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ORIGINAL ARTICLE

Male–female differences following concomitant coronary artery bypass grafting and aortic valve replacement surgery

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Abstract

Aims Combined coronary artery bypass grafting (CABG) and aortic valve replacement (AVR), and female sex are associated with increased perioperative mortality in clinical risk scores. This study investigated male–female differences in short-term outcome stratified by age groups.

Methods and results All patients undergoing AVR and CABG between January 2001 and June 2021 at our institution were included. 1963 patients were grouped by decades into: 59 years and younger (n = 127), 60–69 (n = 471), 70–79 (n = 1070), and 80 years and older (n = 295). The primary end points of this study were 30 and 180 days mortality. Secondary end points were influence of preoperative risk factors and impact of sex on survival and postoperative major adverse events. Female patients showed higher 30 and 180 days mortality after combined CABG and AVR surgery (8.3% vs. 4.2%, $P < 0.01$; 15.8% vs. 9.4%, $P < 0.01$). Stratified by age groups, 30 and 180 days mortality remained significantly higher in septuagenarians (9.6% vs. 2.5%, $P < 0.01$; 16.3% vs. 7.7%, $P < 0.01$). Females were significantly older, had better preserved left ventricular function, and higher incidence of diabetes mellitus compared with male patients in this subgroup ($P < 0.01$; $P = 0.01$; $P < 0.01$). Additionally, females received significantly less internal mammary artery (IMA) conduits ($P < 0.01$). Female sex (OR: 3.33, 95% CI: [1.76–6.31]; 1.93, [1.22–3.06]), higher age (1.28, [1.13–1.45]; 1.16, [1.06–1.26]), diabetes mellitus (1.93, [1.03–3.60]; 1.70, [1.08–2.67]) and LVEF <30% (3.26, [1.48–7.17]; 2.23, [1.24–4.02]) were correlated with 30 and 180 days mortality, respectively. Upon multivariable testing, sex (1.77, [1.21–2.58]) and LVEF <30% (3.71, [2.39–5.76]) remained independent predictors for major adverse postoperative events. Infrequent use of IMA grafts was associated with increased 30 and 180 days mortality as well as adverse events (0.47, [0.25–0.87]; 0.46, [0.29–0.72]; 0.61, [0.42–0.88]).

Conclusions Sex disparities in baseline characteristics may delay operative intervention in female patients. The inherent risk profiles might be responsible for outcome differences in septuagenarians.

Keywords Aortic valve replacement; Coronary revascularization; Disparities; Male–female differences; Mortality; Outcome

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Introduction

Heart disease remains the leading cause of mortality within ESC member countries in men and women.[1] Sex discrepancies in cardiac surgery regarding morbidity and mortality have been previously described, and female sex as a predictor of increased risk is accounted for in clinical risk scores.[2–4] In recent years, an increasing number of female patients are undergoing heart surgery.[5] While clinical and technical advancements have led to overall improved outcomes in cardiac surgery, female sex as a risk factor for short-term mortality and postoperative adverse clinical events is still discussed.[2,6,7] Several studies focused on outcome differences after CABG.[3,8,9]

However, there is a scarcity of data concerning the impact of sex on postoperative outcome after combined AVR and

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CABG surgery, which carries an increased risk of morbidity and mortality when compared with isolated CABG or AVR per se.[10,11] The purpose of this study was to compare male–female differences regarding risk factors and short-term outcomes, stratified by age for concomitant CABG and aortic valve replacement surgery.

Materials and methods

Between January 2001 and June 2021, a total of 1963 patients underwent simultaneous CABG and AVR at our institution and were included in the analysis. Patients having other concurrent valve surgery and patients undergoing isolated CABG or aortic valve surgery were excluded from this study (*Figure S1*). This study was performed in accordance with the ethical standards of the Declaration of Helsinki. Approval was granted by the institutional review board (IRB) of Heidelberg University (ethics approval number: S-247/2020). We obtained written informed consent from patients for their inclusion in the registry and the clinical and scientific use of their data. No additional consent was required since data analysis was restricted to routine clinical follow-up. Clinical data from pre-operative workups, operative notes, intensive care notes, and follow-up assessments from our prospectively maintained clinical database were analysed.

Groups were stratified by age as 59 years and younger (group 1, $n = 127$), 60–69 years (group 2, $n = 471$), 70–79 years (group 3, $n = 1070$), and 80 years or older (group 4, $n = 295$). No patient was lost to follow-up within the included cohort. Male–female differences due to biological sex rather than gender (social role and identity) were explored.

The primary end points of this study were survival at 30- and 180 days after operation. The secondary end points were influence of pre- and perioperative characteristics and impact of sex on survival as well as adverse clinical events. Major adverse events (MACE) such as need for mechanical circulatory support by ECMO or IABP, perioperative myocardial infarction or stroke, the need for postoperative reintubation or tracheostomy, sepsis, and postoperative need for resuscitation were included in the model.

Percentages are reported for categorical variables. Continuous measures are summarized with median and interquartile ranges (IQR) or mean with SD. The Pearson χ^2 was used when appropriate, to test for differences in categorical variables. One-way ANOVA was used to assess differences in continuous variables. Kaplan–Meier analysis of survival with log-rank testing for statistical significance was used for survival estimates. To assess the role of gender for early outcome, logistic regression analysis was used to explore variables associated with survival as well as adverse clinical events as the dependent variable. Known risk factors associated with mortality and adverse clinical events as well as periprocedural differences between genders were included in the analysis. All variables with $P < 0.2$ were then included in a multivariable regression model and eliminated in a backwards stepwise method if $P < 0.1$. Results were described as odds ratio (OR) with a 95% confidence interval (CI).

Statistical analysis was performed using SPSS version 28.0 (IBM Statistics, Armonk, NY, USA) and GraphPad Prism version 9.0 (GraphPad Software, San Diego, CA, USA).

Results

Patients' characteristics and risk factors

Patients' pre-operative characteristics are shown in *Table 1*. The cohort predominantly comprised male patients (73.9%). Across the age brackets, the proportion of female patients undergoing combined coronary revascularization and aortic valve surgery increased steadily from group one through 4 (11.8%, 17%, 30.2%, 31.9%).

Except in the eldest age group, female patients were older than their male counterparts. In septuagenarians, the difference was statistically significant with a mean age of 75.2 ± 2.7 versus 74.5 ± 2.8 years for female versus male patients ($P < 0.01$).

Female patients presented with higher average BMI in all groups except in the youngest age group. This difference was significant in sexagenarians (29.2 ± 6.0 kg/m^2 vs. 27.9 ± 4.5 kg/m^2; $P = 0.02$) as well as septuagenarians (28.1 ± 5.2 kg/m^2 and 27.3 ± 4.4 kg/m^2; $P = 0.01$).

Consequently, the proportion of obese patients (BMI $\geq$ 30 kg/m^2) in these two groups was also significantly higher in female patients. While 42.5% and 34.5% of females, only 29.9% and 25.6% of males showed obesity in groups 2 and 3 ($P = 0.03$ and $P < 0.01$), respectively.

