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

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The affiliations are listed at the end of the article

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 95734 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 42804 isolated CABG procedures (14.2% off-pump procedures) was 2.8%. In 25127 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. In 2010 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).

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. 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-
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).

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of units</td>
<td>21</td>
<td>21</td>
<td>33</td>
<td>46</td>
<td>76</td>
<td>79</td>
<td>79</td>
<td>80</td>
<td>80</td>
<td>79</td>
<td>80</td>
<td>79</td>
</tr>
<tr>
<td>Total number of operations</td>
<td>8,365</td>
<td>10,680</td>
<td>21,705</td>
<td>38,783</td>
<td>78,184</td>
<td>96,194</td>
<td>91,967</td>
<td>91,057</td>
<td>91,618</td>
<td>89,773</td>
<td>86,916</td>
<td>84,686</td>
</tr>
<tr>
<td>Average per unit</td>
<td>398</td>
<td>509</td>
<td>658</td>
<td>843</td>
<td>1,029</td>
<td>1,218</td>
<td>1,164</td>
<td>1,138</td>
<td>1,145</td>
<td>1,136</td>
<td>1,086</td>
<td>1,072</td>
</tr>
</tbody>
</table>

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

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

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

<table>
<thead>
<tr>
<th>Number of operations</th>
<th>&lt; 500</th>
<th>500–999</th>
<th>1,000–1,499</th>
<th>1,500–1,999</th>
<th>2,000–5,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of units</td>
<td>9</td>
<td>21</td>
<td>29</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Average per unit</td>
<td>353</td>
<td>773</td>
<td>1,156</td>
<td>1,722</td>
<td>2,916</td>
</tr>
<tr>
<td>Min–max</td>
<td>167–479</td>
<td>518–986</td>
<td>1,003–1,482</td>
<td>1,571–2,186</td>
<td>2,186–3,865</td>
</tr>
</tbody>
</table>

* One unit performs pediatric cardiac surgery only

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

<table>
<thead>
<tr>
<th>Type of surgery performed</th>
<th>Number of units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary surgery</td>
<td>78</td>
</tr>
<tr>
<td>Valve surgery</td>
<td>78</td>
</tr>
<tr>
<td>Surgery of congenital heart diseases with CPB in children &lt; 1 year</td>
<td>26*</td>
</tr>
<tr>
<td>Heart transplantation</td>
<td>24**</td>
</tr>
<tr>
<td>Heart-lung transplantation</td>
<td>5</td>
</tr>
</tbody>
</table>

* 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 transplants (n = 379); 78% of the total annual heart transplants are performed by 10 of 24 units with > 15 HTxs 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

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

<table>
<thead>
<tr>
<th>Demographic data</th>
<th>2010</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency operations</td>
<td>11,850</td>
<td>12.0%</td>
</tr>
<tr>
<td>Redo procedures</td>
<td>8,458</td>
<td>8.6%</td>
</tr>
<tr>
<td>Age &gt; 69 years</td>
<td>93,646</td>
<td>52.2%</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Male/female ratio among cardiac procedures</th>
<th>2010</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve procedures</td>
<td>56%</td>
<td>44%</td>
</tr>
<tr>
<td>Coronary surgery</td>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td>Congenital surgery</td>
<td>54%</td>
<td>46%</td>
</tr>
<tr>
<td>Surgery of thoracic aorta</td>
<td>68%</td>
<td>32%</td>
</tr>
<tr>
<td>Other cardiac surgery</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>Assist devices</td>
<td>71%</td>
<td>29%</td>
</tr>
<tr>
<td>Pacemaker and ICD</td>
<td>64%</td>
<td>36%</td>
</tr>
<tr>
<td>Extracardiac surgery</td>
<td>64%</td>
<td>36%</td>
</tr>
<tr>
<td>Total</td>
<td>66%</td>
<td>34%</td>
</tr>
</tbody>
</table>

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

Gummert JF et al. Cardiac Surgery in... Thorac Cardiov Surg 2011; 59: 259–267
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.

