

Cardiac Surgery in Germany during 2013: A Report on Behalf of the German Society for Thoracic and Cardiovascular Surgery

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Abstract

Keywords

- cardiac surgery
- outcome
- registry
- congenital heart disease
- aortic surgery
- 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 2013 are presented. In 2013, a total of 99,128 cardiac surgical procedures (implantable cardioverter defibrillator [ICD] and pacemaker procedures excluded) were submitted to the registry. More than 13.8% of the patients were older than 80 years, which remains equal in comparison to the previous year. In-hospital mortality in 40,410 isolated coronary artery bypass grafting procedures (84.5% on-pump and 15.5% off-pump) was 2.9%. In 29,672 isolated valve procedures (including 7,722 catheter-based procedures), an in-hospital mortality of 4.7% 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 (GSTCVS) (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.^{1–24} 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 invasive mitral valve operations and also innovative technologies such as transapical or transvascular aortic valve implantation (TAVI). 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 2013.

Materials and Methods

Since 2004, a standardized questionnaire gathers detailed information about each individual procedure exactly defined

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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 20, 2014, 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 had to be addressed to the office of the GSTCVS. After transaction, the data were decrypted, 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 the complete dataset.

Inclusion criteria for the registry 2013 were all patients receiving cardiac surgical procedures performed between January 1, 2013, and December 31, 2013, 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 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 2013, a total of 79 institutions performed heart surgery. Fortunately, all units answered the questionnaire and delivered a complete dataset for the year 2013 including hospital mortality rates.

Registry Data 2013

► **Table 1** illustrates the development of procedures using extracorporeal circulation (ECC) over one decade in Germany. Since 2010, the count of heart operations using ECC remains on a stable level.

Overall, 180,367 procedures were reported to the registry for the year 2013, an increase of 1.5% (2012: 177,694 procedures). A total of 102,845 cardiac surgical procedures (excluded: implantable cardioverter defibrillator (ICD), pacemakers, and miscellaneous procedures without ECC) display an increase of 0.94% ($n = 958$) compared with the year 2012 (101,887 procedures) (► **Table 2**). ► **Tables 3 to 6, V1 to V7, C1 to C3, Con1 and Con2, Mis1 to Mis5**, and ► **Figs. 1 to 9** demonstrate the compiled registry data of 2013 for various categories.

Compared with the data of previous years, several important developments continued in 2013 almost unchanged. Over the past 10 years, the distribution of patient age (► **Fig. 6**) showed a shift to older patients with presently 54.0% 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 decade (see ► **Fig. 2**). The rate of CABG decreased over the past years, while the relative number of off-pump CABG showed a slight increase to 15.5% (2012: 15.4%) (► **Fig. 3**).

Since 2004, more than 50% of isolated mitral valve procedures are reconstructions, in 2013 mitral valve reconstruction could be achieved in 65.8% 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 al²⁵ patients with mitral valve stenosis, endocarditis, and emergency procedures were excluded. Therefore, the published rate of mitral valve repair must be interpreted with caution compared with this registry.

The continued increase of left ventricular assist device implantations (► **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

Table 1 Open heart procedures under use of ECC in Germany from 2004 to 2013

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Units	79	79	80	80	79	80	79	78	79	79
Operations	96,340	91,967	91,057	91,618	89,773	86,916	84,686	84,402	84,388	84,040
Average per unit	1,219	1,164	1,138	1,145	1,136	1,086	1,072	1,082	1,068	1,064

Abbreviation: ECC, extracorporeal circulation.

Table 2 Cardiac surgery categories 2013 compared with 2012

	With ECC	Without ECC	Total	% change
Heart valve procedures	22,119	7,553	29,672	+ 4.0
Coronary artery bypass grafting	47,582	6,680	54,262	– 1.9
Surgery for CHD	4,721	855	5,576	– 0.3
Surgery of thoracic aorta	7,045	626	7,671	+ 3.9
Cardiac surgery other	1,394	1,225	2,619	+ 5.9
Assist device procedures	791	1,866	2,657	+ 1.5
Pacemaker and ICD procedures	59	25,679	25,738	+ 2.0
Extracardiac surgery	329	51,843	52,172	+ 3.2
Total	84,040	96,327	180,367	+ 1.5

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

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

Procedure volume	< 500	500–999	1,000–1,499	1,500–1,999	2,000–5,000
Units	7	25	26	12	9
Min–max	237–451	557–995	1,028–1,487	1,538–1,987	2,075–3,754
Average per unit	355	808	1,201	1,723	2,727

Abbreviation: ECC, extracorporeal circulation.

