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Ten-Year Trends in the Incidence and Treatment of Cardiogenic Shock

Raban V. Jeger, MD; Dragana Radovanovic, MD, MSc; Patrick R. Hunziker, MD; Matthias E. Pfisterer, MD; Jean-Christophe Stauffer, MD; Paul Erne, MD; and Philip Urban, MD, for the AMIS Plus Registry Investigators

Background: Few studies describe recent changes in the incidence, treatment, and outcomes of cardiogenic shock.

Objective: To examine temporal trends in the incidence, therapeutic management, and mortality rates of patients with the acute coronary syndrome (ACS) and cardiogenic shock, and to assess associations of therapeutic management with death and cardiogenic shock developing during hospitalization.

Design: Analysis of registry data collected among patients admitted to hospitals between 1997 and 2006.

Setting: 70 of the 106 acute cardiac care hospitals in Switzerland.

Patients: 23 696 adults with ACS enrolled in the AMIS (Acute Myocardial Infarction in Switzerland) Plus Registry.

Measurements: Cardiogenic shock incidence; treatment, including rates of percutaneous coronary intervention; and in-hospital mortality rates.

Results: Rates of overall cardiogenic shock (8.3% of patients with ACS) and cardiogenic shock developing during hospitalization (6.0% of patients with ACS and 71.5% of patients with cardiogenic shock) decreased during the past decade ($P < 0.001$ for temporal trend), whereas rates of cardiogenic shock on admission remained constant (2.3% of patients with ACS and 28.5% of patients with cardiogenic shock). Rates of percutaneous coronary intervention increased among patients with cardiogenic shock (7.6% to 65.9%; $P = 0.010$), whereas in-hospital mortality decreased (62.8% to 47.7%; $P = 0.010$). Percutaneous coronary intervention was independently associated with lower risk for both in-hospital mortality in all patients with ACS (odds ratio, 0.47 [95% CI, 0.30 to 0.73]; $P = 0.001$) and cardiogenic shock development during hospitalization in patients with ACS but without cardiogenic shock on admission (odds ratio, 0.59 [CI, 0.39 to 0.89]; $P = 0.012$).

Limitations: There was no central review of cardiogenic shock diagnoses, and follow-up duration was confined to the hospital stay. Unmeasured or inaccurately measured characteristics may have confounded observed associations of treatment with outcomes.

Conclusion: Over the past decade, rates of cardiogenic shock developing during hospitalization and in-hospital mortality decreased among patients with ACS. Increased percutaneous coronary intervention rates were associated with decreased mortality among patients with cardiogenic shock and with decreased development of cardiogenic shock during hospitalization.

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For author affiliations, see end of text.

The incidence of cardiogenic shock complicating the acute coronary syndrome (ACS) differs depending on the exact definitions of cardiogenic shock, but it has been estimated to be between 5% and 10% (1). Recent findings of population-based studies show slightly lower incidence rates of 3.2% to 8.6%, but data on temporal trends are conflicting (2–4). Since the implementation of guideline-recommended early revascularization for cardiogenic shock (5, 6), mortality rates have steadily decreased below 50% (2, 3). This is important because survivors of cardiogenic shock have a long-term outcome similar to that of patients without cardiogenic shock (7, 8). Although decreased mortality rates have been ascribed to improved treatment with higher rates of percutaneous coronary intervention (PCI) and intra-aortic balloon counterpulsation, a strong relationship between improved therapeutic management and lower mortality rates has not been established in population-based studies (4). Also, we still do not know whether early invasive treatment of ACS may prevent hemodynamic deterioration in patients at risk and whether temporal trends in overall cardiogenic shock rates are similar among patients with cardiogenic shock on admission and those who develop cardiogenic shock during hospitalization.

The AMIS (Acute Myocardial Infarction in Switzerland) Plus Registry is a nationwide survey collecting data on hospital admissions for ACS since 1997. Using this database, we analyzed temporal trends in incidence, therapeutic management, and mortality rates of patients with cardiogenic shock during the past decade and assessed predictors of mortality and shock development during hospitalization. Our a priori hypothesis was that in-hospital mortality decreased during the past decade.

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METHODS

The AMIS Plus Registry

Since 1997, 70 of the 106 acute cardiac care hospitals in Switzerland have participated in the AMIS Plus Registry (9–11). All participating hospitals have either a catheterization laboratory (18 hospitals) or direct access to a ter-

tiary care center guaranteeing PCI within 90 minutes for all patients (52 hospitals). The 70 participating hospitals are a representative sample of acute care hospitals in Switzerland in terms of size, available skills, and quality grading (10, 11).

The Swiss Societies of Internal Medicine, Cardiology, and Intensive Care Medicine founded the AMIS Plus Registry project. A steering committee that includes members of the founding medical societies guides the project. The Swiss National Ethical Committee for Clinical Studies and the Board for Data Security approved the registry.

Data Collection

Investigators at participating centers collect data for the registry by using identical Web-based or written questionnaires. The questionnaire has 140 items that address medical history, cardiovascular risk factors, symptoms, out-of-hospital management, clinical presentation, early in-hospital management, reperfusion therapy, hospital course, diagnostic tests used or planned, length of stay, and discharge medication and destination. A data coordinating center checks data for plausibility and consistency. Investigators returned incomplete questionnaires to the participating centers for completion (19% in 2003). This approach helps ensure that few data are missing (<1% overall and 0% for therapeutic interventions) (11).

