Cardiac Surgery in Germany during 2012: A Report on Behalf of the German Society for Thoracic and Cardiovascular Surgery

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Abstract

Keywords

- cardiac surgery
- outcomes
- registry
- heart valve disease
- coronary heart disease
- congenital heart disease
- aortic surgery
- heart rhythm disorders
- organ transplantation

On the basis of a voluntary registry of the German Society for Thoracic and Cardiovascular Surgery (GSTCVS), data of all cardiac surgical procedures performed in 79 German cardiac surgical units during the year 2012 are presented. In 2012, a total of 98,792 cardiac surgical procedures (ICD and pacemaker procedures excluded) were submitted to the registry. More than 13.8% of the patients were older than 80 years, which is a further increase in comparison to previous years. In-hospital mortality in 42,060 isolated coronary artery bypass grafting procedures (84.6% on-pump and 15.4% off-pump) was 2.9%. In 28,521 isolated valve procedures (including 6,804 catheter-based procedures), an in-hospital mortality of 4.8% was observed. This long-lasting registry of the GSTCVS will continue to be an important tool for quality control and voluntary public reporting by illustrating current facts and developments of cardiac surgery in Germany.

Introduction

Increasing demands for quality assurance in medicine—by patients, relatives, insurance companies, and authorities all over the world—have stimulated the development of a wide range of registries and other tools to answer those needs. As early as in 1978, the board of directors of the German Society for Thoracic and Cardiovascular Surgery (www.dgthg.de) decided to set up an annually updated database of all cardiac

surgical procedures in terms of a voluntary registry. Since 1989, the updated data of the registry are published annually.^{1–22} The aim of this registry continues to illustrate developments and trends in cardiac surgery in Germany and it enables each participating cardiac surgical unit to compare its own results with the nationwide achievements.

For monitoring actual conditions as well as the development in cardiac medicine, the registry includes particular techniques such as off-pump cardiac surgery or minimal

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invasive mitral valve operations and also innovative technologies such as transapical or transvascular aortic valve implantation (TAVI) (see ►Table V3). Thereby important findings for present patient safety and the future of patient care may be collected and evaluated.

The data presented in this report comprehend assorted data of the year 2012.

Materials and Methods

Since 2004, a standardized questionnaire gathers detailed information about each individual procedure exactly defined by a German adaption of the International Classification of Procedures in Medicine called operation code (Operationen- und Prozedurenschlüssel).

All participants were requested to complete the structured questionnaire until January 21, 2013, asking for all performed procedures and associated in-hospital mortality. The completed questionnaire had to be sent to the office of the GSTCVS, where they were evaluated for completeness and compiled for further analysis, thus ensuring anonymity for each individual institution. This compilation algorithm guarantees a high compliance for submission of complete datasets.

Inclusion criteria for the registry 2012 were all patients receiving cardiac surgical procedures performed between January 1, 2012, and December 31, 2012, unrelated to the dates of admission or discharge as compared with other registries. Alike to all previous years, the number of procedures was counted rather than individual patients. For example, if a patient required additional coronary artery bypass grafting (CABG) due to a complication after initial aortic valve replacement during one admission, one count in the category “aortic valve replacement” and another in the category “coronary surgery” are enumerated. Thus, the registry contains more procedures than the real number of patients operated on.

Death of patients was defined as in-hospital mortality. As per the definition, the observed mortality is always attributed to the first cardiac procedure, for example, the death of a patient requiring CABG due to a complication of an aortic valve procedure would only be attributed to the aortic valve procedure.

The main reason for this structural setup of the registry—established over several decades—is to keep the German data privacy act with its specific regulations for patients. Furthermore, it seemed to be relevant getting detailed information about all performed procedures and not only the number of

treated patients. Last but not the least, the process of data acquisition had to be simplified for all cardiac surgery units in Germany thus enabling the submission of a complete dataset, regardless of the locally existing hard- and software used for data management.

In 2012, a total of 79 institutions performed heart surgery. Fortunately, all units answered the questionnaire and delivered a complete dataset for the year 2012 including hospital mortality rates.