Table 4 Total number of units according to surgical procedures in 2013

	Units
Coronary artery bypass grafting	78
Heart valve surgery	78
Surgery for CHD in children < 1 y with ECC ^a	24 ^a
Heart transplantation ^b	22 ^b
Heart–lung transplantation	4

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

^a*n* = 2,047; thereof: 2–16 operations in three units, 26–41 operations in seven units, 58–98 operations in six units, and 114–318 operations in eight units.

^b*n* = 301; 67% of the heart transplantations (HTx) in 2013 were performed by 7 of 24 units with ≥ 15 HTx per year; thereof: 1–4 transplantations in eight units, 5–9 transplantations in five units, 10–17 transplantations in six units, and 22–75 transplantations in five units.

Table 5 Additional data for procedures with ECC in 2013 compared with 2012

	2013		2012	
Emergency operations	11,944	11.6%	11,878	11.6%
Redo procedures	8,284	8.1%	8,424	8.2%
Age > 69 y ^a	98,042	54.0%	97,572	53.7%

Abbreviation: ECC, extracorporeal circulation.

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

^aPatients < 20 years are excluded.

Table 6 Gender distribution

Male/female distribution	Male (%)	Female (%)
All procedures	66	34
Heart valve procedures	55	45
Coronary artery bypass grafting	76	24
Surgery for CHD	55	45
Surgery of thoracic aorta	68	32
Cardiac surgery other	48	52
Assist device procedures	73	27
Pacemaker and ICD procedures	64	36
Extracardiac surgery	65	35

Abbreviation: CHD, congenital heart disease.

Note: Coronary artery bypass surgery (47,582 on-pump and 6,680 off-pump procedures) and all procedures for congenital heart surgery are included in this table.

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 2013 a total of 7,246 (38.1%) TAVI were reported to the registry. 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 does not correlate to the recommendations of the European guideline on the management of valvular heart disease, version 2012.²⁶

In this context, the short-, mid-, and long-term results of the German Aortic Valve Registry^{27,28} 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	18,108	622	3.4
Double	3,363	285	8.5
Triple	380	52	13.7
Single transcatheter access	7,712	434	5.6
Double transcatheter access	10	1	10.0
Unspecified	99	6	6.1
Total	29,672	1,400	4.7

Notes: Combined procedures (with CABG, aortic surgery) are excluded. Transcatheter valve procedures: 7,246 aortic valve implantations; 58 mitral valve implantations; 404 mitral valve repairs, 3 tricuspidal valve repairs, 10 combined aortic and mitral valve procedures, and 1 pulmonary valve implantation.

Table V2 Access type in single valve procedures

Position	N	Deaths	%
Aortic valve			
Sternotomy	9,541	294	3.1
Partial sternotomy	2,350	46	2.0
Transvascular	4,360	200	4.6
Transapical	2,886	219	7.6
Mitral valve			
Sternotomy	3,083	199	6.5
Minimal invasive	2,548	30	1.2
Transcatheter	462	14	3.0
Tricuspidal valve			
Sternotomy	424	45	10.6
Minimal invasive	131	8	6.1
Transcatheter	3	1	33.3
Pulmonary valve			
Sternotomy	31	0	0.0
Minimal invasive	0	–	–
Transcatheter	1	0	0.0
Total	25,820	1,056	4.1

Notes: A total of 2,548 (45.2%) mitral valve procedures were performed by a minimally invasive access. The number of isolated aortic valve procedures by sternotomy remained on the same level counting 11,906 procedures in 2012 and 11,891 in 2013.

Table V3 Isolated aortic valve procedures

	N	Deaths	%
Mechanical prosthesis	1,506	26	1.7
Xenograft	10,049	311	3.1
Homograft	210	2	1.0
Repair	122	1	0.8
Total	11,887	340	2.9

Notes: A total of 2,349 procedures (19.8%) were performed via partial sternotomy. Transcatheter procedures and apical aortic conduit procedures were not included.

Table V4 Isolated mitral valve procedures

	N	Deaths	%
Mechanical prosthesis	486	36	7.4
Xenograft	1,432	133	9.3
Homograft	5	0	0.0
Repair	3,708	60	1.6
Total	5,631	229	4.1

Notes: A total of 2,548 procedures (45.2%) were performed via minimally invasive access. Transcatheter procedures were excluded.

