort are shown in Fig. 2a. At 180 days, the combined endpoint was observed in 57.8% of patients, with ED revisit, hospitalization and death observed in 25.5, 40.7, and 16.8%, respectively. When analyzed separately according to from where the patient was discharged (Fig. 2b), we did not observe significant differences in terms of the combined endpoint, although patients discharged from the ED presented higher ED revisits and a lower mortality rate, with no differences in the need for hospitalization after discharge.

Table 2 shows the cumulative rates of 7-, 30-, and 180-day events for the whole cohort and the two subgroups. After adjustment of the HRs for differences between patients discharged from the ED and after

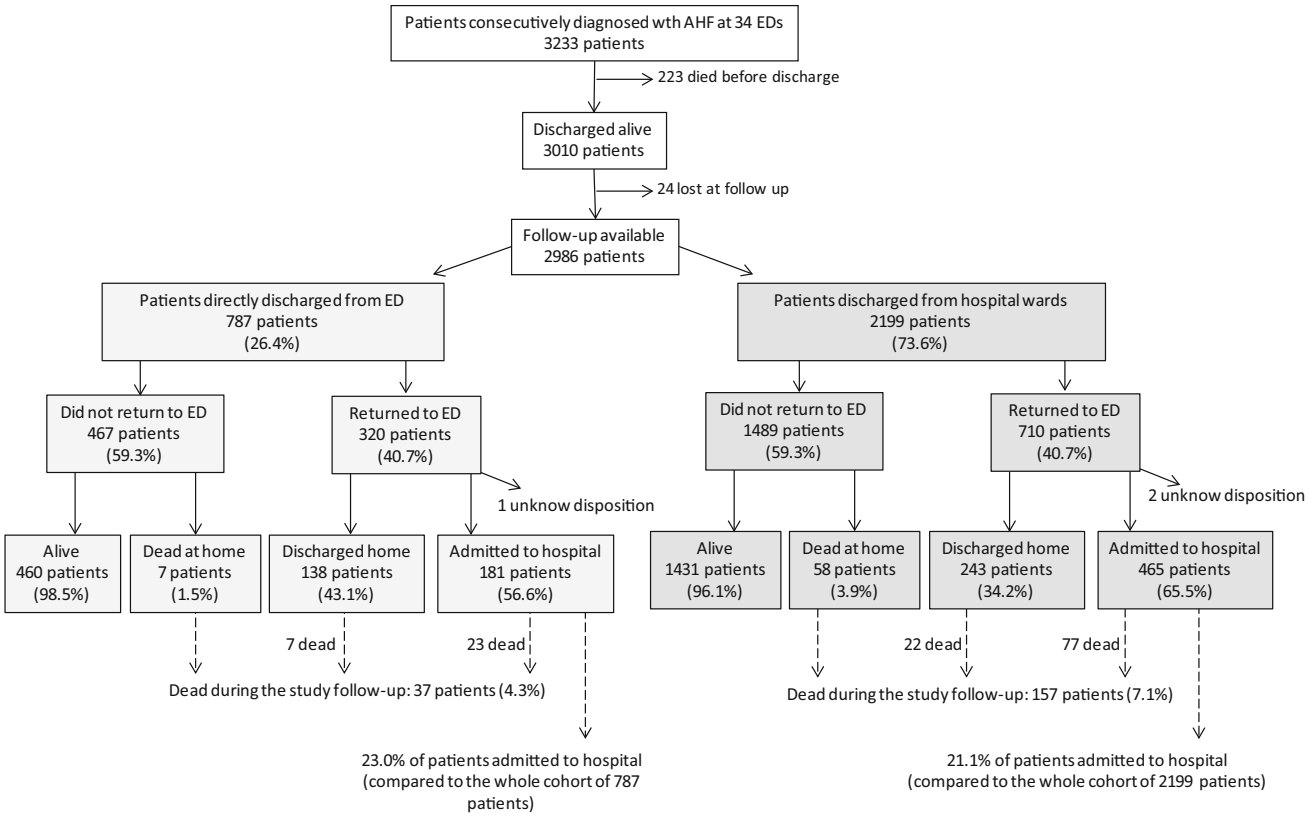

Fig. 1 Flowchart of patient inclusion

hospitalization, we found that both the combined endpoint, ED revisit, and the need for hospitalization were significantly more frequent in patients discharged from the ED. Conversely, although death seemed to be less frequent in patients discharged from the ED based on crude analysis, this difference disappeared after adjustment (HR 0.813, 95% CI 0.504–1.312). Further adjustment by center showed very similar results in all these outcomes; the risk for the combined endpoint, ED revisit and need for hospitalization but not death, remained increased in patients discharged from the ED. On analysis of the HRs by time intervals, the differences with respect to the null effect (HR 1) tended to decrease over time, being greater at the 7-day analysis and the lowest at 180 days (Fig. 3).