Patient Enrollment

Patients were enrolled in the registry if their final diagnosis met 1 of the 3 following definitions: acute myocardial infarction, defined as symptoms or echocardiographic (ECG) changes compatible with ACS (or both) and cardiac markers at least twice the upper limit of normal; ACS with minimum necrosis, defined as symptoms or ECG changes compatible with ACS (or both) and cardiac markers lower than twice the upper limit of normal but still abnormal; or unstable angina, defined as symptoms or ECG changes compatible with ACS (or both) and normal cardiac markers. In this study, we included all patients with ACS entered in the AMIS Plus Registry between 1 January 1997 and 31 December 2006 from the participating hospitals. We excluded patients with unclear or noncardiac causes of ACS. We analyzed and compared patients who had ACS and cardiogenic shock with patients who had ACS without cardiogenic shock.

Definitions

We classified patients who had ST-segment elevation or new left bundle-branch block on their initial ECG as having ST-segment elevation ACS. We classified patients who had ST-segment depression or T-wave abnormalities in the absence of ST-segment elevation on the initial ECG as having non–ST-segment elevation ACS. Patients with cardiogenic shock were those with cardiogenic shock on admission and those who developed cardiogenic shock during hospitalization as a complication of ACS. We defined cardiogenic shock at admission and during hospitalization similarly at participating centers by using the Killip definition of hypotension (systolic blood pressure <90 mm Hg) and evidence of peripheral vasoconstriction (oliguria, cyanosis, or sweating) (12). When they became available, we advised investigators at PCI sites to follow current guidelines recommending the performance of revascularization within 36 hours after shock onset (5, 6), but we did not record the exact timing of PCI.

Context

Are the incidence and management of cardiogenic shock changing?

Contribution

This analysis of hospital registry data from Switzerland showed that rates of cardiogenic shock in patients with acute coronary syndromes declined from 1997 to 2006. Declining rates were due to decreased rates of shock development during hospitalization rather than a change in rates of shock at admission. Use of percutaneous coronary intervention increased, and in-hospital mortality decreased.

Implication

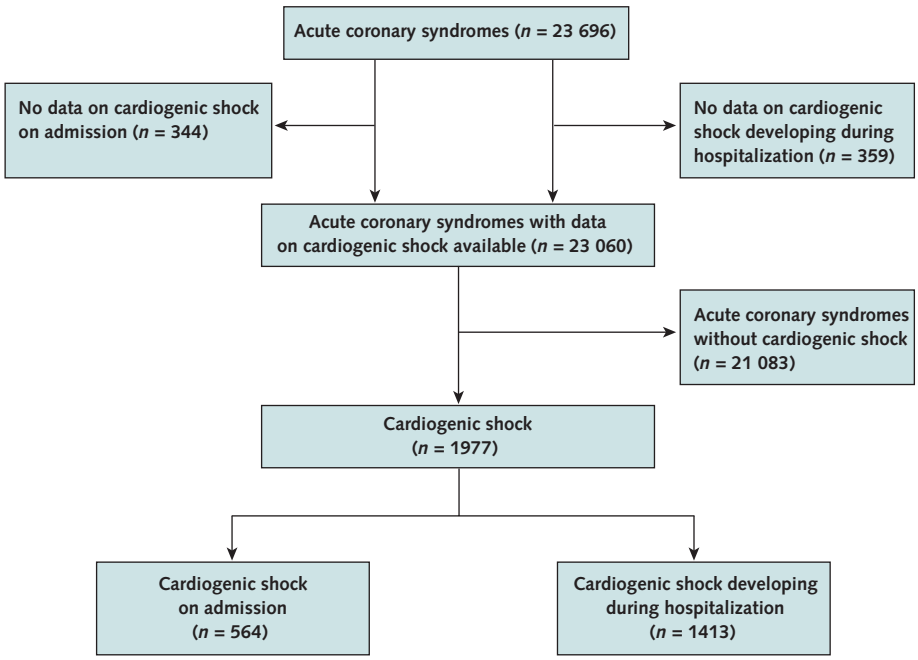
The incidence and mortality of cardiogenic shock in hospitalized patients in Switzerland decreased during the past decade, possibly because of changes in management of patients with acute coronary syndromes.

—The Editors

Statistical Analysis

We present descriptive statistics as means (SDs), medians with interquartile ranges, or percentages. We compared categorical variables and temporal trends by using the chi-square test and continuous variables by using the *t* test. Our primary outcome of interest was in-hospital death, although we also examined major adverse cardiac events during hospitalization (reinfarction, cerebrovascular events, and shock). We used multivariable logistic regression models to examine predictors of in-hospital death and predictors of cardiogenic shock development during hospitalization. We included in these models all of the following available covariates evaluated at admission: age; sex; history of coronary artery disease, hypertension, diabetes, and dyslipidemia; current smoking status; Killip class if applicable; ST-segment elevation ACS; symptom-to-admission delay greater than 6 hours; cardiopulmonary resuscitation before admission; cardioversion or defibrillation before admission; atrial fibrillation; heart rate; systolic and diastolic blood pressures; obesity (body mass index >30 kg/m^2); Charlson Comorbidity Index score (13); the use of various medications, such as acetylsalicylic acid, clopidogrel, glycoprotein IIb/IIIa inhibitors, β-blockers, angiotensin-converting enzyme inhibitors, lipid-lowering drugs, and thrombolytics; primary PCI; intra-aortic balloon counterpulsation; and coronary artery bypass graft surgery. We forced all candidate variables into the final models. We simultaneously

Figure 1. **Study flow diagram.**



adjusted odds ratios for all other predictors. We conducted analyses by using commercially available statistical software (SPSS version 14.0, SPSS, Chicago, Illinois). All *P* values were 2-sided and were considered statistically significant if 0.050 or less.

