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Heart Failure in Patients Undergoing Elective and Emergency Noncardiac Surgery: Still a Poorly Addressed Risk Factor

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ABSTRACT

Background: Noncardiac surgery is increasingly offered to an older, more comorbid population. The aim was to characterize patients with the diagnosis of heart failure (HF) undergoing elective and emergency noncardiac surgery in a broad, contemporary Swedish cohort, and to assess the short- and long-term mortality in patients with HF as compared with patients without HF.

Methods and Results: Data from 200,638 and 97,129 patients undergoing elective and emergency surgical procedures at 23 Swedish university, county, and district hospitals during 2007 to 2013 were analyzed through linkage of the surgical Orbit Database to the National Patient and the Cause of Death registries. In total 7212 patients (3.6%) with a diagnosis of HF before surgery underwent elective and 6455 patients (6.6%) underwent emergency surgery. Patients with HF were older had more comorbidities, and higher mortality than patients without HF. Crude and adjusted risk ratios for 30-day mortality after elective surgery were 5.36 (95% confidence interval [CI] 4.67-6.16) and 1.79 (95% CI 1.50−2.14) (adjusted for comorbidities, surgical risk level, age, and sex). Corresponding data for emergency surgery was 3.84 (95% CI 3.58−4.12) and 1.48 (95% CI 1.31−1.62). Mortality in patients with HF after elective surgery at 30 days, 90 days, and 1 year was 3.2%, 6.5%, and 16.2% and after emergency surgery it was 13.7%, 22.4%, and 39.3%.

Conclusions: Patients with HF undergoing elective or emergency noncardiac surgery in a modern surgical setting have a substantial mortality risk and HF is both a risk factor and a strong marker for increasd risk. The reasons for the high mortality are not well-understood and warrant further attention. (*J Cardiac Fail 2020;00:1−9*)

Keywords: Heart failure, noncardiac surgery, emergency surgery, elective surgery, outcome, perioperative medicine.

Worldwide, more than 300 million patients undergo major noncardiac surgery yearly.[1] Surgery is increasingly offered to an older and more comorbid population,[2] resulting in higher perioperative and subsequent long-term morbidity and mortality.[3] Heart failure (HF) is a deadly syndrome affecting 2%−3% of the population but with a steep increase in prevalence in the elderly, surpassing 10% in the age group of 70 years and older.[4,5]

The prognosis for patients with HF is poor. Depending on HF phenotype, 1-year mortality ranges from 6.3% to 8.8% for patients with chronic HF according to the European HF registry.[6] Swedish data suggest that mortality may be even higher in patients outside registries. Mortality among outpatients registered in the Swedish HF registry is 6.5%, as compared with 11.2% among patients not registered, suggesting the effect of better treatment in patients enrolled in registries.[7]

HF is a well-known risk factor in patients undergoing surgery and is included in several risk indices.[8−14] Yet, clinical perioperative risk assessments and optimization mainly focus on ischemic heart disease (IHD), although HF may attribute a higher risk.[9] During the past decades there has been an increased focus on the syndrome of HF with preserved ejection fraction (HFpEF). Despite this, the knowledge and awareness among medical practitioners outside the field of cardiology is likely still insufficient.[15] Nevertheless, HFpEF is associated with an increased risk, possibly comparable with HF with reduced EF.[8,10] Similarly, the perioperative risk for patients with both symptomatic and asymptomatic HF is increased.[10] Recent data from a predominantly male cohort of patients undergoing elective surgery suggests that HF is, above all, a marker of a

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conglomerate of comorbid conditions contributing to increased perioperative and postoperative risk.[10]

Considering the high risk in patients with HF undergoing elective surgery and lack of routine for postoperative follow-up of patients with HF in Sweden; the aim was to characterize patients with the diagnosis of HF undergoing both elective and emergency noncardiac surgery in a broad, contemporary cohort, to assess mortality in patients with HF, as compared with patients without HF.

Methods

Patient Population

The mortality risk associated with HF in patients undergoing noncardiac surgery was studied using consecutive data from 23, of a total of approximately 70, Swedish university, county, and district hospitals, prospectively collected in the surgical Orbit database. The Orbit is a software for surgical planning used in about one-third of the units performing surgery in Sweden. The database includes date, type, and duration of anesthesia and surgery, patient demographics, and American Society of Anesthesiologists (ASA) physical status classification. Data from Orbit were linked to the National Patient Register (NPR), and the Swedish Cause of Death Registry. The NPR has close to complete coverage of hospital discharge dates and diagnoses. Validation studies of the NPR show 85%−95% correct registration for most diagnoses including HF.[16] The Swedish Cause of Death Registry includes mortality data of all citizens since 1952, with more than 99% coverage.[17]

Patients 18 years or older undergoing surgery between January 1, 2007, and December 31, 2013, were included. HF and additional comorbidities as registered in NPR were considered within 5 years before surgery (Appendix Table 1).

Beyond cardiac surgery, obstetric surgery was a priori excluded because HF in the obstetric population is rare and mainly attributed to specific mechanisms. Very low-risk surgery, namely surgery classified by the Nordic Medico-Statistical Committee surgery codes used in the Nordic countries as minor (T), dermatologic (Q), and ophthalmic surgery (C), was also excluded. Similarly, surgeries classified in the Orbit database as ambulatory were excluded. In case of multiple registrations, patients undergoing both elective and emergency surgery during the study period were included in both cohorts because no comparison between emergency and elective surgery was made and because patients, in real life, may experience several types of procedures, affecting the overall risk. When multiple elective or emergency procedures were registered in a single patient during the study period, only the first surgical procedure in each patient, in each cohort (elective or emergency) was considered (Fig. 1).

