Acute heart failure in the intensive care unit: Epidemiology

Owais Dar, MB ChB, MRCP; Martin R. Cowie, MD, MSc, FRCP

More than a million patients are admitted annually to U.S. hospitals with acute heart failure. Multicentered hospital-based registries and surveys in the United States and Europe have shown that the typical patient is >70 yrs of age, with a history of heart failure, coronary artery disease, and hypertension. There are an equal number of men and women. Patients typically spend several days on the intensive care unit, with longer admissions in Europe than the United States. The in-hospital mortality rate is around 4% to 7%. The risk of subsequent hospital readmission is high. The elderly, those with comorbidities, and those with cardiogenic shock or renal failure do particularly badly. Better treatment by those with expertise in the management of this syndrome and good follow-up care are likely to improve the outcome for this large group of patients. (Crit Care Med 2008; 36[Suppl.]:S3–S8)

Key Words: acute heart failure; registries; surveys

Acute heart failure poses a significant burden on the healthcare services within North America and Europe, largely driven by the cost of the hospitalization required to stabilize the syndrome. Hospital discharges in the United States rose by 174% from 399,000 in 1979 to 1,093,000 in 2003 (1). The total cost of hospitalization in the United States was $15.4 billion in 2006, 52% of the total direct cost of heart failure (2). European data are similar, with ≥60% of the economic cost of heart failure related to hospitalization (3, 4). Despite this enormous healthcare activity, it is only recently that the epidemiology of acute heart failure has become clearer, chiefly as the result of several large-scale registries.

Definition of Acute Heart Failure

There is no universally agreed upon definition of acute heart failure, but it is generally considered to represent the relatively abrupt onset of symptoms severe enough to merit hospitalization. It can occur as the first manifestation of a failing heart (acute *de novo* heart failure) or can occur in patients with chronic heart failure, where the term *acute decompensation* is often applied. Cardiogenic shock is considered to be present when there are symptoms of poor organ perfusion as a consequence of low cardiac output and low blood pressure.

Multicentered hospital-based registries and surveys can provide much valuable information about the syndrome, although they may miss patients with milder presentations who are managed in the doctor's office or in primary care. The patients enrolled in registries and surveys are likely to be more representative of all patients with acute heart failure than the patients enrolled in randomized clinical trials of pharmacologic treatment, where selection forces biased inclusion toward younger male patients with fewer comorbidities.

Heart Failure Registries and Surveys

The largest registry is ADHERE (Acute Decompensated Heart Failure National Registry) in the United States (5). Two shorter term surveys of heart failure have been conducted in Europe under the auspices of the European Society of Cardiology—the EuroHeart Failure Surveys I and II (6, 7). Data are also available from national studies in Italy (8) and England and Wales (9) and from a two-center study in Helsinki (Finland) and Zurich (Switzerland) (10). Two other published studies are of interest because they included a particular subset of patients hospitalized with acute heart failure: a multicentered New York study of heart failure with preserved systolic left ventricular function (11) and an intensive care/coronary care unit survey from France (EFICA) (12).

ADHERE. The ADHERE registry in the United States has enrolled >100,000 patients since 2001 from 282 hospitals across the country. The charts of patients with a primary or secondary discharge diagnosis of heart failure were reviewed retrospectively (5). Acute heart failure was defined as either new-onset heart failure requiring hospitalization or decompensation of chronic established heart failure with symptoms sufficient to warrant hospitalization. ADHERE is a commercially sponsored registry, with a nonrandomized sampling frame of U.S. hospitals. The registry relies on hospital-based coding, and data collection on clinical features may not be complete as the study relies on retrospective chart review. However, comparison with a random sample of Medicare patients suggests that the data are representative of the general U.S. experience (13). In addition, the registry collects information on hospitalizations, not individual patients, so some patients may be represented several times in the data set.

EuroHeart Failure Survey I. The first EuroHeart Failure Survey enrolled 11,327 patients across Europe, with 115 hospitals taking part in 24 European countries in 2000–2001. The charts of patients dying or discharged with a diagnosis of heart failure were reviewed with follow-up data collected from the survivors at 12 wks after discharge (6).

From the National Heart & Lung Institute, Imperial College, London, United Kingdom.

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For information regarding this article, E-mail: m.cowie@imperial.ac.uk

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Table 1. EuroHeart Failure Survey inclusion criteria (6)

A clinical diagnosis of heart failure has been recorded during this admission (regardless of primary reason for this admission).
The patient has had a heart failure diagnosis recorded in the hospital notes at any time in the last 3 yrs.
The patient has received a loop diuretic for any reason other than renal failure during the 24 hrs before death or discharge.
The patient has received treatment for heart failure or major left ventricular dysfunction within the 24 hrs before death or discharge.

