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Female Surgeons in Cardiac Surgery: Does the Surgeon's Gender Affect the Outcome of Routine Coronary Artery Bypass Graft and Isolated Aortic Valve Surgery?

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Abstract

Background The increasing presence of female doctors in the field of cardiac surgery has raised questions about their surgical quality compared to their male colleagues. Despite their success, female surgeons are still underrepresented in leadership positions, and biases and concerns regarding their performance persist. This study aims to examine whether female surgeons perform worse, equally well, or better than their male counterparts in commonly performed procedures that have a significant number of female patients.

Method A retrospective cohort of patients from 2011 to 2020 who underwent isolated coronary artery bypass graft (CABG) and aortic valve surgery was studied. To compare the surgical quality of men and women, a 1:1 propensity score matching (two groups of 680 patients operated by men and women, respectively, factors: age, logarithm of EuroSCORE (ES), elective, urgent or emergent surgery, isolated aortic valve, or isolated CABG) was performed. Procedure time, bypass time, x-clamp time, hospital stay, and early mortality were compared.

Results After propensity score matching between surgeons of both sexes, patients operated by males (PoM) did not differ from patients operated by females (PoF) in mean age (PoM: 66.72 ± 9.33, PoF: 67.24 ± 9.19 years, $p = 0.346$), log. ES (PoM: 5.58 ± 7.35, PoF: 5.53 ± 7.26, $p = 0.507$), or urgency of operation (PoM: 43.09% elective, 48.97% urgent, 7.94% emergency, PoF: 40.88% elective, 55.29% urgent, 3.83% emergency, $p = 0.556$). This was also the case for male and female patients separately. Female surgeons had higher procedure time (PoM: 224.35 ± 110.54 min; PoF: 265.41 ± 53.60 min), bypass time (PoM: 107.46 ± 45.09 min, PoF: 122.42 ± 36.18 min), and x-clamp time (PoM: 61.45 ± 24.77 min; PoF: 72.76 ± 24.43 min). Hospitalization time (PoM: 15.96 ± 8.12,

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PoF: 15.98 ± 6.91 days, $p = 0{,}172$) as well as early mortality (PoM: 2.21%, PoF: 3.09%, $p = 0.328$) did not differ significantly. This was also the case for male and female patients separately.

Conclusion Our study reveals that in routine heart surgery, the gender of the surgeon does not impact the success of the operation or the early outcome of patients. Despite taking more time to perform procedures, female surgeons demonstrated comparable surgical outcomes to their male counterparts. It is possible that women's inclination for thoroughness contributes to the longer duration of procedures, while male surgeons may prioritize efficiency. Nevertheless, this difference in duration did not translate into significant differences in primary outcomes following routine cardiac surgery. These findings highlight the importance of recognizing the equal competence of female surgeons and dispelling biases regarding their surgical performance.

Introduction

Gender Medicine—The Patient's Perspective

Gender medicine deals with gender-specific differences between women and men, biological and social factors, and their influence on health. Its objective is to identify gender-specific diagnostic and therapeutic approaches. According to Rieder and Lhoff, public health research plays an important role in the development of gender medicine in Europe. With the establishment of the public health program, "Gender Working Group" in 1996, the World Health Organization focused for the first time on specific questions in medical areas.[1] The terms "sex" and "gender," which gained prominence following the publication of the report by the National Institute of Medicine in Washington, are now increasingly employed in medical discourse "sex" refers to the biological characteristics of individuals, while "gender" primarily encompasses their social environment and experiences. Medicine has historically centered around the male body as the norm, a trend that still persists today. The interest in gender medicine, however, has increased significantly in recent years. Particularly in challenging surgical procedures such as cardiac surgery female gender has been proven to adversely affect outcome.[2]