Registry Data 2012

►Table 1 illustrates the development of procedures using extracorporeal circulation (ECC) over more than two decades in Germany. The number of heart operations using ECC remains on a stable level.

Overall, 177,694 procedures were reported to the registry for the year 2012, an increase of 2.5% (2011: 173,347 procedures). A total of 101,887 cardiac surgical procedures (excluded: ICD, pacemakers, and miscellaneous procedures without ECC) display an increase of 1.57% ($n = 1,596$) compared with the year 2011 (100,291 procedures) (►Table 2). ►Tables 3 to 6, ►Tables V1 to 7, ►Tables C1 to C3, ►Tables Con1 and Con2, ►Tables Mis1 to 5, and ►Figs. 1 to 9 demonstrate the compiled registry data of 2012 for various categories.

Compared with the data of previous years, several important developments continue unchanged in 2012. Over nearly two decades, the distribution of patient age (►Fig. 6) showed a shift to older patients with presently 53.7% of the cardiac procedures performed in patients of at least 70 years of age and 13.8% in patients of 80 years or older. However, mortality remained on the same low level or even decreased slightly over the represented decades (see ►Fig. 1B). The rate of CABG procedures decreased over the past years while the relative number of off-pump CABG showed a slight increase to 15.4% (2011: 14.7%) (►Fig. 3).

Since 2004 more than 50% of isolated mitral valve procedures are reconstructions, in 2012 mitral valve reconstruction could be achieved in 64.4% of the procedures (►Fig. 8). On the basis of the fact that all isolated mitral valve procedures are included, regardless of the underlying disease, valve morphology, or urgency of operation, it has to be assumed that the relative rate of mitral valve reconstruction would certainly be even higher if patients without possibility or indication for reconstruction would have been excluded (e.g., mitral valve stenosis, calcifications, or endocarditis). In other publications, for example Gammie et al,²³ patients with

Table 1 Frequency of open heart procedures in Germany from 2003 to 2012

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total number of units	78	79	79	80	80	79	80	79	78	79
Total number of operations	94,712	96,340	91,967	91,057	91,618	89,773	86,916	84,686	84,402	84,388
Average per unit	1,214	1,219	1,164	1,138	1,145	1,136	1,086	1,072	1,082	1,068

Table 2 Results of all 79 units performing cardiac surgery in 2012

Category	With ECC	Without ECC	Total	% change
Valve procedures	21,918	6,603	28,521	+ 5.7%
Coronary surgery	48,443	6,859	55,302	+ 0.0%
Congenital heart surgery	4,651	942	5,593	– 0.1%
Surgery of thoracic aorta	6,805	575	7,380	+ 2.5%
Other cardiac surgery	1,276	1,197	2,473	– 6.0%
Assist devices	812	1,806	2,618	+ 24.1%
Pacemaker and ICD	93	25,139	25,232	– 3.0%
Extracardiac surgery	390	50,185	50,575	+ 6.4%
Total	84,388	93,306	177,694	+ 2.5%

Abbreviation: ECC, extracorporeal circulation.

Note: The percentage indicates changes compared with 2011.

Table 3 Distribution of individual units according to the number of cardiac surgery procedures with or without ECC

Number of operations	<500	500–999	1,000–1,499	1,500–1,999	2,000–5,000
Number of units	6	24	26	13	10
Average per unit	378	803	1,186	1,706	2,781
Min–max	271–474	538–990	1,019–1,468	1,517–1,959	2,169–3,814

Abbreviation: ECC, extracorporeal circulation.

Note: One unit only performs operations in patients with congenital heart disease.

Table 4 Distribution of units according to surgical profiles in 2012

Procedures	Number of units
Coronary surgery	78
Valve surgery	78
Congenital heart surgery under use of ECC in children < 1 y	24 ^a
Heart transplantation	22 ^b
Heart–lung transplantation	4

Abbreviation: ECC, extracorporeal circulation.

