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Clinical Research

Trends in Heart Valve Surgery in Korea: A Report from the Heart Valve Surgery Registry Database

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Background: In this study, we present recent trends in heart valve surgery in Korea through analyses of data from the Korea Heart Valve Surgery Registry (KHVSR).
Methods: We enrolled 8,981 patients who were registered in the KHVSR from 2017 to 2020. Yearly trends in patients' baseline characteristics, surgical profiles, and early mortality rates were explored. The observed/expected mortality ratio (O/E ratio), calculated from the actual mortality in the KHVSR and the predicted mortality estimated using the EuroSCORE II, was also analyzed.
Results: The proportion of aortic valve surgery significantly increased from 56.8% in 2017 to 60.3% in 2020. The proportion of all combined procedures and minimally invasive surgery significantly increased over the 4-year study period. The operative mortality rate was 2.9% in the entire cohort, while mitral valve repair showed the lowest mortality risk (0.9%). The mortality rates of isolated aortic valve replacement (AVR) significantly decreased from 2.1% in 2017 to 0.8% in 2020 (p=0.016). Overall, the O/E ratio was 0.784 (95% confidence interval [CI], 0.677–0.902) demonstrating significantly lower actual mortality risks than expected based on the EuroSCORE II. In particular, the O/E ratios were as low as 0.364 (95% CI, 0.208–0.591) for isolated AVR.
Conclusion: The recent data from the KHVSR showed increasing trends for complex procedures and minimally invasive surgery in heart valve surgery in Korea, and demonstrated remarkably low risks of operative mortality.

Keywords: Heart valves, Cardiac surgical procedures, Hospital mortality

Introduction

Since the first open-heart surgery using cardiopulmonary bypass (CPB) was performed in Korea in 1963, the number of major cardiac operations has steadily increased to 13,909 in 2020 [1,2]. Although there has been remarkable progress in major heart valve surgery in Korea in both quantitative and qualitative aspects, clear pictures of this progress have rarely been captured to be shared with the public, and information on the current status and early surgical results through analyses of large databases remains unavailable. To address these issues in the area of

heart valve surgery, the Korea Heart Valve Surgery Registry (KHVSR) was established in 2017 as the official database of the Korean Society of Thoracic and Cardiovascular Surgery [3]. In this study, we sought to analyze the trends in heart valve surgery using data from the KHVSR since its foundation in 2017 and to evaluate the quality of surgical outcomes through assessments of absolute and relative risks of operative mortality.

Methods

Study cohort and data collection

The KHVSR database began enrollment of patients undergoing valve surgery with or without concomitant procedures in January 2017. It contains information on the patients' preoperative characteristics, including laboratory and echocardiographic data, surgical information, as well as postoperative mortality and complications. Data were prospectively registered from each participating institution, using a dedicated electronic case form (available at http://heartvalve.or.kr). When a new institution started to register patients in the KHVSR, prior data from before participation were registered retrospectively, including data from January 2017 and thereafter. The electronic case form was divided into 4 categories: preoperative, operative, discharge, and follow-up notes. Data were available from 11 institutions that voluntarily participated in prospective data registration. All patients registered in the KHVSR signed informed consent and agreed to provide their clinical data.

From January 2017 to December 2020, a total of 9,419 patients were registered in the KHVSR. Among them, 8,981 patients were enrolled in this study, and the following were excluded: 4 patients who did not undergo valve surgery, 99 patients with incomplete preoperative notes, 141 patients with incomplete operative notes, and 194 patients with incomplete discharge notes (Fig. 1).

The surgical period was segmented into 4 groups based on the year of surgery to evaluate the trends in valve procedures (2017: 2,432 patients; 2018: 2,513 patients; 2019: 2,000 patients; and 2020: 2,036 patients). A subgroup analysis was performed for patients whose EuroSCORE II information was available (n=6,744) to compare the actual mortality in the KHVSR against the predicted mortality calculated by the EuroSCORE II. Operative mortality was defined as any death that occurred during the index hospitalization.