Table V5 Multiple heart valve procedures

Combinations	N	Deaths	%
Aortic + mitral	1,420	129	9.1
Mitral + tricuspid	1,618	140	8.7
Aortic + tricuspid	219	13	5.9
Tricuspid + pulmonary	17	2	11.8
Aortic + pulmonary ^a	89	1	1.1
Aortic + mitral + tricuspid	380	51	13.4
Aortic + mitral + pulmonary	0	0	–
Total	3,743	336	9.0

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 2013. The accuracy of this registry is considered to be high due to the implemented compilation algorithm using 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.²⁹ 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 continuous

Table V6 Mitral valve surgery—implantation/replacement versus repair

Mitral valve surgery	N	Total deaths	% death	% repair	Replacement			Repair		
					N	Deaths	% death	N	Deaths	% death
Isolated	5,631	229	4.1	65.8	1,923	169	8.8	3,708	60	1.6
Mitral valve +										
Aortic valve	1,420	129	9.1	46.8	756	99	13.1	664	0	0.0
Tricuspid valve repair ^a	1,559	127	8.1	63.4	571	1	0.2	988	87	8.8
CABG	2,647	239	9.0	71.4	756	100	13.2	1,891	139	7.4
CABG + aortic valve replacement	661	112	16.9	58.5	274	56	20.4	387	56	14.5
Total	11,918	836	7.0	64.1	4,280	425	9.9	7,638	342	4.5

Abbreviation: CABG, coronary artery bypass grafting.

^aFifty-nine procedures (not specified mitral valve + tricuspid valve surgery) were excluded. Deaths: 22.0 (13/59).

Table V7 Transcatheter heart valve procedures

	Total	Deaths	% death	With ECC		Without ECC	
				N	Deaths	N	Deaths
Aortic valve implantation	7,246	419	5.8	161	66	7,085	353
Transvascular ^a	4,360	200	4.6	69	31	4,291	169
Transapical	2,886	219	7.6	92	35	2,794	184
Mitral valve	462	14	3.0	8	2	454	12
Repair	404	13	3.2	4	1	400	12
Implantation ^b	58	1	1.7	4	1	54	0
Tricuspidal valve repair	3	1	33.3	0	0	3	1
Aortic + mitral valve implantation	10	1	10.0	0	0	10	1
Aortic valve implantation ^b + CABG	62	18	29.0	24	12	38	6
Total	7,783	453	5.8	193	80	7,590	373

Abbreviations: CABG, coronary artery bypass grafting; ECC, extracorporeal circulation; TAVI, transapical or transvascular aortic valve implantation. Notes: Pulmonary valve implantation for the correction of congenital lesions are excluded, one procedure was reported for adults without congenital lesion; 39.8% of TAVI procedures were performed by transapical access, 2.2% of TAVI procedures were performed under the use of ECC. It has to be assumed that ECC was mostly used in emergency situations, which explains the mortality of 41.0% 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	40,410	1,187	2.9
CABG +			
TMLR	3	1	33.3
Aneurysm resection	187	9	4.8
Aortic valve replacement	7,893	371	4.7
Transcatheter aortic valve implantation	62	18	29.0
Mitral valve replacement	756	100	13.2
Mitral valve repair	1,891	139	7.4
Aortic + mitral valve replacement	274	56	20.4
Aortic valve replacement + mitral valve repair	387	56	14.5
Other	2,398	134	5.6
Total	54,261	2,071	3.8

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

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

Compared with 2012, 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

Distal anastomosis	N	Deaths	%
Single	1,078	64	5.9
Double	7,113	260	3.7
Triple	14,977	480	3.2
Quadruple	8,247	186	2.3
Quintuple + more	2,742	77	2.8
Total	34,157	1,067	3.1

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

Table C3 Isolated CABG off-pump

Distal anastomosis	N	Deaths	%
Single	1,400	37	2.6
Double	1,780	38	2.1
Triple	2,176	38	1.7
Quadruple	756	7	0.9
Quintuple + more	141	0	0.0
Total	6,253	120	1.9

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 in sense of a contribution for patient safety and to adduce evidence for quality of cardiac surgery in Germany.

