

Cardiac Surgery in Germany during 2010: A Report on Behalf of the German Society for Thoracic and Cardiovascular Surgery

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Key words

- aortic valve
- coronary artery bypass grafts surgery, CABG
- mitral valve surgery
- circulatory assist devices (IABP, LVAD, RVAD, BVAD, TAH)
- congenital heart disease, CHD
- registry

Abstract

▼ All cardiac surgical procedures performed in 79 German cardiac surgical units throughout the year 2010 are presented in this report, based on a voluntary registry which is organized by the German Society for Thoracic and Cardiovascular Surgery. In 2010 a total of 95 734 cardiac surgical procedures (ICD and pacemaker procedures excluded) have been collected in this registry. More than 12.4% of the patients were older than 80

years compared to 11.8% in 2009. Hospital mortality in 42 804 isolated CABG procedures (14.2% off-pump procedures) was 2.8%. In 25 127 isolated valve procedures (including 3660 transcatheter-valve implantations) a mortality of 4.9% 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 the development 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 [1–6] to answer those needs. As early as in 1978 the German Society for Thoracic and Cardiovascular Surgery 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 transapical or transvascular aortic valve replacement (► **Table V2**) have been included in the registry to monitor the development in these fields, important for the future of our speciality. The registry data have been published since 1989 [7–26]. The following report contains the collected data for the year 2010.

Material and Methods

▼ Since 2004 the standardized questionnaire asks for detailed information about each individual procedure exactly defined by one or more operation codes (OPS). All centers were asked to complete the questionnaire until January 21, 2011 asking for all performed procedures and associated hospital mortality in each institution. The questionnaires were sent to the German Society of Thoracic and Cardiovascular Surgery, evaluated for completeness and compiled for further analysis thus ensuring anonymity for the individual center. This compilation algorithm guaranties a high compliance for submission of the complete data set, as demonstrated by a 100% completeness each year. Inclusion criteria for the registry 2010 were all individual surgical procedures performed between January 1, 2010 and December 31, 2010, unrelated to admission or discharge dates as compared to other registries. Alike to all previous years the number of procedures was counted, not individual patients, e.g., 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 regis-

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Bibliography

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Table 1 Development of frequency in open heart procedures with CPB in Germany from 1978 to 2010 (1978–1985: Federal Republic of Germany [West Germany] only).

Year	1978	1980	1985	1990	1995	2002	2005	2006	2007	2008	2009	2010
Total number of units	21	21	33	46	76	79	79	80	80	79	80	79
Total number of operations	8 365	10 680	21 705	38 783	78 184	96 194	91 967	91 057	91 618	89 773	86 916	84 686
Average per unit	398	509	658	843	1 029	1 218	1 164	1 138	1 145	1 136	1 086	1 072

Table 2 Total results of all 79 units performing cardiac surgery in 2010. The % indicates changes compared to 2009.

Category	With CPB	Without CPB	Total	% Change
Valve procedures	21 554	3 573	25 127	+6.7%
Coronary surgery	49 549	6 444	55 993	-4.3%
Congenital lesion	4 691	1 031	5 722	+7.6%
Surgery of thoracic aorta	6 342	426	6 768	+7.5%
Other cardiac surgery	1 398	1 182	2 580	-10.2%
Assist devices	689	1 235	1 924	+31.2%
Pacemaker and ICD	71	24 784	24 855	+4.7%
Extracardiac surgery	392	43 260	43 652	+7.3%
Total	84 686	81 935	166 621	+2.6%

Table 4 Distribution of units according to surgical profiles in 2010.

Type of surgery performed	Number of units
Coronary surgery	78
Valve surgery	78
Surgery of congenital heart diseases with CPB in children < 1 year	26*
Heart transplantation	24**
Heart-lung transplantation	5

* Surgery of congenital heart disease with CPB in children < 1 year (n = 1 975); thereof: 3–6 operations in 3 units, 20–46 operations in 8 units, 54–97 operations in 8 units, 126–262 operations in 7 units; ** Heart transplantations (n = 379): 78% of the total annual heart transplantations are performed by 10 of 24 units with >= 15 HTx per year; thereof: 1–4 transplants in 6 units, 6–9 transplants in 5 units, 10–18 transplants in 7 units, 22–63 transplants in 6 units

try contains more procedures than the actual number of patients operated on.

