

# Cardiac Surgery in Germany during 2014: A Report on Behalf of the German Society for Thoracic and Cardiovascular Surgery

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## Abstract

### Keywords

- cardiac surgery
- outcome
- registry
- heart valve surgery
- congenital heart disease
- aortic surgery

Based on a voluntary registry of the German Society for Thoracic and Cardiovascular Surgery (GSTCVS), data of all heart surgery procedures performed in 78 German cardiac surgical units during the year 2014 are presented. In 2014, a total of 100,398 cardiac surgical procedures (implantable cardioverter-defibrillator and pacemaker procedures excluded) were submitted to the registry. More than 14.2% of the patients were older than 80 years, describing an increase of 0.4% compared with the previous year. The unadjusted in-hospital mortality for 40,006 isolated coronary artery bypass grafting procedures (84.7% on-pump, 15.3% off-pump) was 2.6%. In 31,359 isolated valve procedures (including 9,194 catheter-based procedures), an in-hospital mortality of 4.4% was observed. This annual updated registry of the GSTCVS is published since 1989. It is an important tool for quality assurance and voluntary public reporting by illustrating current standards and actual developments for nearly all cardiac surgical procedures in Germany.

## Introduction

Legitimate demands for a sophisticated 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 activities to answer those needs. As early as 1978, the board of directors of the German Society for Thoracic and Cardiovascular Surgery (GSTCVS; [www.dgthg.de](http://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 annually updated data of the registry are published in the scientific journal of the GSTCVS.<sup>1–25</sup> The aims of this registry

are to gather developments and current trends in cardiac surgery in Germany, compiling various results for nearly all cardiac surgical procedures, enabling each participating cardiac surgical unit a comparison of its own results to the nationwide achievements, and enabling an evaluation on an international level for the society.

For monitoring actual conditions as well as the development in cardiac medicine, the registry covers all relevant techniques and also innovative technologies including off-pump cardiac surgery, minimally invasive heart valve operations, and transcatheter aortic valve implantations [TAVI]. Thereby important findings for current patient

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safety and the future of patient care may be collected and evaluated.

Data and results presented in this report comprehend assorted data of the year 2014.

## Materials and Methods

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

All participants were requested to complete the structured questionnaire until January 16, 2015, asking for all performed procedures and associated in-hospital mortality. The recommended path for data export is an electronic transmission of an encrypted file which has to be addressed to the office of the GSTCVS in Berlin. After transaction, the data are decrypted, evaluated for completeness, and compiled for further analysis, thus ensuring anonymity for each participating institution. This compilation algorithm guarantees a high compliance for submission of complete datasets.

Inclusion criteria for the registry 2014 were all patients receiving cardiac surgical procedures performed between January 1, 2014, and December 31, 2014, unrelated to the date 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 bypass grafting 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 operated patients.

Death of patients was defined as in-hospital mortality. Per definition, the observed mortality is always attributed to the first cardiac procedure; for example, the death of a patient requiring coronary bypass grafting 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 in accordance with the German data privacy act with its specific regulations for patients. Furthermore, it seemed to be relevant to get detailed information about all performed procedures and not only the number of treated patients. Last but not least, the process of data acquisition had to be standardized and feasible 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 2014, a total of 78 institutions performed heart surgery. Fortunately all units answered the questionnaire and delivered a complete dataset for the year 2014 including hospital mortality rates.

## Registry Data 2014

► **Table 1** illustrates the development of procedures using extracorporeal circulation (ECC) in Germany over one decade.

Since 2010, the number of heart operations using ECC shows only a slight decline.

Overall 187,392 procedures were reported to the registry for the year 2014, an increase of 3.9% (2013: 180,367 procedures). A total of 104,484 cardiac surgical procedures (excluded: ICD, pacemakers and miscellaneous procedures without ECC) reveal an increase of 1.6% ( $n = 1,639$ ) compared with the year 2013 (102,845 procedures) (► **Table 2**). ► **Tables 3 to 5, V1 to V7, C1 to C2, C3, ►Table Con1 and Con2, and ►Table Mis 1 to 5 and ►Figs. 1–9** demonstrate the compiled registry data of 2014 for various categories.

Compared to the data of previous years, several important developments continued in 2014 almost unchanged. Over the past 10 years, the age distribution of patients (► **Fig. 6**) showed a shift to elderly patients with presently 54.3% of the cardiac procedures performed in patients of at least 70 years of age and 14.2% in patients of 80 years or older. However, mortality remained on the same low level or even decreased slightly over the last decade (► **Fig. 2**). The rate of coronary artery bypass grafting (CABG) procedures decreased over the past years while the relative number of off-pump CABG showed no relevant variation (2014: 15.3%, 2013: 15.5%) (► **Fig. 3**).

Since 2004, more than 50% of isolated mitral valve procedures were reconstructions. In 2014, the mitral valve reconstruction rate was 65.7% (► **Fig. 8**). Based on the fact that all isolated mitral valve procedures are included in this registry, these data have to be interpreted with caution. Regardless of the underlying valve disease/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,<sup>26</sup> patients with mitral valve stenosis, endocarditis, and emergency procedures were excluded.