Significantly more female patients among sexagenarians and septuagenarians suffered from diabetes mellitus (55% vs. 39.1%; $P = 0.01$ and 44.9% vs. 34.9%; $P < 0.01$). Additionally, the proportion of female diabetics was higher than that of male patients with diabetes in all other age groups.

Conversely, in all age groups, a significantly larger proportion of male patients were active or former smokers. Almost one-third of 70- to 79-year-old men reported smoking history, as opposed to 14.9% of women ($P < 0.01$).

Except in the youngest group, the prevalence of coronary three-vessel disease at admission was higher in male, compared with female patients. This difference was statistically significant in septuagenarians, with 58.9% of men with coronary three-vessel disease compared with 42.4% of women ($P < 0.01$).

Left main stenosis affected predominantly male patients, with the difference reaching statistical significance in the

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Table 1 Preoperative characteristics

	<59 years			60–69 years			70–79 years			>80 years		
	Female (n = 15)	Male (n = 112)	P	Female (n = 80)	Male (n = 391)	P	Female (n = 323)	Male (n = 747)	P	Female (n = 94)	Male (n = 201)	P
Age (years; mean ± SD)	54.8 ± 4.5	54.0 ± 5.1	0.56	65.8 ± 2.5	65.6 ± 2.7	0.65	75.2 ± 2.7	74.5 ± 2.8	**<0.01**	82.1 ± 2.2	82.3 ± 2.2	0.44
BMI (kg/m^2; mean ± SD)	26.5 ± 6.3	27.4 ± 4.8	0.52	29.2 ± 6.0	27.9 ± 4.5	**0.02**	28.1 ± 5.2	27.3 ± 4.4	**0.01**	26.3 ± 4.1	26.2 ± 3.7	0.76
Body surface area (m^2; mean ± SD)	1.8 ± 1.8	2.0 ± 0.2	**<0.01**	1.8 ± 0.2	2.0 ± 0.2	**<0.01**	1.8 ± 0.2	2.0 ± 0.2	**<0.01**	1.7 ± 0.1	1.9 ± 0.2	**<0.01**
Diabetes mellitus (n; %)	4; 26.7%	26; 23.4%	0.78	44; 55.0%	152; 39.1%	**0.01**	145; 44.9%	261; 34.9%	**<0.01**	36; 38.3%	71; 35.5%	0.64
Arterial hypertension (n; %)	11; 73.3%	88; 79.3%	0.60	75; 93.8%	353; 90.5%	0.36	298; 92.3%	693, 93.8%	0.77	86; 91.5%	183; 91.5%	1.00
Hyperlipidaemia (n; %)	11; 73.3%	80; 72.1%	0.92	56; 70.0%	271; 69.5%	0.93	232; 71.8%	556; 74.4%	0.38	68; 72.3%	147; 73.9%	0.78
History of smoking (n; %)	6; 40.0%	77; 70.6%	**0.02**	26; 34.2%	216; 56.5%	**<0.01**	71; 22.5%	301; 41.6%	**<0.01**	22.2%	68; 34.7%	**<0.01**
History of smoking			**0.05**			**<0.01**			**<0.01**			**<0.01**
<8 weeks preoperatively (n; %)	3; 20.0%	50: 45.9%		8; 10.5%	77; 20.2%		24; 7.6%	73; 10.1%		0; 0.0%	7; 3.6%	
Ceased smoking (n; %)	3; 20.0%	27; 24.8%		18; 23.7%	139; 36.4%		47; 14.9%	228; 31.5%		2; 2.2%	61; 31.1%	
Adipositas (n; %)	2; 13.3%	28; 25.2%	0.31	34; 42.5%	117; 29.9%	**0.03**	111; 34.5%	191; 25.6%	**<0.01**	20; 21.3%	30; 14.9%	0.18
Eursoscore logarithmic (mean ± SD)	8.9 ± 6.3	6.7 ± 5.9	0.18	16.8 ± 15.8	13.6 ± 13.1	**0.05**	25.3 ± 16.8	19.6 ± 14.9	**<0.01**	32.6 ± 20.1	29.8 ± 19.4	0.26
Creatinine preoperatively (mg/dL; mean ± SD)	0.8 ± 0.2	1.2 ± 1.2	0.23	1.1 ± 0.8	1.2 ± 1.0	0.35	1.0 ± 0.7	1.1 ± 0.7	**0.02**	1.0 ± 0.4	1.2 ± 0.4	**<0.01**
Kidney function			**0.03**			0.71			0.25			0.42
Normal (n; %)	10; 66.7%	95; 84.8%		65; 81.3%	317; 81.1%		245; 75.9%	586; 78.4%		66; 70.2%	147; 73.1%	
Compensated chronic kidney injury (n; %)	5; 33.3%	11; 9.8%		11; 13.8%	55; 14.1%		69; 21.4%	146; 19.5%		27; 28.7%	53; 26.4%	
Requiring dialysis (n; %)	0; 0.0%	6; 5.4%		3; 3.8%	15; 3.8%		7; 2.2%	8; 1.1%		1; 1.1%	0; 0.0%	
S/P kidney transplantation (n; %)	0; 0.0%	0; 0.0%		0; 0.0%	3; 0.8%		0; 0.0%	5; 0.7%		0; 0.0%	0; 0.0%	
Acute kidney injury (n; %)	0; 0.0%	0; 0.0%		1; 1.3%	1; 0.3%		2; 0.6%	2; 0.3%		0; 0.0%	1; 0.5%	
Unstable AP (n; %)	3; 20.0%	18; 16.2%	0.71	13; 16.3%	49; 12.7%	0.39	36; 11.2%	96; 12.9%	0.44	21; 22.3%	36; 18.1%	0.39
NYHA > 2 (n; %)	10; 66.7%	70; 62.5%	0.75	61; 76.3%	282; 72.3%	0.47	245; 75.9%	540; 72.3%	0.23	82; 87.2%	162; 80.6%	0.16
NYHA (n; %)			0.88			0.63			0.19			0.29
I	1; 6.7%	4; 3.6%		2; 2.5%	9; 2.3%		1; 0.3%	15; 2.0%		0; 0.0%	2; 1.0%	
II	4; 26.7%	38; 33.9%		17; 21.3%	99; 25.4%		77; 23.8%	192; 25.7%		12; 12.8%	37; 18.4%	
III	7; 46.7%	53; 47.3%		51; 63.7%	214; 54.9%		186; 57.6%	428; 57.3%		57.4%	119; 59.2%	
IV	3; 20.0%	15; 13.4%		9; 11.3%	57; 14.6%		54; 16.7%	102; 13.7%		26; 27.7%	37; 18.4%	
V	0; 0.0%	2; 1.8%		1; 1.3%	11; 2.8%		5; 1.5%	10; 1.3%		2; 2.1%	6; 3.0%	
Main stem artery stenosis (n; %)	3; 20.0%	20; 18.0%	0.85	15; 18.8%	99; 25.8%	0.18	72; 22.4%	225; 30.4%	**0.01**	27; 29.3%	80; 40.4%	0.07
LVEF (n; %)			**0.03**			0.05			**0.01**			0.21
>50%	13; 86.7%	55; 49.1%		55; 68.8%	52.2%		213; 65.9%	419; 56.2%		59; 62.8%	105; 52.2%	
31–50%	0; 0.0%	41; 36.6%		18; 22.5%	121; 31.1%		83; 25.7%	225; 30.2%		25; 26.6%	59; 29.4%	
21–30%	2; 13.3%	15; 13.4%		7; 8.8%	61; 15.7%		27; 8.4%	100; 13.4%		10; 10.6%	34; 16.9%	
<20%	0; 0.0%	1; 0.9%		0; 0.0%	4; 1.0%		0; 0.0%	2; 0.3%		0; 0.0%	3; 1.5%	
Severely reduced LVEF (n; %)	2; 13.3%	16; 14.3%	0.92	7; 8.8%	65; 16.7%	0.07	27; 8.4%	102; 13.7%	**0.01**	10; 10.6%	37; 18.4%	0.09
History of heart operation (n; %)	2; 13.3%	3; 2.7%	**0.05**	1; 1.3%	16; 4.1%	0.21	5; 1.5%	26; 3.5%	0.08	3; 3.2%	3; 1.5%	0.34
S/P cardiac infarction (n; %)	2; 13.3%	33; 29.5%	0.19	20; 25.0%	109; 27.9%	0.60	84; 26.0%	200; 26.8%	0.79	28; 29.8%	74; 36.8%	0.24
Atrial fibrillation (n; %)	2; 13.3%	14; 12.5%	0.93	12; 15.0%	69; 17.6%	0.57	67; 20.7%	163; 21.8%	0.69	24; 25.5%	61; 30.3%	0.40
S/P coronary intervention (n; %)	4; 26.7%	21; 18.8%	0.47	17; 21.3%	92; 23.5%	0.66	48; 14.9%	191; 25.6%	**<0.01**	15; 16.1%	38; 18.9%	0.57
Pulmonary hypertension (n; %)	4; 26.7%	29; 25.9%	0.95	26; 32.5%	120; 30.7%	0.75	133; 41.2%	263; 35.2%	0.06	27; 28.7%	73; 36.3%	0.20
PAD (n; %)	1; 6.7%	12; 10.7%	0.63	9; 11.3%	60; 15.1%	0.37	46; 14.2%	116; 15.5%	0.58	11; 11.8%	34; 16.9%	0.26
S/P apoplex (n; %)	1; 6.7%	4; 3.6%	0.56	7; 8.8%	50; 12.8%	0.31	40; 12.4%	92; 12.4%	0.99	14; 14.9%	19; 9.5%	0.17
COPD (n; %)	3; 20.0%	26; 23.2%	0.78	16; 20.0%	105; 26.9%	0.20	68; 21.1%	212; 28.4%	**0.01**	22; 23.4%	42; 20.9%	0.63
Psychiatric disorder (n; %)	1; 6.7%	5; 4.5%	0.71	3; 3.8%	10; 2.6%	0.55	19; 5.9%	19; 2.6%	**0.01**	0; 0.0%	6; 3.0%	0.09
Aortic valve stenosis (n; %)	13; 86.7%	96; 85.7%	0.92	74; 92.5%	355; 90.8%	0.63	312; 96.6%	705; 94.4%	0.13	92; 97.9%	197; 98.0%	0.94
Aortic valve regurgitation (n; %)	7; 46.7%	71; 63.4%	0.21	36; 45.0%	191; 48.8%	0.53	128; 39.6%	312; 41.8%	0.51	33; 35.1%	78; 38.8%	0.54
Comb. aortic valve vitium (n; %)	5; 33.3%	55; 49.1%	0.25	31; 38.8%	156; 39.9%	0.85	118; 36.5%	271; 36.3%	0.94	31; 33.0%	74; 36.8%	0.52

