

Cardiac Surgery in Germany during 2011: A Report on Behalf of the German Society for Thoracic and Cardiovascular Surgery

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Abstract

Keywords

- ▶ cardiac surgery
- ▶ registry
- ▶ heart valve diseases
- ▶ coronary heart disease
- ▶ congenital heart disease
- ▶ vascular surgery
- ▶ organ transplantation
- ▶ heart rhythm disorders

All cardiac surgical procedures performed in 78 German cardiac surgical units throughout the year 2011 are presented in this report, based on a voluntary registry which is organized by the German Society for Thoracic and Cardiovascular Surgery. In 2011, a total of 100,291 cardiac surgical procedures (implantable cardioverter defibrillator and pacemakers procedures excluded) have been collected in this registry. More than 13.4% of the patients were older than 80 years compared with 12.4% in 2010. Hospital mortality in 41,976 isolated coronary artery bypass graft procedures (14.7% off-pump) was 2.9%. In 26,972 isolated valve procedures (including 5,210 catheter-based procedures), an in-hospital mortality of 5.2% has been observed.

This voluntary registry of the German Society for Thoracic and Cardiovascular Surgery will continue to be an important tool enabling quality control and illustrating current facts and the development of cardiac surgery in Germany.

Introduction

Increasing demands for quality control 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 German Society for Thoracic and Cardiovascular Surgery (www.dgthg.de) decided to set up a voluntary registry for cardiac surgical procedures. The aim of this registry continues to illustrate the development of

cardiac surgery in Germany and to allow each individual cardiac surgical unit to compare its own results to the nationwide results.

Innovative technologies as minimal invasive mitral valve surgery, off-pump surgery, and still experimental procedures such as transcatheter (transapical or transvascular) aortic valve implantation (TAVI) (▶ **Table V1**) have been included in the registry to monitor the development in this field, important for the future of patient care.

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The registry data are published once a year since 1989.¹⁻²¹ The following report contains the assorted data for the year 2011.

Materials and Methods

Since 2004, the standardized questionnaire asks for detailed information about each individual procedure exactly defined by one or more operation codes (German Operationen- und Prozedurenschlüssel [OPS]).

All centers had to complete the questionnaire until January 20, 2012, asking for all performed procedures and associated hospital mortality in each institution. The completed questionnaires were sent to the office of the German Society for Thoracic and Cardiovascular Surgery in Berlin, and were evaluated for completeness and compiled for further analysis, thus ensuring anonymity for the individual center. The compilation algorithm guarantees a high compliance for submission of the complete dataset.

Inclusion criteria for the registry 2011 were all individual surgical procedures performed between January 1, 2011 and December 31, 2011, unrelated to admission or discharge dates as compared with other registries.

Alike to all previous reports, the number of procedures was counted, not individual patients, for example, a patient requiring additional coronary surgery due to a complication after aortic valve replacement during the same admission would be

counted in the category "aortic valve replacement" and in the category "coronary surgery." Thus the registry contains more procedures than the actual number of patients operated on.

Mortality was defined as in-hospital mortality. As per the definition, the observed mortality was attributed to the first heart surgical procedure, for example, the death of a patient requiring additional coronary artery bypass grafting (CABG) due to a complication after aortic valve replacement during the same admission would be attributed only to the aortic valve but not to the coronary surgery group.

The main reason for this structural setup of the registry, like in previous years, was getting detailed information on all performed procedures and not only counting the number of the treated patients. Another reason was to simplify the process of data acquisition thus enabling all cardiac surgery units in Germany, the submission of a complete dataset, regardless of their existing hardware and software.

In 2011, a total of 79 units performed heart surgery, 78 units answered the questionnaire and delivered a complete dataset for the year 2011 including hospital mortality rates. Due to technical reasons, one unit with ~200 cases could not deliver the data.

Registry Data 2011

► **Table 1** demonstrates the development of procedures using cardiopulmonary bypass (CPB) over the past 30 years in

Table 1 Frequency in Open Heart Procedures in Germany from 1978 to 2011 (1978 to 1985: Federal Republic of Germany [West Germany] Only)

Year	1978	1980	1985	1990	1995	2005	2007	2008	2009	2010	2011
Total Number of Units	21	21	33	46	76	79	80	79	80	79	78
Total Number of Operations	8365	10680	21705	38783	78184	91967	91618	89773	86916	84686	84402
Average Per Unit	398	509	658	843	1029	1164	1145	1136	1086	1072	1082

Table 2 Total Results of All 78 Units Performing Cardiac Surgery in 2011

Category	With CPB	Without CPB	Total	% Change
Valve Procedures	21887	5085	26972	+ 7.3
Coronary Surgery	48743	6556	55299	- 1.2
Congenital Heart Surgery	4609	990	5599	- 2.1
Surgery of Thoracic Aorta	6658	543	7201	+ 6.4
Other Cardiac Surgery	1300	1330	2630	+ 1.9
Assist Devices	724	1385	2109	+ 9.6
Pacemaker and ICD	76	25929	26005	+ 4.6
Extracardiac Surgery	405	47127	47532	+ 8.9
Total	84402	88945	173347	+ 4.0

ICD, implantable cardioverter defibrillator; CPB, cardiopulmonary bypass.
Note: The % indicates changes compared with 2010.