We found that five variables were independently associated with the combined endpoint at 180 days for patients discharged directly from the ED: the presence of chronic renal disease ($p < 0.05$), ischemic heart disease ($p < 0.05$) and previous episodes of AHF ($p < 0.001$) as comorbidities, a NYHA class III–IV at baseline ($p < 0.001$) and SBP at ED arrival (inverse relationship, $p = 0.001$). For patients discharged after hospitalization, four independent variables were associated with a combined endpoint at 180 days: the presence of heart valve disease ($p < 0.01$), chronic obstructive pulmonary disease ($p = 0.001$) and previous episodes of AHF as comorbidities ($p < 0.01$), and a NYHA class III–IV at baseline ($p < 0.01$).

Discussion

The IMPROV-ED study shows that patients with ADHF discharged from 27 different Spanish EDs present worse outcomes than patients discharged after hospitalization, even after adjustment for their different clinical profiles and by center. This was observed when the outcome considered was ED revisit, need for hospitalization or the combined endpoint, with the highest risk-frame time being seen during the first 7 days when patients seem to be more vulnerable to adverse outcomes. Conversely, the mortality did not differ after ED discharge compared to hospital discharge. Although we did not investigate the main causes of these worse outcomes, our results suggest that the definition and implementation of effective strategies are needed to improve patient selection for direct ED discharge and eliminate this unacceptable increase in risk for patients discharged directly from the ED without hospital admission.

The results of the IMPROV-ED study are very similar to those reported by Brar et al. [8]. They compared the same