Mortality was defined as in-hospital mortality. Per definition the observed mortality was attributed to the first cardiac surgery procedure, e.g., the death of a patient requiring additional coronary surgery due to a complication after aortic valve replacement during the same admission would be attributed only to the aortic valve group, 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 the number of treated patients. Another reason was to simplify the process of data acquisition thus enabling all cardiac surgery units in Germany – regardless of the existing hard- and software used for data management in individual units – to submit a complete data set.

As in previous years (except for 2008) all units answered the questionnaire and delivered a complete data set for the year 2010 including hospital mortality rates. In 2010 the total number of units has decreased from 80 to 79.

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

Number of operations	< 500	500–999*	1 000–1 499	1 500–1 999	2 000–5 000
Number of units	9	21	29	13	7
Average per unit	353	773	1 156	1 722	2 916
Min-max	167–479	518–986	1 003–1 482	1 571–1 932	2 186–3 865

* One unit performs pediatric cardiac surgery only

Table 5 Additional demographic data of procedures with CPB in 2010 and 2009. The numbers in each category reflect procedures and not individual patients.

Demographic data	2010	2009
Emergency operations	11 850	12.0%
Redo procedures	8 458	8.6%
Age > 69 years*	93 646	52.2%

Table 6 Gender distribution. All coronary surgery (49 549 on-pump and 6 444 off-pump procedures) and all congenital surgery procedures are included in this table.

Male/female ratio among cardiac procedures	
Valve procedures	56% / 44%
Coronary surgery	75% / 25%
Congenital surgery	54% / 46%
Surgery of thoracic aorta	68% / 32%
Other cardiac surgery	45% / 55%
Assist devices	71% / 29%
Pacemaker and ICD	64% / 36%
Extracardiac surgery	64% / 36%
Total	66% / 34%

Registry 2010

▼ **Table 1** demonstrates the development of procedures using cardiopulmonary bypass (CPB) over the past 30 years in Germany. The number of heart surgery procedures has stabilized. Overall, 166 621 procedures were reported to the registry for the year 2010, an increase of 2.6% (2009: 162 417 procedures). A total of 98 577 cardiac surgical procedures (excluded: ICD, pacemakers and miscellaneous procedures without CPB) displayed a decrease of 0.01% (n = 14) compared to the year 2009 (98 563 procedures) (Table 2). The following tables and figures (Table 3 to 6, Tables V1 to V7, Tables C1 to C4, Tables Con1 and

Table V1 Isolated valve procedures. Combination procedures (CABG and aortic surgery) are not included. Transcatheter access: 3 629 aortic valve implantations; 6 mitral valve implantations; 23 mitral valve annuloplasties; 1 double aortic and mitral valve procedure; 1 pulmonary valve implantation.

Procedures	n	Deaths	%
Single	17 545	612	3.5
Double	3 466	273	7.9
Triple	344	42	12.2
Transcatheter access	3 660	284	7.8
Not specified	112	8	7.1
Total	25 127	935	3.7

Table V3 Isolated aortic valve procedures. Out of 11 689 procedures, 1 464 (12.5%) were done by a partial sternotomy access. Transcatheter procedures are not included.

Type of valve	n	Deaths	%
Prosthesis	1 840	27	1.5
Xenograft	9 704	323	3.3
Homograft	38	1	2.6
Reconstruction	107	1	0.9
Total	11 689	352	3.0

Table V4 Isolated mitral valve procedures. Out of 5 341 procedures, 2 062 (38.6%) were done using a minimally invasive access.

Type of valve	n	Deaths	%
Prosthesis	598	37	6.2
Xenograft	1 292	116	9.0
Homograft	11	2	18.2
Reconstruction	3 440	61	1.8
Total	5 341	216	4.0

Table V5 Multiple valve procedures. Transcatheter procedures are not included.

Combination	n	Deaths	%
Aortic + mitral	1 770	132	7.5
Mitral + tricuspid	1 333	113	8.5
Aortic + tricuspid	211	22	10.4
Tricuspid + pulmonary	6	0	0.0
Aortic + pulmonary*	146	6	4.1
Aortic + mitral + tricuspid	344	42	12.2
Aortic + mitral + pulmonary	0	0	–
Total	3 810	315	8.3

* Including Ross procedures

Table V6 Mitral valve surgery – replacement vs. reconstruction.

