Thoracic and cardiovascular surgeries in Japan during 2017

Annual report by the Japanese Association for Thoracic Surgery

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The Japanese Association for Thoracic Surgery has conducted annual surveys of thoracic surgery throughout Japan since 1986 to determine statistics pertaining to the number of procedures performed, based on surgical category. Herein, we summarize the results of the association’s annual survey of thoracic surgery performed in 2017.

Adhering to the norm to date, thoracic surgery was classified into three categories: cardiovascular, general thoracic, and esophageal surgeries. Patient data were examined and analyzed for each group. Access to computerized data is available to all members of the association. We honor and value all members’ continued professional support and contributions (Tables 1, 2).

Incidence of hospital mortality was included in the survey to determine nationwide status, which has contributed to Japanese surgeons’ understanding of the present status of thoracic surgery in Japan, while helping to effect progress for improving operative results by enabling them to compare their work with that of others. In this way, the association has been able to gain a better understanding of present problems and future prospects, which is reflected in its activities and the education of its members.

Thirty-day mortality (so-called operative mortality) is defined as death within 30 days of surgery, regardless of the patient’s geographic location, including after the patient is discharged from hospital. Hospital mortality is defined as death within any time interval following surgery if the patient has not been discharged from hospital.

Hospital-to-hospital transfer in the category of esophageal surgery is not considered a form of discharge; transfer to a nursing home or a rehabilitation unit is considered hospital discharge, unless the patient subsequently dies because of complications from surgery. Contrastingly, hospital-to-hospital transfer 30 days following surgery in the categories of cardiovascular and general thoracic surgery is considered discharge, as data related to the National Clinical Database (NCD 2017) were employed in this category, and hospital-to-hospital transfer 30 days following surgery is considered discharge according to the NCD.

Survey abstract

All data pertaining to cardiovascular and thoracic surgeries were obtained from the NCD, whereas data regarding esophageal surgery were collected from a survey questionnaire derived from the Japanese Association for Thoracic Surgery documentation. The reason for this was that NCD information regarding esophageal surgery does not include non-surgical cases (i.e., patients with adjuvant chemotherapy or radiation only).

Because of changes in data collection related to cardiovascular surgery (initially self-reported using questionnaire sheets in each participating institution up to 2014, then by downloading an automatic package from the Japanese Cardiovascular Surgery Database (JCVSD), a cardiovascular sub-section of the NCD), the response rate is not available and is, therefore, not indicated in the cardiovascular surgery category (Table 1). Additionally, the number of institutions (based on surgery count) was not calculated in the cardiovascular surgery category (Table 2).
We are extremely pleased with the cooperation of our colleagues (members) in terms of completing the cardiovascular surgery survey, thereby undoubtedly improving the quality of this annual report. We are truly grateful for the significant efforts made by all within each participating institution in completing the JCVSD/NCD.

Figure 1 illustrates the development of cardiovascular surgery in Japan over the past 30 years. Aneurysm surgery includes only surgeries for thoracic and thoracoabdominal aortic aneurysms. Extra-anatomic bypass surgery for thoracic aneurysm and pacemaker implantation has been excluded from the survey since 2015. The number of assist device implantation surgeries is not included in the total number of surgical procedures but was nonetheless included in the survey.

A total of 70,078 cardiovascular surgeries including 56 heart transplants were performed in 2017, an increase of 3.3% compared with that in the 2016 survey results ($n = 67,867$). The number of cardiovascular surgeries is continuously increasing, despite an apparent decrease in 2015, likely due to major changes in data collection and aggregation approaches.

When compared with data for 2016 [1] and 2007 [2], the number of surgeries in 2017 for congenital heart disease increased by 7.1% (9368 vs. 8744) and 0.2%, respectively; procedures for valvular heart disease increased by 0.2% (23,312 vs. 23,254) and 53.2%, respectively; surgery for thoracic aortic aneurysm increased by 8.7% (20,746 vs. 19,078) and 114.6%, respectively; ischemic heart procedures decreased by 6.6% (13,898 vs. 14,874) and 23.6%,
| Condition                  | Total | Neonate | Infant | 1-17 years | ≥ 18 years | Total |
|---------------------------|-------|---------|--------|------------|------------|-------|
|                           | Cases | Hospital | After discharge | Hospital | After discharge | Hospital | After discharge | Hospital | After discharge | Hospital | After discharge | Hospital | After discharge |
| PDA                       | 1     | 0        | 0      | 4          | 0          | 0      | 0                | 14        | 0          | 0                | 19        | 0          | 0                | 0        |
| Coarctation (complex)     | 7     | 0        | 0      | 11         | 0          | 0      | 0                | 13        | 0          | 0                | 4         | 0          | 0                | 35       |
| +VSD                      | 49    | 0        | 0      | 51         | 2 (3.9)    | 0      | 3 (5.9)          | 13        | 0          | 0                | 0         | 0          | 0                | 113      |
| +DORV                     | 2     | 0        | 0      | 1          | 0          | 0      | 0                | 0         | 0          | 0                | 0         | 0          | 0                | 3        |
| +AVSD                     | 2     | 0        | 0      | 3          | 0          | 0      | 0                | 0         | 0          | 0                | 0         | 0          | 0                | 0        |
| +TGA                      | 0     | 0        | 0      | 0          | 0          | 0      | 0                | 0         | 0          | 0                | 0         | 0          | 0                | 0        |
| +IV                       | 2     | 0        | 0      | 0          | 0          | 0      | 0                | 1         | 0          | 0                | 0         | 0          | 0                | 3        |
| +Others                   | 5     | 0        | 0      | 7          | 0          | 0      | 0                | 0         | 0          | 0                | 2         | 0          | 0                | 22       |
| Interrupt. of Ao (simple) | 0     | 0        | 0      | 0          | 0          | 0      | 0                | 0         | 0          | 0                | 0         | 0          | 0                | 0        |
| +VSD                      | 27    | 0        | 0      | 23         | 0          | 0      | 1 (4.3)          | 12        | 0          | 0                | 0         | 0          | 0                | 62       |
| +DORV                     | 0     | 0        | 0      | 0          | 0          | 0      | 0                | 0         | 0          | 0                | 0         | 0          | 0                | 0        |
| +Truncus                  | 4     | 0        | 0      | 2          | 0          | 0      | 0                | 5         | 0          | 0                | 0         | 0          | 0                | 11       |
| +TGA                      | 0     | 0        | 0      | 0          | 0          | 0      | 0                | 0         | 0          | 0                | 0         | 0          | 0                | 0        |
| +Others                   | 1     | 0        | 0      | 2          | 0          | 0      | 0                | 0         | 0          | 0                | 0         | 0          | 0                | 5        |
| Vascular ring             | 1     | 0        | 0      | 1          | 0          | 0      | 0                | 0         | 0          | 0                | 0         | 0          | 0                | 2        |
| PS                        | 5     | 0        | 0      | 25         | 0          | 0      | 0                | 77        | 1 (1.3)    | 0                | 1 (1.3)   | 26         | 0          | 0          |
| PA-IVS or critical PS     | 15    | 1 (67)   | 0      | 66         | 0          | 0      | 2 (3.0)          | 48        | 0          | 0                | 1 (2.1)   | 2          | 0          | 0          |
| TAPVR                     | 112   | 6 (54)   | 0      | 9 (8.0)    | 59         | 1 (17) | 0                | 17        | 0          | 0                | 1 (5.9)   | 109        | 7 (37)     | 0          |
| PAPVR ± ASD               | 0     | 0        | 0      | 5          | 0          | 0      | 0                | 38        | 0          | 0                | 22        | 0          | 0                | 65       |
| ASD                       | 1     | 0        | 0      | 73         | 0          | 0      | 0                | 583       | 0          | 0                | 764       | 0          | 7 (9.0)    | 7 (9.9)   |
| Cor triatriatum           | 1     | 0        | 0      | 8          | 0          | 0      | 0                | 6         | 0          | 0                | 4         | 0          | 0                | 19       |
| AVSD (partial)            | 1     | 0        | 0      | 7          | 0          | 0      | 1 (14.3)         | 42        | 0          | 0                | 6         | 0          | 0                | 56       |
| AVSD (complete)           | 8     | 0        | 0      | 117        | 3 (26)     | 0      | 4 (3.6)          | 94        | 2 (21)     | 0                | 2 (21)    | 3          | 0          | 0          |
| +TAPVR or DORV            | 2     | 1 (50.0) | 0      | 9          | 0          | 0      | 0                | 14        | 1 (71)     | 0                | 1 (71)    | 0          | 0          | 25        |
| +Others                   | 0     | 0        | 0      | 0          | 0          | 0      | 0                | 0         | 0          | 0                | 0         | 0          | 0                | 0        |
| VSD (subarterial)         | 3     | 0        | 0      | 106        | 0          | 0      | 0                | 142       | 0          | 0                | 14        | 0          | 0                | 265      |
| VSD (perimembr. / muscular)| 17    | 0        | 0      | 729        | 1 (0.1)    | 0      | 1 (0.1)          | 325       | 0          | 0                | 1 (0.3)   | 21         | 0          | 0          |
| VSD (type unknown)        | 0     | 0        | 0      | 5          | 0          | 0      | 0                | 123       | 2 (16)     | 0                | 2 (16)    | 131        | 2 (15)     | 0          |
| VSD + PS                  | 0     | 0        | 0      | 32         | 1 (5.1)    | 0      | 21               | 0         | 0          | 0                | 0         | 54         | 1 (9)       | 0          |
Table 3 continued

| Diagnosis                      | Cases | 30-Day mortality | Hospital mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Hospital mortality |
|--------------------------------|-------|------------------|--------------------|--------------------|-------|------------------|--------------------|--------------------|-------|------------------|--------------------|--------------------|-------|------------------|--------------------|--------------------|-------|------------------|--------------------|--------------------|
| DCRV + VSD                   | 1     | 0                | 0                  | 0                  | 5     | 0                | 0                  | 0                  | 20    | 0                | 0                  | 0                  | 11    | 0                | 0                  | 0                  | 37    | 0                | 0                  | 0                  |
| Anomalies of sinus of Valsalva| 0     | 0                | 0                  | 0                  | 0     | 0                | 0                  | 0                  | 2     | 0                | 0                  | 0                  | 3     | 0                | 0                  | 0                  | 5     | 0                | 0                  | 0                  |
| TOF                           | 13    | 0                | 0                  | 0                  | 174   | 2 (1.1)          | 3 (1.7)            | 212               | 1 (0.5) | 1 (0.5)          | 37                 | 0                  | 0     | 0                | 0                  | 0                  | 496   | 3 (0.7)          | 0                  | 4 (0.9)            |
| PA + VSD                      | 9     | 1 (1.1)          | 1 (1.1)            | 76                | 0     | 0                | 2 (2.6)            | 108               | 1 (0.9) | 3 (2.6)          | 15                 | 0                  | 0     | 0                | 0                  | 0                  | 208   | 2 (1.0)          | 0                  | 6 (2.9)            |
| DORV                          | 24    | 1 (4.2)          | 0                  | 2 (0.3)           | 142   | 0                | 3 (2.1)            | 100               | 0      | 0                | 0                  | 11                 | 0     | 0                | 0                  | 0                  | 352   | 1 (0.3)          | 0                  | 5 (1.5)            |
| AVSD (simple)                 | 97    | 1 (1.0)          | 0                  | 5 (4.1)           | 9     | 1 (11.1)         | 1 (11.1)           | 3                  | 0      | 0                | 0                  | 2                  | 0     | 0                | 0                  | 0                  | 111   | 2 (1.0)          | 0                  | 5 (4.5)            |
| + VSD                         | 40    | 1 (2.5)          | 0                  | 1 (2.5)           | 16    | 0                | 0                  | 9                  | 0      | 0                | 0                  | 2                  | 0     | 0                | 0                  | 0                  | 67    | 1 (1.5)          | 0                  | 1 (1.5)            |
| VSD + PS                      | 0     | 0                | 0                  | 0                  | 0     | 0                | 0                  | 2                  | 0      | 0                | 0                  | 1                  | 0     | 0                | 0                  | 0                  | 3     | 0                | 0                  | 0                  |
| Corrected TGA                 | 2     | 0                | 0                  | 0                  | 17    | 0                | 0                  | 0                  | 33     | 1 (3.0)          | 0                  | 1 (3.0)            | 16    | 0                | 0                  | 0                  | 66    | 1 (1.5)          | 0                  | 1 (1.5)            |
| Truncus arteriosus            | 13    | 0                | 0                  | 0                  | 17    | 1 (5.9)          | 0                  | 1 (5.9)           | 16     | 0                | 0                  | 0                  | 0     | 0                | 0                  | 0                  | 46    | 1 (2.2)          | 0                  | 2 (0.4)            |
| SV                            | 27    | 0                | 0                  | 0                  | 151   | 2 (1.3)          | 1 (0.7)            | 7                  | 4 (6.6) | 213               | 0                  | 0      | 12                | 0                  | 0                  | 403   | 2 (0.5)          | 0                  | 1 (0.2)            |
| TA                            | 5     | 0                | 0                  | 0                  | 39    | 0                | 0                  | 0                  | 47     | 0                | 0                  | 0                  | 1 (2.1) | 6                 | 1 (16.7)          | 0                  | 1 (16.7) | 97    | 1 (1.0)          | 0                  | 3 (31)            |
| HLHS                          | 33    | 6 (18.2)         | 0                  | 11 (33.3)         | 80    | 0                | 0                  | 0                  | 3 (3.8) | 104               | 3 (2.9)            | 0                  | 5 (4.8) | 0                 | 0                  | 0                  | 217    | 9 (4.1)          | 0                  | 19 (5.8)           |
| Aortic valve lesion           | 11    | 1 (9.1)          | 0                  | 2 (18.2)          | 18    | 1 (5.6)          | 0                  | 2 (11.1)          | 104    | 0                | 0                  | 1 (1.0)            | 30     | 2 (6.7)          | 0                  | 2 (6.7)            | 163    | 4 (2.5)          | 0                  | 7 (4.5)            |
| Patent valve stenosis         | 0     | 0                | 0                  | 0                  | 43    | 0                | 0                  | 1 (2.3)           | 70     | 0                | 0                  | 1 (1.6)            | 19     | 1 (10.5)         | 0                  | 2 (10.5)           | 152    | 2 (15.9)         | 0                  | 4 (30)             |
| Marfan syndrome              | 41    | 4 (33.3)         | 0                  | 4 (33.3)          | 12    | 4 (33.3)         | 9                  | 0                  | 0      | 0                | 0                  | 23                 | 0     | 0                | 0                  | 7                  | 51     | 4 (7.8)          | 0                  | 4 (7.8)            |
| Coronary disease             | 2     | 0                | 0                  | 0                  | 10     | 0                | 0                  | 0                  | 18     | 0                | 0                  | 0                  | 1      | 0                | 0                  | 0                  | 31     | 0                | 0                  | 0                  |
| Others                        | 13    | 2 (15.4)         | 0                  | 2 (15.4)          | 27    | 1 (3.7)          | 0                  | 3 (11.1)          | 49     | 0                | 0                  | 11 (2.0)           | 232    | 1 (0.4)          | 0                  | 1 (0.4)            | 321    | 4 (1.2)          | 0                  | 7 (22)             |
| Conduct failure               | 0     | 0                | 0                  | 0                  | 0     | 0                | 0                  | 0                  | 19     | 1 (5.3)          | 0                  | 1 (5.3)            | 7      | 0                | 0                  | 0                  | 28     | 1 (3.6)          | 0                  | 1 (3.6)            |
| Redo (excluding conduit failure) | 0     | 0                | 0                  | 0                  | 41    | 0                | 0                  | 0                  | 2 (4.9) | 106               | 2 (19.0)           | 0                  | 5 (4.7) | 8 (2.44)          | 0                  | 3 (3.6)            | 230    | 4 (17.7)         | 0                  | 10 (4.3)           |
| Total                         | 568   | 25 (4.4)         | 0                  | 44 (7.7)          | 2222  | 15 (0.7)         | 2 (0.1)            | 44 (2.0)          | 2783   | 13 (0.5)         | 0                  | 27 (1.0)           | 1499   | 17 (1.1)         | 0                  | 18 (1.2)           | 7072   | 70 (1.0)         | 2 (0.0)            | 133 (1.9)          |