<table>
<thead>
<tr>
<th>Procedures</th>
<th>n</th>
<th>Deaths</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>17545</td>
<td>612</td>
<td>3.5</td>
</tr>
<tr>
<td>Double</td>
<td>3 466</td>
<td>273</td>
<td>7.9</td>
</tr>
<tr>
<td>Triple</td>
<td>344</td>
<td>42</td>
<td>12.2</td>
</tr>
<tr>
<td>Transcatheter access</td>
<td>3 660</td>
<td>284</td>
<td>7.8</td>
</tr>
<tr>
<td>Not specified</td>
<td>112</td>
<td>8</td>
<td>7.1</td>
</tr>
<tr>
<td>Total</td>
<td>25 127</td>
<td>935</td>
<td>3.7</td>
</tr>
</tbody>
</table>

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).

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

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.

<table>
<thead>
<tr>
<th>Type of valve</th>
<th>n</th>
<th>Deaths</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosthesis</td>
<td>1 840</td>
<td>27</td>
<td>1.5</td>
</tr>
<tr>
<td>Xenograft</td>
<td>9 704</td>
<td>323</td>
<td>3.3</td>
</tr>
<tr>
<td>Homograft</td>
<td>38</td>
<td>1</td>
<td>2.6</td>
</tr>
<tr>
<td>Reconstruction</td>
<td>107</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>11 689</td>
<td>352</td>
<td>3.0</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Type of valve</th>
<th>n</th>
<th>Deaths</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosthesis</td>
<td>598</td>
<td>37</td>
<td>6.2</td>
</tr>
<tr>
<td>Xenograft</td>
<td>1 292</td>
<td>116</td>
<td>9.0</td>
</tr>
<tr>
<td>Homograft</td>
<td>11</td>
<td>2</td>
<td>18.2</td>
</tr>
<tr>
<td>Reconstruction</td>
<td>3 440</td>
<td>61</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>5 341</td>
<td>216</td>
<td>4.0</td>
</tr>
</tbody>
</table>

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

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

* Including Ross procedures

Table V6  Mitral valve surgery – replacement vs. reconstruction.

<table>
<thead>
<tr>
<th>Mitral valve surgery</th>
<th>Total n</th>
<th>Deaths %</th>
<th>% Death</th>
<th>% Reconstruction</th>
<th>Replacement n</th>
<th>Deaths %</th>
<th>% death</th>
<th>Reconstruction n</th>
<th>Deaths %</th>
<th>% Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolated</td>
<td>5 341</td>
<td>216</td>
<td>4.0</td>
<td>64.4</td>
<td>1 901</td>
<td>155</td>
<td>8.2</td>
<td>3 440</td>
<td>61</td>
<td>1.8</td>
</tr>
<tr>
<td>MV +</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>aortic valve</td>
<td>1 770</td>
<td>132</td>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tricuspid valve</td>
<td>1 296</td>
<td>109</td>
<td>8.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CABG</td>
<td>2 588</td>
<td>252</td>
<td>9.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CABG + aortic valve</td>
<td>921</td>
<td>92</td>
<td>10.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11 916</td>
<td>801</td>
<td>6.7</td>
<td></td>
<td>4 157</td>
<td>455</td>
<td>10.9</td>
<td>7 759</td>
<td>346</td>
<td>4.5</td>
</tr>
</tbody>
</table>

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

Table V7  Overview valve surgery.

| Aortic valve replacement | Isolated valve surgery | Mechanical prosthesis | 1 840 | Xeno graft | 9 704 | Combination (valve) | 2 282 | Combination (valve + CABG) | 8 753 | Transfemoral | 1 450 | Traspical | 2 179 | Mitral valve surgery | 11 873 | Replacement | 4 146 | Mechanical prosthesis | 598 | Xeno graft | 1 292 | Combination (valve) | 1 171 | Combination (valve + CABG) | 1 085 | Reconstruction | 7 728 | Isolated valve surgery | 3 440 | Combination (valve) | 1 864 | Combination (valve + CABG) | 2 424 | Tricuspid valve surgery | 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: Age distribution among procedures for the correction of congenital heart defects.