Gender Medicine—The Surgeon's Perspective

Medicine has traditionally been a male-dominated profession: women in surgery are facing the same issues as women in other professions. For decades, women have been discouraged from entering the surgical specialties. Even though the field has considerably opened up to female surgeons over the course of the last century, recent statistics still do not show a change toward equal proportions[3–5] although a growing number of young women enter medical schools and already outnumber the male students in Germany. More female than male students successfully pass their medical exams, more female than male physicians successfully pass their respective board certification exams. But thereafter the careers somehow begin to reverse.[4,6] More male than female physicians enter senior attending positions and less than 20% women climb up toward head positions.[7] In surgery, this proportion is even worse with only 10% of female doctors being the head of a department.[7] In cardiac surgery, the situation is downright sobering. Currently, only one female surgeon heads a department for congenital cardiac surgery among the 78 German cardiosurgical centers, and the gender distribution is similar in American departments and clinics.[8–11] Recent studies demonstrate that female patients operated on by all-male surgical teams are up to 15% more likely to experience postoperative complications compared to male patients.[12] However, when at least one female surgeon is present in the operating room, the outcome improves, as revealed by a Canadian study.[12] Surgical results usually reflect a combination of various factors, including preoperative patient data, joint decision-making or technical and surgical possibilities. Effective communication between doctors and patients also plays a significant role, and women tend to excel in this aspect.[12] It is, therefore, regrettable that women are not sufficiently represented in leadership positions to also use this advantage for the benefit of the patient. In our cohort study of routine cardiac surgery patients undergoing isolated aortic valve or isolated coronary artery bypass graft (CABG) procedures, we aimed to investigate gender differences in outcomes. Additionally, we sought to explore the performance and outcomes of female surgeons and determine whether they exhibit superior or inferior surgical skills.

Methods

We conducted a retrospective cohort study of patients who underwent cardiac surgery at our department between 2011 and 2020. While both, elective and emergency, procedures performed by male and female surgeons were included in this study, we have refrained from including combined interventions, as these have only rarely been performed by women at our heart center to date. We identified 5,477 eligible patients who had one of two index procedures (isolated CABG or aortic valve replacement [AVR]). The Ethics Committee waived the necessity for written informed consent because of the studies single-center, retrospective design (number of ethics vote).

After analyzing the demographic data of these 5,477 patients distinguishing between male and female patients,

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a 1:1 propensity score matching was performed to match the 680 patients operated by female surgeons (PoF) with patients operated upon by male surgeons (PoM). To perform the matching, we utilized the matchit package[13] in R (R Core Team, Vienna, Austria).[14] The matching parameters included age, body mass index, hospitalization time, EuroSCORE, logarithm of ES, as well as the type of surgery (isolated aortic valve or isolated CABG). Subsequently, we compared the procedure time, bypass time, x-clamp time, and early mortality between the matched groups.

First, the entire group was divided into male and female patients in order to look for general patient-sex-related differences (►**Table 1**)

Second, the patients were statistically assigned to the following matched pairs:(►**Table 2**)

1. All patients: female versus male surgeon (►**Table 2**).
   Thereafter, we looked at the surgeon's perspective (►**Table 3**):
2. Female surgeon: female versus male patients.
3. Male surgeon: female versus male patients.
   And the patient's perspective (►**Table 4**):
4. Female patients: female versus male surgeons.
5. Male patients: female versus male surgeons.

Finally, we compared sex concordance (female surgeon/female patient vs. male surgeon/male patient) with sex discordance (female surgeon/male patient vs. male surgeon/female patient; ►**Table 5**).

In order to examine any potential bias related to differences in experience between male and female surgeons, we conducted a series of mixed models using the lme4 package. The objective was to differentiate the effects of experience from those of gender concordance.[15] For this analysis, we selected the number of surgeries performed by each surgeon at our institution as a measure of experience. We included this metric, along with sex concordance, in the mixed models, using an operator identifier as the subject level. This analysis was carried out from both the patient's perspective and the surgeon's perspective, resulting in a total of four different mixed models.

Results

All following results are based upon the dataset of 1,360 patients after propensity score matching between 19 male and 5 female surgeons.

