The Japanese Association for Thoracic Surgery has conducted annual surveys of thoracic surgery throughout Japan since 1986 to determine the statistics regarding the number of procedures according to operative category. Here, we have summarized the results from our annual survey of thoracic surgery performed during 2014.

Thoracic surgery was classified into three categories—cardiovascular, general thoracic, and esophageal surgery—and the patient data were examined and analyzed for each group. Access to the computerized data is offered to all members of this Association. We honor and value all member’s continued kind support and contributions (Tables 1, 2).

The incidence of hospital mortality was added to the survey to determine the nationwide status, which has contributed to the Japanese surgeons to understand the present status of thoracic surgery in Japan and to make progress to improve operative results by comparing their work with those of others. The Association was able to gain a better understanding of the present problems as well as the future prospects, which has been reflected to its activity including education of its members. Thirty-day mortality (so-called “operative mortality”) is defined as death within...
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Hospital-to-hospital transfer is not considered discharge in the categories of cardiovascular surgery and esophageal surgery: transfer to a nursing home or a rehabilitation unit is considered hospital discharge unless the patient subsequently dies of complications of the operation. While hospital-to-hospital transfer after 30 days of operation is considered discharge in the categories of general thoracic surgery, because data of national clinical database (NCD) 2014 were used in this category, and hospital-to-hospital transfer after 30 days of operation is considered discharge in NCD.

Table 1 Questionnaires sent out and received back by the end of December 2015

| Category                      | Sent out | Returned | Response rate (%) |
|-------------------------------|----------|----------|-------------------|
| (A) Cardiovascular surgery    | 578      | 561      | 97.1              |
| (B) General thoracic surgery  | 762      | 732      | 96.1              |
| (C) Esophageal surgery        | 626      | 601      | 96.0              |

Table 2 Categories subclassified according to the number of operations performed

| Number of operations performed | Category          | Cardiovascular surgery | General thoracic surgery |
|-------------------------------|-------------------|-------------------------|--------------------------|
| 0                             | 21                | 30                      |
| 1–24                          | 42                | 81                      |
| 25–49                         | 86                | 108                     |
| 50–99                         | 157               | 202                     |
| 100–149                       | 103               | 137                     |
| 150–199                       | 52                | 80                      |
| ≥200                          | 100               | 94                      |
| Total                         | 561               | 732                     |

| Number of operations performed | Esophageal surgery |
|-------------------------------|--------------------|
| 0                             | 98                 |
| 1–4                           | 145                |
| 5–9                           | 117                |
| 10–19                         | 108                |
| 20–29                         | 39                 |
| 30–39                         | 27                 |
| 40–49                         | 25                 |
| ≥50                           | 42                 |
| Total                         | 601                |

30 days of operation regardless of the patient’s geographic location and even though the patient had been discharged from the hospital.

Hospital mortality is defined as death within any time interval after an operation if the patient had not been discharged from the hospital. Hospital-to-hospital transfer is not considered discharge in the categories of cardiovascular surgery and esophageal surgery: transfer to a nursing home or a rehabilitation unit is considered hospital discharge unless the patient subsequently dies of complications of the operation. While hospital-to-hospital transfer after 30 days of operation is considered discharge in the categories of general thoracic surgery, because data of national clinical database (NCD) 2014 were used in this category, and hospital-to-hospital transfer after 30 days of operation is considered discharge in NCD.

Abstract of the survey

We sent out survey questionnaire forms to the departments of each category in all 1039 institutions (578 cardiovascular, 762 general thoracic, and 626 esophageal) nationwide in early April 2014. The response rates in each category by the end of December 2015 were 97.1, 96.1, and 96.0 %, respectively. This high response rate has been keep throughout recent survey, and more than 96 % response rate in all fields in 2014 survey has to be congratulated.

2014 Final report

(A) Cardiovascular surgery

First, we are very pleased with the high response rate to our survey of cardiovascular surgery (97.1 %), which definitely enhances the quality of this annual report. We very much appreciate the enormous effort put into completing the survey at each participating institution.

Figure 1 shows the development of cardiovascular surgery in Japan over the last 28 years. Aneurysm surgery includes only operations for thoracic and thoracoabdominal aortic aneurysm. Pacemaker implantation includes only transthoracic implantation, and transvenous implantation is excluded. The number of pacemaker and assist device implantation operations is not included in the total number of surgical operations. A total of 66,453 cardiovascular operations were performed at 561 institutions during 2014 alone and included 30 heart transplantations, which were restarted in 1999.

The number of operations for congenital heart disease (9269 cases) decreased slightly (1.0 %) compared with that of 2013 (9366 cases), and 2.9 % decrease when compared with the data of 10 years ago (9545 cases in 2004). The number of operations for adult cardiac disease (21,939 cases in valvular heart disease, 17,498 cases in thoracic aortic aneurysm, and 2118 cases for other procedures) increased compared with those of 2013 (0.8, 11.0, and 13.2 %, respectively) except for ischemic heart disease (15,629 cases), which decreased 5.6 % of that in 2013. During the last 10 years, the numbers of operations for adult heart disease increased constantly except for that for ischemic heart disease (73.8 % increase in valvular heart disease, 26.5 % decrease in ischemic heart disease, 114.5 % increase in thoracic aortic aneurysm, and 56.5 % increase in other procedures compared those of 2004). The concomitant coronary artery bypass grafting procedure (CABG) is not included in ischemic heart disease but included in other categories, such as valvular heart disease.
and thoracic aneurysm in our study, and then, the number of CABG still remained over 20,000 cases per year (20,991 cases) in 2014.

Data for individual categories are summarized in tables through 3 to 9.

In 2014, 6894 open-heart operations for congenital heart disease were performed with overall hospital mortality of 2.3 %. The number of operations for congenital heart disease was quite steady throughout these 10 years (maximum 7,386 cases in 2006), while overall hospital mortality decreased gradually from that of 3.9 % in 2004. In detail, the most common disease was atrial septal defect (1,248 cases); however, its number deceased to 64.3 % of that in 2004, which might be partially due to the recent development of catheter closure of atrial septal defect in Japan. In the last 10 years, hospital mortality for complex congenital heart disease improved in some anomalies such as, complete atroventricular septal defect (5.4–1.7 %), tetralogy of Fallot (2.5–1.1 %), transposition of the great arteries with and without ventricular septal defect (9.8–3.9 and 7.1–6.6 %, respectively), single ventricle (8.5–4.3 %), and hypoplastic left heart syndrome (27.7–9.8 %). Right heart bypass surgery is now commonly performed (351 bidirectional Glenn procedures excluding 56 Damus–Kaye–Stansel procedures and 397 Fontan-type procedures including total cavopulmonary connection) with acceptable hospital mortality (1.2 and 1.0 %). Norwood type I procedure was performed in 125 cases with relatively low hospital mortality rate of 15.2 %.

As previously mentioned, the number of operations for valvular heart disease increased by 73.8 % in the last 10 years, and the hospital mortality associated with primary single valve replacement was 2.4 and 5.9 % for the aortic and the mitral position, while that for primary mitral valve repair was 1.1 %. However, hospital mortality rate for redo valve surgery was still high and was 9.4 and 7.8 % for aortic and mitral procedure, respectively. Finally, overall hospital mortality did not show dramatic improvement during the last 10 years (3.8 % in 2004 and 3.1 % in 2014), which might be partially due to the recent progression of age of the patients. Repair of the valve became popular procedure (397 cases in the aortic, 6527 cases in the mitral, and 5066 cases in the tricuspid), and mitral valve repair constituted 29.8 % of all valvular heart disease operation and 59.6 % of all mitral valve procedure (10,957 procedures), which are similar to those of the last 5 years and increased compared with those of 2004 (23.6 and 42.8 %, respectively). Aortic and mitral valve replacements with bioprosthesis were performed in 10,220 cases and 2,765 cases, respectively, with the number consistently increasing in the aortic position. The ratio of prostheses changed dramatically during the last 10 years and the usage of bioprosthesis is 77.5 % at the aortic position (36.7 % in 2004) and 25.2 % at the mitral position (14.8 % in 2004). CABG as a concomitant procedure performed in 17.3 % of operations for all valvular heart disease (13.3 % in 2004).

Isolated CABG was performed in 14,454 cases which were only 72.5 % of that of 10 years ago (2004). Among these 14,454 cases, off-pump CABG was intended in 9,006 cases (62.3 %) with a success rate of 98.3 %, so final success rate of off-pump CABG was 61.2 %. The percentage of intended off-pump CABG reached 60.3 % in 2004, and then was kept over 60 % until now. In 14,454 isolated CABG patients, 95.4 % of them received at least one arterial graft, while all arterial graft CABG was performed only 21.4 % of them.

The operative and hospital mortality rates associated with primary elective CABG procedures in 12335 cases were 0.8 and 1.3 %, respectively. Similar data analysis of CABG, including primary/redo and elective/emergency data, was begun in 2003, and the operative and hospital mortality rates associated with primary elective CABG procedures in 2003 were 1.0 and 1.5 %, respectively, so operative results of primary CABG has been stable, while hospital mortality of primary emergency CABG in 1,959 cases was still high and was 7.9 %. During these 10 years, the results of conversion from off-pump CABG improved both in conversion rate (3.1–1.7 %) and in hospital mortality (10.4–4.5 %).

A total of 1175 patients underwent surgery for complications of myocardial infarction, including 329 operations for a left ventricular aneurysm or ventricular septal perforation or cardiac rupture and 261 operations for ischemic mitral regurgitation.

Operations for arrhythmia were performed mainly as a concomitant procedure in 3855 cases with satisfactory mortality (1.6 % hospital mortality) including 3,486 MAZE procedures. MAZE procedure has become quite popular procedure when compared with that in 2004 (1837 cases).

Operations for thoracic aortic dissection were performed in 7733 cases. For 4953 Stanford type A acute aortic dissections, hospital mortality remained high and was 10.6 %. Operations for a non-dissected thoracic aneurysm were carried out in 9765 cases, with overall hospital mortality of 4.7 %. The hospital mortality associated with unruptured aneurysm was 3.3 %, and that of ruptured aneurysm was 21.2 %, which remains markedly high.

The number of stent graft procedures remarkably increased recently. A total of 1,625 patients with aortic dissection underwent stent graft placement: thoracic endovascular aortic repair (TEVAR) in 1,382 cases and open stent grafting in 243 cases. The number of TEVAR for type B chronic aortic dissections increased from 69
cases in 2004 to 835 cases in 2014. The hospital mortality rates associated with TEVAR for type B aortic dissection were 5.5% in acute cases and 2.9% for chronic cases, respectively.

A total of 3922 patients with non-dissected aortic aneurysm underwent stent graft placement; TEVAR in 3521 cases (12.4% increase compared with that in 2013) and open stent grafting in 401 cases (145% increase compared with that in 2013). The reason of dramatic increase in open stent grafting might be due to commercially availability since 2014. The hospital mortality rates for TEVAR were 2.4 and 17.1% for non-ruptured and ruptured aneurysm, respectively.

In summary, the total cardiovascular operations increased during 2014 by 1141 cases with steadily improving results in almost all categories throughout these 10 years.

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**Fig. 1** Cardiovascular surgery. *IHD* ischemic heart disease
| Condition            | Cases  | 30-day mortality | Hospital mortality | After discharge |
|----------------------|--------|------------------|--------------------|-----------------|
| **Infant**           |        |                  |                    |                 |
| CPB                  | 3030   | 30-day mortality | Hospital mortality | After discharge |
| Atrial septal defect | 45     | 0                | 0                  | 0               |
| Patent foramen ovale | 10    | 0                | 0                  | 0               |
| Mitral valve stenosis| 5      | 0                | 0                  | 0               |
| Mitral valve regurgitation| 3 | 0                | 0                  | 0               |
| Pulmonary valve stenosis| 2 | 0                | 0                  | 0               |
| Pulmonary valve regurgitation| 1 | 0                | 0                  | 0               |
| **Total**            | 3030   | 30-day mortality | Hospital mortality | After discharge |
| **18 years**         |        |                  |                    |                 |
| CPB                  | 6894   | 30-day mortality | Hospital mortality | After discharge |
| Atrial septal defect | 45     | 0                | 0                  | 0               |
| Patent foramen ovale | 10    | 0                | 0                  | 0               |
| Mitral valve stenosis| 5      | 0                | 0                  | 0               |
| Mitral valve regurgitation| 3 | 0                | 0                  | 0               |
| Pulmonary valve stenosis| 2 | 0                | 0                  | 0               |
| Pulmonary valve regurgitation| 1 | 0                | 0                  | 0               |
| **Total**            | 6894   | 30-day mortality | Hospital mortality | After discharge |
| **Total**            | 9269   | 30-day mortality | Hospital mortality | After discharge |
Table 3 continued