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

Again a remarkable trend is the still ongoing increase of TAVI procedures in Germany (► **Fig. 5**), while the number of isolated aortic valve replacement procedures remained on a nearly unchanged level. Starting in 2006 with just 78 implantations (0.67% of isolated aortic valve procedures), in 2014 a total of 8,631 (42.3%) TAVIs were reported to the registry. It must be emphasized that the 78 institutions which contribute their data to this registry do not represent all departments performing TAVI in Germany. It is well known that some additional institutions in Germany perform TAVI procedures under different infrastructure conditions and various external cooperations. This practice does not correlate to the recommendations of the European guideline<sup>27</sup> on the management of valvular heart disease. Considering this background, on January 22, 2015, the Federal Joint Committee (G-BA)—as the highest decision-making body of the joint self-government in Germany—issued the first version of the quality assurance directive for “minimal invasive heart valve interventions (TAVI, Mitral Clip reconstruction)” in which obligatory structures, defined processes, and qualified personnel are exactly specified.<sup>28</sup>

In addition, the short-, mid-, and long-term results of the German Aortic Valve Registry (GARY)<sup>29–33</sup> and the annual analyses of the legal quality assurance (§137 SGB V) are of outstanding patient benefit.

## Discussion

The registry of the GSTCVS enables a comprehensive overview of all cardiac surgical procedures performed in Germany during 2014. The accuracy of this registry is considered to be high due to the implemented compilation algorithm using standardized operation coding as a relevant criterion for reimbursement purposes. This is supported by other authors who could demonstrate a high accuracy for major outcome parameters in unaudited registries.<sup>30</sup> In continuation with previous years, it can be concluded that cardiac surgery in Germany is performed on a constantly high level with high in-hospital survival rates compared with other international registries. This conclusion is especially important in an era of demographic change of the German population, resulting in a continuous increase of patient age and related comorbidities, both leading to a higher preoperative risk profile.

Compared with 2013, the count of cardiac surgery procedures remains almost on the same level, which is partly due to the still increasing number of catheter-based heart valve procedures.

Further improvements in the basic configuration of the registry are recommended to enable a more detailed and particularly a risk-adjusted data analyses.<sup>34</sup> 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 in the sense of a contribution for patient safety and to adduce evidence for the quality of cardiac surgery in Germany.

## Acknowledgments

On behalf of the German Society for Thoracic and Cardiovascular Surgery, the authors would like to thank the heads of departments of all cardiac surgery units in Germany and their employees for their continued cooperation and support to realize this registry.

## Appendix: Tables and Figures

**Table 1** Open heart procedures using extracorporeal circulation (2005–2014)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Units	79	80	80	79	80	79	78	79	79	78
Operations	91,967	91,057	91,618	89,773	86,916	84,686	84,402	84,388	84,040	83,787
Average per unit	1,164	1,138	1,145	1,136	1,086	1,072	1,082	1,068	1,064	1,074

**Table 2** Cardiac surgery categories (comparison: 2014 vs. 2013)

Category	With ECC	Without ECC	Total	% change
Heart valve procedures	22,335	9,024	31,359	+ 5.7
Coronary artery bypass grafting	47,246	6,559	53,805	– 0.8
Surgery for congenital heart disease	4,755	1,024	5,779	+ 3.6
Surgery of thoracic aorta	7,117	638	7,755	+ 1.1
Cardiac surgery, other	1,172	1,302	2,474	– 5.5
Assist device procedures	760	2,150	2,910	+ 9.5
Pacemaker and ICD procedures	40	26,212	26,252	+ 2.0
Extracardiac surgery	362	56,696	57,058	+ 9.4
Total	83,787	103,605	187,392	+ 3.9

Abbreviation: ECC, extracorporeal circulation.

**Table 3** Units assorted by volume categories (procedures with or without ECC)

Quantity of operations	< 500	500–999	1,000–1,499	1,500–1,999	2,000–5,000
Number of units	7	20	26	12	13
Average per unit	342	928	1,152	1,864	2,087
Min–Max	238–427	546–988	1,027–1,495	1,513–1,992	2,045–3,972

Abbreviation: ECC, extracorporeal circulation.

**Table 4** Total number of units according to surgical procedures in 2014

Type of surgery performed	Number of units
Coronary artery bypass grafting	77
Heart valve surgery	77
Surgery for CHD in children <1 y with ECC	23 <sup>a</sup>
Heart transplantation	21 <sup>b</sup>
Heart-lung transplantation	5

Abbreviations: CHD, congenital heart disease; ECC, extracorporeal circulation.

<sup>a</sup>*n* = 2,090 thereof: 7–19 procedures in 4 units, 23–47 procedures in 4 units, 59–90 procedures in 7 units, 104–296 procedures in 8 units.

<sup>b</sup>*n* = 294: 58% of heart transplantations (HTx) in 2014 were performed by 6 of 21 units with ≥ 15 HTx per year; thereof: 1–3 HTx in 4 units, 5–9 HTx in 5 units, 12–18 HTx in 10 units, 21–85 HTx in 2 units.