Table Con1 Congenital heart surgery with/without ECC

Age	N	Deaths	%
(A) Without ECC			
Older than 18 y	26	0	0.0
1–17 y	144	3	2.1
Younger than 1 y	685	18	2.6
Total A	855	21	2.5
(B) With ECC			
Older than 18 y	962	27	2.8
1–17 y	1,712	15	0.9
Younger than 1 y	2,047	67	3.3
Total B	4,721	109	2.3

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	35	0	0.0	252	0	0.0	277	7	2.5
Complete AV canal	175	4	2.3	81	1	1.2	17	0	0.0
VSD	302	2	0.7	119	0	0.0	29	2	6.9
Fallot tetralogy	195	2	1.0	42	1	2.4	3	0	0.0
DORV	43	0	0.0	14	0	0.0	1	0	0.0
TGA	150	0	0.0	2	0	0.0	0	0	–
TGA + VSD	48	3	6.3	3	0	0.0	0	0	–
Truncus arteriosus	31	2	6.5	5	0	0.0	0	0	–
Fontan	4	0	0.0	246	3	1.2	6	1	16.7
Norwood	150	22	14.7	0	0	–	0	0	–
Pulmonary valve	66	1	1.5	226	0	0.0	71	2	2.8
Transcatheter pulmonary valve implantation	0	0	–	14	0	0.0	10	0	0.0
Aortic valve	48	3	6.3	195	0	0.0	276	3	1.1
Ross procedure	6	0	0.0	27	0	0.0	20	0	0.0
Mitral valve	41	1	2.4	109	3	2.8	94	5	5.3
Tricuspid valve	76	0	0.0	54	2	3.7	56	2	3.6
PDA	245	5	2.0	13	0	0.0	0	0	–
Coarctation	194	2	1.0	30	0	0.0	8	0	0.0
Transplantation heart	2	0	0.0	33	0	0.0	0	0	–
Transplantation heart + lung	0	0	–	0	0	–	0	0	–
Transplantation lung	0	0	–	12	1	8.3	0	0	–
Others	921	38	4.1	379	7	1.8	120	5	4.2
Total	2,732	85	3.1	1,856	18	1.0	988	27	2.7

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)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
In patients ≥ 18 y	250	235	228	261	207	175	184	134	117	107
In patients < 18 y	50	46	50	34	42	54	43	40	36	33
Total	300	281	278	295	249	229	227	174	153	140

Table Mis2 Organ transplantation

Transplantation	With ECC			Without ECC		
	N	Deaths	%	N	Deaths	%
Heart	301	41	13.6			
Heart + lung	12	4	33.3			
Lung	114	18	15.8	209	10	4.8

Abbreviation: ECC, extracorporeal circulation.

Notes: All pediatric transplantations (demonstrated in ► **Table Con2**) are included in this table. Eurotransplant (ET) has reported for the same period 297 heart transplantations (HTx), 2 heart + kidney transplantations, 1 heart + liver transplantations, 12 heart–lung transplantations (HLT_x), 320 double lung (DLT_x), 38 single lung transplantations (SLT_x), 0 lung + kidney transplantations, and 0 lung + liver transplantations.

Table Mis3 Aortic surgery

Aortic surgery ^a	With ECC			Without ECC		
	N	Deaths	%	N	Deaths	%
Supracoronary ascending aorta replacement	1,634	115	7.0			
Supracoronary ascending + aortic valve replacement	1,280	62	4.8			
Infracoronary ascending aorta replacement			–			
Mechanical valve conduit	490	29	5.9			
Biological valve conduit	872	89	10.2			
David procedure	472	12	2.5			
Yacoub procedure	169	2	1.2			
Other	292	13	4.5			
Aortic arch replacement ^b	1,680	212	12.6			
Replacement of descending aorta	69	5	7.2	11	2	18.2
Thoraco-abdominal aortic replacement	81	13	16.0	26	4	15.4
Endostent descending aorta	6	0	0.0	589	37	6.3
Total	7,045	552	7.8	626	43	6.9

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

Notes: All procedures involving aortic surgery are included in this table. 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: 549 abdominal procedures and 609 endovascular abdominal stents.