| Neonate | Infant | 1–17 years | ≥ 18 years | Total |
|---------|--------|------------|------------|-------|
|         | Hospital mortality | After discharge | Hospital mortality | After discharge | Hospital mortality | After discharge | Hospital mortality | After discharge | Hospital mortality | After discharge | Hospital mortality | After discharge |
| Cases   | 30-day mortality |                   | Cases   | 30-day mortality |                   | Cases   | 30-day mortality |                   | Cases   | 30-day mortality |                   | Cases   | 30-day mortality |                   |
| 36 VSD + PS | 1 | 0 | 0 | 0 | 11 | 0 | 0 | 1 | (9.1) | 15 | 1 | (6.7) | 0 | 1 | (6.7) | 6 | 0 | 0 | 0 | 33 | 1 | (3.0) | 0 | 2 | (6.1) |
| 37 Corrected TGA | 3 | 0 | 0 | 0 | 23 | 0 | 0 | 0 | 40 | 1 | (2.5) | 0 | 2 | (5.0) | 49 | 1 | (2.0) | 0 | 2 | (4.1) |
| 38 Truncus arteriosus | 11 | 1 | (9.1) | 0 | 1 | (9.1) | 14 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 49 | 1 | (2.0) | 0 | 2 | (4.1) |
| 39 SV | 22 | 2 | (9.1) | 0 | 7 | (31.8) | 202 | 4 | (20) | 0 | 6 | (30) | 263 | 4 | (15.5) | 1 | (0.4) | 8 | (30) | 20 | 1 | (5.0) | 0 | 1 | (5.0) | 507 | 11 | (2.2) | 1 | (0.2) | 22 | (4.3) |
| 40 TA | 5 | 0 | 0 | 0 | 4 | 1 | (2.3) | 0 | 1 | (2.3) | 53 | 0 | 0 | 0 | 1 | (19) | 10 | 0 | 0 | 0 | 112 | 1 | (0.9) | 0 | 2 | (1.8) |
| 41 HLHS | 40 | 2 | (5.0) | 0 | 5 | (12.5) | 124 | 9 | (7.5) | 0 | 15 | (12.1) | 60 | 1 | (1.7) | 0 | 2 | (3.3) | 0 | 0 | 0 | 0 | 224 | 12 | (5.4) | 0 | 2 | (9.8) |
| 42 Aortic valve lesion | 6 | 0 | 0 | 0 | 14 | 1 | (7.1) | 0 | 1 | (7.1) | 89 | 1 | (11.1) | 0 | 1 | (1.1) | 16 | 1 | (6.3) | 0 | 1 | (6.3) | 125 | 3 | (2.4) | 0 | 3 | (2.4) |
| 43 Mitral valve lesion | 2 | 0 | 0 | 0 | 28 | 1 | (3.6) | 0 | 1 | (3.6) | 72 | 1 | (1.4) | 0 | 2 | (2.8) | 8 | 0 | 0 | 0 | 110 | 2 | (1.8) | 0 | 3 | (2.7) |
| 44 Ebstein | 15 | 0 | 0 | 0 | 3 | (20.0) | 14 | 0 | 0 | 0 | 34 | 0 | 0 | 0 | 16 | 2 | (12.5) | 0 | 2 | (12.5) | 79 | 2 | (2.5) | 0 | 6 | (7.6) |
| 45 Coronary disease | 1 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 14 | 1 | (7.1) | 0 | 1 | (7.1) | 22 | 0 | 0 | 0 | 45 | 1 | (2.2) | 0 | 1 | (2.2) |
| 46 Others | 21 | 0 | 0 | 0 | 1 | (4.8) | 46 | 1 | (22) | 0 | 3 | (6.5) | 35 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 111 | 1 | (0.9) | 0 | 5 | (4.5) |
| 47 Redo VSD | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 86 | 0 | 0 | 0 | 0 |
| 48 PS release | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 52 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 86 | 0 | 0 | 0 | 0 |
| 49 RV-PA conduit replace | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 54 | 0 | 0 | 0 | 37 | 0 | 0 | 0 | 95 | 0 | 0 | 0 | 0 |
| 50 Others | 4 | 0 | 0 | 0 | 1 | (25.0) | 41 | 2 | (49) | 0 | 3 | (7.3) | 97 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 185 | 2 | (11.1) | 0 | 4 | (2.2) |

Values in parenthesis represent mortality %

CPB cardiopulmonary bypass, PDA patient ductus arteriosus, VSD ventricular septal defect, DORV double outlet right ventricle, AVSD atrioventricular septal defect, TGA transposition of great arteries, SV single ventricle, Interupt. of Ao. interruption of aorta, PS pulmonary stenosis, PA-IVS pulmonary atresia with intact ventricular septum, TAPVR total anomalous pulmonary venous return, PAPVR partial anomalous pulmonary venous return, ASD atrial septal defect, TOF tetralogy of Fallot, DCRV double-chambered right ventricle, TA tricuspid atresia, HLHS hypoplastic left heart syndrome, RV-PA right ventricle-pulmonary artery
| Table 3 continued |
|-------------------|
| (2) CPB (−) (total; 2375) |

| Case | 30-day mortality | Hospital mortality |
|------|------------------|--------------------|
| Neonate | Infant | 1–17 years | ≥18 years | Total |
| Cases | Hospital | After discharge | Cases | Hospital | After discharge | Cases | Hospital | After discharge | Cases | Hospital | After discharge | Cases | Hospital | After discharge | Cases | Hospital | After discharge |
| 1 | PDA | 430 | 4 (0.9) | 0 | 5 (1.2) | 230 | 2 (0.9) | 0 | 4 (1.7) | 40 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 702 | 6 (0.9) | 0 | 9 (1.3) |
| 2 | Coarctation (simple) | 21 | 1 (4.8) | 0 | 1 (4.8) | 27 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 52 | 1 (1.9) | 0 | 1 (1.9) |
| 3 | +VSD | 39 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 59 | 0 | 0 | 0 |
| 4 | +DORV | 9 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 |
| 5 | +AVSD | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| 6 | +TGA | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 0 | 0 | 0 |
| 7 | +SV | 12 | 0 | 0 | 1 (8.3) | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 1 (5.0) |
| 8 | +Others | 8 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 |
| 9 | Interrupt. of Ao (simple) | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| 10 | +VSD | 25 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 35 | 0 | 0 | 0 |
| 11 | +DORV | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| 12 | +Truncus | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 13 | +TGA | 1 | 0 | 0 | 1 (100.0) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 1 (50.0) |
| 14 | +Others | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| 15 | Vascular ring | 5 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 |
| 16 | PS | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| 17 | PAIVS or critical PS | 25 | 1 (4.0) | 0 | 1 (4.0) | 20 | 0 | 0 | 1 (5.0) | 8 | 1 (12.5) | 0 | 2 (5.0) | 0 | 0 | 0 | 0 | 53 | 2 (3.8) | 0 | 4 (7.5) |
| 18 | TAPVR | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 13 | 2 (15.4) | 0 | 2 (15.4) |
| 19 | PAPVR ± ASD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| 20 | ASD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | Cor truncaatum | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| 22 | AVSD (partial) | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| 23 | AVSD (complete) | 35 | 0 | 0 | 1 (2.9) | 72 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 110 | 0 | 0 | 1 (0.9) |
| 24 | +TOF or DORV | 2 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 |
| 25 | +Others | 7 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 |
| 26 | VSD (subarteral) | 1 | 0 | 0 | 0 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 |
| 27 | VSD | 49 | 0 | 0 | 0 | 2 (4.1) | 107 | 0 | 0 | 0 | 2 (1.9) | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 160 | 0 | 0 | 4 (2.5) |
| (perimembr/muscular) | | | | | | | | | | | | | | | | | | | | | | | |
| 28 | VSD + PS | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 29 | DCRV ± VSD | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| 30 | Aneurysm of sinus vasaalva | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | TOF | 28 | 2 (7.1) | 0 | 2 (7.1) | 88 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 124 | 2 (1.6) | 0 | 2 (1.6) |
| 32 | PA + VSD | 23 | 0 | 0 | 0 | 69 | 1 (4.4) | 0 | 1 (1.4) | 23 | 1 (4.3) | 0 | 1 (4.3) | 0 | 0 | 0 | 0 | 15 | 2 (1.7) | 0 | 2 (1.7) |
| 33 | DORV | 36 | 0 | 0 | 0 | 55 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 105 | 0 | 0 | 0 |
| 34 | TGA (simple) | 6 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| Cases | 30-day mortality | Hospital mortality | After discharge | Cases | 30-day mortality | Hospital mortality | After discharge | Cases | 30-day mortality | Hospital mortality | After discharge | Cases | 30-day mortality | Hospital mortality | After discharge | Cases | 30-day mortality | Hospital mortality | After discharge |
|-------|------------------|--------------------|----------------|-------|------------------|--------------------|----------------|-------|------------------|--------------------|----------------|-------|------------------|--------------------|----------------|-------|------------------|--------------------|----------------|
| 35    | VSD              | 7                  | 0              | 0     | 0                | 0                  | 0             | 3     | 0                | 0                  | 0             | 0     | 14               | 0                  | 0             | 0     |
| 36    | VSD + PS         | 12                 | 0              | 0     | 0                | 0                  | 0             | 1     | 0                | 0                  | 0             | 0     | 40               | 0                  | 0             | 0     |
| 37    | Corrected TGA    | 8                  | 0              | 0     | 0                | 0                  | 0             | 8     | 0                | 0                  | 0             | 0     | 50               | 0                  | 0             | 0     |
| 38    | Truncus arteriosus | 15                | 1 (6.7)        | 0     | 0                | 0                  | 0             | 5     | 0                | 0                  | 0             | 0     | 25               | 1 (4.0)            | 0             | 0     |
| 39    | SV               | 73                 | 2 (2.7)        | 0     | 0                | 0                  | 0             | 24    | 0                | 0                  | 0             | 0     | 161              | 4 (2.5)            | 0             | 7     |
| 40    | TA               | 25                 | 0              | 0     | 0                | 0                  | 0             | 9     | 0                | 0                  | 0             | 0     | 47               | 1 (2.1)            | 0             | 1     |
| 41    | HLHS             | 97                 | 3 (3.1)        | 0     | 0                | 0                  | 0             | 16    | 0                | 0                  | 2 (12.5)       | 1     | 128              | 3 (2.3)            | 0             | 9     |
| 42    | Aortic valve lesion | 1                | 0              | 0     | 0                | 0                  | 0             | 1     | 0                | 0                  | 0             | 0     | 4                | 0                  | 0             | 0     |
| 43    | Mitral valve lesion | 2                | 0              | 0     | 0                | 0                  | 0             | 0     | 0                | 0                  | 0             | 0     | 2                | 0                  | 0             | 0     |
| 44    | Ebstein          | 6                  | 0              | 0     | 0                | 0                  | 0             | 3     | 0                | 0                  | 0             | 1     | 11               | 0                  | 0             | 0     |
| 45    | Coronary disease | 1                  | 0              | 0     | 0                | 0                  | 0             | 4     | 0                | 0                  | 0             | 0     | 7                | 1 (14.3)           | 0             | 1     |
| 46    | Others           | 15                 | 1 (6.7)        | 0     | 0                | 0                  | 0             | 56    | 0                | 0                  | 18            | 0     | 141              | 1 (0.7)            | 0             | 1     |
| 47    | Redo VSD         | 0                  | 0              | 0     | 0                | 0                  | 0             | 0     | 0                | 0                  | 0             | 0     | 0                | 0                  | 0             | 0     |
| 48    | PS release       | 1                  | 0              | 0     | 0                | 0                  | 0             | 1     | 0                | 0                  | 0             | 0     | 4                | 0                  | 1 (25.0)       |
| 49    | RV-PA conduit replace | 0               | 0              | 0     | 0                | 0                  | 0             | 0     | 0                | 0                  | 0             | 0     | 0                | 0                  | 0             | 0     |
| 50    | Others           | 6                  | 0              | 0     | 0                | 0                  | 0             | 22    | 0                | 0                  | 1 (4.5)        | 21   | 54               | 1 (1.9)            | 0             | 2 (3.7) |
| Total | 1051             | 15 (1.4)           | 28 (2.7)       | 973   | 9 (0.9)          | 36 (16)           | 285           | 3 (1.1) | 6 (2.1)          | 66                 | 0             | 2375 | 27 (1.1)         | 0                 | 50            | 2 (1.1) |