Table 3 Distribution of Individual Units According to the Number of Cardiac Surgery Procedures with or without CPB

Number of Operations	< 500	500–999 ^a	1000–1499	1500–1999	2000–5000
Number of Units	5	25	26	13	9
Average Per Unit	396	777	1194	1742	2802
Minimum–Maximum	245–477	510–974	1002–1458	1516–1968	2075–3823

CPB, cardiopulmonary bypass.

^aOne unit is performing pediatric cardiac surgery only.

Table 4 Distribution of Units According to Surgical Profiles in 2011

Type of Surgery Performed	Number of Units
Coronary Surgery	77
Valve Surgery	77
Surgery of Congenital Heart Diseases With CPB in Children < 1 Year	26 ^a
Heart Transplantation	22 ^b
Heart–Lung Transplantation	5

CPB, cardiopulmonary bypass.

^aSurgery for congenital heart disease with CPB in children < 1 year (n = 2037); thereof: 2 to 18 operations in five units, 26–45 operations in five units, 52–84 operations in eight units, and 109–250 operations in eight units.

^bHeart transplantations (n = 355): 70% of the total annual heart transplantations are performed by 8 of 22 units with ≥ 15 heart transplantation per year; thereof: 1–4 transplants in three units, 5–9 transplants in six units, 10–19 transplants in seven units, and 21–77 transplants in six units.

Table 5 Additional Demographic Data for Procedures with CPB in 2011 and 2010

Demographic Data	2011		2010	
Emergency Operations	11911	11.9%	11850	12.0%
Redo Procedures	8511	8.5%	8458	8.6%
Age > 69 Years ^a	95456	53.6%	93646	52.2%

CPB, cardiopulmonary bypass.

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

^aWithout patients younger than 20 years.

Germany. The number of heart operations procedures with CPB remains on a stable level.

Overall, 173,347 procedures were reported to the registry for the year 2011, an increase of 4.0% (2010: 166,621 procedures). A total of 100,291 cardiac surgical procedures (excluded: implantable cardioverter defibrillator (ICD), pacemakers, and miscellaneous procedures without CPB) display an increase of 1.74% (n = 1,714) compared with the year of 2010 (98,755 procedures) (►Table 2). The following tables and figures (►Tables 3 to 6, ►Tables V1 to V7, ►Tables C1 to C3, ►Tables Con1 and Con2, ►Tables Mis1 to Mis5 and ►Figs. 1 to 11) represent the compiled registry data for 2011 classified in individual categories.

As in previous years, several important developments continued also in 2011. Over the past 18 years, the age distribution (►Fig. 6) demonstrates a shift to the categories with older patients. Currently, 53.6% of the cardiac procedures are performed in patients 70 years or older and 13.4% in patients 80 years or older. However, mortality remains the

Table 6 Gender Distribution

Male/Female Ratio among Cardiac Procedures		
Heart Valve Procedures	55%	45%
Coronary Surgery	75%	25%
Congenital Heart Surgery	52%	48%
Surgery of Thoracic Aorta	68%	32%
Other Cardiac Surgery	44%	56%
Assist Devices	71%	29%
Pacemaker and ICD	59%	41%
Extracardiac Surgery	63%	37%
Total	65%	35%

ICD, implantable cardioverter defibrillator.

Note: All coronary surgery (48743 on-pump and 6556 off-pump procedures) and all congenital surgery procedures are included in this table.

Table V1 Single Heart Valve Procedures

Position	n	Deaths	%
Aortic Sternotomy	9874	331	3.4
Aortic Part. Sternotomy	1794	49	2.7
Aortic Endovascular	2306	117	5.1
Aortic Transapical	2777	241	8.7
Mitral Sternotomy	3231	193	6.0
Mitral Mic	2280	56	2.5
Mitral Transcatheter	120	5	4.2
Tricuspidal Sternotomy	363	38	10.5
Tricuspidal Mic	92	5	5.4
Pulmonary Sternotomy	42	1	2.4
Pulmonary Mic	0	–	–
Pulmonary Transcatheter	1	0	0.0
Total	22880	1036	4.5

part., partial; mic, minimally invasive surgery.

Note: A total of 2280 (41%) mitral valve procedures were done using a minimally invasive access. The number of isolated conventional aortic valve replacement showed no difference from 2010 to 2011 (2010: 11689 and 2011:11668 procedures).

Table V2 Isolated Aortic Valve Procedures

Type of Valve	n	Deaths	%
Prosthesis	1689	41	2.4
Xenograft	9846	334	3.4
Homograft	37	2	5.4
Reconstruction	96	3	3.1
Total	11668	380	3.3

Abbreviation: transcatheter aortic valve implantation.