Table 1 Characteristics of the patients included in the IMPROV-ED study

	Total, $N = 2986$	Discharged directly from the ED, $N = 787$	Discharged after hospitalization, $N = 2199$	p
Epidemiologic variables				
Age (years) [mean (SD)]	79.8 (10.0)	78.6 (9.5)	80.2 (10.2)	**<0.001**
Sex female [*n* (%)]	1634 (55.1)	427 (54.8)	1207 (55.2)	0.87
Comorbidity [*n* (%)]				
Hypertension	2545 (85.3)	672 (85.6)	1873 (85.3)	0.86
Diabetes mellitus	1270 (42.6)	321 (40.9)	949 (43.2)	0.28
Dyslipidemia	1414 (47.4)	365 (46.5)	1049 (47.7)	0.57
Ischemic heart disease	915 (30.7)	256 (32.6)	659 (30.0)	0.19
Heart valve disease	844 (28.3)	223 (28.4)	621 (28.3)	0.98
Atrial fibrillation	1446 (48.5)	382 (48.7)	1064 (48.4)	0.94
Chronic renal disease (creatinine >2 mg/dL)	720 (24.2)	176 (22.4)	544 (24.8)	0.20
Cerebrovascular disease	372 (12.5)	84 (10.7)	288 (13.1)	0.09
Chronic obstructive pulmonary disease	779 (26.1)	200 (25.5)	579 (26.4)	0.66
Peripheral vascular disease	284 (9.5)	58 (7.4)	226 (10.3)	**<0.05**
Dementia	386 (12.9)	67 (8.5)	319 (14.5)	**<0.001**
Previous episodes of acute-decompensated heart failure	1674 (56.3)	405 (51.7)	1269 (57.9)	**<0.01**
Baseline status (30 days before decompensation)				
NYHA class III–IV [*n* (%)]	620 (24.4)	119 (16.6)	501 (24.4)	**<0.001**
Barthel index (points, from 0 to 100) [mean (SD)]	82 (22)	87 (19)	80 (21)	**<0.001**
Reduced LVEF[a] [*n* (%)]	580 (48.7)	145 (50.0)	435 (48.3)	0.65
LVEF (%, for patients with systolic dysfunction) [mean (SD)]	38 (12)	39 (13)	37 (12)	0.13
Vitals at ED arrival [mean (SD)]				
Systolic blood pressure at ED arrival (mmHg)	143 (27)	142 (25)	143 (27)	0.54
Heart rate at ED arrival (bpm)	88 (24)	84 (22)	89 (24)	**<0.001**
Room-air pulsioxymetry (%)	92 (6)	95 (3)	92 (7)	**<0.001**
Clinical data of congestion at ED arrival				
Legs edema	2043 (68.5)	541 (68.8)	1502 (68.4)	0.87
Increased jugular venous pressure	603 (20.2)	145 (18.4)	458 (20.9)	0.16
Hepatomegaly	149 (5.0)	33 (4.2)	116 (5.3)	0.27
Laboratory data at ED				
Hemoglobin at ED arrival (g/L) [mean (SD)]	121 (21)	123 (20)	120 (22)	**<0.01**
Creatinine at ED arrival (mg/dL) [mean (SD)]	1.3 (9.9)	1.2 (0.8)	1.4 (0.9)	**<0.001**
Sodium at ED arrival (mmol/L) [mean (SD)]	138 (5)	138 (4)	138 (5)	**0.001**
Potassium at ED arrival (mmol/L) [mean (SD)]	4.4 (0.7)	4.3 (0.6)	4.4 (0.7)	**<0.05**
Treatment at discharge [*n* (%)]				
Loop diuretics	2066 (73.2)	556 (73.6)	1510 (73.0)	0.78
Thiazide diuretics	350 (12.4)	103 (13.6)	247 (12.0)	0.26
Aldosterone-receptor blockers	605 (21.5)	134 (17.8)	471 (22.8)	**<0.01**
ACEI or ARA-II	1528 (54.2)	414 (54.8)	1114 (53.9)	0.71
Betablockers	1215 (43.1)	308 (40.8)	907 (43.9)	0.15
Digoxin	412 (14.6)	117 (15.5)	295 (14.3)	0.46

Bold values refer the variables with a statistical significance between the two groups of the study

ED emergency department, *LVEF* left ventricular ejection fraction, *ACEI* angiotensin-converting-enzyme inhibitor, *ARA-II* angiotensin-II receptor antagonist, *SD* standard deviation