( ) % mortality
CPR cardiopulmonary bypass, PDA patent ductus arteriosus, VSD ventricular septal defect, DORV double-outlet right ventricle, AVSD-ventricular septal defect, TGA transposition of great arteries, SV single ventricle, Interrupt. of Ao. interruption of aorta, PS pulmonary stenosis, PA-IVS pulmonary atresia with intact ventricular septum, TAPVR total anomalous pulmonary veins return, PAPVR partial anomalous pulmonary veins 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
| Condition                        | Neonate Cases | 30-Day mortality | Hospital mortality | After discharge | Infant Cases | 30-Day mortality | Hospital mortality | After discharge | 1-17 years Cases | 30-Day mortality | Hospital mortality | After discharge | ≥ 18 years Cases | 30-Day mortality | Hospital mortality | After discharge | Total Cases | 30-Day mortality | Hospital mortality | After discharge |
|--------------------------------|----------------|------------------|--------------------|-----------------|--------------|------------------|--------------------|-----------------|------------------|------------------|--------------------|-----------------|------------------|------------------|--------------------|-----------------|--------------|------------------|--------------------|-----------------|
| PDA                            | 93             | 2 (2.1)          | 1 (1.1)            | 0               | 2296         | 11 (2.1)         | 0                  | 18 (3.5)        | 0                | 514             | 11 (2.1)          | 0                | 18 (3.5)         | 0                | 18 (3.5)          | 0                |
| Coarctation (simple)           | 26             | 2 (7.7)          | 0                  | 0               | 15           | 0                | 0                  | 0               | 0                | 15               | 0                | 0                | 0                | 0                | 0                | 0                |
| + VSD                          | 1              | 0                | 0                  | 0               | 235          | 1 (3.4)          | 0                  | 4 (1.7)         | 0                | 33              | 1 (3.0)           | 0                | 3 (0.9)          | 0                | 3 (0.9)           | 0                |
| + DORV                         | 2              | 0                | 0                  | 0               | 43           | 0                | 0                  | 0               | 0                | 43               | 0                | 0                | 0                | 0                | 0                | 0                |
| + AVSD                         | 1              | 0                | 0                  | 0               | 47           | 0                | 0                  | 0               | 0                | 47               | 0                | 0                | 0                | 0                | 0                | 0                |
| + TGA                          | 0              | 0                | 0                  | 0               | 58           | 0                | 0                  | 0               | 0                | 58               | 3 (5.2)          | 0                | 5 (0.6)          | 0                | 5 (0.6)           | 0                |
| + SV                           | 0              | 0                | 0                  | 0               | 7            | 0                | 0                  | 0               | 0                | 7               | 0                | 0                | 0                | 0                | 0                | 0                |
| + Others                       | 4              | 0                | 0                  | 0               | 19           | 0                | 0                  | 0               | 1                | 19               | 0                | 0                | 1 (5.3)          | 0                | 1 (5.3)           | 0                |
| Interrupt. of Ao (simple)      | 2              | 0                | 0                  | 0               | 2            | 0                | 0                  | 0               | 0                | 2               | 0                | 0                | 1 (5.0)          | 0                | 1 (5.0)           | 0                |
| + VSD                          | 1              | 0                | 0                  | 0               | 4            | 0                | 0                  | 0               | 0                | 4               | 1 (2.3)          | 0                | 2 (4.5)          | 0                | 2 (4.5)           | 0                |
| + DORV                         | 0              | 0                | 0                  | 0               | 2            | 0                | 0                  | 0               | 0                | 2               | 0                | 0                | 0                | 0                | 0                | 0                |
| + Truncus                      | 0              | 0                | 0                  | 0               | 12           | 0                | 0                  | 0               | 0                | 12              | 0                | 0                | 0                | 0                | 0                | 0                |
| + TGA                          | 0              | 0                | 0                  | 0               | 2            | 0                | 0                  | 0               | 0                | 2               | 0                | 0                | 0                | 0                | 0                | 0                |
| + Others                       | 2              | 0                | 0                  | 0               | 4            | 0                | 0                  | 0               | 0                | 4               | 0                | 0                | 0                | 0                | 0                | 0                |
| Vascular ring                  | 0              | 0                | 0                  | 0               | 18           | 0                | 0                  | 0               | 0                | 18              | 0                | 0                | 0                | 0                | 0                | 0                |
| PS                             | 1              | 0                | 0                  | 0               | 16           | 0                | 0                  | 0               | 0                | 16              | 0                | 0                | 0                | 0                | 0                | 0                |
| PA+IVS or critical PS          | 3              | 0                | 0                  | 0               | 65           | 1 (1.5)          | 0                  | 1 (1.5)         | 0                | 65              | 1 (1.5)          | 0                | 1 (1.5)          | 0                | 1 (1.5)           | 0                |
| TAPVR                         | 22             | 0 (9.1)          | 0                  | 0               | 35           | 2 (5.7)          | 0                  | 5 (4.3)         | 0                | 35              | 2 (5.7)          | 0                | 5 (4.3)          | 0                | 5 (4.3)           | 0                |
| PAPVR+ASD                      | 0              | 0                | 0                  | 0               | 1            | 0                | 0                  | 0               | 0                | 1               | 0                | 0                | 0                | 0                | 0                | 0                |
| ASD                            | 0              | 0                | 0                  | 0               | 4            | 0                | 0                  | 0               | 0                | 4               | 0                | 0                | 0                | 0                | 0                | 0                |
| Cor triatratium                | 0              | 0                | 0                  | 0               | 1            | 0                | 0                  | 0               | 0                | 1               | 0                | 0                | 0                | 0                | 0                | 0                |
| AVSD (partial)                 | 0              | 0                | 0                  | 0               | 2            | 0                | 0                  | 0               | 0                | 2               | 0                | 0                | 0                | 0                | 0                | 0                |
| AVSD (complete)                | 51             | 0                | 0                  | 0               | 152          | 3 (2.0)          | 0                  | 6 (3.9)         | 0                | 152             | 3 (2.0)          | 0                | 6 (3.9)          | 0                | 6 (3.9)           | 0                |
| + TOF or DORV                  | 1              | 0                | 0                  | 0               | 10           | 0                | 0                  | 0               | 0                | 10              | 0                | 0                | 0                | 0                | 0                | 0                |
| + Others                       | 0              | 0                | 0                  | 0               | 0            | 0                | 0                  | 0               | 0                | 0               | 0                | 0                | 0                | 0                | 0                | 0                |
| VSD (subarterial)              | 2              | 0                | 0                  | 0               | 9            | 0                | 0                  | 0               | 0                | 9               | 0                | 0                | 0                | 0                | 0                | 0                |
| VSD (perimembr/muscular)       | 67             | 2 (3.0)          | 0                  | 0               | 204          | 4 (2.0)          | 0                  | 5 (2.5)         | 0                | 204             | 4 (2.0)          | 0                | 5 (2.5)          | 0                | 5 (2.5)           | 0                |
| VSD (Type Unknown)             | 0              | 0                | 0                  | 0               | 0            | 0                | 0                  | 0               | 0                | 0               | 0                | 0                | 0                | 0                | 0                | 0                |
| VSD+PS                         | 1              | 0                | 0                  | 0               | 1            | 0                | 0                  | 0               | 0                | 1               | 0                | 0                | 0                | 0                | 0                | 0                |
| DORV+VSD                       | 0              | 0                | 0                  | 0               | 1            | 0                | 0                  | 0               | 0                | 1               | 0                | 0                | 0                | 0                | 0                | 0                |
| Aneurysm of sinus of Valsalva  | 0              | 0                | 0                  | 0               | 0            | 0                | 0                  | 0               | 0                | 0               | 0                | 0                | 0                | 0                | 0                | 0                |
| TOF                            | 19             | 0                | 0                  | 0               | 108          | 2 (1.9)          | 0                  | 3 (2.8)         | 0                | 108             | 2 (1.9)          | 0                | 3 (2.8)          | 0                | 3 (2.8)           | 0                |
| PA+VSD                         | 20             | 2 (10.0)         | 0                  | 0               | 95           | 2 (2.1)          | 0                  | 5 (5.3)         | 0                | 95              | 2 (2.1)          | 0                | 5 (5.3)          | 0                | 5 (5.3)           | 0                |
| Diagnosis                  | Cases | 30-Day Mortality | Hospital Mortality | After discharge |
|----------------------------|-------|------------------|-------------------|----------------|
| DORV                       | 46    | 0                | 0                 | 3 (6.5)        |
| TGA (simple)               | 6     | 0                | 0                 | 0              |
| + VSD                       | 12    | 0                | 0                 | 0              |
| VSD + PS                   | 0     | 0                | 0                 | 0              |
| Corrected TGA              | 7     | 0                | 0                 | 0              |
| Truncus arteriosus          | 18    | 1 (5.6)          | 0                 | 2 (11.1)       |
| SV                          | 50    | 2 (4.0)          | 0                 | 4 (8.0)        |
| TA                          | 23    | 0                | 0                 | 2 (8.7)        |
| HLHS                       | 66    | 4 (6.1)          | 0                 | 17 (25.8)      |
| Aortic valve lesion        | 8     | 1 (12.5)         | 0                 | 2 (25.0)       |
| Mitral valve lesion        | 3     | 1 (33.3)         | 0                 | 1 (33.3)       |
| Ebstein                    | 8     | 0                | 0                 | 4 (50.0)       |
| Coronary disease           | 1     | 0                | 0                 | 0              |
| Others                     | 13    | 1 (7.7)          | 0                 | 1 (7.7)        |
| Conduct failure            | 0     | 0                | 0                 | 3              |
| Redo (excluding conduit failure) | 16 | 1 (6.3)          | 0                 | 2 (1.2)        |
| Total                      | 932   | 32 (3.4)         | 0                 | 70 (7.5)       |