►**Table 1** presents the baseline characteristics of the 250 female and 1,110 male patients. Women were found to be significantly older compared to men and had higher EuroSCORE and log. EuroSCORE values. Additionally, the surgery length, bypass time, and x-clamp time were significantly lower for women. However, the risk profile slightly increased for female patients, indicating a trend toward worse risks (as determined by the Cochran–Armitage test for trends in proportions).

All Patients: Female versus Male Surgeons

Within the entire cohort, female surgeons exhibited longer procedure, bypass, and x-clamp times compared to their male counterparts. Patients who were operated on by female surgeons had a higher incidence of preoperative myocardial infarction. However, there was no significant difference in early mortality between the two groups (as shown in ►**Table 2**).

Surgeon's Perspective

Female surgeon: female versus male patients:

When looking at female surgeons only, female patients were older, hospitalization time, EuroSCORE, Log. ES was higher, they had lower procedure time, bypass time, and x-clamp time. Early mortality did not differ (►**Table 3**)

Male surgeon: female versus male patients:

Women were older than men, and procedure times, bypass times, and x-clamp times were lower than in men. Early mortality did not differ (►**Table 3**).

Table 1 Baseline characteristics

	Female patients (250)	Male patients (1,110)	*p*-Value
Age (years)	70.17 ± 8.3	66.26 ± 9.31	<0.001
BMI	29.2 ± 5.5	28.66 ± 4.43	0.434
log.ES	8.1 ± 8.08	4.98 ± 6.99	<0.001
Surgery length [min]	232.7 ± 84.74	247.62 ± 90.02	0.002
Bypass time (min)	111.57 ± 52.95	115.7 ± 38.5	0.012
x-Clamp time (min)	62.83 ± 22.63	68.07 ± 25.7	0.011
Urgency			0.031
Elective	36.8% (92)	43.15% (479)	
Urgent	55.2% (138)	51.44% (571)	
Emergency	7.6% (19)	5.14% (57)	
Ultima ratio	0.4% (1)	0.27% (3)	
In-hospital mortality	2.8% (7)	2.61% (29)	1

Abbreviations: BMI, body mass index; log. ES, logarithm of ES.

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Table 2 Female vs. male surgeons, propensity score matched data

	Female surgeon (680)	Male surgeon (680)	*p*-Value
Age (years)	67.24 ± 9.19	66.72 ± 9.33	0.346
BMI	28.71 ± 4.78	28.8 ± 4.51	0.626
log.ES	5.53 ± 7.26	5.58 ± 7.35	0.507
Surgery length (min)	265.41 ± −53.6	224.35 ± −110.54	<0.001
Bypass time (min)	122.42 ± 36.18	107.46 ± 45.09	<0.001
x-Clamp time (min)	72.76 ± 24.43	61.45 ± 24.77	<0.001
Urgency			0.556
Elective	40.88% (278)	43.09% (293)	
Urgent	55.29% (376)	48.97% (333)	
Emergency	3.53% (24)	7.65% (52)	
Ultima ratio	0.29% (2)	0.29% (2)	
In-hospital mortality	3.09% (21)	2.21% (15)	0.398

Abbreviations: BMI, body mass index; log. ES, logarithm of ES.

Table 3 Surgeon's perspective

	Female surgeons			Male surgeons		
	female patients [122]	male patients [558]	*p*-Value	female patients [128]	male patients [552]	*p*-Value
Age (years)	70.57 ± 7.48	66.51 ± 9.37	<0.001	69.79 ± 9.03	66.01 ± 9.26	<0.001
BMI	29.21 ± 5.29	28.6 ± 4.66	0.355	29.19 ± 5.72	28.71 ± 4.19	0.821
log.ES	7.61 ± 6.63	5.07 ± 7.31	<0.001	8.57 ± 9.25	4.89 ± 6.65	<0.001
Surgery length [min]	255.1 ± 40.53	267.67 ± 55.83	0.02	211.34 ± 107.58	227.36 ± 111.09	0.005
Bypass time [min]	115.17 ± 30.08	124 ± 37.22	0.021	108.14 ± 67.91	107.3 ± 37.98	0.154
x-Clamp time [min]	67.25 ± 21.33	73.96 ± 24.91	0.019	58.62 ± 23.1	62.11 ± 25.12	0.137
Urgency			0.118			0.135
Elective	34.43% (42)	42.29% (236)		39.06% (50)	44.02% (243)	
Urgent	61.48% (75)	53.94% (301)		49.22% (63)	48.91% (270)	
Emergency	3.28% (4)	3.58% (20)		11.72% (15)	6.7% (37)	
Ultima ratio	0.82% (1)	0.18% (1)		0% (0)	0.36% (2)	
In-hospital mortality	3.28% (4)	3.05% (17)	0.779	2.34% (3)	2.17% (12)	1

