

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 guarantees 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 (● **Tables 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 | 42 804 | 1 212 | 2.8 |
| CABG + | | | |
| ▶ TMLR | 41 | 2 | 4.9 |
| ▶ aneurysma resection | 224 | 12 | 5.4 |
| ▶ aortic valve replacement | 7 832 | 436 | 5.6 |
| ▶ transcatheter aortic valve implantation | 18 | 7 | 38.9 |
| ▶ mitral valve replacement | 816 | 103 | 12.6 |
| ▶ mitral valve repair | 1 772 | 149 | 8.4 |
| ▶ aortic + mitral valve replacement | 269 | 47 | 17.5 |
| ▶ aortic valve replacement + mitral valve repair | 652 | 45 | 6.9 |
| ▶ other | 1 565 | 108 | 6.9 |
| Total | 55 993 | 2 121 | 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 | 1 031 | 25 | 2.4 |
| B) With CPB | | | |
| ▶ over 18 years | 936 | 23 | 2.5 |
| ▶ 1–17 years | 1 780 | 19 | 1.1 |
| ▶ under 1 year | 1 975 | 82 | 4.2 |
| Total B | 4 691 | 124 | 2.6 |

Table C2 Isolated CABG surgery with CPB.

| Number of grafts | n | Deaths | % |
|------------------|--------|--------|-----|
| Single | 1 227 | 72 | 5.9 |
| Double | 7 985 | 282 | 3.5 |
| Triple | 15 752 | 469 | 3.0 |
| Quadruple | 8 812 | 227 | 2.6 |
| Quintuple + more | 2 935 | 58 | 2.0 |
| Total | 36 711 | 1 108 | 3.0 |

Table C3 Off-pump Isolated CABG surgery.

| Number of grafts | n | Deaths | % |
|------------------|-------|--------|-----|
| Single | 1 502 | 31 | 2.1 |
| Double | 1 842 | 35 | 1.9 |
| Triple | 1 987 | 31 | 1.6 |
| Quadruple | 533 | 7 | 1.3 |
| Quintuple + more | 229 | 0 | 0.0 |
| Total | 6 093 | 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 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 | 2 752 | 109 | 4.0 | 1 952 | 27 | 1.4 | 1 018 | 24 | 2.4 |

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 (HLT_x), 237 double lung (DLT_x), 44 single-lung transplantations (SLT_x), 1 lung + kidney transplantations and 0 lung + liver transplantations. The differences (ET: – 11 LT_x, – 3 HT_x) 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 | 1 483 | 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 | 1 166 | 60 | 5.1 | | | |
| Aortic arch replacement** | 1 316 | 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 | 6 342 | 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 | | | | With CPB | | Without CPB | |
|-----------------------------|-------|--------|---------|----------|--------|-------------|--------|
| | Total | Deaths | Death % | 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 | Endocardiac ablation (n) | Endocardiac ablation (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 |

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

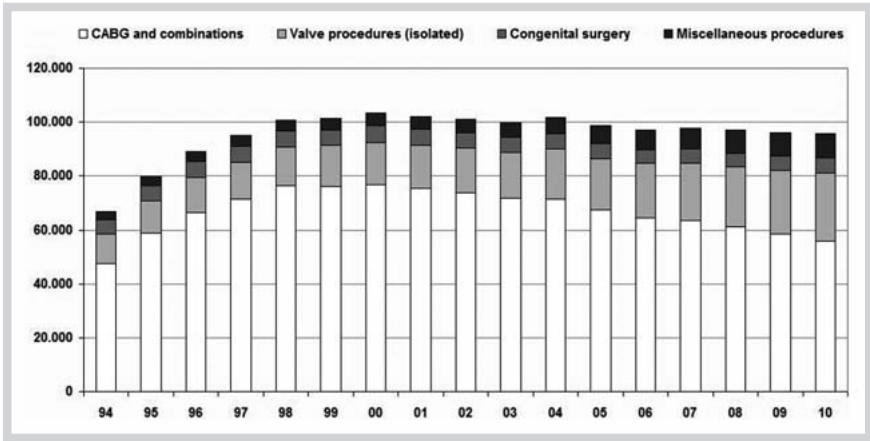


Fig. 1 Development of cardiac surgery in Germany between 1994 and 2010. 1) Coronary surgery and combined procedures include all types of isolated coronary surgery with or without CPB and any combined procedures. 2) Valve procedures include all types of isolated valvular surgery. Combinations of aortic 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.