Mitral valve surgery	Total				Replacement			Reconstruction		
	n	Deaths	% Death	% Recon-struction	n	Deaths	% death	n	Deaths	% Death
Isolated	5 341	216	4.0	64.4	1 901	155	8.2	3 440	61	1.8
MV +										
▶ aortic valve	1 770	132	7.5	61.1	688	94	13.7	1 082	38	3.5
▶ tricuspid valve reconstruction*	1 296	109	8.4	61.0	483	56	11.6	813	53	6.5
▶ CABG	2 588	252	9.7	68.5	816	103	12.6	1 772	149	8.4
▶ CABG + aortic valve replacement	921	92	10.0	70.8	269	47	17.5	652	45	6.9
Total	11 916	801	6.7	64.9	4 157	455	10.9	7 759	346	4.5

* 37 procedures (not specified mitral valve + tricuspid valve surgery) excluded. Deaths %: 10.8 (4/37)

Table V2 Single valve procedures. 2 062 (38.6%) mitral valve procedures were done using a minimally invasive access. The number of isolated aortic valve procedures by sternotomy decreased from 11 981 procedures in 2009 to 11 689 in 2010, perhaps as an effect of the increase in catheter-based valve implantations (2010: n = 3 629, 2009: n = 2 198).

Position	n	Deaths	%
Aortic sternotomy	10 225	319	3.1
Aortic part. sternotomy	1 464	33	2.3
Aortic transvascular	1 450	111	7.7
Aortic transapical	2 179	173	7.9
Mitral sternotomy	3 279	178	5.4
Mitral mic	2 062	38	1.8
Mitral transcatheter	29	0	0.0
Tricuspidal sternotomy	388	35	9.0
Tricuspidal mic	83	8	9.6
Pulmonary sternotomy	44	1	2.3
Pulmonary mic	0	–	–
Pulmonary transcatheter	1	0	0.0
Total	21 204	896	4.2

Table V7 Overview valve surgery.

Aortic valve replacement	26 208
Isolated valve surgery	11 544
Mechanical prosthesis	1 840
Xeno graft	9 704
Combination (valve) ¹	2 282
Combination (valve + CABG) ¹	8 753
Transfemoral	1 450
Transapical	2 179
Mitral valve surgery	11 873
Replacement	4 146
Mechanical prosthesis	598
Xeno graft	1 292
Combination (valve) ¹	1 171
Combination (valve + CABG) ¹	1 085
Reconstruction	7 728
Isolated mitral valve surgery	3 440
Combination (valve)	1 864
Combination (valve + CABG)	2 424
Tricuspid valve surgery²	1 961
Isolated replacement (xeno)	111
Isolated replacement (mechanical)	27
Reconstruction (isolated)	332
Reconstruction (combined – valve)	1 491

¹ Currently it is not possible to distinguish between mechanical prosthesis and xenografts in combination procedures. ² Currently it is not possible to separate combined CABG and tricuspid valve procedures

Table C1 Isolated CABG surgery with CPB and combined procedures with CPB.

Procedures	n	Deaths	%
CABG	42804	1212	2.8
CABG +			
▶ TMLR	41	2	4.9
▶ aneurysma resection	224	12	5.4
▶ aortic valve replacement	7832	436	5.6
▶ transcatheter aortic valve implantation	18	7	38.9
▶ mitral valve replacement	816	103	12.6
▶ mitral valve repair	1772	149	8.4
▶ aortic + mitral valve replacement	269	47	17.5
▶ aortic valve replacement + mitral valve repair	652	45	6.9
▶ other	1565	108	6.9
Total	55993	2121	3.8

Table Con1 Age distribution among procedures for the correction of congenital heart defects.

Age	n	Deaths	%
A) Without CPB			
▶ over 18 years	82	1	1.2
▶ 1–17 years	172	1	0.6
▶ under 1 year	777	23	3.0
Total A	1031	25	2.4
B) With CPB			
▶ over 18 years	936	23	2.5
▶ 1–17 years	1780	19	1.1
▶ under 1 year	1975	82	4.2
Total B	4691	124	2.6

Table Con2 Procedures for the correction of congenital heart defects with and without CPB.