CPB: cardiopulmonary bypass; PDA: patent ductus arteriosus; VSD: ventricular septal defect; DORV: double-outlet right ventricle; AVSD: atrioventricular septal defect; TGA: transposition of the great arteries; SV: single ventricle; Interrupt. 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; DORV: double-outlet right ventricle; TA: tricuspid atresia; HLHS: hypoplastic left heart syndrome; RV-PA: right ventricle-pulmonary artery
| Main procedure | Neonate | | | Infant | 1-17 years | ≥ 18 years | Total | | | Hospital after discharge | Hospital mortality | 30-Day mortality | Hospital after discharge | Hospital mortality | 30-Day mortality | Hospital after discharge | Hospital mortality | 30-Day mortality | Hospital after discharge | Hospital mortality | 30-Day mortality | Hospital after discharge | Hospital mortality | 30-Day mortality |
|----------------|---------|---------|---------|---------|---------|---------|-------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| SP shunt       | 169     | 5 (3.0) | 0       | 12 (7.1) | 356     | 1 (0.3) | 0      | 6 (1.7) | 55      | 0       | 0       | 1       | 1.8     | 0       | 0       | 581     | 6 (1.0) | 0       | 19 (3.3) |
| PAIR           | 388     | 3 (1.0) | 0       | 14 (4.5) | 311     | 4 (1.3) | 0      | 9 (2.9) | 15      | 1 (0.6) | 0       | 1 (0.6) | 1.6     | 0       | 0       | 635     | 8 (1.3) | 0       | 24 (3.8) |
| Bidirectional Glenn or hemi-Fontan ± TOF | 1     | 0       | 0       | 0       | 240     | 0       | 0      | 3 (1.3) | 103     | 1 (1.0) | 0       | 1 (1.0) | 1.0     | 0       | 0       | 350     | 1 (0.3) | 0       | 4 (1.1)  |
| Damus-Kaye-Stansel operation | 3     | 1 (33.3) | 0       | 1 (33.3) | 21      | 1 (48) | 0      | 1 (4.8) | 4       | 0       | 0       | 0       | 0       | 0       | 2       | 2 (7.1) | 0       | 2 (7.1)  |
| PA reconstruction repair (including redo) | 19   | 1 (5.3) | 0       | 2 (10.5) | 190     | 4 (21) | 0      | 7 (3.7) | 180     | 1 (0.6) | 0       | 3 (1.7) | 1.7     | 0       | 0       | 406     | 6 (1.5) | 0       | 12 (3.0) |
| IVOT reconstruction repair | 6     | 0       | 0       | 0       | 200     | 1 (0.5) | 0      | 1 (0.5) | 338     | 1 (0.3) | 0       | 1 (0.3) | 0.3     | 0       | 0       | 563     | 2 (0.3) | 1 (0.2) | 3 (0.5)  |
| Rastelli procedure | 3     | 0       | 0       | 0       | 31      | 0       | 0      | 0       | 96      | 1 (10)  | 0       | 2 (2.1) | 5       | 0       | 0       | 135     | 1 (0.7) | 0       | 2 (1.5)  |
| Arterial switch procedure | 143  | 3 (2.1) | 0       | 7 (4.9) | 22      | 0       | 0      | 0       | 5       | 0       | 0       | 0       | 0       | 0       | 0       | 170     | 3 (1.8) | 0       | 7 (4.1)  |
| Atrial switch procedure | 0     | 0       | 0       | 0       | 1       | 0       | 0      | 0       | 7       | 1 (14.3) | 0       | 1 (14.3) | 0      | 0       | 0       | 8       | 1 (12.5) | 0       | 1 (12.5) |
| Double-switch procedure | 0     | 0       | 0       | 0       | 1       | 0       | 0      | 0       | 12      | 0       | 0       | 0       | 0       | 0       | 0       | 13       | 0       | 0       | 0       |
| Repair of anomalies origin of CA | 0     | 0       | 0       | 0       | 4       | 0       | 0      | 0       | 3       | 0       | 0       | 0       | 0       | 0       | 0       | 7       | 0       | 0       | 0       |
| Closure of coronary AV fistula | 3     | 0       | 0       | 0       | 1       | 0       | 0      | 0       | 6       | 0       | 0       | 0       | 0       | 0       | 2       | 0       | 0       | 0       | 0       |
| Fontan/TCPC | 0     | 0       | 0       | 0       | 1       | 0       | 0      | 0       | 40      | 2 (5.0) | 0       | 4 (10)  | 2       | 7 (7.4) | 0       | 2       | 7 (7.4) | 429     | 4 (9.9) | 0       | 6 (1.4)  |
| Norwood procedure | 34   | 5 (14.7) | 0       | 8 (23.5) | 70      | 1 (1.4) | 0      | 5 (7.1) | 4       | 0       | 0       | 0       | 0       | 0       | 0       | 108     | 6 (5.6) | 0       | 13 (12.0) |
| Ventricular septation | 0     | 0       | 0       | 0       | 0       | 0       | 0      | 0       | 1       | 0       | 0       | 0       | 0       | 0       | 0       | 1       | 0       | 0       | 0       |
| Left-side AV valve repair (including redo) | 0     | 0       | 0       | 0       | 46      | 0       | 0      | 1 (2.2) | 77      | 1 (1.3) | 0       | 2 (2.6) | 15      | 0       | 0       | 138     | 1 (0.7) | 0       | 3 (2.2)  |
| Left-side AV valve repair (including redo) | 19   | 6 (31.6) | 0       | 6 (31.6) | 82      | 1 (12)  | 0      | 2 (2.4) | 85      | 1 (12)  | 0       | 2 (2.4) | 72      | 0       | 0       | 258     | 8 (31)  | 0       | 10 (3.9) |
| Right-side AV valve repair (including redo) | 0     | 0       | 0       | 0       | 2       | 0       | 0      | 0       | 12      | 0       | 0       | 0       | 36      | 1 (28)  | 0       | 12 (28) | 50      | 1 (20)  | 0       | 1 (2.0)  |
| Common AV valve repair (including redo) | 4     | 1 (25.0) | 0       | 1 (25.0) | 20      | 2 (10.0) | 1 (5.0) | 3 (15.0) | 5       | 0       | 0       | 0       | 3       | 0       | 0       | 32       | 3 (9.4) | 1 (3.1) | 4 (12.5) |
| Common AV valve repair (including redo) | 0     | 0       | 0       | 0       | 4       | 0       | 0      | 0       | 8       | 0       | 0       | 1 (12.5) | 1       | 0       | 0       | 13       | 0       | 0       | 1 (7.7)  |
| Repair of supra-aortic stenosis | 0     | 0       | 0       | 0       | 10      | 0       | 0      | 1 (10.0) | 19      | 0       | 0       | 1 (5.3) | 2       | 0       | 0       | 31       | 0       | 0       | 2 (6.5)  |
| Repair of subaortic stenosis (including redo) | 1     | 0       | 0       | 0       | 6       | 0       | 0      | 0       | 32      | 0       | 0       | 0       | 1       | 0       | 0       | 40       | 0       | 0       | 0       |
| Aortic valve plasty ± VSD closure | 5     | 0       | 0       | 0       | 10      | 0       | 0      | 0       | 37      | 1 (27)  | 0       | 1 (27)  | 2       | 0       | 0       | 54       | 1 (19)  | 0       | 1 (19)  |
| Aortic valve replacement | 1     | 0       | 0       | 0       | 0       | 0       | 0      | 0       | 27      | 1 (37)  | 0       | 2 (7.4) | 30      | 0       | 0       | 58       | 1 (17)  | 0       | 2 (3.4)  |
| AVR with annular enlargement | 0     | 0       | 0       | 0       | 0       | 0       | 0      | 0       | 9       | 0       | 0       | 0       | 0       | 0       | 0       | 9       | 0       | 0       | 0       |
| Table 3 continued |
|-------------------|
|                  | Neonate | Infant | 1-17 years | ≥ 18 years | Total |
|                  | Cases   | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality |
|                  |         | After discharge |       | After discharge | |       | After discharge | |       | After discharge | |       | After discharge | |
| 27 Aortic root replace (except Ross) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 1 (14.3) | 0 | 1 (14.3) | 16 | 1 (6.3) | 0 | 1 (6.3) |
| 28 Ross procedure | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 20 | 0 | 0 | 0 |
| 29 Bilateral pulmonary artery banding | 143 | 9 (6.3) | 0 | 28 (19.6) | 9 | 0 | 0 | 1 (11.1) | 0 | 0 | 0 | 0 | 152 | 9 (5.9) | 0 | 29 (19.1) |
| Total | 863 | 34 (3.9) | 0 | 79 (9.2) | 1,649 | 15 (0.9) | 2 (0.1) | 42 (2.5) | 1,969 | 13 (0.8) | 0 | 24 (1.5) | 280 | 5 (1.8) | 0 | 5 (1.8) |

( ), % 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 valve aortic valve, VSD ventricular septal defect, AVR aortic valve replacement
| Value | Cases | Operation | Mechanical | Bioprosthesis | Repair | Unknown | WITH CABG | 30-Day mortality | Hospital mortality | Redo |
|-------|-------|-----------|------------|---------------|--------|---------|-----------|------------------|------------------|------|
|       |       |           |            |               |        |         |           |                   |                  | Cases | 30-Day mortality | Hospital mortality |
|       |       |           |            |               |        |         |           |                   |                  |                   |                  |
| Isolated A 10,690 | 1511 | 8508 | 293 | 381 | 2641 | 187 (1.9) | 4 (1.4) | 1 (0.01) | 0 | 308 (3.1) | 12 (4.1) | 0 | 35 (5.6) |
| M 4687 | 498 | 832 | 3264 | 93 | 593 | 52 (3.9) | 29 (0.9) | 2 (0.2) | 0 | 70 (5.3) | 39 (1.2) | 542 | 31 (5.7) | 2 (0.4) | 38 (7.0) |
| T 615 | 11 | 94 | 503 | 7 | 57 | 2 (1.9) | 15 (3.0) | 0 | 0 | 7 (6.7) | 32 (6.4) | 110 | 6 (5.5) | 0 | 12 (10.9) |
| P 32 | 2 | 21 | 7 | 2 | 2 | 0 | 0 | 0 | 0 | 1 (4.4) | 0 | 20 | 0 | 0 | 1 (5.0) |
| A+M 1415 | 247 | 68 (4.8) | 1 (0.1) | 0 | 112 (7.9) | 161 | 15 (9.3) | 0 | 18 (11.2) |
| A 1276 | 1030 | 57 | 52 &n| | |
| M 1084 | 736 | 37 &n| | |
| A+T 569 | 94 | 18 (3.2) | 0 | 29 (5.1) | 73 | 5 (6.9) | 0 | 5 (6.9) |
| A 185 | 446 | 13 | 25 &n| | |
| T 11 | 6 | 550 | 37 &n| | |
| M+T 3924 | 346 | 6 (1.6) | 1 (0.01) | 107 (27) | 421 | 12 (29) | 0 | 20 (48) |
| M 403 | 1033 | 2402 | 86 &n| | |
| T 3 | 35 | 3383 | 33 &n| | |
| A+M+T 1196 | 155 | 52 (4.4) | 0 | 84 (7.0) | 123 | 7 (5.7) | 0 | 15 (12.2) |
| A 217 | 880 | 42 | 47 &n| | |
| M 165 | 448 | 554 | 29 &n| | |
| T 0 | 8 | 1175 | 13 &n| | |
| Others 184 | 9 | 34 | 4 | 137 | 21 | 3 (3.8) | 0 | 10 (5.4) | 39 | 3 (7.7) | 0 | 4 (10.3) |
| Total 23,312 | 4156 | 51 (2.2) | 5 (0.02) | 837 (36) | 2116 | 100 (4.7) | 2 (0.1) | 148 (7.0) |

| TAVR | Cases | 30-Day mortality |
|------|-------|------------------|
|      | 4632  | 55 (1.2)         |
Table 4 (continued)

(2) Ischemic heart disease (total, (A)+(B): 13,898)

|                  | Primary, elective | Primary, emergent | Redo, elective | Redo, emergent | Artery only | Artery +SVG | SVG only | Others | Unclear |
|------------------|-------------------|-------------------|----------------|----------------|-------------|------------|----------|--------|---------|
| Cases            |                   |                   |                |                |             |            |          |        |         |
|                  |                   |                   |                |                |             |            |          |        |         |
| 1VD              |                   |                   |                |                |             |            |          |        |         |
|                  |                   |                   |                |                |             |            |          |        |         |
| 2VD              |                   |                   |                |                |             |            |          |        |         |
| 3VD              |                   |                   |                |                |             |            |          |        |         |
| LMT              |                   |                   |                |                |             |            |          |        |         |
| No info          |                   |                   |                |                |             |            |          |        |         |
| Total            |                   |                   |                |                |             |            |          |        |         |
| Kawasaki         |                   |                   |                |                |             |            |          |        |         |
| On dialysis      |                   |                   |                |                |             |            |          |        |         |
| 1VD              |                   |                   |                |                |             |            |          |        |         |
| 2VD              |                   |                   |                |                |             |            |          |        |         |
| 3VD              |                   |                   |                |                |             |            |          |        |         |
| LMT              |                   |                   |                |                |             |            |          |        |         |
| No info          |                   |                   |                |                |             |            |          |        |         |
| Total            |                   |                   |                |                |             |            |          |        |         |
| Kawasaki         |                   |                   |                |                |             |            |          |        |         |
| On dialysis      |                   |                   |                |                |             |            |          |        |         |

(1), % mortality

LMT includes LMT alone or LMT with other branch diseases

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

(a-1) On-pump arrest CABG (total: 2875)

|                  | Primary, elective | Primary, emergent | Redo, elective | Redo, emergent | Artery only | Artery +SVG | SVG only | Others | Unclear |
|------------------|-------------------|-------------------|----------------|----------------|-------------|------------|----------|--------|---------|
| Cases            |                   |                   |                |                |             |            |          |        |         |
|                  |                   |                   |                |                |             |            |          |        |         |
| 1VD              |                   |                   |                |                |             |            |          |        |         |
|                  |                   |                   |                |                |             |            |          |        |         |
| 2VD              |                   |                   |                |                |             |            |          |        |         |
| 3VD              |                   |                   |                |                |             |            |          |        |         |
| LMT              |                   |                   |                |                |             |            |          |        |         |
| No info          |                   |                   |                |                |             |            |          |        |         |
| Total            |                   |                   |                |                |             |            |          |        |         |
| Kawasaki         |                   |                   |                |                |             |            |          |        |         |
| On dialysis      |                   |                   |                |                |             |            |          |        |         |
| 1VD              |                   |                   |                |                |             |            |          |        |         |
| 2VD              |                   |                   |                |                |             |            |          |        |         |
| 3VD              |                   |                   |                |                |             |            |          |        |         |
| LMT              |                   |                   |                |                |             |            |          |        |         |
| No info          |                   |                   |                |                |             |            |          |        |         |
| Total            |                   |                   |                |                |             |            |          |        |         |
| Kawasaki         |                   |                   |                |                |             |            |          |        |         |
| On dialysis      |                   |                   |                |                |             |            |          |        |         |

(1), % mortality

LMT includes LMT alone or LMT with other branch diseases

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

(a-2) On-pump beating CABG (total: 2323)

|                  | Primary, elective | Primary, emergent | Redo, elective | Redo, emergent | Artery only | Artery +SVG | SVG only | Others | Unclear |
|------------------|-------------------|-------------------|----------------|----------------|-------------|------------|----------|--------|---------|
| Cases            |                   |                   |                |                |             |            |          |        |         |
|                  |                   |                   |                |                |             |            |          |        |         |
| 1VD              |                   |                   |                |                |             |            |          |        |         |
|                  |                   |                   |                |                |             |            |          |        |         |
| 2VD              |                   |                   |                |                |             |            |          |        |         |
| 3VD              |                   |                   |                |                |             |            |          |        |         |
| LMT              |                   |                   |                |                |             |            |          |        |         |
| No info          |                   |                   |                |                |             |            |          |        |         |
| Total            |                   |                   |                |                |             |            |          |        |         |
| Kawasaki         |                   |                   |                |                |             |            |          |        |         |
| On dialysis      |                   |                   |                |                |             |            |          |        |         |

(1), % mortality

LMT includes LMT alone or LMT with other branch diseases

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

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(b) Off-pump CABG (total: 7,431)

(Including 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)

| Artery | Primary, elective | Primary, emergent | Redo, elective | Redo, emergent | Artery only | Artery +SVG | SVG only | Others | Unclear |
|--------|-------------------|-------------------|----------------|----------------|-------------|------------|---------|--------|---------|
|        | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality |
|        | 1VD | 347 | 1 (0.3) | 0 | 4 (1.2) | 45 | 1 (2.2) | 0 | 1 (2.2) | 7 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 284 | 79 | 33 | 0 | 4 |
|        | 2VD | 948 | 1 (0.1) | 0 | 1 (0.1) | 117 | 4 (3.4) | 0 | 5 (4.3) | 11 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 364 | 666 | 38 | 2 | 7 |
|        | 3VD | 2341 | 19 (0.8) | 1 (0.0) | 35 (1.5) | 301 | 7 (2.3) | 0 | 10 (3.3) | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 598 | 1978 | 60 | 12 | 10 |
|        | LMT | 2394 | 26 (1.1) | 0 | 38 (1.6) | 622 | 21 (3.4) | 0 | 27 (4.3) | 27 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 913 | 2031 | 91 | 6 | 10 |
| no info | 185 | 1 (0.5) | 0 | 2 (1.1) | 40 | 2 (4.1) | 0 | 2 (4.1) | 7 | 0 | 0 | 0 | 4 | 1 (25.0) | 0 | 1 (25.0) | 84 | 142 | 13 | 2 | 4 |
| Total | 6215 | 48 (0.8) | 2 (0.0) | 83 (1.3) | 1134 | 35 (3.1) | 0 | 45 (4.0) | 66 | 0 | 0 | 0 | 1 | 16 | 1 (6.3) | 0 | 1 (6.3) | 2243 | 4896 | 235 | 22 | 35 |
| Kawasaki | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 0 | 0 | 0 |
| On dialysis | 725 | 15 (2.1) | 1 (0.1) | 34 (4.7) | 123 | 9 (7.3) | 0 | 11 (8.9) | 9 | 0 | 0 | 0 | 4 | 1 (25.0) | 0 | 1 (25.0) | 202 | 618 | 33 | 3 | 5 |

( ), % mortality

LMT includes LMT alone or LMT with other branch diseases.

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.