Surgical procedures are presented in 11 categories based on surgical domain as coded in the Nordic countries (Nordic Medico-Statistical Committee): neuro, endocrine, ear-nose-throat, thoracic noncardiac, breast, gastrointestinal (GI), urologic, gynecologic, orthopedic, and vascular. Specific surgical procedures were clustered into 3 risk groups, irrespective of surgical domain, according to surgical risk estimates.[14]

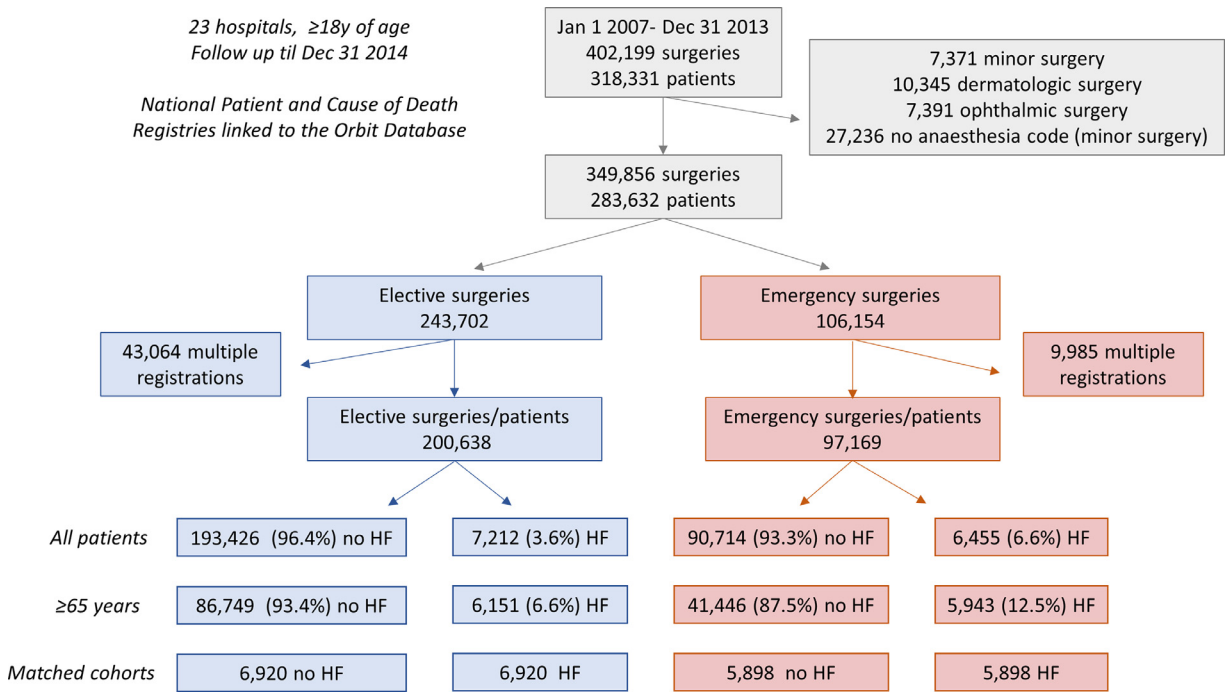

Fig. 1. Study outline. The Orbit database was linked to the National Patient and Cause of Death registries. Very low risk surgery was excluded. Procedures were divided into "elective" and "emergency" and the first surgical procedure of each patient, in each cohort was included. Subsequent analyses were made in elective and emergency surgery respectively in all patients, in the subgroup of patients aged 65 years and older, and in propensity score matched cohorts. HF, heart failure.

The end of follow-up was December 31, 2014, which ensured a minimum of 1-year of complete follow-up. The primary end point was all-cause 30-day mortality, with 90-day and 1-year all-cause mortality as secondary end points.

The study was approved by the Regional Ethics Committee of Stockholm, Sweden, waiving the need for individual patient informed consent.

Statistics

Patients undergoing elective and emergency surgery were analyzed separately. Continuous data are presented in patients with vs without the diagnosis of HF as median and interquartile range (IQR), and categorical data as number and percentage. For comparison the Mann−Whitney *U* test or the χ^2 test were used as appropriate.

The risk ratios (RRs) for 30-day, 90-day, and 1-year mortality were estimated for patients with HF undergoing elective and emergency surgery respectively, with patients without the diagnosis of HF during the previous 5 years as a reference, using the modified Poisson regression approach (a Poisson regression with a robust error variance) according to Zou.[18]

A priori−defined subgroup analyses were also performed in the 2 most common specific surgical domains among patients with HF; GI and orthopedic surgery in elective and emergency surgery, respectively.

Because HF is associated with comorbidities associated with increased risk, both crude risk and adjusted RRs from the Poisson regressions are presented. Bivariate analyses, including only HF and one other variable at a time, are presented in order to analyze which covariates affected the risk associated with HF the most. Covariates in the multivariable analyses were chosen based on clinical significance: age, sex, surgical risk level, and major comorbidities (diabetes, renal disease, cerebrovascular disease, chronic obstructive pulmonary disease [COPD], peripheral arterial disease, atrial fibrillation/flutter (AF), IHD, and hypertension).