Lesion	Age < 1 year			Age 1 to under 18 years			Age ≥ 18 years		
	n	Deaths	%	n	Deaths	%	n	Deaths	%
ASD	63	0	0.0	303	0	0.0	246	4	1.6
Complete AV-canal	168	1	0.6	65	1	1.5	15	0	0.0
VSD	362	2	0.6	136	0	0.0	36	1	2.8
Fallot's tetralogy	169	3	1.8	28	0	0.0	1	0	0.0
DORV	63	1	1.6	15	0	0.0	1	0	0.0
TGA	119	3	2.5	11	0	0.0	0	0	–
TGA + VSD	62	1	1.6	4	0	0.0	0	0	–
Truncus arteriosus	29	2	6.9	10	0	0.0	1	0	0.0
Fontan	1	0	0.0	246	4	1.6	14	2	14.3
Norwood	146	16	11.0	2	1	50.0	0	0	–
Pulmonary valve	63	3	4.8	219	3	1.4	81	1	1.2
Transcatheter pulmonary valve implantation	0	0	–	1	0	0.0	7	0	0.0
Aortic valve	48	2	4.2	195	1	0.5	315	5	1.6
Ross procedure	13	4	30.8	30	0	0.0	43	0	0.0
Mitral valve	26	0	0.0	107	0	0.0	57	3	5.3
Tricuspid valve	60	1	1.7	68	1	1.5	60	7	11.7
PDA	329	15	4.6	20	1	5.0	9	0	0.0
Coarctation	198	1	0.5	33	0	0.0	10	0	0.0
Transpl. heart	8	2	25.0	34	1	2.9	0	0	–
Transpl. heart + lung	0	0	–	2	0	0.0	0	0	–
Transpl. lung	0	0	–	11	1	9.1	0	0	–
Others	825	52	6.3	412	13	3.2	122	1	0.8
Total	2752	109	4.0	1952	27	1.4	1018	24	2.4

Table C2 Isolated CABG surgery with CPB.

Number of grafts	n	Deaths	%
Single	1227	72	5.9
Double	7985	282	3.5
Triple	15752	469	3.0
Quadruple	8812	227	2.6
Quintuple + more	2935	58	2.0
Total	36711	1108	3.0

Table C3 Off-pump Isolated CABG surgery.

Number of grafts	n	Deaths	%
Single	1502	31	2.1
Double	1842	35	1.9
Triple	1987	31	1.6
Quadruple	533	7	1.3
Quintuple + more	229	0	0.0
Total	6093	104	1.7

Table C4 Transmyocardial laser revascularization (TMLR).

Procedures	n	Deaths	%
TMLR with ACB	28	1	3.6
TMLR without ACB	13	1	7.7
Total	41	2	4.9

Table Mis1 Development of Ross procedures in various age groups.

Autologous aortic valve replacement (ROSS procedure)	n (2010)	n (2009)	n (2008)	n (2007)	n (2006)	n (2005)	n (2004)	n (2003)	n (2002)	n (2001)
In patients ≥ 18 years	184	175	207	261	228	235	250	170	163	140
In patients < 18 years	43	54	42	34	50	46	50	37	61	41
Total	227	229	249	295	278	281	300	207	224	181

Table Mis2 Transplantation. All pediatric transplantations (demonstrated in **Table Con2**) are included in this table. Eurotransplant (ET) has reported for the same period 368 heart transplantations (HTx), 6 heart + kidney transplantations, 1 heart + liver transplantations, 15 heart-lung transplantations (HLTx), 237 double lung (DLTx), 44 single-lung transplantations (SLTx), 1 lung + kidney transplantations and 0 lung + liver transplantations. The differences (ET: - 11 LTx, - 3 HTx) may be explained by different inclusion criteria (time of transplantation) for the registry and the ET database.

Transplantation	With CPB			Without CPB		
	n	Deaths	%	n	Deaths	%
Heart	379	44	11.6			
Heart + lung	16	3	18.8			
Lung	83	18	21.7	183	11	6.0

Table Mis3 Aortic Surgery. All procedures involving aortic surgery are included in this table. Isolated aortic surgery as well as all possible combination procedures (e.g., additional coronary surgery) are summarized in this category.

Aortic surgery*	With CPB			Without CPB		
	n	Deaths	%	n	Deaths	%
Supracoronary ascending	1483	115	7.8			
Infracoronary ascending						
▶ mechanical valve conduits	626	45	7.2			
▶ biological valve conduits	678	72	10.6			
▶ David	476	10	2.1			
▶ Yacoub	125	5	4.0			
▶ other	275	23	8.4			
Supracoronary ascending + aortic valve replacement	1166	60	5.1			
Aortic arch replacement**	1316	140	10.6			
Descending	99	10	10.1	15	3	20.0
Thoracoabdominal	91	10	11.0	55	11	20.0
Endostent descending	7	1	14.3	356	25	7.0
Total	6342	491	7.7	426	39	9.2

*Abdominal aortic surgery is not included: 617 abdominal and 389 endostent abdominal. ** All possible combined procedures are included in this category; the only common denominator is aortic arch surgery

Table Mis4 Pacemaker and ICD implantation.

