Thoracic and cardiovascular surgeries in Japan during 2018

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 according to surgical categories. We herein summarize the results of the association’s annual survey of thoracic surgeries performed in 2018.

Adhering to the norm thus far, thoracic surgery had been classified into three categories, cardiovascular, general thoracic, and esophageal surgeries, with patient data for each group being examined and analyzed. We honor and value all members’ continued professional support and contributions.

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 improvements in surgical outcomes by enabling comparisons between their work and that of others. This approach has enabled the association to gain a better understanding of present problems and future prospects, which is reflected in its activities and member education.

Thirty-day mortality (otherwise known as operative mortality) is defined as death within 30 days of surgery, regardless of the patient’s geographic location, including post-discharge from the hospital. Hospital mortality is defined as death within any time interval following surgery among patients yet to be discharged from the hospital.

While hospital-to-hospital transfer during 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 of complications from surgery. In contrast, hospital-to-hospital transfer 30 days following cardiovascular and general thoracic surgeries is considered discharge given that data related to the National Clinical Database (NCD) were employed in these categories.

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. This is because NCD information regarding esophageal surgery does not include non-surgical cases (i.e., patients with adjuvant chemotherapy or radiation only).

Given the changes in data collection related to cardiovascular surgery [initially self-reported using questionnaire sheets in each participating institution up to 2014, followed by downloading of an automatic package from the Japanese Cardiovascular Surgery Database (JCVSD), a
cardiovascular subsection of the NCD], response rates were unavailable and were 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).

Table 1 Number of institutions involved in the survey

| Questionnaires                  | (A) Cardiovascular surgery | (B) General Thoracic Surgery | (C) Esophageal Surgery |
|--------------------------------|----------------------------|------------------------------|------------------------|
| Sent out                       | 749                        | 552                          |                        |
| Responded                      | 676                        | 552                          | 552                    |
| Response rate                  | 90.3%                      |                              |                        |

Table 2 Categories subclassified according to the number of operations performed

| Number of operations performed | Category         | General thoracic surgery    |
|--------------------------------|------------------|-----------------------------|
| 0                              |                  | 5                           |
| 1–24                           |                  | 38                          |
| 25–49                          |                  | 94                          |
| 50–99                          |                  | 193                         |
| 100–149                        |                  | 121                         |
| 150–199                        |                  | 107                         |
| ≥ 200                          |                  | 118                         |
| Total                          |                  | 676                         |

cardiovascular subsection of the NCD], response rates were unavailable and were 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).

Final report: 2018

(A) Cardiovascular surgery

We are extremely pleased with the cooperation of our colleagues (members) in completing the cardiovascular surgery survey, which has undoubtedly improved the quality of this annual report. We are truly grateful for the significant efforts made by all participants within each participating institution in completing the JCVSD/NCD.

Figure 1 illustrates the development of cardiovascular surgery in Japan over the past 32 years. Aneurysm surgery includes only surgeries for thoracic and thoracoabdominal aortic aneurysms. Extra-anatomic bypass surgery for thoracic aneurysm and pacemaker implantation have been excluded from the survey since 2015. Assist device implantations were not included in the total number of surgical procedures but were nonetheless included in the survey.

A total of 69,063 cardiovascular surgeries, including 51 heart transplants, had been performed in 2018, a decrease of 0.7% compared to that in 2017 (n = 70,078).

Compared to data for 2017 [1] and 2008 [2], data for 2018 showed 1.2% (9253 vs. 9368) and 3.6% fewer surgeries for congenital heart disease, 0.5% (23,205 vs. 23,312) fewer and 38.6% more surgeries for valvular heart disease, 12.7% (12,135 vs. 13,898) and 36.9% fewer surgeries for ischemic heart procedures, and 4.2% (21,624 vs. 20,746) and 96.6% more surgeries for thoracic aortic aneurysm, respectively. Data for individual categories are summarized in Tables 3, 4, 5, 6, 7, 8.

Cardiovascular Surgery

![Cardiovascular Surgery](image)