Abbreviations: BMI, body mass index; log. ES, logarithm of ES.

Patient's Perspective

Female patients: female versus male surgeons:

Female surgeons had higher procedure times, bypass times, and x-clamp times than male surgeons. Female surgeons operated upon more patients with preoperative myocardial infarction than male surgeons. Early mortality did not differ (►**Table 4**).

Male patients: female versus male surgeons:

Female surgeons needed more procedure time, bypass time, and x-clamp time than their male colleagues, and myocardial infarction was more often operated upon by female surgeons than male surgeons. Early mortality did not differ (►**Table 4**).

Gender-Concordance/Discordance Perspective

From this perspective, women who were operated on by women were found to be older, had higher risk factors (EuroSCORE, log. EuroSCORE), longer hospital stays, and longer procedure times (surgery length, bypass time, x-clamp time). They also had a higher incidence of preoperative myocardial infarction compared to the corresponding male surgeon/male patient pairs.

On the other hand, men who were operated on by women were younger, had lower risk profiles, longer procedure times, a lower incidence of endocarditis, and a higher incidence of preoperative myocardial infarction. There was no significant difference in early mortality observed between

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Table 4 Patient's perspective

	Female patients			Male patients		
	Female surgeon (122)	Male surgeon (128)	*p*-Value	Female surgeon (558)	Male surgeon (552)	*p*-Value
Age (years)	70.57 ± 7.48	69.79 ± 9.03	0.973	66.51 ± 9.37	66.01 ± 9.26	0.342
BMI	29.21 ± 5.29	29.19 ± 5.72	0.823	28.6 ± 4.66	28.71 ± 4.19	0.492
log.ES	7.61 ± 6.63	8.57 ± 9.25	0.93	5.07 ± 7.31	4.89 ± 6.65	0.516
In-hospital stay (d)	16.61 ± 6.34	17.48 ± 8.6	0.906	15.84 ± 7.02	15.61 ± 7.97	0.142
Surgery length (min)	255.1 ± 40.53	211.34 ± 107.58	<0.001	267.67 ± 55.83	227.36 ± 111.09	<0.001
Bypass time (min)	115.17 ± 30.08	108.14 ± 67.91	<0.001	124 ± 37.22	107.3 ± 37.98	<0.001
x-Clamp time (min)	67.25 ± 21.33	58.62 ± 23.1	<0.001	73.96 ± 24.91	62.11 ± 25.12	<0.001
Urgency			0.781			0.622
Elective	34.43% (42)	39.06% (50)		42.29% (236)	44.02% (243)	
Urgent	61.48% (75)	49.22% (63)		53.94% (301)	48.91% (270)	
Emergency	3.28% (4)	11.72% (15)		3.58% (20)	6.7% (37)	
Ultima ratio	0.82% (1)	0% (0)		0.18% (1)	0.36% (2)	
In-hospital mortality	3.28% (4)	2.34% (3)	0.717	3.05% (17)	2.17% (12)	0.47

Abbreviations: BMI, body mass index; log. ES, logarithm of ES.