**Table V1** Isolated valve procedures (categories)

Procedures	N	Deaths	%
Single	18,408	625	3.4
Double	3,288	314	9.5
Triple	372	50	13.4
Transcatheter access (single value)	9,184	386	4.2
Transcatheter access (double value)	10	1	10.0
Not specified	97	8	8.2
Total	31,359	998	3.2

Notes: Combined procedures (with coronary artery bypass grafting, aortic surgery) are excluded.

Transcatheter valve procedures: 8,631 aortic valve implantations; 91 mitral valve implantations; 457 mitral valve repairs; 3 tricuspid valve implantations; 2 tricuspidal valve repairs; 10 combined procedures, aortic and mitral valve procedure; no pulmonary valve implantation.

**Table V3** Isolated aortic valve procedures (prosthesis)

Prosthesis/native valve	N	Deaths	%
Mechanical prosthesis	1,360	29	2.1
Xenograft	10,375	292	2.8
Homograft	29	2	6.9
Reconstruction	117	2	1.7
Total	11,881	325	2.7

Notes: A total of 2,781 (23.4%) procedures were performed by a partial sternotomy. Transcatheter procedures and apical aortic conduits procedures (*n* = 1) are not included.

**Table 5** Additional data for cardiac procedures with ECC in 2014 and 2013

	2014		2013	
Emergency operations	12,583	12.0%	11,944	11.6%
Redo procedures	8,809	8.4%	8,284	8.1%

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

**Table V2** Single valve procedures (access type)

Heart valve/access	N	Deaths	%
<b>Aortic valve</b>			
Sternotomy	9,100	282	3.1
Partial sternotomy	2,781	43	1.5
Transvascular	5,570	184	3.3
Transapical	3,061	167	5.5
<b>Mitral valve</b>			
Sternotomy	3,121	200	6.4
Minimal invasive	2,792	43	1.5
Transcatheter	548	33	6.0
<b>Tricuspid valve</b>			
Sternotomy	428	50	11.7
Minimal invasive	133	6	4.5
Transcatheter	5	2	40.0
<b>Pulmonary valve</b>			
Sternotomy	50	1	2.0
Minimal invasive	2	0	0.0
Transcatheter	0	0	–
Total	27,591	1,011	3.7

Notes: The absolute quantity of isolated aortic valve procedures via sternotomy remained on a constant level counting 11,881 in 2014 compared with 11,891 procedures in 2013.

A total of 2,792 (47.2%) mitral valve procedures were performed by a minimally invasive access.

Transcatheter procedures and apical aortic conduits procedures (*n* = 1) are not included.

**Table V4** Isolated mitral valve procedures (prosthesis)

Prosthesis/native valve	N	Deaths	%
Mechanical prosthesis	488	34	7.0
Xenograft	1,530	145	9.5
Homograft	8	1	12.5
Reconstruction	3,887	63	1.6
Total	5,913	243	4.1

Notes: A total of 2,792 (47.2%) were performed via minimally invasive access. Transcatheter procedures are excluded.

**Table V5** Multiple valve procedures (categories)

Combination	N	Deaths	%
Aortic + mitral	1,335	144	10.8
Mitral + tricuspid	1,640	145	8.8
Aortic + tricuspid	220	22	10.0
Tricuspid + pulmonary	11	2	18.2
Aortic + pulmonary <sup>a</sup>	82	1	1.2
Aortic + mitral + tricuspid	369	49	13.3
Aortic + mitral + pulmonary	3	1	33.3
Total	3,660	364	9.9

Note: Transcatheter procedures are excluded.

<sup>a</sup>Including Ross procedures.

**Table V6** Mitral valve surgery—implantation/replacement versus repair

Mitral valve surgery	N	Total deaths	% death	% repair	Implantation/replacement			Repair		
					N	Deaths	% death	N	Deaths	% death
Isolated	5,913	243	4.1	65.7	2,026	180	8.9	3,887	63	1.6
Mitral valve + aortic valve	1,335	144	10.8	47.0	707	104	14.7	628	0	0.0
Tricuspid valve repair <sup>a</sup>	1,602	137	8.6	65.5	552	1	0.2	1,050	81	7.7
CABG	2,630	256	9.7	70.1	787	124	15.8	1,843	132	7.2
CABG + aortic valve replacement	658	113	17.2	55.9	290	58	20.0	368	55	14.9
Total	12,138	893	7.4	64.1	4,362	467	10.7	7,776	331	4.3

<sup>a</sup>Thirty-eight procedures (not specified mitral valve + tricuspid valve surgery) are excluded. Deaths: 21.1 (8/38).