The inclusion criteria for the EuroHeart Failure Survey are shown in Table 1. The criteria are considerably wider than the ADHERE criteria and include patients developing heart failure while in hospital and those given intravenous diuretic therapy with a suspicion of heart failure. The inclusion of milder cases may explain the better outcome and slightly different demographic features of patients included in this survey compared with the other studies. Centers were included on a volunteer basis, and patients may not necessarily be representative of all patients admitted to hospitals in Europe with acute heart failure.

EuroHeart Failure Survey II. This second European survey was conducted in 2004–2005 and enrolled 3,580 patients (7). The entry criteria were simpler than the first survey and closer to those of the ADHERE registry in the United States. Patients hospitalized with dyspnea and a heart failure diagnosis confirmed by the presence of symptoms and pulmonary congestion on the chest radiograph were included. Some 3,580 patients were enrolled from 133 hospitals in 30 countries. Similar to the first EuroHeart Failure Survey, centers were included on a volunteer basis.

Italian Registry. A survey of 206 of the 396 Italian cardiology centers with an intensive care unit was performed in 2004. The survey enrolled 2,807 consecutive patients admitted with a diagnosis of acute heart failure, either *de novo* or acute decompensation of chronic heart failure, provided they had required intravenous therapy (8).

England and Wales Survey. The Health Care Commission (the audit arm of the National Health Service in England and Wales) completed an audit of eight conditions that lead to hospitalization, including acute heart failure admissions, across all hospitals during 2005. Fifty consecutive patients with a death or discharge code of heart failure were included at each hospital, giving rise to a representative sample of 9,387 patients (9).

Japanese Registry. The Japanese Cardiac Registry of Heart Failure in Cardiology (JCARE-CARD) has been set up in 164 teaching hospitals in Japan, with data to be collected from a broad spectrum of hospitalized patients fulfilling the Framingham criteria for heart failure (14). No results have been published to date.

Helsinki-Zurich Study. A two-center study from Zurich and Helsinki has published results on the clinical characteristics and outcome from a survey of 312 consecutive patients admitted with acute heart failure in two hospitals in Finland and Switzerland (10).

New York Registry. A short-term prospective registry was set up in 24 medical centers in the metropolitan New York area, with recruitment from 17 of these. This registry only enrolled patients who were hospitalized with a primary diagnosis of heart failure, had a normal left ventricular ejection fraction (≥50%), and had clinical and radiographic evidence of heart failure; those primarily hospitalized with acute coronary syndrome were excluded (11). This registry enrolled 619 patients between January 1, 1999, and June 30, 2001.

EFICA Study (Etude Française de l'Insuffisance Cardiaque Aiguë). This study enrolled 599 patients admitted to 60 intensive care/coronary care units randomly sampled from across France who had the signs and symptoms of acute heart failure in the opinion of the attending physician in 2001 (12). Patients admitted directly to the general ward were not included in the survey. Follow-up was conducted at 4 wks and 12 months.

Characteristics of Patients Admitted With Acute Heart Failure. Table 2 and 3 allow comparison of the clinical features, length of stay, and outcomes for patients with acute heart failure from the published major studies.

Demographics and Medical History. All of the data sets suggest that the typical patient hospitalized with heart failure is elderly, with a mean age in the low 70s. A slightly higher proportion of patients will be male rather than female, except for those with preserved systolic left ventricular function, a group in which women are dominant. The majority of patients will present with acute decompensation of chronic heart failure, rather than *de novo* heart failure, with most having a history of both coronary artery disease and hypertension. A history of hypertension is more common in those with preserved systolic function and possibly also those in the United States compared with Europe.

Comorbidity is the rule: One fourth of patients will have atrial fibrillation, and up to a half will have diabetes mellitus. Renal dysfunction, although defined differently in the studies, is present in almost half of patients. Chronic lung disease is not uncommon, at a prevalence of around 20% to 25%.

Preserved systolic function is found in around one third of patients, particularly elderly hypertensive women, with some suggestion in the United States that non-Hispanic blacks are more likely to present with hypertension and preserved systolic function, even at a younger age, than their white counterparts (11).