^aSurgery for congenital heart disease with ECC in children < 1 year ($n = 2,024$); thereof: 1–19 operations in 3 units, 21–45 operations in 7 units, 50–90 operations in 6 units, and 109–269 operations in 8 units.

^bHeart transplantations (HTx) ($n = 327$): 64% of the HTx in 2012 were performed by 6 units with ≥ 15 HTx per year; thereof: 1–4 transplantations in 4 units, 5–7 transplantations in 6 units, 10–14 transplantations in 6 units, and 21–73 transplantations in 6 units.

Table 5 Additional demographic data for procedures with ECC in 2012 and 2011

	2012		2011	
Emergency operations	11,878	11.6%	11,911	11.9%
Redo procedures	8,424	8.2%	8,511	8.5%
Age > 69 y	97,572	53.7%	95,456	53.6%

Abbreviation: ECC, extracorporeal circulation.

Note: The numbers in each category reflect procedures and not individual patients.

Table 6 Gender distribution

Male/female ratio among cardiac procedures		
Valve procedures	56%	44%
Coronary surgery	76%	24%
Congenital heart surgery	53%	47%
Surgery of thoracic aorta	69%	31%
Other cardiac surgery	52%	48%
Assist devices	77%	23%
Pacemaker and ICD	65%	35%
Extracardiac surgery	63%	37%
Total	66%	34%

Note: Coronary surgery (48,443 on-pump and 6,859 off-pump procedures) and all congenital heart surgery procedures are included in this table.

mitral valve stenosis, endocarditis, and emergency procedures were excluded, so the reconstruction rate must be interpreted with caution compared to this registry.

The continued increase of left ventricular assist device implantation (► **Fig. 10**) emphasizes the increasing relevance of mechanical circulatory support.

Again the most remarkable trend is the repeated extensive increase of TAVI procedures (► **Fig. 5**), although the number of isolated aortic valve replacement procedures remained on a stable level. Starting in 2006 with just 78 implantations (0.67% of isolated aortic valve procedures), in 2012 a total of 6,479 (35.5%) TAVI were reported to the registry in 2012. It must be emphasized that the 79 institutions which contribute their data to this registry do not represent all departments performing TAVI in Germany. In addition, there are some institutions performing TAVI via transvascular access without a cardiac surgery on-site. This proceeding is not in accordance with the recommendations of the European guideline on the management of valvular heart disease version 2012.²⁴

In this context, the short-, mid-, and long-term results of the German Aortic Valve Registry and the annual findings of the legal quality assurance (§137 SGB V), conducted by the AQUA Institute, are of outstanding patient benefit.

Table V1 Isolated heart valve procedures

Procedures	n	Deaths	%
Single	18,094	624	3.4
Double	3,133	289	9.2
Triple	400	52	13.0
Single, transcatheter access	6,795	382	5.6
Double, transcatheter access	9	2	22.2
Not specified	90	7	7.8
Total	28,521	1,356	4.8

Notes: Combined procedures (with CABG, aortic surgery) are excluded. Transcatheter procedures: 6,479 aortic valve implantations; 42 mitral valve implantations; 269 mitral valve repairs, 5 tricuspidal valve repairs, 9 double aortic and mitral valve procedures, and no pulmonary valve implantation.

Table V2 Access type in single valve procedures

Position	n	Deaths	%
Aortic sternotomy	9,738	314	3.2
Aortic part. sternotomy	2,168	36	1.7
Aortic transvascular	3,550	167	4.7
Aortic transapical	2,929	210	7.2
Mitral sternotomy	3,110	186	6.0
Mitral mis	2,512	42	1.7
Mitral transcatheter	311	4	1.3
Tricuspid sternotomy	407	36	8.8
Tricuspid mis	109	7	6.4
Tricuspid transcatheter	5	1	20.0
Pulmonary sternotomy	50	3	6.0
Pulmonary mis	0	–	–
Pulmonary transcatheter	0	0	–
Total	24,889	1,006	4.0

Notes: A total of 2,512 (45%) mitral valve procedures were performed by a minimally invasive access. The number of isolated aortic valve procedures by sternotomy increased from 11,668 procedures in 2011 to 11,906 in 2012.