Role of the Funding Source

The AMIS Plus Registry project was supported by the following sources (all in Switzerland; then were grouped by city, rather than by grant size or any other preferential factor): Swiss Heart Foundation and Novartis Pharma Schweiz, Bern; A. Menarini, Bayer (Schweiz), Pfizer, SPSS (Schweiz), and St. Jude Medical, Zurich; AstraZeneca, Zug; Biotronik Schweiz, Bristol-Myers Squibb, and Schering, Baar; Boehringer Ingelheim (Schweiz), Basel; Boston Scientific, Solothurn; Cordis, Johnson & Johnson, Spreitenbach; GlaxoSmithKline, Münchenbuchsee; Invatec, Schaffhausen; Medtronic Schweiz, Tolochenaz; MCM medsys, Kirchberg; Merck Sharp & Dohme Chibret, Opfikon-Glattbrugg; Nycomed Pharma, Dübendorf; Sanofi-Aventis (Suisse) and Servier (Suisse), Meyrin; and Takeda Pharma, Lachen. The funding sources had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

RESULTS

Patients

From January 1997 to December 2006, 23 696 patients with ACS were enrolled in the AMIS Plus Registry (**Figure 1** and **Table 1**). Overall, 1977 patients (8.3%) had cardiogenic shock. Of these, 564 patients (2.3% of those with ACS and 28.5% of those with cardiogenic shock) had cardiogenic shock on admission and 1413 patients (6.0% of those with ACS and 71.5% of those with cardiogenic shock) developed cardiogenic shock during hospitalization. Baseline risk for cardiovascular disease was higher among patients with cardiogenic shock than among those without (**Table 1**); this difference was mainly driven by patients who developed cardiogenic shock during hospitalization. Patients with cardiogenic shock on admission were similar to patients without cardiogenic shock in terms of sex and age.

Multivariable Analysis

In the ACS group, variables indicative of higher baseline risk, such as older age, history of diabetes, higher Killip classes, ST-segment elevation ACS, cardiopulmonary resuscitation on admission, faster heart rate, lower systolic blood pressure, higher Charlson Comorbidity Index score, and intra-aortic balloon counterpulsation, were associated with increased risk for in-hospital death. β-Blockers, angiotensin-converting enzyme inhibitors, and PCI were associated with lower risk for in-hospital death (**Table 2**).

In patients with ACS and no cardiogenic shock on admission, independent predictors of cardiogenic shock development during hospitalization included older age, ST-segment elevation ACS, faster heart rate, and lower systolic blood pressure. Lipid-lowering drugs and PCI were associated with lower risk for cardiogenic shock, whereas

intra-aortic balloon counterpulsation was associated with higher risk.

Temporal Trends

Between 1997 and 2006, overall rates of cardiogenic shock decreased from 12.9% to 5.5% ($P = 0.001$) (**Figure 2**). This decrease was mainly due to a decrease in cardiogenic shock developing during hospitalization, from 10.6% to 2.7% ($P < 0.001$). Rates of cardiogenic shock on admission remained stable.

In overall cardiogenic shock, rates of PCI and intra-aortic balloon counterpulsation increased, whereas rates of fibrinolytic therapy decreased. In contrast, rates of coronary artery bypass graft surgery remained stable (**Figure 3**). Patients with cardiogenic shock on admission were treated more often with PCI than were patients with cardiogenic shock during hospitalization (**Table 1**). During the observation period, increases occurred in the use of aspirin (from 80.4% to 89.2%; $P = 0.021$), clopidogrel (from 11.7% to 65.5%; $P < 0.001$), glycoprotein IIb/IIIa inhibitors (available from 1999 to 2006) (from 11.8% to 35.4%; $P = 0.014$), lipid-lowering drugs (available from 1999 to 2006) (from 14.3% to