(c) Cases of conversion, during surgery, from off-pump CABG to on-pump CABG or on-pump beating-heart CABG (these cases are also included in category (b))

| Artery | Primary, elective | Primary, emergent | Redo, elective | Redo, emergent |
|--------|-------------------|-------------------|----------------|----------------|
|        | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality |
|        | Convened to arrest | 34 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|        | Convened to beating | 131 | 5 (3.8) | 0 | 9 (69) | 45 | 6 (13.3) | 0 | 6 (13.3) | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
|        | Total | 165 | 5 (3.0) | 0 | 9 (55) | 51 | 6 (11.8) | 0 | 6 (11.8) | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
|        | On dialysis | 31 | 1 (3.2) | 0 | 3 (97) | 9 | 4 (44.4) | 0 | 4 (44.4) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

( ), % mortality

CABG coronary artery bypass grafting.
Table 4 (continued)

| (B) Operation for complications of MI (total: 1269) |
|--------------------------------------------------|
| Chronic Acute Concomitant operation              |
| Cases 30-Day mortality Hospital mortality        |
| Hospital After discharge                         |
|  | Infarctectomy or aneurysmectomy 122 7 (5.7) 0 8 (6.6) 24 5 (20.8) 0 7 (29.2) 87 22 10 |
|  | VSP closure 66 10 (15.2) 0 13 (19.7) 24 60 (24.8) 0 81 (33.5) 86 23 |
|  | Cardiac rupture 28 7 (25.0) 1 (3.6) 10 (35.7) 221 64 (29.0) 0 86 (38.9) 35 2 5 |
|  | Mitral regurgitation 1) Papillary muscle rupture 21 1 (4.8) 0 1 (4.8) 47 14 (29.8) 0 17 (36.2) 28 15 53 |
|  | 2) Ischemic 295 15 (5.1) 0 29 (9.8) 36 10 (27.8) 1 (2.8) 14 (38.9) 235 198 138 |
|  | Others 80 3 (3.8) 0 4 (5.0) 87 20 (23.0) 0 30 (34.5) 38 10 6 |
| Total 612 43 (7.0) 1 (0.2) 65 (10.6) 657 173 (26.3) 1 (0.2) 235 (35.8) 529 244 215 |

( ), % 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

| (3) Operation for arrhythmia (total: 5066) |
|------------------------------------------|
| Cases 30-Day mortality Hospital mortality Concomitant operation |
| Hospital After discharge Isolated Congenital Valve IHD Others Multiple combination 2 categories 3 categories |
| Maze 3286 52 (1.6) 1 (0.03) 89 (2.7) 120 185 2844 561 257 627 46 |
| For WPW 4 0 0 0 0 1 3 0 0 1 0 |
| For ventricular tachyarrhythmia 35 2 (5.7) 0 3 (8.6) 2 1 10 18 5 7 1 |
| Others 1741 34 (2.0) 3 (0.17) 52 (3.0) 31 124 1512 324 145 370 24 |
| Total 5066 88 (1.7) 4 (0.08) 144 (2.8) 153 311 4369 903 407 1005 71 |

( ), % mortality
Except for 153 isolated cases, all remaining 4913 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; 216)

| CPB (+) | CPB (-) |
|------------------|------------------|
| Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality |
| | Hospital | After discharge | | Hospital | After discharge |
| Total | 116 | 9 (7.8) | 0 | 17 (14.7) | 100 | 2 (2.0) | 0 | 9 (9.0) |

( ), % mortality
CPB cardiopulmonary bypass

(5) Cardiac tumor (total; 622)

| | Cases | 30-Day mortality | Hospital mortality | Concomitant operation |
|------------------|------------------|------------------|------------------|------------------|
| | Hospital | After discharge | Hospital | | AVR | MVR | CABG | others |
| Benign tumor | 548 | 6 (1.1) | 0 | 11 (2.0) | 19 | 15 | 47 | 112 |
| (Cardiac myxoma) | 385 | 6 (1.6) | 0 | 9 (2.3) | 6 | 6 | 26 | 61 |
| Malignant tumor | 74 | 2 (2.7) | 0 | 5 (6.8) | 1 | 3 | 2 | 18 |
| (Primary) | 9 | 0 | 0 | 0 | 1 | 1 | 1 | 4 |

( ), % mortality
AVR aortic valve replacement, MVR mitral valve replacement, CABG coronary artery bypass grafting

(6) HOCM and DCM (total; 302)

| | Cases | 30-Day mortality | Hospital mortality | Concomitant operation |
|------------------|------------------|------------------|------------------|------------------|
| | Hospital | After discharge | Hospital | | AVR | MVR | MVP | CABG |
| Myectomy | 138 | 2 (1.4) | 0 | 4 (2.9) | 63 | 20 | 17 | 12 |
| Myotomy | 11 | 0 | 0 | 0 | 2 | 0 | 3 | 1 |
| No resection | 144 | 8 (5.6) | 0 | 12 (8.3) | 30 | 70 | 74 | 13 |
| Volume reduction surgery of the left ventricle | 9 | 1 (11.1) | 0 | 2 (22.2) | 0 | 2 | 4 | 1 |
| Total | 302 | 11 (3.6) | 0 | 18 (6.0) | 95 | 92 | 98 | 27 |

( ), % 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
respectively. Data for individual categories are summarized in Tables 3, 4, 5, 6, 7, and 8.

In 2017, among 9368 procedures for congenital heart disease, 7072 open-heart surgeries were performed with an overall hospital mortality of 1.9%. Compared with data for 2007, the number of surgeries for neonates and infants has not changed significantly; however, hospital mortality decreased significantly from 13.7 to 7.7% for neonates and from 3.9 to 2.0% for infants. In 2017, atrial septal defect was once again the most common disease (1418 cases) for the first time in 3 years. This was primarily due to a doubling in the number of surgeries for patients above the age of 18 years (from 372 to 761 cases). Ventricular septal defect (perimemb/muscular) was the second most common health issue (1092 cases) and had previously been the most common disease in 2015 and 2016. In the past 10 years, hospital mortality for complex congenital heart disease was as follows (2007 [2], 2012 [3], and 2017): complete atrioventricular septal defect (4.3%, 3.2%, and 2.7%, respectively), tetralogy of Fallot (1.4%, 1.1%, and 0.9%, respectively), transposition of the great arteries with intact septum (2.7%, 2.6%, and 4.5%, respectively) and with ventricular septal defect (5.6%, 3.2%, and 1.5%, respectively), and single ventricle (5.4%, 5.5%, and 2.2%, respectively) and hypoplastic left heart syndrome (20.1%, 10.2%, and 8.8%, respectively). Right heart bypass surgery is now commonly performed (350 bidirectional Glenn procedures excluding 28 Damus–Kaye–Stansel procedures and 429 Fontan type procedures including total cavopulmonary connection) at an acceptable hospital mortality rate (1.1% and 1.4%). The Norwood type I procedure was performed in 108 cases, with a relatively low hospital mortality rate of 12.0% (Table 9).

The total number of procedures for valvular heart disease is increasing. The number of isolated aortic valve replacement/repair with/without coronary artery bypass grafting (CABG) \((n=10,690)\) increased by 12.9% from the previous year \((n=9472)\) and by 10.3% from 5 years ago \((n=9688)\), despite the rapid spread of transcatheter aortic valve replacement \((n=4632\) in 2017). On the other hand, the number of isolated mitral valve replacement/repair with/without CABG \((n=4687)\) remained stable, with a 2.4% increase from the previous year \((n=4576)\) and a 1.5% increase from 5 years ago \((n=4617)\). Aortic and mitral valve replacements with bioprostheses procedures were performed in 10,871 cases and 2747 cases, respectively. The ratio for employing bioprostheses increased dramatically from the 30% level in the early 2000s [4, 5] and was 83.9% and 68.7% in the aortic and mitral positions, respectively, in 2017. Additionally, CABG was performed as a concomitant procedure in 17.8% for all valvular procedures (15.7% in 2007 [2] and 18.2% in 2012 [3]). Repair of the valve was a popular procedure in mitral and tricuspid
Table 5 Thoracic aortic aneurysm (total; 20,746) (1) Dissection (total; 10,086)

| Location          | Stanford A | Stanford B | Cases | Hospital mortality | 30-Day mortality | Hospital mortality | Cases | Hospital mortality | 30-Day mortality | Hospital mortality | Cases | Hospital mortality | 30-Day mortality | Hospital mortality | Cases |
|-------------------|------------|------------|-------|--------------------|------------------|--------------------|-------|--------------------|------------------|--------------------|-------|--------------------|------------------|--------------------|-------|
| Ascending Ao.     | 2328       | 206 (8.8)  | 2 (0.1) | 2.55 (11.0)        | 3                | 1 (33.3)           | 0     | 1 (33.3)           | 0                | 1 (33.3)           | 225   | 5 (2.2)            | 0                | 12 (5.3)           | 8     |
| Aortic Root       | 229        | 39 (17.0)  | 0      | 47 (20.5)          | 2                | 0 (0.0)            | 0     | 0                  | 0                | 0                  | 86    | 6 (7.0)            | 0                | 7 (8.1)            | 7     |
| Arch              | 2038       | 156 (7.7)  | 3 (0.1) | 192 (9.4)          | 35               | 1 (2.9)            | 0     | 1 (2.9)            | 0                | 0                  | 371   | 14 (38.3)          | 0                | 17 (46.6)          | 173   |
| Aortic root + acc. Ao. + Arch | 199 | 22 (11.1)  | 0      | 25 (12.6)          | 3                | 0 (0.0)            | 0     | 0 (0.0)            | 0                | 0                  | 50    | 2 (4.0)            | 0                | 4 (8.0)            | 10    |
| Descending Ao.    | 56         | 6 (10.7)   | 0      | 9 (16.1)           | 37               | 5 (13.5)           | 0     | 6 (16.2)           | 75               | 4 (5.3)            | 267   | 5 (19)             | 1 (6.4)           | 10 (3.7)           | 3     |
| Thoracoabdominal  | 10         | 0          | 0      | 1 (10.0)           | 11               | 1 (9.1)            | 0     | 1 (9.1)            | 49               | 3 (6.1)            | 222   | 8 (36)             | 0                | 15 (6.8)           | 0     |
| TEVAR without BR  | 75         | 12 (16.0)  | 0      | 15 (20.0)          | 318              | 26 (8.2)           | 2 (0.6)| 32 (10.1)          | 175              | 3 (1.7)            | 919   | 10 (1.1)           | 1 (0.1)           | 14 (1.5)           | 0     |
| Open stent graft with/without BR | 1035 | 98 (9.5)   | 0      | 118 (11.4)         | 71               | 12 (16.9)          | 0     | 12 (16.9)          | 222              | 12 (5.4)           | 256   | 6 (23)             | 0                | 10 (3.9)           | 48    |
| Arch TEVAR with BR| 15         | 4 (26.7)   | 0      | 5 (33.3)           | 77               | 7 (9.1)            | 0     | 7 (9.1)            | 66               | 1 (1.5)            | 324   | 4 (12)             | 2 (6.6)           | 6 (19)            | 0     |
| Thoracoabdominal TEVAR with BR | 2 | 1 (50.0)   | 0      | 1 (50.0)           | 1                | 0 (0.0)            | 0     | 0                  | 1                | 0                  | 12    | 1 (25.0)           | 0                | 1 (25.0)           | 0     |
| Other             | 8          | 1 (12.5)   | 0      | 2 (25.0)           | 5                | 2 (40.0)           | 0     | 2 (40.0)           | 3                | 0                  | 13    | 1 (77)             | 0                | 1 (77)            | 0     |
| 5995              | 545 (9.1)  | 5 (0.1)    | 670 (11.2)| 563          | 55 (9.8)           | 2 (0.4)           | 62 (11.0)| 1323             | 50 (38)           | 0                  | 67    | 5 (7.5)            | 2205             | 42 (1.9)           | 4 (2)  |

(1), % 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, BR, branch reconstruction
Table 5 (continued)  
(2) Non-dissection (total: 10,660)

|                  | Unruptured |                  |                  |                  |                  |                  |                  |                  |                  |
|------------------|------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                  | Cases      | 30-Day mortality | Hospital mortality | Hospital mortality | Cases      | 30-Day mortality | Hospital mortality | Hospital mortality |                  |
|                  |            |                  | Hospital          | After discharge   |            |                  | Hospital          | After discharge   |                  |
| 1 Ascending Ao.  | 1406       | 35 (2.5)         | 0                 | 54 (3.8)         | 52         | 6 (11.5)         | 0                 | 11 (21.2)        | 81               |
| 2 Aortic root    | 1066       | 35 (3.3)         | 0                 | 50 (4.7)         | 36         | 4 (11.1)         | 0                 | 7 (19.4)         | 394              |
| 3 Arch           | 2193       | 65 (3.0)         | 2 (0.1)           | 104 (4.7)        | 97         | 16 (16.5)        | 1 (0.1)           | 18 (18.6)        | 48               |
| 4 Aortic root + a. Ao + Arch | 206 | 6 (2.3)    | 0                 | 9 (3.4)         | 8          | 1 (12.5)         | 0                 | 3 (37.5)         | 32               |
| 5 Descending Ao. | 264        | 7 (2.7)          | 1 (0.4)           | 14 (5.3)         | 40         | 6 (15.0)         | 1 (2.5)           | 8 (20.0)         | 0                |
| 6 Thoracoabdominal | 305       | 22 (7.0)         | 0                 | 35 (9.0)         | 36         | 8 (22.2)         | 0                 | 9 (25.0)         | 0                |
| 7d TEVAR without BR | 1970    | 26 (1.4)         | 1 (0.1)           | 46 (2.4)         | 281        | 49 (17.4)        | 2 (0.7)           | 59 (21.0)        | 0                |
| 7c Arch TEVAR with BR | 940 | 20 (2.1)  | 2 (0.2)           | 35 (3.7)         | 78         | 12 (15.4)        | 0                 | 19 (24.4)        | 0                |
| 7d Thoracoabdominal TEVAR with BR | 19 | 1 (5.0)  | 0                 | 1 (5.0)         | 4          | 1 (25.0)        | 0                 | 1 (25.0)        | 0                |
| 9 Other          | 158        | 8 (5.1)          | 0                 | 9 (5.7)         | 22         | 5 (22.7)         | 0                 | 6 (27.3)         | 2                |
|                  | 9009       | 273 (2.8)        | 6 (0.1)           | 422 (4.3)        | 751        | 131 (17.4)       | 5 (0.7)           | 169 (22.5)       | 479              |
|                  |            |                  |                  |                  |            |                  |                  |                  |                  |
|                  |            | 273 (2.8)        | 6 (0.1)           | 422 (4.3)        | 751        | 131 (17.4)       | 5 (0.7)           | 169 (22.5)       | 479              |
|                  |            |                  |                  |                  |            |                  |                  |                  |                  |
|                  |            |                  |                  |                  |            |                  |                  |                  |                  |
|                  |            |                  |                  |                  |            |                  |                  |                  |                  |

1. % 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, TBR thoracoabdominal branch reconstruction, SABR supra-aortic branch reconstruction.
valve positions (6976 cases in the mitral and 6061 cases in the tricuspid) but is less frequently observed in aortic valve positions (405 patients, only 2.7% of all aortic valve procedures). Mitral valve repair constituted 29.9% of all valvular operations and 62.2% of all mitral valve procedures. Hospital mortality for single valve replacement was 3.1% and 5.3% for the aortic and mitral positions, respectively, whereas for mitral valve repair, this was only 1.2%. The hospital mortality for redo valve surgery was 3.4% and 5.7% in the aortic and mitral positions, respectively. Finally, overall hospital mortality did not show dramatic improvement during the past 10 years (3.8% in 2007, 3.2% in 2012, and 3.6% in 2017).