Table V3 Isolated aortic valve procedures

Type	n	Deaths	%
Mechanical prosthesis	1652	37	2.2
Xenograft	10091	308	3.1
Homograft	36	4	11.1
Reconstruction	127	1	0.8
Total	11906	350	2.9

Notes: Of 11,906 procedures, 2168 (18%) were performed via partial sternotomy. Transcatheter procedures were not included.

Table V4 Isolated mitral valve procedures

Type	n	Deaths	%
Mechanical prosthesis	570	38	6.7
Xenograft	1,425	131	9.2
Homograft	6	0	0.0
Reconstruction	3,621	59	1.6
Total	5,622	228	4.1

Notes: Of 5,622 procedures, 2,512 (45%) were performed via minimally invasive access. Transcatheter procedures were excluded.

Table V5 Multiple heart valve procedures

Combination	n	Deaths	%
Aortic + mitral	1,345	165	12.3
Mitral + tricuspid	1,489	103	6.9
Aortic + tricuspid	185	18	9.7
Tricuspid + pulmonary	16	1	6.3
Aortic + pulmonary ^a	98	2	2.0
Aortic + mitral + tricuspid	399	52	13.0
Aortic + mitral + pulmonary	1	0	0.0
Total	3,533	341	9.7

Note: Transcatheter procedures were excluded.

^aIncluding Ross procedures.

Discussion

The registry of the GSTCVS enables a comprehensive overview of all cardiac surgical procedures performed in Germany in 2012. The accuracy of this registry is considered to be high due to the implemented compilation algorithm using operation codes. This is supported by other authors who could demonstrate a high accuracy for major outcome parameters in unaudited registries.²⁵ In continuation to previous years, it can be concluded that cardiac surgery in Germany is performed on a constantly high level with a low in-hospital mortality compared with other international registries. This conclusion is especially important in an era of demographic change of the German population resulting in a continuously

Table V6 Mitral valve surgery—implantation resp. replacement versus reconstruction

Mitral valve surgery	n	Total deaths	% death	% reconstruction	Replacement		% death	Reconstruction		% death
					n	Deaths		n	Deaths	
Isolated	5,622	228	4.1	64.4	2,001	169	8.4	3,621	59	1.6
Mitral valve +										
Aortic valve	1,345	165	12.3	42.5	773	115	14.9	572	50	8.7
Tricuspid valve reconstruction ^a	1,445	99	6.9	65.3	501	54	10.8	944	45	4.8
CABG	2,640	252	9.5	70.2	786	129	16.4	1,854	123	6.6
CABG + aortic valve replacement	674	119	17.7	53.1	316	68	21.5	358	51	14.2
Total	11,726	863	7.4	62.7	4,377	535	12.2	7,349	328	4.5

Abbreviation: CABG, coronary artery bypass grafting.

^aForty-four procedures (not specified mitral valve + tricuspid valve surgery) were excluded. Deaths: 9.1% (4/44).

Table V7 Transcatheter valve procedures: 45.2% of TAVI were performed by transapical access

	Total	Deaths	Death %	With ECC		Without ECC	
				n	Deaths	n	Deaths
Aortic valve implantation	6,479	377	5.8	182	62	6,297	315
Transvascular access ^a	3,550	167	4.7	80	24	3,470	143
Transapical access	2,929	210	7.2	102	38	2,827	172
Mitral valve	311	4	1.3	16	1	295	3
Repair	269	4	1.5	11	1	258	3
Implantation ^b	42	0	0.0	5	0	37	0
Tricuspid valve repair	5	1	20.0	2	0	3	1
Aortic + mitral valve implantation	9	2	22.2	1	0	8	2
Aortic valve implantation ^b + CABG	23	5	21.7	3	2	20	3
Total	6,827	389	5.7	204	65	6,623	324

Abbreviations: CABG, coronary artery bypass grafting; ECC, extracorporeal circulation; TAVI, transapical or transvascular aortic valve implantation. Notes: Pulmonary valve implantation for congenital heart disease are excluded, no procedure was reported for adults without congenital lesion. 2.8% of TAVI procedures were performed under use of ECC. It has to be assumed that ECC was mostly used in emergency situations, which explains the mortality of 34.1% in this group. Nevertheless, this underlines the necessity of a cardiac surgery on-site for TAVI procedures.