Fig. 1 Cardiovascular surgery. IHD ischemic heart disease

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| Procedure                  | Neonate Cases | Hospital mortality | After discharge | Infant Cases | Hospital mortality | After discharge | 1-17 years Cases | Hospital mortality | After discharge | ≥ 18 years Cases | Hospital mortality | After discharge | Total Cases | Hospital mortality | After discharge |
|----------------------------|---------------|--------------------|-----------------|--------------|-------------------|-----------------|------------------|-------------------|-----------------|------------------|-------------------|-----------------|-------------|--------------------|------------------|
| PDA                        | 1             | 0                  | 0               | 8            | 0                 | 0               | 6                | 0                 | 0               | 19               | 1 (53)           | 0               | 34          | 1 (29)            | 0                |
| Coarctation (simple)       | 4             | 0                  | 0               | 14           | 0                 | 0               | 10               | 0                 | 0               | 7                | 0                 | 0               | 35          | 0                 | 0                |
| + VSD                      | 43            | 1 (2.3)            | 0               | 41           | 1 (2.4)           | 0               | 12               | 0                 | 0               | 1                | 0                 | 0               | 97          | 2 (2.1)           | 0                |
| + DORV                     | 3             | 0                  | 0               | 0            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 3           | 0                 | 0                |
| + AVSD                     | 4             | 0                  | 0               | 1            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 5           | 0                 | 0                |
| + TGA                      | 0             | 0                  | 0               | 1            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 1           | 0                 | 0                |
| + SV                       | 2             | 0                  | 0               | 0            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 2           | 0                 | 0                |
| + Others                   | 5             | 0                  | 0               | 6            | 0                 | 0               | 12               | 0                 | 0               | 1 (8.3)          | 0                 | 0               | 23          | 0                 | 1 (4.3)          |
| Interrupt. of Ao (simple)  | 0             | 0                  | 0               | 0            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 0           | 0                 | 0                |
| + VSD                      | 21            | 1 (48)             | 0               | 35           | 1 (2.9)           | 0               | 19               | 0                 | 0               | 0                | 0                 | 0               | 75          | 2 (2.7)           | 0                |
| + DORV                     | 3             | 0                  | 0               | 0            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 0           | 0                 | 0                |
| + Truncus                  | 3             | 0                  | 0               | 6            | 0                 | 0               | 2                | 0                 | 0               | 0                | 0                 | 0               | 11          | 0                 | 0                |
| + TGA                      | 1             | 0                  | 0               | 0            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 1           | 0                 | 0                |
| + Others                   | 2             | 0                  | 0               | 1            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 4           | 0                 | 0                |
| Vascular ring              | 1             | 0                  | 0               | 3            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 4           | 0                 | 0                |
| PS                         | 2             | 0                  | 0               | 26           | 0                 | 0               | 57               | 0                 | 0               | 24               | 0                 | 0               | 109         | 0                 | 0                |
| PAIVS or Critical PS       | 14            | 0                  | 0               | 60           | 1 (1.7)           | 0               | 1 (1.7)          | 59                | 0               | 0                | 7                | 0               | 140         | 1 (0.7)           | 0                |
| TAPVR                      | 117           | 6 (5.1)            | 0               | 14 (12.0)    | 75               | 3 (4.0)          | 4 (5.3)          | 18               | 0               | 1 (5.6)          | 1                | 0               | 211         | 9 (4.3)           | 0                |
| PAPVR ± ASD                | 0             | 0                  | 0               | 6            | 0                 | 0               | 39               | 0                 | 0               | 11               | 0                 | 0               | 56          | 0                 | 0                |
| ASD                        | 1             | 0                  | 0               | 51           | 0                 | 0               | 52 (8)           | 0                 | 0               | 0                | 822              | 13 (1.6)        | 13 (1.6)    | 1402             | 13 (0.9)        |
| Cot malformation           | 0             | 0                  | 0               | 12           | 0                 | 0               | 1 (0.3)          | 5                | 0               | 0                | 0                 | 0               | 17          | 0                 | 1 (5.9)         |
| AVSD (partial)             | 1             | 0                  | 0               | 7            | 0                 | 0               | 37               | 0                 | 0               | 9                | 0                 | 0               | 54          | 0                 | 0                |
| AVSD (complex)             | 6             | 0                  | 1 (16.7)        | 106          | 0                 | 1 (0.9)         | 96               | 1 (1.2)          | 0               | 3 (5.5)          | 0                | 5                | 203         | 1 (0.5)           | 5                |
| + TOF or DORV              | 0             | 0                  | 0               | 8            | 0                 | 0               | 1 (12.5)         | 7                | 0               | 0                | 2                | 0               | 17          | 0                 | 1 (5.9)         |
| + Others                   | 0             | 0                  | 0               | 0            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 0           | 0                 | 0                |
| VSD (subarterial)          | 3             | 0                  | 0               | 94           | 1 (1.1)           | 0               | 1 (1.1)          | 169              | 0               | 0                | 5                | 0               | 271         | 1 (0.4)           | 0                |
| VSD (perimembranous)       | 15            | 0                  | 0               | 706          | 0                 | 0               | 365              | 0                 | 0               | 1 (0.3)          | 28               | 0               | 1114        | 0                 | 1 (0.1)         |
| VSD (type unknown)         | 0             | 0                  | 0               | 0            | 0                 | 0               | 1                 | 0                 | 0               | 142              | 4 (28)           | 0               | 4 (2.8)     | 143              | 4 (28)          |
| VSD + PS                   | 1             | 0                  | 0               | 37           | 0                 | 0               | 32               | 0                 | 0               | 2                | 0                 | 0               | 72          | 0                 | 0                |
| DORV ± VSD                 | 0             | 0                  | 0               | 6            | 0                 | 0               | 28               | 0                 | 0               | 4                | 0                 | 0               | 38          | 0                 | 0                |
| Aneurysm of sinus of Valsalva | 0              | 0                  | 0               | 0            | 0                 | 0               | 0                | 0                 | 0               | 0                | 0                 | 0               | 0           | 0                 | 0                |
| TOF                        | 9             | 0                  | 0               | 189          | 3 (1.6)           | 0               | 4 (2.1)          | 227              | 1 (0.4)         | 0               | 1 (0.4)           | 38          | 0           | 463              | 0 (0.9)         |
| TOF + PS                   | 1             | 0                  | 0               | 37           | 0                 | 0               | 32               | 0                 | 0               | 2                | 0                 | 0               | 72          | 0                 | 0                |
| DORV ± VSD                 | 0             | 0                  | 0               | 6            | 0                 | 0               | 28               | 0                 | 0               | 4                | 0                 | 0               | 38          | 0                 | 0                |
Table 3 (continued)

| Condition | Neonate | Infant | 1–17 years | ≥ 18 years | Total |
|-----------|---------|--------|------------|------------|-------|
|           | Cases   | 30-Day mortality | Hospital mortality | After discharge | Cases | 30-Day mortality | Hospital mortality | After discharge | Cases | 30-Day mortality | Hospital mortality | After discharge | Cases | 30-Day mortality | Hospital mortality | After discharge | Cases | 30-Day mortality | Hospital mortality | After discharge |
| PA + VSD  | 7       | 0      | 1 (14.3)   | 0          | 80    | 4 (5.0)          | 0      | 0              | 0          | 11    | 0              | 0          | 0          | 234   | 4 (1.7)         | 1 (0.4)          | 0          | 5 (2.1)          |
| DORV      | 26      | 2 (7.7)         | 0          | 3 (11.5)   | 148   | 2 (1.4)          | 0      | 4 (2.7)        | 0          | 154   | 0              | 0          | 2 (1.3)     | 239   | 4 (1.2)         | 0          | 8 (2.4)     |
| TGA (simple) | 86     | 2 (2.3)       | 0          | 5 (2.3)    | 4     | 0              | 0      | 0              | 0          | 2     | 0              | 0          | 0          | 94    | 2 (2.1)         | 0          | 2 (2.1)     |
| + VSD      | 42      | 1 (2.4)         | 0          | 3 (7.1)    | 18    | 0              | 0      | 2 (11.1)      | 0          | 10    | 0              | 0          | 2          | 0     | 72               | 1 (1.4)        | 0          | 5 (6.9)          |
| VSD + PS   | 0       | 0              | 0          | 0          | 1     | 0              | 0      | 0              | 0          | 1     | 0              | 0          | 0          | 2     | 0               | 0          | 0          |
| Corrected TGA | 0       | 0          | 0          | 0          | 8     | 0              | 0      | 0              | 0          | 25    | 0              | 0          | 0          | 10    | 0               | 1 (100)        | 0          | 1 (2.3)          |
| Truncus arteriosus | 7       | 0          | 0          | 0          | 25    | 0              | 0      | 1 (4.0)       | 0          | 22    | 0              | 0          | 1          | 0     | 55               | 0          | 1 (1.8)     |
| SV         | 17      | 2 (11.8)       | 0          | 4 (23.5)   | 138   | 2 (1.4)         | 0      | 7 (5.1)       | 179       | 3 (1.7) | 1 (0.6)        | 6 (3.4) | 22 | 1 (4.5)         | 0          | 1 (4.5)     |
| TA         | 3       | 0              | 0          | 0          | 47    | 1 (2.1)         | 0      | 3 (6.4)       | 52        | 0      | 0              | 1 (1.9) | 10 | 0               | 0          | 112         | 1 (0.9) | 4 (3.6)          |
| HLHS       | 35      | 4 (11.4)       | 0          | 11 (31.4)  | 113   | 2 (1.8)         | 0      | 6 (5.3)       | 78        | 3 (3.0) | 0              | 3 (3.8) | 0   | 0               | 0          | 226         | 9 (4.0) | 20 (8.8)         |
| Aortic valve lesion | 3    | 0              | 0          | 0          | 27    | 0              | 0      | 1 (3.7)       | 115       | 0      | 0              | 1 (0.9) | 42 | 1 (2.4)         | 0          | 1 (2.4)     |
| Mitral valve lesion | 1    | 0              | 0          | 0          | 31    | 1 (3.2)         | 0      | 3 (9.7)       | 83        | 0      | 0              | 0          | 20 | 0               | 0          | 20          | 1 (5.0) | 135         | 1 (0.7) | 0 (0.0) |
| Ebstein    | 10      | 1 (10.0)       | 0          | 1 (10.0)   | 17    | 0              | 0      | 0              | 30        | 0      | 0              | 0          | 14 | 0               | 0          | 71          | 1 (1.4) | 2 (2.8)          |
| Coronary disease | 1     | 0              | 0          | 0          | 17    | 0              | 0      | 2 (11.8)      | 25        | 0      | 0              | 0          | 4   | 0               | 0          | 47          | 0 (0.0) | 2 (4.3)          |
| Others     | 9       | 1 (11.1)       | 0          | 1 (11.1)   | 32    | 1 (3.1)         | 0      | 2 (6.3)       | 43        | 1 (2.3) | 0              | 3 (7.0) | 257 | 3 (3.3)         | 0          | 3 (3.3)     |
| Conduct failure | 1      | 0              | 0          | 0          | 0     | 0              | 0      | 0              | 20        | 0      | 0              | 0          | 6   | 0               | 0          | 27          | 0 (0.0) | 0 (0.0)          |
| Redo (excluding conduit failure) | 1 | 0 | 0 | 0 | 52 | 1 (19.2) | 0 | 2 (3.8) | 78 | 0 | 0 | 1 (1.3) | 68 | 1 (1.5) | 0 | 3 (4.4) | 199 | 2 (1.0) | 0 | 6 (3.0) |
| Total      | 508     | 21 (4.1)       | 1 (0.2)    | 42 (8.3)   | 2257  | 24 (1.1)        | 0      | 54 (2.4)      | 2772  | 9 (0.3) | 1 (0.0)        | 23 (0.8) | 1590 | 24 (1.5)       | 0          | 29 (1.8)    |