[a] Available in 1191 (39.9%) patients

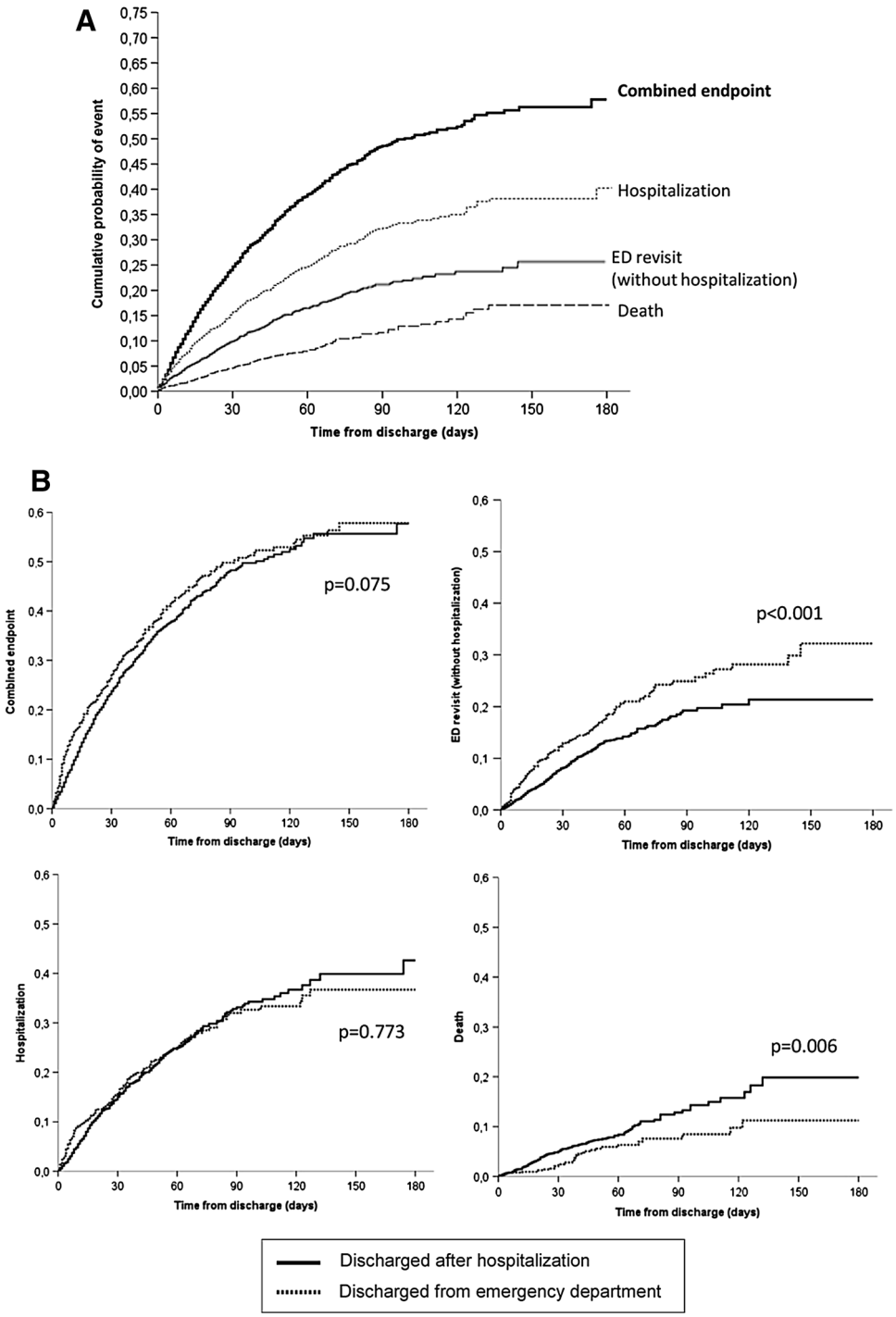

Fig. 2 Survival curves for primary and secondary outcomes for the whole cohort (**a**) and for the subgroups of patients discharged from the emergency department and after hospitalization (**b**)

composite outcome used in our study (death, hospitalization, and ED visit) over a 30-day period and found higher rates for patients discharged directly from the ED (30.2, 35.3, and 44.9% for high-, medium-, and low-volume EDs) compared to patients discharged after hospital admission (23.5, 30.1, and 37.5%, respectively). Interestingly, these differences diminished over time on evaluating outcomes at 90 days, being very similar to what we observed. However, the two studies had two methodological differences. Brar et al. considered all-cause ED revisit or hospitalization, while we only considered those due to heart failure. This could explain the higher rates reported in the study by Brar et al. compared to ours (23.8% for hospital discharge and 27.2% for ED discharge). In addition, they considered the index event (i.e., ED attendance) as the starting point for the follow-up period. This could have led to an overestimation of the differences between ED and hospital discharge reported by these authors, since ED