Note: Out of 11668 procedures, 1794 (15%) were done by a partial sternotomy access. TAVI excluded.

Table V3 Isolated Heart Valve Procedures

Procedures	n	Deaths	%
Single	17676	673	3.8
Double	3600	299	8.3
Triple	362	53	14.6
Transcatheter Access	5210	363	7.0
Not Specified	124	10	8.1
Total	26972	1398	5.2

Note: Combined procedures (coronary artery bypass graft and aortic surgery) are not included.

same or even decreased slightly over the past 18 years (see ►Fig. 2). Although the number of CABG decreased while the number of off-pump procedures for coronary heart disease increased to 14.7% (2010: 14.2%) (►Fig. 3).

Table V4 Isolated Mitral Valve Procedures

Type of Valve	n	Deaths	%
Prosthesis	579	28	4.8
Xenograft	1334	152	11.4
Homograft	11	3	27.3
Reconstruction	3587	66	1.8
Total	5511	249	4.5

Note: Out of 5511 procedures, 2280 (41%) were done using a minimally invasive access. Transcatheter procedures excluded.

Table V5 Multiple heart Valve Procedures

Combination	n	Deaths	%
Aortic + Mitral	1854	153	8.3
Mitral + Tricuspid	1419	110	7.8
Aortic + Tricuspid	188	33	17.6
Tricuspid + Pulmonary	17	2	11.8
Aortic + Pulmonary ^a	122	1	0.8
Aortic + Mitral + Tricuspid	357	50	14.0
Aortic + Mitral + Pulmonary	5	3	60.0
Total	3962	352	8.9

Note: Transcatheter procedures are not included.

^aIncluding Ross procedures.

Since 2004 more than 50% of isolated mitral valve procedures are reconstructions, in 2011 more than 65% of the patients with mitral valve disease received a mitral valve reconstruction (►Fig. 8). For correct interpretation of ►Fig. 8, it is important to assert that, due to the data collection method (German OPS), all patients with various mitral valve diseases such as mitral valve stenosis, valve calcification, endocarditis, and patients under emergent conditions are included. The operation codes by itself give no information about the underlying disease. The reconstruction rate would certainly be higher if only patients would be included where a reconstruction is feasible. In other publications, for example, Gammie et al,²² the reconstruction rate must be interpreted very carefully compared with our registry data because in their publication, patients with mitral valve stenosis, endocarditis, and in emergent conditions are excluded.

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

The most remarkable evolution is the extensive increase of TAVI over the past 6 years (►Fig. 5), while the number of isolated aortic valve replacements by open surgery remains stable. Starting in 2006 with 78 procedures (0.67% of isolated aortic valve procedures), 5,083 TAVI are reported in 2011 (30.5%). However, it should be kept in mind that the 78 units which contribute at this registry are not the only sites which are performing TAVI in Germany. TAVI via transvascular access are also performed in cardiology units without

Table V6 Mitral Valve Surgery—Implantation/Replacement Versus Reconstruction

Mitral Valve Surgery					Replacement			Reconstruction		
	<i>n</i>	Total Deaths	% Death	% Reconstruction	<i>n</i>	Deaths	% Death	<i>n</i>	Deaths	% Death
Isolated	5511	249	4.5	65.1	1924	183	9.5	3587	66	1.8
Mitral Valve +										
Aortic Valve	1854	153	8.3	62.8	689	103	14.9	1165	50	4.3
Tricuspid Valve Reconstruction ^a	1390	104	7.5	64.3	496	55	11.1	894	49	5.5
CABG	2590	269	10.4	68.6	812	139	17.1	1778	130	7.3
CABG + Aortic Valve Replacement	957	114	11.9	70.7	280	52	18.6	677	62	9.2
Total	12302	889	7.2	65.9	4201	532	12.7	8101	357	4.4

CABG, coronary artery bypass graft.

^aTwenty-nine procedures (not specified Mitral valve + tricuspid valve surgery) excluded. Deaths %: 20.7 (6/29).

Table V7 Transcatheter Heart Valve Procedures: 54.6% of TAVI were Done Using a Transapical Access

				With CPB		Without CPB	
	Total	Deaths	Death %	<i>n</i>	Deaths	<i>n</i>	Deaths
Aortic Valve Implantation	5083	358	7.0	121	42	4962	316
Transvascular Access ^a	2306	117	5.1	34	13	2272	104
Transapical Access	2777	241	8.7	87	29	2690	212
Mitral Valve	120	5	4.2	2	0	118	5
Repair	94	1	1.1	1	0	93	1
Implantation ^b	26	4	15.4	1	0	25	4
Aortic Valve Implantation ^b + CABG	38	8	21.1	15	5	23	3
Total	10444	734	7.0	261	89	10183	645

TAVI, transcatheter aortic valve implantation; CPB, cardiopulmonary bypass; CABG, coronary artery bypass graft.