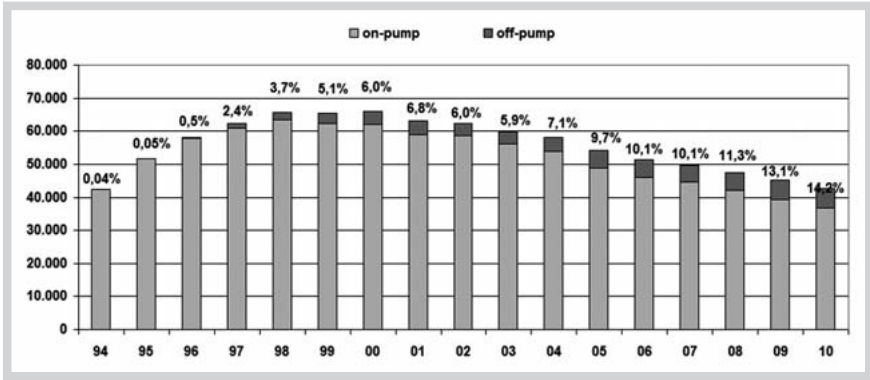


Fig. 2 The number of coronary artery bypass procedures is continuously declining since the year 2000. The proportion of off-pump procedures has slightly increased compared to previous years but still has not reached the percentage as in other comparable countries.

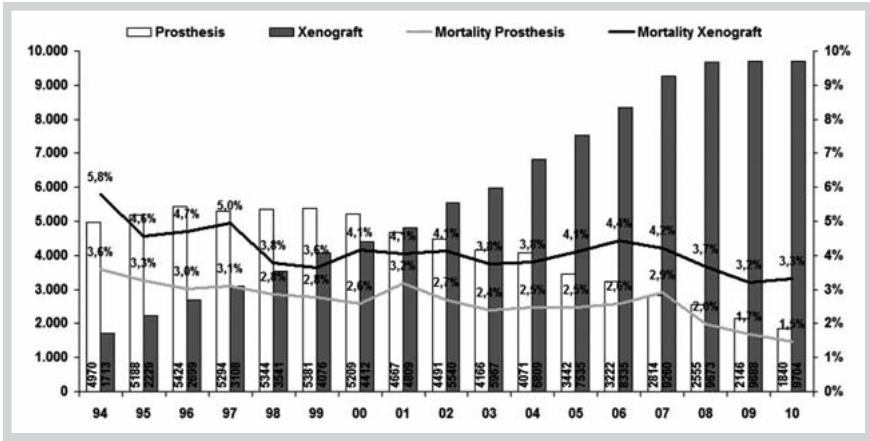


Fig. 3 Isolated aortic valve replacement between 1994 and 2010 in Germany. The number of xenograft valve replacements is steadily increasing. There is a marked difference in mortality which is probably age related. Ross procedures, homograft procedures and transcatheter valve implantations are excluded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