Table 5 Gender-concordance/discordance perspective

	Concordance			Disconcordance		
	fS/fP (122)	mS/mP (552)	*p*-Value	fS/mP (558)	mS/fP (128)	*p*-Value
Age (years)	70.57 ± 7.48	66.01 ± 9.26	<0.001	66.51 ± 9.37	69.79 ± 9.03	<0.001
BMI	29.21 ± 5.29	28.71 ± 4.19	0.584	28.6 ± 4.66	29.19 ± 5.72	0.602
log.ES	7.61 ± 6.63	4.89 ± 6.65	<0.001	5.07 ± 7.31	8.57 ± 9.25	<0.001
Surgery length (min)	255.1 ± 40.53	227.36 ± 111.09	<0.001	267.67 ± 55.83	211.34 ± 107.58	<0.001
Bypass time (min)	115.17 ± 30.08	107.3 ± 37.98	0.005	124 ± 37.22	108.14 ± 67.91	<0.001
x-Clamp time (min)	67.25 ± 21.33	62.11 ± 25.12	0.001	73.96 ± 24.91	58.62 ± 23.1	<0.001
Urgency			0.249			0.055
Elective	34.43% (42)	44.02% (243)		39.06% (50)	42.29% (236)	
Urgent	61.48% (75)	48.91% (270)		49.22% (63)	53.94% (301)	
Emergency	3.28% (4)	6.7% (37)		11.72% (15)	3.58% (20)	
Ultima ratio	0.82% (1)	0.36% (2)		0% (0)	0.18% (1)	
In-hospital mortality	3.28% (4)	2.17% (12)	0.508	3.05% (17)	2.34% (3)	1

Abbreviations: BMI, body mass index; log. ES, logarithm of ES; fS/fP, female Surgeons/female Patients; mS/mP, male Surgeons/male Patients.

both the concordance and discordance groups (as depicted in ►**Table 5**).

Separation of Experience and Sex Concordance Effect

To separate the effect of surgeons' experience from gender concordance, we performed a series of mixed models (►**Table 6**). These models implied that there is no significant effect of concordance on the mentioned outcome variables from the patient perspective after separation and only a slight effect on surgery length, bypass- and x-clamp time from the female surgeon's perspective. Instead, we see significant effects of the surgeon experience from the male surgeon's perspective in some cases.

The results of the mixed models, as well as the direction of the respective effects are demonstrated in ►**Figs. 1** and **2**. As can be seen, comparing the effects of concordance are in most cases minimal (represented in the comparison between lines of the same color), when separated from the experience effect. One notable exception is the bypass time, especially from the perspective of the female patient (►**Fig. 2d**, pink lines).

Discussion

Our data indicate that female patients exhibit higher levels of demand compared to male patients, as evidenced by their higher EuroSCORE and log. EuroSCORE, which is consistent

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Table 6 *p*-Values of mixed models separating sex concordance and experience effects on multiple outcome variables

		Patient perspective		Surgeon perspective	
		Female	Male	Female	Male
Hospitalization time (days)	Concordance	0.830	0.289	0.275	0.028
	Experience	0.236	0.135	0.665	0.152
Intensive care (days)	Concordance	0.722	0.590	0.636	0.787
	Experience	0.463	0.085	0.066	0.178
Surgery length (minutes)	Concordance	0.160	0.119	0.019	0.166
	Experience	0.988	0.701	0.167	0.533
Bypass time (minutes)	Concordance	0.010	0.972	0.015	0.801
	Experience	0.902	0.349	<0.001	0.115
Cross-clamp time (minutes)	Concordance	0.256	0.484	0.004	0.093
	Experience	0.180	0.142	0.159	<0.001
In-hospital mortality (%)	Concordance	0.888	0.388	0.936	0.841
	Experience	0.604	0.897	0.311	0.392