Table 1. **Baseline Characteristics, Treatment, and In-Hospital Outcome**

Characteristic	Total (*n* = 23 696)	Cardiogenic Shock (*n* = 1977)	No Cardiogenic Shock (*n* = 21 083)	*P* Value	Cardiogenic Shock on Admission (*n* = 564)	Cardiogenic Shock during Hospitalization (*n* = 1413)	*P* Value
Demographic and medical							
Mean age (SD), *y*	66 (13)	70 (12)	65 (13)	<0.001	66.9 (12.7)	71.1 (11.9)	<0.001
Women, *n (%)*	6588 (27.8)	654 (33.1)	5766 (27.3)	<0.001	153 (27.1)	501 (35.5)	<0.001
History of CAD, *n (%)*	8116 (39.0)	688 (42.1)	7230 (38.8)	0.008	191 (38.3)	497 (43.8)	0.039
History of hypertension, *n (%)*	12 766 (56.2)	1066 (60.0)	11 384 (55.9)	0.001	289 (60.8)	777 (59.7)	0.66
History of diabetes, *n (%)*	4611 (20.1)	550 (30.3)	3926 (19.1)	<0.001	159 (32.1)	391 (29.6)	0.30
History of dyslipidemia, *n (%)*	12 343 (58.0)	807 (50.3)	7885 (41.2)	<0.001	248 (55.1)	549 (47.6)	0.008
Current smoking, *n (%)*	8543 (38.2)	626 (36.9)	7696 (38.3)	0.006	205 (44.9)	421 (33.9)	<0.001
Clinical presentation at admission							
Killip class, *n (%)*							
I	17 832 (76.4)	670 (34.8)	16 886 (80.1)	<0.001	0	670 (49.2)	NA
II	3865 (16.6)	429 (22.3)	3395 (16.1)	<0.001	0	429 (31.5)	NA
III	1091 (4.7)	262 (13.6)	802 (3.8)	<0.001	0	262 (19.3)	NA
IV	564 (2.4)	564 (29.3)	0	NA	564 (100)	0	NA
ST-segment elevation ACS, *n (%)*	14 022 (59.2)	1466 (74.9)	12 173 (57.8)	<0.001	363 (65.9)	935 (66.8)	0.71
Median symptom-to-admission delay (IQR), *min*	240 (120–723)	225 (105–723)	245 (120–720)	0.20	145 (75–368)	270 (120–865)	<0.001
Preadmission CPR, *n (%)*	838 (3.7)	361 (18.9)	425 (2.1)	<0.001	232 (42.0)	180 (12.9)	<0.001
Preadmission cardioversion/defibrillation, *n (%)*	771 (3.4)	318 (16.7)	433 (2.1)	<0.001	178 (32.1)	414 (29.7)	0.30
Atrial fibrillation, *n (%)*	945 (5.2)	125 (10.0)	806 (4.8)	<0.001	47 (11.2)	78 (9.4)	0.32
Mean heart rate (SD), *beats/min*	79 (21)	90 (28)	78 (19)	<0.001	95 (32)	89 (27)	<0.001
Mean systolic BP (SD), *mm Hg*	136 (27)	114 (31)	138 (26)	<0.001	98 (30)	121 (29)	<0.001
Mean diastolic BP (SD), *mm Hg*	79 (17)	68 (23)	80 (16)	<0.001	60 (30)	72 (19)	<0.001
Treatment							
Acetylsalicylic acid, *n (%)*	22 172 (93.9)	1668 (85.3)	19 934 (94.8)	<0.001	449 (80.8)	1219 (87.1)	<0.001
Clopidogrel, *n (%)*	10 999 (46.8)	630 (32.4)	10 121 (48.3)	<0.001	223 (40.3)	407 (29.2)	<0.001
Glycoprotein IIb/IIIa inhibitor, *n (%)*	6221 (34.1)	382 (29.9)	5734 (34.5)	0.001	130 (30.0)	252 (29.8)	0.49
β-Blocker, *n (%)*	16 840 (71.1)	752 (38.7)	15 679 (74.7)	<0.001	153 (27.8)	599 (43.0)	<0.001
ACE inhibitor, *n (%)*	9448 (40.6)	531 (27.6)	8682 (41.8)	<0.001	115 (21.2)	416 (30.1)	<0.001
Lipid-lowering drug, *n (%)*	10 762 (71.8)	458 (47.9)	10 080 (73.5)	<0.001	174 (46.9)	284 (48.5)	0.64
Vasopressors, *n (%)**	466 (7.4)	199 (53.9)	267 (4.5)	<0.001	97 (58.8)	102 (50.0)	0.057
Thrombolysis, *n (%)*	3695 (15.6)	363 (18.4)	3195 (15.2)	<0.001	86 (15.3)	277 (19.7)	0.024
Primary PCI, *n (%)*	8930 (37.9)	599 (30.5)	8173 (39.0)	<0.001	254 (45.4)	345 (24.6)	<0.001
Median door-to-balloon time (IQR), *min*	130 (45–825)	75 (30–212)	135 (47–890)	<0.001	43 (22–107)	117 (50–400)	<0.001
Intra-aortic balloon counterpulsation, *n (%)*	784 (3.4)	420 (22.0)	356 (1.7)	<0.001	141 (26.4)	279 (20.3)	0.006
Coronary artery bypass graft surgery, *n (%)*	636 (2.7)	65 (3.4)	556 (2.7)	0.003	14 (2.6)	51 (3.7)	0.24
In-hospital events after admission, *n (%)*							
Cardiogenic shock	1413 (6.1)	1413 (71.8)	0	NA	0	1413 (100)	NA
Major adverse cardiac events	2205 (9.7)	1147 (58.5)	1006 (4.9)	<0.001	297 (53.5)	850 (60.5)	0.005
Reinfarction	608 (2.6)	215 (11.3)	379 (1.8)	<0.001	22 (4.1)	193 (14.1)	<0.001
Cerebrovascular event	249 (1.1)	72 (3.8)	175 (0.8)	<0.001	32 (5.9)	40 (2.9)	0.003
In-hospital death	1709 (7.2)	1073 (54.3)	595 (2.1)	<0.001	279 (49.5)	794 (56.2)	0.007

ACE = angiotensin-converting enzyme; ACS = acute coronary syndrome; BP = blood pressure; CAD = coronary artery disease; CPR = cardiopulmonary resuscitation; IQR = interquartile range; NA = not applicable; PCI = percutaneous coronary intervention.
* From 2005 to 2006, *n* = 6339.