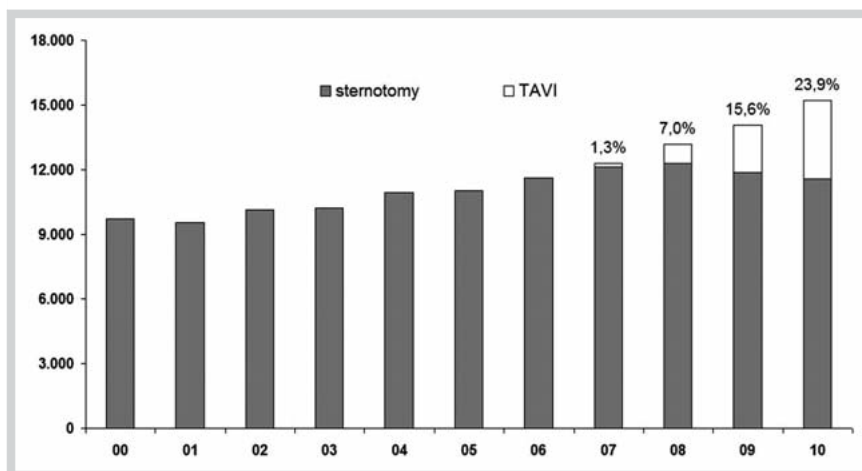


Fig. 4 Isolated aortic valve replacement via sternotomy or catheter-based procedures. The figure shows the significant increase in catheter-based procedures. In 2010 more than 23% of isolated aortic valve procedure were performed using a vascular or transapical approach. This development underlines that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

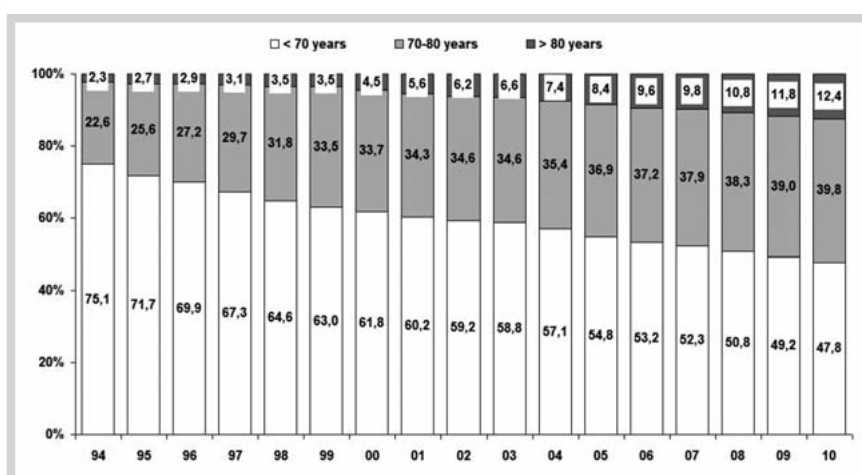


Fig. 5 Age distribution of cardiac procedures (without ICD and pacemaker) over the last 15 years. Currently more than 50% of the patients are older than 70 years. Patients younger than 20 years are excluded.

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

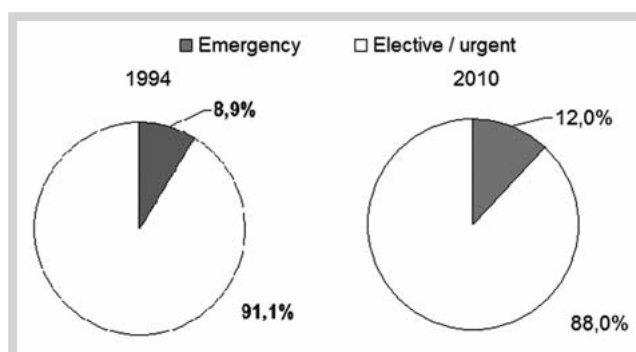


Fig. 6 Distribution of urgency 1994 and 2010. The incidence of emergency procedures has not changed significantly.

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.

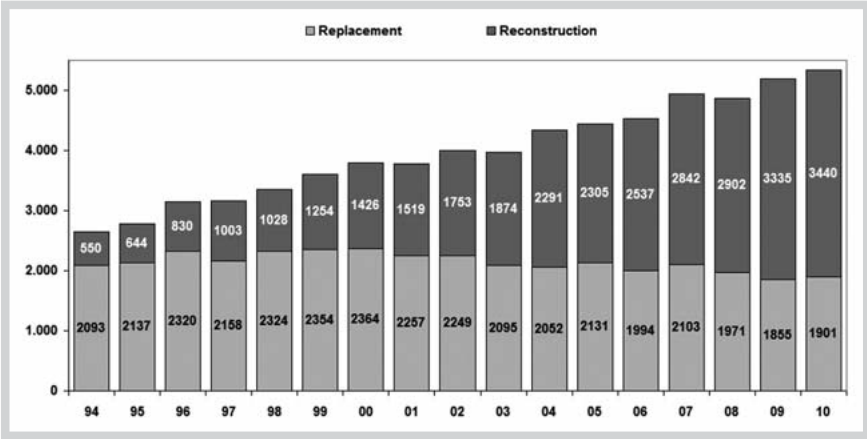


Fig. 7 Isolated mitral valve surgery over the last 15 years. More reconstructions (64%) than replacements (36%) were performed. In 1994 the percentage of reconstructions was only 21%. It is important for the interpretation of this figure that due to the data collection method all isolated mitral valve 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.