( ), % mortality

CPB, cardiopulmonary bypass; PDA, patent ductus arteriosus; VSD, ventricular septal defect; DORV, double-outlet right ventricle; AVSD, atrioventricular septal defect; TGA, transposition of great arteries; SV, single ventricle; HLHS, hypoplastic left heart syndrome; RV-PA, right ventricle-pulmonary artery; PAPVR, partial anomalous pulmonary venous return; PA-IVS, pulmonary atresia with intact ventricular septum; TAPVR, total anomalous pulmonary venous return; ASD, atrial septal defect; TOF, tetralogy of Fallot; DORV, double-outlet right ventricle; TA, tricuspid atresia; AVSD, atrioventricular septal defect; TGA, transposition of great arteries; SV, single ventricle; HLHS, hypoplastic left heart syndrome; RV-PA, right ventricle-pulmonary artery.
| Condition                                      | Neonate Cases | Hospital After discharge mortality | Infant Cases | Hospital After discharge mortality | 1-17 years Cases | Hospital After discharge mortality | ≥ 18 years Cases | Hospital After discharge mortality | Total Cases | Hospital After discharge mortality |
|-----------------------------------------------|---------------|-----------------------------------|--------------|-----------------------------------|-----------------|----------------------------------|-----------------|-----------------------------------|-------------|-----------------------------------|
| PDA                                           | 305           | 5 (1.6)                           | 12 (3.9)     | 151                               | 2 (1.3)         | 5 (3.3)                          | 25              | 0                                 | 2             | 0                                 | 483         | 7 (1.4)                           |
| Coarctation (simple)                          | 22            | 0                                 | 0             | 15                                | 0               | 1                                | 0               | 0                                 | 1            | 0                                 | 39          | 0                                 |
| + VSD                                         | 47            | 0                                 | 0             | 14                                | 0               | 1 (7.1)                          | 1               | 0                                 | 0             | 0                                 | 62          | 0                                 |
| + DORV                                        | 3             | 0                                 | 0             | 0                                 | 0               | 1                                | 0               | 0                                 | 0             | 0                                 | 4           | 0                                 |
| + AVSD                                        | 4             | 0                                 | 0             | 2 (50.0)                          | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 4           | 0                                 |
| + TGA                                         | 0             | 0                                 | 0             | 1                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 1           | 0                                 |
| + SV                                          | 0             | 0                                 | 0             | 0                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 0           | 0                                 |
| + Others                                      | 8             | 0                                 | 0             | 5                                 | 0               | 1                                | 0               | 0                                 | 0             | 0                                 | 14          | 0                                 |
| Interrupt. of Ao (simple)                     | 0             | 0                                 | 0             | 0                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 0           | 0                                 |
| + VSD                                         | 29            | 1 (3.4)                           | 2 (6.9)       | 8                                 | 0               | 2                                | 0               | 0                                 | 0             | 0                                 | 39          | 1 (2.6)                           |
| + DORV                                        | 0             | 0                                 | 0             | 0                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 0           | 0                                 |
| + Truncus                                     | 1             | 0                                 | 0             | 0                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 1           | 0                                 |
| + TGA                                         | 0             | 0                                 | 0             | 0                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 0           | 0                                 |
| + Others                                      | 2             | 0                                 | 0             | 0                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 2           | 0                                 |
| Vascular ring                                 | 5             | 0                                 | 0             | 15                                | 0               | 1 (6.7)                          | 6               | 0                                 | 0             | 0                                 | 26          | 0                                 |
| PS                                            | 4             | 0                                 | 0             | 7                                 | 0               | 1                                | 0               | 0                                 | 0             | 0                                 | 12          | 0                                 |
| PA/IVS or Critical PS                         | 15            | 0                                 | 0             | 20                                | 0               | 3                                | 0               | 1 (3.3)                           | 0             | 0                                 | 38          | 0                                 |
| TAPVR                                         | 16            | 1 (6.3)                           | 0             | 12                                | 0               | 3                                | 0               | 0                                 | 0             | 0                                 | 31          | 1 (3.2)                           |
| PAPVR ± ASD                                   | 0             | 0                                 | 0             | 0                                 | 0               | 1                                | 0               | 0                                 | 2             | 0                                 | 0           | 0                                 |
| ASD                                           | 2             | 0                                 | 0             | 2                                 | 0               | 1                                | 0               | 0                                 | 3             | 0                                 | 8           | 0                                 |
| Coarctation (total)                           | 1             | 0                                 | 0             | 2                                 | 0               | 2                                | 0               | 0                                 | 1             | 0                                 | 4           | 0                                 |
| ASD (partial)                                 | 50            | 0                                 | 0             | 2                                 | 0               | 1 (4.0)                          | 13               | 0                                 | 0             | 134                                | 3 (2.2)     |
| + TOF or DORV                                 | 3             | 0                                 | 0             | 6                                 | 0               | 2                                | 0               | 0                                 | 1             | 0                                 | 12          | 0                                 |
| + Others                                      | 0             | 0                                 | 0             | 0                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 0           | 0                                 |
| VSD (subarterial)                             | 1             | 0                                 | 0             | 6                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 7           | 0                                 |
| VSD (perimembranous)                          | 46            | 2 (4.3)                           | 0             | 4                                 | 0               | 1 (8.7)                          | 6               | 0                                 | 0             | 0                                 | 172         | 2 (1.2)                           |
| VSD (Type Unifocal)                           | 0             | 0                                 | 0             | 0                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 0           | 0                                 |
| VSD + PS                                      | 0             | 0                                 | 0             | 2                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 2           | 0                                 |
| DORV ± VSD                                    | 0             | 0                                 | 0             | 1                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 1           | 0                                 |
| Aneurysm of sinus of Valsalva                 | 0             | 0                                 | 0             | 0                                 | 0               | 0                                | 0               | 0                                 | 0             | 0                                 | 0           | 0                                 |
| TOF                                           | 19            | 0                                 | 0             | 82                                | 0               | 11                               | 0               | 0                                 | 2             | 0                                 | 114         | 0                                 |
### Table 3 (continued)