Table 2 Cumulative proportion of events at different timepoints and unadjusted and adjusted by hazard ratios (HR) with 95% confidence interval

	Total, $N = 2986$ (%)	Discharged directly from the ED, $N = 787$ (%)	Discharged after hospitalization, $N = 2199$ (%)	Unadjusted HR (95% CI) for direct ED discharge	Adjusted[a] HR (95% CI) for direct ED discharge	Adjusted[b] HR (95% CI) for direct ED discharge
Combined endpoint						
At 7 days	7.8	11.5	6.4	1.847 (1.417–2.407)	2476 (1.758–3.488)	2.373 (1.678–3.355)
At 30 days	24.7	27.2	23.8	1.197 (1.019–1.406)	1.504 (1.230–1.838)	1.448 (1.183–1.773)
At 180 days	57.8	57.8	57.7	1.125 (0.987–1.282)	1.400 (1.118–1.651)	1.368 (1.160–1.674)
ED revisit (without hospitalization)						
At 7 days	2.5	4.3	1.9	2.247 (1.415–3.568)	2.035 (1.175–3.523)	2.069 (1.188–3.602)
At 30 days	9.4	13.0	8.2	1.668 (1.288–2.160)	1.758 (1.284–2.406)	1.741 (1.269–2.389)
At 180 days	25.5	32.2	21.4	1.493 (1.210–1.842)	1.626 (1.254–2.109)	1.642 (1.265–2.132)
Hospitalization						
At 7 days	4.6	7.1	4.7	1.960 (1.387–2.771)	3.399 (2.130–5.424)	3.071 (1.915–4.922)
At 30 days	15.3	15.9	15.0	1.097 (0.885–1.358)	1.479 (1.129–1–936)	1.393 (1.062–1.825)
At 180 days	40.7	36.7	42.6	1.026 (0.863–1.220)	1.364 (1.094–1.701)	1.302 (1.044–1.623)
Death						
At 7 days	0.9	0.8	1.0	0.660 (0.329–2.021)	0.327 (0.041–2.597)	0.333 (0.041–2.695)
At 30 days	4.3	2.3	5.0	0.440 (0.256–0.758)	0.408 (0.173–0.960)	0.431 (0.182–1.019)
At 180 days	16.8	11.2	19.9	0.608 (0.424–0.872)	0.813 (0.504–1.312)	0.818 (0.506–1.324)

ED emergency department

[a] Adjusted for 13 variables: age, peripheral vascular disease, dementia, previous episodes of acute-decompensated heart failure, NYHA class, Barthel index, heart rate, room-air pulsioxymetry, hemoglobin, creatinine, sodium, potassium and treatment with aldosterone-receptor blocker