Precipitating Factors. Acute coronary syndrome is a frequent precipitant of acute heart failure. In the EHFS II survey (7), acute coronary syndrome was the identified precipitant in 42% of *de novo* cases—with three fourths of these cases being myocardial infarction rather than unstable angina. This compares with acute coronary syndrome being the precipitant for decompensation in only 23% of cases of chronic heart failure. The relative contribution of arrhythmia (such as atrial fibrillation) or infection appears similar in both presentations, at around 30% and 20%, respectively. In acute decompensation, noncompliance with medication was the major precipitant in more than one fifth of cases, compared with <10% of *de novo* cases. The Italian survey also identified acute coronary syndrome as a common precipitant—with a similar proportion to that in the EHFS II survey (40% of *de novo* cases and 27% of acute decompensation cases) (8). Ischemia is a particularly common precipitant of cardiogenic shock, being responsible for 50% to 70% of cases (7, 8).

The triggers identified in the Helsinki-Zurich study were similar, with acute ischemia identified in 25%, new atrial fibrillation in 15%, and hypertension (defined as systolic blood pressure ≥150 mm Hg on admission) in 35%

Table 2. Characteristics of acute heart failure patients enrolled in the key surveys

Clinical Profile at Presentation	ADHERE (5, 13) 2002–2004 (n = 105,388)	Euro-HF I (6) 2000–2001 (n = 11,327)	Euro-HF II (7) 2004–2005 (n = 3,580)	Italian Survey (8) 2004 (n = 2,807)	E&W Study (9) 2005 (n = 9,837)	Helsinki-Zurich Study (10) 2001–2002 (n = 312)	EFICA (12) 2001 (n = 599)	New York Study (11) 1999–2001 (n = 619)
Age, yrs (mean, SD)	72 (14)	71	70 (12)	73 (11)	77 (11)	73 (12)	73 (13)	72 (14)
Gender, % male	48	53	61	60	50	56	59	28
History, %								
Prior evidence of heart failure	75	65	63	56	56	72	66	
Coronary artery disease	57	68	54	NA	NA	62	46	43
Myocardial infarction	31	39	NA	36	NA	NA	22	NA
Cardiac valvular disease	22	29	34	NA	NA	NA	NA	NA
AF	31	9 (fast AF)	39	28	37	29	25 at admission	23
Hypertension	73	53	62	66	NA	54	60	78
Chronic renal failure	30	17	17	25	NA	41	53	Approx 50
Chronic respiratory disease	30	32	19	30	NA	NA	NA	24
Diabetes mellitus	44	27	33	38	NA	32	27	46
Presenting features								
Dyspnea at rest, %	32	40	NA	NA	NA	NA	NA	11
Dyspnea with exertion, %	44 (NYHA III)	35	NA	NA	NA	NA	NA	75
Rales, %	68	N/K	NA	34	NA	NA	NA	NA
Peripheral edema, %	66	23	NA	59	NA	NA	NA	NA
Mean systolic BP, mm Hg	144	133	135	141	NA	140	126	160
Systolic BP >140 mm Hg, %	50	29	NA	43	NA	50	NA	NA
Mean diastolic BP, mm Hg	78	78	NA	NA	NA	NA	71	84
Heart rate, beats/min	89	75	95	97	NA	90	NA	NA
Cardiogenic shock, %	3%	<1%	3.9	7.7	NA	4.2	29	NA
HF with preserved systolic function, %	46 (EF >40%)	55 (EF ≥40%)	34 (EF ≥45%)	34% (EF >40%)	NA	33 (EF ≥50%)	27 (EF >45%)	Entry criterion: EF ≥50%

ADHERE, Decompensated Heart Failure National Registry; Euro-HF, EuroHeart Failure Survey; E&W, England and Wales; EFICA, Etude Française de l'Insuffisance Cardiaque Aiguë; NA, not available; AF, atrial fibrillation; NYHA, New York Heart Association; BP, blood pressure; HF, heart failure; EF, ejection fraction.