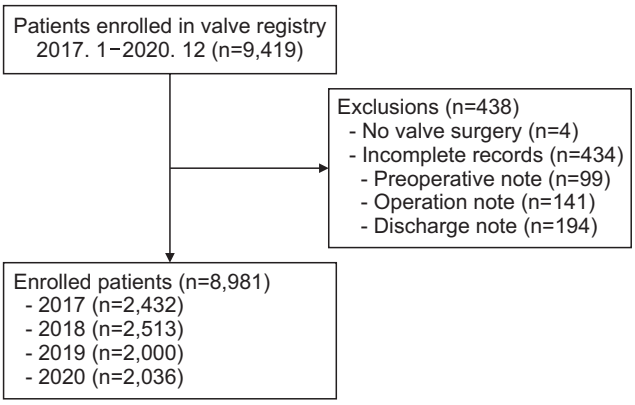

Fig. 1. Summary flow diagram of patient enrollment.

Statistical analysis

Statistical analyses were performed using IBM SPSS ver. 26.0 (IBM Corp., Armonk, NY, USA) and SAS ver. 9.4 (SAS Institute Inc., Cary, NC, USA). Data are expressed as the mean±standard deviation. The Cochran-Armitage test was used to analyze trends in valve surgery in the proportion of variables.

The observed/expected event ratio (O/E ratio) was defined as observed mortality divided by expected events. An O/E ratio >1.0 meant that the actual mortality was higher than the predicted mortality calculated by the EuroSCORE II, while an O/E ratio <1.0 meant that the actual mortality was lower than the predicted mortality calculated by the EuroSCORE II. If the 95% confidence interval (CI) of the O/E ratio excluded the value of 1.0, the result was considered statistically significant [4-6]. The 95% CI was calculated using either Byar's approximation for more than 5 observed events or the Mid-p exact test for fewer than 5 observed events. A p-value <0.05 was considered to indicate statistical significance.

Ethics statement

The study protocol was reviewed by the Institutional Review Board and approved as an exempt study (approval number: E-2110-051-1261) that did not require additional individual consent for this particular research.

Results

Preoperative characteristics

Patients' preoperative characteristics are summarized in

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Table 1. Their mean age was 63 years, and 11.5% of patients had a history of previous cardiac surgery. Approximately 4% of operations were performed in an emergency setting. The mean EuroSCORE II (n=6,744) was 3.67%±5.50%.

Trends in operative characteristics

The operative characteristics are summarized in Table 2 and Table 3. The most frequently performed valve surgery

Table 1. Preoperative characteristics of the study patients

Characteristic	Overall (n =8,981)	Year			
		2017 (n=2,432)	2018 (n=2,513)	2019 (n=2,000)	2020 (n=2,036)
Age (yr)	63.1±24.3	62.8±41.8	62.7±12.8	63.3±12.7	63.7±12.5
Male sex	4,540 (53.2)	1,274 (52.4)	1,365 (54.3)	1,060 (53.0)	1,130 (55.5)
Body mass index >25 kg/m^2	3,205 (35.7)	842 (34.7)	926 (36.9)	692 (34.6)	745 (36.7)
Body surface area (m^2)	1.67±0.20	1.67±0.20	1.68±0.20	1.67±0.20	1.67±0.22
NYHA Fc ≥3	2,175 (25.5)	732 (32.4)	513 (23.0)	497 (24.9)	433 (21.3)
Smoking (n=8,963)	2,484 (27.7)	656 (27.1)	732 (29.2)	502 (25.1)	594 (29.2)
Diabetes mellitus	1,832 (20.4)	445 (18.3)	518 (20.6)	427 (21.3)	442 (21.7)
Hypertension	4,323 (48.1)	1,096 (45.1)	1,167 (46.5)	1,001 (50.1)	1,059 (52.0)
CKD (GFR <60 mL/min)	738 (8.2)	182 (7.5)	188 (7.5)	184 (9.2)	184 (9.0)
CKD requiring hemodialysis	257 (2.9)	60 (2.5)	80 (3.2)	53 (2.7)	64 (3.1)
Atrial fibrillation	2,987 (33.3)	815 (33.5)	830 (33.0)	669 (33.5)	673 (33.1)
Pneumonia	219 (3.0)	42 (2.6)	59 (3.6)	66 (3.3)	52 (2.6)
Dyslipidemia	2,895 (32.2)	567 (23.3)	714 (28.4)	746 (37.3)	868 (42.6)
Left ventricular dysfunction (LVEF ≤30%)	231 (2.6)	62 (2.6)	59 (2.4)	55 (2.8)	55 (2.7)
History of cardiac surgery	1,030 (11.5)	247 (10.2)	189 (7.5)	295 (14.8)	299 (14.7)
Prior myocardial infarction	263 (2.9)	72 (3.0)	82 (3.3)	55 (2.8)	54 (2.7)
Emergency	342 (3.8)	112 (4.6)	86 (3.4)	80 (4.0)	64 (3.1)
Infective endocarditis	608 (6.8)	167 (6.9)	165 (6.6)	136 (6.8)	140 (6.9)
EuroSCORE II (n=6,744)	3.67±5.50	4.42±6.28	3.75±5.48	3.43±5.34	3.37±5.01