**Table V7** Transcatheter heart valve procedures

	Total	Deaths	% death	With ECC		Without ECC	
				N	Deaths	N	Deaths
Aortic valve implantation	8,631	351	4.1	136	38	8,495	313
Transvascular	5,570	184	3.3	58	18	5,512	166
Transapical	3,061	167	5.5	78	20	2,983	147
Mitral valve	548	33	6.0	30	7	518	26
Repair	457	19	4.2	21	1	436	18
Implantation	91	14	15.4	9	6	82	8
Tricuspid valve repair	5	2	40.0	0	—	5	2
Repair	2	1	50.0	0	—	2	1
Implantation	3	1	33.3	0	—	3	1
Aortic + mitral valve implantation	10	1	10.0	4	0	6	1
Aortic valve implantation <sup>a</sup> + CABG	46	12	26.1	17	6	29	6
Mitral valve implantation <sup>b</sup> + CABG	2	1	50.0	1	1	1	0
Total	9,242	400	4.3	188	52	9,054	348

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

Notes: Pulmonary valve implantations for the correction of congenital heart defects are not included; no procedure for adults without congenital lesion was reported; 35.5% of transcatheter aortic valve implantations (TAVIs) were performed by transapical access; 1.6% of TAVI procedures were performed using ECC. It has to be assumed that use of ECC is mostly an emergent procedure in a life-threatening situation for the patient resulting in an observed mortality of 27.9% in this group. Nevertheless, this underlines the necessity of well-defined directives including infrastructure, processes, and qualified employees for invasive heart valve procedures (e.g., TAVI).

<sup>a</sup>Femoral, subclavian, or transaortic access.

<sup>b</sup>Transvascular and transapical access.

**Table Con1** Congenital heart surgery with/without ECC

Age (y)	N	Deaths	%
Without ECC			
≥ 18	37	0	0.0
1–17	195	0	0.0
< 1	792	24	3.0
Total	1024	24	2.3
With ECC			
≥ 18	934	26	2.8
1 to 17	1731	11	0.6
< 1	2090	59	2.8
Total	4755	96	2.0

Abbreviation: ECC, extracorporeal circulation.

**Table Con2** Procedures for congenital heart disease with and without ECC

Lesion	Age < 1 y			Age 1–17 y			Age ≥18 y		
	N	Deaths	%	N	Deaths	%	N	Deaths	%
ASD	52	1	1.9	263	0	0.0	266	4	1.5
Complete AV-canal	193	6	3.1	77	2	2.6	24	1	4.2
VSD	318	3	0.9	89	0	0.0	18	0	0.0
Fallot tetralogy	202	2	1.0	30	1	3.3	1	0	0.0
DORV	49	0	0.0	23	1	4.3	0	–	–
TGA	142	2	1.4	6	0	0.0	0	–	–
TGA + VSD	62	2	3.2	17	0	0.0	1	0	0.0
Truncus arteriosus	42	2	4.8	5	0	0.0	0	–	–
Fontan	1	0	0.0	232	1	0.4	6	0	0.0
Norwood	160	19	11.9	0	–	–	0	–	–
Pulmonary valve	58	1	1.7	249	0	0.0	86	1	1.2
Transcatheter pulmonary valve implantation	0	–	–	7	0	0.0	14	0	0.0
Aortic valve	59	0	0.0	215	0	0.0	304	9	3.0
Ross procedure	10	3	30.0	27	0	0.0	13	1	7.7
Mitral valve	48	0	0.0	111	1	0.9	88	6	6.8
Tricuspid valve	88	1	1.1	70	0	0.0	42	4	9.5
PDA	251	5	2.0	13	0	0.0	2	0	0.0
Coarctation	202	1	0.5	35	0	0.0	9	0	0.0
Heart transplant	4	0	0.0	25	0	0.0	0	–	–
Heart + lung transplant	0	–	–	0	–	–	0	–	–
Lung transplant	0	–	–	10	–	0.0	0	–	–
Others	962	35	3.6	451	6	1.3	97	0	0.0
Total	2903	83	2.9	1955	12	0.6	971	26	2.7

Abbreviations: ASD, atrial septal defect; DORV, double outlet right ventricle; ECC, extracorporeal circulation; PDA, persistent ductus arteriosus; TGA, transposition of great arteries; VSD, ventricular septal defect.

**Table C1** Isolated CABG and combined procedures with ECC

Procedures	N	Deaths	%
CABG	40,006	1,042	2.6
CABG +			
Aortic valve replacement	7,809	382	4.9
Mitral valve repair	1,843	132	7.2
Mitral valve replacement	787	124	15.8
Aortic valve replacement + mitral valve repair	368	55	14.9
Aortic + mitral valve replacement	290	58	20.0
Aneurysmal resection	152	5	3.3
Transcatheter aortic valve implantation	46	12	26.1
TMLR	0	–	–
Other	2,502	131	5.2
Total	53,803	1,941	3.6

Abbreviations: CABG, coronary artery bypass grafting; ECC, extracorporeal circulation; TMLR, transmyocardial laser revascularization.

**Table C2** Isolated CABG with ECC

Number of grafts	N	Deaths	%
Single	1,193	63	5.3
Double	7,146	243	3.4
Triple	15,018	401	2.7
Quadruple	8,099	182	2.2
Quintuple + more	2,422	54	2.2
Total	33,878	943	2.8

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

**Table C3** Isolated CABG off-pump

Number of grafts	N	Deaths	%
Single	1,361	17	1.2
Double	1,765	42	2.4
Triple	2,092	29	1.4
Quadruple	751	8	1.1
Quintuple + more	159	3	1.9
Total	6,128	99	1.6

Abbreviation: CABG, coronary artery bypass grafting.