BMI, body mass index; COPD, chronic obstructive pulmonary disease; LVEF, left ventricular ejection fraction; NYHA, New York heart association; PAD, peripheral artery disease; SD, standard deviation.
Statistically significant P-values are in bold.

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70- to 79-year-old (group 3: 22.4% of women vs. 30.4% of men; $P = 0.01$).

Across all age groups, predominantly men had suffered from previous myocardial infarction prior to surgery. Accordingly, significantly more septuagenarian men presented with a history of coronary intervention (25.6% vs. 14.9%, $P < 0.01$).

Left ventricular ejection fraction (LVEF) was recorded as a preoperative parameter for cardiac function. Male patients presented with a LVEF less than 30% more frequently, with the difference reaching statistical significance in septuagenarians (13.7% vs. 8.4%; $P = 0.01$). Chronic obstructive pulmonary disease (COPD) was more prevalent among males, reaching statistical significance in septuagenarians (28.4% of men vs. 21.1% of women, $P = 0.02$).

Other cardiovascular risk factors, such as arterial hypertension and hyperlipidaemia were distributed equally between female and male patients across the study groups as presented in *Table 1*. An overview of the preoperative differences for the entire cohort can be found in Table S1.

Operative characteristics

Operative parameters are summarized in *Table 2*. Across all age groups, the mean amount of intraoperative blood transfusion was significantly higher in female patients (*P*-values: 0.02; <0.01; <0.01, 0.02).

Bypass time was significantly shorter in septuagenarian women with 134.1 ± 44.5 min versus 139.8 ± 41.2 min ($P = 0.04$).

While the use of internal mammary artery (IMA) as a bypass graft was generally more frequent in men than in women, this difference was only significant in septuagenarians, where 71.5% of men versus 59.1% of women ($P < 0.01$) underwent IMA revascularization. No significant sex-related difference was seen comparing patients who received only arterial grafts.

Furthermore, the number of vascular grafts, as well as the number of peripheral and central anastomoses were examined. Likewise in septuagenarians, female patients received, on average fewer grafts with fewer anastomoses as presented in *Table 2* ($P < 0.01$, $P = 0.04$, and $P < 0.01$).

Significantly larger valve implants were used in males than females in all age groups ($P < 0.01$). The differences for the entire cohort are summarized in Table S2.

Postoperative course

Mean follow-up time of the patients' collective was 204.15 ± 286.83 days (median: 196 days). In addition to the primary event, postoperative adverse clinical events are presented in *Table 3*. Except for the youngest age group, perioperative myocardial infarction occurred more often in women, albeit not reaching statistical significance.

Circulatory arrest with the need for cardiopulmonary resuscitation during the postoperative course was needed in 3.4% of the entire cohort. This was more common among women than men in all age groups- except in sexagenarians. The difference was most distinctive in septuagenarians, where over thrice as many women underwent CPR (7.1% vs. 2.1%; $P < 0.01$).