^aFemoral, subclavian, or transaortic access.

^bTransvascular and transapical access.

Table C1 Isolated CABG with ECC and combined procedures with ECC

Procedures	n	Deaths	%
CABG	42,060	1,217	2.9
CABG +			
Transmyocardial laser revascularization	6	0	0.0
Left ventricular-aneurysm resection	168	11	6.5
Aortic valve replacement	8,216	432	5.3
Transcatheter aortic valve implantation	23	5	21.7
Mitral valve replacement	786	129	16.4
Mitral valve repair	1,854	123	6.6
Aortic + mitral valve replacement	316	68	21.5
Aortic valve replacement + mitral valve repair	358	51	14.2
Other	1,515	95	6.3
Total	55,302	2,131	3.9

Abbreviations: CABG, coronary artery bypass grafting; ECC, extracorporeal circulation.

increasing patient age and related comorbidities, both leading to a higher preoperative risk profile.

Compared with 2011, the number of cardiac surgery procedures nearly remains on the same level due to the still increasing number of catheter-based valve procedures.

Table C2 Isolated CABG with ECC

Number of grafts	N	Deaths	%
Single	1,213	73	6.0
Double	7,399	250	3.4
Triple	15,667	466	3.0
Quadruple	8,734	242	2.8
Quintuple + more	2,560	57	2.2
Total	35,573	1,088	3.1

Abbreviations: CABG, coronary artery bypass grafting; ECC, extracorporeal circulation.

Table C3 Isolated CABG off-pump

Number of grafts	n	Deaths	%
Single	1,525	33	2.2
Double	1,938	45	2.3
Triple	2,132	40	1.9
Quadruple	750	10	1.3
Quintuple + more	142	1	0.7
Total	6,487	129	2.0

Abbreviation: CABG, coronary artery bypass grafting.

Further improvements in the basic configuration of the registry are necessary to allow a more detailed and particularly a risk-adjusted analysis of the data. However, if significant structural changes of data collection for the registry are conducted, it must be ensured that data compatibility still allows further longitudinal data analysis.

Completeness, validity, and further developments will depend on continued efforts of the GSTCVS in close collaboration with all cardiac surgical units in Germany. This will be of outstanding importance for the contribution to patient safety as well as to facilitate a high quality of cardiac surgery in Germany.

Table Con1 Patient's age distribution for congenital heart surgery

Age	n	Deaths	%
(A) Without ECC			
Older than 18 y	34	1	2.9
1–17 y	142	0	0.0
Younger than 1 y	766	20	2.6
Total A	942	21	2.2
(B) With ECC			
Older than 18 y	989	23	2.3
1–17 y	1,638	16	1.0
Younger than 1 y	2,024	79	3.9
Total B	4,651	118	2.5

Abbreviation: ECC, extracorporeal circulation.