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

Table Mis4 Pacemaker and ICD procedures

Device/category	Total	Deaths	% death	With ECC		Without ECC	
				N	Deaths	N	Deaths
Pacemaker total	14,397	104	0.7	29	3	14,368	101
Implantation	9,315	74	0.8	4	2	9,311	72
Battery exchange	2,030	7	0.3	1	0	2,029	7
Revision procedures	3,052	23	0.8	24	1	3,028	22
ICD total	9,942	82	0.8	29	7	9,913	75
Implantation	4,613	24	0.5	0	0	4,613	24
Battery exchange	2,022	2	0.1	0	0	2,022	2
Revision procedures	3,307	56	1.7	29	7	3,278	49
Miscellaneous	1,399	7	0.5	1	0	1,398	7
Total	25,738	193	0.7	59	10	25,679	183

Table Mis5 Surgical ablation procedures

Energy source	Total	Endocardiac		Epicardiac	
		N		N	
Unipolar radiofrequency	166	116		50	
Unipolar cryoradiofrequency	421	246		175	
Bipolar radiofrequency	2,348	296		2,052	
Cryotherapy	1,593	1,387		206	
Microwave	13	2		11	
Focused ultrasound	434	27		407	
Laser	0	0		0	
Other	4	0		4	
Total	4,979	2,074		2,905	

Notes: All isolated ablation procedures and all possible combination of procedures (e.g., CABG + ablation) are included. Total of $n = 379$ procedures are not specified with regard to endocardiac/epicardiac ablation.

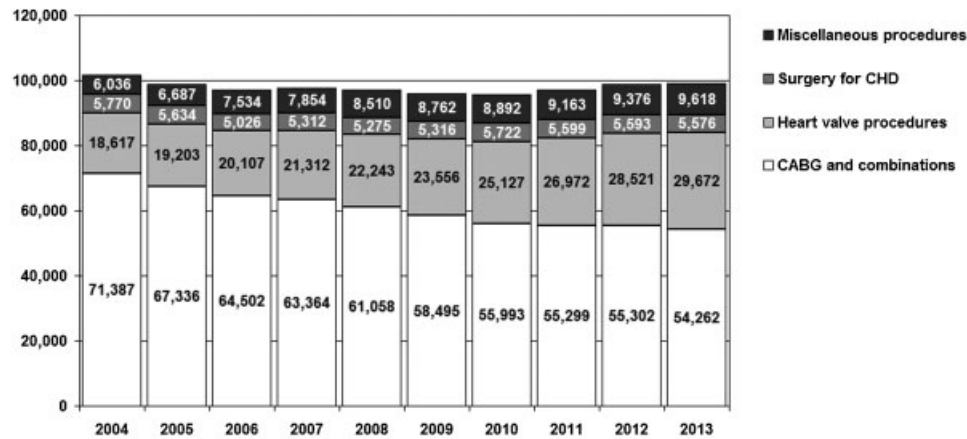


Fig. 1 Cardiac surgery in Germany from 2004 to 2013. (1) Coronary artery bypass grafting (CABG) and combinations: all types of isolated coronary surgery with or without extracorporeal circulation (ECC) and any combined procedure. (2) Valve procedures: all types of isolated heart valve surgery; heart 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.

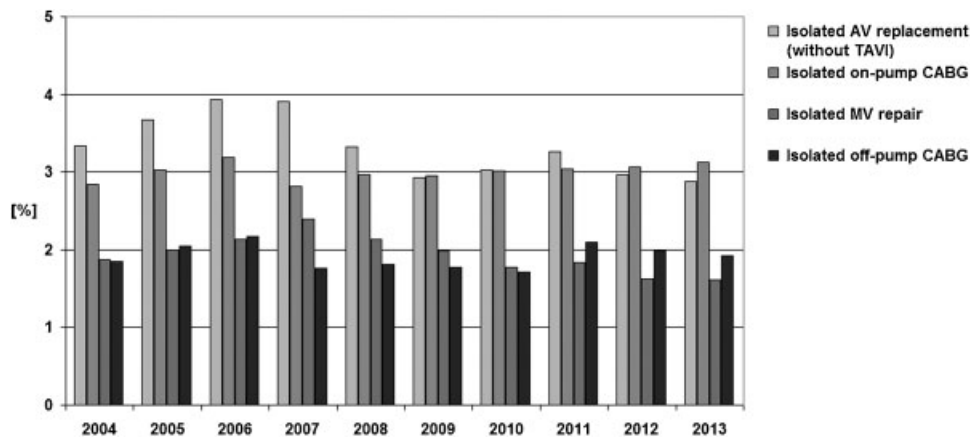


Fig. 2 Unadjusted mortality for selected procedures 2004 to 2013.