Isolated CABG was performed in 12,629 cases, representing only 73.0% of the number performed 10 years ago (n=17,295). Among these, off-pump CABG was intended in 7431 cases (58.8%) at a success rate of 97.1%. The percentage of intended off-pump CABG in 2017 was less than 60% for the first time in 13 years, since 2004.

Hospital mortality associated with primary elective CABG procedures in 10,283 cases was 1.6%, unchanged from 2003 (1.5%). Hospital mortality for primary emergency CABG in 2211 cases was still as high as 7.1%. The result of conversion from off-pump CABG was 2.9%, and hospital mortality in this context was 6.9%. Hospital mortality was higher in patients with end-stage renal failure on dialysis, regardless of surgical procedures (on-pump arrest, on-pump beating, and off-pump). In this report, the number of concomitant CABGs alongside other major procedures was not included in the category of ischemic heart disease but in other categories such as valvular heart disease and thoracic aortic aneurysm. Accordingly, the overall number of CABGs, including concomitant CABG with other major procedures, remained more than 18,000 cases per year in 2017.

Measures for arrhythmia were performed primarily as concomitant procedures in 5066 cases, with hospital mortality of 2.8%. Implantation of pacemaker and implantable cardioverter–defibrillator was not included in this category.

Table 6: Pulmonary thromboembolism (total; 174)

| Cases | 30-Day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  |                    |
|       |                  | Hospital | After discharge |
| Acute | 101              | 11 (10.9) | 0              | 12 (11.9) |
| Chronic | 73               | 3 (4.1)  | 0              | 7 (9.6)   |
| Total | 174              | 14 (8.0) | 0              | 19 (10.9) |

(), % mortality

Table 7: Implantation of VAD (total; 172)

| Cases | 30-Day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  |                    |
|       |                  | Hospital | After discharge |
| Implantation of VAD | 172        | 5 (2.9)  | 7 (4.1)         |

(), mortality %

VAD ventricular assist device

Table 8: Heart transplantation (total; 56)

| Cases | 30-Day mortality | Hospital mortality |
|-------|------------------|--------------------|
|       |                  |                    |
|       |                  | Hospital | After discharge |
| Heart transplantation | 56         | 1 (1.8)  | 0              | 1 (1.8) |
| Heart and lung transplantation | 0        | 0          | 0              | 0        |
| Total | 56               | 1 (1.8)  | 0              | 1 (1.8) |

(), mortality %

In 2017, 20,746 procedures were performed for thoracic and thoracoabdominal aortic diseases; 10,086 and 10,660 were for aortic dissection and non-dissection, respectively. The number of surgeries for aortic dissection increased by 6.9% this year, compared with that in the preceding year (n=9441). The hospital mortality of procedures for Stanford type A acute aortic dissections remained as high as 11.2%. The number of procedures for non-dissected aneurysm increased by 10.6%, with overall hospital mortality of 5.5%, and 4.3% and 22.5% for unruptured and ruptured aneurysms, respectively. The rate of thoracic endovascular aortic repair (TEVAR) among all operative
procedures for aortic diseases is increasing. A total of 3563 patients with aortic dissection underwent stent graft placement: 1969 TEVARs and 1594 open stent graftings, respectively. The number of TEVARs for type B chronic aortic dissections was 1505 cases and accounted for 68.3% of total cases. The hospital mortality rates associated with TEVAR for type B aortic dissection were 11.0% and 3.1% in acute and chronic cases, respectively. A total of 4656 patients with non-dissected aortic aneurysm underwent stent graft placement, comprising 3269 TEVARs (a 6.7% increase compared with that in 2016, \( n = 3063 \)) and 1387 open stent graftings (a 16.2% increase compared with that in 2016, \( n = 1194 \)). The hospital mortality rates for TEVARs and open stenting were as follows: TEVAR, 2.8% and 21.7% for unruptured and ruptured aneurysms, respectively, and open stent grafting, 5.1% and 28.7% for unruptured and ruptured aneurysms, respectively.

**Table 9** Total cases of general thoracic surgery during 2017

| Diagnosis                                             | Cases | %  |
|-------------------------------------------------------|-------|----|
| Benign pulmonary tumor                                | 2197  | 2.6|
| Primary lung cancer                                   | 44,140| 51.7|
| Other primary malignant pulmonary tumor               | 423   | 0.5|
| Metastatic pulmonary tumor                            | 8950  | 10.5|
| Tracheal tumor                                        | 120   | 0.1|
| Mesothelioma                                          | 698   | 0.8|
| Chest wall tumor                                      | 691   | 0.8|
| Mediastinal tumor                                     | 5197  | 6.1|
| Thymectomy for MG without thymoma                     | 189   | 0.2|
| Inflammatory pulmonary disease                         | 2423  | 2.8|
| Empyema                                               | 2962  | 3.5|
| Bullous disease excluding pneumothorax                | 400   | 0.5|
| Pneumothorax                                          | 14,499| 17.0|
| Chest wall deformity                                  | 193   | 0.2|
| Diaphragmatic hernia including traumatic              | 28    | 0.0|
| Chest trauma excluding diaphragmatic hernia           | 443   | 0.5|
| Lung transplantation                                  | 68    | 0.1|
| Others                                                | 1686  | 2.0|
| Total                                                 | 85,307| 100.0|

(B) General thoracic surgery

The 2017 survey of general thoracic surgery comprised 678 surgical units, with the bulk of data submitted via a web-based collection system of the NCD [1]. In total, 85,307 procedures were reported by general thoracic surgery departments in 2017, twice the number of operations in 2000 and 12,560 more than in 2012 (Fig. 2).

In 2017, 44,140 procedures for primary lung cancer were performed, a number that has increased annually. The 2017 value was 2.4 times that of 2000. Procedures for lung cancer represented 52% of all general thoracic surgery instances.

The number of video-assisted thoracoscopic surgery (VATS) instances, defined by a surgical procedure utilizing a skin incision longer than 8 cm and/or a minithoracotomy (hybrid) approach, has been noted since the 2015 annual report. The number of VATS procedures for benign pulmonary tumors and primary lung cancer, and the total number of VATS procedures in 2016 are shown in Tables 10, 11, 13, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, and 27, respectively.

In 2017, 2197 procedures were conducted for benign pulmonary tumors (Table 10), a similar number to that recorded in 2016. Hamartoma was the most frequent diagnosis in procedures for benign pulmonary tumors. VATS was performed for 2071 patients (94%).

Additional information on primary malignant pulmonary tumors is shown in Tables 11 and 12. With regard to lung cancer sub-type, adenocarcinoma was by far the most frequent diagnosis (71% of all lung cancer procedures), followed by squamous cell carcinoma (18%). Sublobar resection was performed in 11,784 lung cancer cases (27% of all cases) and lobectomy in 31,584 cases (72% of
Sleeve lobectomy was performed in 496 cases, and pneumonectomy was required in 403 cases (0.9% of all cases). VATS lobectomy for lung cancer was performed in 21,992 cases (70% of all lobectomy cases). The number of VATS procedures for primary lung cancer was slightly higher in 2017 than that in 2016. The number of the patients aged 80 years or older who underwent lung cancer surgery was 5779 (13%). In total, 121 patients died prior to hospital discharge within 30 days following surgery, and 32 patients died following discharge within 30 days after surgery. Therefore, 153 patients died within 30 days after surgery (30-day mortality rate 0.3%). In total, 247 patients died prior to discharge (hospital mortality rate 0.6%), and the 30-day mortality rate, according to procedure, was 0.2% for segmentectomy, 0.3% for lobectomy, and 2% for pneumonectomy. Interstitial pneumonia was the leading cause of death following lung cancer surgery, followed by pneumonia, respiratory failure, and cardiovascular events.

Table 10 Benign pulmonary tumor

| Benign pulmonary tumor          | Cases | 30-Day mortality | Hospital | After discharge | VATS |
|---------------------------------|-------|------------------|----------|-----------------|------|
| Hamartoma                       | 518   | 0                | 0        | 0               | 498  |
| Sclerosing hemangioma           | 76    | 0                | 0        | 0               | 73   |
| Papilloma                       | 23    | 0                | 0        | 0               | 21   |
| Mucous gland adenoma bronchial  | 2     | 0                | 0        | 0               | 2    |
| Fibroma                         | 132   | 0                | 0        | 0               | 129  |
| Lipoma                          | 4     | 0                | 0        | 0               | 4    |
| Neurogenic tumor                | 21    | 0                | 0        | 0               | 17   |
| Clear cell tumor                | 3     | 0                | 0        | 0               | 3    |
| Leiomyoma                       | 18    | 0                | 0        | 0               | 17   |
| Chondroma                       | 7     | 0                | 0        | 0               | 7    |
| Inflammatory myofibroblastic tumor | 5   | 0                | 0        | 0               | 5    |
| Pseudolymphoma                  | 19    | 0                | 0        | 0               | 17   |
| Histiocytosis                   | 13    | 0                | 0        | 0               | 12   |
| Teratoma                        | 6     | 0                | 0        | 0               | 2    |
| Others                          | 1350  | 2 (0.1)          | 2 (0.1)  | 5 (0.4)         | 1264 |
| Total                           | 2197  | 2 (0.1)          | 2 (0.09) | 5 (0.2)         | 2071 |

(1), mortality %

Table 11 Primary malignant pulmonary tumor

| Primary malignant pulmonary tumor | Cases | 30-Day mortality | Hospital | After discharge | VATS |
|-----------------------------------|-------|------------------|----------|-----------------|------|
| Lung cancer                       | 44,563| 122 (0.3)        | 32 (0.1) | 247 (0.6)       | 32.206 |
| Adenocarcinoma                    | 44,140| 121 (0.3)        | 31 (0.1) | 244 (0.6)       | 32.206 |
| Squamous cell carcinoma           | 31,119| 52 (0.2)         | 15 (0.0) | 91 (0.3)        |       |
| Large cell carcinoma              | 8132  | 56 (0.7)         | 14 (0.2) | 121 (1.5)       |       |
| LCNEC                             | 301   | 1 (0.3)          | 1 (0.3)  | 4 (1.3)         |       |
| Small cell carcinoma              | 601   | 3 (0.5)          | 0        | 4 (0.7)         |       |
| Adenosquamous carcinoma           | 823   | 2 (0.2)          | 0        | 4 (0.5)         |       |
| Carcinoma with pleomorphic, sarcomatoid or sarcomatous elements | 493 | 2 (0.4) | 0 | 9 (1.8) | |
| Carcinoid                         | 233   | 0                | 0        | 0               |       |
| Carcinomas of salivary-gland type | 38    | 0                | 0        | 1 (2.6)         |       |
| Unclassified                      | 43    | 0                | 0        | 0               |       |
| Multiple lung cancer              | 1464  | 3 (0.2)          | 1 (0)    | 6 (0.4)         |       |
| Others                            | 322   | 1 (0.3)          | 0        | 2 (0.6)         |       |
| Wedge resection                   | 7099  | 14 (0.2)         | 8 (0.1)  | 28 (0.4)        | 6299  |
| Segmental excision                | 4685  | 9 (0.19)         | 2 (0.0)  | 16 (0.3)        | 3698  |
| (Sleeve segmental excision)       | 14    | 0                | 0        | 3               |       |
| Lobectomy                         | 31,584| 85 (0.3)         | 18 (0.1) | 179 (0.6)       | 21,992|
| (Sleeve lobectomy)                | 496   | 1 (0.2)          | 2 (0.4)  | 2 (0.4)         | 71    |
| Pneumonectomy                     | 403   | 8 (2.0)          | 1 (0.2)  | 15 (3.7)        | 33    |
| (Sleeve pneumonectomy)            | 10    | 2 (20.0)         | 0        | 2 (20.0)        | 2     |
| Other bronchopneumectomy          | 33    | 0                | 0        | 0               | 4     |
| Pleuropneumonectomy               | 1     | 0                | 0        | 0               | 0     |
| Others                            | 335   | 5 (1.5)          | 2 (0.6)  | 6 (1.8)         | 180   |
| Unknown                           | 0     | 0                | 0        | 0               |       |
| Sarcoma                           | 56    | 1 (1.8)          | 1 (1.8)  | 1 (1.8)         |       |
| AAH                               | 117   | 0                | 0        | 0               |       |
| Others                            | 250   | 0                | 0        | 2 (0.8)         |       |

(1), mortality %

There were 46 procedures for malignant tracheal tumor in 2017; however, 21 patients were treated with sleeve resection and reconstruction (Table 14).

Pleural tumors numbered 698 in 2017 (Table 15). Diffuse malignant pleural mesothelioma was the most frequent histologic diagnosis. Total pleurectomy was performed in 104 cases and extrapleural pneumonectomy in 65 cases. The 30-day mortality rate was 0% following total pleurectomy and 2% after extrapleural pneumonectomy, both representing better outcomes than before.

In total, 691 chest wall tumors were resected in 2017 (Table 16), 362 (52%) of which were benign. Among the 329 malignant chest wall tumors, 189 (57%) were metastatic tumors.
Mediastinal tumors were resected in 5197 patients in 2017, a slight increase from the previous year (Table 17). Thymic epithelial tumor—including 1939 thymomas, 368 thymic carcinomas, and 39 thymic carcinoids—was the most frequent mediastinal tumor type in 2017.

Thymectomy for myasthenia gravis was performed in 508 patients (Table 18); 319 procedures were associated with thymoma, and the remaining was not associated with thymoma.

Procedures for non-neoplastic disease were performed for 22,634 patients. There were 2423 cases of lung resection for inflammatory lung diseases (Table 19), 20% of which were associated with atypical mycobacterium infections and 15% with fungal infections. Procedures for inflammatory nodules were performed in cases where lung cancer was suspected prior to surgery (in 918 cases, 38%).

The 2962 procedures for empyema (Table 20) comprised 2226 cases (75%) of acute empyema and 736 cases of chronic empyema. Bronchopleural fistula was reported in 453 patients with acute empyema and in 355 patients with chronic empyema. The hospital mortality rate was 15% among patients with acute empyema with fistula.

In 2017, 101 operations were performed for descending necrotizing mediastinitis (Table 21). The hospital mortality rate was 7%. Furthermore, 400 procedures were conducted for bullous diseases (Table 22); lung volume reduction surgery was performed in only 28 patients.