Values in parenthesis represent mortality %

CPB cardiopulmonary bypass, PDA patient ductus arteriosus, VSD ventricular septal defect, DORV double outlet right ventricle, AVSD atroventricular septal defect, TGA transposition of great arteries, SV single ventricle, Interupt. of Ao. interruption of aorta, PS pulmonary stenosis, PA-IVS pulmonary atresia with intact ventricular septum, TAPVR total anomalous pulmonary venous return, PAPVR partial anomalous pulmonary venous return, ASD atrial septal defect, TOF tetralogy of Fallot, DCRV double-chambered right ventricle, TA tricuspid atresia, HLHS hypoplastic left heart syndrome, RV-PA right ventricle-pulmonary artery
| Neurate | Infant | 1–17 years | ≥18 years | Total |
|---------|--------|------------|-----------|-------|
| Cases   | Cases  | Cases      | Cases     | Cases  |
|         | Hospital | Hospital | Hospital | Hospital |
| 1       | SP shunt | 149       | 357       | 42      | 549    |
|          |          | 4 (2.7)   | 6 (1.7)   | 1 (2.4) | 10 (1.8) |
|          | 8 (5.4)   | 2 (0.8)   | 2 (0.8)   | 0 (0.0) | 3 (0.5) |
| 2       | PAB      | 387       | 263       | 11      | 661    |
|          |          | 7 (1.8)   | 2 (0.8)   | 0 (0.0) | 9 (1.4) |
|          | 13 (3.9)  | 5 (1.9)   | 1 (0.9)   | 0 (0.0) | 3 (0.9) |
| 3       | Bidirectional Glenn or hemi-Fontan ± aorta | 1       | 240       | 106     | 351    |
|          |          | 0 (0.0)   | 2 (0.8)   | 1 (0.9) | 3 (0.9) |
| 4       | Damus–Kaye–Stansel operation | 2       | 36        | 15      | 56     |
|          |          | 0 (0.0)   | 1 (2.8)   | 0 (0.0) | 1 (1.8) |
| 5       | PA reconstruction/repair (including redo) | 16      | 106       | 140     | 287    |
|          |          | 0 (0.0)   | 2 (1.9)   | 3 (2.8) | 2 (0.7) |
| 6       | RVOT reconstruction/repair | 12      | 111       | 202     | 378    |
|          |          | 0 (0.0)   | 1 (0.9)   | 3 (1.5) | 2 (0.5) |
| 7       | Rastelli procedure | 9       | 39        | 94      | 153    |
|          |          | 0 (0.0)   | 1 (2.6)   | 2 (2.1) | 0 (0.0) |
| 8       | Arterial switch procedure | 134     | 9 (6.7)   | 202     | 378    |
|          |          | 1 (0.7)   | 1 (0.5)   | 3 (1.5) | 2 (0.5) |
| 9       | Atrial switch procedure | 2       | 40        | 9       | 176    |
|          |          | 1 (50.0)  | 1 (2.5)   | 2 (1.0) | 1 (4.3) |
| 10      | Double switch procedure | 0       | 0         | 0       | 7      |
|          |          | 0 (0.0)   | 0 (0.0)   | 0 (0.0) | 1 (14.3)|
| 11      | Repair of anomalous origin of CA | 1       | 4         | 8       | 17     |
|          |          | 0 (0.0)   | 0 (0.0)   | 0 (0.0) | 0 (0.0) |
| 12      | Closure of coronary AV fistula | 1       | 5         | 4       | 29     |
|          |          | 0 (0.0)   | 0 (0.0)   | 0 (0.0) | 0 (0.0) |
| 13      | Fontan/TCPC | 0       | 0         | 362     | 397    |
|          |          | 0 (0.0)   | 0 (0.0)   | 1 (0.3) | 1 (0.3) |
| 14      | Norwood procedure | 29      | 93        | 17      | 125    |
|          |          | 2 (6.9)   | 8 (8.6)   | 2 (13.3) | 8 (6.4) |
| 15      | Ventricular septation | 0       | 10        | 4       | 15     |
|          |          | 0 (0.0)   | 0 (0.0)   | 0 (0.0) | 0 (0.0) |
| 16      | Left side AV valve repair (including Redo) | 3       | 45        | 71      | 147    |
|          |          | 1 (33.3)  | 2 (4.4)   | 2 (4.4) | 3 (2.0) |
| 17      | Left side AV valve replace (including Redo) | 0       | 9         | 37      | 65     |
|          |          | 0 (0.0)   | 0 (0.0)   | 2 (5.4) | 2 (3.1) |
| 18      | Right side AV valve repair (including Redo) | 4       | 14        | 34      | 90     |
|          |          | 0 (0.0)   | 0 (0.0)   | 1 (7.1) | 3 (3.3) |
| 19      | Right side AV valve replace (including Redo) | 0       | 2         | 34      | 90     |
|          |          | 0 (0.0)   | 1 (50.0)  | 0 (0.0) | 3 (1.3) |
| 20      | Common AV valve repair (including Redo) | 2       | 33        | 34      | 70     |
|          |          | 0 (0.0)   | 1 (3.0)   | 2 (5.9) | 3 (4.3) |
| 21      | Common AV valve replace (including Redo) | 1       | 2         | 7       | 11     |
|          |          | 0 (0.0)   | 0 (0.0)   | 0 (0.0) | 1 (9.1) |
| 22      | Repair of supravalvular aortic stenosis | 3       | 9         | 15      | 29     |
|          |          | 0 (0.0)   | 0 (0.0)   | 0 (0.0) | 0 (0.0) |
| 23      | Repair of subaortic stenosis (including Redo) | 2       | 24        | 24      | 40     |
|          |          | 0 (0.0)   | 2 (8.3)   | 2 (8.3) | 5 (10.0)|
| 24      | Aortic valve plasty ± VSD closure | 4       | 31        | 4       | 45     |
|          |          | 0 (0.0)   | 0 (0.0)   | 0 (0.0) | 0 (0.0) |
| 25      | Aortic valve replacement | 0       | 19        | 23      | 42     |
|          |          | 0 (0.0)   | 0 (0.0)   | 0 (0.0) | 0 (0.0) |
| 26      | AVR with annular enlargement | 0       | 12        | 3       | 15     |
|          |          | 0 (0.0)   | 0 (0.0)   | 1 (33.3) | 1 (6.7) |
### Table 3 continued

(3) Main procedure

|                | Neonate | Infant | 1–17 years | ≥ 18 years | Total |
|----------------|---------|--------|------------|------------|-------|
|                | Cases   | 30-day mortality | Hospital mortality | Hospital mortality | Hospital mortality | Cases   | 30-day mortality | Hospital mortality | Hospital mortality | Hospital mortality |
|                | Hospital | After discharge   | Hospital | After discharge | Hospital | After discharge | Hospital | After discharge | Hospital | After discharge | Hospital | After discharge |
| 27 Aortic root replace (except Ross) | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 16 | 0 | 0 | 0 |
| 28 Ross procedure | 0 | 0 | 0 | 0 | 0 | 11 | 1 (9.1) | 0 | 1 (9.1) | 2 | 0 | 0 | 0 | 13 | 1 (7.7) | 0 | 1 (7.7) |
| Total          | 762     | 22 (2.9) | 1 (0.1) | 42 (5.5) | 1443 | 27 (1.9) | 0 | 48 (3.3) | 1322 | 11 (0.8) | 0 | 23 (1.7) | 308 | 3 (1.0) | 0 | 5 (1.6) | 3835 | 63 (1.6) | 1 (0.03) | 118 (3.1) |

Values in parenthesis represent mortality %

SP systemic-pulmonary, PAB pulmonary artery banding, PA pulmonary artery, RVOT right ventricular outflow tract, CA coronary artery, AV fistula arteriovenous fistula, TCPC total cavopulmonary connection, AV fistula arteriovenous fistula, VSD ventricular septal defect, AVR aortic valve replacement
### Table 4

Acquired (total, (1) + (2) + (4) + (5) + (6) + (7) + isolated ope. for arrhythmia in (3); 39,485

(1) Valvular heart disease (total; 21,939)

| Valve | Cases | Operation | 30-day mortality | Hospital mortality | Redo |
|-------|-------|-----------|------------------|--------------------|------|
|       |       |           | Hospital & Repair | After discharge & Repair | Cases | 30-day mortality | Hospital mortality |
|       |       |           | Replace & Repair  |                      |       |                  |                      |
|       |       |           |                  |                     |       |                  |                      |
|       |       |           |                  |                     |       |                  |                      |

| Isolated | A 10,219 | 1884 8037 1 297 2298 | 156 (1.6) 5 (1.7) 3 (0.03) 0 | 238 (2.4) 9 (3.0) 0 | 371 20 (5.4) 0 35 (9.4) |
| M 4851 | 684 918 3249 716 | 56 (3.5) 16 (0.5) 2 (0.1) 0 | 95 (5.9) 35 (1.1) 0 | 344 10 (2.9) 0 27 (7.8) |
| T 253 | 10 68 175 25 | 5 (6.4) 5 (2.9) 0 0 | 9 (11.5) 7 (4.0) 0 | 48 3 (6.3) 0 6 (12.5) |
| P 13 | 2 9 2 0 | 0 0 0 0 | 0 0 0 0 | 4 0 0 0 |
| A + M | A 1537 | 388 1085 0 55 238 | 75 (4.9) 0 | 112 (7.3) 0 | 91 13 (14.3) 0 16 (17.6) |
| M 275 | 422 0 832 |
| A + T | A 448 | 96 339 1 6 63 | 11 (2.5) 0 | 23 (5.1) 0 | 42 2 (4.8) 0 4 (9.5) |
| T 3 | 5 0 435 |
| M + T | M 3513 | 494 1044 1972 313 | 53 (1.5) 0 | 94 (2.7) 0 | 234 13 (5.6) 0 22 (9.4) |
| T 12 | 70 3424 |
| A + M + T | A 1056 | 255 759 0 39 130 | 39 (3.7) 0 | 64 (6.1) 0 | 66 8 (12.1) 0 11 (16.7) |
| M 198 | 381 0 474 |
| T 4 | 17 0 1032 |
| Others | 49 | 5 22 0 14 2 1 (2.0) 0 | 2 (0.2) 0 | 10 0 0 0 |
| Total | 21,939 | 4310 13,176 2 12,006 3785 | 422 (1.9) 5 (0.02) | 688 (3.1) 0 | 1210 69 (5.7) 0 121 (10.0) |

Number of redo cases is included in total case number of 21,939

Values in parenthesis represent mortality %

CABG coronary artery bypass grafting, A aortic valve, M mitral valve, T tricuspid valve, P pulmonary valve
Table 4 continued

(2) Ischemic heart disease (total, (A) + (B) + (C); 15,629)

(A) Isolated CABG (total; 14,454)

| (a-1) on-pump arrest CABG (total; 3277) | Primary, elective | Primary, emergency | Redo, elective | Redo, emergency | Arterial graft only | Artery graft + SVG | SVG only | Others | Unclear |
|----------------------------------------|-------------------|--------------------|----------------|----------------|-------------------|-------------------|---------|--------|---------|
| 1VD                                    | 93                | (1.1)              | 0              | (1.1)          | 19                | (2.0)             | 0       | (2.0)  | 0       |
| 2VD                                    | 461               | (3.0)              | 0              | (3.0)          | 47                | (4.3)             | 0       | (4.3)  | 0       |
| 3VD                                    | 1512              | (10.7)             | 0              | (12.8)         | 161               | (11.8)            | 15      | (11.8) | 2 (3.3) |
| LMT                                    | 741               | (8.1)              | 0              | (12.6)         | 190               | (15.7)            | 3       | (13.3) | 0       |
| Total                                  | 2827              | (22.0)             | 0              | (31.1)         | 417               | (39.4)            | 30      | (4.3)  | 7       |
| Kawasaki                               | 7                 | 0                  | 0              | 1              | 0                 | 0                 | 0       | 0      | 0       |
| Hemodialysis                           | 172               | (6.3)              | 0              | (8.4)          | 28                | (10.7)            | 0       | (7.9)  | 10      |

Values in parenthesis represent mortality %
CABG coronary artery bypass grafting, 1VD one-vessel disease, 2VD two-vessel disease, 3VD three-vessel disease, LMT left main trunk, SVG saphenous vein graft, LMT includes LMT alone or LMT with other branch diseases

(b) off-pump CABG (total; 9006)

(The present section also includes cases of planned off-pump CABG in which, during surgery, the change is made to an on-pump CABG or on-pump beating-heart procedure)

| (b) on-pump beating CABG (total; 2171) | Primary, elective | Primary, emergency | Redo, elective | Redo, emergency | Arterial graft only | Artery graft + SVG | SVG only | Others | Unclear |
|----------------------------------------|-------------------|--------------------|----------------|----------------|-------------------|-------------------|---------|--------|---------|
| 1VD                                    | 35                | (2.5)              | 0              | (2.5)          | 31                | (2.0)             | 4       | (2.5)  | 0       |
| 2VD                                    | 255               | (4.6)              | 0              | (6.2)          | 51                | (4.1)             | 11      | (6.2)  | 0       |
| 3VD                                    | 894               | (15.7)             | 0              | (17.1)         | 170               | (15.8)            | 7       | (4.1)  | 0       |
| LMT                                    | 479               | (6.1)              | 0              | (7.1)          | 216               | (24.1)            | 6       | (11.8) | 0       |
| Total                                  | 1663              | (27.1)             | 0              | (44.2)         | 468               | (45.9)            | 28      | (3.6)  | 12      |
| Kawasaki                               | 2                 | 0                  | 0              | 1              | 0                 | 0                 | 1       | 0      | 0       |
| Hemodialysis                           | 139               | (4.2)              | 0              | (11.7)         | 30                | (10.0)            | 6       | (13.3) | 17      |

Values in parenthesis represent mortality %
CABG coronary artery bypass grafting, 1VD one-vessel disease, 2VD two-vessel disease, 3VD three-vessel disease, LMT left main trunk, SVG saphenous vein graft, LMT includes LMT alone or LMT with other branch diseases
(c) Includes cases of conversion, during surgery, from off-pump CABG to on-pump CABG or on-pump beating-heart CABG (total: 156)

| Operation | Cases | 30-day mortality | Hospital mortality | After discharge |
|-----------|-------|-------------------|--------------------|-----------------|
| A conversion to on-pump CABG | 27 | 1 (3.7) | 0 | 0 |
| A conversion to on-pump beating-heart CABG | 100 | 4 (4.0) | 0 | 4 (4.0) |
| Total | 127 | 5 (3.9) | 0 | 4 (3.1) |
| Hemodialysis | 15 | 1 (6.7) | 0 | 1 (6.7) |

Values in parenthesis represent mortality %

CABG coronary artery bypass grafting

(B) Operation for complications of MI (total; 1175)

| Operation | Chronic | Acute | Concomitant operation |
|-----------|---------|-------|-----------------------|
| Infarctectomy or aneurysmectomy | 257 | 6 (2.3) | 0 | 13 (5.1) | 38 | 6 (15.8) | 0 | 7 (18.4) | 164 | 59 | 19 |
| VSP closure | 51 | 4 (7.8) | 0 | 5 (9.8) | 245 | 70 (28.6) | 0 | 82 (33.5) | 77 | 1 | 7 |
| Cardiac rupture | 21 | 1 (4.8) | 0 | 5 (23.8) | 199 | 73 (36.7) | 0 | 78 (39.2) | 23 | 1 | 1 |
| Mitral regurgitation | | | | | | | | |
| 1) Papillary muscle rupture | 10 | 1 (10.0) | 0 | 1 (10.0) | 46 | 10 (21.7) | 1 (2.2) | 12 (26.1) | 18 | 11 | 46 |
| 2) Ischemic | 251 | 7 (2.8) | 0 | 17 (6.8) | 27 | 7 (25.9) | 0 | 7 (25.9) | 221 | 174 | 53 |
| Others | 19 | 0 | 0 | 11 | 1 (9.1) | 0 | 3 (27.3) | 3 | 4 | 0 |
| Total | 609 | 19 (3.1) | 0 | 41 (6.7) | 566 | 167 (29.5) | 1 (0.2) | 189 (33.4) | 506 | 250 | 126 |

Values in parenthesis represent mortality %

Acute, within 2 weeks from the onset of myocardial infarction

MI myocardial infarction, CABG coronary artery bypass grafting, MVP mitral valve repair, MVR mitral valve replacement, VSP ventricular septal perforation
### (C) TMLR (total; 0)

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| Isolated | 0 | 0 | 0 | 0 |
| With CABG | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 0 | 0 |

TMLR transmyocardial laser revascularization

### (3) Operation for arrhythmia (total; 3855)

| Cases | 30-day mortality | Hospital mortality | Concomitant operation |
|-------|------------------|--------------------|-----------------------|
|       |                  | Hospital | After discharge | Isolated | Congenital | Valve | IHD | Others | Multiple combination |
| Maze | 3486             | 34 (1.0)  | 0 | 55 (1.6) | 15 | 127 | 3,162 | 375 | 216 | 440 | 32 |
| For WPW | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| For ventricular tachyarrhythmia | 35 | 2 (5.7) | 0 | 3 (8.6) | 2 | 2 | 14 | 13 | 5 | 2 | 0 |
| Others | 332 | 3 (0.9) | 0 | 4 (1.2) | 89 | 7 | 193 | 57 | 25 | 34 | 3 |
| Total | 3855 | 39 (1.0) | 0 | 62 (1.6) | 106 | 138 | 3370 | 445 | 246 | 476 | 35 |

Values in parenthesis represent mortality %. Except for 106 isolated cases, all remaining 3749 cases are doubly allocated, one for this subgroup and the other for the subgroup corresponding to the concomitant operations.