Note: Pulmonary valve implantation for the correction of congenital lesions are not included, one procedure was reported for adults without congenital lesion. With the use of CPB, 2.3% of TAVI procedures were performed. It has to be assumed that CPB was mostly used in emergency situations, which explains the lethality of 34.7% in this group. Nevertheless, this underlines the necessity of a fully equipped surrounding for TAVI procedures where CPB is on standby for urgent use.

^aFemoral, subclavian or transaortic access.

^bEndovascular and transapical access.

Table C1 Isolated CABG with CPB and Combined Procedures with CPB

Procedures	<i>n</i>	Deaths	%
CABG	41976	1217	2.9
CABG+			
TMLR	4	0	0.0
Aneurysm Resection	230	18	7.8
Aortic Valve Replacement	8023	441	5.5
Transcatheter Aortic Valve Implantation	38	8	21.1
Mitral Valve Replacement	812	139	17.1
Mitral Valve Repair	1778	130	7.3
Aortic + Mitral Valve Replacement	280	52	18.6
Aortic Valve Replacement + Mitral Valve Repair	677	62	9.2
Other	1481	102	6.9
Total	55299	2169	3.9

CABG, coronary artery bypass graft; CPB, cardiopulmonary bypass.

Table C2 Isolated CABG with CPB

Number of Grafts	n	Deaths	%
Single	1126	66	5.9
Double	7748	226	2.9
Triple	15749	489	3.1
Quadruple	8767	236	2.7
Quintuple + more	2431	71	2.9
Total	35821	1088	3.0

CABG, coronary artery bypass graft; CPB, cardiopulmonary bypass.

Table C3 Off-Pump Isolated CABG

Number of Grafts	n	Deaths	%
Single	1514	34	2.2
Double	1807	53	2.9
Triple	2004	33	1.6
Quadruple	708	8	1.1
Quintuple + More	122	1	0.8
Total	6155	129	2.1

CABG, coronary artery bypass graft.

Table Con1 Age Distribution among Procedures for Congenital Heart Disease

Age	n	Deaths	%
Without CPB			
Over 18 Years	79	2	2.5
1–17 Years	178	1	0.6
Under 1 Year	733	11	1.5
Total of A	990	14	1.4
With CPB			
Over 18 Years	878	25	2.8
1–17 Years	1694	8	0.5
Under 1 Year	2037	73	3.6
Total of B	4609	106	2.3

CPB, cardiopulmonary bypass.

availability of a heart surgical unit. With the use of CPB, 2.3% of TAVI procedures were performed. It has to be assumed that CPB was mostly used in emergency situations, which explains the lethality of 34.7% in this group. Nevertheless, this underlines the necessity of a fully equipped surrounding for TAVI procedures where CPB is on standby for urgent use.

Table Con2 Procedures for Congenital Heart Disease with and without CPB

Lesion	Age < 1 Year			Age 1–17 Years			Age ≥ 18 Years		
	n	Deaths	%	n	Deaths	%	n	Deaths	%
ASD	74	0	0.0	279	0	0.0	271	6	2.2
Complete AV Canal	180	5	2.8	76	0	0.0	14	1	7.1
VSD	303	1	0.3	121	0	0.0	26	1	3.8
Fallot's Tetralogy	206	5	2.4	36	1	2.8	6	0	0.0
DORV	65	1	1.5	14	0	0.0	0	0	–
TGA	132	4	3.0	7	0	0.0	0	0	–
TGA + VSD	65	2	3.1	7	0	0.0	0	0	–
Truncus Arteriosus	27	2	7.4	8	0	0.0	0	0	–
Fontan	5	0	0.0	275	1	0.4	10	2	20.0
Norwood Type	162	21	13.0	4	1	25.0	0	0	–
Pulmonary Valve	70	1	1.4	238	1	0.4	75	2	2.7
Transcatheter Pulmonary Valve Implantation	0	0	–	7	1	14.3	7	0	0.0
Aortic Valve	55	4	7.3	185	1	0.5	305	5	1.6
Ross Procedure	12	2	16.7	28	0	0.0	25	1	4.0
Mitral Valve	39	4	10.3	77	0	0.0	74	7	9.5
Tricuspid Valve	66	0	0.0	47	0	0.0	44	0	0.0
PDA	282	5	1.8	20	0	0.0	5	0	0.0
Coarctation	184	2	1.1	45	0	0.0	4	0	0.0
Heart Transplantation	4	0	0.0	18	0	0.0	0	0	–
Heart–Lung Transplantation	0	0	–	0	0	–	0	0	–
Lung Transplantation	0	0	–	9	0	0.0	0	0	–
Others	839	30	3.6	371	11	3.0	91	2	2.2
Total	2770	89	3.2	1872	17	0.9	957	27	2.8

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

Table Mis1 Development of Ross Procedures in Various Age Groups

Autologous Aortic Valve Replacement (Ross Procedure)	n (2002)	n (2003)	n (2004)	n (2005)	n (2006)	n (2007)	n (2008)	n (2009)	n (2010)	n (2011)
In Patients ≥ 18 Years	163	170	250	235	228	261	207	175	184	134
In Patients < 18 Years	61	37	50	46	50	34	42	54	43	40
Total	224	207	300	281	278	295	249	229	227	174

Table Mis2 Transplantation All Pediatric Transplantations (Demonstrated in Table Con2) Are Included in This Table

Transplantation	With CPB			Without CPB		
	n	Deaths	%	n	Deaths	%
Heart	355	36	10.1			
Heart + Lung	10	0	0.0			
Lung	61	8	13.1	238	13	5.5

Note: Eurotransplant (ET) has 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 (LuTx), 1 lung + kidney transplantations, and 1 lung + liver transplantations. The differences (ET: –28 LuTx, –1 HTx) may be explained by different inclusion criteria (time of transplantation) for the registry and the ET database.