In consequence, mechanical circulatory support (ECLS/ECMO) was necessary in septuagenarian women more than men ($P < 0.01$).

The incidence of ventricular arrhythmias postoperatively as well as atrioventricular block (AV block) did not show statistically significant differences as detailed in *Table 3*.

Overall, endocarditis occurred rarely early after surgery, and no sex-specific predominance was observed. More male patients suffered from deep sternal wound infections (DSWI) in all age groups except in group 4, because octogenarian women were more affected from DSWI (2.1% vs. 0%; $P = 0.04$). Postoperative course differences for the entire cohort can be found in Table S3.

30 day mortality and 180 day mortality

Overall, female patients showed significantly higher 30 and 180 days mortality after combined CABG and AVR surgery for the entire cohort (8.3% vs. 4.2%, $P < 0.01$; and 15.8% vs. 9.4%, $P < 0.01$). Stratified by age groups, 30 day mortality in women remained higher than men, except for sexagenarians. However, this difference was statistically significant only in septuagenarians, where 30 day mortality for women was almost 4 times that of their male counterparts (9.6% vs. 2.5%; $P < 0.01$). Similarly, in all age groups, except for sexagenarians, the 180 day mortality of females was numerically higher than that of male patients. Consistently, statistical significance was only observed in septuagenarians (16.3% vs. 7.7%, $P < 0.01$).

Survival time analysis by Kaplan–Meier estimates is shown in *Figure 1*.

The cumulative survival at 30 days in females was 88.9% (standard error 1.9%), and in males 97.1% (standard error 0.7%). At 180 days, statistical survival for women was 83.7% (standard error 2.2%), whereas for men it was 92.3% (standard error 1.1%). The difference in cumulative statistical survival comparing the genders was significant by log-rank test with $P < 0.01$. The survival estimates of the entire cohort are provided in Figure S2.

To elucidate potential factors influencing survival, stepwise analysis of known risk factors through binomial logistic regression was carried out for septuagenarians.

Factors associated with mortality in univariable model are summarized in *Table 4*.

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Table 2 Intraoperative characteristics

	<59 years			60–69 years			70–79 years			>80 years		
	Female (n = 15)	Male (n = 112)	P	Female (n = 80)	Male (n = 391)	P	Female (n = 323)	Male (n = 747)	P	Female (n = 94)	Male (n = 201)	P
Urgency (n; %)			0.82			0.69			0.61			0.14
Elective	6; 40.0%	51; 45.5%		31; 38.8%	147; 37.6%		106; 32.8%	272; 36.4%		18; 19.1%	65; 32.3%	
Urgent	8; 53.3%	57; 50.9%		42; 52.5%	215; 55.0%		192; 59.4%	427; 57.2%		66; 70.2%	117; 58.2%	
Emergency	1; 6.7%	3; 2.7%		7; 8.8%	25; 6.4%		24; 7.4%	47; 6.3%		8; 8.5%	15; 7.5%	
Ultima ratio/ reanimation	0; 0.0%	1; 0.9%		0; 0.0%	4; 1.0%		1; 0.3%	1; 0.1%		2; 2.1%	4; 2.0%	
Duration of intubation (h; mean ± SD)	21.9 ± 31.6	41.6 ± 129.1	0.56	32.2 ± 46.8	42.9 ± 110.9	0.40	59.6 ± 126.0	43.0 ± 135.1	0.06	92.3 ± 332.7	59.6 ± 163.7	0.26
Blood transfusion intraoperatively (mL; mean ± SD)	1111.5 ± 921.5	583.2 ± 750.4	**0.02**	1171.2 ± 806.3	832.3 ± 935.3	<**0.01**	1298.6 ± 998.9	900.7 ± 911.2	<**0.01**	1368.3 ± 925.7	1095.4 ± 866.7	**0.02**
Time on bypass (min; mean ± SD)	164.1 ± 84.7	149.7 ± 54.3	0.37	141.0 ± 42.4	143.0 ± 49.2	0.75	134.1 ± 44.5	139.8 ± 41.2	**0.04**	135.8 ± 48.4	133.0 ± 43.6	0.62
Cross-clamping time (min; mean ± SD)	101.1 ± 33.1	95.3 ± 28.2	0.47	91.2 ± 23.4	91.3 ± 26.2	0.96	85.3 ± 23.5	89.6 ± 22.7	<**0.01**	84.1 ± 23.4	86.7 ± 25.8	0.40
IMA as graft (n; %)	8; 53.3%	79; 70.5%	0.18	52; 65.0%	277; 70.8%	0.30	191; 59.1%	534; 71.5%	<**0.01**	50; 53.2%	124; 61.7%	0.17
Only arterial grafts (n; %)	4; 26.7%	31; 27.7%	0.93	20; 25.0%	103; 26.3%	0.80	91; 28.2%	169; 22.6%	**0.05**	26; 27.7%	39; 19.4%	0.11
Number of grafts (mean ± SD)	1.6 ± 0.8	1.7 ± 0.6	0.70	1.6 ± 0.6	1.6 ± 0.6	0.96	1.5 ± 0.6	1.7 ± 0.6	<**0.01**	1.5 ± 0.6	1.6 ± 0.6	0.13
Number of central anastomoses (mean ± SD)	0.9 ± 0.7	0.9 ± 0.6	0.98	0.9 ± 0.6	0.9 ± 0.6	0.92	0.8 ± 0.6	0.9 ± 0.6	**0.04**	0.9 ± 0.7	1.0 ± 0.6	0.67
Number of peripheral anastomoses (mean ± SD)	1.9 ± 1.2	1.9 ± 0.8	0.84	1.9 ± 1.0	1.9 ± 1.0	0.73	1.7 ± 0.9	1.9 ± 0.9	<**0.01**	1.7 ± 0.9	1.9 ± 0.8	0.12
Diameter of prothesis (mm; mean ± SD)	21.8 ± 1.7	24.0 ± 1.9	<**0.01**	21.8 ± 1.5	23.9 ± 1.7	<**0.01**	21.6 ± 1.4	23.8 ± 1.6	<**0.01**	21.4 ± 1.3	23.7 ± 1.6	<**0.01**

IMA, internal mammary artery; SD, standard deviation.
Statistically significant P-values are in bold.