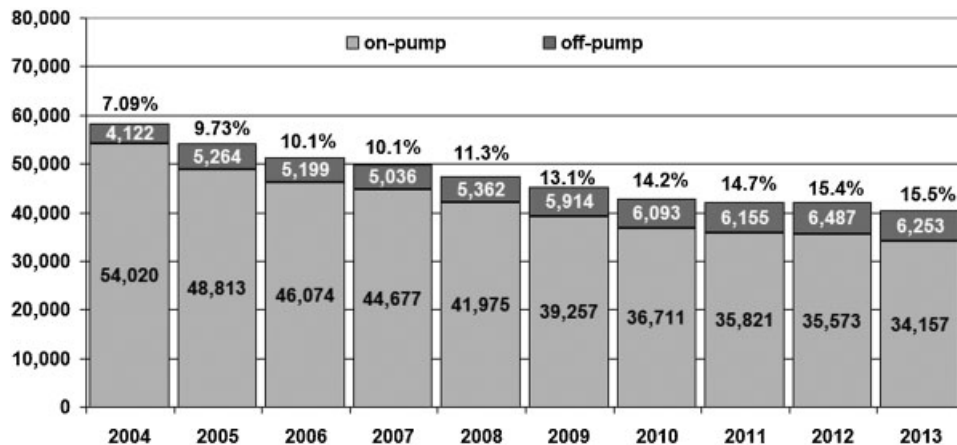


Fig. 3 Isolated coronary artery bypass grafting. The number of coronary artery bypass procedures declined since the year 2004 while the percentage of off-pump procedures slightly increased.

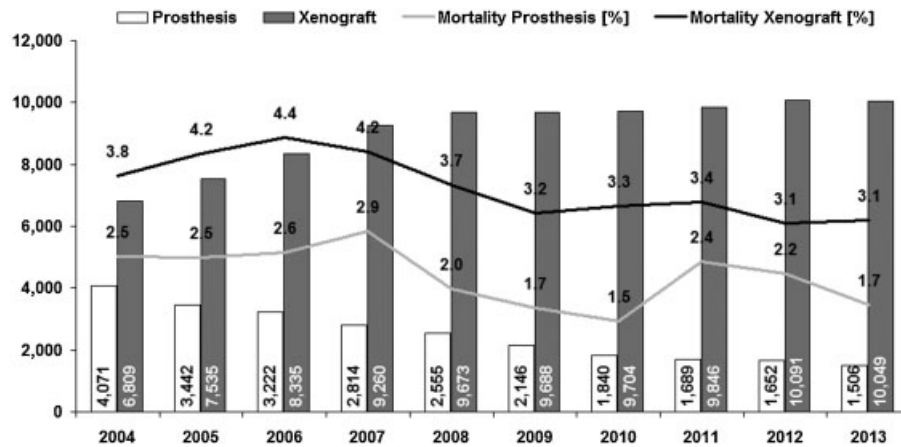


Fig. 4 Isolated aortic valve replacement from 2004 to 2013 in Germany. The use of xenografts continuously increased till 2008 and remained almost the same since then. Aortic valve replacement (AVR) using mechanical prosthesis decreased over the past 10 years. The sustained difference in mortality seems to be related to the difference in age pattern. (Ross, homograft implantations, and transapical or transvascular aortic valve implantation [TAVI] are excluded.)