Because patients with HF tend to be older, sensitivity analyses were performed in patients aged 65 years and older and in propensity score−matched cohorts. A propensity score for HF was estimated using logistic regression, including the same variables as in the multivariable model separately for elective and emergency surgery. Matching was thereafter performed in a 1:1 ratio using nearest-neighbor matching without replacement, allowing for matches if the propensity score differed by 0.01 or less. To model the dependency between matched pairs generalized estimating equations models were used when analyzing the association between HF and the respective outcomes.

The crude and adjusted (age, sex, surgical risk, diabetes, renal disease, cerebrovascular disease, COPD, peripheral arterial disease, AF, IHD, and hypertension) population attributable mortality fraction (PAF) for HF was also calculated for 30-day, 90-day, and 1-year mortality in the entire cohort and in the subgroup of patients aged 65 years and older.[19]

The level of significance was set to 5%, 2-sided. Data was analyzed using STATA version 14.2 (Stata Corp., College Station, TX) and R v 3.6.2 (R Core Team 2019, Vienna, Austria).

Results

In a total of 200,638 patients undergoing elective surgical procedures were analyzed, of whom 7212 (3.6%) had a diagnosis of HF before surgery. Corresponding numbers for emergency surgery were 97,169 and 6455 (6.6%), respectively (Fig. 1 and Table 1). The matched cohorts consisted of 6920 patients with HF and 6920 patients without HF undergoing elective surgery and 5898 patients with HF vs 5898 patients without HF undergoing emergency surgery (Table 2). A subgroup analysis was made in patients aged 65 and older: 92,900 elective procedures, with 6151 (6.6%) in patients with HF, and 47,389 emergency surgeries, with 5943 (12.5%) in patients with HF (Fig. 1 and Appendix Table 2).

Elective Surgery: Patient Characteristics and Surgical Procedures

Patients with the diagnosis of HF were older than patients without, median 77 years (IQR 69−83 years) vs 63 years (IQR 48−72 years). Patients with HF were less likely to be female (42% vs 57%) and comorbidities such as hypertension, IHD, AF, diabetes, and COPD were 3- to 7-fold more common in patients with HF. Consistent with these findings, patients with HF had a higher ASA classification, and less than 1% of patients with HF were classified as ASA 1, and 17% as ASA 2. The pattern was largely similar in patients 65 years and older (Appendix Table 2).

Patients with HF underwent fewer low-risk procedures, but the duration of surgery was slightly shorter. Among the 11 surgical domains studied, the 2 most common were orthopedic and GI surgery. The length of stay was longer in patients with HF, median 5 days (IQR 2−9 days) vs 3 days (IQR 2−6 days) in the entire cohort, and 5 days (IQR 2−10 days) vs 4 days (IQR 2−7 days) in patients 65 years and older.

Emergency Surgery: Patient Characteristics and Surgical Procedures

As in the elective surgery cohort, patients with HF were older. The sex distribution in patients with vs without HF was more even. Again, comorbidities were much more common among patients with HF.

Similar to patients undergoing elective surgery, patients with HF underwent fewer low-risk procedures, the duration of surgery was slightly shorter, and the most common surgical domains were orthopedic and GI surgery. The median length of stay was 5 days longer in patients with HF, median 10 days (IQR 6−18 days) vs 5 days (IQR 5−11 days) in the entire cohort. The difference was smaller in patients 65 years and older, 11 days (IQR 6−18 days) vs 9 days (IQR 4−15 days).