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

Con2, Tables Mis1 to Mis5 and Figs. 1 to 9) represent the compiled data of the registry 2010 for the various subcategories. Several figures highlight important developments of cardiac surgery in Germany over the last decade. Remarkable is the development of age distribution over the last 15 years (**Fig. 5**) with

presently 52.2% of the cardiac procedures in patients 70 years or older and 12.4% in patients 80 years or older. However, mortality has been the same or even decreased slightly over the past 15 years (e.g., isolated aortic valve replacement 4.1% in 1994, 2.9% in 2009, 3.0% in 2010, isolated CABG 3.1% in 1994, 2.8% in 2009

Table Mis5 Surgical atrial ablation. 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 endocardial/epicardial ablation.

Energy	Total	Endocardial ablation (n)	Endocardial ablation (n)
unipolar radiofrequency	315	283	32
unipolar cryo-radiofrequency	532	327	205
bipolar radiofrequency	1 621	193	1 428
Cryotherapy	1 494	1 136	358
Microwave	56	8	48
Focused ultrasound	465	48	417
Laser	0	0	0
other	19	1	18
Total	4 502	1 996	2 506

and in 2010). The proportion of off-pump coronary bypass procedures has increased to 14.2% (2009: 13.1%).

Another remarkable evolution is the steady increase of mitral valve reconstruction over the last 16 years. Since 2004 more than 50% of isolated mitral valve procedures are reconstructions, in 2010 mitral valves could be reconstructed in more than 64% (Fig. 7). It is important for the interpretation of this figure that due to the data collection method (OPS) all isolated mitral valve procedures including all patients with mitral valve stenosis, valve calcification, endocarditis and emergency procedures are included. Operation codes give no information about the underlying disease. The reconstruction rate is certainly higher if only patients are included where a reconstruction would be feasible. In other publications, e.g., Gammie et al. [27] the reconstruction rate must be interpreted with caution compared to this data since

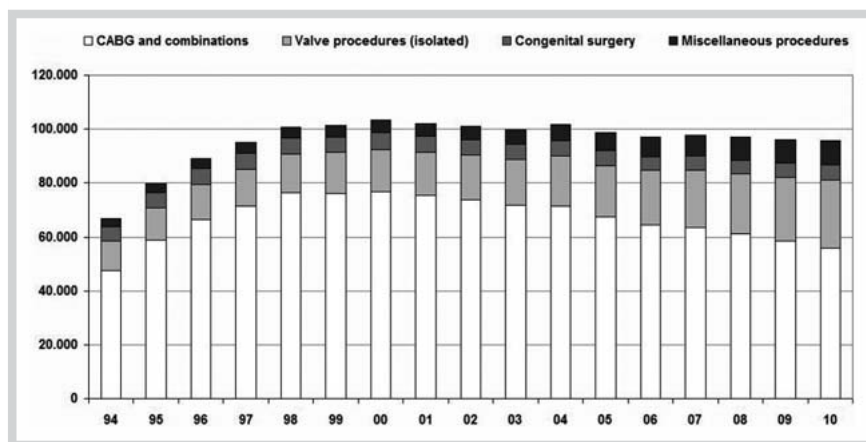


Fig. 1 Development of cardiac surgery in Germany between 1994 and 2010. 1) Coronary surgery and combined procedures include all types of isolated coronary surgery with or without CPB and any combined procedures. 2) Valve procedures include all types of isolated valvular surgery. Combinations of aortic surgery and valve procedures are summarized in the miscellaneous group. 3) Congenital surgery includes all types of procedures with or without CPB. ASD repair in adults in combination with coronary or valve surgery are summarized in the coronary or valve surgery group. 4) Miscellaneous includes all other types of procedures with CPB.