**Table Mis1** Ross procedures (age groups)

Autologous AVR and PVR	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
In patients $\geq$ 18 y	235	228	261	207	175	184	134	117	107	90
In patients < 18 y	46	50	34	42	54	43	40	36	33	37
Total	281	278	295	249	229	227	174	153	140	127

**Table Mis2** Heart and lung transplantation

	With ECC			Without ECC		
	N	Deaths	%	N	Deaths	%
HTx	294	33	11.2			
HLTx	9	4	44.4			
LTx	62	7	11.3	244	13	5.3

Abbreviation: ECC, extracorporeal circulation.

Notes: All pediatric transplantations (demonstrated in table Con3) are included in this table.

Eurotransplant (ET) has reported for the same period 292 heart transplantations (HTx), 3 heart + kidney transplantations, 0 heart + liver transplantations, 9 heart–lung transplantations (HLTx), 296 double lung (DLTx), 46 single lung transplantations (SLTx), 0 lung + kidney transplantations, and 1 lung + liver transplantations.

**Table Mis3** Aortic surgery

Replacement <sup>a</sup>	With ECC			Without ECC		
	N	Deaths	%	N	Deaths	%
Supracoronary ascending aorta	1,560	118	7.6			
Supracoronary ascending aorta+ AVR	1,218	47	3.9			



**Table Mis3** (Continued)

Replacement <sup>a</sup>	With ECC			Without ECC		
	N	Deaths	%	N	Deaths	%
Infracoronary ascending aorta						
Mechanical heart valve conduits	456	22	4.8			
Biological heart valve conduits	891	98	11.0			
David procedure	493	7	1.4			
Yacoub procedure	117	7	6.0			
Other	267	15	5.6			
Aortic arch <sup>b</sup>	1,968	241	12.2			
Descending aorta	68	14	20.6	6	1	16.7
Thoracoabdominal aorta	76	10	13.2	18	7	38.9
Endostent descending aorta	3	1	33.3	614	35	5.7
Total	7,117	580	8.1	638	43	6.7

Notes: All procedures involving aortic surgery are included in this table (Isolated and all possible combined procedures, e.g., additional coronary artery bypass grafting).

<sup>a</sup>Procedures for abdominal aortic diseases are not included: 549 abdominal procedures and 609 endovascular abdominal stents.

<sup>b</sup>All possible combined procedures are included in this category; the only common denominator is aortic arch surgery.

**Table Mis4** Pacemaker and ICD procedures

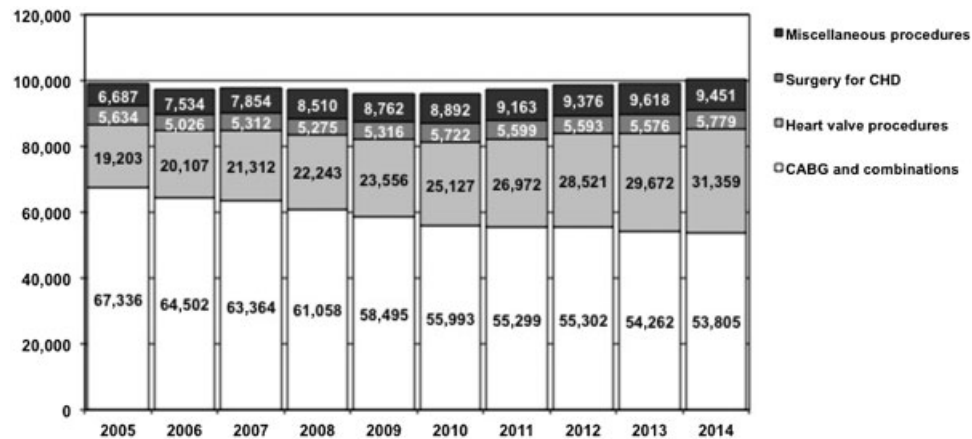
Device/category	N	Deaths	% death	With ECC		Without ECC	
				N	Deaths	N	Deaths
Pacemaker	14,398	97	0.7	14	3	14,384	94
Implantation	9,299	67	0.7	0	0	9,299	67
Battery exchange	2,033	0	0.0	0	0	2,033	0
Revision	3,066	30	1.0	14	3	3,052	27
ICD	10,104	73	0.7	25	4	10,079	69
Implantation	4,660	17	0.4	0	0	4,660	17
Battery exchange	2,031	4	0.2	0	0	2,031	4
Revision	3,413	52	1.5	25	4	3,388	48
Miscellaneous	1,750	10	0.6	1	1	1,749	9
Total	26,252	180	0.7	40	8	26,212	172