CPB, cardiopulmonary bypass.

In the context of TAVI, two other quality assurance initiatives in Germany will be of great interest: the German Aortic Valve Registry and the legal quality assurance (§137 SGB V), which the AQUA-Institute is responsible for.

Discussion

This report enables a comprehensive overview of all cardiac surgical procedures performed in Germany in 2011. The

Table Mis3 Aortic Surgery

Aortic Surgery ^a	With CPB			Without CPB		
	n	Deaths	%	n	Deaths	%
Supracoronary Ascending	1523	88	5.8			
Infracoronary Ascending			–			
Mechanical Valve Conduits	623	40	6.4			
Biological Valve Conduits	681	76	11.2			
David	477	7	1.5			
Yacoub	130	4	3.1			
Other	277	21	7.6			
Supracoronary Ascending + Aortic Valve Replacement	1331	56	4.2			
Aortic Arch Replacement ^b	1419	165	11.6			
Descending	105	13	12.4	16	4	25.0
Thoracoabdominal	78	23	29.5	31	6	19.4
Endostent Descending	14	0	0.0	496	27	5.4
Total	6658	493	7.4	543	37	6.8

Note: 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.

^aAbdominal aortic surgery is not included; 580 abdominal and 467 endostent abdominal.

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

CPB, cardiopulmonary bypass; CABG, coronary artery bypass graft.

Table Mis4 Pacemaker and ICD Procedures

Pacemaker and ICD	Total	Deaths	Death %	With CPB		Without CPB	
				n	Deaths	n	Deaths
Pacemaker: Implantation	9223	59	0.6	3	0	9220	59
Pacemaker: Battery Exchange	1974	2	0.1	3	0	1971	2
Pacemaker: Revision	2828	12	0.4	39	0	2789	12
ICD: Implantation	5380	14	0.3	2	0	5378	14
ICD: Battery Exchange	1946	3	0.2	0	0	1946	3
ICD: Revision	2853	23	0.8	22	2	2831	21
Miscellaneous	651	2	0.3	2	0	649	2
Total	24855	115	0.5	71	2	24784	113

ICD, implantable cardioverter defibrillator; CPB, cardiopulmonary bypass.

Table Mis5 Surgical Ablation Procedures

Energy	Total	Endocardiac Ablation	Epicardiac Ablation
		n	n
Unipolar Radiofrequency	315	283	32
Unipolar Cryo-Radiofrequency	532	327	205
Bipolar Radiofrequency	1621	193	1428
Cryotherapy	1494	1136	358
Microwave	56	8	48
Focused Ultrasound	465	48	417
Laser	0	0	0
Other	19	1	18
Total	4502	1996	2506

Note: Included in this table are all isolated ablation procedures and all possible combination procedures (e.g., CABG + ablation). Total of $n = 343$ procedures are not specified with regard to endocardiac/epicardiac ablation. CABG, coronary artery bypass graft.

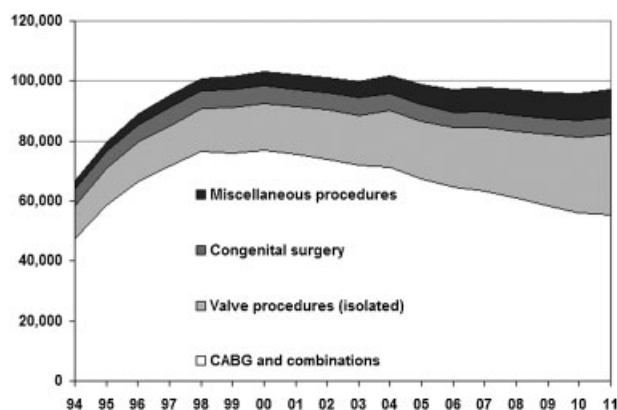


Figure 1 Development of cardiac surgery in Germany from 1994 to 2011. Coronary surgery and combined procedures include all types of isolated coronary surgery with or without CPB and any combined procedure. Heart valve procedures include all types of isolated valve surgery. Combinations of aortic surgery and heart valve procedures are summarized in the miscellaneous group. Congenital heart surgery includes all types of procedures with or without CPB. ASD repair in adults in combination with coronary or heart valve surgery are summarized in the coronary or heart valve surgery group. Miscellaneous includes all other types of procedures with CPB. ASD, atrial septal defect; CPB, cardiopulmonary bypass.

accuracy of this registry is reliable due to the implemented compilation algorithm using operation codes. This assumption is supported by other authors who could demonstrate a high accuracy for major outcome parameters in unaudited registries.²³ Alike to previous reports, we can conclude that cardiac surgery is performed on a high level with a low in-hospital mortality compared with other international registries. This conclusion is important especially in the era of continuously increasing patient age combined with relevant comorbidities, both leading to a higher perioperative risk profile.