Values are presented as mean±standard deviation or number (%).
NYHA Fc, New York Hear Association Functional Classification; CKD, chronic kidney disease; GFR, glomerular filtration rate; LVEF, left ventricular ejection fraction.

Table 2. Operative characteristics of the study patients

Variable	Total (n=8,981)	Year				p-value[a]
		2017 (n=2,432)	2018 (n=2,513)	2019 (n=2,000)	2020 (n=2,036)	
Aortic valve surgery	5,220 (58.1)	1,382 (56.8)	1,435 (57.1)	1,175 (58.8)	1,228 (60.3)	0.010
Mitral valve surgery	4,291 (47.8)	1,218 (50.1)	1,166 (46.4)	982 (49.1)	925 (45.4)	0.017
Tricuspid valve surgery	2,405 (26.8)	681 (28.0)	657 (26.1)	523 (26.2)	544 (26.7)	0.338
Pulmonary valve surgery	44 (0.5)	7 (0.3)	11 (0.4)	13 (0.7)	13 (0.6)	0.054
Double-valve surgery	2,084 (23.2)	618 (25.4)	547 (21.8)	477 (23.8)	442 (21.7)	0.022
Triple-valve surgery	449 (5.0)	119 (4.9)	106 (4.2)	108 (5.4)	116 (5.7)	0.089
Combined procedure	3,330 (37.1)	726 (29.9)	734 (29.2)	910 (45.5)	960 (47.2)	<0.001
Coronary artery bypass grafting	530 (5.9)	83 (3.4)	138 (5.5)	147 (7.4)	162 (8.0)	<0.001
Cox-maze procedure	1,454 (16.2)	262 (10.8)	302 (12.0)	427 (21.3)	463 (31.8)	<0.001
Aorta surgery (replacement or wrapping)	678 (7.5)	165 (6.8)	149 (5.9)	176 (8.8)	188 (9.2)	<0.001
Others	1,252 (13.9)	360 (14.8)	263 (10.5)	318 (15.9)	311 (15.3)	0.047
Approach (n=8,853)		2,397	2,477	1,957	2,022	
Median sternotomy	6,560 (74.1)	1,908 (79.6)	1,832 (74.0)	1,434 (73.3)	1,386 (68.5)	<0.001
Minimally invasive surgery	2,283 (25.8)	488 (20.4)	645 (26.0)	520 (26.6)	630 (31.2)	<0.001
Others	10 (0.1)	1 (0.04)	0	3 (0.1)	6 (0.2)	

Values are presented as number (%) or number.
[a]By the Cochran-Armitage test for trend.