**Table Mis5** Surgical ablation procedures for arrhythmia

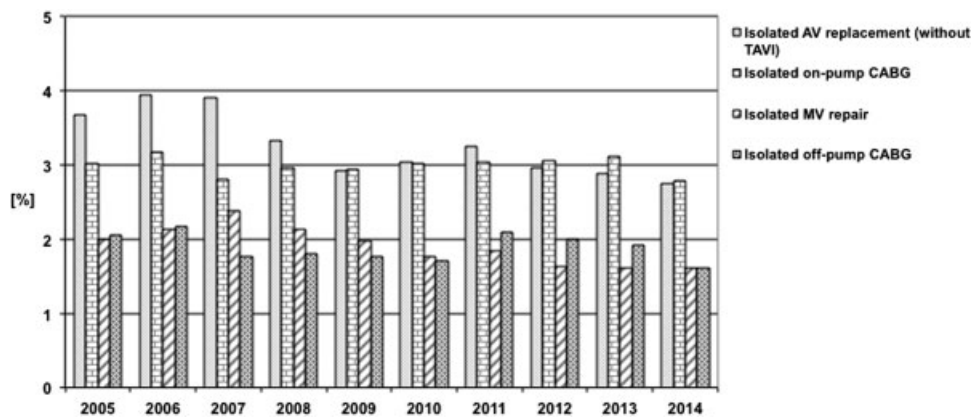
	Total	Endocardiac (n)	Epicardiac (n)
Energy source			
Unipolar radiofrequency	205	92	113
Unipolar cryo-radiofrequency	329	201	128
Bipolar radiofrequency	2,396	312	2,084
Cryotherapy	1,760	1,464	296
Microwave	17	4	13
Focused ultrasound	224	28	196
Laser	0	0	0
Other	20	7	13
Total	4,951	2,108	2,843

Notes: All isolated ablation procedures and all possible combination of procedures (e.g., coronary artery bypass grafting + ablation) are included. A total of 484 procedures are not specified with regard to endocardiac/epicardiac ablation.

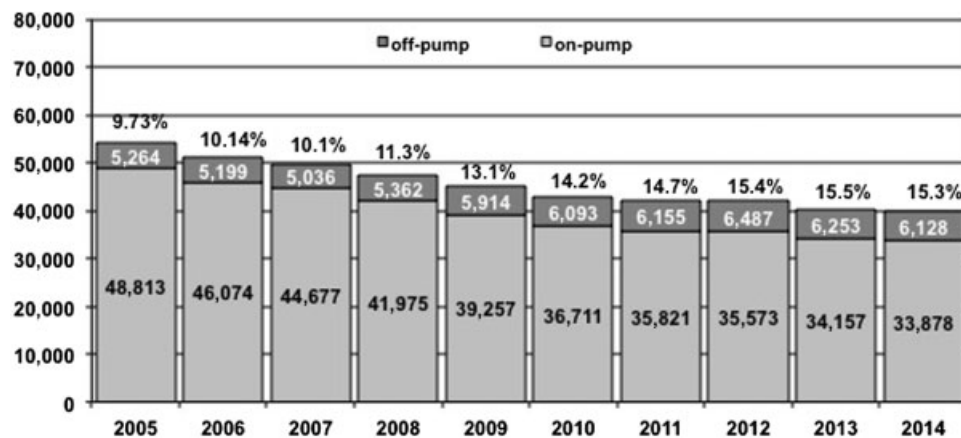




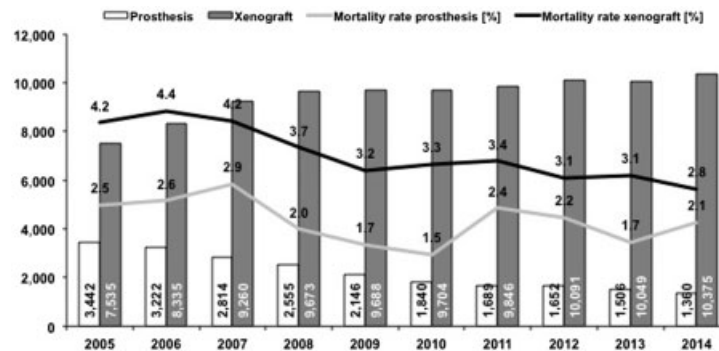
**Fig. 1** Cardiac surgery in Germany (2005–2014). (1) Coronary artery bypass grafting (CABG) and combinations: all types of isolated coronary surgery with or without extracorporeal circulation (ECC) and any combined procedure. (2) Heart valve procedures: all types of isolated heart valve surgery; heart 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.



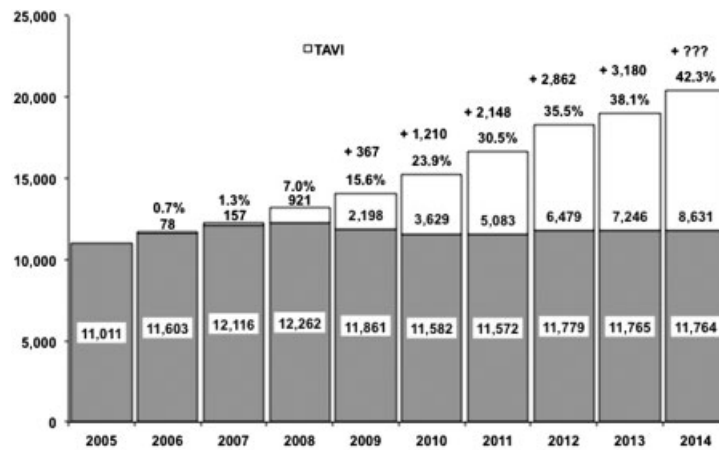
**Fig. 2** Unadjusted mortality for selected procedures (2005–2014).