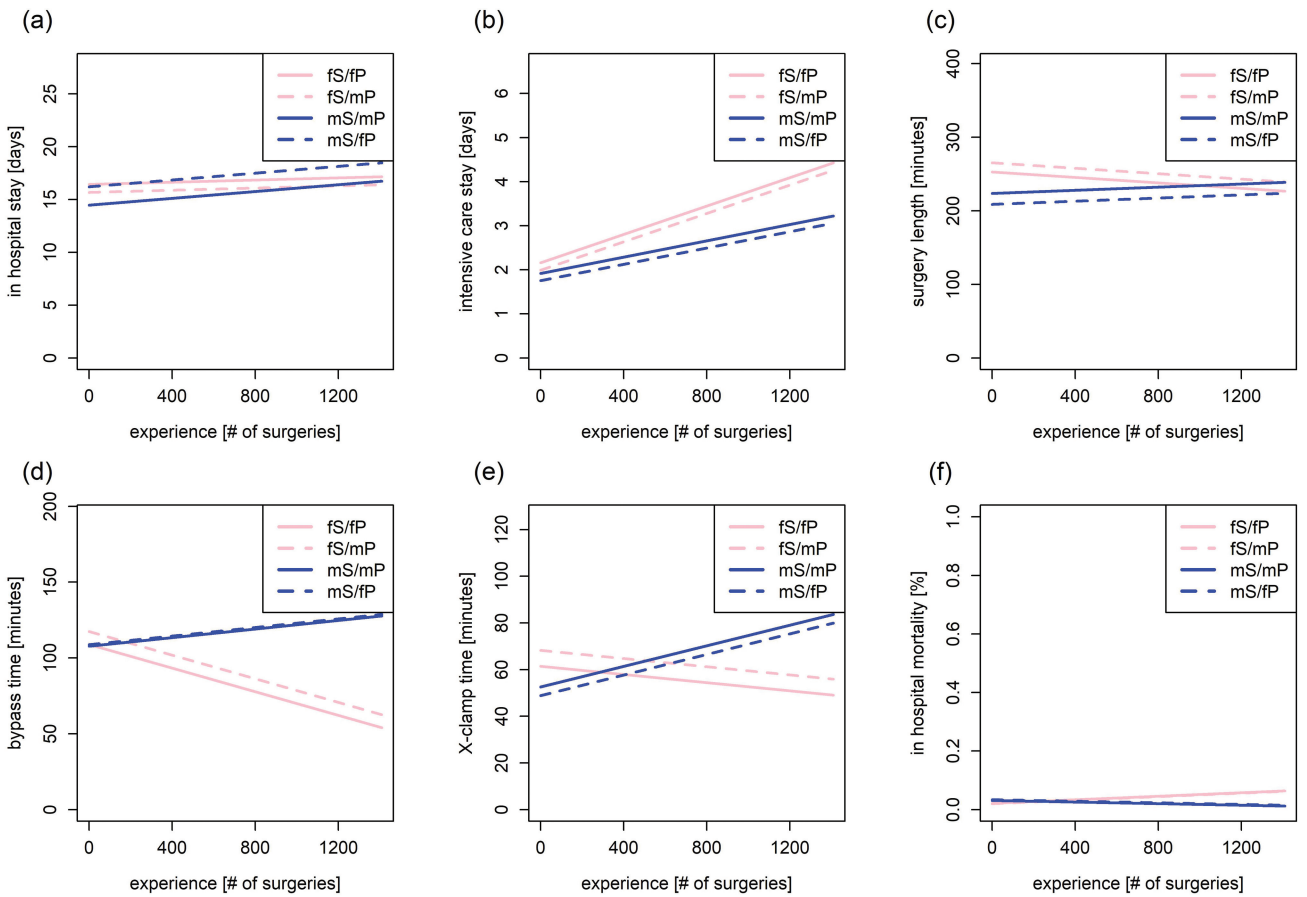

Fig. 1 Results of the mixed models from the surgeons perspective regarding the influence of experience and sex concordance on hospital stay (**a**), intensive care stay (**b**), surgery length (**c**), bypass time (**d**), X-clamp time (**e**), and in hospital mortality (**f**). Sex concordant operations are depicted as solid, disconcordant as dashed lines. Operations by female surgeons are colored pink, those of male surgeons blue.