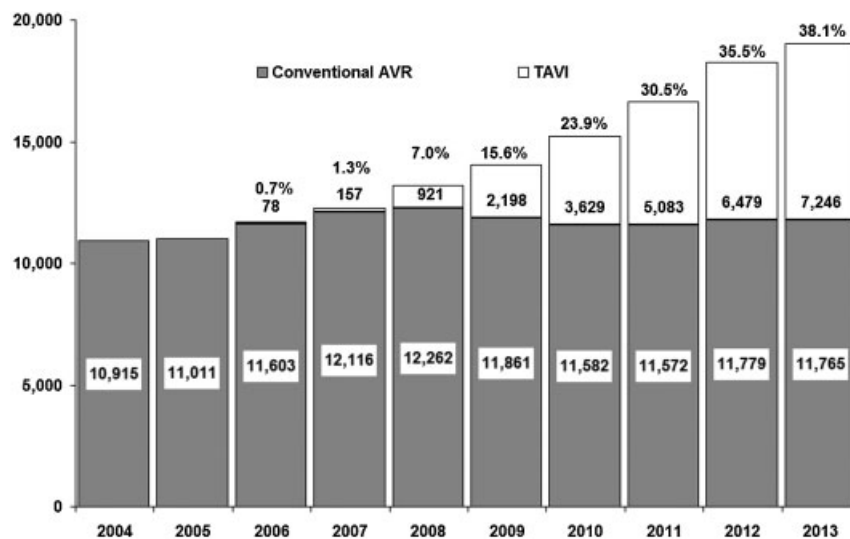


Fig. 5 Isolated AVR and transapical or transvascular aortic valve implantation (TAVI). The figure shows almost unvaried quantity of AVR and an obvious increase of TAVI. In 2013, 38.1% of reported isolated aortic valve procedures were performed by transvascular or transapical implantation.

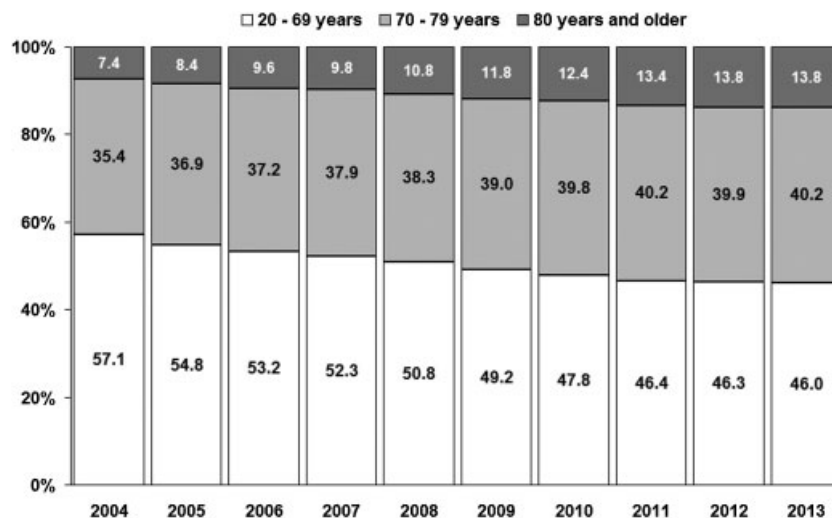


Fig. 6 Age distribution of cardiac procedures since 2004. Currently, 54.0% of the patients are at least 70 years (patients < 20 years and ICD/pacemaker procedures are excluded).

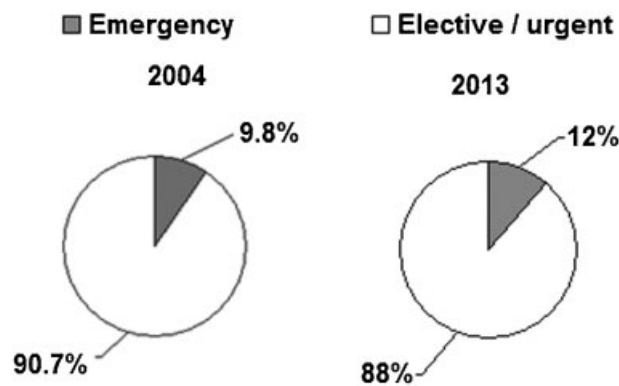


Fig. 7 Urgency 2004 and 2013.