|                | Neonate | Infant | 1–17 years | ≥ 18 years | Total |
|----------------|---------|--------|------------|------------|-------|
|                | Cases   | Hospital After discharge | Hospital After discharge | Hospital After discharge | Hospital After discharge |
| **Cases**      |         |                     |                     |                     |       |
| **30-Day mortality** |         |                     |                     |                     |       |
| PA + VSD       | 15      | 1 (67)             | 0                    | 1 (67)             | 0      |
| DORV           | 48      | 1 (2.2)            | 1 (1.4)              | 2 (2.7)            | 12     |
| TGA (single)   | 4       | 0                   | 0                    | 0                   | 0      |
| + VSD          | 13      | 0                   | 0                    | 0                   | 0      |
| VSD + PS       | 0       | 0                   | 0                    | 0                   | 0      |
| Corrected TGA  | 6       | 0                   | 0                    | 9                   | 0      |
| Transc aa      | 18      | 0                   | 1 (5.6)              | 0                   | 5      |
| SV             | 48      | 2 (42)              | 0                    | 2 (3.5)            | 20     |
| TA             | 14      | 0                   | 0                    | 3                   | 0      |
| HLHS           | 80      | 1 (13)              | 0                    | 3 (3.8)            | 28     |
| Aortic valve lesion | 5      | 0                   | 0                    | 2                   | 0      |
| Mitral valve lesion | 3      | 0                   | 0                    | 5                   | 0      |
| Ebstein        | 6       | 1 (16.7)            | 0                    | 3                   | 0      |
| Coronary disease | 0       | 0                   | 0                    | 8                   | 0      |
| Others         | 9       | 0                   | 2 (22.2)             | 13                  | 2 (15.4)|
| Conduct failure | 0       | 0                   | 0                    | 0                   | 0      |
| redo (excluding conduit failure) | 26   | 0                   | 0                    | 113                 | 2 (13.8)|
| Total          | 875     | 14 (1.6)            | 0                    | 35 (4.0)           | 905    |

CPR = cardiopulmonary bypass; PDA = patent ductus arteriosus; VSD = ventricular septal defect; DORV = double-outlet right ventricle; AVSD = atroventricular septal defect; TGA = transposition of the great arteries; SV = single ventricle; Interrupt. of Ao = interruption of aorta; PDA-IVS = pulmonary atresia with intact ventricular septum; TAPVR = total anomalous pulmonary venous return; PAPVR = partial anomalous pulmonary venous return; ASD = atrial septal defect; TOF = tetralogy of Fallot; DCRV = double-chambered right ventricle; TA = tricuspid atresia; HLHS = hypoplastic left heart syndrome; RV-PA = right ventricle-pulmonary artery.
| Procedure                                | Cases | 30-Day mortality | Hospital mortality | After discharge | Cases | 30-Day mortality | Hospital mortality | After discharge | Cases | 30-Day mortality | Hospital mortality | After discharge | Cases | 30-Day mortality | Hospital mortality | After discharge |
|------------------------------------------|-------|------------------|--------------------|------------------|-------|------------------|--------------------|------------------|-------|------------------|--------------------|------------------|-------|------------------|--------------------|------------------|
| SP Shunt                                | 102   | 2 (2.0)          | 0                  | 3 (2.9)          | 360   | 6 (1.7)          | 1 (0.3)            | 10 (2.8)         | 50    | 0                | 4 (8.0)            | 1 (0.3)          | 1     | 0                | 0                  | 513             |
| PAB                                      | 275   | 2 (0.7)          | 0                  | 9 (3.3)          | 304   | 0                | 0                  | 5 (1.6)          | 20    | 0                | 0                  | 0                | 0     | 0                | 0                  | 601             |
| Bidirectional Glenn or hemi-Fontan ± ±   | 1     | 0                | 0                  | 257              | 1 (0.4) | 0                  | 5 (1.9)            | 98               | 2 (2.0) | 0                | 3 (31)             | 3                | 0     | 0                | 0                  | 359             |
| Doman-Keys-Starr operation               | 0     | 0                | 0                  | 27               | 0      | 0                | 2 (7.4)            | 8                | 0      | 0                | 0                  | 1                | 0     | 0                | 0                  | 36              |
| PA reconstruction/repair (including redo)| 16    | 0                | 0                  | 1 (63)           | 180   | 2 (1.1)          | 0                  | 4 (2.2)          | 195   | 0                | 3 (1.5)            | 16               | 0     | 0                | 0                  | 407             |
| Rastelli procedure                       | 5     | 0                | 1 (20)             | 0                | 208   | 2 (1.0)          | 0                  | 3 (1.4)          | 309   | 1 (0.3)          | 0                  | 1 (0.3)          | 43    | 0                | 0                  | 565             |
| Rastelli procedure                       | 2     | 0                | 0                  | 40               | 1 (2.0) | 0                  | 1 (2.0)            | 114              | 0      | 0                | 1 (0.9)            | 2                | 0     | 0                | 0                  | 167             |
| Arterial switch procedure                | 140   | 6 (43)           | 0                  | 9 (6.4)          | 23    | 1 (4.3)          | 0                  | 2 (8.7)          | 2     | 0                | 0                  | 0                | 0     | 0                | 0                  | 165             |
| Atrial switch procedure                  | 9     | 0                | 0                  | 0                | 0      | 0                | 4                  | 0               | 0      | 2                | 0                  | 0                | 2     | 0                | 0                  | 6               |
| Double switch procedure                  | 0     | 0                | 0                  | 1                | 0      | 0                | 6                  | 0               | 0      | 0                | 0                  | 0                | 0     | 0                | 0                  | 7               |
| Repair of anomalous origin of CA        | 0     | 0                | 0                  | 9                | 0      | 0                | 2 (22)             | 4                | 0      | 0                | 0                  | 0                | 0     | 13               | 0                  | 2 (15.4) |
| Closure of coronary AV fistula           | 1     | 0                | 0                  | 4                | 0      | 0                | 6                  | 0               | 0      | 2                | 0                  | 0                | 0     | 13               | 0                  | 0               |
| Fontan/CPC                               | 0     | 0                | 0                  | 1                | 0      | 0                | 355                | 1 (0.3)          | 44    | 1 (2.5)          | 0                  | 1 (0.9)          | 43    | 0                | 0                  | 565             |
| Norwood procedure                        | 31    | 3 (97)           | 0                  | 5 (16.1)         | 95    | 7 (7.4)          | 0                  | 14 (14.7)        | 4     | 1 (25.0)        | 0                  | 1 (25.0)        | 0     | 0                | 0                  | 130             |
| Ventricular septation                    | 0     | 0                | 0                  | 0                | 0      | 0                | 0                  | 0               | 0      | 0                | 0                  | 0                | 0     | 0                | 0                  | 0               |
| Left side AV valve repair (including Redo)| 0    | 0                | 0                  | 23               | 0      | 0                | 88                | 0               | 0      | 17               | 0                  | 0                | 128  | 0                | 0                  | 0               |
| Left side AV valve replace (including Redo)| 1   | 0                | 0                  | 0                | 10     | 0                | 1 (10.0)           | 46               | 0      | 0                | 1 (22)             | 18               | 0     | 2 (11)           | 0                 | 75              |
| Right side AV valve repair (including Redo)| 12  | 2 (16.7)         | 0                  | 2 (16.7)         | 71    | 0                | 0                  | 81               | 0      | 0                | 67               | 0                | 0     | 1 (1.5)          | 0                 | 231             |
| Right side AV valve replace (including Redo)| 0  | 0                | 0                  | 1                | 0      | 0                | 9                  | 1 (11.1)         | 1     | 0 (11.1)        | 26               | 0                | 0     | 36               | 1 (2.8)            | 0               |
| Common AV valve repair (including Redo)   | 3     | 0                | 0                  | 2 (66.7)         | 17    | 0                | 1 (59)             | 11               | 0      | 0                | 0                  | 0                | 2     | 0                | 0                  | 33              |
| Common AV valve replace (including Redo)  | 0     | 0                | 0                  | 4                | 1 (25.0) | 0              | 2 (50.0)           | 7                | 0      | 1 (14.3)        | 0                  | 2                | 0     | 0                | 0                  | 13              |
| Common AV valve replace (including Redo)  | 0     | 0                | 0                  | 5                | 0      | 0                | 1 (20.0)           | 16               | 0      | 0                | 0                  | 1                | 0     | 0                | 0                  | 22              |
| Repair of supraspastic stenosis           | 0     | 0                | 0                  | 8                | 0      | 0                | 42                | 0               | 0      | 5                | 0                  | 0                | 0     | 55               | 0                  | 0               |
| Repair of subarachnoid stenosis           | 4     | 0                | 0                  | 15               | 0      | 0                | 1 (6.7)            | 29               | 0      | 0                | 0                  | 5                | 0     | 0                | 0                  | 53              |
| Aortic valve plasty ± VSD Closure         | 0     | 0                | 0                  | 32               | 0      | 0                | 30                | 1 (3.3)          | 64    | 1 (1.6)          | 0                  | 1 (1.6)          | 64    | 1 (1.6)          | 0                  | 1 (1.6)         |
| Aortic valve replacement                  | 0     | 0                | 0                  | 3                | 0      | 0                | 9                  | 0               | 0      | 1 (11.1)        | 2                | 0                | 0     | 14               | 0                  | 1 (7.1)         |
| Aortic root replacement (except Ross)     | 0     | 0                | 0                  | 8                | 0      | 0                | 19                | 0               | 0      | 0                | 0                  | 27               | 0     | 0                | 0                  | 0               |
| Ross procedure                           | 0     | 0                | 0                  | 3                | 0      | 0                | 13                | 0               | 0      | 0                | 0                  | 0                | 16    | 0                | 0                  | 0               |
| 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   | Hospital           |       | After discharge   | Hospital           |       | After discharge   | Hospital           |       | After discharge   | Hospital           |
| 29    | Bilateral pulmonary artery banding | 175 (5.9) | 14 (0.0) | 8 | 0 | 0 | 1 (1.2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 183 | 5 (2.7) | 0 | 15 (0.2) |
| Total |                  | 768 (26) | 1 (0.1) | 45 | 5 (5.9) | 1668 | 21 (1.2) | 1 (0.1) | 1564 | 6 (0.4) | 1 (0.1) | 207 | 3 (1.3) | 0 | 6 (2.0) | 4327 | 50 (1.2) | 3 (0.07) | 126 (2.9) |