WPW Wolff–Parkinson–White syndrome, IHD ischemic heart disease

### (4) Operation for constrictive pericarditis (total; 178)

| CPB (+) | Cases | 30-day mortality | Hospital mortality |
|---------|-------|------------------|--------------------|
|         |       | Hospital | After discharge |
| Total | 102 | 12 (11.8) | 0 | 15 (14.7) |

Values in parenthesis represent mortality %

CPB cardiopulmonary bypass

### (5) Cardiac tumor (total; 602)

| Cases | 30-day mortality | Hospital mortality | Concomitant operation |
|-------|------------------|--------------------|-----------------------|
|       |                  | Hospital | After discharge | Isolated | AVR | MVR | CABG | Others |
| Benign tumor | 530 | 4 (0.8) | 0 | 7 (1.3) | 10 | 11 | 25 | 70 |
| Cardiac myxoma | 419 | 2 (0.5) | 0 | 2 (0.5) | 4 | 8 | 20 | 59 |
| Papillary fibroelastoma | 46 | 0 | 0 | 2 (4.3) | 4 | 2 | 1 | 7 |
| Rhabdomyoma | 4 | 1 (25.0) | 0 | 1 (25.0) | 0 | 0 | 0 | 0 |
| Others | 61 | 1 (1.6) | 0 | 2 (3.3) | 2 | 1 | 4 | 4 |
| Malignant tumor | 72 | 4 (5.6) | 1 (1.4) | 11 (15.3) | 2 | 3 | 2 | 11 |
| Primary | 45 | 2 (4.4) | 0 | 3 (6.7) | 2 | 3 | 1 | 7 |
| Metastatic | 27 | 2 (7.4) | 1 (3.7) | 8 (29.6) | 0 | 0 | 1 | 4 |

Values in parenthesis represent mortality %

AVR aortic valve replacement, MVR mitral valve replacement, CABG coronary artery bypass grafting

### (6) HOCM and DCM (total; 211)

| Cases | 30-day mortality | Hospital mortality | Concomitant operation |
|-------|------------------|--------------------|-----------------------|
|       |                  | Hospital | After discharge | Isolated | AVR | MVR | MVP | CABG |
| Myectomy | 171 | 5 (2.9) | 0 | 8 (4.7) | 110 | 19 | 23 | 13 |
| Myotomy | 5 | 0 | 0 | 0 | 1 | 2 | 0 | 0 |
| No-resection | 14 | 1 (7.1) | 0 | 1 (7.1) | 2 | 5 | 16 | 0 |
| Volume reduction surgery of the left ventricle | 21 | 3 (14.3) | 0 | 4 (19.0) | 0 | 6 | 6 | 4 |
| Total | 211 | 9 (4.3) | 0 | 13 (6.2) | 113 | 32 | 45 | 17 |

Values in parenthesis represent mortality %

HOCM hypertrophic obstructive cardiomyopathy, DCM dilated cardiomyopathy, AVR aortic valve replacement, MVR mitral valve replacement, MVP mitral valve repair, CABG coronary artery bypass grafting

### (7) Other open-heart operation (total; 820)

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| Total | 820 | 36 (4.4) | 0 | 42 (5.1) |

Values in parenthesis represent mortality %
| Replaced site                  | Stanford type | Chronic                  | Concomitant operation | Redo                        |
|-------------------------------|---------------|--------------------------|-----------------------|-----------------------------|
|                              | Acute A       | Acute B                  | Chronic A             | Chronic B                  |
|                              | Cases         | 30-day mortality         | Hospital mortality    | After discharge             | Cases         | 30-day mortality         | Hospital mortality    | After discharge             |
|                              | After         |                          | Hospital After        |                          | After         |                          | Hospital After         |                          |
|                              | discharge      |                          | discharge              |                          | discharge      |                          | discharge              |                          |
|                              | Hospital       |                          | Hospital               |                          | Hospital       |                          | Hospital               |                          |
|                              | mortality      |                          | mortality              |                          | mortality      |                          | mortality              |                          |
|                              |                |                          |                       |                            |                |                          |                        |                            |
| 1. Ascending Ao.              | 2787          | 220 (7.9)                | 1 (0.04)              | 267 (9.6)                 | 0             | 0                        | 0                      | 0                          |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| 2. Aortic Root                | 197           | 42 (21.3)                | 1 (0.04)              | 48 (24.4)                 | 0             | 0                        | 0                      | 0                          |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| 3. Ascending Ao. + Arch       | 1525          | 129 (8.5)                | 0                     | 156 (10.2)                | 41 (24.4)     | 0                        | 8 (49.5)               | 295 (18.3)                |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| 4. Arch + descending Ao.      | 57            | 2 (3.5)                  | 0                     | 5 (8.8)                   | 16 (51.3)     | 0                        | 6 (37.5)               | 24 (14.2)                 |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| 5. Aortic root + Asc. Ao. + Arch | 129        | 21 (16.3)                | 0                     | 23 (17.8)                 | 0             | 0                        | 0                      | 0                          |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| 6. Descending Ao.             | 16            | 1 (6.3)                  | 0                     | 1 (6.3)                   | 41 (9.8)      | 0                        | 7 (17.1)               | 63 (2.32)                 |
|                               | 0             | 0                        | 0                      | 0                          | 3             | 0                        | 0                      | 0                          |
| 7. Thoracoabdominal Ao.       | 2             | 0 (50.0)                 | 11 (3.73)             | 4 (36.4)                  | 27 (2.74)     | 0                        | 3 (11.1)               | 138 (7.5)                |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| 8. Extra-anatomic bypass      | 7             | 1 (14.3)                 | 0                     | 1 (14.3)                  | 8             | 0                        | 0                      | 0                          |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| 9. Stent grafa                 | 233           | 18 (7.7)                 | 0                     | 25 (10.7)                 | 277 (11.4)    | 11 (40.0)                | 16 (5.8)              | 232 (4.17)                |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| 1) TEVARb                     | 105           | 8 (7.6)                  | 0                     | 11 (10.5)                 | 272 (11.4)    | 11 (40.0)                | 15 (5.5)              | 170 (1.06)                |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| 2) Open stent                 | 128           | 10 (7.8)                 | 0                     | 14 (10.9)                 | 5 (50.0)      | 0                        | 1 (20.0)              | 62 (34.8)                 |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| a) With total archac         | 127           | 10 (7.9)                 | 0                     | 14 (11.0)                 | 4 (0.0)       | 0                        | 1 (25.0)              | 54 (3.56)                 |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| b) Without total archbd       | 1             | 0 (0.0)                  | 0                     | 1 (0.0)                   | 0             | 0                        | 0                      | 0                          |
|                               | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |
| Total                        | 4953          | 434 (8.8)                | 1 (0.02)              | 527 (10.6)                | 396 (8.1)     | 28 (7.1)                 | 41 (80.4)             | 967 (27.8)                |
|                              | 0             | 0                        | 0                      | 0                          | 0             | 0                        | 0                      | 0                          |

Values in parenthesis represent mortality %

**Ao aorta, AVP aortic valve repair, AVR aortic valve replacement, MVP mitral valve repair, MVR mitral valve replacement, CABG coronary artery bypass grafting, TEVAR thoracic endovascular aortic (aneurysm) repair**

Acute, within 2 weeks from the onset

*a = b + c + d + unspecified*
Table 5 continued (2) Non-dissection (total: 9765)

| Replaced site | Unruptured | Ruptured | Concomitant operation | Reth | CPB (--) |
|---------------|------------|----------|-----------------------|------|---------|
|                | Cases      | 30-day mortality | Hospital mortality | After discharge | Hospital mortality | After discharge | AVP | AVR | MVP | MVR | CABG | Cases | 30-day mortality | Hospital mortality | After discharge | | 
| 1. Ascending Ao. | 1369       | 24 (1.8) | 0 | 38 (2.8) | 36 | 4 (11.1) | 0 | 7 (19.4) | 82 | 872 | 67 | 50 | 171 | 122 | 5 (4.1) | 0 | 9 (7.4) | – | – | – |
| 2. Aortic Root | 1022       | 27 (2.6) | 0 | 32 (3.1) | 35 | 8 (22.9) | 0 | 10 (28.6) | 250 | 498 | 71 | 19 | 121 | 129 | 17 (13.2) | 0 | 22 (17.1) | – | – | – |
| 3. Ascending Ao. + Arch | 2139      | 43 (2.0) | 0 | 75 (3.5) | 162 | 29 (17.9) | 4 (2.5) | 38 (23.5) | 44 | 181 | 21 | 8 | 351 | 90 | 5 (3.6) | 0 | 6 (6.7) | – | – | – |
| 4. Arch + descending Ao. | 137       | 10 (7.3) | 0 | 14 (10.2) | 22 | 2 (9.1) | 0 | 4 (18.2) | 0 | 11 | 0 | 0 | 9 | 7 | 1 (14.3) | 0 | 2 (28.6) | – | – | – |
| 5. Aortic root + Asc. Ao. + Arch | 130       | 2 (1.7) | 0 | 3 (2.5) | 2 | 0 | 0 | 0 | 26 | 90 | 3 | 1 | 12 | 10 | 0 | 0 | 1 (100) | – | – | – |
| 6. Descending Ao. | 255        | 8 (3.1) | 0 | 12 (4.7) | 64 | 11 (17.2) | 0 | 17 (26.6) | 0 | 0 | 0 | 0 | 5 | 16 | 4 (25.0) | 0 | 6 (37.5) | 8 | 1 (12.5) | 0 | 1 (12.5) |
| 7. Thoracoabdominal Ao. | 390       | 21 (5.4) | 0 | 28 (7.2) | 65 | 14 (21.5) | 0 | 20 (30.8) | 0 | 0 | 0 | 0 | 0 | 24 | 3 (12.5) | 0 | 4 (16.7) | 9 | 0 | 0 | 0 |
| 8. Extra-anatomical bypass | 25 | 0 | 1 (4.0) | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 3 | 0 | 0 | 1 (33.3) | 10 | 0 | 0 | 1 (10.0) |
| 9. Stent graft\(^a\) | 3528       | 55 (1.6) | 3 (0.1) | 95 (2.7) | 394 | 46 (11.7) | 0 | 69 (17.5) | 12 | 14 | 2 | 1 | 50 | 159 | 11 (6.9) | 0 | 25 (15.7) | 1100 | 23 (2.1) | 1 (0.1) | 35 (3.2) |
| 1) TEVAR\(^b\) | 3158       | 43 (1.4) | 3 (0.1) | 75 (2.4) | 863 | 42 (11.6) | 0 | 62 (17.1) | 6 | 1 | 1 | 0 | 11 | 148 | 8 (5.4) | 0 | 22 (14.9) | 1100 | 23 (2.1) | 1 (0.1) | 35 (3.2) |
| 2) Open stent | 330        | 12 (3.2) | 0 | 20 (3.4) | 31 | 4 (12.9) | 0 | 7 (22.6) | 6 | 13 | 1 | 1 | 39 | 11 | 3 (27.3) | 0 | 3 (27.3) | – | – | – |
| a) With total arch\(^c\) | 205        | 8 (3.2) | 0 | 16 (5.6) | 23 | 1 (4.3) | 0 | 4 (17.4) | 6 | 13 | 1 | 1 | 35 | 8 | 2 (25.0) | 0 | 2 (25.0) | – | – | – |
| b) Without total arch\(^d\) | 85 | 4 (4.7) | 0 | 4 (4.7) | 8 | 3 (37.5) | 0 | 3 (37.5) | 0 | 0 | 0 | 0 | 4 | 3 | 1 (33.3) | 0 | 1 (33.3) | – | – | – |
| 3) Unspecified | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 8985 | 190 (2.1) | 4 (0.04) | 297 (3.3) | 780 | 114 (14.6) | 4 (0.5) | 165 (21.2) | 414 | 1867 | 164 | 79 | 721 | 560 | 46 (8.2) | 0 | 76 (13.6) | 1127 | 24 (2.1) | 1 (0.1) | 37 (3.3) |

Values in parenthesis represent mortality %

Ao aorta, AVP aortic valve repair, AVR aortic valve replacement, MVP mitral valve repair, MVR mitral valve replacement, CABG coronary artery bypass grafting, TEVAR thoracic endovascular aortic (aneurysm) repair

\(^a\) = \(^b\) + \(^c\) + \(^d\) + unspecified
Table 6 Pulmonary thromboembolism (total; 171)

| Cases     | 30-day mortality | Hospital mortality |
|-----------|------------------|--------------------|
|           |                  | Hospital | After discharge |
| Acute     | 110              | 15 (13.6) | 6 (5.5)      |
| Chronic   | 61               | 6 (9.8)   | 0            |
| Total     | 171              | 21 (12.3) | 6 (3.5)      |