Table 2. **Multivariable Analysis Models***

Variable	Independent Predictors of In-Hospital Mortality in Patients with ACS (n = 7380)		Independent Predictors of Cardiogenic Shock in Patients with ACS without Cardiogenic Shock on Admission (n = 7375)	
	Odds Ratio (95% CI)	*P* Value	Odds Ratio (95% CI)	*P* Value
Age (per 1-year increase)	1.08 (1.06–1.11)	<0.001	1.03 (1.02–1.05)	<0.001
Male sex	0.79 (0.56–1.11)	0.174	0.84 (0.59–1.20)	0.34
History of coronary artery disease	1.05 (0.75–1.48)	0.77	1.21 (0.86–1.70)	0.28
History of hypertension	0.92 (0.65–1.30)	0.65	0.92 (0.66–1.28)	0.61
History of diabetes	1.45 (1.00–2.11)	0.048	1.39 (0.94–2.07)	0.101
History of dyslipidemia	1.18 (0.86–1.62)	0.32	0.95 (0.70–1.31)	0.77
Current smoking	1.35 (0.93–1.94)	0.112	1.25 (0.88–1.76)	0.21
Killip class				
II (vs. I)	1.50 (1.03–2.17)	0.035	NA	NA
III (vs. I)	2.24 (1.34–3.76)	0.002	NA	NA
IV (vs. I)	3.92 (1.99–7.72)	<0.001	NA	NA
ST-segment elevation ACS	1.63 (1.16–2.29)	0.005	2.89 (1.97–4.22)	<0.001
Symptom-to-admission delay >6 h	1.12 (0.82–1.55)	0.47	1.27 (0.93–1.75)	0.135
Preadmission CPR	4.61 (1.88–11.4)	0.001	1.89 (0.72–4.93)	0.195
Preadmission cardioversion/defibrillation	0.95 (0.39–2.32)	0.90	0.48 (0.19–1.22)	0.122
Atrial fibrillation	0.85 (0.48–1.51)	0.59	1.29 (0.72–2.32)	0.39
Heart rate (per 1-beat/min increase)	1.01 (1.00–1.02)	0.001	1.02 (1.01–1.02)	<0.001
Systolic BP (per 1–mm Hg increase)	0.99 (0.98–0.99)	0.002	0.99 (0.98–1.00)	0.002
Diastolic BP (per 1–mm Hg increase)	0.99 (0.98–1.01)	0.68	1.00 (0.99–1.01)	0.83
Obesity (BMI >30 kg/m^2)	0.88 (0.54–1.37)	0.56	0.83 (0.55–1.27)	0.40
Charlson Comorbidity Index score†				
1 (vs. 0)	1.28 (0.81–2.00)	0.29	0.95 (0.62–1.48)	0.83
2 (vs. 0)	1.82 (1.11–2.97)	0.017	1.46 (0.89–2.40)	0.139
≥3 (vs. 0)	1.78 (1.07–2.95)	0.026	1.49 (0.89–2.49)	0.129
Acetylsalicylic acid	1.15 (0.65–2.04)	0.63	0.98 (0.53–1.82)	0.95
Clopidogrel	0.90 (0.63–1.29)	0.58	1.02 (0.71–1.45)	0.92
Glycoprotein IIb/IIIa inhibitor	1.11 (0.75–1.62)	0.61	1.13 (0.79–1. 61)	0.50
β-Blocker	0.59 (0.42–0.82)	0.002	0.78 (0.56–1.10)	0.156
ACE inhibitor	0.66 (0.47–0.92)	0.015	0.72 (0.52–1.01)	0.054
Lipid-lowering drug	0.74 (0.52–1.05)	0.087	0.52 (0.37–0.73)	<0.001
Thrombolysis	0.97 (0.53–1.79)	0.92	0.93 (0.51–1.70)	0.82
Primary PCI	0.47 (0.30–0.73)	0.001	0.59 (0.39–0.89)	0.012
Intra-aortic balloon counterpulsation	9.25 (5.86–14.6)	<0.001	16.6 (11.2–24.6)	<0.001
Coronary artery bypass graft surgery	0.80 (0.58–1.10)	0.164	0.82 (0.60–1.11)	0.195

ACE = angiotensin-converting enzyme; ACS = acute coronary syndrome; BMI = body mass index; BP = blood pressure; CPR = cardiopulmonary resuscitation; NA = not applicable; PCI = percutaneous coronary intervention.
* All covariates were assessed on admission.
† The Charlson Comorbidity Index (13) gives an estimate of survival based on the following variables: AIDS status, cerebrovascular disease, chronic pulmonary disease, congestive heart failure, connective tissue disease, dementia, hemiplegia, leukemia, malignant lymphoma, myocardial infarction, peripheral vascular disease, ulcer disease, diabetes mellitus, liver disease, renal disease, and malignant solid tumor. Higher scores denote higher risk.

77.8%; $P < 0.001$), and β-blockers (from 32.7% to 40.0%; $P = 0.079$) in patients with cardiogenic shock.

In-hospital mortality rates decreased in overall cardiogenic shock (from 62.8% to 47.7%; $P = 0.010$), cardiogenic shock on admission (from 73.8% to 46.6%; $P = 0.009$), and cardiogenic shock developing during hospitalization (from 60.9% to 48.9%; $P = 0.094$) (**Figure 4**).