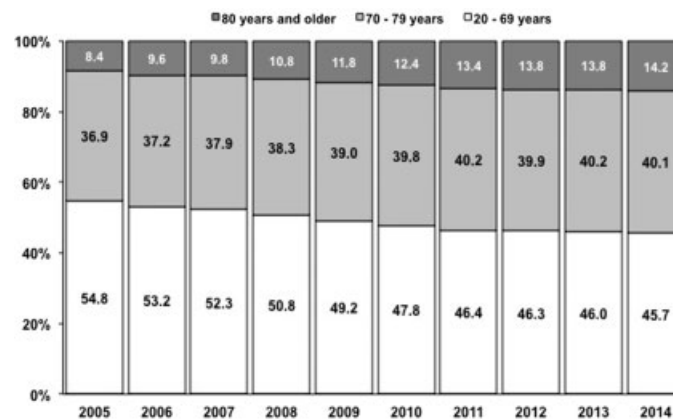
**Fig. 3** Isolated coronary artery bypass grafting (CABG) (2005–2014). The quantity of coronary artery bypass procedures declined since the year 2005 while the CABG off-pump procedures reached a nearly constant level of 15.3%.



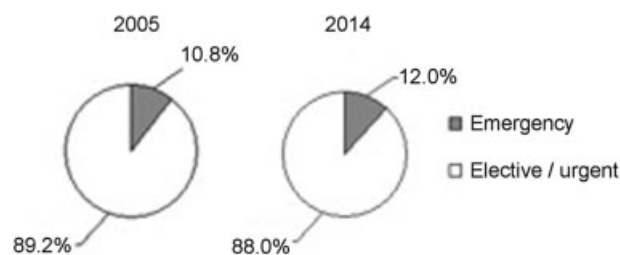
**Fig. 4** Isolated aortic valve replacement (2005–2014). The use of xenografts continuously increased till 2008 and reached a stable count since then. AVR implanting mechanical prosthesis decreased over the past 10 years. The observed difference in patients' mortality was probably based on the difference in age pattern and related comorbidities (Ross procedure, homograft implantations, and transcatheter aortic valve implantation are excluded).



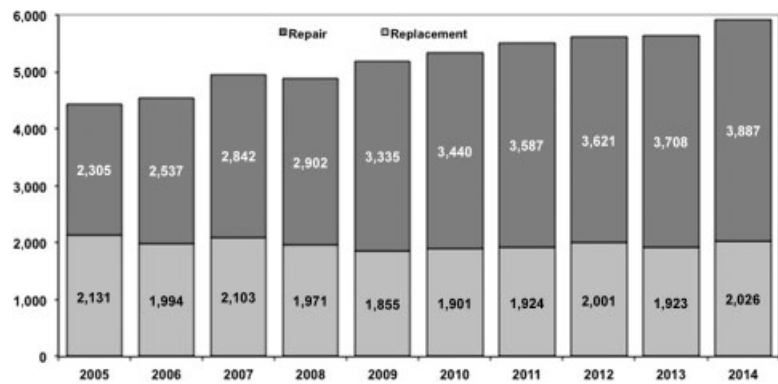
**Fig. 5** Isolated AVR and transcatheter aortic valve implantation (TAVI). The figure shows a stable quantity of AVR procedures and a continuous increase of TAVI. In 2014, 8,631 TAVI were reported to the voluntary registry of the GSTCVS; however, this number does not represent all TAVI procedures performed in Germany in 2014. +Additional patients with TAVI procedures calculated from the German legal quality assurance program, § 137 SGB V.



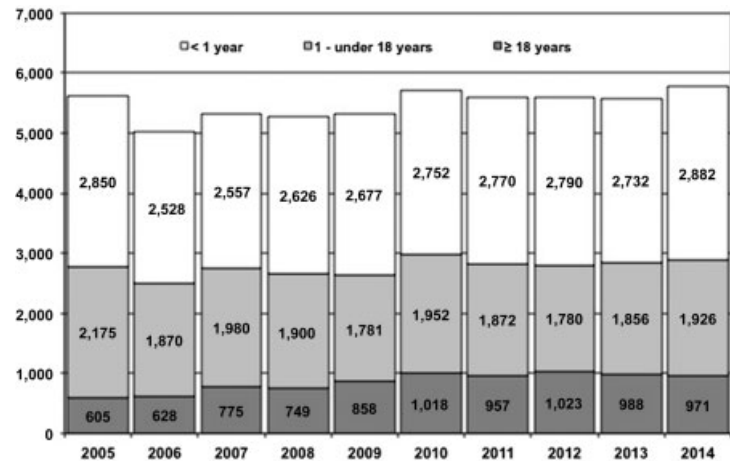
**Fig. 6** Age distribution of cardiac procedures (2005–2014). In 2014, 54.3% of the patients are at least 70 years (patients < 20 years and ICD/pacemaker procedures excluded).