A total of 14,499 procedures were performed for spontaneous pneumothorax (Table 23). The 11,113 procedures for primary pneumothorax comprised 2838 patients (26%) who underwent bullectomy only and 7488 patients (67%) who underwent an additional procedure. There were 3386
### Table 13  Metastatic pulmonary tumor

| Case Description                    | Cases | 30-Day mortality | Hospital mortality | VATS |
|-------------------------------------|-------|------------------|--------------------|------|
|                                     |       | Hospital         | After discharge    |      |
| Metastatic pulmonary tumor          | 8950  | 12 (0.1)         | 4 (0.0)            | 18 (0.2) | 8298 |
| Colorectal                          | 4240  | 5 (0.1)          | 0                  | 7 (0.2) | 3965 |
| Hepatobiliary/pancreatic            | 422   | 0                | 0                  | 1 (0.2) | 400  |
| Uterine                             | 448   | 0                | 0                  | 0      | 425  |
| Mammary                             | 545   | 0                | 1 (0.2)            | 0      | 517  |
| Ovarian                             | 71    | 0                | 0                  | 0      | 65   |
| Testicular                          | 72    | 1 (1.4)          | 1 (1.4)            | 1 (1.4) | 66   |
| Renal                               | 746   | 0                | 0                  | 0      | 706  |
| Skeletal                            | 144   | 0                | 0                  | 1 (0.7) | 124  |
| Soft tissue                         | 274   | 0                | 1 (0.4)            | 0      | 248  |
| Otorhinolaryngological              | 435   | 0                | 0                  | 0      | 397  |
| Pulmonary                           | 573   | 3 (0.5)          | 0                  | 4 (0.7) | 483  |
| Others                              | 980   | 3 (0.3)          | 1 (0.1)            | 4 (0.4) | 902  |

(), mortality %

### Table 14  Tracheal tumor

| Case Description                    | Cases | 30-Day mortality | Hospital mortality |
|-------------------------------------|-------|------------------|--------------------|
|                                     |       | Hospital         | After discharge    |
| Tracheal tumor                      | 120   | 2 (1.7)          | 2 (1.7)            | 4 (3.3) |
| A. Primary malignant tumor          |       |                  |                    |
| Histological classification         |       |                  |                    |
| Squamous cell carcinoma             | 10    | 0                | 0                  | 0      |
| Adenoid cystic carcinoma            | 20    | 0                | 0                  | 0      |
| Mucoepidermoid carcinoma            | 4     | 0                | 0                  | 0      |
| Others                              | 12    | 0                | 1 (8.3)            | 0      |
| Total                               | 46    | 0                | 1 (2.2)            | 0      |
| B. Metastatic/invasive malignant tumor (e.g., invasion of thyroid cancer) | 36 | 0 | 1 (2.8) | 2 (5.6) |
| C. Benign tracheal tumor            |       |                  |                    |
| Histological classification         |       |                  |                    |
| Papilloma                           | 5     | 0                | 0                  | 0      |
| Adenoma                             | 1     | 0                | 0                  | 0      |
| Neurofibroma                        | 0     | 0                | 0                  | 0      |
| Chondroma                           | 0     | 0                | 0                  | 0      |
| Leiomyoma                           | 2     | 0                | 0                  | 0      |
| Others                              | 30    | 2 (6.7)          | 0                  | 2 (6.7) |
| Histology unknown                   | 0     | 0                | 0                  | 0      |
| Total                               | 38    | 2 (5.3)          | 0                  | 2 (5.3) |
| Operation                           |       |                  |                    |
| Sleeve resection with reconstruction | 21    | 0                | 0                  | 0      |
| Wedge with simple closure           | 2     | 0                | 0                  | 0      |
| Wedge with patch closure            | 1     | 0                | 0                  | 0      |
| Total laryngectomy with tracheostomy| 0     | 0                | 0                  | 0      |
| Others                              | 3     | 0                | 0                  | 0      |
| Unknown                             | 0     | 0                | 0                  | 0      |
| Total                               | 27    | 0                | 0                  | 0      |

(), mortality %
procedures for secondary pneumothorax, where COPD was by far the most prevalent associated disease (69%). The hospital mortality rate for secondary pneumothorax associated with COPD was 2.6%.

The 2017 survey reported 193 procedures for chest wall deformity (Table 24). However, this may have been underestimated, because the Nuss procedure for pectus excavatum was more likely to have been performed in pediatric surgery centers not associated with the Japanese Association for Thoracic Surgery.

Diaphragmatic hernia was treated surgically in 28 patients (Table 25). This figure may also have been underestimated, as procedures may have been classified as gastrointestinal surgery.

The survey reported 443 procedures for chest trauma excluding iatrogenic injuries (Table 26). In this context, hospital mortality rate was 5%.

Table 27 shows procedures for other diseases, including 89 cases of arteriovenous malformation and 92 cases of pulmonary sequestration.

A total of 68 lung transplantations were performed in 2017 (Table 28): 57 patients received lung transplants from brain-dead donors, and 11 patients received transplants from living, related donors.

The number of VATS procedures has increased annually to reach 68,458 (80% of all general thoracic surgeries) in 2017 (Table 29).

The details of tracheobronchoplasty, pediatric surgery, and combined resection of neighboring organs are shown in Tables 30, 31, 32, and 33.

| Table 15 | Tumor of pleural origin |
|----------|-------------------------|
| Histological classification | Cases | 30-Day mortality | Hospital mortality |
| | | Hospital | After discharge | |
| Tumor of pleural origin | | | |
| Solitary fibrous tumor | 131 | 0 | 0 | 0 |
| Diffuse malignant pleural mesothelioma | 264 | 2 (0.8) | 0 | 8 (3.0) |
| Localized malignant pleural mesothelioma | 35 | 1 (2.9) | 0 | 1 (2.9) |
| Others | 268 | 1 (0.4) | 1 (0.4) | 5 (1.9) |
| Total | 698 | 4 (0.6) | 1 (0.1) | 14 (2.0) |
| Operative procedure | Cases | 30-Day mortality | Hospital mortality |
| | | Hospital | After discharge | |
| Extrapleural pneumonectomy | 65 | 1 (1.5) | 0 | 1 (1.5) |
| Total pleurectomy | 104 | 0 | 0 | 3 (2.9) |
| Others | 95 | 1 (1.1) | 0 | 4 (4.2) |
| Total | 264 | 2 (0.8) | 0 | 8 (3.0) |

(), mortality %

| Table 16 | Chest wall tumor |
|----------|-----------------|
| Chest wall tumor | Cases | 30-Day mortality | Hospital mortality |
| | | Hospital | After discharge | |
| Primary malignant tumor | 140 | 1 (0.7) | 1 (0.7) | 6 (4.3) |
| Metastatic malignant tumor | 189 | 0 | 1 (0.5) | 0 |
| Benign tumor | 362 | 1 (0.3) | 0 | 1 (0.3) |
| Total | 691 | 2 (0.3) | 2 (0.3) | 7 (1.0) |

(), mortality %
### Table 17 Mediastinal tumor

| Cases | 30-Day mortality | Hospital mortality | By VATS |
|-------|------------------|--------------------|--------|
|       | Hospital | After discharge |          |        |
| Mediastinal tumor | 5197 | 3 (0.1) | 3 (0.06) | 9 (0.2) | 3808 |
| Thymoma* | 1939 | 1 (0.1) | 2 (0.1) | 3 (0.2) | 1222 |
| Thymic cancer | 368 | 0 | 1 (0.3) | 1 (0.3) | 189 |
| Thymus carcinoid | 39 | 0 | 0 | 0 | 19 |
| Germ cell tumor | 85 | 0 | 0 | 0 | 59 |
| Benign | 66 | 0 | 0 | 0 | 51 |
| Malignant | 19 | 0 | 0 | 0 | 8 |
| Neurogenic tumor | 489 | 0 | 0 | 0 | 447 |
| Congenital cyst | 1185 | 1 (0.1) | 0 | 1 (0.1) | 1071 |
| Goiter | 68 | 0 | 0 | 0 | 29 |
| Lymphatic tumor | 185 | 0 | 0 | 1 (0.5) | 134 |
| Excision of pleural recurrence of thymoma | 27 | 0 | 0 | 0 | 20 |
| Thymolipoma | 19 | 0 | 0 | 0 | 14 |
| Others | 793 | 1 (0.1) | 0 | 3 (0.4) | 604 |

() , mortality %

### Table 18 Thymectomy for myasthenia gravis with thymoma

| Cases | 30-Day mortality | Hospital mortality | By VATS |
|-------|------------------|--------------------|--------|
|       | Hospital | After discharge |          |        |
| Thymectomy for myasthenia gravis with thymoma | 508 | 0 | 0 | 1 (0.2) | 298 |
| 319 | 0 | 0 | 1 (0.3) | 175 |

() , mortality %

### Table 19 Operations for non-neoplastic diseases

| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|-----|
|       | Hospital | After discharge |          |      |
| Operations for non-neoplastic diseases | 22,634 | 214 (0.9) | 31 (0.1) | 467 (2.1) |
| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|-----|
|       | Hospital | After discharge |          |      |
| A. Inflammatory pulmonary disease | 2423 | 3 (0.1) | 2 (0.1) | 9 (0.4) | 2165 |
| Tuberculous infection | 46 | 0 | 0 | 0 | 41 |
| Mycobacterial infection | 496 | 0 | 1 (0.2) | 1 (0.2) | 447 |
| Fungal infection | 361 | 1 (0.3) | 0 | 3 (0.8) | 284 |
| Bronchiectasis | 58 | 0 | 0 | 0 | 43 |
| Tuberculous nodule | 79 | 0 | 0 | 0 | 70 |
| Inflammatory pseudotumor | 918 | 0 | 1 (0.1) | 0 | 858 |
| Interpulmonary lymph node | 76 | 0 | 0 | 0 | 74 |
| Others | 389 | 2 (0.5) | 0 | 5 (1.3) | 348 |

() , mortality %
### Table 20  B. Empyema

| Cases | 30-Day mortality | Hospital mortality | By VATS |
|-------|------------------|--------------------|--------|
|       |                  | Hospital | After discharge |         |
| Acute empyema | 2226 | 54 (2.4) | 5 (0.2) | 128 (5.8) | 1858 |
| With fistula  | 453  | 26 (5.7) | 1 (0.2) | 69 (15.2) | 251  |
| Without fistula | 1756 | 27 (1.5) | 4 (0.2) | 57 (3.2) | 1592 |
| Unknown       | 17   | 1 (5.9)  | 0       | 2 (11.8) | 15   |
| Chronic empyema | 736  | 20 (2.7) | 3 (0.4) | 58 (7.9) | 406  |
| With fistula  | 355  | 9 (2.5)  | 2 (0.6) | 23 (6.5) | 148  |
| Without fistula | 357  | 11 (3.1) | 1 (0.3) | 33 (9.2) | 236  |
| Unknown       | 24   | 0        | 0       | 2 (8.3)  | 22   |
| Total         | 2962 | 74 (2.5) | 8 (0.3) | 186 (6.3) | 2264 |

( ), mortality %

### Table 21  C. Descending necrotizing mediastinitis

| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|-----|
|       |                  | Hospital | After discharge |     |
| C. Descending necrotizing mediastinitis | 101  | 5 (5.0) | 0 | 7 (6.9) | 75  |

( ), mortality %

### Table 22  D. Bullous diseases

| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|-----|
|       |                  | Hospital | After discharge |     |
| D. Bullous diseases | 400  | 2 (0.5) | 0 | 5 (1.3) | 371  |
| Emphysematous bulla | 308  | 2 (0.6) | 0 | 5 (1.6) | 289  |
| Bronchogenic cyst | 13   | 0       | 0 | 0      | 12   |
| Emphysema with LVRS | 28   | 0       | 0 | 0      | 28   |
| Others | 51   | 0       | 0 | 0      | 42   |

( ), mortality %

*LVRS* lung volume reduction surgery
| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|------|
|       | Hospital         | After discharge    |      |
| 14,999| 70 (0.5)         | 16 (0.1)           | 156 (1.1) |

Spontaneous pneumothorax

| Operative procedure | Cases | 30-Day mortality | Hospital mortality | VATS |
|---------------------|-------|------------------|--------------------|------|
|                     |       | Hospital         | After discharge    |      |
| Bullectomy          | 2838  | 2 (0.1)          | 1 (0.04)           | 8 (0.3) |
| Bullectomy with additional procedure | 7488  | 7 (0.1)          | 1 (0.01)           | 17 (0.2) |
| Coverage with artificial material | 7233  | 7 (0.1)          | 1 (0.01)           | 17 (0.2) |
| Parietal pleurectomy | 28    | 0                | 0                  | 0     |
| Coverage and parietal pleurectomy | 79    | 0                | 0                  | 0     |
| Others              | 148   | 0                | 0                  | 0     |
| Others              | 783   | 6 (0.8)          | 3 (0.4)            | 12 (1.5) |
| Unknown             | 4     | 0                | 0                  | 0     |
| Total               | 11,113| 15 (0.1)         | 5 (0.04)           | 37 (0.3) |

Secondary pneumothorax

| Associated disease | Cases | 30-Day mortality | Hospital mortality | VATS |
|-------------------|-------|------------------|--------------------|------|
|                   |       | Hospital         | After discharge    |      |
| COPD              | 2350  | 28 (1.2)         | 6 (0.3)            | 62 (2.6) |
| Tumorous disease  | 130   | 5 (3.8)          | 2 (1.5)            | 14 (10.8) |
| Catamenal         | 157   | 0                | 0                  | 0     |
| LAM               | 41    | 0                | 0                  | 0     |
| Others (excluding pneumothorax by trauma) | 708   | 22 (3.1)         | 3 (0.4)            | 43 (6.1) |
| Unknown           | 0     | 0                | 0                  | 0     |
| Total             | 3386  | 55 (1.6)         | 11 (0.3)           | 119 (3.5) |

| Operative procedure | Cases | 30-Day mortality | Hospital mortality | VATS |
|---------------------|-------|------------------|--------------------|------|
|                     |       | Hospital         | After discharge    |      |
| Bullectomy          | 571   | 6 (1.1)          | 3 (0.5)            | 18 (3.2) |
| Bullectomy with additional procedure | 2016  | 25 (1.2)         | 6 (0.3)            | 44 (2.2) |
| Coverage with artificial material | 1914  | 24 (1.3)         | 5 (0.3)            | 43 (2.2) |
| Parietal pleurectomy | 8     | 0                | 0                  | 0     |
| Coverage and parietal pleurectomy | 29    | 1 (3.4)          | 0                  | 1 (3.4) |
| Others              | 65    | 0                | 1 (1.5)            | 0     |
| Others              | 793   | 24 (3.0)         | 2 (0.3)            | 57 (7.2) |
| Unknown             | 6     | 0                | 0                  | 0     |
| Total               | 3386  | 55 (1.6)         | 11 (0.3)           | 119 (3.5) |

( ), mortality %
### Table 24  F. Chest wall deformity

| Cases | 30-Day mortality | Hospital mortality | After discharge |
|-------|------------------|--------------------|----------------|
| Funnel chest | 193 | 1 (0.5) | 0 | 1 (0.5) |
| Others | 182 | 0 | 0 | 0 |
| Others | 11 | 1 (9.1) | 0 | 1 (9.1) |

(), mortality %

### Table 25  G. Diaphragmatic hernia

| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|------|
| Congenital | 28 | 1 (3.6) | 0 | 1 (3.6) |
| Traumatic | 10 | 0 | 0 | 0 |
| Others | 14 | 1 (7.1) | 0 | 1 (7.1) |