Values in parenthesis represent mortality %

Table 7 Assisted circulation (total; 1679)

| Sites               | VAD | Heart–lung assist |
|---------------------|-----|-------------------|
| Device              |     | Results           |
| Centrifugal         |     |                  |
| VAS (extra)         |     |      |                  |
| VAS (implant)       |     |      |                  |
| Results             |     |                  |
| Not weaned On going | 51  |
| Death               | 13 (39.4) | 0 |
| Transplant          | 12  | 3 (9.1) |
| Weaned              | 3   | 0 |
| Alive               | 0   | 0 |
| Heart–lung assist   |     |                  |
| Method              |     |                  |
| PCPS                | 52  | 101              |
| Others              | 6   | 18               |
| Results             |     |                  |
| Not weaned On going | 20  |
| Death               | 56 (29.2) | 6 |
| Transplant          | 7   | 7 (3.6) |
| Weaned              | 3   | 0 |
| Alive               | 2   | 1 (12.5) |
| Deaths              | 1679| 61               |
| Transplant          | 332 | 61               |
| Deaths              | 111 | 281              |
| Alive               | 79  | 157              |
| Deaths              | 205 | 508              |

Values in parenthesis represent mortality %

Table 8 Heart transplantation (total; 30)

| Cases     | 30-day mortality | Hospital mortality |
|-----------|------------------|--------------------|
|           |                  | Hospital | After discharge |
| Heart transplantation | 30  | 1 (3.3) | 2 (6.7) |
| Heart and lung transplantation | 0   | 0      | 0 |
| Total     | 30               | 1 (3.3) | 2 (6.7) |

Values in parenthesis represent mortality %

Table 9 Pacemaker + ICD (total; 4923)

| Pacemaker | ICD |
|-----------|-----|
| V         | A-V | CRT | CRTD | ICD |
| Initial   | 570 | 1,971| 94 | 245 | 383 |
| Exchange  | 454 | 807 | 29 | 116 | 254 |
| Unclear   | 0   | 0   | 0  | 0   | 0 |
| Total     | 1024| 2778| 123| 361 | 637 |

ICD implantable cardioverter-defibrillator, CRTD cardiac resynchronization therapy devise with incorporated ICD devise
(B) General thoracic surgery

The total number of operations reported in 2014 in general thoracic surgery has reached 77,070, which means 1.74-fold of that in 2001, and increased by 1,764 cases compared with that in 2013 (Fig. 2, Table 10).

The number of operations for primary lung cancer was 38,085 in 2014 (Table 10), showing the steady increase (31,301; 2009, 32,801; 2010, 33,878; 2011, 35,667; 2012, 37,008; 2013), and 1.95-fold of the number of operations in 2001. Surgery for lung cancer consists 49.4% of all the general thoracic surgery.

Surgery for benign pulmonary tumor was 2,171 in 2014 (Table 11).

Further information of primary malignant pulmonary tumors is shown in Tables 12 and 13. Among lung cancer subtypes, adenocarcinoma comprises an overwhelming percentage of 69.2% of the total lung cancer surgery, followed by squamous cell carcinoma of 19.3%. Limited resection by wedge resection or segmentectomy was performed in 9,581 lung cancer patients, which is 25.2% of the entire cases. Lobectomy was performed in 27,584 patients, which is 72.4% of the entire cases. Sleeve lobectomy was done in 471 patients. Pneumonectomy was done in 521 patients which is 1.4% of the entire cases.

There were 103 patients who died without discharge within 30 days after lung cancer surgery, and 59 patients who were discharged from hospital but died within 30 days after lung cancer surgery, indicating that 162 patients died within 30 days after lung cancer surgery (30-day mortality rate; 0.42%). There were 266 patients died without discharge (hospital mortality rate; 0.70%). 30-day mortality rate in regard to procedures is 0.12% in segmentectomy, 0.48% in lobectomy, and 1.53% in pneumonectomy. Interstitial pneumonia was the leading cause of death after lung cancer surgery, followed by pneumonia, respiratory failure, cardiovascular event, and bronchopleural fistula.

Surgery for metastatic pulmonary tumors is denoted in Table 14. The number of patients undergoing operations for metastatic pulmonary tumor was 8,057 in 2014 with steady increase similarly to lung cancer surgery (6,248; 2009, 6,748; 2010, 7,210; 2011, 7,403; 2012, 7,829; 2013). Colorectal cancer was by far the most prevalent associated disease (67.2%). It should be noted that hospital mortality rate for metastatic pulmonary tumors was as high as 15.1% in patients of acute empyema with fistula.

Operation for descending necrotizing mediastinitis was done in 103 patients in 2014 (Table 22). Hospital mortality rate was 8.7%.

Operation for bullous diseases was done in 415 patients in 2014 (Table 23). Lung volume reduction surgery was done in only 28 patients, while emphysematous bulla was the principal target of operation.

14,572 operations for pneumothorax were reported in 2014 (Table 24).

The number of operations for spontaneous pneumothorax was 11,948. Among them, 3,410 patients (28.5%) underwent bullectomy alone, while additional procedure was performed in 7,625 patients (63.8%).

The number of operations for secondary pneumothorax was 2,624. COPD was by far the most prevalent associated disease (67.2%). It should be noted that hospital mortality rate of operation for pneumothorax associated with tumorous disease was as high as 16.7%.

217 cases of surgery for chest wall deformity were reported in 2014 survey (Table 25). This number might be underestimated compared with the real number of operations, because chest wall deformity is more likely to be
treated in the institutes which are not associated with JATS.

Diaphragmatic hernia was treated by surgery in 55 patients in 2014 (Table 26).

Chest trauma was treated by surgery in 394 patients in 2014 (Table 27).

Table 28 denotes operations for other diseases, including 77 arteriovenous malformations and 104 pulmonary sequestrations.

Table 29 denotes lung transplantation in 2014. A total of 60 lung transplantations were performed in 2014. The number of patients undergoing lung transplantation from brain-dead donors and living-related donors was 40 and 20, respectively. The number of lung transplantation is almost constant these several years, and lung transplantation is still dependent on living-related donors in Japan.

Details of tracheabronchoplasty, pediatric surgery, and combined resection of neighboring organs are denoted in Tables 30, 31, 32, and 33.

Committee for Scientific Affairs in JATS changed the method of surveying general thoracic surgery in 2014. JATS had investigated the number of diseases and operative procedures based on questionnaires until 2013 surveys, but JATS started to collect the number of procedures in general thoracic surgery using the database in National Clinical Database (NCD) registry. There were some differences in definition in VATS procedure between surveys by JATS before 2013 and that using NCD after 2014. While the length of skin incision in definition of VATS procedure had been less than 8 cm by JATS survey before 2013 following Swanson et al’s proposal [1], NCD registry did not limit the length of skin incision in VATS procedures. On the other hand, NCD required the surgeons to choose the approach among complete VATS procedure without thoracotomy, the procedure using both thoracotomy and VATS which includes hybrid approach, and conventional thoracotomy without VATS procedure. It is presumed that hybrid approach was included in VATS procedure as far as the skin incision was shorter than 8 cm in JATS survey before 2013, but this does not seem to apply to survey in 2014 based on NCD registry, suggesting possible inconsistency in comparison between JATS survey before 2013 and NCD 2014 registry. In this report, therefore, analysis with regard to VATS procedure was not conducted.

Fig. 2 General thoracic surgery
### Table 10: Total entry cases of general thoracic surgery during 2014

| Case Description                        | Cases | %  |
|-----------------------------------------|-------|----|
| Benign pulmonary tumor                  | 2171  | 2.8|
| Primary lung cancer                     | 38,085| 49.4|
| Other primary malignant pulmonary tumor | 359   | 0.5|
| Metastatic pulmonary tumor              | 8057  | 10.5|
| Tracheal tumor                          | 118   | 0.2|
| Mesothelioma                            | 673   | 0.9|
| Chest wall tumor                        | 698   | 0.9|
| Mediastinal tumor                       | 4685  | 6.1|
| Thymectomy for MG without thymoma      | 188   | 0.2|
| Inflammatory pulmonary disease          | 2287  | 3.0|
| Empyema                                 | 2608  | 3.4|
| Bullous disease excluding pneumothorax  | 415   | 0.5|
| Pneumothorax                            | 14,572| 18.9|
| Chest wall deformity                    | 217   | 0.3|
| Diaphragmatic hernia including traumatic| 55    | 0.1|
| Chest trauma excluding diaphragmatic hernia | 394  | 0.5|
| Lung transplantation                     | 60    | 0.1|
| Others                                  | 1428  | 1.9|
| Total                                   | 77,070| 100.0|

### Table 11: Benign pulmonary tumor

| Case Description                        | Cases | 30-day mortality | Hospital mortality |
|-----------------------------------------|-------|------------------|--------------------|
|                                          |       | Hospital         | After discharge    |
|                                          |       | mortality        |                    |
| Hamartoma                                | 481   | 0                | 0                  |
| Sclerosing hemangioma                    | 103   | 0                | 0                  |
| Papilloma                                | 18    | 0                | 0                  |
| Mucous gland adenoma bronchial           | 7     | 0                | 0                  |
| Fibroma                                  | 129   | 0                | 0                  |
| Lipoma                                   | 6     | 0                | 0                  |
| Neurogenic tumor                         | 17    | 0                | 0                  |
| Clear cell tumor                         | 2     | 0                | 0                  |
| Leiomyoma                                | 19    | 0                | 0                  |
| Chondroma                                | 5     | 0                | 0                  |
| Inflammatory myofibroblastic tumor       | 1     | 0                | 0                  |
| Pseudolymphoma                           | 32    | 0                | 0                  |
| Histiocytosis                            | 23    | 0                | 0                  |
| Teratoma                                 | 0     | 0                | 0                  |
| Others                                   | 1328  | 2 (0.2)          | 1 (0.1)            |
| Total                                    | 2171  | 2 (0.1)          | 1 (0.05)           |

Values in parenthesis represent mortality %

### Table 12: Primary malignant pulmonary tumor

| Case Description                        | Cases | 30-day mortality | Hospital mortality |
|-----------------------------------------|-------|------------------|--------------------|
|                                          |       | Hospital         | After discharge    |
|                                          |       | mortality        |                    |
| 2. Primary malignant pulmonary tumor    |       |                  |                    |
| Lung cancer                             | 38,444| 104 (0.3)        | 59 (0.2)           |
| Adenocarcinoma                          | 38,085| 103 (0.3)        | 59 (0.2)           |
| Squamous cell carcinoma                 | 26,338| 33 (0.1)         | 23 (0.1)           |
| Large cell carcinoma                    | 7367  | 46 (0.6)         | 22 (0.3)           |
| (LCNEC)                                 | 835   | 5 (0.6)          | 6 (0.7)            |
| Small cell carcinoma                    | 462   | 4 (0.9)          | 1 (0.2)            |
| Adenosquamous carcinoma                 | 601   | 1 (0.2)          | 1 (0.2)            |
| Carcinoma with pleomorphic, sarcomatoid or sarcomatous elements | 548 | 7 (1.3) | 0 | 14 (2.6) |
| Carcinoid                               | 528   | 6 (1.1)          | 2 (0.4)            |
| Carcinomas of salivary-gland type       | 198   | 0                | 0                  |
| Unclassified                            | 45    | 0                | 0                  |
| Multiple lung cancer                    | 55    | 2 (3.6)          | 0                  |
| Others                                  | 1227  | 1 (0.1)          | 3 (0.2)            |
| Others                                  | 343   | 2 (0.6)          | 2 (0.6)            |
| Segmental excision                      | 5438  | 4 (0.1)          | 4 (0.1)            |
| (Sleeve segmental excision)             | 4143  | 2 (0.05)         | 3 (0.1)            |
| Lobectomy                               | 16    | 0                | 0                  |
| (Sleeve lobectomy)                      | 27,584| 82 (0.3)         | 51 (0.2)           |
| Pneumonectomy                           | 471   | 5 (1.1)          | 7 (1.5)            |
| (Sleeve pneumonectomy)                  | 521   | 8 (1.5)          | 0                  |
| Other bronchoplasty                     | 13    | 0                | 0                  |
| Other pneumonectomy                     | 46    | 2 (4.3)          | 0                  |
| Other pneumonectomy                     | 1     | 0                | 0                  |
| Others                                  | 343   | 5 (1.5)          | 1 (0.3)            |
| Others                                  | 126   | 0                | 0                  |
| Others                                  | 193   | 1 (0.5)          | 0                  |

Values in parenthesis represent mortality %
### Table 13 Details of lung cancer operation

| c-Stage (TNM) | Cases |
|---------------|-------|
| Ia            | 22,809|
| Ib            | 7213  |
| IIa           | 2982  |
| IIb           | 1780  |
| IIIa          | 2505  |
| IIIb          | 204   |
| IV            | 481   |
| NA            | 111   |
| Total         | 38,085|

| Sex           | Cases |
|---------------|-------|
| Male          | 23,540|
| Female        | 14,516|
| NA            | 29    |
| Total         | 38,085|

| Cause of death                  | Cases |
|---------------------------------|-------|
| Cardiovascular                  | 23    |
| Pneumonia                       | 47    |
| Pyothorax                       | 4     |
| Bronchopleural fistula          | 16    |
| Respiratory failure             | 41    |
| Pulmonary embolism              | 11    |
| Interstitial pneumonia          | 78    |
| Brain infarction or bleeding    | 14    |
| Others                          | 80    |
| Unknown                         | 11    |
| Total                           | 325   |