( ), % 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 atrioventricular valve, VSD ventricular septal defect, AVR aortic valve replacement
Table 4  Acquired (total, (1) + (2) + (4) + (5) + (6) + (7) + isolated operations for arrhythmia in (3); 39,307
(1) Valvalar heart disease (total; 23,205)

|        | Value | Cases | Operation | 30-Day mortality | Hospital mortality | Redo | TAVR Cases 30-Day mortality | Hospital mortality |
|--------|-------|-------|-----------|------------------|-------------------|------|---------------------------|-------------------|
|        |       |       |           | Replace | Repair | Replace | Repair | Cases | 30-Day mortality | Hospital mortality |
|        |       |       |           |         |         |         |         |       |               |                   |
| Isolated | A     | 10,584| Mechanical | 1512   | 261     | 2562    | 168    | 2 (0.8) | 7 (0.1) | 295 (3.0) | 6 (2.3) | 688 | 33 (4.8) | 0 | 53 (7.7) |
|         | M     | 4898  | Bioprosthesis | 479    | 887     | 3447    | 577    | 35 (1.0) | 0 | 97 (7.1) | 50 (1.5) | 505 | 15 (2.5) | 0 | 35 (5.9) |
|         | T     | 596   | Repair | 8      | 84      | 495     | 63     | 9 (1.8) | 0 | 8 (8.7) | 24 (4.9) | 113 | 3 (2.7) | 0 | 11 (9.7) |
|         | P     | 22    | With CABG | 0      | 17      | 5       | 1      | 2 (40) | 0 | 0 | 2 (40) | 12 | 0 | 0 | 0 |
|         | A + M | 1326  |           | 206    | 950     | 48      | 52     |         | 0 | 99 (7.5) | 133 | 4 (3.0) | 0 | 13 (9.8) |
|         | A     | 236   |         | 950    | 48      | 52     |         | 0 | 36 (6.0) | 69 | 4 (5.8) | 0 | 5 (7.3) |
|         | M     | 186   |         | 378    | 727     | 35     |         | 0 | 36 (6.0) | 69 | 4 (5.8) | 0 | 5 (7.3) |
|         | A + T | 599   |         | 95     | 17      | (2.8)    | 0     | 36 (6.0) | 69 | 4 (5.8) | 0 | 5 (7.3) |
|         | A     | 68    |         | 491    | 16      | 24     |         | 0 | 36 (6.0) | 69 | 4 (5.8) | 0 | 5 (7.3) |
|         | M     | 1     |         | 11     | 574     | 13     |         | 0 | 36 (6.0) | 69 | 4 (5.8) | 0 | 5 (7.3) |
|         | T     | 1     |         | 1      | 547     | 13     |         | 0 | 36 (6.0) | 69 | 4 (5.8) | 0 | 5 (7.3) |
|         | M + T | 3937  |         | 371    | 74      | (19)    | 0     | 128 (3.3) | 474 | 16 (3.4) | 0 | 33 (7.0) |
|         | M     | 330   |         | 1070   | 2437    | 60     |         | 0 | 128 (3.3) | 474 | 16 (3.4) | 0 | 33 (7.0) |
|         | T     | 1     |         | 56     | 3847    | 33     |         | 0 | 128 (3.3) | 474 | 16 (3.4) | 0 | 33 (7.0) |
|         | A + M + T | 1135 |         | 117    | 49      | (4.3)    | 0     | 72 (6.3) | 138 | 10 (7.3) | 0 | 14 (10.0) |
|         | A     | 200   |         | 876    | 23      | 36     |         | 0 | 72 (6.3) | 138 | 10 (7.3) | 0 | 14 (10.0) |
|         | M     | 147   |         | 422    | 536     | 30     |         | 0 | 72 (6.3) | 138 | 10 (7.3) | 0 | 14 (10.0) |
|         | T     | 0     |         | 10     | 1116    | 9      |         | 0 | 72 (6.3) | 138 | 10 (7.3) | 0 | 14 (10.0) |
| Others  | 108   |       |         | 15     | 0       | 0       | 2 (1.9) | 2 (0.0) | 2 (1.9) | 22 | 0 | 0 | 1 (4.6) |
| Total   | 23,205|       |         | 4007   | 479      | (2.1)   | 7 (0.03) | 819 (3.5) | 2444 | 85 (3.7) | 0 | 165 (7.4) |