Compared with 2010, the number of cardiac surgical procedures has stabilized due to the high volume of TAVI.

Further improvements for the structure of the registry are necessary to allow a more detailed and risk adjusted analysis of the collected data. However, significant structural changes of the registry have to ensure data compatibility to allow further longitudinal data analysis.

The future of this voluntary registry as well as its further development will depend on continuous efforts of each individual cardiac surgical unit. This will be of outstanding importance to guarantee the ongoing high quality of cardiac surgery in Germany.

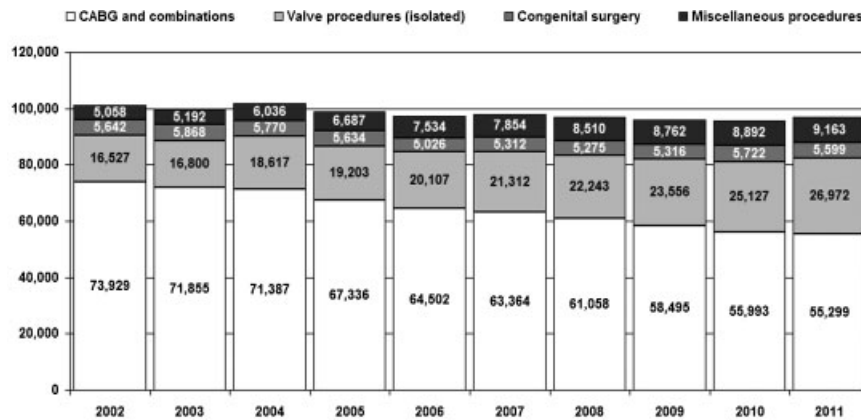


Figure 2 Development of cardiac surgery in Germany during the past 10 years.

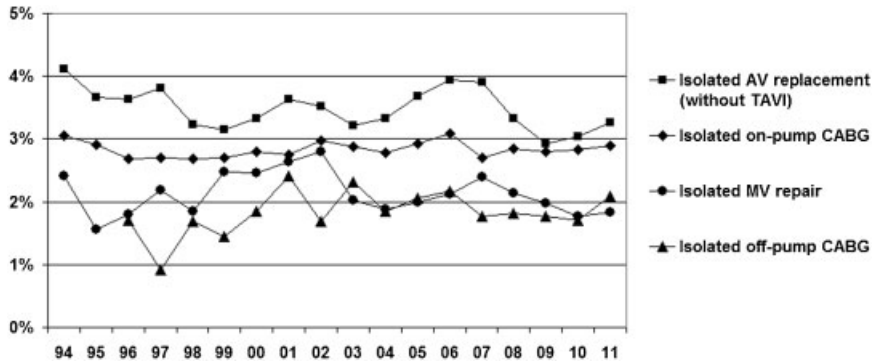


Figure 3 Development of mortality for selected procedures.

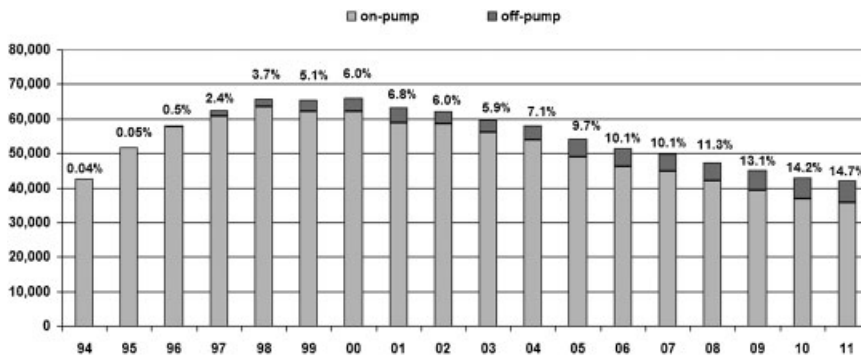


Figure 4 Isolated coronary bypass surgery. The number of coronary artery bypass procedures declined since the year 2000. The percentage of off-pump procedures has slightly increased compared with previous years but still has not reached the quantity of other comparable countries.