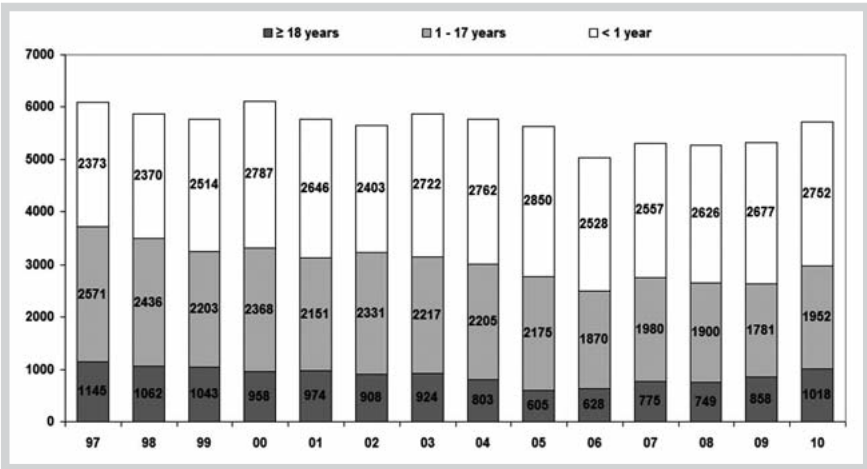


Fig. 8 Development of congenital surgery in Germany over the last 14 years. The downward tendency in the age groups below 18 years reached in 2006 its lowest point. In these age groups the number of surgical procedures is slightly increasing since then. In patients older than 17 years there may be a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

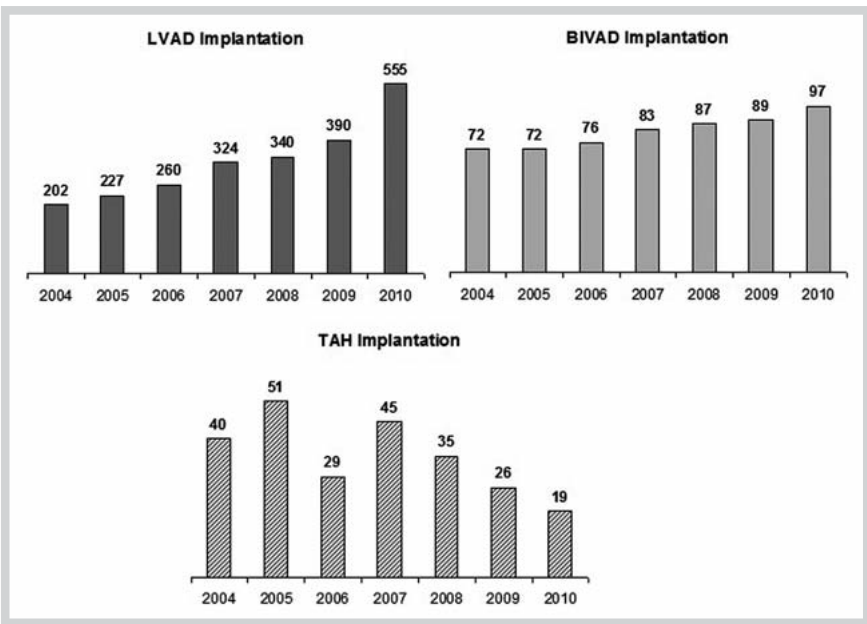


Fig. 9 Development of mechanical circulatory support in Germany over the last 7 years. There is a significant increase in left ventricular assist devices (LVAD). However, the number of paracorporeal bi-ventricular support systems (BIVAD) is only slowly growing and the number of total artificial hearts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

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