Table 3. CPB time and ACC time of valve surgery

Variable	CPB time (min)	ACC time (min)
Primary single-valve surgery without combined procedure (n=3,968)	113.7±50.7	75.8±36.6
Aortic valve replacement (n=2,445)	110.4±48.8	76.6±36.4
Mitral valve replacement (n=378)	124.9±65.9	79.5±36.0
Mitral valve repair (n=908)	119.0±46.0	77.1±33.6
Tricuspid valve replacement (n=53)	110.7±57.1	44.4±49.3
Tricuspid valve repair (n=149)	110.1±54.6	58.3±41.8
Primary double-valve surgery without combined procedure (n=830)	147.3±57.3	101.3±42.3
Primary triple-valve surgery without combined procedure (n=163)	170.7±68.1	126.2±45.0
Patients with history of cardiac surgery (n=1,030)	179.9±77.9	112.8±60.2
Second cardiac surgery (n=817)	175.7±74.3	112.7±58.4
Third or more cardiac surgery (n=212)	196.0±89.0	113.1±66.6

Values are presented as mean±standard deviation.
CPB, cardiopulmonary bypass; ACC, aortic cross-clamp.

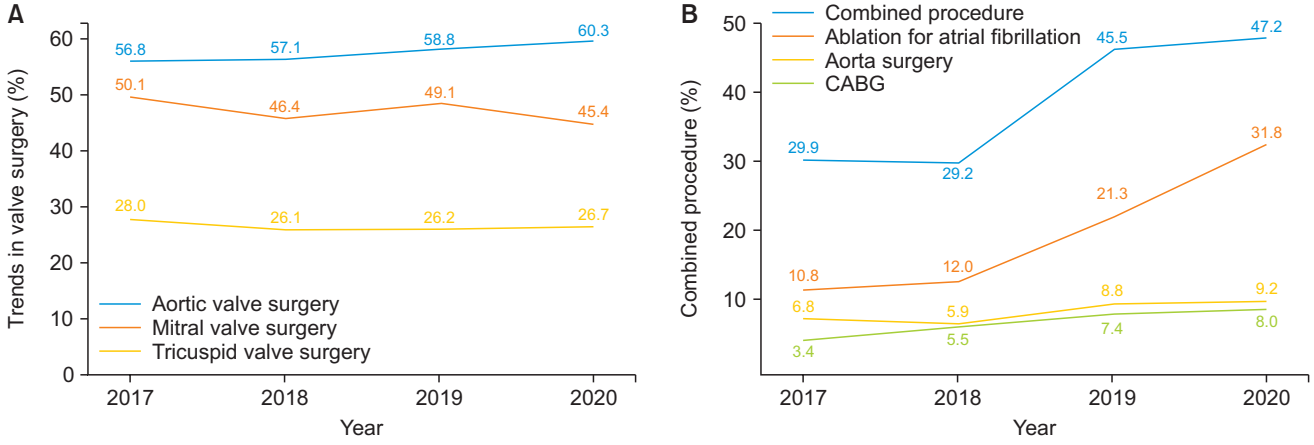

Fig. 2. Trends in (A) valve surgery and (B) combined procedures in Korea. CABG, coronary artery bypass grafting.

was aortic valve surgery, followed by mitral valve surgery, and then tricuspid valve surgery. The proportion of aortic valve surgery significantly increased from 56.8% in 2017 to 60.3% in 2020 (Fig. 2A). The proportion of mitral valve surgery and double-valve surgery showed a statistically significant tendency to decrease (p=0.017 and p=0.022, respectively). A combined procedure was performed in 37.1% of patients, and ablation for atrial fibrillation (AF) was the most commonly performed combined procedure (16.2%). The proportion of all combined procedures, including AF ablation, coronary artery bypass grafting (CABG), and aortic surgery, significantly increased over the 4 years (Table 2, Fig. 2B). Minimally invasive surgery was performed in approximately one-quarter of patients, and the proportion of minimally invasive operations significantly increased from 20.4% in 2017 to 31.2% in 2020 (p<0.001).

The CPB time and aortic cross-clamp (ACC) time of primary valve surgery without any combined procedure are summarized in Table 3. Primary single-valve surgery without a combined procedure, on average, required a CPB time of less than 2 hours and an ACC time of less than 80 minutes. For cardiac surgery reoperations, the mean required CPB and ACC times were 179.9±77.9 and 112.8±60.2 minutes, respectively.