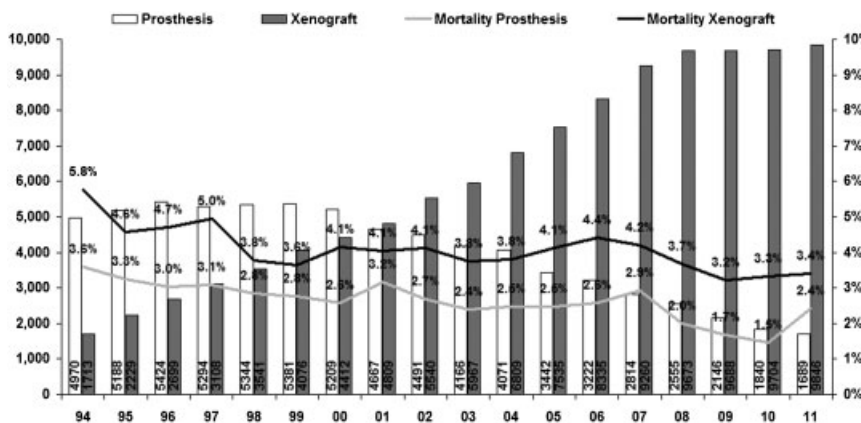


Figure 5 Isolated aortic valve replacement from 1994 to 2011 in Germany. The use of xenografts is steadily increasing. There is a remarkable difference in mortality which is probably age related. Ross or other homograft procedures and transcatheter valve implantations are excluded in this overview.

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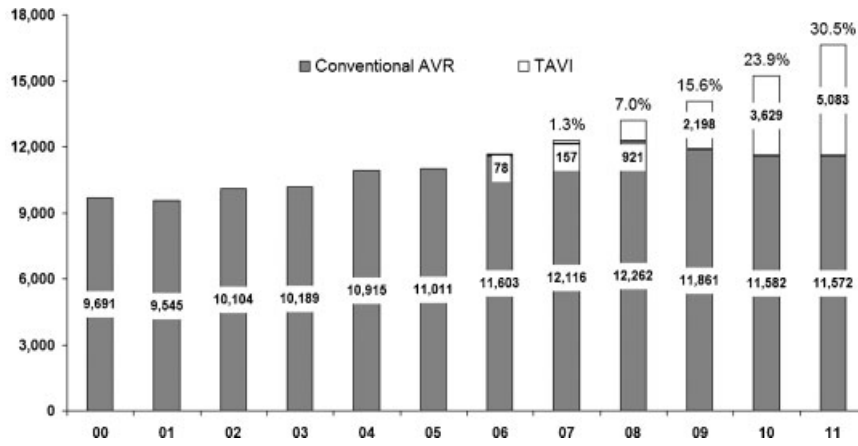


Figure 6 Conventional isolated aortic valve replacement or catheter-based procedures. The figure shows a significant increase in catheter-based procedures. In 2011, more than 30% of isolated aortic valve procedures were performed using an endovascular or transapical approach. This development underlines the importance of the new founded national aortic valve registry to get valid information about this relatively new therapy.

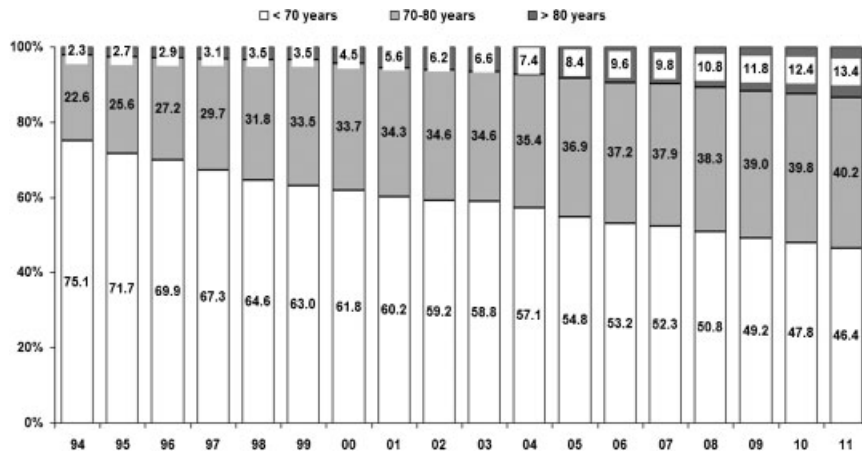


Figure 7 Age distribution of cardiac procedures (without ICD and pacemaker procedures) since 1994. Currently, more than 53% of the patients are older than 70 years. Patients younger than 20 years are excluded. ICD, implantable cardioverter defibrillator.

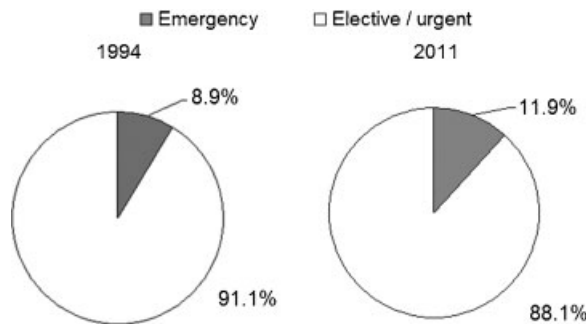


Figure 8 Distribution of urgency 1994 and 2011.