with current evidence.[16] Fortunately, these higher risk profiles did not have a negative impact on early survival in our study. Interestingly, intervention times were actually shorter for all female patients in this study compared to male patients. One might assume that female patients would require more time-consuming procedures than male patients because of the higher morbidity and risks indicated by the risk scores. However, this was obviously not the case,

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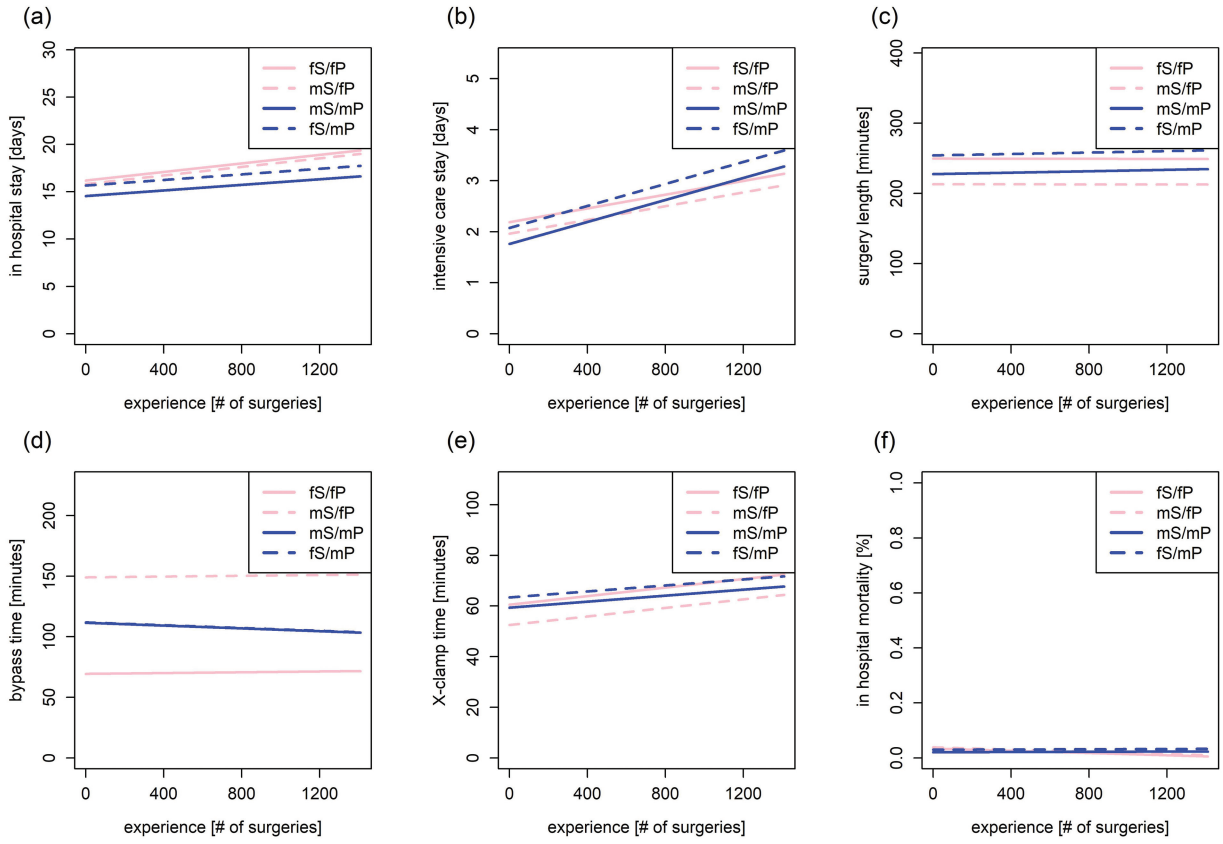

Fig. 2 Results of the mixed models from the patients perspective regarding the influence of experience and sex concordance on hospital stay (**a**), intensive care stay (**b**), surgery length (**c**), bypass time (**d**), X-clamp time (**e**), and in hospital mortality (**f**). Sex concordant operations are depicted as solid, disconcordant as dashed lines. Operations by female surgeons are colored pink, those of male surgeons blue.