### Table 13 continued

| Age      | Cases |
|----------|-------|
| <20      | 85    |
| 20–29    | 33    |
| 30–39    | 219   |
| 40–49    | 1009  |
| 50–59    | 3646  |
| 60–69    | 12,731|
| 70–79    | 15,765|
| 80–89    | 4532  |
| ≥90      | 58    |
| NA       | 7     |
| Total    | 38,085|

| p-Stage | Cases |
|---------|-------|
| 0 (pCR) | 295   |
| Ia      | 19,666|
| Ib      | 7601  |
| IIa     | 3213  |
| IIb     | 2087  |
| IIIa    | 3761  |
| IIIb    | 179   |
| IV      | 1072  |
| NA      | 211   |
| Total   | 38,085|
Table 14
3. Metastatic pulmonary tumor

| Case | 30-day mortality | Hospital mortality |
|------|------------------|--------------------|
|      | Hospital         | After discharge     |

| Tumor Type                        | Cases | 30-day mortality | Hospital mortality |
|-----------------------------------|-------|------------------|--------------------|
|                                   |       | Hospital         | After discharge     |
| 3. Metastatic pulmonary tumor     | 8057  | 17 (0.2)         | 8 (0.1)            | 30 (0.4)           |
| Colo-rectal                       | 3902  | 2 (0.1)          | 0                  | 5 (0.1)            |
| Hepatobiliary/pancreatic          | 388   | 2 (0.5)          | 0                  | 2 (0.5)            |
| Uterine                           | 387   | 0                | 0                  | 0                  |
| Mammary                           | 445   | 0                | 0                  | 0                  |
| Ovarian                           | 56    | 0                | 0                  | 0                  |
| Testicular                        | 84    | 0                | 0                  | 0                  |
| Renal                             | 618   | 3 (0.5)          | 2 (0.3)            | 3 (0.5)            |
| Skeletal                          | 148   | 0                | 1 (0.7)            | 0                  |
| Soft tissue                       | 235   | 0                | 1 (0.4)            | 2 (0.9)            |
| Otorhinolaryngological            | 422   | 2 (0.5)          | 1 (0.2)            | 2 (0.5)            |
| Pulmonary                         | 497   | 8 (1.6)          | 1 (0.2)            | 11 (2.2)           |
| Others                            | 875   | 0                | 2 (0.2)            | 5 (0.6)            |

Values in parenthesis represent mortality %

Table 15
4. Tracheal tumor

| Tumor Type                        | Cases | 30-day mortality | Hospital mortality |
|-----------------------------------|-------|------------------|--------------------|
|                                   |       | Hospital         | After discharge     |

| Case | 30-day mortality | Hospital mortality |
|------|------------------|--------------------|

| Tumor Type                        | Cases | 30-day mortality | Hospital mortality |
|-----------------------------------|-------|------------------|--------------------|
|                                   |       | Hospital         | After discharge     |
| 4. Tracheal tumor                 | 118   | 4 (3.4)          | 1 (0.8)            | 10 (8.5)           |
| (A) Primary malignant tumor       |       |                  |                    |
| (histological classification)     |       |                  |                    |
| Squamous cell carcinoma           | 15    | 0                | 0                  | 1 (6.7)            |
| Adenoid cystic carcinoma          | 9     | 0                | 0                  | 0                  |
| Mucoepidermoid carcinoma          | 2     | 0                | 0                  | 0                  |
| Others                            | 10    | 0                | 0                  | 0                  |
| Total                             | 36    | 0                | 0                  | 1 (2.8)            |
| (B) Metastatic/invasive malignant tumor, e.g. invasion of thyroid cancer | | |
|                                   | 48    | 4 (8.3)          | 1 (2.1)            | 9 (18.8)           |
| (C) Benign tracheal tumor          |       |                  |                    |
| (histological classification)     |       |                  |                    |
| Papilloma                         | 0     | 0                | 0                  | 0                  |
| Adenoma                           | 3     | 0                | 0                  | 0                  |
| Neurofibroma                      | 1     | 0                | 0                  | 0                  |
| Chondroma                         | 0     | 0                | 0                  | 0                  |
| Leiomyoma                         | 3     | 0                | 0                  | 0                  |
| Others                            | 27    | 0                | 0                  | 0                  |
| Histology unknown                 | 0     | 0                | 0                  | 0                  |
| Total                             | 34    | 0                | 0                  | 0                  |
| Operation                         |       |                  |                    |
| Sleeve resection with reconstruction | 13    | 0                | 0                  | 1 (7.7)            |
| Wedge with simple closure         | 0     | 0                | 0                  | 0                  |
| Wedge with patch closure          | 0     | 0                | 0                  | 0                  |
| Total laryngectomy with tracheostomy | 0     | 0                | 0                  | 0                  |
| Others                            | 29    | 0                | 0                  | 0                  |
| Unknown                           | 0     | 0                | 0                  | 0                  |
| Total                             | 42    | 0                | 0                  | 1 (2.4)            |

Values in parenthesis represent mortality %
### Table 16
5. Tumor of pleural origin

| Histological classification                      | Cases  | 30-day mortality | Hospital mortality |
|-------------------------------------------------|--------|------------------|--------------------|
| Solitary fibrous tumor                          | 122    | 0                | 0                  |
| Diffuse malignant pleural mesothelioma          | 283    | 3 (1.1)          | 10 (3.5)           |
| Localized malignant pleural mesothelioma        | 26     | 0                | 1 (3.8)            |
| Others                                          | 242    | 3 (1.2)          | 2 (0.8)            |
| **Total**                                       | 673    | 6 (0.9)          | 20 (3.0)           |

| Operative procedure                              | Cases  | 30-day mortality | Hospital mortality |
|-------------------------------------------------|--------|------------------|--------------------|
| Extrapleural pneumonectomy                       | 70     | 1 (1.4)          | 3 (4.3)            |
| Total pleurectomy                               | 73     | 1 (1.4)          | 3 (4.1)            |
| Others                                          | 140    | 1 (0.7)          | 4 (2.9)            |
| **Total**                                       | 283    | 3 (1.1)          | 10 (3.5)           |

Values in parenthesis represent mortality %

### Table 17
6. Chest wall tumor

| Type of Tumor                                      | Cases  | 30-day mortality | Hospital mortality |
|---------------------------------------------------|--------|------------------|--------------------|
| Primary malignant tumor                           | 128    | 1 (0.8)          | 5 (3.9)            |
| Metastatic malignant tumor                        | 208    | 0                | 3 (1.4)            |
| Benign tumor                                      | 362    | 0                | 0                  |
| **Total**                                         | 698    | 1 (0.1)          | 8 (1.1)            |

Values in parenthesis represent mortality %

### Table 18
7. Mediastinal tumor

| Type of Tumor                                      | Cases  | 30-day mortality | Hospital mortality |
|---------------------------------------------------|--------|------------------|--------------------|
| 7. Mediastinal tumor                              | 4685   | 5 (0.1)          | 17 (0.4)           |
| Thymoma\*                                         | 1773   | 5 (0.3)          | 9 (0.5)            |
| Thymic cancer                                     | 296    | 0                | 1 (0.3)            |
| Thymus carcinoma                                  | 35     | 0                | 0                  |
| Germ cell tumor                                   | 122    | 0                | 0                  |
| **Benign**                                        | 87     | 0                | 0                  |
| **Malignant**                                     | 35     | 0                | 0                  |
| Neurogenic tumor                                  | 481    | 0                | 0                  |
| Congenital cyst                                   | 932    | 1 (0.1)          | 5 (0.5)            |
| Goiter                                            | 75     | 0                | 1 (1.3)            |
| Lympthatic tumor                                  | 214    | 0                | 0                  |
| Excision of pleural recurrence of thymoma        | 43     | 0                | 0                  |
| Thymolipoma                                       | 14     | 0                | 0                  |
| Others                                            | 700    | 0                | 1 (0.1)            |

Values in parenthesis represent mortality %
\* Includes those with myasthenia gravis

### Table 19
8. Thymectomy for myasthenia gravis

| Type of Tumor                                      | Cases  | 30-day mortality | Hospital mortality |
|---------------------------------------------------|--------|------------------|--------------------|
| 8. Thymectomy for myasthenia gravis              | 495    | 1 (0.2)          | 1 (0.2)            |
| With thymoma                                      | 307    | 1 (0.3)          | 1 (0.3)            |

Values in parenthesis represent mortality %
### Table 20
9. Operation for non-neoplastic disease
(A) Inflammatory pulmonary disease

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| 21,976| 197 (0.9)        | 14 (0.1) | 425 (1.9) |
| 2287  | 6 (0.3)          | 2 (0.1)  | 17 (0.7)  |

(T) Inflammatory pulmonary disease

| Tuberculosis infection | 73 | 0 | 0 |
|------------------------|----|---|---|
| Mycobacterial infection| 501| 1 (0.2)| 1 (0.2)| 3 (0.6) |
| Fungal infection       | 345| 1 (0.3)| 1 (0.3)| 6 (1.7) |
| Bronchiectasis         | 67 | 0 | 0 |
| Tuberculous nodule     | 133| 0 | 0 |
| Inflammatory pseudo tumor| 566| 0 | 0 |
| Interpulmonary lymph node| 63 | 0 | 0 |
| Others                 | 539| 4 (0.7)| 0 | 7 (1.3) |

Values in parenthesis represent mortality %

### Table 21
9. Operation for non-neoplastic disease
(B) Empyema

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| 1911  | 52 (2.7)         | 3 (0.2)  | 126 (6.6) |
| 469   | 28 (6.0)         | 1 (0.2)  | 71 (15.1) |
| 1425  | 23 (1.6)         | 2 (0.1)  | 52 (3.6)  |
| 17    | 1 (5.9)          | 0        | 3 (17.6)  |
| 697   | 14 (2.0)         | 1 (0.1)  | 38 (5.5)  |
| 345   | 12 (3.5)         | 1 (0.3)  | 27 (7.8)  |
| 328   | 2 (0.6)          | 0        | 10 (3.0)  |
| 24    | 0                | 0        | 1 (4.2)   |
| Total | 2608             | 66 (2.5) | 4 (0.2) | 164 (6.3) |

Values in parenthesis represent mortality %

### Table 22
9. Operation for non-neoplastic disease
(C) Descending necrotizing mediastinitis

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| 103   | 6 (5.8)          | 0        | 9 (8.7) |

Values in parenthesis represent mortality %

### Table 23
9. Operation for non-neoplastic disease
(D) Bullous disease

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| 415   | 1 (0.2)          | 0        | 1 (0.2) |
| 322   | 1 (0.3)          | 0        | 1 (0.3) |
| 18    | 0                | 0        | 0        |
| 28    | 0                | 0        | 0        |
| 47    | 0                | 0        | 0        |

Values in parenthesis represent mortality %

LVRS lung volume reduction surgery

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### Table 24
9. Operation for non-neoplastic disease

#### (E) Pneumothorax

| Cases | 30-day mortality | Hospital mortality | After discharge |
|-------|------------------|--------------------|-----------------|
| 14,572 | 60 (0.4) | 8 (0.1) | 133 (0.9) |

**Spontaneous pneumothorax**

| Operative procedure | Cases | 30-day mortality | Hospital mortality | After discharge |
|---------------------|-------|------------------|--------------------|-----------------|
| Bullectomy | 3410 | 3 (0.1) | 0 | 12 (0.4) |
| Bullectomy with additional procedure | 7625 | 2 (0.03) | 1 (0.01) | 7 (0.1) |
| Coverage with artificial material | 7241 | 2 (0.03) | 0 | 6 (0.1) |
| Parietal pleurectomy | 51 | 0 | 0 | 1 (2.0) |
| Coverage and parietal pleurectomy | 92 | 0 | 0 | 0 |
| Others | 241 | 0 | 1 (0.4) | 0 |
| Others | 905 | 8 (0.9) | 0 | 12 (1.3) |
| Unknown | 8 | 0 | 0 | 0 |
| Total | 11,948 | 13 (0.1) | 1 (0.01) | 31 (0.3) |

**Secondary pneumothorax**

| Associated disease | Cases | 30-day mortality | Hospital mortality | After discharge |
|-------------------|-------|------------------|--------------------|-----------------|
| COPD | 1763 | 18 (1.0) | 2 (0.1) | 51 (2.9) |
| Tumorous disease | 84 | 7 (8.3) | 3 (3.6) | 14 (16.7) |
| Catamenial | 148 | 0 | 0 | 0 |
| LAM | 47 | 0 | 0 | 0 |
| Others (excluding pneumothorax by trauma) | 582 | 22 (3.8) | 2 (0.3) | 37 (6.4) |
| Unknown | | | | |
| Operative procedure | Cases | 30-day mortality | Hospital mortality | After discharge |
|---------------------|-------|------------------|--------------------|-----------------|
| Bullectomy | 372 | 2 (0.5) | 1 (0.3) | 3 (0.8) |
| Bullectomy with additional procedure | 1509 | 16 (1.1) | 2 (0.1) | 37 (2.5) |
| Coverage with artificial material | 1423 | 16 (1.1) | 2 (0.1) | 37 (2.6) |
| Parietal pleurectomy | 9 | 0 | 0 | 0 |
| Coverage and parietal pleurectomy | 18 | 0 | 0 | 0 |
| Others | 59 | 0 | 0 | 0 |
| Others | 735 | 29 (3.9) | 4 (0.5) | 62 (8.4) |
| Unknown | 8 | 0 | 0 | 0 |
| Total | 2624 | 47 (1.8) | 7 (0.3) | 102 (3.9) |

Values in parenthesis represent mortality %.