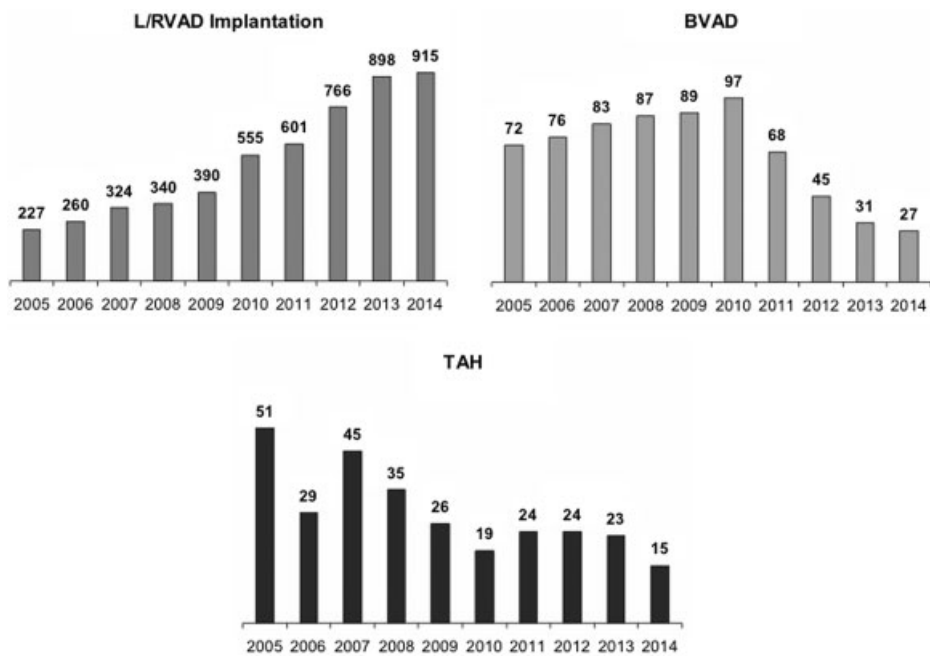
**Fig. 7** Procedures timing (2005 vs. 2014).



**Fig. 8** Isolated mitral valve surgery (2005–2014). In 2014, 65.7% MV reconstructions and 34.3% MV replacements were performed. Two decades ago, the repair rate was only 21%.



**Fig. 9** Age distribution for congenital heart surgery (2005–2014). There are no relevant changes over the past 10 years. However, there may be a bias because not all relevant procedures can be allocated clearly to the congenital heart surgery category for patients older than 18 years (e.g., aortic valve disease).



**Fig. 10** Development of mechanical circulatory support (2005–2014). Continuous increase of left ventricular assist device (LVAD) implantations. However, the number of implanted paracorporeal biventricular assist devices (BVAD) decreases furthermore and the count of total artificial heart implantations (TAH) dropped down to 15 in 2014.

## 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 Kalmar P, Irrgang E. Cardiac surgery in Germany during 2000. *Thorac Cardiovasc Surg* 2001;49(5):33–38
- 13 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
- 14 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
- 15 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
- 16 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
- 17 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
- 18 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
- 19 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
- 20 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
- 21 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
- 22 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
- 23 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
- 24 Beckmann A, Funkat AK, Lewandowski J, et al. Cardiac surgery in Germany during 2012: a report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2014;62(1):5–17
- 25 Funkat A, Beckmann A, Lewandowski J, et al. Cardiac surgery in Germany during 2013: a report on behalf of the German Society for Thoracic and Cardiovascular Surgery. *Thorac Cardiovasc Surg* 2014;62(5):380–392
- 26 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, 1410.e1, discussion 1408–1410
- 27 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
- 28 G-BA Richtlinie zu minimalinvasiven Herzklappeninterventionen. Available at: <https://www.g-ba.de/informationen/beschluesse/2165/>
- 29 Beckmann A, Hamm C, Figulla HR, et al; GARY Executive Board. The German Aortic Valve Registry (GARY): a nationwide registry for patients undergoing invasive therapy for severe aortic valve stenosis. *Thorac Cardiovasc Surg* 2012;60(5):319–325
- 30 Hamm CW, Möllmann H, Holzhey D, et al; GARY-Executive Board. The German Aortic Valve Registry (GARY): in-hospital outcome. *Eur Heart J* 2014;35(24):1588–1598
- 31 Mohr FW, Holzhey D, Möllmann H, et al; GARY Executive Board. The German Aortic Valve Registry: 1-year results from 13,680 patients with aortic valve disease. *Eur J Cardiothorac Surg* 2014;46(5):808–816
- 32 Lauten A, Figulla HR, Möllmann H, et al; GARY Executive Board. TAVI for low-flow, low-gradient severe aortic stenosis with preserved or reduced ejection fraction: a subgroup analysis from the German Aortic Valve Registry (GARY). *EuroIntervention* 2014;10(7):850–859
- 33 Walther T, Hamm CW, Schuler G, et al; GARY executive board. Peri-operative results and complications in 15,964 transcatheter aortic valve implantations from the German Aortic valve Registry (GARY). *J Am Coll Cardiol* 2015. doi: 10.1016/j.jacc.2015.03.034
- 34 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

Table V1 has been corrected in the above article as per erratum published online on June 10, 2015. DOI of erratum is: 10.1055/s-0035-1556566.