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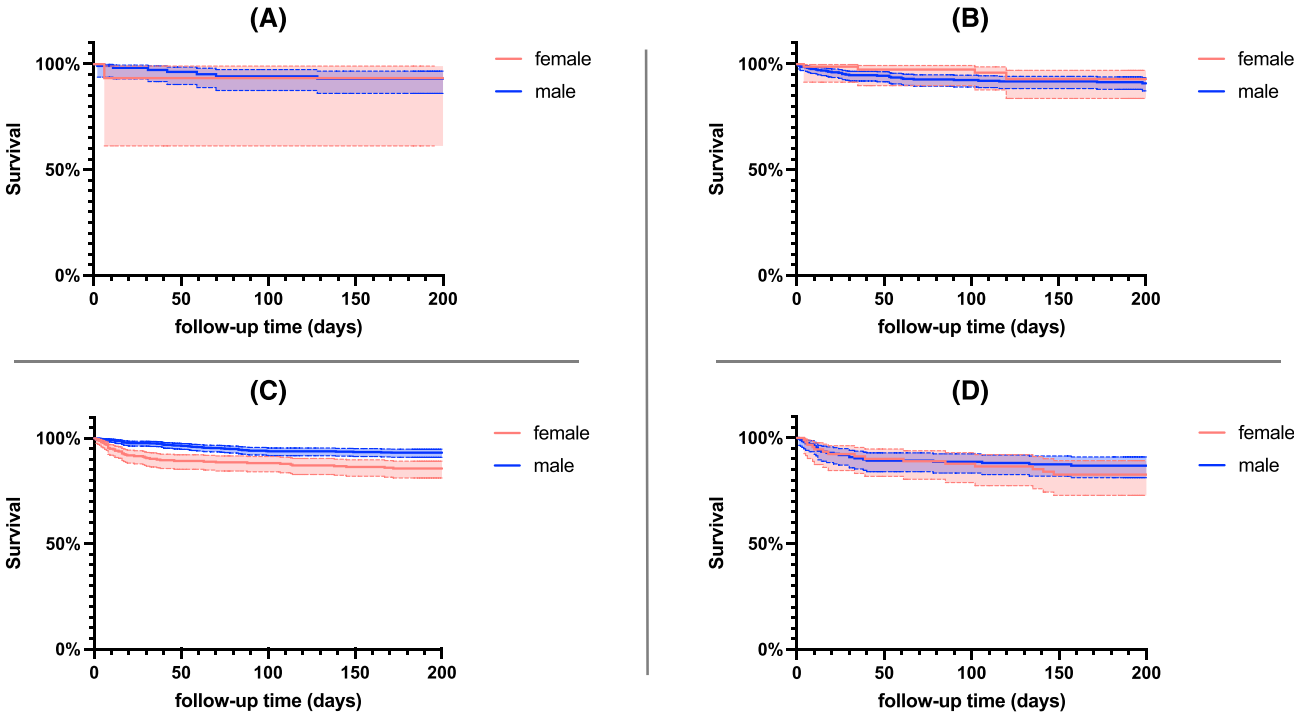
Table 3 Postoperative course