Table 1. Baseline Characteristics

Variables	Elective (n = 200,638)		Emergency (n = 97,169)	
	No HF diagnosis (n = 193,426)	Diagnosis of HF (n = 7212 [3.6%])	No HF diagnosis (n = 90,714)	Diagnosis of HF (n = 6455 [6.6%])
Age, years	63 (48−72)	77 (69−83)	62 (41−78)	83 (76−88)
Female sex	109,527 (57)	2993 (42)	48,511 (54)	3335 (52)
ASA class				
1	46,679 (24)	49 (0.7)	22,084 (24)	20 (0.3)
2	76,478 (40)	1190 (17)	24,065 (27)	605 (9)
3	31,098 (16)	3959 (55)	19,752 (22)	3320 (51)
4	1181 (0.6)	450 (6)	2556 (3)	850 (13)
Missing	37,990 (20)	1564 (22)	22,257 (25)	1660 (26)
Duration of surgery, minutes	93 (60−144)	85 (49−137)	63 (37,101)	60 (36−93)
Length of stay, days	3 (2−6)	5 (2−9)	5 (2−11)	10 (6−18)
Surgical risk level				
Low	54,621 (28)	1530 (21)	30,492 (34)	963 (15)
Intermediate	123,129 (64)	4952 (69)	50,299 (55)	4862 (75)
High	15,676 (8)	730 (10)	9923 (11)	630 (10)
Level of care				
District hospital	34,496 (18)	1241 (17)	9508 (11)	963 (15)
County hospital	47,945 (25)	1969 (27)	35,930 (40)	2471 (38)
University hospital	110,985 (57)	4002 (56)	45,276 (50)	3021 (47)
Types of surgery				
Neuro	14,413 (7.5)	390 (5.4)	5801 (6.4)	290 (4.5)
Endocrine	7387 (3.8)	152 (2.1)	57 (0.1)	3 (<1)
ENT	9039 (4.7)	132 (1.8)	457 (0.5)	23 (0.4)
Orofacial	11,074 (5.7)	125 (1.7)	1236 (1.4)	15 (0.2)
Thoracic (noncardiac)	2748 (1.4)	114 (1.6)	1271 (1.4)	96 (1.5)
Breast	12,959 (6.7)	251 (3.5)	169 (0.2)	5 (0.1)
Gastrointestinal	31,510 (16.3)	1330 (18.4)	30,130 (33.2)	1068 (16.5)
Urologic	25,598 (13.2)	1293 (17.9)	4713 (5.2)	291 (4.5)
Gynecologic	20,645 (10.7)	416 (5.8)	3650 (4.0)	40 (0.6)
Orthopedic	48,668 (25.2)	2012 (27.9)	40,815 (45.0)	4179 (64.7)
Vascular	9385 (4.9)	997 (13.8)	2415 (2.7)	445 (6.9)
Comorbidities (diagnosis present within 5 years before surgery)				
AMI	3145 (2)	1335 (19)	1742 (2)	1329 (21)
IHD (including AMI)	12,635 (7)	3699 (51)	6107 (7)	3261 (51)
Hypertension	37,521 (19)	4523 (63)	16,225 (18)	3860 (60)
Valve disease	2698 (1)	1059 (15)	1205 (1)	958 (15)
Diabetes	14,151 (7)	2113 (29)	7370 (8)	1943 (30)
Renal disease	7092 (4)	1420 (20)	3421 (4)	1334 (21)
Cerebrovascular disease	7896 (4)	1037 (14)	5236 (6)	1299 (20)
COPD	4361 (2)	1088 (15)	2553 (3)	1142 (18)
Peripheral arterial disease	7548 (4)	1310 (18)	3741 (4)	1375 (21)
Atrial fibrillation/flutter	8410 (4)	3367 (47)	5055 (6)	3308 (51)

Values are median (interquartile range) or number (%). $P < .001$ for all pairwise comparisons in elective and emergency surgery respectively. AMI, acute myocardial infarction; ASA, American Society of Anesthesiology; COPD, chronic obstructive pulmonary disease; ENT, ear, nose throat; HF, heart failure; IHD, ischemic heart disease.

Mortality After Elective Surgery

Patients with HF had increased mortality risk at all 3 time points, regardless of the surgery being elective or emergency. Crude mortality at 30 days, 90 days, and 1 year for patients with HF vs without HF undergoing elective surgery was 3.2% vs 0.6%, 6.5% vs 1.4%, and 16.2% vs 4.2% respectively (Fig. 2).

The crude risk of death within 30 days after surgery was thus more than 5 times higher in patients with HF (RR 5.36, 95% confidence interval [CI] 4.67−6.16).

After adjustment for age, sex, surgical risk, and important comorbidities (diabetes, renal disease, cerebrovascular disease, COPD, peripheral arterial disease, AF, IHD, and hypertension), the risk was still almost 80% higher in patients with HF (RR 1.79, 95% CI 1.50−2.14). In bivariate analysis, the factors affecting the association between HF and 30-day mortality the most were age, AF, and hypertension. Corresponding crude and adjusted RRs for 90-day and 1-year mortality were 4.72 (95% CI 4.29−5,19) and 1.55 (95% CI 1.38−1.75) vs 3.88 (95% CI 3.66−4.10) and 1.40 (95% CI 1.31−1.50). Results are presented in Fig. 3 and Appendix Table 3 and for the subgroup analyses of patients aged 65 years and older in Appendix Fig. 2 and Appendix Table 4.

The 1:1 propensity score matching based on all variables included in the multivariable model and 6920 patients with vs 6920 without HF showed similar results with RRs for 30-day, 90-day, and 1-year mortality (RR 1.71 [95% CI 1.38−2.12]; RR 1.57 [95% CI 1.36−1.81], and RR 1.42 [95% CI 1.31−1.54]).

For patients undergoing orthopedic surgery, the crude risk of 30-day mortality was 10 times higher for patients with HF (RR 10.44; 95% CI 8.09−14.47) and after