as in this cohort the proportion of isolated AVR and isolated CABG was almost identical in both sexes. From the patient's perspective, it appeared that both women and men took more procedural time when operated on by female surgeons as opposed to male surgeons. From the surgeon's perspective, it was clear that both female and male surgeons needed less time for female patients than for male patients. Again, this was not associated with differences in early outcomes. When looking at gender concordance, it became evident that female surgeons overall took longer to perform surgeries compared to their male colleagues, regardless of the gender of the patient. Consequently, there were no significant gender differences in outcomes from both the surgeon's and the patient's perspectives. However, it is unclear why female surgeons tended to take more time. One possible assumption could be that women are more likely to take their time for reasons of thoroughness, while male surgeons may find more personal satisfaction in quickly performed procedures. In the end, however, no relevant differences in results could be found in relation to the gender of the surgeon. Women performed neither worse nor better than men in routine cardiac procedures such as CABG and AVR.

This was underlined by further examinations using mixed models to separate the effect of surgeon experience from gender concordance, which led to the disappearance of almost all differences caused by disconcordance. This implies that the differences presented in ►**Tables 3** to **5** are more likely caused by discrepancies in surgeon experience between both sexes than the sex of the surgeon itself. In conclusion, our data point toward a hypothesis of "equal outcomes for equal experiences".

These findings strongly support the importance of striving for equal representation of female and male surgeons in cardiac surgery programs. However, it is crucial to acknowledge the social aspect that currently exists and can cause issues in the interaction among professionals in these programs. The misconception that longer procedure times indicate inexperience and inadequate performance is prevalent, despite the data contradicting this bias. It is important to remember that cardiac surgery departments often operate under time constraints and value efficiency, which can lead to a preference for speed. Slower procedures may sometimes be met with impatience or frustration, as everyone aims to complete their work within the allocated time.

Limitations

The retrospective nature of the study is indeed a limitation. At the outset of the study, female surgeons had less experience compared to their male colleagues, creating a potential bias. Although we attempted to mitigate this by focusing on isolated CABG and aortic valve operations, the bias may still be present. Consequently, female surgeons may have undergone a steeper learning curve compared to their male colleagues. It is unfortunate that the majority of surgeons in surgical disciplines are still

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predominantly male, and this is reflected in our clinic as well.[17] There are multiple reasons for this. The gender ratio and allocation observed in our study introduce a bias. Therefore, it was crucial to create a propensity score-matched subset of our patient population to compare surgeries with similar characteristics between male and female surgeons. It should be noted that there is no specific matching process between surgeons and patients in our clinic. Although the assignment of surgeries may seem random, complex procedures are typically entrusted to experienced surgeons, even if they are relatively simple isolated procedures such as CABG or AVR. Emergency procedures are also more frequently performed by experienced surgeons.

Conclusion

One crucial implication of these findings is that, from the patient's perspective, there is no significant difference in outcomes based on the sex of the surgeon. This indicates that female surgeons, at comparable experience levels, perform equally well as their male counterparts. Consequently, it is time to move beyond outdated notions of gender differences in performance within surgical specialties. By eliminating structural imbalances in career opportunities for both sexes, we can pave the way for an increase in female role models and create a more equitable environment.

Even in countries that have achieved full equality of rights and opportunities for men and women, traditional role models still persist, which can hinder women's decision to pursue demanding medical professions.[17,18] As long as women continue to take on primary responsibilities in terms of pregnancy, early motherhood, and household duties, and as long as they perceive themselves as primarily fulfilling these roles, while men tend to prioritize career-oriented work in professional settings, meaningful change may be challenging to achieve.

Conflict of Interest
None declared.

Acknowledgment
F.S. carried out the statistical work on the manuscript as well as the very elaborate additional statistical evaluation of the revision, in which we responded to the reviewer's suggestion to statistically analyze the influence of each surgeon's degree of experience and to include it in the overall consideration. Given the relevance of this additional work, we believe that F.S. has made an equal contribution to this work.

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