ST-Segment Elevation vs. Non–ST-Segment Elevation Myocardial Infarction

Cardiogenic shock incidence was higher in ST-segment elevation ACS than in non–ST-segment elevation ACS (10.7% vs. 5.2%; $P < 0.001$) but decreased similarly in both groups during the observation period (from 14.7% to 7.1% [$P < 0.001$] vs. 8.9% to 3.4% [$P < 0.001$]). Rates of cardiogenic shock during hospitalization decreased similarly in both groups (from 11.9% to 3.6% [$P < 0.001$] vs. 7.8% to 1.7% [$P < 0.001$]), but the incidence of cardiogenic shock on admission remained unchanged (from 0.8% to 1.7% [$P = 0.30$] vs. 2.4% to 3.6% [$P = 0.180$]).

Percutaneous coronary intervention was performed more frequently in patients with cardiogenic shock and ST-segment elevation ACS than in those with non–ST-segment elevation ACS (32.4% vs. 25.4%; $P = 0.004$). Similarly, thrombolysis was performed more frequently in patients with cardiogenic shock and ST-segment elevation ACS than in those with non–ST-segment elevation ACS (23.0% vs. 5.3%; $P < 0.001$). The use of intra-aortic balloon counterpulsation did not differ between patients with cardiogenic shock and ST-segment elevation ACS and those with non–ST-segment elevation ACS (23.1% vs. 19.2%; $P = 0.084$).

Mortality was lower in patients with cardiogenic shock and ST-segment elevation ACS than in patients with non–

ST-segment elevation ACS (52.5% vs. 58.0%; $P = 0.041$). In cardiogenic shock on admission, mortality in patients with ST-segment elevation ACS was 50.2% compared with 44.4% in patients with non–ST-segment elevation ACS ($P = 0.27$), whereas in cardiogenic shock developing during hospitalization, rates were 53.4% and 63.0%, respectively ($P = 0.002$).

Elderly Patients

Cardiogenic shock incidence was higher in patients age 75 years or older than in younger patients (12.2% vs. 7.3%; $P < 0.001$). Rates of PCI, thrombolysis, and intra-aortic balloon counterpulsation were lower in patients with cardiogenic shock age 75 years or older than in patients younger than 75 years (15.1% vs. 39.7% [$P < 0.001$], 13.8% vs. 21.2% [$P = 0.001$], and 10.5% vs. 28.8% [$P < 0.001$], respectively).

Mortality in cardiogenic shock was higher in patients age 75 years or older than in younger patients (73.7% vs. 42.8%; $P < 0.001$) but decreased similarly in both groups between 1997 and 2006 (from 82.8% to 65.6% [$P = 0.065$] vs. 52.7% to 38.3% [$P = 0.020$]). This was true for both cardiogenic shock during hospitalization (decrease from 81.7% to 66.7% [$P = 0.194$] vs. 49.7% to 38.2% [$P = 0.047$]) and cardiogenic shock on admission (decrease from 90.9% to 64.3% [$P = 0.6$] vs. 67.7% to 38.3% [$P = 0.021$]).

DISCUSSION

In this analysis of a large, population-based registry covering 10 years of observation, rates of cardiogenic shock on admission remained constant, whereas the incidence of cardiogenic shock as a complication of ACS steadily decreased over time because fewer patients in recent years developed cardiogenic shock during hospitalization. Although rates of PCI and intra-aortic balloon counterpulsation use in cardiogenic shock increased to greater than 60% and greater than 30%, respectively, mortality decreased to less than 50% in all subgroups. However, this decrease was not statistically significant in the subgroup of patients with cardiogenic shock developing during hospitalization. Similarly, use of antithrombotic and anti-ischemic drug therapy increased over time. Both PCI and lipid-lowering treatment were associated with lower mortality rates among all patients with ACS and with lower rates of cardiogenic shock development during hospitalization among patients with ACS without cardiogenic shock on admission.

To identify other pertinent studies, we searched PubMed for English-language articles published from 1950 to 30 July 2008. We found that recent data provided conflicting information about temporal trends in cardiogenic shock. Results from the National Hospital Discharge Survey in the United States showed decreasing rates of cardiogenic shock from 1979 to 2004, along with increasing rates of PCI and intra-aortic balloon counterpulsation (3). In contrast, data from the National Registry of Myocardial Infarction in the United States showed constant or even increasing rates of cardiogenic shock during 1995 to 2004, specifically in patients younger than age 75 years, and increasing PCI rates during the same period (2). The reason for this inconsistency is unclear, but it may be due to the study of different populations. Although the National Hospital Discharge Survey Registry is based on random samples of patients from participating hospitals with a discharge diagnosis of cardiogenic shock (3), the National Registry of Myocardial Infarction reported data from patients with ST-segment elevation myocardial infarction with cardiogenic shock admitted to selected hospitals that were voluntarily participating in a series of industry-spon-

Figure 2. **Temporal trends from 1997 to 2006 in the incidence of overall cardiogenic shock (*CS*), CS on admission, and CS developing during hospitalization in patients with the acute coronary syndrome.**