### Table 25
9. Operation for non-neoplastic disease

#### (F) Chest wall deformity

| Cases | 30-day mortality | Hospital mortality | After discharge |
|-------|------------------|--------------------|-----------------|
| (F) Chest wall deformity | 217 | 0 | 0 | 0 |
| Funnel chest | 209 | 0 | 0 | 0 |
| Others | 8 | 0 | 0 | 0 |

### Table 26
9. Operation for non-neoplastic disease

#### (G) Diaphragmatic hernia

| Cases | 30-day mortality | Hospital mortality | After discharge |
|-------|------------------|--------------------|-----------------|
| (G) Diaphragmatic hernia | 55 | 1 (1.8) | 0 | 1 (1.8) |
| Congenital | 22 | 0 | 0 | 0 |
| Traumatic | 9 | 0 | 0 | 0 |
| Others | 24 | 1 (4.2) | 0 | 1 (4.2) |

Values in parenthesis represent mortality %.
Table 27
9. Operation for non-neoplastic disease
(H) Chest trauma
Values in parenthesis represent mortality %

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| (H) Chest trauma | 394 | 29 (7.4) | 0 | 36 (9.1) |

Table 28
9. Operation for non-neoplastic disease
(I) Other respiratory surgery
Values in parenthesis represent mortality %

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| (I) Other respiratory surgery | 1325 | 28 (2.1) | 0 | 64 (4.8) |
| Arteriovenous malformation* | 77 | 0 | 0 | 0 |
| Pulmonary sequestration | 104 | 0 | 0 | 0 |
| Postoperative bleeding air leakage | 386 | 11 (2.8) | 0 | 30 (7.8) |
| Chylothorax | 65 | 1 (1.5) | 0 | 2 (3.1) |
| Others | 693 | 16 (2.3) | 0 | 32 (4.6) |

Table 29
10. Lung transplantation
Values in parenthesis represent mortality %

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| Single lung transplantation from brain dead donor | 23 | 0 | 0 | 0 |
| Bilateral lung transplantation from brain dead donor | 17 | 0 | 0 | 0 |
| Lung transplantation from living donor | 20 | 0 | 0 | 2 (10.0) |
| Total of lung transplantation | 60 | 0 | 0 | 2 (3.3) |
| Donor of living donor lung transplantation | 37 | 0 | 0 | 0 |

Table 30
11. Tracheobronchoplasty
Values in parenthesis represent mortality %

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| 11. Tracheobronchoplasty | 649 | 9 (1.4) | 7 (1.1) | 16 (2.5) |
| Trachea | 27 | 0 | 0 | 1 (3.7) |
| Sleeve resection with reconstruction | 20 | 0 | 0 | 1 (5.0) |
| Wedge with simple closure | 0 | 0 | 0 | 0 |
| Wedge with patch closure | 0 | 0 | 0 | 0 |
| Total laryngectomy with tracheostomy | 0 | 0 | 0 | 0 |
| Others | 7 | 0 | 0 | 0 |
| Carinal reconstruction | 28 | 2 (7.1) | 0 | 2 (7.1) |
| Sleeve pneumonectomy | 15 | 0 | 0 | 1 (6.7) |
| Sleeve lobectomy | 476 | 5 (1.1) | 7 (1.5) | 10 (2.1) |
| Sleeve segmental excision | 22 | 0 | 0 | 0 |
| Bronchoplasty without lung resection | 13 | 1 (7.7) | 0 | 1 (7.7) |
| Others | 68 | 1 (1.5) | 0 | 1 (1.5) |

Table 31
12. Pediatric surgery
Values in parenthesis represent mortality %

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  | Hospital | After discharge |
| 12. Pediatric surgery | 580 | 3 (0.5) | 0 | 7 (1.2) |
During 2014 alone, a total of 13,958 patients with esophageal diseases were registered from 601 institutions (response rate: 96.0 %) which affiliated to the Japanese Association for Thoracic Surgery and/or to the Japan Esophageal Society. Among these institutions, those where 20 or more patients underwent esophageal surgeries within the year of 2014 were 133 institutions (22.1 %), which shows no definite shift of esophageal operations to high volume institutions when compared to the data of 2013 (33.3 %) (Table 34) Of 3,956 patients with a benign esophageal disease, 1660 (42.0 %) patients underwent surgery, and 57 (1.4 %) patients underwent endoscopic resection, while 2239 (56.6 %) patients did not undergo any surgical treatment. (Table 35) Of 10,638 patients with a malignant esophageal tumor, 8135 (76.5 %) patients underwent resection, esophagectomy for 6247 (59.0 %) and endoscopic mucosal resection (EMR) or endoscopic submucosal dissection (ESD) for 1851 (17.5 %), while 2492 (23.5 %) patients did not undergo any resection. (Tables 36, 37) The patients registered, particularly those undergoing ESD or EMR for a malignant esophageal disease, have been increasing since 1990 (Fig. 3).

### Table 32
13. Combined resection of neighboring organ(s)

| Organ resected                           | Cases | 30-day mortality | Hospital mortality |
|------------------------------------------|-------|------------------|--------------------|
|                                          |       | 30-day mortality | Hospital mortality |
|                                          |       | Hospital         | After discharge    |
| 13. Combined resection of neighboring organ(s) | 1408  | 7 (0.5)          | 3 (0.2)            | 25 (1.8) |
| (A) Primary lung cancer (organ resected) |       |                  |                    |
| Aorta                                    | 16    | 0                | 1 (6.3)            |
| Superior vena cava                       | 26    | 0                | 2 (7.7)            |
| Brachiocephalic vein                     | 13    | 1 (7.7)          | 1 (7.7)            |
| Pericardium                              | 143   | 1 (0.7)          | 4 (2.8)            |
| Pulmonary artery                         | 158   | 1 (0.6)          | 2 (1.3)            |
| Left atrium                              | 30    | 0                | 0                  |
| Diaphragm                                | 51    | 0                | 0                  |
| Chest wall (including ribs)              | 360   | 3 (0.8)          | 17 (4.7)           |
| Vertebral                                | 16    | 1 (6.3)          | 2 (12.5)           |
| Esophagus                                | 9     | 0                | 0                  |
| Total                                    | 822   | 7 (0.9)          | 29 (3.5)           |
| (B) Mediastinal tumor (organ resected)   |       |                  |                    |
| Aorta                                    | 2     | 0                | 1 (50.0)           |
| Superior vena cava                       | 59    | 0                | 1 (1.7)            |
| Brachiocephalic vein                     | 89    | 0                | 0                  |
| Pericardium                              | 340   | 2 (0.6)          | 3 (0.9)            |
| Pulmonary artery                         | 3     | 0                | 0                  |
| Left atrium                              | 0     | 0                | 0                  |
| Diaphragm                                | 34    | 0                | 1 (2.9)            |
| Chest wall (including ribs)              | 9     | 0                | 0                  |
| Vertebral                                | 13    | 0                | 0                  |
| Esophagus                                | 4     | 0                | 0                  |
| Lung                                     | 461   | 0                | 6 (0.6)            |
| Total                                    | 1014  | 2 (0.2)          | 6 (0.6)            |

Values in parenthesis represent mortality %

### Table 33
14. Operation of lung cancer invading the chest wall of the apex

| Cases | 30-day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       | 30-day mortality | Hospital mortality |
|       | Hospital         | After discharge    |
| 14. Operation of lung cancer invading the chest wall of the apex | 737 | 2 (0.3) | 5 (0.7) | 15 (2.0) |

Values in parenthesis represent mortality %

Includes tumors invading the anterior apical chest wall and posterior apical chest wall (superior sulcus tumor, so-called Pancoast type)

(C) Esophageal surgery

During 2014 alone, a total of 13,958 patients with esophageal diseases were registered from 601 institutions (response rate: 96.0 %) which affiliated to the Japanese Association for Thoracic Surgery and/or to the Japan Esophageal Society. Among these institutions, those where 20 or more patients underwent esophageal surgeries within the year of 2014 were 133 institutions (22.1 %), which shows no definite shift of esophageal operations to high volume institutions when compared to the data of 2013 (33.3 %) (Table 34) Of 3,956 patients with a benign esophageal disease, 1660 (42.0 %) patients underwent surgery, and 57 (1.4 %) patients underwent endoscopic resection, while 2239 (56.6 %) patients did not undergo any surgical treatment. (Table 35) Of 10,638 patients with a malignant esophageal tumor, 8135 (76.5 %) patients underwent resection, esophagectomy for 6247 (59.0 %) and endoscopic mucosal resection (EMR) or endoscopic submucosal dissection (ESD) for 1851 (17.5 %), while 2492 (23.5 %) patients did not undergo any resection. (Tables 36, 37) The patients registered, particularly those undergoing ESD or EMR for a malignant esophageal disease, have been increasing since 1990 (Fig. 3).

Among benign esophageal diseases (Table 35), hiatal hernia, esophageal varices, esophagitis (including reflux
esophagitis) and achalasia were the most common conditions in Japan. On the other hand, spontaneous rupture of the esophagus, benign esophageal tumors and congenital esophageal atresia were common diseases which were surgically treated as well as the above-mentioned diseases. The thoracoscopic and/or laparoscopic procedures have been widely adopted for benign esophageal diseases, in particular achalasia, hiatal hernia and benign tumors. Open surgery was performed in 1072 patients with a benign esophageal disease, with 30-day mortality in 14 (1.3 %), while thoracoscopic and/or laparoscopic surgery was performed for 588 patients, with 1(0.2 %) of the 30-day mortality The difference in these death rates between open and scopic surgery seems to be related the conditions requiring open surgery.

The majority of malignant diseases were carcinomas (Table 36). Among esophageal carcinomas, the incidence of squamous cell carcinoma was 90.5 %, while that of adenocarcinomas including Barrett cancer was 7.1 %. The resection rate for patients with a squamous cell carcinoma was 76.4 %, while that for patients with an adenocarcinoma was 88.3 %.

According to location, cancer in the thoracic esophagus was the most common (Table 37). Of the 3950 patients (37.3 % of total esophageal malignancies) having superficial esophageal cancers within mucosal and submucosal layers, 1892 (47.9 %) patients underwent esophagectomy, while 1848 (46.8 %) patients underwent EMR or ESD. The 30-day mortality rate and hospital mortality rate after esophagectomy for patients with a superficial cancer were 0.5 and 1.2 % respectively. Advanced esophageal cancer invading deeper than the submucosal layer was observed in 6628 (62.6 %) patients. Of the 6628 patients with advanced esophageal cancer, 4344 (65.5 %) underwent esophagectomy, with 0.9 % of the 30-day mortality rate, and with 2.4 % of the hospital mortality rate.

Multiple primary cancers were observed in 1908 (18.0 %) of all the 10,584 patients with esophageal cancer. Synchronous cancer was found in 982 (51.5 %) patients, while metachronous cancer (found before esophageal cancer) was observed in 926 (48.5 %) patients. The stomach is the commonest site for both synchronous and metachronous malignancy followed by head and neck cancer (Table 37).

Among esophagectomy procedures, transthoracic esophagectomy through right thoracotomy was the most commonly adopted for patients with a superficial cancer as well as for those with an advanced cancer (Table 38). Transhiatal esophagectomy commonly performed in Western countries was adopted in only 2.8 % of patients having a superficial cancer who underwent esophagectomy and in 1.6 % of those having an advanced cancer in Japan. The thoracoscopic and/or laparoscopic esophagectomy were adopted for 1134 patients (59.9 %) with a superficial cancer, and for 1666 patients (38.3 %) with an advanced cancer. The number of cases of thoracoscopic and/or laparoscopic surgery for superficial or advanced cancer has been increasing for these several years (Fig. 4).

Combined resection of the neighboring organs during resection of an esophageal cancer was performed in 330 patients (Tables 38, 39). Resection of the aorta together with the esophagectomy was performed in 2 cases. Tracheal and/or bronchial resection combined with esophagectomy was performed in 24 patients, with the 30-day mortality rate at 0 % and the hospital mortality rate at 4.2 %. Lung resection combined with esophagectomy was performed in 77 patients, with the 30-day mortality rate at 3.9 % and the hospital mortality rate at 7.8 %.

Salvage surgery after definitive (chemo-) radiotherapy was performed in 262 patients, with the 30-day mortality rate at 1.5 % and with the hospital mortality rate at 3.8 % (Table 38).

Last, in spite of the efforts of the Committee to cover wider patient populations to this annual survey, the majority of the institutions which responded to the questionnaire were the departments of thoracic or esophageal surgery. It should be noted that larger number of patients with esophageal diseases should have been treated medically and endoscopically. We should continue our effort for complete survey through more active collaboration with the Japan Esophageal Society and other-related societies.
Table 34 Distribution of number of esophageal operations in 2014 in each institution

| Esophageal surgery | Number of operations in 2014 | Benign esophageal diseases | Malignant esophageal disease | Benign + malignant |
|--------------------|-----------------------------|---------------------------|-----------------------------|-------------------|
| 0                  | 289                         | 136                       | 98                          |
| 1–4                | 245                         | 148                       | 145                         |
| 5–9                | 45                          | 120                       | 117                         |
| 10–19              | 17                          | 81                        | 108                         |
| 20–29              | 3                           | 36                        | 39                          |
| 30–39              | 1                           | 23                        | 27                          |
| 40–49              | 0                           | 20                        | 25                          |
| ≥50                | 1                           | 37                        | 42                          |
| Total              | 601                         | 601                       | 601                         |
## Table 35 Benign esophageal diseases

| Operation (+) | Hospital mortality | Endoscopic resection | Operation (−) | Total |
|---------------|--------------------|----------------------|---------------|-------|
|                | Number of patients |                      |               |       |
|                | Total | Open | T/L*3 | Total | Open | T/L*3 | Total | Open | T/L*3 | Total |
|                | ~30 days | | | ~30 days | | | ~30 days | | | ~30 days |
|                | 31–90 days | | | 31–90 days | | | 31–90 days | | | 31–90 days |
|                | Total | (including 91 days mortality) | | Total | (including 91 days mortality) | | Total | (including 91 days mortality) | | Total | (including 91 days mortality) |
| 1. Achalasia | 338 | 179 | 159 | 1 (0.6) | 0 | 1 (0.6) | 0 | 0 | 0 | 1 (0.3) | 52 | 390 |
| 2. Benign tumor | 111 | 73 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 18 | 172 |
| (1) Leiomyoma | 70 | 43 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 9 | 96 |
| (2) Cyst | 12 | 7 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| (3) Others | 29 | 23 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 6 | 61 |
| (4) Not specified | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| 3. Diverticulum | 55 | 39 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 18 | 172 |
| 4. Hiatal hernia | 739 | 423 | 316 | 2 (0.5) | 2 (0.5) | 4 (0.9) | 1 (0.3) | 1 (0.3) | 2 (0.6) | 6 (0.8) | 193 | 932 |
| 5. Spontaneous rupture of the esophagus | 95 | 87 | 8 | 4 (4.6) | 1 (1.1) | 5 (5.7) | 0 | 0 | 0 | 5 (5.3) | 13 | 108 |
| 6. Esophagotracheal fistula | 41 | 17 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 5 | 31 |
| 7. Congenital esophageal atresia | 51 | 47 | 4 | 0 | 1 (2.1) | 1 (2.1) | 0 | 0 | 0 | 1 (2.0) | 1 | 52 |
| 8. Congenital esophageal stenosis | 10 | 9 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 14 |
| 9. Corrosive stricture of the esophagus | 11 | 8 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 21 |
| 10. Esophagitis, esophageal ulcer | 87 | 61 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 1199 | 1286 |
| 11. Esophageal varices | 70 | 67 | 3 | 2 (3.0) | 0 | 2 (3.0) | 0 | 0 | 0 | 2 (2.9) | 685 | 755 |
| (1) Laparotomy | 9 | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| (2) Sclerotherapy | | | | | | | | | | | 201 |
| (3) EVL | | | | | | | | | | | 344 |
| 12. Others | 75 | 62 | 13 | 5 (8.1) | 0 | 5 (8.1) | 0 | 0 | 0 | 5 (6.7) | 14 | 35 |
| Total | 1660 | 1072 | 588 | 14 (1.3) | 4 (0.4) | 18 (1.7) | 1 (0.2) | 1 (0.2) | 2 (0.3) | 20 (1.2) | 57 | 2239 |

Table values in parenthesis represent mortality %.