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>Deaths</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) Without CPB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; over 18 years</td>
<td>82</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>&gt; 1–17 years</td>
<td>172</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>&gt; under 1 year</td>
<td>777</td>
<td>23</td>
<td>3.0</td>
</tr>
<tr>
<td>Total A</td>
<td>1031</td>
<td>25</td>
<td>2.4</td>
</tr>
<tr>
<td>B) With CPB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; over 18 years</td>
<td>936</td>
<td>23</td>
<td>2.5</td>
</tr>
<tr>
<td>&gt; 1–17 years</td>
<td>1780</td>
<td>11</td>
<td>0.6</td>
</tr>
<tr>
<td>&gt; under 1 year</td>
<td>1975</td>
<td>82</td>
<td>4.2</td>
</tr>
<tr>
<td>Total B</td>
<td>4691</td>
<td>124</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Table C2: Procedures for the correction of congenital heart defects with and without CPB.

<table>
<thead>
<tr>
<th>Lesion</th>
<th>n</th>
<th>Deaths</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASD</td>
<td>63</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Complete AV-canal</td>
<td>168</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>VSD</td>
<td>362</td>
<td>2</td>
<td>0.6</td>
</tr>
<tr>
<td>Fallot’s tetralogy</td>
<td>169</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td>DORV</td>
<td>63</td>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td>TGA</td>
<td>119</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>TGA + VSD</td>
<td>62</td>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td>Truncus arteriosus</td>
<td>29</td>
<td>2</td>
<td>6.9</td>
</tr>
<tr>
<td>Fontan</td>
<td>1</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Norwood</td>
<td>146</td>
<td>16</td>
<td>11.0</td>
</tr>
<tr>
<td>Pulmonary valve</td>
<td>63</td>
<td>3</td>
<td>4.8</td>
</tr>
<tr>
<td>Transcatheter pulmonary valve implantation</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Aortic valve</td>
<td>48</td>
<td>2</td>
<td>4.2</td>
</tr>
<tr>
<td>Ross procedure</td>
<td>13</td>
<td>4</td>
<td>30.8</td>
</tr>
<tr>
<td>Mitral valve</td>
<td>26</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Tricuspid valve</td>
<td>60</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>PDA</td>
<td>329</td>
<td>15</td>
<td>4.6</td>
</tr>
<tr>
<td>Coarctation</td>
<td>198</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Transpl. heart</td>
<td>8</td>
<td>2</td>
<td>25.0</td>
</tr>
<tr>
<td>Transpl. heart + lung</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Transpl. lung</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Others</td>
<td>825</td>
<td>52</td>
<td>6.3</td>
</tr>
<tr>
<td>Total</td>
<td>2752</td>
<td>109</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Table C3: Isolated CABG surgery with CPB and combined procedures with CPB.

<table>
<thead>
<tr>
<th>Procedures</th>
<th>n</th>
<th>Deaths</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABG</td>
<td>42804</td>
<td>1212</td>
<td>2.8</td>
</tr>
<tr>
<td>CABG + TMLR</td>
<td>41</td>
<td>2</td>
<td>4.9</td>
</tr>
<tr>
<td>aorto-aneurysma resection</td>
<td>224</td>
<td>12</td>
<td>5.4</td>
</tr>
<tr>
<td>aortic valve replacement</td>
<td>7832</td>
<td>436</td>
<td>5.6</td>
</tr>
<tr>
<td>transcatheter aortic valve implantation</td>
<td>18</td>
<td>7</td>
<td>38.9</td>
</tr>
<tr>
<td>mitral valve replacement</td>
<td>816</td>
<td>103</td>
<td>12.6</td>
</tr>
<tr>
<td>mitral valve repair</td>
<td>1772</td>
<td>149</td>
<td>8.4</td>
</tr>
<tr>
<td>aortic + mitral valve replacement</td>
<td>269</td>
<td>47</td>
<td>17.5</td>
</tr>
<tr>
<td>aortic valve replacement + mitral valve repair</td>
<td>652</td>
<td>45</td>
<td>6.9</td>
</tr>
<tr>
<td>other</td>
<td>1565</td>
<td>108</td>
<td>6.9</td>
</tr>
<tr>
<td>Total</td>
<td>55993</td>
<td>2121</td>
<td>3.8</td>
</tr>
</tbody>
</table>
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 (Table Mis1, 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 Mis1 Development of Ross procedures in various age groups.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In patients &gt;= 18 years</td>
<td>184</td>
<td>175</td>
<td>207</td>
<td>261</td>
<td>228</td>
<td>235</td>
<td>250</td>
<td>170</td>
<td>163</td>
<td>140</td>
</tr>
<tr>
<td>In patients &lt; 18 years</td>
<td>43</td>
<td>54</td>
<td>42</td>
<td>34</td>
<td>50</td>
<td>46</td>
<td>50</td>
<td>37</td>
<td>61</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td>227</td>
<td>229</td>
<td>249</td>
<td>295</td>
<td>278</td>
<td>281</td>
<td>300</td>
<td>207</td>
<td>224</td>
<td>181</td>
</tr>
</tbody>
</table>