Table 2. Baseline Characteristics of the Matched Cohorts

Variables	Elective Surgery					Emergency Surgery				
	Missing (%)	No HF Diagnosis (n = 6920)	Diagnosis of HF (n = 6920)	SMD	*P* Value	Missing (%)	No HF Diagnosis (n = 5898)	Diagnosis of HF (n = 5898)	SMD	*P* Value
Age, years	0.0	77 [70−82]	76 [69−83]	0.056	.085	0.0	83 [76−88]	83 [74−88]	0.088	.001
Female sex	0.0	2905 (42.0)	2911 (42.1)	0.002	.931	0.0	3114 (52.8)	3103 (52.6)	0.004	.854
ASA class										
Missing	21.2			0.453	<.001	24.9			0.337	<.001
1		181 (3.3)	49 (0.9)				74 (1.7)	19 (0.4)		
2		2121 (38.6)	1165 (21.5)				1036 (23.1)	585 (13.4)		
3		3016 (54.9)	3789 (70.0)				2951 (65.8)	3031 (69.3)		
4		179 (3.3)	409 (7.6)				423 (9.4)	740 (16.9)		
Duration of surgery, minutes	0.0	86 [50−139]	86 [50−137]	0.017	.306	0.0	63 [38−95]	60 [36−93]	0.037	.003
Length of stay, days	0.0	4 [2−8]	5 [2−9]	0.062	<.001	0.0	10 [5−16]	10 [6−17]	0.081	.001
Surgical risk level	0.0			0.040	.060	0.0			0.019	.579
Low		1479 (21.4)	1460 (21.1)				838 (14.2)	878 (14.9)		
Intermediate		4663 (67.4)	4763 (68.8)				4480 (76.0)	4445 (75.4)		
High		778 (11.2)	697 (10.1)				580 (9.8)	575 (9.7)		
Level of care	0.0			0.081	<.001	0.0			0.088	<.001
District hospital		1350 (19.5)	1206 (17.4)				804 (13.6)	883 (15.0)		
County hospital		2012 (29.1)	1882 (27.2)				2534 (43.0)	2282 (38.7)		
University hospital		3558 (51.4)	3832 (55.4)				2560 (43.4)	2733 (46.3)		
Type of surgery	0.0			0.089	.002	0.0			0.116	<.001
Neuro		405 (5.9)	377 (5.4)				294 (5.0)	267 (4.5)		
Endocrine		143 (2.1)	149 (2.2)				6 (0.1)	3 (0.1)		
ENT		127 (1.8)	130 (1.9)				17 (0.3)	22 (0.4)		
Orofacial		127 (1.8)	120 (1.7)				13 (0.2)	15 (0.3)		
Thoracic (noncardiac)		97 (1.4)	107 (1.5)				63 (1.1)	92 (1.6)		
Breast		250 (3.6)	248 (3.6)				4 (0.1)	4 (0.1)		
Gastrointestinal		1226 (17.7)	1289 (18.6)				1129 (19.1)	987 (16.7)		
Urologic		1439 (20.8)	1223 (17.7)				355 (6.0)	263 (4.5)		
Gynecologic		371 (5.4)	403 (5.8)				29 (0.5)	37 (0.6)		
Orthopedic		1903 (27.5)	1953 (28.2)				3588 (60.8)	3815 (64.7)		
Vascular		832 (12.0)	921 (13.3)				400 (6.8)	393 (6.7)		
Comorbidities										
AMI	0.0	861 (12.4)	1232 (17.8)	0.150	<.001	0.0	786 (13.3)	1112 (18.9)	0.151	<.001
IHD (including AMI)	0.0	3443 (49.8)	3422 (49.5)	0.006	.734	0.0	2722 (46.2)	2745 (46.5)	0.008	.685
Hypertension	0.0	4455 (64.4)	4279 (61.8)	0.053	.002	0.0	3632 (61.6)	3419 (58.0)	0.074	<.001
Valve disease	0.0	440 (6.4)	996 (14.4)	0.266	<.001	0.0	369 (6.3)	851 (14.4)	0.271	<.001
Diabetes	0.0	1992 (28.8)	1952 (28.2)	0.013	.463	0.0	1625 (27.6)	1652 (28.0)	0.010	.593
Renal disease	0.0	1181 (17.1)	1228 (17.7)	0.018	.302	0.0	984 (16.7)	1045 (17.7)	0.027	.143
Cerebrovascular disease	0.0	957 (13.8)	971 (14.0)	0.006	.750	0.0	1178 (20.0)	1145 (19.4)	0.014	.459
COPD	0.0	940 (13.6)	945 (13.7)	0.002	.921	0.0	884 (15.0)	915 (15.5)	0.015	.442
Peripheral arterial disease	0.0	1158 (16.7)	1183 (17.1)	0.010	.586	0.0	1080 (18.3)	1117 (18.9)	0.016	.395
Atrial fibrillation/flutter	0.0	2940 (42.5)	3083 (44.6)	0.042	.015	0.0	2673 (45.3)	2788 (47.3)	0.039	.035

Values are median [interquartile range] or number (%). The matching was based on the same covariates as in the multivariable Poisson model: age, sex, surgical risk level, and major comorbidities. AMI, acute myocardial infarction; ASA, American Society of Anesthesiology; COPD, chronic obstructive pulmonary disease; ENT, ear, nose throat; HF, heart failure; IHD, ischemic heart disease; SMD, standardized mean difference.

multivariable adjustment the risk was more than doubled (RR 2.29, 95% CI 1.62−3.24). The corresponding RR for GI surgery was 4.11 (95% CI 3.22−5.26) vs an adjusted RR of 1.71 (95% CI 1.27−2.30). In the matched cohort, the RRs for 30-day mortality were rather similar; 2.15 (95% CI 1.44−3.20) for patients undergoing orthopedic surgery and 1.70 (95% CI 1.16−2.49) for GI surgery.

The crude fraction of 30-day mortality (PAF) after elective surgery attributed to HF was 13.6% (95% CI 11.5%−15.5%), and the adjusted PAF 7.3% (95% CI 4.9%−9.7%) (Fig. 2).

Mortality After Emergency Surgery

Crude mortality after emergency surgery at 30 days, 90 days, and 1 year in patients with HF compared with patients without was 13.7% vs 3.6%, 22.4% vs 6.5%, and 39.3% vs 11.6%, respectively (Fig. 2).