	<59 years			60–69 years			70–79 years			>80 years		
	Female (*n* = 15)	Male (*n* = 112)	*P*	Female (*n* = 80)	Male (*n* = 391)	*P*	Female (*n* = 323)	Male (*n* = 747)	*P*	Female (*n* = 94)	Male (*n* = 201)	*P*
Cardiac infarction perioperatively (*n*; %)	0; 0.0%	3; 2.7%	0.52	4; 5.0%	6; 1.5%	**0.05**	9; 2.8%	9; 1.2%	0.07	2; 2.1%	3; 1.5%	0.69
ECMO postoperatively (*n*; %)	0; 0.0%	2; 1.8%	0.60	0; 0.0%	2; 0.5%	0.52	1; 0.3%	0; 0.0%	0.13	0; 0.0%	0; 0.0%	
IABP postoperatively (*n*; %)	0; 0.0%	2; 1.8%	0.60	3; 3.8%	20; 5.1%	0.61	13; 4.0%	17; 2.3%	0.11	4; 4.3%	13; 6.5%	0.45
Low-output-syndrome postoperatively (*n*; %)	1; 6.7%	6; 5.4%	0.84	5; 6.3%	41; 10.5%	0.25	34; 10.5%	54; 7.2%	0.07	10; 10.6%	22; 10.9%	0.94
Ventricular arrhythmias (*n*; %)	1; 6.7%	8; 7.1%	0.95	10; 12.5%	41; 10.5%	0.60	36; 11.1%	80; 10.7%	0.83	7; 7.4%	22; 10.9%	0.35
Postoperative AV-block (*n*; %)	0; 0.0%	3; 2.7%	0.52	1; 1.3%	11; 2.8%	0.42	17; 5.3%	50; 6.7%	0.38	5; 5.3%	12; 6.0%	0.82
Postoperative pacemaker implantation (*n*; %)	0; 0.0%	0; 0.0%		0; 0.0%	6; 1.5%	0.27	8; 2.5%	21; 2.8%	0.76	2; 2.1%	12; 6.0%	0.15
Reanimation (*n*; %)	1; 6.7%	3; 2.7%	0.41	1; 1.3%	10; 2.6%	0.48	23; 7.1%	16; 2.1%	<**0.01**	5; 5.3%	8; 4.0%	0.60
Intensive respiratory therapy (*n*; %)	6; 40.0%	53; 47.3%	0.59	37; 46.3%	217; 55.5%	0.13	182; 56.3%	403; 53.9%	0.47	44; 46.8%	120; 59.7%	**0.04**
Reintubation (*n*; %)	0; 0.0%	0; 0.0%		0; 0.0%	6; 1.5%	0.27	5; 1.5%	14; 1.9%	0.71	2; 2.1%	3; 1.5%	0.69
Tracheotomy (*n*; %)	1; 6.7%	2; 1.8%	0.24	2; 2.5%	9; 2.3%	0.92	15; 4.6%	22; 2.9%	0.16	5; 5.3%	12; 6.0%	0.82
Unstable sternum (*n*; %)	0; 0.0%	2; 1.8%	0.60	0; 0.0%	6; 1.5%	0.27	2; 0.6%	17; 2.3%	0.06	2; 2.1%	1; 0.5%	0.19
Delirium (*n*; %)	1; 6.7%	12; 10.7%	0.63	11; 13.8%	68; 17.4%	0.43	23.8%	27.3%	0.24	18; 19.1%	60; 29.9%	**0.05**
Neurologic complications (*n*; %)	0; 0.0%	0; 0.0%		0; 0.0%	1; 0.3%	0.65	1; 0.3%	0; 0.0%	0.12	0; 0.0%	0; 0.0%	
Stroke postoperatively (*n*; %)	0; 0.0%	1; 0.9%	0.71	1; 1.3%	7; 1.8%	0.73	5; 1.5%	13; 1.7%	0.82	2; 2.1%	3; 1.5%	0.69
Postoperative gastrointestinal complications (*n*; %)	1; 6.7%	3; 2.7%	0.41	3; 3.8%	20; 5.1%	0.61	23; 7.1%	40; 5.4%	0.26	9; 9.6%	9; 4.5%	0.09
Sepsis (*n*; %)	0; 0.0%	3; 2.7%	0.52	2; 2.5%	23; 5.9%	0.22	28; 8.7%	43; 5.8%	0.08	7; 7.4%	16; 8.0%	0.88
Pneumonia (*n*; %)	0; 0.0%	9; 8.0%	0.26	3; 3.8%	31; 7.9%	0.19	38; 11.8%	75; 10.0%	0.40	9; 9.6%	26; 12.9%	0.41
Endocarditis (*n*; %)	0; 0.0%	5; 4.5%	0.40	3; 3.8%	12; 3.1%	0.75	4; 1.2%	16; 2.1%	0.32	1; 1.1%	2; 1.0%	0.96
Other infections (*n*; %)	1; 6.7%	9; 8.0%	0.85	9; 11.3%	32; 8.2%	0.38	34; 10.5%	63; 8.4%	0.27	13; 13.8%	16; 8.0%	0.12
Wound infections (*n*; %)	0; 0.0%	2; 1.8%	0.60	0; 0.0%	9; 2.3%	0.17	6; 1.9%	20; 2.7%	0.42	2; 2.1%	0; 0.0%	**0.04**
Bleeding (*n*; %)	0; 0.0%	10; 8.9%	0.23	2; 2.5%	34; 8.7%	0.06	29; 9.0%	62; 8.3%	0.72	9; 9.6%	20; 10.0%	0.92
Reoperation because of tamponade (*n*; %)	1; 6.7%	2; 1.8%	0.24	3; 3.8%	8; 2.0%	0.36	13; 4.0%	26; 3.5%	0.66	4; 4.3%	2; 1.0%	0.07
Re-thoracotomy (*n*; %)	0; 0.0%	8; 7.1%	0.29	4; 5.0%	23; 5.9%	0.76	23; 7.1%	49; 6.6%	0.74	8; 8.5%	9; 4.5%	0.17
Reason for re-thoracotomy			0.77			0.32			0.37			0.38
Bleeding/hematoma (*n*; %)	0; 0.0%	6; 5.4%		3; 3.8%	19; 4.9%		19; 5.9%	27; 3.6%		7; 7.4%	8; 4.0%	
LCOS (*n*; %)	0; 0.0%	0; 0.0%		1; 1.3%	0; 0.0%		0; 0.0%	1; 0.1%		0; 0.0%	0; 0.0%	
Tamponade (*n*; %)	0; 0.0%	0; 0.0%		0; 0.0%	2; 0.5%		0; 0.0%	6; 0.8%		0; 0.0%	0; 0.0%	
Ischaemia (*n*; %)	0; 0.0%	0; 0.0%		0; 0.0%	1; 0.3%		0; 0.0%	1; 0.1%		0; 0.0%	0; 0.0%	
Wound infection/mediastinitis (*n*; %)	0; 0.0%	1; 0.9%		0; 0.0%	0; 0.0%		0; 0.0%	3; 0.4%		0; 0.0%	0; 0.0%	
Dissection (*n*; %)	0; 0.0%	0; 0.0%		0; 0.0%	0; 0.0%		0; 0.0%	0; 0.0%		0; 0.0%	0; 0.0%	
Dysfunction of prothesis (*n*; %)	0; 0.0%	0; 0.0%		0; 0.0%	0; 0.0%		0; 0.0%	0; 0.0%		0; 0.0%	0; 0.0%	
Unstable sternum (*n*; %)	0; 0.0%	1; 0.9%		0; 0.0%	1; 0.3%		3; 0.9%	8; 1.1%		1; 1.1%	1; 0.5%	
Chylothorax (*n*; %)	0; 0.0%	0; 0.0%		0; 0.0%	0; 0.0%		0; 0.0%	0; 0.0%		0; 0.0%	0; 0.0%	
Other (*n*; %)	0; 0.0%	0; 0.0%		0; 0.0%	0; 0.0%		1; 0.3%	3; 0.4%		0; 0.0%	0; 0.0%	
Laparotomy (*n*; %)	1; 6.7%	1; 0.9%	0.09	0; 0.0%	6; 1.5%	0.27	51.5%	13; 1.7%	0.82	1; 1.1%	0; 0.0%	0.14
Wound revision (*n*; %)	0; 0.0%	3; 2.7%	0.52	1; 1.3%	10; 2.6%	0.48	7; 2.2%	17; 2.3%	0.91	3; 3.2%	1; 0.5%	0.06
Postoperative blood transfusion (mL; mean ± SD)	397.4 ± 165.1	629.0 ± 124.5	0.51	395.7 ± 59.0	923.0 ± 98.8	**0.02**	972.6 ± 94.2	874.6 ± 90.2	0.52	1294.6 ± 326.2	1067.5 ± 128.1	0.44
Death first 30 days (*n*; %)	1; 7.1%	2; 1.9%	0.23	1; 1.3%	21; 5.6%	0.12	30; 9.6%	18; 2.5%	<**0.01**	9; 9.8%	18; 9.3%	0.89
Death first 180 days (*n*; %)	1; 9.1%	7; 7.9%	0.89	5; 7.9%	32; 10.0%	0.61	44; 16.3%	48; 7.7%	<**0.01**	17; 21.5%	25; 15.0%	0.20
Follow-up time (days; mean ± SD)	150.3 ± 81.7	251.1 ± 407.8	0.34	195.4 ± 218.7	243.5 ± 448.1	0.35	191.3 ± 230.1	198.5 ± 226.2	0.63	159.0 ± 76.4	171.8 ± 135.0	0.39

ECMO, extracorporeal membrane oxygenation; IABP, intraaortic ballon pump; LCOS, low-cardiac-output-syndrome; SD, standard deviation.
Statistically significant *P*-values are in bold.

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Figure 1 Survival time analysis by Kaplan–Meier estimates after combined CABG and AVR surgery for male and female patients in groups stratified by age as 59 years and younger (A), 60–69 years (B), 70–79 years (C) and 80 years or older (D).



These parameters formed the basis of a multiple binary logistic regression model. Herein, female sex retained its independent influence on mortality within 30, as well as 180 days ($P < 0.01$ and $P < 0.01$). The odds ratios were 3.33 and 2.04, respectively. Older age was an independent predictor of increased 30 and 180 days mortality with an odds ratio (OR) of 1.28 ($P < 0.01$) and 1.15 ($P < 0.01$), respectively. Cardiovascular risk factors correlating with survival were diabetes mellitus with an OR of 1.90 ($P = 0.05$) for 30 and 1.63 for 180 days ($P = 0.04$), creatinine levels preoperatively with an OR of 1.26 ($P = 0.02$) for 30 and 1.48 for 180 days ($P < 0.01$) while reduced LVEF showed an OR of 2.86 ($P = 0.01$) for 30 days mortality respectively. Internal mammary artery grafting favourably influenced 30 and 180 days mortality with an odds ratio of 0.46; $P = 0.02$ and 0.50; $P < 0.01$ respectively.

Major adverse events in age group 70–79 years old

Logistic regression analysis was performed to detect the correlation with the incidence of secondary endpoints (MACE).