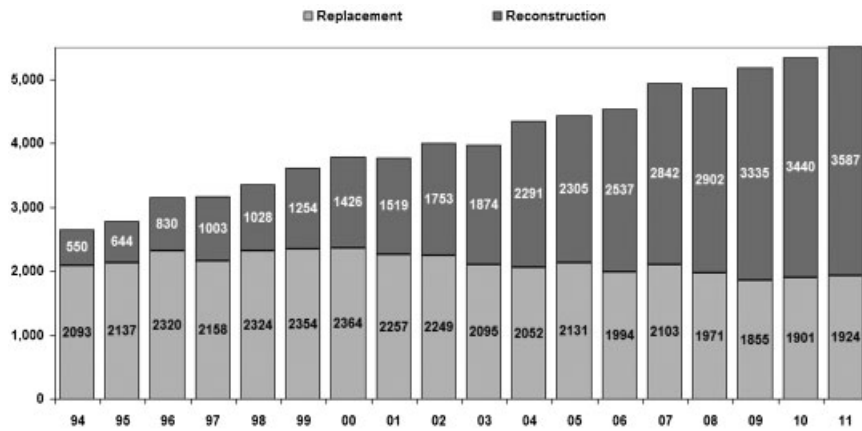


Figure 9 Isolated mitral valve surgery over the past 18 years. More reconstructions (64%) than replacements (36%) were performed. In 1994, the percentage of reconstructions was only 21%. Due to the data collection method which is based on procedure codes, all isolated mitral valve procedures regardless of diagnosis, morphology, or urgency type are included. The rate of valve reconstruction would certainly be higher if patients with mitral valve stenosis, severe calcification, or endocarditis would have been excluded as it has been done in other publications, for example, Gammie et al.

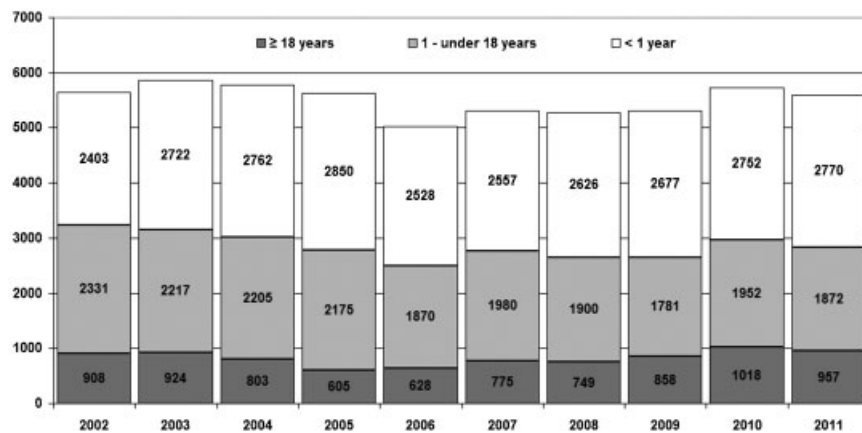


Figure 10 Development of congenital heart surgery in Germany over the past 10 years. Numbers remain more or less stable across previous years. However, there may be a bias since not all procedures for congenital heart surgery are necessarily counted in patients older than 18 years (e.g., aortic valve surgery).

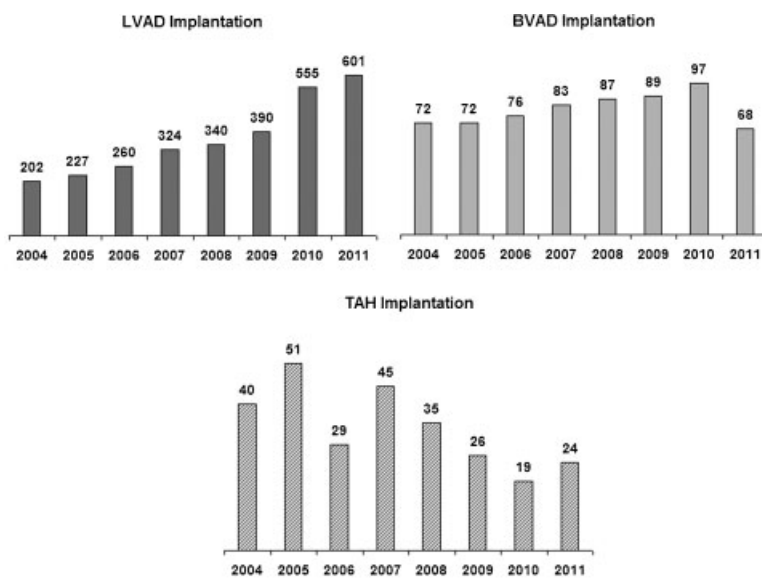


Figure 11 Development of mechanical circulatory support in Germany over the past 8 years. There is a significant increase in implantations of left ventricular assist devices (LVAD). However, in 2011, the number of implanted paracorporeal biventricular support systems (BVAD) was only 70% compared with the previous year. The number of total artificial heart implantations (TAH) is still low.

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