Operative mortality of heart valve surgery

The operative mortality rate was 2.9% (259 out of 8,981 patients) in the entire patient cohort. Information on the hospital stay was available for 7,262 patients, and the median hospital stay was 9 days (interquartile range, 7–14 days). Data on the mean hospital stay are summarized in Table 4. No significant difference was found in overall operative mortality according to the year of surgery. Data on opera-

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Table 4. Hospital stay of patients who underwent valve surgery

Variable	Total (n=7,262)	Year			
		2017 (n=1,603)	2018 (n=1,640)	2019 (n=1,992)	2020 (n=2,027)
Overall (n=7,262)	14.6±26.5	13.6±14.0	14.1±26.1	15.5±32.6	14.8±27.6
Primary SV surgery without combined procedure (n=2,692)	11.5±16.1	11.1±11.4	12.1±13.9	11.6±18.1	11.2±18.4
Aortic valve replacement (n=1,712)	11.3±16.2	11.4±12.9	11.9±15.4	11.6±21.0	10.6±13.6
Mitral valve replacement (n=237)	15.8±14.9	13.6±11.0	17.8±15.7	15.2±13.3	15.7±18.5
Mitral valve repair (n=583)	9.4±8.0	9.0±6.7	9.2±6.1	9.8±9.9	9.6±8.2
Tricuspid valve replacement (n=27)	12.6±10.2	12.1±7.2	15.3±14.8	10.7±11.3	12.4±6.3
Tricuspid valve repair (n=69)	17.0±44.3	11.8±8.0	11.3±7.8	10.3±6.2	29.5±77.4
Primary DV surgery without combined procedure (n=512)	14.6±20.3	14.0±12.1	13.0±10.3	16.8±35.3	15.3±16.8
Primary triple-valve surgery without combined procedure (n=104)	18.9±32.2	15.7±12.2	16.5±29.8	28.4±58.0	16.8±9.3
Patients history of cardiac surgery (n=964)	20.7±33.5	19.6±20.1	23.3±52.5	21.0±30.6	19.9±30.6
Second cardiac surgery (n=767)	19.9±28.3	19.7±21.3	18.9±19.8	20.8±33.4	19.9±31.9
Third or more cardiac surgery (n=197)	23.9±48.7	19.5±13.9	53.0±136.0	21.4±18.5	19.9±25.6

Values are presented as mean±standard deviation.
SV, single valve; DV, double valve.

Table 5. Operative mortality of valve surgery for overall patients

Variable	Total (n=8,981)	Year				p-value[a]
		2017 (n=2,432)	2018 (n=2,513)	2019 (n=2,000)	2020 (n=2,036)	
Operative mortality (n=8,981)	259 (2.9)	71 (2.9)	66 (2.6)	63 (3.2)	59 (2.9)	0.776
Primary SV surgery without combined procedure (n=3,968)	75 (1.9)	27/1179 (2.3)	27/1272 (2.1)	8/763 (1.0)	13/754 (1.7)	0.142
Aortic valve replacement (n=2,445)	42 (1.7)	15/707 (2.1)	20/768 (2.6)	3/480 (0.6)	4/490 (0.8)	0.016
Mitral valve replacement (n=378)	17 (4.5)	8/131 (6.1)	3/135 (2.2)	1/59 (1.7)	5/53 (9.4)	0.739
Mitral valve repair (n=908)	8 (0.9)	1/259 (0.4)	2/277 (0.7)	2/192 (1.0)	3/180 (1.7)	0.150
Tricuspid valve replacement (n=53)	3 (5.7)	1/17 (5.9)	1/24 (4.2)	1/7 (14.3)	0/5 (0.0)	>0.999
Tricuspid valve repair (n=149)	5 (3.4)	2/53 (3.8)	1/58 (1.7)	1/16 (6.3)	1/22 (4.5)	0.735
Primary DV surgery without combined procedure (n=830)	28 (3.4)	9/312 (2.9)	10/301 (3.3)	4/116 (3.4)	5/101 (5.0)	0.357
Primary triple-valve surgery without combined procedure (n=163)	7 (4.3)	3/70 (4.3)	2/53 (3.8)	2/23 (8.7)	0/17 (0.0)	0.864
Patients history of cardiac surgery (n=1,030)	61 (5.9)	12/247 (4.9)	10/189 (5.3)	21/295 (7.1)	18/299 (6.0)	0.434
Second cardiac surgery (n=817)	44 (5.4)	7/199 (3.5)	6/161 (3.7)	17/227 (7.5)	14/230 (6.1)	0.110
Third or more cardiac surgery (n=212)	17 (8.0)	5/48 (10.4)	4/28 (14.3)	4/67 (6.0)	4/69 (5.8)	0.215