The crude risk of death within 30 days after surgery was hence almost 4-fold higher in patients with HF (RR 3.84, 95% CI 3.58−4.12). After multivariable adjustment as above, the risk was still almost 50% higher in patients with HF (RR 1.48, 95% CI 1.31−1.62). The corresponding risk in the 1:1 propensity score-matched cohort based on all variables included in the multivariable model and 5898 patients with vs 5898 without HF showed similar results with RR for 30-day mortality being 1.45 (95% CI 1.31−1.61).

Corresponding data for 90-day and 1-year mortality for the entire cohort is shown in Fig. 3 and Appendix Table 3, and for patients aged 65 years and older in Appendix Fig. 2 and Appendix Table 4.

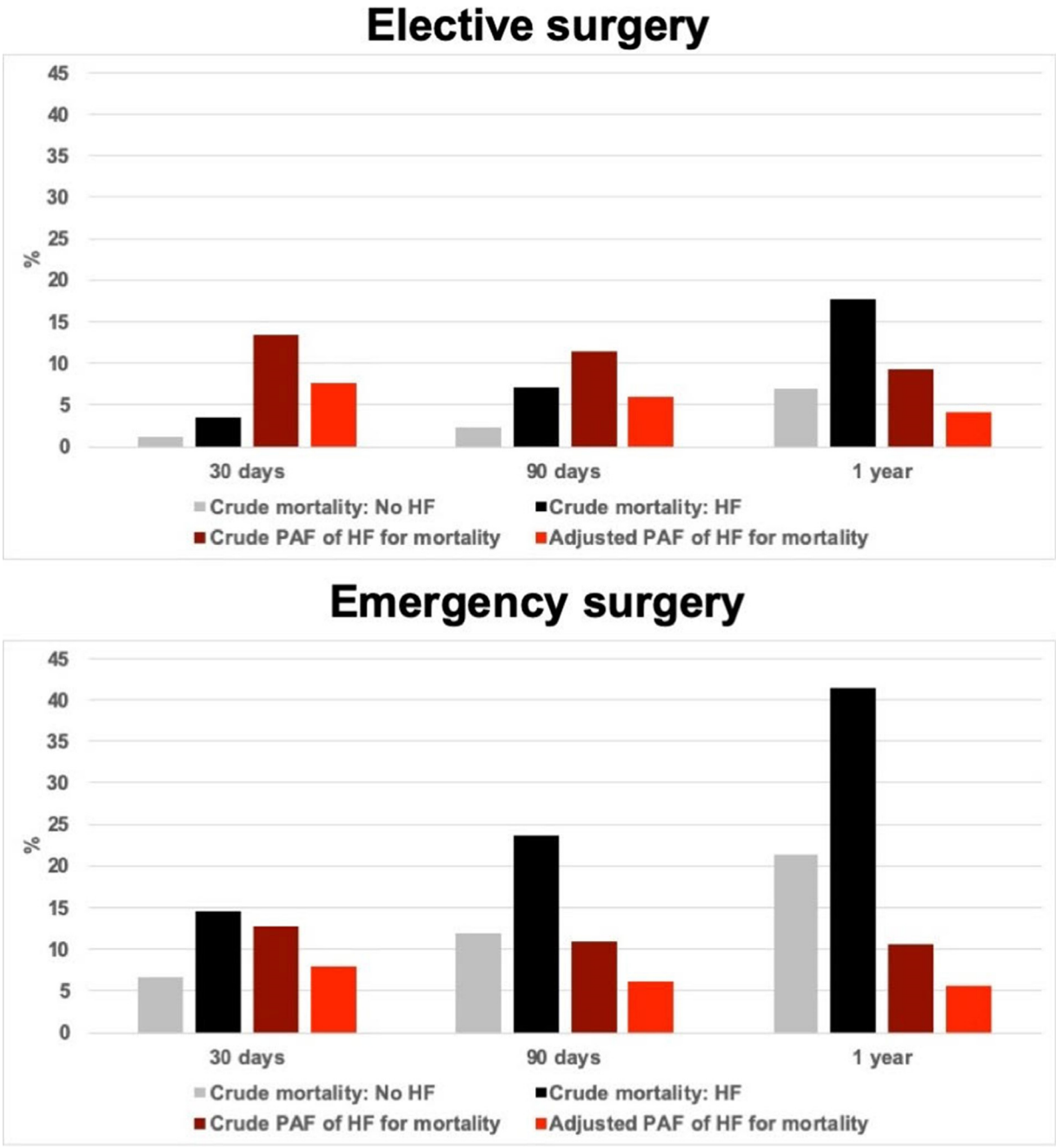

Fig. 2. Mortality in patients with vs without heart failure (HF) and population attributable fraction (PAF) of HF for mortality. All-cause mortality after surgery in patients without vs with HF and PAF for mortality of HF in elective and emergency surgery, crude and adjusted (comorbidities, age, sex, and surgical risk). The *P* value for pair-wise comparisons was less than .001 for all. Mortality in patients without vs with HF at 30-days, 90-days, and 1-year after elective surgery was 0,6 vs 3.2, 1.4 vs 6.5, and 4.2 vs 16.2% and emergency surgery 3.6 vs 13.7, 6.5 vs 22.4, and 11.6 vs 39.3%. Crude PAF for mortality of HF at the same time points were 13.6 (11.5-15.5), 11.8 (10.5-13.0), and 9.4 (8.7-10.0%), and for emergency surgery 15.9 (14.6-17.1), 14.1 (13.2-14.9), and 13.6 (13.0-14.2). Corresponding data for adjusted PAF for elective surgery were 7.3 (4.9-9.7), 5.3 (3.8-6.8), and 3.6 (2.8-4.4%) and for emergency surgery 7.0 (5.4- 8.5), 5.2 (4.1-6.3), and 4.6 (3.9-5.3).