(), mortality %

### Table 26  H. Chest trauma

| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|------|
| Total lung transplantation | 443 | 20 (4.5) | 0 | 23 (5.2) |

(), mortality %

### Table 27  I. Other respiratory surgery

| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|------|
| Arteriovenous malformation* | 1585 | 38 (2.4) | 5 (0.3) | 79 (5.0) | 1161 |
| Pulmonary sequestration | 89 | 0 | 0 | 0 | 84 |
| Postoperative bleeding - air leakage | 92 | 0 | 0 | 0 | 84 |
| Chylothorax | 492 | 17 (3.5) | 1 (0.2) | 30 (6.1) | 339 |
| Others | 62 | 2 (3.2) | 0 | 4 (6.5) | 52 |

(), mortality %

### Table 28  Lung transplantation

| Cases | 30-Day mortality | Hospital mortality | After discharge |
|-------|------------------|--------------------|----------------|
| Single-lung transplantation from brain-dead donor | 29 | 0 | 0 | 3 (10.3) |
| Bilateral lung transplantation from brain-dead donor | 28 | 0 | 0 | 0 |
| Lung transplantation from living donor | 11 | 0 | 0 | 0 |
| Total lung transplantation | 68 | 0 | 0 | 3 (4.4) |
| Donor of living donor lung transplantation | 19 | 0 | 0 | 0 |

(), mortality %

### Table 29  Video-assisted thoracic surgery

| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|------|
| Video-assisted thoracic surgery | 68,458 | 218 (0.3) | 51 (0.07) | 470 (0.7) |

(), mortality %

(including thoracic sympathectomy 160)%
### Table 30 Tracheobronchoplasty

| Procedure                                      | Cases | 30-Day mortality | Hospital mortality | Hospital After discharge |
|------------------------------------------------|-------|------------------|--------------------|--------------------------|
| Tracheobronchoplasty                           | 774   | 7 (0.9)          | 4 (0.5)            | 16 (2.1)                 |
| Trachea                                        | 40    | 0                | 0                  | 1 (2.5)                  |
| Sleeve resection with reconstruction           | 28    | 0                | 0                  | 1 (3.6)                  |
| Wedge with simple closure                     | 4     | 0                | 0                  | 0                        |
| Wedge with patch closure                      | 1     | 0                | 0                  | 0                        |
| Total laryngectomy with tracheostomy          | 0     | 0                | 0                  | 0                        |
| Others                                         | 7     | 0                | 0                  | 0                        |
| Carinal reconstruction                         | 31    | 1 (3.2)          | 0                  | 2 (6.5)                  |
| Sleeve pneumonecctomy                          | 12    | 2 (16.7)         | 0                  | 2 (16.7)                 |
| Sleeve lobectomy                               | 492   | 1 (0.2)          | 2 (0.4)            | 2 (0.4)                  |
| Sleeve segmental excision                      | 14    | 0                | 0                  | 0                        |
| Bronchoplasty without lung resection           | 29    | 1 (3.4)          | 0                  | 1 (3.4)                  |
| Others                                         | 156   | 2 (1.3)          | 2 (1.3)            | 8 (5.1)                  |

(), mortality %

### Table 31 Pediatric surgery

| Procedure | Cases | 30-Day mortality | Hospital mortality | Hospital After discharge |
|-----------|-------|------------------|--------------------|--------------------------|
| Pediatric surgery | 292 | 3 (1.0)          | 0                  | 3 (1.0)                  |

(), mortality %

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

| Organ resected                      | Cases | 30-Day mortality | Hospital mortality | Hospital After discharge |
|-------------------------------------|-------|------------------|--------------------|--------------------------|
| Combined resection of neighboring organ(s) | 1371 | 7 (0.5)          | 0                  | 21 (1.5)                 |

| Organ resected                      | Cases | 30-Day mortality | Hospital mortality | Hospital After discharge |
|-------------------------------------|-------|------------------|--------------------|--------------------------|
| A. Primary lung cancer              |       |                  |                    |                          |
| Aorta                              | 11    | 0                | 0                  | 0                        |
| Superior vena cava                  | 14    | 1 (7.1)          | 0                  | 1 (7.1)                  |
| Brachiocephalic vein                | 8     | 0                | 0                  | 1 (12.5)                 |
| Pericardium                         | 108   | 1 (0.9)          | 0                  | 2 (1.9)                  |
| Pulmonary artery                    | 127   | 1 (0.8)          | 0                  | 1 (0.8)                  |
| Left atrium                         | 19    | 1 (5.3)          | 0                  | 2 (10.5)                 |
| Diaphragm                           | 55    | 1 (1.8)          | 0                  | 1 (1.8)                  |
| Chest wall (including ribs)         | 352   | 4 (1.1)          | 0                  | 12 (3.4)                 |
| Vertebral                           | 19    | 0                | 0                  | 0                        |
| Esophagus                           | 3     | 0                | 0                  | 0                        |
| Total                               | 716   | 9 (1.3)          | 0                  | 20 (2.8)                 |

| Organ resected                      | Cases | 30-Day mortality | Hospital mortality | Hospital After discharge |
|-------------------------------------|-------|------------------|--------------------|--------------------------|
| B. Mediastinal tumor                |       |                  |                    |                          |
| Aorta                              | 7     | 0                | 0                  | 0                        |
| Superior vena cava                  | 54    | 0                | 0                  | 0                        |
| Brachiocephalic vein                | 107   | 0                | 0                  | 2 (1.9)                  |
| Pericardium                         | 351   | 0                | 0                  | 3 (0.9)                  |
| Pulmonary artery                    | 3     | 0                | 0                  | 1 (33.3)                 |
| Left atrium                         | 0     | 0                | 0                  | 0                        |
| Diaphragm                           | 21    | 0                | 0                  | 0                        |
| Chest wall (including ribs)         | 10    | 0                | 0                  | 0                        |
| Vertebral                           | 5     | 0                | 0                  | 0                        |
| Esophagus                           | 3     | 0                | 0                  | 0                        |
| Lung                                | 476   | 0                | 0                  | 2 (0.4)                  |
| Total                               | 1037  | 0                | 0                  | 8 (0.8)                  |

(), mortality %

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

| Procedure                                      | Cases | 30-Day mortality | Hospital mortality | Hospital After discharge |
|------------------------------------------------|-------|------------------|--------------------|--------------------------|
| 15. Operation of lung cancer invading the chest wall of the apex | 743 | 7 (0.9)          | 2 (0.3)            | 15 (2.0)                 |

(), mortality %

Includes tumors invading the anterior apical chest wall and posterior apical chest wall (superior sulcus tumor, so-called Pancoast type)
During 2017, a total of 12,336 patients with esophageal diseases were registered from 523 institutions (response rate: 92.1%) affiliated with the Japanese Association for Thoracic Surgery and/or the Japan Esophageal Society. Among these institutions, there were 139 (26.6%) where 20 or more patients underwent esophageal surgeries within the year 2017, indicating no definite shift from esophageal procedures to high-volume institutions when compared with the data from 2016 (24.5%) (Table 34). Among 2427 patients with a benign esophageal disease, 1614 (66.5%) underwent surgery and 73 (3.0%) underwent endoscopic resection, whereas 740 (30.5%) patients did not undergo surgical treatment (Tables 35, 36). Among 10,554 patients with a malignant esophageal tumor, 8525 (80.8%) underwent resection, esophagectomy was performed for 6319 (74.1%), and endoscopic mucosal resection (EMR) or endoscopic submucosal dissection (ESD) was performed for 2170 (25.5%); 2025 (23.8%) patients did not undergo any resection (Tables 36 and 37). Annual trends among registered inpatients with esophageal diseases have not changed for the past last decades (Fig. 3).

Among benign esophageal diseases (Table 35), hiatal hernia, achalasia, esophageal varices, and esophagitis (including reflux esophagitis) were the most common conditions in Japan. On the other hand, benign esophageal tumors, spontaneous rupture of the esophagus, and congenital esophageal atresia were common diseases that were surgically treated in addition to the aforementioned diseases. Open surgery was performed in 1009 (57.7%) patients with a benign esophageal disease, with 30-day mortality in 3 (0.3%) patients, whereas thoracoscopic and/or laparoscopic surgery was performed for 605 (37.5%) patients, with no instances of 30-day mortality. The difference in these death rates between open and scopic surgery appears to be related to conditions requiring open surgery.

The majority of malignant diseases were carcinomas (Table 36). Among esophageal carcinomas, the incidence of squamous cell carcinoma was 88.8%, whereas that of adenocarcinomas, including Barrett’s cancer, was 4.3%. The resection rate for patients with a squamous cell carcinoma was 79.9%, whereas that for patients with adenocarcinoma was 93.8%.

On the basis of location, cancer in the thoracic esophagus was the most common (Table 37). Among 4303 patients (40.9% of total esophageal malignancies) with superficial esophageal cancers within mucosal and submucosal layers, 6319 (60.1%) patients underwent esophagectomy, whereas 2170 (20.6%) 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 1.0%, respectively.

Multiple primary cancers were observed in 2077 (19.8%) of all 10,514 patients with esophageal cancer. Synchronous cancer was found in 1008 (9.3%) patients, whereas metachronous cancer was observed in 1063 (10.1%) patients. The stomach and head and neck were common sites for both synchronous and metachronous malignancies (Table 37).

Among esophagectomy procedures, transthoracic esophagectomy via right thoracotomy was most commonly adopted for patients with a superficial cancer, as well as for those with advanced cancer (Table 38). Transhiatal esophagectomy, which is commonly performed in Western countries, was adopted in only 9.1% of patients with a superficial cancer or advanced cancer who underwent esophagectomy in Japan. Thoracoscopic and/or laparoscopic esophagectomy was adopted for 1434 patients (74.0%) with a superficial cancer and for 2422 patients (55.3%) with an advanced cancer. The number of cases of thoracoscopic and/or laparoscopic surgery for superficial or advanced cancer has been increasing for a number of years (Fig. 4).

Combined resection of the neighboring organs during the resection of an esophageal cancer was performed in 296 patients (Tables 38 and 39). Resection of the aorta, together with esophagectomy, was performed in eight cases. Tracheal and/or bronchial resection combined with esophagectomy was performed for 20 patients, with both 30-day mortality rate and hospital mortality rate at 0%. Lung resection combined with esophagectomy was performed for 60 patients, with both 30-day mortality rate and hospital mortality rate at 0%.

Salvage surgery following definitive (chemo)radiotherapy was performed for 230 patients, with 30-day mortality rate at 1.7% and hospital mortality rate at 2.6% (Table 38).
Table 35 Benign esophageal diseases

| Operation (+) | Number of patients | Hospital mortality | Endoscopic resection | Operation (-) | Total |
|---------------|--------------------|--------------------|----------------------|---------------|-------|
|               |                    | ~30 days 31–90 days| ~30 days 31–90 days  |               |       |
| operation     | Total Open T/L*3   | Open surgery       | Total (including after 91-day mortality) | Total (including after 91-day mortality) |       |
|               |                    |                    |                      |               |       |
| 1. Achalasia  | 261                | 146                | 115                  | 0             | 0     | 0     | 32   | 295 |
| 2. Benign tumor | 140              | 86                 | 54                   | 0             | 0     | 1 (1.2) | 2 (1.4) | 14   | 193 |
| (1) Leiomyoma | 78                 | 46                 | 32                   | 0             | 0     | 1 (2.2) | 2 (2.6) | 10   | 114 |
| (2) Cyst      | 16                 | 10                 | 6                    | 0             | 0     | 0      | 0    | 16  |
| (3) Others    | 46                 | 30                 | 16                   | 0             | 0     | 0      | 0    | 13  | 63  |
| (4) Not specified | 0               | 0                  | 0                    | 0             | 0     | 0      | 0    | 0   |
| 3. Hiatal hernia | 42               | 28                 | 14                   | 0             | 0     | 0      | 0    | 13  |
| 4. Spontaneous rupture of the esophagus | 110 | 96 | 14 | 1 (1.0) | 2 (2.1) | 3 (3.1) | 0 | 2 (14.3) | 2 (14.3) | 5 (4.5) | 10 | 120 |
| 5. Esophago-tracheal fistula | 14 | 13 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 18 |
| 6. Congenital esophageal atresia | 13 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 20 |
| 7. Congenital esophageal stenosis | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 21 |
| 8. Esophageal varices | 93 | 52 | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 93 |
| 9. Corrosive stricture of the esophagus | 11 | 56 | 0 | 1 (1.8) | 0 | 1 (1.8) | 0 | 0 | 1 (1.8) | 471 | 527 |
| 10. Esophagitis, esophageal ulcer | 56 | 56 | 0 | 1 (1.6) | 1 (1.6) | 2 (3.2) | 0 | 0 | 0 | 2 (2.6) | 34 | 134 |
| (1) Laparotomy | 12 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| (2) Sclerotherapy | 89 | 89 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 89 |
| (3) EVL | 329 | 329 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 329 |
| 12. Others | 76 | 63 | 13 | 1 (1.6) | 1 (1.6) | 2 (3.2) | 0 | 3 (0.5) | 4 (0.7) | 12 | 73 | 740 | 2427 |

(1), mortality
T/L, thoracoscopic and/or laparoscopic %
### Table 36 Malignant esophageal diseases (histologic classification)

| Carcinomas | Resection (+) | Resection (–) | Total |
|-------------|---------------|---------------|-------|
|             | 8473          | 2025          | 10,498|
| 1 Squamous cell carcinoma | 7455          | 1870          | 9325  |
| 2 Basaloid(-squamous)carcinoma | 86            | 8             | 94    |
| 3 Carcinosarcoma | 48            | 5             | 53    |
| 4 Adenocarcinoma in the Barrett’s esophagus | 426          | 28            | 454   |
| 5 Other adenocarcinoma | 369          | 62            | 431   |
| 6 Adenosquamous carcinoma | 20            | 3             | 23    |
| 7 Mucoepidermoid carcinoma | 2             | 0             | 2     |
| 8 Adenoid cystic carcinoma | 4             | 0             | 4     |
| 9 Endocrine cell carcinoma | 39            | 26            | 65    |
| 10 Undifferentiated carcinoma | 8             | 6             | 14    |
| 11 Others | 16            | 17            | 33    |
| Other malignancies | 36            | 4             | 40    |
| 1 Malignant non-epithelial tumors | 8             | 1             | 9     |
| 2 Malignant melanoma | 20            | 2             | 22    |
| 3 Other malignant tumors | 8             | 1             | 9     |
| Not specified | 16            | 0             | 16    |
| Total | 8525          | 2029          | 10,554|