Values are presented as number (%).
SV, single valve; DV, double valve.
[a]By the Cochran-Armitage test for trend.

tive mortality are summarized in Table 5 and Fig. 3 according to the type of surgery. The mortality rate of primary single-valve surgery without a combined procedure was 1.9%. Mitral valve repair (MVr) showed the lowest mortality rate (0.9%). For cardiac surgery reoperations, the operative mortality rate was 5.9%, while the third or greater cardiac operation had a mortality of 8%. Over 4 years, there were no significant differences in mortality rates among various types of surgery except for aortic valve replacement (AVR) (Table 5). The mortality rate of isolated AVR significantly decreased from 2.1% in 2017 to 0.8% in 2020 (p=0.016).

Operative mortality in patients with EuroSCORE II information

Data on the EuroSCORE II was available in 6,744 patients (Table 6). In this subgroup, the observed operative

mortality rate was 2.9% (194/6,744) while the predicted mortality rate calculated from the EuroSCORE II was 3.67%±5.50%. The O/E ratio was 0.784, and the actual mortality was significantly lower than the expected mortality calculated by the EuroSCORE II (95% CI, 0.677–0.902). The actual mortality of AVR was also significantly lower than the expected mortality (O/E ratio, 0.364; 95% CI, 0.208–0.591). In tricuspid valve replacement (TVR), the actual mortality was higher than the expected mortality, but there was no statistical significance (O/E ratio, 3.333; 95% CI, 0.848–9.072).

Trends in bioprosthetic valves in the aortic position

Among the 2,697 patients who underwent AVR with a bioprosthetic valve, 527 patients (19.5%) underwent sutureless or rapid-deployment valve AVR (Table 7). Overall, in patients with a bioprosthetic valve AVR, the proportion of sutureless or rapid-deployment valves increased from 15.1% in 2017 to 25.1% in 2019 and then decreased to 19.0% in 2020, but the overall increasing trend was significant for the 4-year study period (p=0.017).

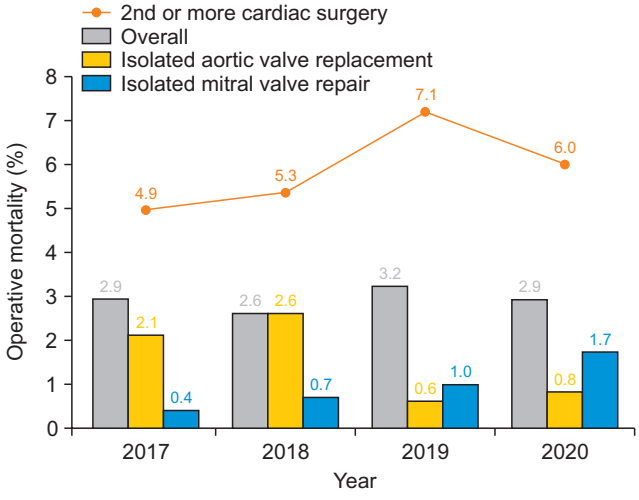

Fig. 3. Operative mortality in valve surgery in Korea.