Univariable association with MACE is shown in *Table 5*. Upon multiple regression modelling as outlined, female sex remained independently associated with adverse clinical events with an odds ratio of 1.87; $P < 0.01$. Reduced left ventricular ejection fraction was also significantly associated with major adverse events (odds ratio: 3.37; $P < 0.01$). Furthermore, inverse correlation with adverse events with an odds ratio of 0.58 was noted for internal mammary artery grafting ($P = 0.01$).

Discussion

Male–female-disparities in outcome after cardiac surgery remains a relevant issue. Studies focusing on myocardial revascularization conclude that cardiovascular disease is understudied and underdiagnosed in women. While some reports indicate that younger women are more prone to adverse clinical events and increased mortality, others see females at an absolute risk.[2,11–14]

Similarly, although less often reported, a combination of AVR and CABG surgery in female patients is associated with higher perioperative mortality than in men.[15,16] In addition to age as an independent predictor, sex-related differences in preoperative risk profiles are associated with differences in outcome.[17]

Hence, this study investigated male–female differences in short and mid-term outcome after combined CABG and AVR surgery stratified by age groups.

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Table 4 Potential risk factor for 30 and 180 days mortality

Potential risk factor 30 days mortality	Binomial logistic regression			Multiple binary logistic regression		
	Odds ratio	95% confidence interval	*P*	Odds ratio	95% confidence interval	*P*
Female	**4.19**	**2.30–7.63**	**<0.01**	**3.33**	**1.76–6.31**	**<0.01**
Age	**1.26**	**1.12–1.42**	**<0.01**	**1.28**	**1.12–1.45**	**<0.01**
BMI	0.97	0.91–1.04	0.38			
Diabetes mellitus	**2.14**	**1.19–3.84**	**0.01**	**1.90**	**0.99–3.60**	**0.05**
Smoking < 8 weeks preoperatively	0.95	0.33–2.78	0.93			
Ex-smoker	1.19	0.62–2.28	0.61			
COPD	0.92	0.47–1.79	0.80			
Psychiatric disease	1.88	0.56–6.34	0.31			
Creatinine level preoperative	**1.28**	**0.96–1.72**	**0.09**	**1.26**	**0.91–1.76**	**0.02**
3 vessel CHD	**0.54**	**0.30–0.98**	**0.04**	0.57	0.29–1.10	0.10
Left main vessel disease	0.78	0.39–1.56	0.49			
LVEF <30%	**2.29**	**1.14–4.62**	**0.02**	**2.86**	**1.25–6.53**	**0.01**
S/P myocardial infarction	1.40	0.76–2.60	0.28			
S/P coronary intervention	1.18	0.60–2.30	0.63			
S/P heart surgery	1.50	0.35–6.49	0.59			
Aortic cross-clamping time	1.00	0.99–1.02	0.69			
Number of grafts	0.77	0.47–1.24	0.28			
Number of central anastomoses	1.39	0.84–2.29	0.20			
Number of peripheral anastomoses	0.97	0.70–1.35	0.87			
IMA as graft	**0.36**	**0.20–0.64**	**<0.01**	**0.46**	**0.25–0.87**	**0.02**
Only arterial grafts	0.81	0.40–1.66	0.57			

Potential risk factor 180 days mortality	Binomial logistic regression			Multiple binary logistic regression		
	Odds ratio	95% confidence interval	*P*	Odds ratio	95% confidence interval	*P*
Female	**2.32**	**1.50–3.59**	**<0.01**	**2.04**	**1.27–3.29**	**<0.01**
Age	**1.16**	**1.06–1.26**	**<0.01**	**1.15**	**1.06–1.26**	**<0.01**
BMI	0.97	0.93–1.02	0.26			
Diabetes mellitus	**1.91**	**1.24–2.96**	**<0.01**	**1.63**	**1.02–2.61**	**0.04**
Smoking < 8 weeks preoperatively	1.51	0.75–3.03	0.25			
Ex-smoker	1.07	0.65–1.77	0.78			
COPD	1.08	0.67–1.73	0.76			
Psychiatric disease	1.93	0.71–5.20	0.20			
Creatinine level preoperative	**1.54**	**1.20–1.99**	**<0.01**	**1.48**	**1.13–1.93**	**<0.01**
3 vessel CHD	0.80	0.52–1.24	0.32			
Left main vessel disease	0.95	0.58–1.55	0.82			
LVEF <30%	**2.07**	**1.19–3.59**	**0.01**	1.71	0.89–3.28	0.11
S/P myocardial infarction	**1.44**	**0.90–2.29**	**0.13**	1.15	0.69–1.91	0.60
S/P coronary intervention	0.87	0.51–1.48	0.60			
S/P heart surgery	**1.94**	**0.72–5.22**	**0.19**	1.22	0.38–3.94	0.74
Aortic cross-clamping time	1.00	0.99–1.01	0.72			
Number of grafts	0.84	0.59–1.20	0.33			
Number of central anastomoses	**1.43**	**0.98–2.09**	**0.07**	1.05	0.67–1.65	0.84
Number of peripheral anastomoses	1.00	0.79–1.28	0.98			
IMA as graft	**0.40**	**0.26–0.62**	**<0.01**	**0.50**	**0.31–0.83**	**<0.01**
Only arterial grafts	0.70	0.40–1.22	0.21			

BMI, body mass index; CHD, coronary heart disease; COPD, chronic obstructive pulmonary disease; IMA, internal mammary artery; LVEF, left ventricular ejection fraction.
Statistically significant *P*-values are in bold.

Several findings are noteworthy, looking at the demographics of this cohort. Patients were predominantly male (73.9%) and only with increasing decades the proportion of females inclined. This observation is ubiquitous throughout different centres.[12]

According to the 2021 ESC cardiovascular disease statistics, ischaemic heart disease is more common in male patients with higher reported incidence and prevalence per 100 000 people. However, for calcific aortic valve disease the incidence and prevalence estimates were higher in females.[1] Yet surgical treatment for combined AVR and CABG surgery followed a distribution pattern comparable to cardiac revascularization in this study. The proportion of female patients undergoing combined surgery raised notably from 17% in sexagenarians to 30.2% in septuagenarians. Additionally, across most age groups, female patients were older than their male counterparts at the time of surgery. Hence, younger women are underrepresented as seen in the shift of sex proportion in older decades.