Table 3. Health care utilization and outcome of patients admitted with acute heart failure in the key published studies

	ADHERE (5, 13) 2002–2004 (n = 105,388)	Euro-HF I (6) 2000–2001 (n = 11,327)	Euro-HF II (7) 2004–2005 (n = 3,580)	Italian Survey (8) 2004 (n = 2,807)	E&W Study (9) 2005 (n = 9,387)	Helsinki-Zurich (10) Study 2001–2002 (n = 312)	EFICA (12) 2001 (n = 599)	New York Study (11) 1999–2001 (n = 619)
HF admission to ICU, %	19	NA	51	69	12	39	100	NA
Length of stay in intensive or coronary care unit, median, days (IQR)	2.6	NA	3 (2–5)	4 (2–6)	NA	3	7.6 if cardiogenic shock; 5.7 days if not	NA
Total length of stay, median, days (IQR)	4.3	11	9 (6–14)	9 (6–13)	8 (4–14)	9	15.1 days if cardiogenic shock; 14.5 days if not	6
Requiring inotropes, %	13	NA	NA	25	2.2	NA	NA	NA
In-hospital mortality, %	3.8	6.9	6.7	7.3	15	8	NA	4.2
Postdischarge mortality, %	10 at 30 days, 36 at 12 mos	13 at 3 mos	NA	13 at 6 mos	NA	18 at 3 mos	27.4 at 4 wks; 46.5 at 12 mos	NA
Postdischarge readmission rate, %	NA	24 within 90 days	NA	38 within 6 mos	NA	NA	NA	NA

ADHERE, Decompensated Heart Failure National Registry; Euro-HF, EuroHeart Failure Survey; E&W, England and Wales; EFICA, Etude Française de l'Insuffisance Cardiaque Aiguë; HF, heart failure; ICU, intensive care unit; NA, not available; IQR, interquartile range.

(10). The data are also similar for the more severely unwell patients admitted to French intensive care units/coronary care units, with an ischemic precipitant in 42%, arrhythmia in 25%, and infection in 20% (12). For patients with preserved left ventricular systolic function, acute ischemia appears to be a less common precipitant (10% of cases in the New York registry), and poorly controlled blood pressure (13% with presenting systolic blood pressure >200 mm Hg) and poor compliance with medication for hypertension or heart failure (13%) were common (11).

Length of Stay and Mortality. The median length of stay is markedly shorter in the United States than in Europe (Table 3), presumably related to the structure of the healthcare systems. For patients admitted to the intensive care unit, the length of stay is similar in both regions, the longer duration of care being due to a longer period of stabilization on the lower intensity wards in Europe. Mortality in hospital is <10%, rising to around 15% at 3 months, with a substantially higher in-hospital mortality for those with cardiogenic shock (Fig. 1).

Drug Therapy. Many of the patients are already on disease-modifying therapy at the time of hospitalization—with high usage of diuretics, β-blockers, and angiotensin converting enzyme inhibitors/angiotensin receptor blockers (Table 4) (5, 7). This is not surprising since the majority of patients present with acute decompensation of chronic heart failure, where the use of such medication is particularly high. Presumably the relatively common use of such drugs also in the *de novo* presentations relates to the high degree of cardiovascular comorbidity in this patient group, such as hypertension, diabetes, coronary artery disease, and atrial fibrillation. Use of such medications increases by the time of discharge from hospital (7), but data from both ADHERE and EuroHeart Failure Survey II suggest there is considerable room for improvement (5, 7).

Prognostic Factors. Mortality differs by the mode of presentation (Fig. 1). Annual mortality in the Helsinki-Zurich study was related to older age, degree of impairment of left ventricular systolic function, and renal insufficiency (10) but was most powerfully influenced by hemodynamic status on admission—the 30-day and 12-month mortality rates for cardiogenic shock were 46% and 62%, respectively. Patients with a history of hypertension had a lower mortality rate than those without such a history (30-day mortality 6.5% vs. 15%, $p = .016$). No significant differences in survival were reported from Helsinki-Zurich based on gender, previous history of heart failure, underlying coronary artery disease, or diabetes mellitus.

In the Italian survey, multivariable analysis identified eight factors independently associated with in-hospital all-cause mortality (Table 5). Older age, higher blood urea nitrogen, higher tro-

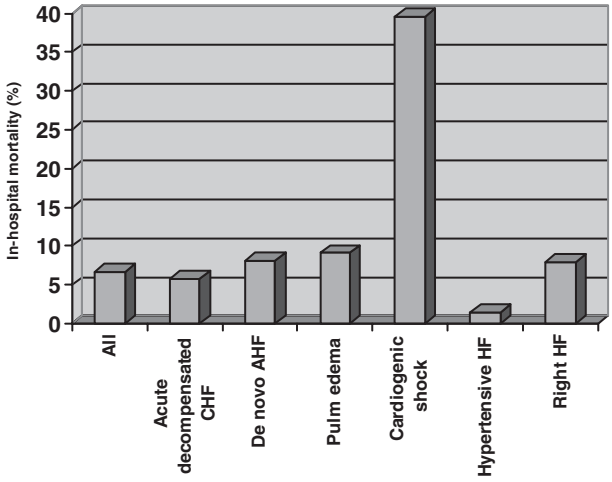

Figure 1. In-hospital mortality in the EuroHeart Failure Survey II by history of heart failure (*HF*) and clinical presentation. Modified, with permission, from Nieminen et al (7). *AHF*, acute heart failure; *CHF*, chronic heart failure; Pulm, pulmonary.