[b] Adjusted for the above-mentioned 13 variables and by center

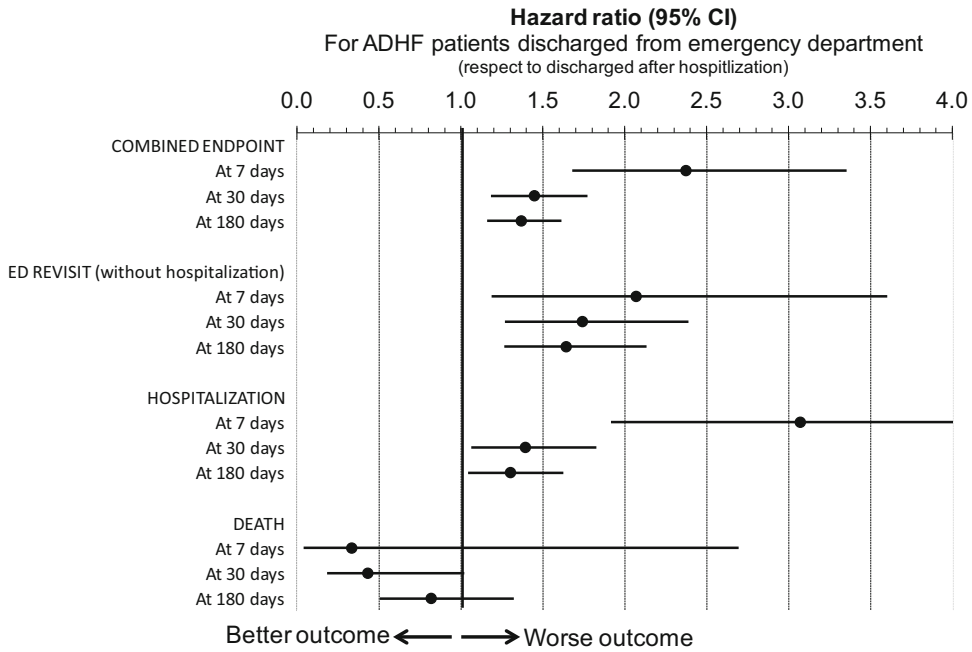

Fig. 3 Representation of the hazard ratios (HR) with 95% confidence interval (CI) of patients with acute-decompensated heart failure (ADHF) discharged from the emergency department compared to those discharged after hospitalization, after adjustment for the 13 variables for which they were different (age, peripheral vascular disease, dementia, previous episodes of ADHF, NYHA class, Barthel index, heart rate, room-air pulsioxymetry, hemoglobin, creatinine, sodium, potassium, and treatment with aldosterone-receptor blocker) and by center

reconsultation and rehospitalization is not possible during the time of hospitalization in patients discharged from the hospital. Accordingly, it could be argued that the better outcomes of patients discharged from hospital observed by the Brar group were spurious due to this fact, while these doubts are eliminated by our results, because the starting point was patient discharge. The design of our study makes comparisons more reasonable, because, regardless of whether patients are discharged from the ED or the hospital, discharge decisions are made when physicians are

sure that patients are well enough to return home and patients in both groups are in a similar situation in terms of clinical stability.

The results of the present study and those by Brar et al. are in contrast with others published by Lee et al. [9], who reported that short-term mortality (the sole endpoint evaluated by this group) was very similar on comparing patients discharged from the ED versus those discharged after hospital admission (with comparable predicted risks of 7- and 30-day death) but divergent thereafter, with patients discharged from the ED showing a worse outcome. Since the most plausible cause for this mid-term increase (at 100 days) in mortality lays mainly in ambulatory follow-up rather than in the ED or hospital decision of discharge itself, a potential explanation may be some defects in follow-up arrangements when patients are discharged directly from ED. We found no differences in terms of mortality and, in fact, we found a non significant decrease in mortality in patients discharged from the ED compared to those discharged after hospitalization. Moreover, the HR tended to shift towards the null effect over time (HR of 1). Therefore, although the decision of direct ED discharge has a negative impact on ED revisit, hospitalization, or combined event risks, we can conclude that ED discharge of patients with ADHF has no negative effect on mortality.

Ideally, outcomes should be better for patients discharged from the ED, as emergency physicians are more likely to reserve this approach for patients at lowest risk. The paradoxical finding of higher ED revisits and hospitalization risk among patients discharged from the ED found in the present study, especially short term after ED discharge, highlights the need for robust risk-stratification instruments and structured discharge planning. Although we have tried to equate the patient risk profile with adjustment of patient differences, we did not assess patient interactions with health care resources and health care giver interventions during follow-up. Therefore, follow-up arrangements after hospital discharge may have been better than those made after ED discharge, and could account, at least in part, for these differences. Failure to initiate guideline-directed medical therapy and the lack of timely, outpatient follow-up post-discharge are two variables that repeatedly appear to be particularly important in the determination of patient outcome [17–19]. Alternatively to poorer ED management, increased ED revisit by patients discharged from the ED could be due, at least to some extent, by some patients possibly using the ED as a substitute for primary care physicians either because they believe they receive better service, or because they are ill-educated. Therefore, it is clear that, although not directly investigated in the present study, patient psychology plays an important role in the patient choice to go to the ED rather than primary care for mild decompensations.