Discussion

This study showed 3 main findings. First, increasing trends were observed in the proportion of combined procedures, minimally invasive approaches, and aortic valve surgery in heart valve surgery. Second, valvular surgery in Korea showed very satisfactory results in terms of early mortality; in particular, the operative mortality of primary AVR decreased significantly over 4 years. Third, the operative mortality rate of primary AVR was significantly lower than the expected mortality calculated by the EuroSCORE II.

In this cohort, increases in the proportions of combined procedures, minimally invasive approaches, and aortic valve surgery were identified. These trends can be related to the development of new devices in valve surgery and favorable results from transcatheter aortic valve implantation (TAVI) for intermediate- and high-risk patients [7,8]. In Korea, sutureless valves and rapid-deployment valves were introduced in December 2014 and March 2016, respectively, and the Korean National Health Insurance Service began covering them in December 2016. Since then, the use of sutureless valves and rapid-deployment valves has markedly increased, especially in elderly patients and those requiring concomitant surgery [9]. In this study population, a sutureless or rapid-deployment valve in the aortic position was used in 527 patients, and the use of a sutureless or

Table 6. Operative mortality of valve surgery for patients with EuroSCORE II information

Variable	Observed events	EuroSCORE II	Expected events	O/E ratio (95% CI)
Operative mortality (n=6,744)	194 (2.9)	3.67±5.50	247.5	0.784 (0.677–0.902)
Primary SV surgery without combined procedure (n=2,482)	36 (1.5)	2.39±3.89	59.3	0.607 (0.425–0.841)
Aortic valve replacement (n=1,573)	16 (1.1)	2.28±3.19	44.0	0.364 (0.208–0.591)
Mitral valve replacement (n=220)	8 (3.6)	3.22±4.08	7.1	1.127 (0.485–2.220)
Mitral valve repair (n=537)	5 (0.9)	1.99±4.03	10.7	0.467 (0.171–1.036)
Tricuspid valve replacement (n=27)	3 (11.1)	3.42±3.76	0.9	3.333 (0.848–9.072)
Tricuspid valve repair (n=62)	3 (4.8)	2.64±5.11	1.6	1.875 (0.477–5.103)
Primary DV surgery without combined procedure (n=421)	12 (2.9)	3.14±3.96	13.2	0.909 (0.469–1.588)
Primary triple-valve surgery without combined procedure (n=75)	2 (2.7)	4.79±7.23	3.6	0.556 (0.093–1.835)
Patients history of cardiac surgery (n=923)	59 (6.4)	7.71±7.75	71.2	0.829 (0.631–1.069)
Second cardiac surgery (n=728)	42 (5.8)	7.73±7.84	56.3	0.746 (0.538–1.008)
Third or more cardiac surgery (n=195)	17 (8.7)	7.64±7.44	14.9	1.141 (0.664–1.827)

Values are presented as number (%), mean±standard deviation, number, or O/E ratio (95% CI).
O/E ratio, observed/expected event ratio; CI, confidence interval; SV, single valve; DV, double valve.

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Table 7. Trends in bioprosthetic valves in the aortic position

Variable	Total (n=2,697)	Year				p-value[a]
		2017 (n=649)	2018 (n=743)	2019 (n=614)	2020 (n=691)	
Total (n=2,697)						0.017
Conventional bioprostheses	2,170 (80.5)	551 (84.9)	599 (80.6)	460 (74.9)	560 (81.0)	
Sutureless or rapid-deployment valve	527 (19.5)	98 (15.1)	144 (19.4)	154 (25.1)	131 (19.0)	
Combined procedure (n=1,351)						0.160
Conventional bioprostheses	1,136 (84.1)	298 (86.9)	297 (84.9)	247 (79.9)	294 (84.2)	
Sutureless or rapid-deployment valve	215 (15.9)	45 (13.1)	53 (15.1)	62 (20.1)	55 (15.8)	
Age >70 yr (n=1,594)						0.807
Conventional bioprostheses	1,229 (77.1)	280 (79.5)	295 (74.9)	284 (73.8)	370 (79.9)	
Sutureless or rapid-deployment valve	365 (22.9)	72 (20.5)	99 (25.1)	101 (26.2)	93 (20.1)	
Age >80 yr (n=333)						0.302
Conventional bioprostheses	223 (67.0)	55 (76.4)	51 (63.0)	51 (62.2)	66 (67.3)	
Sutureless or rapid-deployment valve	110 (33.0)	17 (23.6)	30 (37.0)	31 (37.8|)	32 (32.7)	

Values are presented as number (%).
[a]By the Cochran-Armitage test for trend.

rapid-deployment valve increased significantly during the 4-year study period (p=0.017) (Table 7).