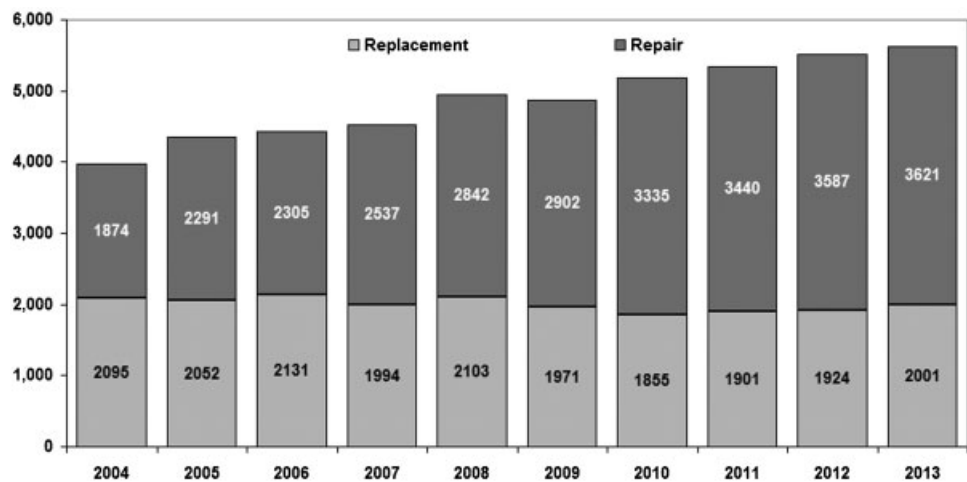


Fig. 8 Isolated mitral valve surgery over the past 10 years. In 65.8% mitral valve (MV) repairs and in 34.2% MV replacements were performed. In 1994, the rate of reconstruction just reached 21%.

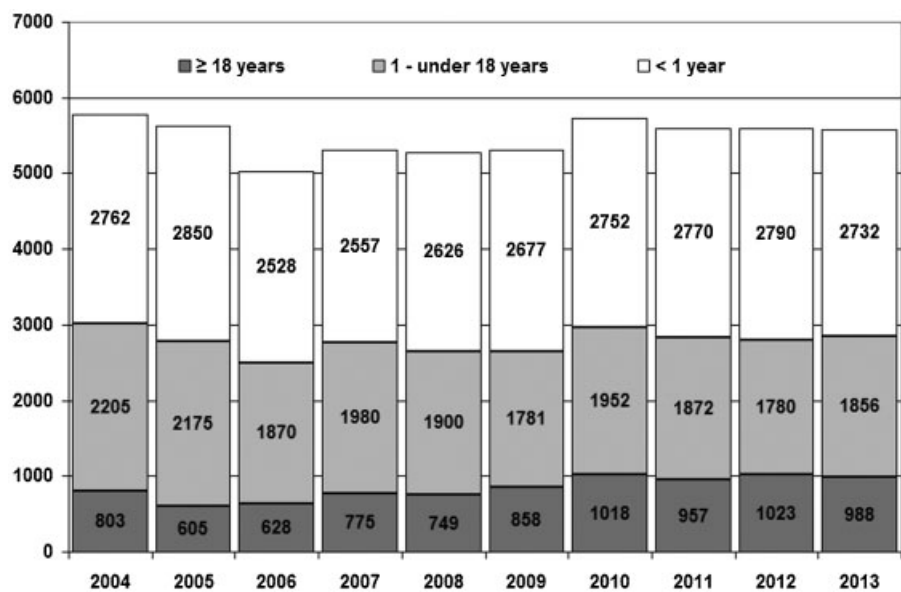


Fig. 9 Age distribution for congenital heart surgery in Germany over the past 10 years. No relevant changes can be observed. However, there may be a bias since not all relevant procedures can be allocated clearly to the congenital heart disease group in patients older than 18 years (e.g., aortic valve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

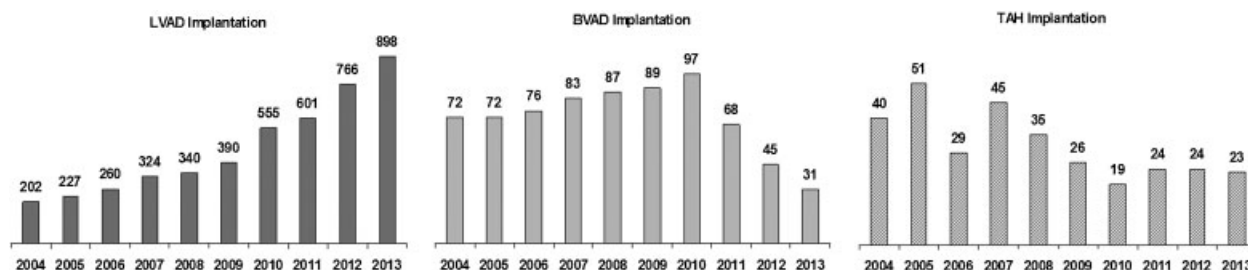


Fig. 10 Development of mechanical circulatory support in Germany over the past 10 years. Significant increase of left ventricular assist device (LVAD) implantations. However, the number of implanted paracorporeal biventricular assist devices (BVAD) dropped down by 68% during the past 4 years. The number of total artificial heart implantations (TAH) remained on the same low level.

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