### 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.

<table>
<thead>
<tr>
<th>Transplantation</th>
<th>With CPB</th>
<th>Without CPB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Deaths</td>
</tr>
<tr>
<td>Heart</td>
<td>379</td>
<td>44</td>
</tr>
<tr>
<td>Heart + lung</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>Lung</td>
<td>83</td>
<td>18</td>
</tr>
</tbody>
</table>

### 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.

<table>
<thead>
<tr>
<th>Aortic surgery*</th>
<th>With CPB</th>
<th>Without CPB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Deaths</td>
</tr>
<tr>
<td>Supracoronary ascending</td>
<td>1483</td>
<td>115</td>
</tr>
<tr>
<td>Infracoronary ascending</td>
<td>626</td>
<td>45</td>
</tr>
<tr>
<td>≥ mechanical valve conduits</td>
<td>678</td>
<td>72</td>
</tr>
<tr>
<td>≥ biological valve conduits</td>
<td>476</td>
<td>10</td>
</tr>
<tr>
<td>≥ David</td>
<td>125</td>
<td>5</td>
</tr>
<tr>
<td>≥ Yacoub</td>
<td>275</td>
<td>23</td>
</tr>
<tr>
<td>≥ other</td>
<td>83</td>
<td>18</td>
</tr>
<tr>
<td>Supracoronary ascending + aortic valve replacement</td>
<td>1166</td>
<td>60</td>
</tr>
<tr>
<td>Aortic arch replacement**</td>
<td>1316</td>
<td>140</td>
</tr>
<tr>
<td>Descending</td>
<td>99</td>
<td>10</td>
</tr>
<tr>
<td>Thoracoabdominal</td>
<td>91</td>
<td>10</td>
</tr>
<tr>
<td>Endostent descending</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>6342</td>
<td>491</td>
</tr>
</tbody>
</table>

*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 | n | Deaths | | Without CPB | 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.

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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

### 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 endocardiac/epicardiac ablation.

<table>
<thead>
<tr>
<th>Energy</th>
<th>Total</th>
<th>Endocardiac ablation (n)</th>
<th>Endocardiac ablation (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>unipolar radiofrequency</td>
<td>315</td>
<td>283</td>
<td>32</td>
</tr>
<tr>
<td>unipolar cryo-radiofrequency</td>
<td>532</td>
<td>327</td>
<td>205</td>
</tr>
<tr>
<td>bipolar radiofrequency</td>
<td>1621</td>
<td>193</td>
<td>1428</td>
</tr>
<tr>
<td>Cryothermy</td>
<td>1494</td>
<td>1136</td>
<td>358</td>
</tr>
<tr>
<td>Microwave</td>
<td>56</td>
<td>8</td>
<td>48</td>
</tr>
<tr>
<td>Focused ultrasound</td>
<td>465</td>
<td>48</td>
<td>417</td>
</tr>
<tr>
<td>Laser</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>other</td>
<td>19</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>4502</td>
<td>1996</td>
<td>2506</td>
</tr>
</tbody>
</table>

**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 xenovale 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.
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 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.
Acknowledgement

On behalf of the German Society for Thoracic and Cardiovascular Surgery the authors would like to thank the chairmen and their coworkers of all cardiac surgery units in Germany for their continuous cooperation and support for realizing this registry report. The authors would like to thank Mrs. J. Lewandowski for her excellent support in data collection.
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