|        | TAVR | Cases | 30-Day mortality |
|--------|------|-------|------------------|
|        |      |       |                  |
|        | 6630 | 69 | (1.0) |

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Table 4 (continued)

(2) Ischemic heart disease (total, (A) + (B)), 13,445

(A) Isolated CABG (total, (a) + (b)), 12,135

(a-1) On-pump arrest CABG (total, 2662)

| Cases | 30 Day mortality | Hospital mortality | Hospital After discharge | 30 Day mortality | Hospital mortality | Hospital After discharge | 30 Day mortality | Hospital mortality | Hospital After discharge | 30 Day mortality | Hospital mortality | Hospital After discharge | 30 Day mortality | Hospital mortality | Hospital After discharge | 30 Day mortality | Hospital mortality | Hospital After discharge |
|-------|------------------|--------------------|--------------------------|------------------|--------------------|-------------------------|------------------|--------------------|------------------------|------------------|--------------------|--------------------------|------------------|--------------------|------------------------|------------------|--------------------|------------------------|
| 1VD   | 56               | (1.8)              | 1                        | 5                | 0                  | 0                       | 0                | 0                  | 0                      | 2                | 0                  | 0                       | 0                | 23                | 27                     | 11                | 1                  | 1                      |
| 2VD   | 292              | 0                  | 3 (1.0)                  | 35               | 2 (5.7)            | 0                       | 4 (11.4)          | 2                  | 0                       | 0                      | 0                | 0                  | 0                       | 0                | 38                | 273                    | 16                | 0                  | 2                      |
| 3VD   | 985              | 11 (1.1)           | 0                        | 129              | 10 (7.8)           | 0                       | 15 (12.6)         | 1                  | 0                       | 0                      | 0                | 0                  | 0                       | 0                | 52                | 1010                    | 41                | 7                  | 5                      |
| LMT   | 832              | 8 (1.0)            | 14 (1.7)                 | 226              | 14 (6.2)           | 0                       | 17 (7.5)          | 8                  | 0                       | 0                      | 0                | 0                  | 3                       | 0                | 86                | 916                     | 60                | 2                  | 5                      |
| No info | 70               | 0                  | 0                        | 15               | 1 (6.7)            | 0                       | 1 (6.7)           | 0                  | 0                       | 0                      | 0                | 0                  | 1                       | 0                | 1 (100.0)        | 23                     | 48                | 9                  | 2                      |
| Total  | 2235             | 20 (0.9)           | 37 (1.7)                 | 410              | 27 (6.6)           | 0                       | 37 (9.0)          | 11                 | 0                       | 0                      | 0                | 0                  | 6                       | 0                | 2 (33.3)        | 222                     | 2275              | 137               | 12                     |
| Kawasaki | 4              | 0                  | 0                        | 1                | 0 (0.0)            | 0                       | 0                | 0                  | 0                      | 0                | 0                  | 0                       | 0                | 2                  | 2                     | 1                  | 0                  | 0                      |
| On dialysis | 251         | 5 (2.0)           | 11 (4.4)                 | 41               | 8 (19.5)           | 0                       | 12 (20.3)        | 4                  | 0                       | 0                      | 0                | 0                  | 3                       | 1 (33.3)        | 0                  | 1 (33.3)               | 9                  | 262                | 22                      |

(2-1) On-pump beating CABG (total, 2276)

| Cases | 30 Day mortality | Hospital mortality | Hospital After discharge | 30 Day mortality | Hospital mortality | Hospital After discharge | 30 Day mortality | Hospital mortality | Hospital After discharge | 30 Day mortality | Hospital mortality | Hospital After discharge | 30 Day mortality | Hospital mortality | Hospital After discharge | 30 Day mortality | Hospital mortality | Hospital After discharge |
|-------|------------------|--------------------|--------------------------|------------------|--------------------|-------------------------|------------------|--------------------|------------------------|------------------|--------------------|--------------------------|------------------|--------------------|------------------------|------------------|--------------------|------------------------|
| 1VD   | 27               | 0                  | 0                        | 0 (0.0)          | 11                 | 1 (9.1)                 | 0                | 1 (9.1)            | 2                      | 0                | 0                  | 0                       | 0                | 0                  | 0                      | 13                | 21                | 6                       |
| 2VD   | 196              | 6 (3.0)            | 0                        | 11 (5.8)         | 41                 | 5 (12.2)                | 0                | 8 (19.5)          | 5                      | 0                | 0                  | 1                       | 0                | 0                  | 0                      | 45                | 174               | 17                      |
| 3VD   | 680              | 5 (0.7)            | 0                        | 13 (1.9)         | 193                | 15 (7.8)                | 0                | 21 (10.9)         | 4                      | 0                | 0                  | 1 (25.0)                | 0                | 0                  | 0                      | 73                | 360               | 40                      |
| LMT   | 609              | 7 (1.0)            | 0                        | 14 (2.1)         | 341                | 26 (7.6)                | 1 (0.3)          | 39 (11.4)         | 17                     | 1                | 5 (9)               | 1 (5.9)                  | 0                | 0                  | 0                      | 157               | 798               | 65                      |
| No info | 49               | 0 (0.8)            | 0                        | 0                 | 0                  | 0 (0.0)                | 0                | 0 (0.0)           | 0                      | 0                | 0                  | 0                       | 0                | 0                  | 0                      | 11                | 55                | 12                      |
| Total  | 1600             | 18 (1.1)           | 0                        | 38 (2.3)         | 612                | 46 (7.8)                | 1 (0.2)          | 72 (11.8)         | 29                     | 1                | 3 (4)               | 2 (6.9)                  | 0                | 0                  | 0                      | 299               | 1808              | 140                     |
| Kawasaki | 3               | 0                  | 0                        | 0                 | 0                  | 0 (0.0)                | 0                | 0 (0.0)           | 0                      | 0                | 0                  | 0                       | 0                | 3                  | 0                      | 0                  | 0                  | 0                      |
| On dialysis | 221         | 11 (5.0)           | 0                        | 23 (10.4)        | 87                 | 11(12.6)                | 1 (1.1)          | 13 (14.9)         | 6                      | 1                | 16.7                | 1 (33.3)                 | 2                | 0                  | 0                      | 34                | 284               | 30                      |