Table 4. Medications at admission in ADHERE (5) and EuroHeart Failure Survey II (7)

Medication	ADHERE[5] (n = 105,388)	Euro-HF II[7] All (n = 3,580)	*De novo* AHF (n = 1329)	Acute Decompensated CHF (n = 2251)
Diuretics	70	71	50	83
Spironolactone/eplerenone	NA	28	11	38
ACE inhibitors (ACE-I)	41	55	41	63
ARB	12	9	9	10
ACE-I or ARB	NA	63	49	72
β-blocker	48	43	38	46
Digoxin	28	27	13	34
Oral nitrate	26	28	21	32
Antiarrhythmic agent	11	13	7	16

ADHERE, Decompensated Heart Failure National Registry; Euro-HF, EuroHeart Failure Survey; AHF, acute heart failure; CHF, chronic heart failure; NA, not applicable; ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker.

All values are percentages.

Table 5. Independent predictors of in-hospital all-cause mortality in 2807 patients admitted to 206 cardiology centers in Italy with *de novo* acute heart failure or worsening chronic heart failure

Variable	*p* Value	Odds Ratio	95% Confidence Interval
Intravenous inotropes	<.0001	2.862	1.909–4.292
Elevated troponin	.0071	1.882	1.188–2.984
Prior revascularization	.0484	0.588	0.347–0.996
Systolic blood pressure at admission (continuous)	<.0001	0.985	0.979–0.992
Age (continuous)	.0004	1.036	1.016–1.056
Blood urea nitrogen (continuous)	.0012	1.007	1.003–1.012
Hemoglobin (continuous)	.0102	0.893	0.819–0.974
Sodium (continuous)	.0269	0.962	0.930–0.996

Modified with permission from Tavazzi et al (8).

ponin, and use of inotropes were associated with a worse prognosis, with prior revascularization, higher systolic blood pressure on admission, higher hemoglobin, and higher sodium associated with a better outcome. Blood urea nitrogen and systolic blood pressure on presentation were also found to be powerful predictors of outcome in the ADHERE registry (15).

Diastolic Heart Failure. Registry data suggest that half of the patients presenting with acute heart failure have preserved left ventricular systolic function (6, 15). Such patients are more likely to be women, the elderly, and those with a history of hypertension (15–17), although clinical symptoms do not reliably identify those with impaired or preserved systolic function (15, 18). Imaging of the ventricle is required for diagnosis, usually by transthoracic echocardiography.

The New York registry of acute heart failure hospitalization with preserved left ventricular systolic function reports a high prevalence of comorbidity, with 46% of patients having diabetes and obesity, 43% having coronary artery disease, and 23% having atrial fibrillation (11). The in-hospital mortality appears to be similar to that reported in the ADHERE registry for all patients with acute heart failure, at 4.2% (11).

Secular Trends. The Framingham Heart Study and Rochester-Olmstead studies suggest that the incidence of heart failure has been stable in the United States since 1979 (19–21). No reliable data are available from Europe. The prognosis of heart failure has improved over the past 2 decades (19–22) with in-hospital mortality mirroring this trend: In the United States the proportion of hospitalized heart failure patients who died in hospital declined during 1982–2002 from 11.6% to 4.1% in those ≥65 yrs and from 4.5% to 1.1% in those aged 45–65 yrs (23). With the rapid aging of populations in the western world (24, 25), the total number of people living with heart failure has increased, but recent health care utilization data suggest that hospitalization rates may have reached their peak and are now declining in many European countries (23, 26, 27).

CONCLUSIONS

Acute heart failure hospitalization is common and with an aging population will remain a significant healthcare burden for the foreseeable future. The majority of patients have a history of heart failure, and coronary artery disease and hypertension are common. Comorbidity is common within this often elderly population. Patients typically spend several days on the intensive care unit and are at high risk of death or readmission. Those presenting with cardiogenic shock have a particularly poor prognosis, as do the very elderly and those with renal failure. Better treatment by those with expertise in the management of this syndrome and good follow-up care are likely to improve the outcome for this high-risk group of patients.

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