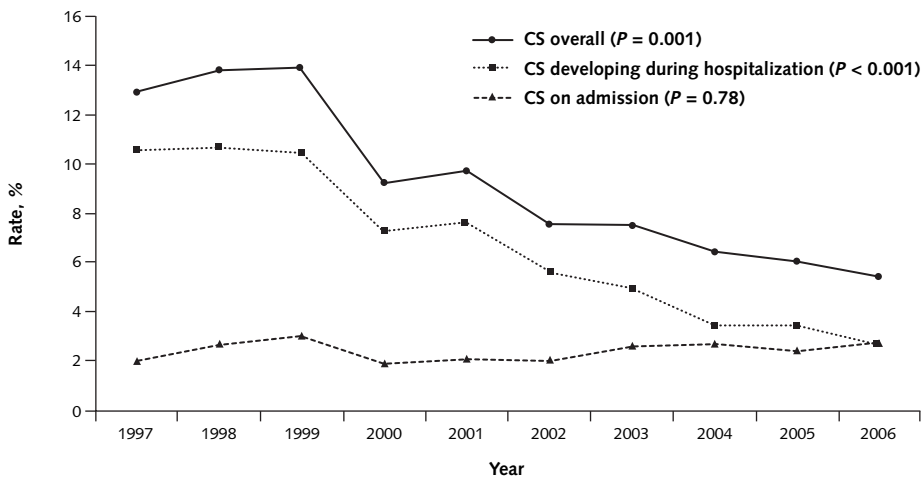
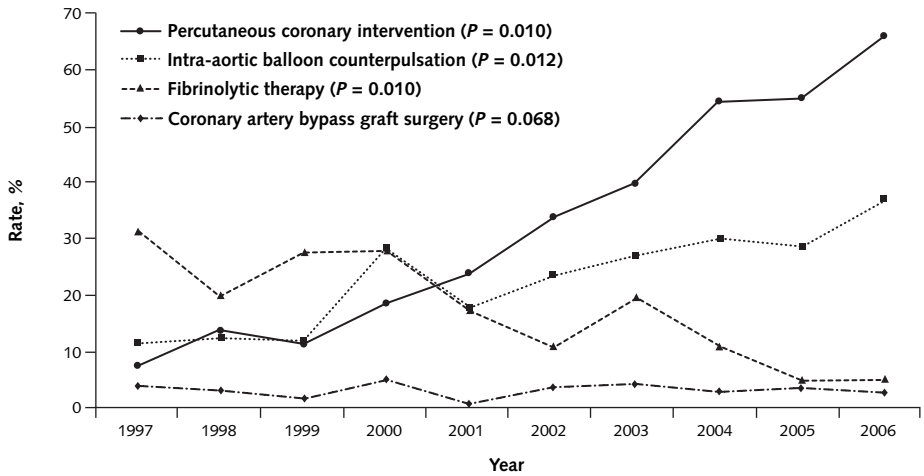


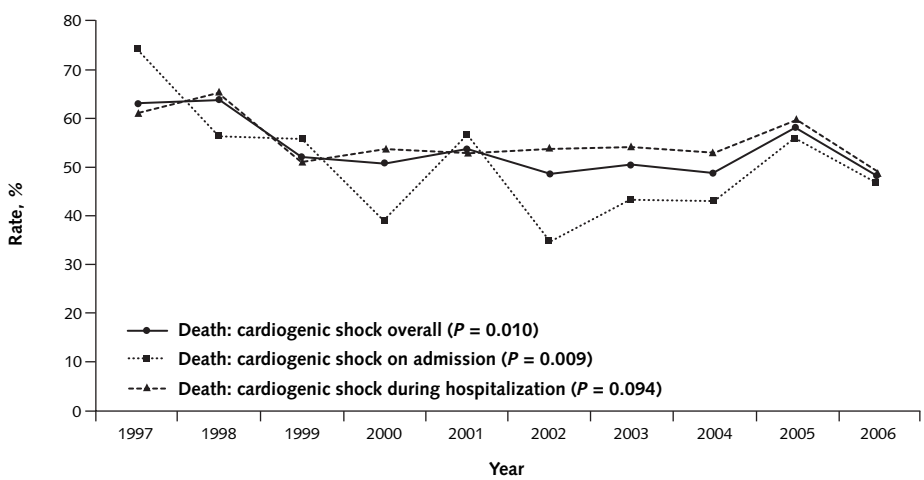
Figure 3. **Temporal trends from 1997 to 2006 in the frequency of percutaneous coronary intervention, coronary artery bypass graft surgery, fibrinolytic therapy, and intra-aortic balloon counterpulsation in patients with cardiogenic shock.**



sored registries (2). Thus, both registries report data on a somewhat selected patient population, whereas the AMIS Plus Registry collected data on a daily basis in a large proportion of patients with ACS in national acute cardiac care hospitals and therefore reflects daily practice in these hospitals. In addition, medical systems differ in many ways in the countries where the registries were conducted.

In 1999, the pivotal SHOCK (SHould we revascularize Occluded Coronaries for cardiogenic shocK?) trial and the Swiss Multicenter Trial of Angioplasty for Shock demonstrated the beneficial effect of early revascularization and intra-aortic balloon counterpulsation in patients with cardiogenic shock as a complication of myocardial infarction (14, 15). Correspondingly, rates of cardiogenic shock mortality in population-based registries, such as the National Hospital Discharge Survey and National Registry of Myocardial Infarction, decreased below 50%, but no strong relationships could be established between these decreases and temporal changes in patient management (2, 3). Similarly, recent data from the Global Registry of Acute Coronary Events showed that improvements in the management of patients with ACS paralleled substantial reductions in the incidence of mortality and cardiogenic shock but did not establish strong or causal relationships

Figure 4. **Temporal trends from 1997 to 2006 in rates of death in patients with overall cardiogenic shock, cardiogenic shock on admission, and cardiogenic shock developing during hospitalization.**



between treatments and outcomes (4). In contrast, our study suggests an inverse association between increased PCI rates and decreased rates of in-hospital mortality in patients with ACS but points particularly to an association between increased PCI rates and decreased rates of cardiogenic shock development during hospitalization. Therefore, our findings underscore the importance of an adequate interventional and medical assessment of patients with ACS and cardiogenic shock, specifically in terms of interventional and drug therapy, as outlined in international guidelines (5, 6, 16, 17).