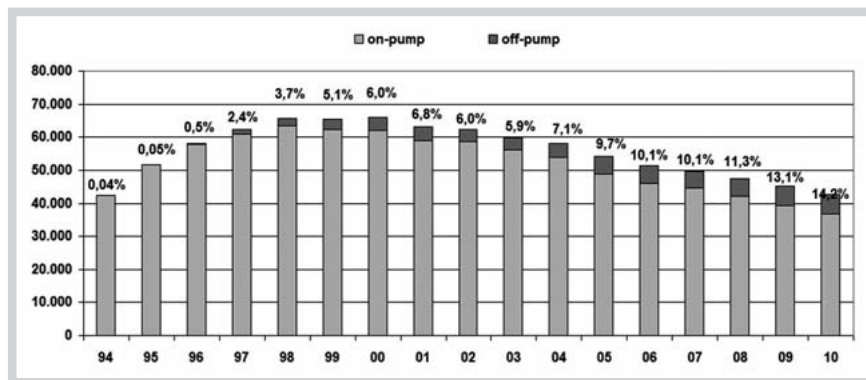


Fig. 2 The number of coronary artery bypass procedures is continuously declining since the year 2000. The proportion of off-pump procedures has slightly increased compared to previous years but still has not reached the percentage as in other comparable countries.

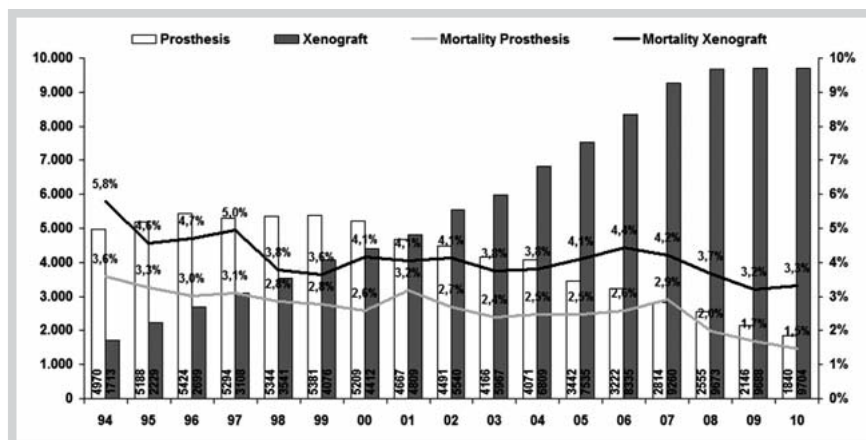


Fig. 3 Isolated aortic valve replacement between 1994 and 2010 in Germany. The number of xenograft replacements is steadily increasing. There is a marked difference in mortality which is probably age related. Ross procedures, homograft procedures and transcatheter valve implantations are excluded in this overview.

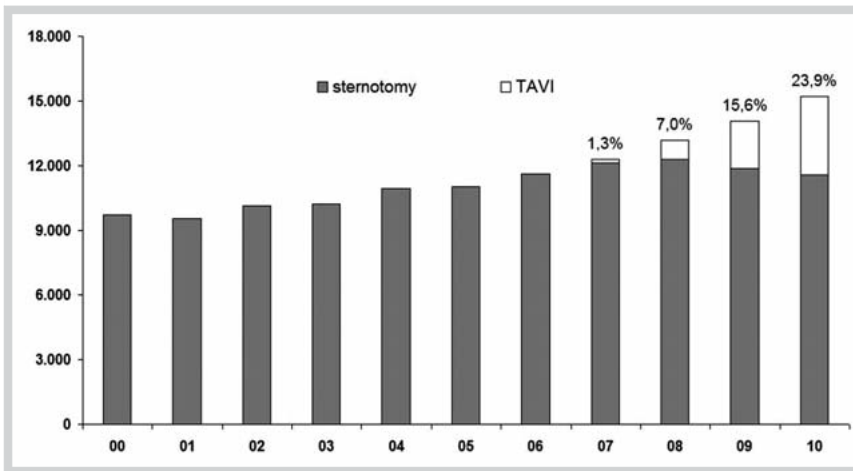


Fig. 4 Isolated aortic valve replacement via sternotomy or catheter-based procedures. The figure shows the significant increase in catheter-based procedures. In 2010 more than 23% of isolated aortic valve procedure were performed using a vascular or transapical approach. This development underlines that the new found national aortic valve registry is mandatory to get valid information to further evaluate this development.