The combination of later treatment and the significantly higher mean age at operation raises the question whether there is a referral and treatment bias between genders. This

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Table 5 Regressions for major adverse event

Potential risk factor major adverse event	Binomial logistic regression			Multiple binary logistic regression		
	Odds ratio	95% confidence interval	*P*	Odds ratio	95% confidence interval	*P*
Female	**1.72**	**1.20–2.46**	**<0.01**	**1.87**	**1.26–2.76**	**<0.01**
Age	0.98	0.92–1.04	0.43			
BMI	0.98	0.94–1.02	0.23			
Diabetes mellitus	**1.58**	**1.11–2.25**	**0.01**	1.33	0.92–1.97	0.13
Smoking < 8 weeks preoperatively	1.07	0.58–1.96	0.83			
Ex-smoker	0.95	0.63–1.44	0.82			
COPD	**1.37**	**0.94–2.01**	**0.10**	1.31	0.87–1.96	0.19
Psychiatric disease	0.96	0.37–2.50	0.94			
Creatinine level preoperative	**1.29**	**1.06–1.56**	**0.12**	1.14	0.93–1.41	0.21
3 vessel CHD	**1.29**	**0.90–1.84**	**0.16**	1.37	0.91–2.07	0.14
Left main vessel disease	0.94	0.63–1.39	0.76			
LVEF <30%	**3.57**	**2.34–5.47**	**<0.01**	**3.37**	**2.13–5.35**	**<0.01**
S/P myocardial infarction	**1.34**	**0.92–1.96**	**0.13**	0.97	0.64–1.48	0.89
S/P coronary intervention	1.19	0.79–1.78	0.41			
S/P heart surgery	0.94	0.33–2.74	0.92			
Aortic cross-clamping time	1.00	0.99–1.01	0.61			
Number of grafts	1.01	0.76–1.34	0.94			
Number of central anastomoses	**1.23**	**0.91–1.68**	**0.18**	0.88	0.54–1.45	0.63
Number of peripheral anastomoses	1.04	0.86–1.27	0.66			
IMA as graft	**0.55**	**0.39–0.79**	**<0.01**	**0.58**	**0.37–0.88**	**0.01**
Only arterial grafts	0.72	0.46–1.12	0.13	0.97	0.49–1.92	0.93

BMI, body mass index; CHD, coronary heart disease; COPD, chronic obstructive pulmonary disease; IMA, internal mammary artery; LVEF, left ventricular ejection fraction.

uneven distribution has been previously encountered in similar studies.[14,18] Female patients often report unspecific symptoms and are thus often underrecognized and underdiagnosed.[19] Additionally, the analysis of the national adult cardiac surgery audit by Dixon et al. found 58.3% of isolated AVR surgery to be performed in males.[11] Previous data from a national cohort study by Mokhles et al., revealed comparable in-hospital mortality for isolated AVR surgery, while female patients showed significantly higher mortality for combined CABG/AVR procedures.[20] The severity of cardiac disease in women might be underestimate, especially when applying the same diagnostic thresholds for male patients. Men present more often with obvious features and located lesions that are amenable to intervention.[21] This is reflected in the current data, with more left main and three vessel disease as well as reduced LVEF encountered in males.

While 30 and 180 days mortality in females were double that for men across the entire cohort, the difference was significant in septuagenarians with a mortality rate almost four times as high. Interestingly in this subgroup, females presented to surgery with more preserved LVEF compared with male patients as seen in prior studies.[21–23] In this study LVEF <30%, correlated with 30 days mortality, as well as the occurrence of major adverse events. Because more male patients presented with reduced LVEF—despite having better survival—this parameter might be misleading, especially since women outnumber men in heart failure with preserved ejection fraction (HFpEF) 2:1.[24] Future efforts should be focused on identifying thresholds and markers for disease progression in women.

Known risk factors for cardiovascular disease differed significantly in septuagenarians. While men showed more history of smoking and COPD, women presented with a higher incidence of obesity and diabetes mellitus, in accordance with other observations.[12,13,25] While ESC statistics state the median obesity prevalence in females to be 21.6% versus 23.6% in males,[1] the proportion of female patients presenting to surgical correction carried a significantly higher burden of these risk factors. In this cohort, these parameters correlated with mortality upon multivariable regression analysis, further supporting the assumption that women present at a later stage of disease.[19]

Another important insight from the operative data depicts treatment differences. The significantly reduced use of IMA as a bypass graft in septuagenarian females was previously encountered in studies focusing on revascularization surgery.[10,11] Infrequent use of the internal mammary artery was associated with a significantly increased risk of 30 and 180 days mortality and the occurrence of major adverse events.

Furthermore, current analysis indicates that females receive less central and less peripheral anastomosis. This is the result of more single LIMA to LAD-anastomosis plus surgical AVR in women, whereas males more often received additional grafts. While male patients present more often with left main, or three vessel disease, women are often affected by a diffuse form of arteriosclerotic lesions. In combination with anatomically smaller vessels, female patients may be more likely to be undergoing incomplete revascularization.[13,26,27] Nevertheless, the number of grafts, or the sole use of arterial conduits, did not correlate with

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mortality or the incidence of adverse postoperative events in this cohort.

Over the entire study population, smaller aortic protheses were implanted in female patients. To some extent, this is expected, due to innate anatomical properties. Smaller prothesis sizes are often linked to the developing of patient prothesis mismatch, which in turn correlates with unfavourable outcome and higher mortality.[16,28] Inadequate reduction of pressure gradient over the aortic valve prevents adequate remodelling of left ventricular mass postoperatively.[21] Concentrically, hypertrophied LV-geometry and increased relative wall thickness are associated with worse outcome and mortality following aortic valve replacement.[29,30] Thus, the current practice applying the same measurements for left ventricular hypertrophy and aortic valve orifice area may not be reflecting the progression of the disease in females accordingly. While perioperative myocardial infarction was only numerically higher, the need for resuscitation was significantly higher in female patients.

Especially combined with the anatomic challenges women pose at revascularization surgery, significant ischaemia of the severely hypertrophied myocardium is probable, possibly leading to the observed early morbidity in septuagenarian women.

Previous studies concerned with long-term follow-up after CABG suggest that differences in mortality and morbidity may be narrowing after the index procedure.[31] Celik and colleagues reported higher age-matched long-term survival in women after predominantly AVR.[32] Further analysis of the long-term results after concomitant CABG and AVR surgery is needed to provide more insight regarding sex related differences in this patient's population.

Strength and limitations

This study is a single centre observational study and thus succumbs to the inherent bias associated with such design. However, to our knowledge, this is one of the largest studies focusing on outcome analysis for AVR and concomitant CABG, without including other valve surgeries, stratified by age. Furthermore, the data collection was complete, allowing the testing of sex- and age-related risk factors. The inclusion of pre- and perioperative characteristics further strengthens the analysis.

Conclusions

This study suggests delayed operative intervention in female patients which increases the burden of co-morbidities, resulting in higher operative risk. Treating physicians should be sensitive of cardiovascular disease in women, before known risk factors for cardiovascular disease are pronounced.

Even after the indication for surgery is made, recommended revascularization strategies such as use of LIMA and maximum prothesis size are less likely to be applied in women compared with men. This may translate into disparities in outcome, prompting us to improve medical attention to female patients with adjusted thresholds, and therapeutic approaches to improve outcome results.

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Conflict of interest

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Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. Preoperative characteristics for the entire cohort.
Table S2. Intraoperative characteristics for the entire cohort.
Table S3. Postoperative course for the entire cohort.
Figure S1. Flowchart outlining patient inclusion.
Figure S2. Survival time analysis by Kaplan-Meyer estimates after combined CABG and AVR surgery for male and female patients.

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