Our findings were true for patients with both ST-segment elevation ACS and non–ST-segment elevation ACS and also for patients age 75 years or older and younger patients. Previous analyses from the SHOCK database showed a higher-risk profile and at least a similar mortality rate for cardiogenic shock in patients age 75 years or older (18) and in patients with non–ST-segment elevation ACS (19). Although mortality rates were higher in higher-risk patients, they considerably improved during the observed period in all patient groups.

Of great interest, rates of cardiogenic shock on admission were stable over the years, whereas rates of cardiogenic shock developing during hospitalization decreased. This meant that the proportion of cardiogenic shock cases on admission relative to that of overall cardiogenic shock cases increased during the past decade, such that shock present on admission accounted for about 50% of all patients with shock in 2006. Previous studies reported frequencies of up to 25% for shock on admission but did not give information on temporal trends (2, 20–25). Therefore, because the relative frequency of cardiogenic shock on admission increased during the observation period, the importance of adequately treating patients arriving at the hospital with cardiogenic shock should attract more attention. Although previous analyses from the SHOCK trial showed higher mortality rates in cardiogenic shock on admission than in cardiogenic shock developing during hospitalization, which was attributed to selection bias (24), our analysis in a nonselected patient population demonstrates a similar prognosis in both groups.

Our study had several limitations. The AMIS Plus Registry represents a high-risk cohort with an ST-segment elevation ACS rate of more than 50%. The exact number of patients with cardiogenic shock due to mechanical complications of myocardial infarction, generally accounting for approximately 15% of all cardiogenic shock cases (26), is not known because enrollment was not limited to patients with cardiogenic shock due to left ventricular failure but included all types of cardiogenic shock. Furthermore, we had no exact information on the timing of revascularization. As an inherent limitation of all registries, we did not perform a central review of shock diagnoses. However, we defined cardiogenic shock before the start of this registry (12, 27). These definitions were provided to the investigators in both the written and online questionnaires, and the definitions used did not change during the study period. As with all nonrandomized data, we cannot exclude possible selection bias, confounding by indication, and residual confounding. Therefore, no causal relationship can be established, and interactions among various residual unknown predictors of outcomes cannot be tested. In addition, the measurement of some potential predictors of outcome may be inaccurate, and unevaluated interactions may be possible. Finally, follow-up time was limited to the hospital stay, but previous data show that survival in patients with cardiogenic shock discharged from the hospital usually is good (7).

During the past decade, rates of cardiogenic shock on admission remained constant. However, rates of overall cardiogenic shock decreased, mainly because of lower rates of cardiogenic shock developing during hospitalization. Improvements in medical management, mainly increased PCI rates, were associated with lower mortality rates among patients with ACS and with lower rates of cardiogenic shock development during hospitalization.

From University Hospital Basel, Basel; University of Zurich, Zurich; University Hospital Lausanne, Lausanne; Cantonal Hospital Lucerne, Lucerne; and La Tour Hospital, Geneva, Switzerland.

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Requests for Single Reprints: Philip Urban, MD, Cardiovascular Department, La Tour Hospital, Avenue Maillard 1, 1217 Meyrin-Geneva, Switzerland; e-mail, philip.urban@latour.ch.

Current author addresses and author contributions are available at www.annals.org.

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Current Author Addresses: Drs. Jeger and Pfisterer: Cardiology, University Hospital, Petersgraben 4, CH-4031 Basel, Switzerland.
Dr. Radovanovic: AMIS Plus Data Center, Institute of Social and Preventive Medicine, University of Zurich, Hirschengraben 84, CH-8001 Zurich, Switzerland.
Dr. Hunziker: Medical Intensive Care Unit, University Hospital, Petersgraben 4, CH-4031 Basel, Switzerland.
Dr. Stauffer: Cardiology, University Hospital, Rue du Bugnon 46, CH-1101 Lausanne, Switzerland.
Dr. Erne: Cardiology, Cantonal Hospital, CH-6000 Lucerne 16, Switzerland.
Dr. Urban: Cardiovascular Department, La Tour Hospital, Avenue Maillard 1, 1217 Meyrin-Geneva, Switzerland.

Author Contributions: Conception and design: R.V. Jeger, P.R. Hunziker.
Analysis and interpretation of the data: R.V. Jeger, D. Radovanovic, M.E. Pfisterer, J.C. Stauffer.
Drafting of the article: R.V. Jeger, P.R. Hunziker.
Critical revision of the article for important intellectual content: D. Radovanovic, P.R. Hunziker, M.E. Pfisterer, J.C. Stauffer.
Final approval of the article: R.V. Jeger, D. Radovanovic, P.R. Hunziker, M.E. Pfisterer, J.C. Stauffer.
Provision of study materials or patients: P.R. Hunziker, J.C. Stauffer.
Statistical expertise: R.V. Jeger.
Administrative, technical, or logistic support: R.V. Jeger, P.R. Hunziker.
Collection and assembly of data: P.R. Hunziker.