For patients with HF undergoing emergency orthopedic surgery, the crude risk of 30-day mortality was 3.3 times higher (RR 3.32, 95% CI 3.32−3.99), and after multivariable adjustment the risk was still 50% higher (RR 1.53, 95% CI 1.37−1.70). The RR was rather similar in the matched cohort (1.46, 95% CI 1.28−1,67). Corresponding data for GI surgery was an RR of 5.17 (95% CI 4.46−5.99) vs an adjusted RR of 1.38 (95% CI 1.15−1.65) vs 1.40 (95% CI 1.13−1.72) in the matched cohort.

The crude PAF at 30 days attributed to HF in emergency surgery was 15.9% (95% CI 14.6%−17.1%) and the

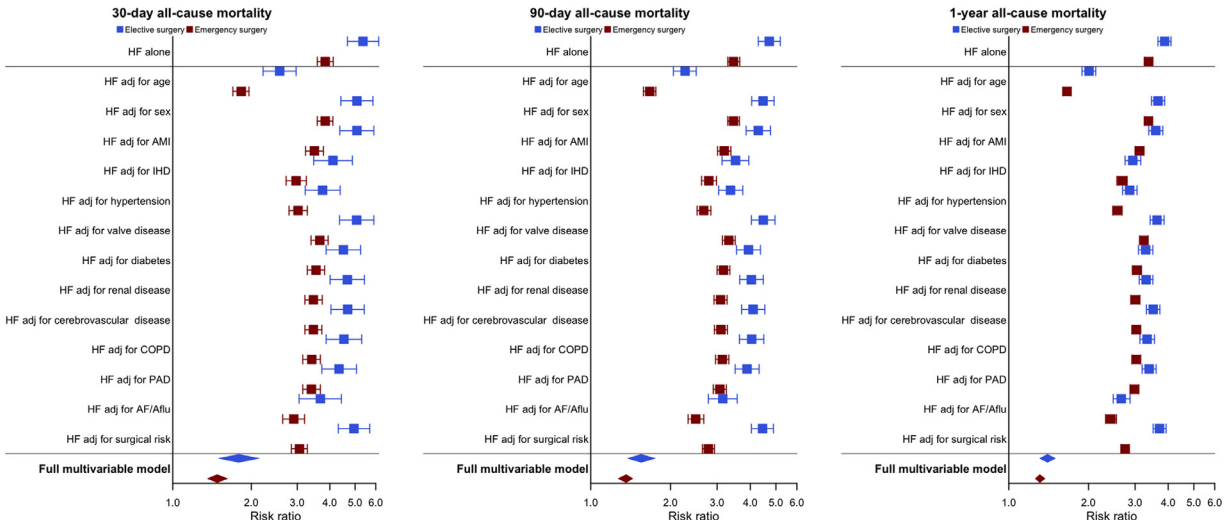

Fig. 3. Crude and adjusted risk ratios for mortality for patients with HF. Crude and adjusted risk ratio for 30-day, 90-day, and 1-year mortality rates in patients with HF vs without HF undergoing elective and emergency surgery. *P* value for all comparisons was less than .001. Covariates in the full multivariable model include HF, age, sex, surgical risk, diabetes, renal disease, cerebrovascular disease, COPD, PAD, atrial arrhythmia, IHD, and hypertension. The *P* value for all comparisons was less than .001. AMI, acute myocardial infarction; COPD, chronic obstructive pulmonary disease; HF, heart failure; IHD, ischemic heart disease; PAD, peripheral arterial disease; AF/Aflu, atrial fibrillation/flutter.

adjusted PAF was 7.0% (5.4%−8.5%) (Fig. 2). Corresponding data for mortality within 90 days and 1 year and in patients 65 years and older is shown in Appendix Fig. 1.

Discussion

In this study of almost 300,000 patients undergoing elective or emergency noncardiac surgery in Sweden, 3.6% of elective and 6.6% of emergency surgery patients had HF. Patients with HF were older, had more comorbidities, and substantial mortality after surgery. Mortality within 30 days after elective and emergency surgery was 3.2% and 13.7% in patients with HF. Corresponding 90-day and 1-year mortality fraction for patients with HF was as high as 6.5% and 22.4%, and 16.4% and 39.3%. HF was indeed a marker of a 4- to 5-fold higher postoperative risk in both elective and emergency surgery, but also an independent risk factor associated with 50%−80% increased risk of mortality within 30 days after surgery.

HF and Mortality

Patients with HF were, similar to previous studies, older, had more comorbidities, had a longer length of stay, and underwent more high-risk procedures than patients without HF.[10] Mortality in patients with HF after elective surgery was comparable with a recent large US study of mainly male patients undergoing elective surgery, where the 90-day mortality in asymptomatic patients with HF was 5.49%, with higher mortality (10.11%) in symptomatic patients.[10] A novel finding in the present study was the high mortality in patients with HF undergoing emergency surgery, with 14% mortality within 30 days, more than 1 in 5 patients dead after 90 days, and almost 2 out of 5 after 1 year. Emergency surgery is generally associated with higher mortality than elective surgery and optimizing the patient's status preoperatively is more difficult because time for treatment optimization is limited and the surgical condition may decrease the therapeutic options.