Table Con2 Congenital heart surgery with and without ECC

Lesion/procedure	Age < 1 y			Age 1–17 y			Age ≥ 18 y		
	n	Deaths	%	n	Deaths	%	n	Deaths	%
ASD	51	0	0.0	254	0	0.0	287	6	2.1
Complete AV canal	174	5	2.9	62	0	0.0	11	0	0.0
VSD	326	3	0.9	112	1	0.9	21	0	0.0
Fallot tetralogy	177	5	2.8	45	0	0.0	9	0	0.0
DORV	44	2	4.5	12	0	0.0	2	0	0.0
TGA	159	4	2.5	3	0	0.0	1	0	0.0
TGA + VSD	65	0	0.0	8	1	12.5	0	0	–
Truncus arteriosus	31	2	6.5	5	0	0.0	1	0	0.0
Fontan	5	0	0.0	231	5	2.2	10	2	20.0
Norwood	187	26	13.9	2	0	0.0	0	0	–
Pulmonary valve	48	0	0.0	225	4	1.8	82	0	0.0
Transcatheter pulmonary valve implantation	1	0	0.0	6	0	0.0	9	1	11.1
Aortic valve	61	0	0.0	209	1	0.5	319	7	2.2
Ross procedure	10	1	10.0	26	0	0.0	29	0	0.0
Mitral valve	43	1	2.3	93	1	1.1	69	5	7.2
Tricuspid valve	44	2	4.5	51	0	0.0	44	1	2.3
PDA	286	9	3.1	14	0	0.0	3	0	0.0
Coarctation	195	1	0.5	44	0	0.0	6	0	0.0
Transplantation heart	6	0	0.0	17	1	5.9	0	0	–
Transplantation heart + lung	0	0	–	1	0	0.0	0	0	–
Transplantation lung	0	0	–	9	1	11.1	0	0	–
Others	877	53	6.0	351	24	6.8	120	3	2.5
Total	2,790	114	4.1	1,780	39	2.2	1,023	25	2.4

Abbreviations: ASD, atrial septal defect; AV, atrioventricular; DORV, double outlet right ventricle; PDA, patent ductus arteriosus; TGA, transposition at the great arteries; VSD, ventricular septal defect.

Table Mis1 Development of Ross procedures in various age groups

Autologous aortic valve replacement (Ross procedure)	2002	2005	2008	2009	2010	2011	2012
	n	n	n	n	n	n	n
Patients ≥ 18 y	163	235	207	175	184	134	117
Patients < 18 y	61	46	42	54	43	40	36
Total	224	281	249	229	227	174	153

Table Mis2 Transplantation all pediatric transplantations (demonstrated in Table Con3) are included in this table

Transplantation	With ECC			Without ECC		
	n	Deaths	%	n	Deaths	%
Heart	327	38	11.6			
Heart + lung	14	1	7.1			
Lung	71	4	5.6	244	11	4.5

Notes: Eurotransplant (ET) reported for the same period 341 heart transplantations (HTx), 13 heart + kidney transplantations, 2 heart + liver transplantations, 10 heart–lung transplantations, 268 double lung, 57 single lung transplantations, 1 lung + kidney transplantations, and 1 lung + liver transplantations. The differences (ET: – 28 LTx, – 5 HTx) may be explained by different inclusion criteria (time of transplantation) for the registry and the ET database.

Table Mis3 Aortic surgery

Aortic surgery ^a	With ECC			Without ECC		
	<i>n</i>	Deaths	%	<i>n</i>	Deaths	%
Supracoronary ascending	1,623	110	6.8			
Infracoronary ascending			–			
Mechanical valve conduits	510	36	7.1			
Biological valve conduits	806	79	9.8			
David technique	463	10	2.2			
Yacoub technique	119	4	3.4			
Other	263	27	10.3			
Supracoronary ascending + aortic valve replacement	1,363	66	4.8			
Aortic arch replacement ^b	1,472	194	13.2			
Descending	90	6	6.7	14	3	21.4
Thoracoabdominal	89	7	7.9	59	7	11.9
Endovascular stent, descending	7	0	0.0	502	24	4.8
Total	6,805	539	7.9	575	34	5.9

Notes: All procedures involving aortic surgery are included. Isolated aortic surgery as well as all possible combined procedures (e.g., additional CABG) are summarized in this category.

^aProcedures for abdominal aortic diseases are not included: 486 abdominal and 488 endovascular stents, abdominal.

^bAll possible combined procedures are included in this category; the only common denominator is aortic arch surgery.