(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
Table 4 (continued)

(b) Off-pump CABG (total: 7197)

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.

|               | Primary, elective | Primary, emergent | Redo, elective | Redo, emergent | Artery only | Artery +SVG only | SyG only | Others | Unclear |
|---------------|------------------|-------------------|----------------|----------------|-------------|------------------|----------|--------|---------|
| Cases         | 6077             | 37 (0.6)          | 65 (1.1)       | 1055           | 34 (3.2)    | 50 (4.7)        | 3 (5.4)  | 9      | 1 (11.1) |
| 1VD           | 314              | 3 (1.0)           | 4 (1.3)        | 43             | 0           | 0                | 1 (2.3)  | 8      | 0       |
| 2VD           | 935              | 6 (0.6)           | 8 (0.9)        | 129            | 1 (0.8)     | 0                | 3 (2.3)  | 9      | 0       |
| 3VD           | 2401             | 21 (0.9)          | 38 (1.6)       | 317            | 14 (4.4)    | 0                | 19 (60)  | 13     | 0       |
| LMT           | 2252             | 6 (0.3)           | 2 (0.1)        | 525            | 19 (36)     | 0                | 25 (48)  | 18     | 0       |
| No info       | 175              | 1 (0.6)           | 1 (0.6)        | 41             | 0           | 0                | 2 (4.9)  | 8      | 0       |
| Total         | 6077             | 37 (0.6)          | 3 (0.0)        | 1055           | 34 (3.2)    | 0                | 50 (4.7) | 56     | 0       |
| Kawasaki      | 15               | 0                 | 0              | 0              | 0           | 0                | 0        | 0      | 0       |
| On dialysis   | 738              | 14 (1.9)          | 1 (0.1)        | 31 (4.2)       | 127 (5.5)   | 0                | 11 (8.7) | 13     | 0       |

(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

(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)]

|               | Primary, elective | Primary, emergent | Redo, elective | Redo, emergent | Artery only | Artery +SVG only | SyG only | Others | Unclear |
|---------------|------------------|-------------------|----------------|----------------|-------------|------------------|----------|--------|---------|
| Cases         | 150              | 2 (1.3)           | 5 (3.3)        | 37             | 5 (13.5)    | 0                | 6 (16.2) | 2      | 0       |
| Converted to arrest | 30       | 0                 | 0              | 2 (6.7)        | 4           | 0                | 0        | 1      | 0       |
| Converted to beating | 120     | 2 (1.7)           | 0              | 3 (2.5)        | 33          | 5 (15.2)        | 6 (18.2) | 1      | 0       |
| Total         | 150              | 2 (1.3)           | 5 (3.3)        | 37             | 5 (13.5)    | 0                | 6 (16.2) | 2      | 0       |
| On dialysis   | 24               | 2 (8.3)           | 0              | 5 (208)        | 9           | 3 (33.3)        | 4 (44.4) | 1      | 0       |

(1). % mortality
CABG coronary artery bypass grafting
### Table 4 (continued)

#### (B) Operation for complications of MI (total; 1310)

| Concomitant operation | Chronic | Acute | Hospital mortality | Hospital mortality | Total | 30-Day mortality | 30-Day mortality |
|-----------------------|---------|-------|--------------------|--------------------|-------|-----------------|-----------------|
|                       | Cases   | Hospital | After discharge | Hospital | After discharge | CABG | MVP | MVR | CABG | MVP | MVR |
| Infarctectomy or Aneurysmectomy | 108 | 6 (5.6) | 0 | 7 (6.5) | 26 | 5 (19.2) | 0 | 8 (30.8) | 77 | 24 | 13 |
| VSP closure | 78 | 12 (15.4) | 0 | 20 (25.6) | 284 | 68 (23.9) | 0 | 112 (39.4) | 95 | 3 | 3 |
| Cardiac rupture | 25 | 5 (20.0) | 0 | 5 (20.0) | 227 | 72 (31.7) | 0 | 87 (38.3) | 32 | 4 | 2 |
| Mitral regurgitation | | | | | | | | | | | |
| (1) Papillary muscle rupture | 8 | 1 (12.5) | 0 | 1 (12.5) | 58 | 22 (37.9) | 0 | 23 (39.7) | 29 | 11 | 55 |
| (2) Ischemic | 250 | 10 (4.0) | 0 | 18 (7.2) | 50 | 9 (18.0) | 0 | 10 (20.0) | 221 | 169 | 131 |
| Others | 89 | 4 (4.5) | 0 | 7 (7.9) | 107 | 23 (21.5) | 0 | 36 (33.6) | 68 | 13 | 6 |
| Total | 558 | 38 (6.8) | 0 | 38 (6.8) | 752 | 199 (26.5) | 0 | 236 (36.7) | 522 | 224 | 210 |

( ), % 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; 5334)

| Concomitant operation | Cases | Hospital mortality | Hospital mortality | Concomitant operation | Isolated | Congenital | Valve | IHD | Others | Multiple combination |
|-----------------------|-------|--------------------|--------------------|-----------------------|-----------|-----------|-------|-----|--------|---------------------|
|                       | Hospital | After discharge | | Isolated | 2 Categories | 3 Categories | | | | |
| Maze | 3274 | 64 (2.0) | 2 (0.06) | 106 (3.2) | 136 | 177 | 2792 | 540 | 292 | 637 | 43 |
| For WPW | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 |
| For ventricular tachycardia | 33 | 1 (3.0) | 0 | 1 (3.0) | 3 | 0 | 15 | 18 | 3 | 0 | 0 |
| Others | 2024 | 39 (1.9) | 0 | 65 (3.2) | 31 | 113 | 1708 | 359 | 200 | 397 | 32 |
| Total | 5334 | 104 (1.9) | 2 (0.04) | 172 (3.2) | 170 | 290 | 4516 | 919 | 495 | 1034 | 75 |

( ), % mortality
Except for 170 isolated cases, all remaining 5,164 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
### Table 4 (continued)

(4) Operation for constrictive pericarditis (total: 210)

|                  | CPB (+) |          |          | CPB (-) |          |          |
|------------------|---------|----------|----------|---------|----------|----------|
|                  | Cases   | 30-Day mortality | Hospital mortality | Cases   | 30-Day mortality | Hospital mortality |
|                  |         | Hospital | After discharge |         | Hospital | After discharge |
| Total            | 95      | 4 (4.2)  | 0         | 115     | 10 (8.7) | 0         |