Resection: including endoscopic resection
Table 37 Malignant esophageal disease (clinical characteristics)

| Location | Cases | Hospital mortality | Total (including after 91-day mortality) |
|----------|-------|--------------------|------------------------------------------|
|          | ~30 days | 31–90 days |         |
| 1. Esophageal cancer | 6319 | 33 (0.5) | 30 (0.5) | 83 (1.3) | 2170 | 2025 | 10,514 |
| (1) Cervical esophagus | 223 | 0 | 0 | 2 (0.9) | 102 | 142 | 467 |
| (2) Thoracic esophagus | 5117 | 30 (0.6) | 27 (0.5) | 75 (1.5) | 1637 | 1682 | 8436 |
| (3) Abdominal esophagus | 718 | 2 (0.3) | 3 (0.4) | 5 (0.7) | 119 | 99 | 936 |
| (4) Multiple cancers | 261 | 1 (0.4) | 0 | 1 (0.4) | 216 | 41 | 518 |
| (5) Others/not described | 0 | 0 | 0 | 0 | 96 | 61 | 157 |
| 2. Multiple primary cancers | 1167 | 7 (0.6) | 9 (0.8) | 19 (1.6) | 611 | 299 | 2077 |
| (1) Head and neck | 658 | 6 (0.9) | 8 (1.2) | 16 (2.4) | 260 | 145 | 1063 |
| (2) Stomach | 203 | 3 (1.5) | 4 (2.0) | 9 (4.4) | 66 | 34 | 303 |
| (3) Colorectum | 83 | 1 (1.2) | 0 | 1 (1.2) | 16 | 12 | 111 |
| (4) Lung | 42 | 1 (2.4) | 0 | 1 (2.4) | 8 | 17 | 67 |
| (5) Pancreas | 2 | 0 | 0 | 0 | 3 | 2 | 7 |
| (6) Liver | 6 | 0 | 0 | 0 | 1 | 2 | 9 |
| (7) Others | 56 | 0 | 1 (1.8) | 0 | 16 | 17 | 89 |
| (8) Triple cancers | 35 | 0 | 1 (2.9) | 1 (2.9) | 17 | 11 | 63 |
| (9) Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2. Metachronous | 509 | 1 (0.2) | 1 (0.2) | 3 (0.6) | 351 | 154 | 1014 |
| (1) Head and neck | 98 | 0 | 0 | 0 | 117 | 31 | 246 |
| (2) Stomach | 104 | 0 | 0 | 0 | 76 | 31 | 211 |
| (3) Colorectum | 70 | 0 | 0 | 1 (1.4) | 35 | 20 | 125 |
| (4) Lung | 47 | 0 | 0 | 0 | 10 | 19 | 76 |
| (5) Pancreas | 3 | 0 | 0 | 0 | 2 | 0 | 5 |
| (6) Liver | 5 | 0 | 0 | 0 | 1 | 2 | 8 |
| (7) Others | 148 | 1 (0.7) | 1 (0.7) | 2 (1.4) | 60 | 31 | 239 |
| (8) Triple cancers | 34 | 0 | 0 | 0 | 49 | 20 | 103 |
| (9) Unknown | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

()*, mortality %

EMR endoscopic mucosal resection (including endoscopic submucosal dissection)
Fig. 3 Annual trend of inpatients with esophageal diseases. EMR endoscopic mucosal resection (including endoscopic submucosal)
### Table 38: Malignant esophageal disease (surgical procedures)

| Operation (+)                      | Cases | Hospital mortality | Thoracoscopic and/or laparoscopic procedure | EMR or ESD |
|-----------------------------------|-------|--------------------|-------------------------------------------|------------|
|                                   | ~ 30 days | 31–90 days | Total (including after 91-day mortality) | ~ 30 days | 31–90 days | Total (including after 91-day mortality) |
| Superficial cancer (T1)           | 1938  | 10 (0.5) | 6 (0.3) | 19 (1.0) | 1434  | 8 (0.6) | 5 (0.3) | 15 (1.0) | 2162  |
| Mucosal cancer (T1a)              | 346   | 1 (0.3)  | 1 (0.3) | 4 (1.2)  | 210   | 1 (0.5) | 1 (0.5) | 4 (1.9)  | 1557  |
| Esophagectomy                     | 1938  | 10 (0.5) | 6 (0.3) | 19 (1.0) | 1434  | 8 (0.6) | 5 (0.3) | 15 (1.0) | 2162  |
| (1) Transhiatal esophagectomy,    | 176   | 0 (0.0)  | 0 (0.0) | 1 (0.6)  | 85    | 0 (0.0) | 0 (0.0) | 1 (1.2)  |        |
| mediascope-assisted esophagectomy |       |           |         |          |       |           |         |          |        |
| (2) Thoracic (rt.) esophagectomy  | 1649  | 10 (0.6) | 5 (0.3) | 16 (1.0) | 1296  | 8 (0.6) | 5 (0.4) | 13 (1.0) |        |
| (3) Transhiatal esophagectomy and | 31    | 0 (0.0)  | 1 (3.2) | 1 (3.2)  | 9     | 0 (0.0) | 0 (0.0) |          |        |
| reconstruction                    |       |           |         |          |       |           |         |          |        |
| (4) Cervical esophageal resection | 20    | 0 (0.0)  | 0 (0.0) | 0 (0.0)  | 5     | 0 (0.0) | 0 (0.0) |          |        |
| and reconstruction                |       |           |         |          |       |           |         |          |        |
| (5) Robot-assisted esophagectomy  | 19    | 0 (0.0)  | 0 (0.0) | 0 (0.0)  | 19    | 0 (0.0) | 0 (0.0) |          |        |
| (6) Others                        | 28    | 0 (0.0)  | 0 (0.0) | 0 (0.0)  | 12    | 0 (0.0) | 0 (0.0) |          |        |
| (7) Esophagectomy without         | 9     | 0 (0.0)  | 0 (0.0) | 1 (11.1) | 2     | 0 (0.0) | 0 (0.0) | 1 (50.0) |        |
| reconstruction                    |       |           |         |          |       |           |         |          |        |
| (8) Not specified                 | 6     | 0 (0.0)  | 0 (0.0) | 0 (0.0)  | 6     | 0 (0.0) | 0 (0.0) |          |        |

**Advanced cancer (T2–T4)**

| Esophagectomy                     | 4377  | 23 (0.5) | 24 (0.5) | 64 (1.5) | 2422  | 11 (0.5) | 10 (0.4) | 28 (1.2) | 5       |
| (1) Transhiatal esophagectomy,    | 240   | 1 (0.4)  | 1 (0.4)  | 2 (0.8)  | 92    | 0 (1.1)  | 1 (1.1)  |          |        |
| mediascope-assisted esophagectomy |       |           |         |          |       |           |         |          |        |
| (2) Thoracic (rt.) esophagectomy  | 3818  | 21 (0.6) | 20 (0.5) | 55 (1.4) | 2255  | 10 (0.4) | 9 (0.4)  | 25 (1.1) |        |
| and reconstruction                |       |           |         |          |       |           |         |          |        |
| (3) Thoracic (lt.) esophagectomy  | 89    | 0 (0.0)  | 0 (0.0) | 0 (0.0)  | 4     | 0 (0.0)  | 0 (0.0) |          |        |
| and reconstruction                |       |           |         |          |       |           |         |          |        |
| (4) Cervical esophageal resection | 105   | 0 (0.0)  | 0 (0.0) | 1 (1.0)  | 6     | 0 (0.0)  | 0 (0.0) |          |        |
| and reconstruction                |       |           |         |          |       |           |         |          |        |
| (5) Robot-assisted esophagectomy  | 19    | 0 (0.0)  | 0 (0.0) | 0 (0.0)  | 19    | 0 (0.0)  | 0 (0.0) |          |        |
| (6) Others                        | 57    | 1 (1.8)  | 1 (1.8)  | 2 (3.5)  | 22    | 1 (4.5)  | 0 (4.5)  |          |        |
| (7) Esophagectomy without         | 43    | 0 (0.0)  | 2 (4.7)  | 4 (9.3)  | 19    | 0 (0.0)  | 0 (0.0)  | 1 (5.3)  |        |
| reconstruction                    |       |           |         |          |       |           |         |          |        |
| (8) Not specified                 | 6     | 0 (0.0)  | 0 (0.0) | 0 (0.0)  | 5     | 0 (0.0)  | 0 (0.0) |          |        |
| (Depth not specified)             | 4     | 0 (0.0)  | 0 (0.0) | 0 (0.0)  | 3     | 0 (0.0)  | 0 (0.0) |          | 3       |

**Combined resection of other organs**

| Combined resection of other organs | 296   | 3 (1.0)  | 3 (1.0)  | 7 (2.4)  | 70    | 1 (1.4)  | 0 (1.4)  | 1 (1.4)  | 25      |
| (1) Aorta                         | 8     | 1 (12.5) | 0 (12.5) |          |        |           |         |          |        |
| (2) Trachea, bronchus             | 20    | 0 (0.0)  | 0 (0.0)  | 1 (5.0)  |        |           |         |          |        |
| (3) Lung                          | 60    | 0 (0.0)  | 0 (0.0)  |          |        |           |         |          |        |
| (4) Others                        | 208   | 2 (1.0)  | 3 (1.4)  | 5 (2.4)  |        |           |         |          |        |
| Unknown                           | 0     | 0 (0.0)  | 0 (0.0)  |          |        |           |         |          |        |

**Salvage surgery**

| Salvage surgery                  | 230   | 4 (1.7)  | 1 (0.4)  | 6 (2.6)  | 70    | 1 (1.4)  | 0 (1.4)  |          | 25      |
**Table 39** Mortality after combined resection of the neighbouring organs

| Year | Esophagectomy | Combined resection |
|------|---------------|--------------------|
|      | a: 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 |
|      | a | b | c | 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% | 78 | 4 | 5.13% |
| 1997 | 4441 | 127 | 2.86% | 1 | 0 | 0.00% | 34 | 5 | 14.71% | 56 | 1 | 1.79% | 94 | 3 | 3.19% |
| 1998 | 4878 | 136 | 2.79% | 4 | 0 | 0.00% | 29 | 0 | 0.00% | 74 | 1 | 1.35% | 128 | 2 | 1.56% |
| 1999 | 5015 | 116 | 2.31% | 5 | 0 | 0.00% | 23 | 2 | 8.70% | 68 | 0 | 0.00% | 122 | 1 | 0.82% |
| 2000 | 5350 | 81 | 1.51% | 2 | 0 | 0.00% | 23 | 2 | 8.70% | 69 | 0 | 0.00% | 96 | 1 | 1.04% |
| 2001 | 5521 | 110 | 1.99% | 1 | 0 | 0.00% | 26 | 1 | 3.85% | 83 | 3 | 3.61% | 99 | 2 | 2.02% |
| 2002 | 4904 | 66 | 1.35% | 3 | 1 | 33.33% | 20 | 2 | 10.00% | 63 | 0 | 0.00% | 63 | 1 | 1.59% |
| 2003 | 4639 | 45 | 0.97% | 0 | 0 | 0.00% | 24 | 2 | 8.33% | 58 | 0 | 0.00% | 88 | 1 | 1.14% |
| 2004 | 4739 | 64 | 1.35% | 2 | 0 | 0.00% | 17 | 0 | 0.00% | 59 | 5 | 8.47% | 119 | 2 | 1.68% |
| 2005 | 5163 | 52 | 1.01% | 1 | 0 | 0.00% | 11 | 1 | 9.09% | 67 | 1 | 1.49% | 73 | 1 | 1.37% |
| 2006 | 5236 | 63 | 1.20% | 0 | 0 | 0.00% | 17 | 0 | 0.00% | 62 | 2 | 3.23% | 122 | 3 | 2.46% |
| 2007 | 4990 | 60 | 1.20% | 0 | 0 | 0.00% | 25 | 1 | 4.00% | 44 | 1 | 2.27% | 138 | 2 | 1.45% |
| 2008 | 5124 | 63 | 1.23% | 0 | 0 | 0.00% | 17 | 1 | 5.88% | 48 | 1 | 2.08% | 185 | 0 | 0.00% |
| 2009 | 5260 | 63 | 1.20% | 0 | 0 | 0.00% | 19 | 2 | 10.53% | 58 | 2 | 3.45% | 211 | 3 | 1.42% |
| 2010 | 5180 | 45 | 0.87% | 2 | 0 | 0.00% | 33 | 0 | 0.00% | 58 | 0 | 0.00% | 245 | 5 | 2.04% |
| 2011 | 5430 | 38 | 0.70% | 4 | 0 | 0.00% | 26 | 0 | 0.00% | 41 | 0 | 0.00% | 179 | 5 | 2.79% |
| 2012 | 6055 | 47 | 0.78% | 2 | 0 | 0.00% | 23 | 1 | 4.35% | 69 | 0 | 0.00% | 240 | 1 | 0.42% |
| 2013 | 5824 | 41 | 0.70% | 2 | 0 | 0.00% | 44 | 0 | 0.00% | 77 | 1 | 1.30% | 156 | 3 | 1.92% |
| 2014 | 6244 | 47 | 0.75% | 2 | 0 | 0.00% | 24 | 0 | 0.00% | 77 | 3 | 3.90% | 227 | 3 | 1.32% |
| 2015 | 6151 | 39 | 0.63% | 3 | 0 | 0.00% | 15 | 0 | 0.00% | 67 | 3 | 4.48% | 266 | 4 | 1.50% |
| 2016 | 6158 | 40 | 0.65% | 3 | 0 | 0.00% | 12 | 0 | 0.00% | 56 | 0 | 0.00% | 155 | 1 | 0.65% |
| 2017 | 6319 | 33 | 0.52% | 8 | 1 | 12.50% | 20 | 0 | 0.00% | 60 | 0 | 0.00% | 208 | 2 | 0.96% |
| Total | 116,815 | 1496 | 1.28% | 52 | 5 | 9.62% | 506 | 20 | 3.95% | 1364 | 26 | 1.91% | 3292 | 50 | 1.52% |

Fig. 4 Annual trend of video-assisted esophagectomy for esophageal malignancy

![Graph showing annual trend of video-assisted esophagectomy for esophageal malignancy](#)
We aim to continue our efforts to gather all-encompassing survey data via more active collaboration with the Japan Esophageal Society and other related institutions.

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**References**

1. Shimizu H, Endo S, Natsugoe S, et al. Thoracic and cardiovascular surgery in Japan during 2016—annual report by the Japanese Association for Thoracic Surgery. Gen Thorac Cardiovasc Surg. 2019;67:377–411.
2. Ueda Y, Fujiy Y, Kuwano H. Thoracic and cardiovascular surgery in Japan during 2007—annual report by the Japanese Association for Thoracic Surgery. Gen Thorac Cardiovasc Surg. 2009;57:488–513.
3. Masuda M, Kuwano H, Okumura M, et al. Thoracic and cardiovascular surgery in Japan during 2012—annual report by the Japanese Association for Thoracic Surgery. Gen Thorac Cardiovasc Surg. 2014;62:734–64.
4. Kazui T, Wada H, Fujita H. Thoracic and cardiovascular surgery in Japan during 2003—annual report by the Japanese Association for Thoracic Surgery. Jpn J Thorac Cardiovasc Surg. 2005;53:517–36.
5. Kazui T, Osada H, Fujita H. Thoracic and cardiovascular surgery in Japan during 2004—annual report by the Japanese Association for Thoracic Surgery. Jpn J Thorac Cardiovasc Surg. 2006;54:363–86.

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