Table Mis4 Pacemaker and ICD procedures

Pacemaker and ICD	Total	Deaths	Death %	With ECC		Without ECC	
				<i>n</i>	Deaths	<i>n</i>	Deaths
Pacemaker: implantation	9,276	54	0.6	17	2	9,259	52
Pacemaker: exchange	1,976	5	0.3	0	0	1,976	5
Pacemaker: revision	2,966	38	1.3	42	4	2,924	34
ICD: implantation	4,963	12	0.2	1	0	4,962	12
ICD: exchange	1,812	1	0.1	0	0	1,812	1
ICD: revision	3,228	44	1.4	29	0	3,199	44
Miscellaneous	1,011	6	0.6	4	0	1,007	6
Total	25,232	160	0.6	93	6	25,139	154

Table Mis5 Surgical ablation procedures

Energy	Total	Endocardiac ablation, <i>n</i>	Total, <i>n</i>
Unipolar radiofrequency	198	159	39
Unipolar cryoradiofrequency	469	272	197
Bipolar radiofrequency	1,967	263	1,704
Cryotherapy	1,706	1,439	267
Microwave	38	22	16
Focused ultrasound	688	71	617
Laser	1	0	1
other	11	2	9
Total	5,078	2,228	2,850

Notes: All isolated ablation procedures and all possible combination of procedures (e.g., CABG + ablation) are included. Total of *n* = 319 procedures are not specified with regard to endocardiac/epicardiac ablation.

Fig. 1 (A) Cardiac surgery in Germany from 2003 to 2012. (1) CABG and combinations: all types of isolated coronary surgery with or without ECC and any combined procedure. (2) Valve procedures: all types of isolated heart valve surgery; heart valve procedures in combination with aortic surgery are summarized in the miscellaneous group. (3) Congenital heart surgery: all procedures with or without ECC; atrial septal defect repair in adults in combination with CABG or heart valve surgery are summarized in the CABG or heart valve surgery group. (4) Miscellaneous procedures: all other types of procedures with ECC. (B) Development of cardiac surgery in Germany during the past 10 years. CABG, coronary artery bypass grafting; ECC, extracorporeal circulation.

Fig. 2 Development of mortality for selected procedures.

Fig. 3 Isolated CABG: the number of CABG declined since the year 2003 while the percentage of off-pump procedures slightly increased. CABG, coronary artery bypass grafting.

Fig. 4 Isolated aortic valve replacement from 2003 to 2012 in Germany. The use of xenografts continuously increased while the AVR using mechanical prostheses decreased. The sustained difference in mortality seems to be related to the difference in age pattern. Ross, homograft procedures, and TAVI are excluded in this overview. TAVI, transcatheter aortic valve implantation.

Fig. 5 Surgical aortic valve replacement or TAVI. The figure shows an obvious increase of TAVI. In 2012, 35.5% of isolated aortic valve procedures were performed by endovascular or transapical implantation. TAVI, transcatheter aortic valve implantation.

Fig. 6 Age distribution of cardiac procedures (ICD and pacemaker procedures excluded) since 2003. Currently, 53.7% of the patients are at least 70 years. Patients younger than 20 years are excluded.

Fig. 7 Distribution of urgency 2003 and 2012.

Fig. 8 Isolated mitral valve surgery over the past 10 years. In 64.4% MV reconstructions and in 35.6% MV replacements were performed. In 1994, the rate of reconstruction just reached 21%.

Fig. 9 Age distribution of patients undergoing congenital heart surgery in Germany over the past 10 years. No relevant changes can be observed. However, there may be a bias since not all relevant procedures can be allocated exactly to the congenital heart disease group in patients older than 18 years (e.g., aortic valve disease).

Fig. 10 Development of mechanical circulatory support in Germany over the past 9 years. There is a significant increase in implantations of left ventricular assist devices (LVAD). However, in 2012, the number of implanted paracorporeal biventricular support systems (BVAD) was only 66% compared with the previous years. The number of total artificial heart (TAH) implantations remained on a low level.