T/L thoracoscopic and/or laparoscopic.

## Table 36 Malignant esophageal diseases (histologic classification)

| Carcinomas | Resection (+) | Resection (−) | Total |
|------------|---------------|---------------|-------|
| 1. Squamous cell carcinoma | 8100 | 2495 | 10,595 |
| 2. Basaloid (-squamous) carcinoma | 7233 | 2355 | 9588 |
| 3. Carcinosarcoma | 79 | 2 | 81 |
| 4. Adenocarcinoma in the Barrett’s esophagus | 43 | 3 | 46 |
| 5. Other adenocarcinoma | 319 | 21 | 340 |
| 6. Adenosquamous carcinoma | 350 | 67 | 417 |
| 7. Mucoepidermoid carcinoma | 22 | 5 | 27 |
| 8. Adenoid cystic carcinoma | 7 | 4 | 11 |
| 9. Enderline cell carcinoma | 10 | 13 | 23 |
| 10. Undifferentiated carcinoma | 35 | 8 | 43 |
| 11. Others | 8 | 2 | 10 |
| Other malignancies | 20 | 5 | 25 |
| Not specified | 7 | 1 | 8 |

Resection: including endoscopic resection.

Total 8135 2503 10,638
Table 37 Malignant esophageal disease (clinical characteristics)

| Location                        | Operation (+) | EMR or ESD | Operation (-) | Total |
|--------------------------------|---------------|------------|---------------|-------|
|                                | Cases         | Hospital mortality | ~30 days  | 31–90 days | Total (including after 91 days mortality) |
| 1. Esophageal cancer           | 6247          | 47 (0.8)   | 46 (0.7)    | 128 (2.0) | 1851 | 2492 | 10,584 |
| (1) Cervical esophagus         | 258           | 0          | 1 (0.4)     | 3 (1.2)   | 76   | 178  | 512   |
| (2) Thoracic esophagus         | 5041          | 45 (0.9)   | 39 (0.8)    | 112 (2.2) | 1501 | 2133 | 8675  |
| (3) Abdominal esophagus        | 644           | 2 (0.3)    | 3 (0.5)     | 7 (1.1)   | 100  | 177  | 861   |
| (4) Multiple cancers           | 301           | 0          | 3 (1.0)     | 6 (2.0)   | 174  | 61   | 536   |
| (5) Others/not described       | 3             | 0          | 0           | 0         | 0    | 3    | 0     |
| Tumor depth                    |               |            |             |           |      |      |       |
| (A) Superficial cancer (T1)    | 1892          | 9 (0.5)    | 9 (0.5)     | 22 (1.2)  | 1848 | 210  | 3950  |
| Mucosal cancer (T1a)           | 415           | 0          | 2 (0.5)     | 2 (0.5)   | 1514 | 49   | 1978  |
| (B) Advanced cancer (T2–T4)   | 4344          | 37 (0.9)   | 37 (0.9)    | 105 (2.4) | 2    | 2282 | 6628  |
| (C) Not specified              | 11            | 1 (9.1)    | 0           | 1 (9.1)   | 1    | 0    | 12    |
| 2. Multiple primary cancers    | 1050          | 7 (0.7)    | 7 (0.7)     | 21 (2.0)  | 520  | 338  | 1908  |
| (1) Synchronous                | 587           | 4 (0.7)    | 2 (0.3)     | 10 (1.7)  | 210  | 185  | 982   |
| (1) Head and neck              | 184           | 0          | 0           | 1 (0.5)   | 84   | 59   | 327   |
| (2) Stomach                    | 226           | 2 (0.9)    | 0           | 4 (1.8)   | 72   | 65   | 363   |
| (3) Others                     | 144           | 1 (0.7)    | 2 (1.4)     | 4 (2.8)   | 41   | 42   | 227   |
| (4) Triple cancers             | 33            | 1 (3.0)    | 0           | 1 (3.0)   | 13   | 19   | 65    |
| (5) Unknown                    | 0             | 0          | 0           | 0         | 0    | 0    | 0     |
| 2) Metachronous                | 463           | 3 (0.6)    | 5 (1.1)     | 11 (2.4)  | 310  | 153  | 926   |
| (1) Head and neck              | 102           | 0          | 1 (1.0)     | 2 (2.0)   | 107  | 38   | 247   |
| (2) Stomach                    | 114           | 2 (1.8)    | 1 (0.9)     | 3 (2.6)   | 75   | 36   | 225   |
| (3) Others                     | 221           | 1 (0.5)    | 2 (0.9)     | 5 (2.3)   | 86   | 60   | 367   |
| (4) Triple cancers             | 26            | 0          | 1 (3.8)     | 1 (3.8)   | 42   | 19   | 87    |
| (5) Unknown                    | 0             | 0          | 0           | 0         | 0    | 0    | 0     |
| Unknown                        | 0             | 0          | 0           | 0         | 0    | 0    | 0     |

Values in parenthesis represent mortality %

EMR endoscopic mucosal resection (including endoscopic submucosal dissection)
| Operation (+) | Cases | Hospital mortality | Thoracoscopic and/or laparoscopic procedure | EMR or ESD |
|--------------|-------|--------------------|------------------------------------------|------------|
|              | ~30 days | 31–90 days | Total (including after 91 days mortality) | ~30 days | 31–90 days | Total (including after 91 days mortality) |   |
| Superficial cancer (T1) | 1892 | 9 (0.5) | 9 (0.5) | 22 (1.2) | 1134 | 3 (0.3) | 7 (0.6) | 14 (1.2) | 1848 |
| Mucosal cancer (T1a) | 415 | 0 | 2 (0.5) | 2 (0.5) | 223 | 0 | 0 | 0 | 1514 |
| Esophagectomy | 1892 | 9 (0.5) | 9 (0.5) | 22 (1.2) | 1134 | 3 (0.3) | 7 (0.6) | 14 (1.2) | 1848 |
| 1) Transhiatal esophagectomy | 53 | 1 (1.9) | 1 (1.9) | 2 (3.8) | 4 | 0 | 0 | 0 |   |
| 2) Transthoracic (rt.) esophagectomy and reconstruction | 1579 | 5 (0.3) | 8 (0.5) | 17 (1.1) | 1037 | 2 (0.2) | 7 (0.7) | 13 (1.3) |   |
| 3) Transthoracic (lt.) esophagectomy and reconstruction | 43 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |   |
| 4) Cervical esophageal resection and reconstruction | 35 | 0 | 0 | 0 | 16 | 0 | 0 | 0 |   |
| 5) Two-stage operation | 27 | 0 | 0 | 0 | 13 | 0 | 0 | 0 |   |
| 6) Others | 155 | 3 (1.9) | 0 | 3 (1.9) | 57 | 1 (1.8) | 0 | 1 (1.8) |   |
| 7) Not specified | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |   |
| Advanced cancer (T2–T4) | 4344 | 37 (0.9) | 37 (0.9) | 105 (2.4) | 1666 | 11 (0.7) | 11 (0.7) | 32 (1.9) | 2 |
| 1) Transhiatal esophagectomy | 68 | 0 | 1 (1.5) | 1 (1.5) | 7 | 0 | 0 | 0 |   |
| 2) Transthoracic (rt.) esophagectomy and reconstruction | 3661 | 31 (0.8) | 26 (0.7) | 78 (2.1) | 1522 | 9 (0.6) | 10 (0.7) | 27 (1.8) |   |
| 3) Transthoracic (lt.) esophagectomy and reconstruction | 137 | 1 (0.7) | 2 (1.5) | 3 (2.2) | 14 | 0 | 0 | 0 |   |
| 4) Cervical esophageal resection and reconstruction | 171 | 1 (0.6) | 2 (1.2) | 8 (4.7) | 35 | 1 (2.9) | 0 | 2 (5.7) |   |
| 5) Two-stage operation | 84 | 1 (1.2) | 1 (1.2) | 4 (4.8) | 25 | 0 | 0 | 0 |   |
| 6) Others/not specified | 223 | 3 (1.3) | 5 (2.2) | 11 (4.9) | 63 | 1 (1.6) | 1 (1.6) | 3 (4.8) |   |
| 7) Not specified | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |   |
| (Depth not specified) | 11 | 1 (9.1) | 0 | 1 (9.1) | 0 | 0 | 0 | 0 | 1 |
| Combined resection of other organs | 330 | 6 (1.8) | 4 (1.2) | 13 (3.9) |   |
| 1) Aorta | 2 | 0 | 0 | 0 |   |
| 2) Trachea, bronchus | 24 | 0 | 0 | 1 (4.2) |   |
| 3) Lung | 77 | 3 (3.9) | 2 (2.6) | 6 (7.8) |   |
| 4) Others | 227 | 3 (1.3) | 2 (0.9) | 6 (2.6) |   |
| Unknown | 0 | 0 | 0 | 0 |   |
| Salvage surgery | 262 | 4 (1.5) | 4 (1.5) | 10 (3.8) | 55 | 0 | 2 (3.6) | 2 (3.6) | 26 |

Values in parenthesis represent mortality %
Table 39 Mortality after combined resection of the neighboring organs

| Year | Esophagectomy | Combined resection |
|------|--------------|--------------------|
|      | a   | b   | c (%) | a   | b   | c (%) | a   | b   | c (%) | a   | b   | c (%) |
| 1996 | 4194 | 120 | 2.86  | 7   | 3   | 42.86 | 24  | 0   | 0.00  | 50  | 2   | 4.00  |
| 1997 | 4441 | 127 | 2.86  | 1   | 0   | 0.00  | 34  | 5   | 14.71 | 56  | 1   | 1.79  |
| 1998 | 4878 | 136 | 2.79  | 4   | 0   | 0.00  | 29  | 0   | 0.00  | 74  | 1   | 1.35  |
| 1999 | 5015 | 116 | 2.31  | 5   | 0   | 0.00  | 23  | 2   | 8.70  | 68  | 0   | 0.00  |
| 2000 | 5350 | 81  | 1.51  | 2   | 0   | 0.00  | 23  | 2   | 8.70  | 69  | 0   | 0.00  |
| 2001 | 5521 | 110 | 1.99  | 1   | 0   | 0.00  | 26  | 1   | 3.85  | 83  | 3   | 3.61  |
| 2002 | 4904 | 66  | 1.35  | 3   | 1   | 33.33 | 20  | 2   | 10.00 | 63  | 0   | 0.00  |
| 2003 | 4639 | 45  | 0.97  | 0   | 0   | 0.00  | 24  | 2   | 8.33  | 58  | 0   | 0.00  |
| 2004 | 4739 | 64  | 1.35  | 2   | 0   | 0.00  | 17  | 0   | 0.00  | 59  | 5   | 8.47  |
| 2005 | 5163 | 52  | 1.01  | 1   | 0   | 0.00  | 11  | 1   | 9.09  | 67  | 1   | 1.49  |
| 2006 | 5236 | 63  | 1.20  | 0   | 0   | 0.00  | 17  | 0   | 0.00  | 62  | 2   | 3.23  |
| 2007 | 4990 | 60  | 1.20  | 0   | 0   | 0.00  | 25  | 1   | 4.00  | 44  | 1   | 2.27  |
| 2008 | 5124 | 63  | 1.23  | 0   | 0   | 0.00  | 17  | 1   | 5.88  | 48  | 1   | 2.08  |
| 2009 | 5260 | 63  | 1.20  | 0   | 0   | 0.00  | 19  | 2   | 10.53 | 58  | 2   | 3.45  |
| 2010 | 5180 | 45  | 0.87  | 2   | 0   | 0.00  | 33  | 0   | 0.00  | 58  | 0   | 0.00  |
| 2011 | 5430 | 38  | 0.70  | 4   | 0   | 0.00  | 26  | 0   | 0.00  | 41  | 0   | 0.00  |
| 2012 | 6055 | 47  | 0.78  | 2   | 0   | 0.00  | 23  | 1   | 4.35  | 69  | 0   | 0.00  |
| 2013 | 5824 | 41  | 0.70  | 2   | 0   | 0.00  | 44  | 0   | 0.00  | 77  | 1   | 1.30  |
| 2014 | 6247 | 47  | 0.75  | 2   | 0   | 0.00  | 24  | 0   | 0.00  | 77  | 3   | 3.90  |
| Total| 98,190|1384|1.41 |38 |4 |10.53 |273 |20 |7.33 |1181 |23 |1.95 |

- **a** The number of patients who underwent the operation,
- **b** number of patients died within 30 days after operation,
- **c** % ratio of b/a, i.e., direct operative mortality.

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Reference

1. Swanson SJ, Herndon II JE, D’Amico TA, et al. Video-assisted thoracic surgery lobectomy: report of CALGB 39802—a prospective, multi-institution feasibility study. J Clin Oncol. 2007;25:4993–7.