Despite the rather low prevalence, the crude attributable mortality fraction of patients with the diagnosis of HF to 30-day mortality was almost 14% for elective surgery and 16% for emergency surgery. No data on HF symptoms at time of surgery was available, but 1-year mortality by far exceeded the expected mortality for chronic patients with HF and even mortality for patients hospitalized for HF.[6,20] Similar to previous findings, HF was a strong marker of high risk in surgery, and patients tended to suffer not only from HF but from several comorbidities likely affecting surgical outcome.[10] The factors that modified the risk associated with HF the most were age, hypertension, and AF in patients undergoing elective surgery and age, IHD, and AF in patients undergoing emergency surgery. Yet, the adjustment for AF may be problematic. HFpEF and AF often coexist and patients with both conditions may have similar comorbidities and symptoms, as well as elevated natriuretic peptides.[21] The awareness of HFpEF may possibly have been lower during the time of the early study period, which raises concerns that some patients with AF may also have had undiagnosed HFpEF. Nevertheless, even after adjustment for important comorbidities, age, and surgical risk, HF was still associated with almost 80% increased 30-day mortality risk after elective surgical procedures.

Specific Surgical Domains

A subgroup analysis in the 2 most common surgical domains, namely, orthopedic and GI surgery, gave similar results of HF being a strong risk marker, but also an

independent risk factor for mortality. This was particularly true for orthopedic surgery, where the crude mortality was 10-fold greater and adjusted mortality twice as high for patients with HF. One explanation for the increased risk in patients with HF may of course be more high-risk surgery performed. Nevertheless, adjusting for surgical risk only weakly modified the RR.

A major limitation to the present study was the lack of data on EF phenotype. Indeed, low EF has been identified as an important risk factor in patients undergoing surgery.[10,14] However, recent data from patients undergoing hip fracture surgery showed a similarly increased risk of major adverse cardiovascular and cerebrovascular events and mortality in HFpEF and HF with reduced EF,[8] suggesting that the risk attributed to patients with HFpEF may be underestimated or depend on surgical discipline.

Perioperative and Postoperative Care of Patients With HF

Current guidelines recommend that patients with HF undergoing surgery should be on optimal medical treatment, be euvolemic with stable blood pressure, and optimal end-organ perfusion.[14] Although patients undergoing surgery in Sweden are routinely assessed by the surgeon and the anesthesiologist before surgery, cardiology expertise is sought only when considered relevant. This requires a high awareness and knowledge among surgeons and anesthesiologist of the complex syndrome of HF and available therapies.

Although there are guidelines for preoperative and early postoperative care and optimization for patients with HF,[14] no guidelines focus on the later postoperative period. There is furthermore no routine nonsurgical postoperative assessment of patients with HF, nor any routine outpatient follow-up. After hospitalization for HF, as many as 49% of patients are incompletely decongested at the time of discharge.[22,23] Despite risk factors in terms of perioperative fluid therapy and stress response to surgery, there are no corresponding data for patients with HF undergoing noncardiac surgery. In addition, the majority of these patients are most likely not routinely examined by cardiologists. Although guidelines recommend continuation of HF therapy during the perioperative period, data on HF therapy adherence perioperatively and postoperatively in noncardiac surgery is lacking.

The only outcome assessed in this study was mortality, but HF is also a well-known risk factor for serious morbidity, reoperation, and readmission.[13,14] The specific reasons for the increased risk are not fully understood, but the greater incremental risk of HF in postoperative setting vs in chronic or even postacute HF suggests an interaction between HF and surgery.

Whether merely a risk marker or a risk factor during surgery, patients with HF and HF-related comorbidities still constitute a high-risk population when undergoing both elective and emergency noncardiac surgery in a modern surgical setting. The high mortality, despite a contemporary surgical setting and HF therapy, warrants further attention. It is possible that improved, multidisciplinary postoperative care, in particular in the late postoperative or even outpatient, phase, could improve the outcome of these patients.

Limitations

HF was defined as the presence of the diagnosis of HF of any kind during 5 years before surgery. A major limitation is that no data on HF or EF phenotype, HF duration, symptoms, or severity were available. The registries used have good coverage and validity but, despite extensive adjustments, we cannot rule out potential residual confounding.

Furthermore, the risk for patients with HF undergoing surgery may be underestimated owing to the sickest patients being retained from surgery and hence not present in the study population.

Only all-cause mortality was considered as an outcome measure and the burden of morbidity, in addition to mortality, is likely to be substantial. Although our findings are in line with previous data, the generalizability to other countries depends on similarities in population characteristics, health care organization and delivery, and HF management.

Conclusions

In this comprehensive study of almost 300,000 patients undergoing elective or emergency noncardiac surgery in a modern surgical setting in Sweden, patients with HF were older, had more comorbidities, and had substantially higher mortality after both elective and emergency surgeries. This finding warrants further attention and improved multidisciplinary care in the later postoperative phase may improve patient outcomes.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.cardfail.2020.06.015.

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