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References

1 Kalmar P, Irrgang E. Cardiac surgery in the Federal Republic of Germany during 1989. A report by the German Society for Thoracic and Cardiovascular Surgery. Thorac Cardiovasc Surg 1990;38(3):198–200
2 Kalmar P, Irrgang E. Cardiac surgery in the Federal Republic of Germany during 1990. A report by the German Society for

- Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 1991;39(3):167–169
- 3 Kalmar P, Irrgang E. Cardiac surgery in Germany during 1991. A report by the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 1992;40(3):163–165
 - 4 Kalmar P, Irrgang E. Cardiac surgery in Germany during 1992. A report by the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 1993;41(3):202–204
 - 5 Kalmar P, Irrgang E. Cardiac surgery in Germany during 1993. A report by the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 1994;42(3):194–196
 - 6 Kalmar P, Irrgang E. Cardiac surgery in Germany during 1994. A report by the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 1995;43(3):181–183
 - 7 Kalmár P, Irrgang E. Cardiac surgery in Germany during 1995. A report by the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 1996;44(3):161–164
 - 8 Kalmár P, Irrgang E. Cardiac surgery in Germany during 1996. A report by the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 1997;45(3):134–137
 - 9 Kalmár P, Irrgang E. Cardiac surgery in Germany during 1997. A report by the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 1998;46(5):307–310
 - 10 Kalmár P, Irrgang E. Cardiac surgery in Germany during 1998. A report by the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 1999;47(4):260–263
 - 11 Kalmár P, Irrgang E. Cardiac surgery in Germany during 1999. *Thorac Cardiovasc Surg* 2000;48(4):XXVII–XXX
 - 12 Kalmár P, Irrgang E. Cardiac surgery in Germany during 2001: a report by the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2002;50(6):30–35
 - 13 Kalmár P, Irrgang E; German Society for Thoracic and Cardiovascular Surgery. Cardiac surgery in Germany during 2002: a report by German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2003;51(5):25–29
 - 14 Kalmár P, Irrgang E; German Society for Thoracic and Cardiovascular Surgery. Cardiac surgery in Germany during 2003: a report by the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2004;52(5):312–317
 - 15 Gummert JF, Funkat A, Krian A. Cardiac surgery in Germany during 2004: a report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2005;53(6):391–399
 - 16 Gummert JF, Funkat A, Beckmann A, Hekmat K, Ernst M, Krian A. Cardiac surgery in Germany during 2005: a report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2006;54(5):362–371
 - 17 Gummert JF, Funkat A, Beckmann A, et al. Cardiac surgery in Germany during 2006: a report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2007;55(6):343–350
 - 18 Gummert JF, Funkat A, Beckmann A, et al; German Society for Thoracic and Cardiovascular Surgery. Cardiac surgery in Germany during 2007: a report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2008;56(6):328–336
 - 19 Gummert JF, Funkat A, Beckmann A, et al. Cardiac surgery in Germany during 2008. A report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2009;57(6):315–323
 - 20 Gummert JF, Funkat A, Beckmann A, et al. Cardiac surgery in Germany during 2009. A report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2010;58(7):379–386
 - 21 Gummert JF, Funkat AK, Beckmann A, et al. Cardiac surgery in Germany during 2010: a report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2011;59(5):259–267
 - 22 Funkat AK, Beckmann A, Lewandowski J, et al. Cardiac surgery in Germany during 2011: a report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2012;60(6):371–382
 - 23 Gammie JS, Zhao Y, Peterson ED, O'Brien SM, Rankin JS, Griffith BPJ. J. Maxwell Chamberlain Memorial Paper for adult cardiac surgery. Less-invasive mitral valve operations: trends and outcomes from the Society of Thoracic Surgeons Adult Cardiac Surgery Database. *Ann Thorac Surg* 2010;90(5):1401–1408, e1, discussion 1408–1410
 - 24 Vahanian A, Alfieri O, Andreotti F, et al; Joint Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology (ESC); European Association for Cardio-Thoracic Surgery (EACTS). Guidelines on the management of valvular heart disease (version 2012). *Eur Heart J* 2012;33(19):2451–2496
 - 25 Herbert MA, Prince SL, Williams JL, Magee MJ, Mack MJ. Are unaudited records from an outcomes registry database accurate? *Ann Thorac Surg* 2004;77(6):1960–1964, discussion 1964–1965