Our findings have several different repercussions. Inadequate patient discharge, regardless of whether it is done from the ED or after hospitalization, could be one of the main reasons for the lack of improvement in the prognosis of patients with ADHF over the last decades [20, 21]. In addition, an analysis based on a representative sample of ED visits between 2002 and 2010 in the United States found no change in the number of ED visits for ADHF or in the rate of hospitalization following ED visits [22]. Indeed, specific guidelines for ADHF management have only very recently become available, being focused more on the diagnosis and treatment of ADHF rather than on decision-making related to patient disposition [16, 19, 23–25]. Several recent expert consensuses have raised this pitfall and have recommended the development of specific tools to stratify patient risk to better detect high-risk patients for prompt aggressive treatment and proper hospital allocation, as well as better identify low-risk patients for safe ED discharge [26–29]. It is important to note that predictive factors for bad outcomes can differ for patient discharged from ED and after hospitalization [5–10, 30, 31]. As shown in the IMPROV-ED study, two risk factors were common in both groups of patients (previous episodes of ADHF and NYHA class III–IV at baseline), but chronic renal disease, ischemic heart disease, and SBP at ED arrival were specific for patients directly discharged from ED. Therefore, this should be taken into account when developing specific scales to guide patient discharge. In addition, such predictive instruments that identify patients who can safely be discharged from the ED while simultaneously addressing barriers against successful outpatient management could have a potentially significant impact on quality of life and resource expenditures [28]. In addition, in the US, the cost of unplanned hospital readmissions to Medicare in 2004 was estimated to be 17.4 billion USD [1], and the Centers for Medicare and Medicaid Services reduced payments to inpatient prospective payment system hospitals with excess readmissions in 2012 [32]. Understandably, there is enormous economic interest in detecting areas of improvement and designing interventions to mitigate hospital readmissions, and ADHF is one of the leading causes of ED and hospital readmissions [33, 34]. In this sense, the short-stay units of hospitalization, an organizational option in halfway between direct discharge and hospitalization in a regular ward, have proved to save days of hospitalization in patients with ADHF while not affecting clinically relevant outcomes [35].

The IMPROV-ED study has some limitations. First, the Spanish EDs participating in the study were not randomly selected. Second, Spain has a public health care system, and all the EDs corresponded to this public network. This could influence patient management, especially in regard to trends in admission and readmission dynamics, which could differ from those observed in countries with a mainly

private health care system. Third, it would have been of interest to know how the decision-making of the emergency physicians of either sending patients home or admitting them to the hospital was carried out to, but we did not ask them about this specific issue and current guidelines do not include specific recommendations on this aspect. Fourth, patients who died during hospital admission were excluded from this study. However, patients who were sent home from the ED, but died a few days later were not excluded. Although this could be considered a bias, it should be noted that time 0 was set at the time of patient discharge, when the doctor (emergency physician or another hospital specialist) considered that the patient was ready to be discharged, as our main objective was to know if decisions taken by emergency physicians put patients at increased risk of adverse events. Fifth, we did not assess the medical or social interventions given to patients after ED or hospital discharge, but rather we evaluated the presence of primary or secondary endpoints. For example, some patients were discharged without loop diuretics. Although the most frequent reasons were because patients were treated with antihypertensive drugs that contained thiazides and for some patients volume overload was minimal, we did not check if loop diuretic were added in the ambulatory after discharge. Sixth, we estimated the sample size for the primary outcome (combined endpoint) at 180 days. Consequently, some estimations made for other outcomes and at other time-points (especially at 7 days when the number of events is more limited) could include a beta-error. Despite these limitations, we believe our data demonstrate that, even though direct ED discharge of patients with ADHF is not associated with a greater mortality, it implies an increased risk of later ED revisit, hospitalization, or combined events, especially during the more vulnerable period within the first 7 days after discharge. It is, therefore, crucial to develop and implement measures to counteract this increased risk.

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Compliance with ethical standards

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