Additionally, Cor-Knot automated fasteners (LSI Solutions, Victor, NY, USA) were introduced in February 2019. These new devices facilitate minimally invasive surgery and combined surgery by reducing the technical difficulties and operating time. Additionally, the less invasive characteristics of TAVI might have contributed to the overall increment in the number of patients referred to the heart valve center, by which significant proportions of them—if not the majority—might have been rerouted to surgical AVR, resulting in increasing case volumes of AVR.

In the present study, the overall operative mortality was 2.9%. This value was similar or superior to other large sample studies. For example, the operative mortality based on the Society of Thoracic Surgeons (STS) National Database 2019 annual report was 2.6% for various valve surgical procedures, including AVR, AVR+CABG, mitral valve replacement (MVR), MVR+CABG, MVr, and MVr+CABG [10]. Considering that mortality was calculated excluding cases where tricuspid valve surgery, concomitant aorta surgery, and surgical arrhythmia ablation were performed in the STS database [11], the results of the KHVSR may be viewed as excellent. In Japanese data between 2015 and 2016, the operative mortality of AVR, MVR, MVr, and TVR was reported to be 4.1%, 7.1%, 2.2%, and 10.5%, respectively; these figures seem to be higher than those from the KHVSR data, although simple comparisons between 2 countries bear a number of pitfalls attributable to differences in medical and social environments, as well as information bias [12].

Among various types of valve surgery, the mortality associated with AVR significantly decreased over 4 years. The development of TAVI and new surgical devices, such as sutureless or rapid-deployment valves and Cor-Knot, might have contributed to these results by reducing the burden of TAVI on high-risk patients and shortening the ACC times. In addition, the significantly lower operative mortality observed in AVR than the expected mortality risk according to the EuroSCORE II might also be associated with the development of new surgical devices and techniques. Considering that the EuroSCORE II was developed based on a cohort of patients who underwent cardiac surgery in 2010 [13], advances in surgical techniques and postoperative care could have also contributed to the better operative mortality demonstrated in the present paper.

The present study has several limitations. First, although the KHVSR is an official database of the Korean Society of Thoracic and Cardiovascular Surgery, this database does not include all patients who underwent heart valve surgery in Korea. According to the reports of the Korean Heart Foundation [2], the number of registered patients in the KHVSR was approximately half of the actual patients who underwent heart valve surgery in Korea. Additionally, most participating hospitals in the KHVSR were large-volume centers. These factors highlight the possibility that the operative mortality identified using the KHVSR data is lower than the overall mortality of valve surgery in Korea. In particular, this selection bias may have had a particularly strong influence on the results regarding minimally invasive cardiac surgery, which is often performed at large-volume centers. Second, although only 4 years have passed

since the KHVSR started registration, the proportion of 4.6% (434/9,419) of records with incomplete data is quite high. Incomplete data could lead to underestimations of operative mortality because problematic cases usually require a prolonged hospital stay and the records easily remain incomplete. A previous study using the KHVSR that received additional data for the missing values from each hospital showed slightly higher operative mortality rates than reported in this study in 2017 and 2018 [3].

In conclusion, although the complexity of heart valve surgery has increased due to an increase in combined procedures and minimally invasive surgery, heart valve surgery has shown excellent outcomes in terms of operative mortality in Korea. However, the KHVSR still has some weaknesses regarding the proportion of registered patients and missing values. Ongoing efforts are needed to increase the quality and quantity of the database, including making it nationally mandated.

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Conflict of interest

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