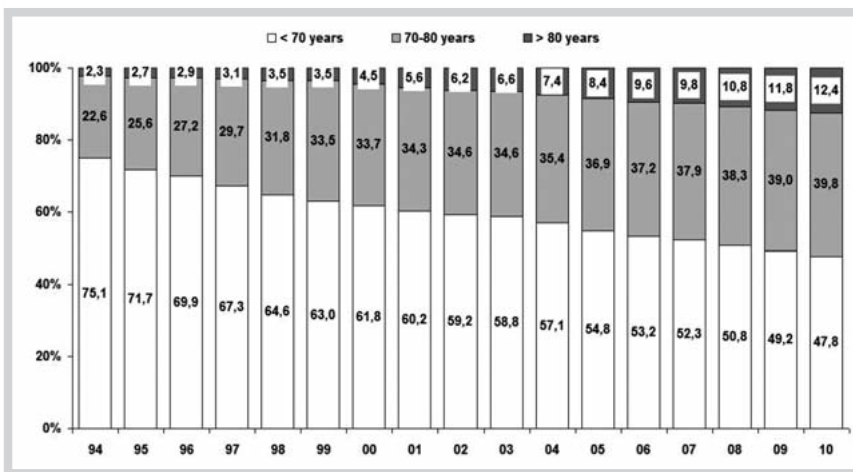


Fig. 5 Age distribution of cardiac procedures (without ICD and pacemaker) over the last 15 years. Currently more than 50% of the patients are older than 70 years. Patients younger than 20 years are excluded.

patients with mitral valve stenosis, endocarditis and emergency procedures were excluded.

The increase of left ventricular assist device implantation (Fig. 9) emphasizes the increasing relevance of mechanical circulatory support.

Discussion

This report enables a comprehensive overview of all cardiac surgical procedures performed in Germany in 2010. The accuracy of this registry is thought to be high due to the implemented compilation algorithm using operation codes (OPS). This is supported by other authors who could demonstrate a high accuracy for major outcome parameters in unaudited registries [28]. Alike to previous years we can conclude that cardiac surgery is performed on a high level with a low in hospital mortality compared to other international registries. This observation is important in an era of continuously increasing patient age and comorbidities, both leading to a higher perioperative risk profile.

Compared to 2009 the number of cardiac surgery procedures has stabilized due to the high volume of transcatheter aortic valve implantations.

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

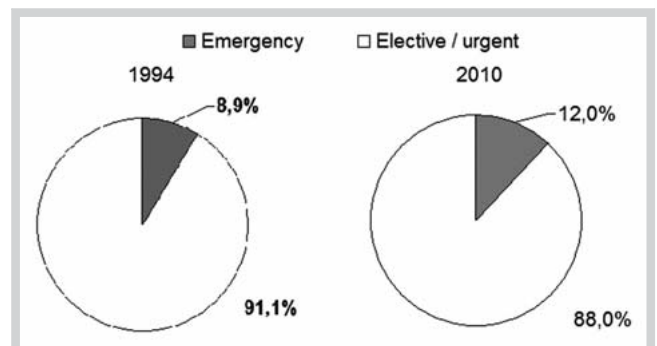


Fig. 6 Distribution of urgency 1994 and 2010. The incidence of emergency procedures has not changed significantly.

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.

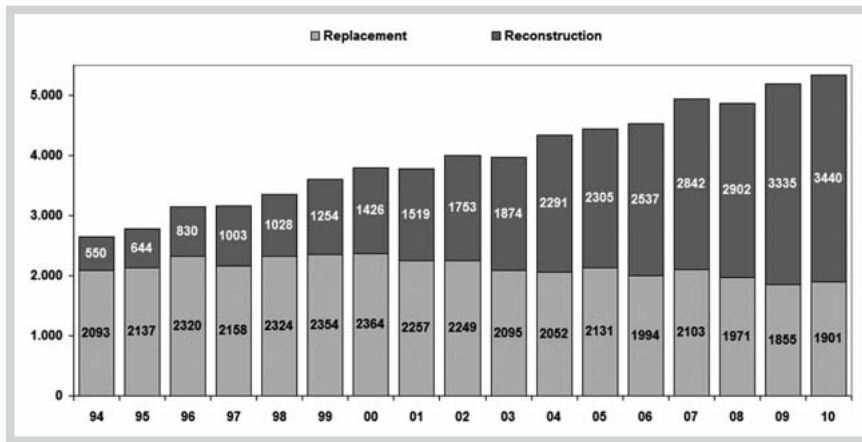


Fig. 7 Isolated mitral valve surgery over the last 15 years. More reconstructions (64%) than replacements (36%) were performed. In 1994 the percentage of reconstructions was only 21%. It is important for the interpretation of this figure that due to the data collection method all isolated mitral valve procedures including all patients with mitral valve stenosis, valve calcification, endocarditis and emergency procedures are included. The reconstruction rate is certainly higher if only patients where a reconstruction would be feasible were included. In other publications, e.g. Gammie et al. the reconstruction rate must be interpreted with caution compared to this data since patients with mitral valve stenosis, endocarditis and emergency procedures were excluded.

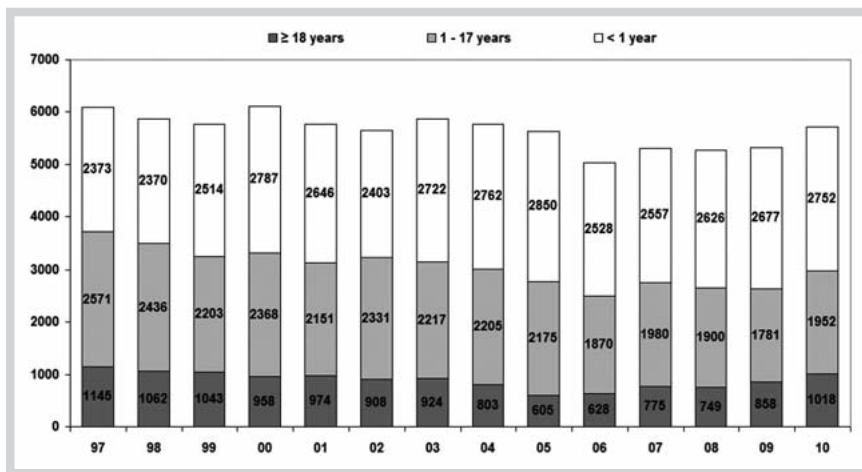


Fig. 8 Development of congenital surgery in Germany over the last 14 years. The downward tendency in the age groups below 18 years reached in 2006 its lowest point. In these age groups the number of surgical procedures is slightly increasing since then. In patients older than 17 years there may be a bias since not all procedures are necessarily counted as congenital surgery (e.g., aortic valve surgery).

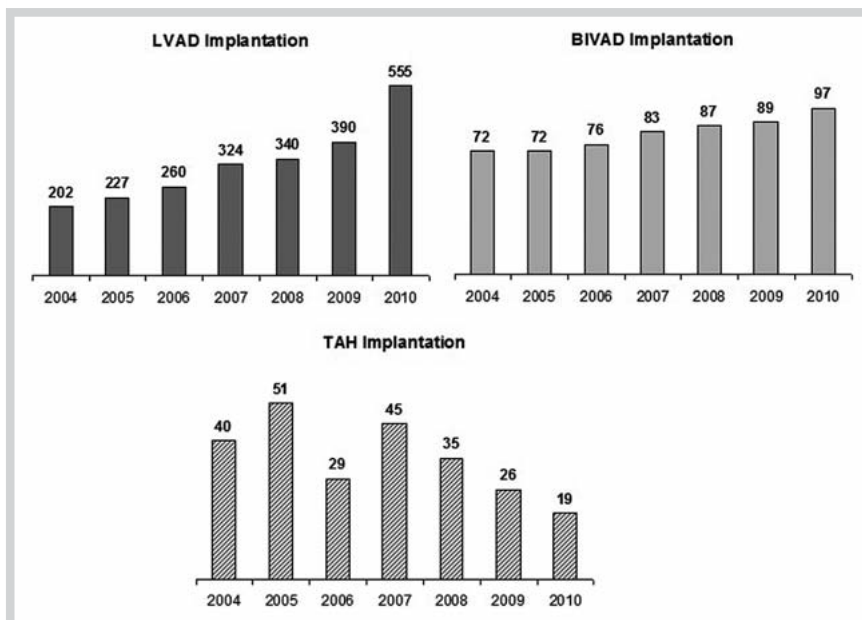


Fig. 9 Development of mechanical circulatory support in Germany over the last 7 years. There is a significant increase in left ventricular assist devices (LVAD). However, the number of paracorporeal bi-ventricular support systems (BIVAD) is only slowly growing and the number of total artificial hearts (TAH) has decreased.

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