( ), % mortality

CPB cardiopulmonary bypass

(5) Cardiac tumor (total: 725)

|                  | Cases   | 30-Day mortality | Hospital mortality | Concomitant operation |
|------------------|---------|------------------|-------------------|-----------------------|
|                  |         | Hospital | After discharge |          | AVR | MVR | CABG | Others |
| Benign tumor     | 625     | 1 (0.2)  | 0         | 9 (1.4)   | 25  | 12  | 45   | 138    |
| (Cardiac myxoma) | 427     | 5 (1.2)  | 0         | 2 (0.5)   | 10  | 5   | 24   | 79     |
| Malignant tumor  | 100     | 3 (3.0)  | 0         | 5 (5.0)   | 1   | 5   | 5    | 22     |
| (Primary)        | 9       | 0       | 0         | 0         | 0   | 1   | 1    | 2      |

( ), % mortality

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

(6) HOCM and DCM (total: 338)

|                  | Cases   | 30-Day mortality | Hospital mortality | Concomitant operation |
|------------------|---------|------------------|-------------------|-----------------------|
|                  |         | Hospital | After discharge |          | AVR | MVR | MVP | CABG |
| Myectomy         | 348     | 5 (3.4)  | 0         | 6 (4.1)   | 61  | 17  | 24  | 14    |
| Myotomy          | 12      | 0       | 0         | 1 (8.3)   | 2   | 1   | 3   | 2     |
| No-resection     | 171     | 8 (4.7)  | 0         | 14 (8.2)  | 27  | 93  | 78  | 20    |
| Volume reduction surgery of the left ventricle | 7 | 0 | 0 | 0 | 1 | 1 | 2 | 0 |
| Total            | 338     | 13 (3.8) | 0         | 21 (6.2)  | 91  | 112 | 107 | 36    |

( ), % 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

Pulmonary hypertension

( ), % mortality
Among the 9253 procedures for congenital heart disease conducted in 2018, 7130 were open-heart surgeries, with an overall hospital mortality rate of 2.1%. The number of surgeries for neonates and infants in 2018 did not differ significantly compared to that in 2008; however, hospital mortality improved from 10.8 to 8.3% for neonates and from 3.8 to 2.4% for infants. In 2018, atrial septal defect was the most common disease (1402 cases), with patients aged 18 or older accounting for 58.6% of atrial septal defect surgery. Ventricular septal defect (perimembranous/muscular), which had been the most common disease in 2015 and 2016, was the second most common disease (1114 cases).

Within the past 10 years, hospital mortality for complex congenital heart disease was as follows (2008 [2], 2013 [3], and 2018): complete atrio-ventricular septal defect (3.5%, 0.6%, and 2.5%, respectively); tetralogy of Fallot (1.8%, 1.4%, and 1.1%, respectively); transposition of the great arteries with intact septum (3.8%, 3.6%, and 2.1%, respectively), ventricular septal defect (5.5%, 5.2%, and 6.9%, respectively), and single ventricle (5.5%, 5.7%, and 5.1%, respectively); and hypoplastic left heart syndrome (12.9%, 9.1%, and 8.8%, respectively). Currently, right heart bypass surgery has been commonly performed (359 bidirectional Glenn procedures excluding 36 Damus–Kaye–Stansel procedures and 395 Fontan-type procedures including total cavopulmonary connection) with acceptable hospital mortality rates (2.2% and 1.5%). The Norwood type I procedure was performed in 130 cases, with a relatively low hospital mortality rate (15.4%).

The total number of valvular heart disease procedures, excluding transcatheter procedures, was slightly lower than that in the previous year. Moreover, the number of isolated aortic valve replacement/repair with/without coronary artery bypass grafting (CABG) (n = 10,584) was 1.0% lower than that in the previous year (n = 10,690) but 2.0% higher than that 5 years ago (n = 10,379), despite the rapid utilization of transcatheter aortic valve replacement (n = 6610 in 2018). The number of isolated mitral valve replacement/repair with/without CABG (n = 4898) was 4.5% higher than that in the previous year (n = 4687) and 2.2% higher than that 5 years ago (n = 4793). A total of 10,744 and 2757 cases underwent aortic and mitral valve replacement with bioprosthesis, respectively. The rate at which bioprosthesis was utilized had increased dramatically from 30% in the early 2000s [4, 5] to 83.9% and 70.0% in 2018 for aortic and mitral valve positions, respectively. Additionally, CABG was performed as a concomitant procedure in 17.3% of all valvular procedures (16.7% in 2008 [2] and 17.8% in 2013 [3]). Valve repair had been popular for mitral and tricuspid valve positions (7147 and 6032 cases, respectively), but had been less frequently observed for aortic valve positions (348 patients, only 2.6%...
Table 5  Thoracic aortic aneurysm (total: 21,624)
(1) Dissection (total: 10,453)

| Replaced site          | Acute | Chronic |
|------------------------|-------|---------|
|                        | A     | B       |
|                        | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality | Cases | 30-Day mortality | Hospital mortality |
|                        |       | Hospital | After discharge |       | Hospital | After discharge |       | Hospital | After discharge |       | Hospital | After discharge |
| Ascending Ao           | 2254  | 169 (7.2) | 1 (0.04)       | 282 (8.6) | 3 | 1 (33.3) | 0       | 1 (33.3) | 231 | 7 (3.0) | 0       | 13 (5.6) | 6 | 0 | 0 | 0       | 106 | 137 | 18 | 12 | 134 | 116 |
| Aortic Root            | 218   | 35 (14.7) | 0       | 42 (17.6) | 0 | 0 | 0       | 0       | 81 | 7 (8.6) | 1 (1.2) | 8 (9.9) | 5 | 0 | 0 | 0       | 45 | 200 | 5 | 5 | 73 | 16 |
| Arch                   | 1956  | 151 (7.7) | 3 (0.15)     | 198 (101) | 32 | 3 (9.4) | 0       | 4 (12.5) | 410 | 8 (2.0) | 0       | 10 (2.4) | 177 | 5 (28) | 0 | 6 (3.4) | 84 | 113 | 9 | 7 | 123 | 76 |
| Aortic root + asc. Ao + Arch | 186  | 23 (12.4) | 0       | 26 (14.0) | 0 | 0 | 0       | 0       | 39 | 2 (5.1) | 0       | 2 (5.1) | 7 | 1 (14.3) | 0 | 1 (14.3) | 27 | 135 | 4 | 0 | 46 | 8 |
| Ascending Ao           | 60    | 9 (15.0) | 0       | 9 (15.0) | 30 | 3 (10.0) | 0       | 4 (13.3) | 73 | 2 (2.7) | 0       | 3 (41) | 262 | 11 (4.2) | 2 (0.8) | 12 (4.6) | 1 | 7 | 0 | 0 | 7 | 3 |
| Thoracoabdominal       | 15    | 2 (13.3) | 0       | 2 (13.3) | 13 | 2 (15.4) | 0       | 2 (15.4) | 55 | 4 (7.3) | 0       | 4 (7.3) | 212 | 9 (42) | 0 | 16 (7.5) | 1 | 0 | 0 | 0 | 3 | 2 |
| Simple TEVAR           | 68    | 9 (13.2) | 0       | 9 (13.2) | 327 | 16 (4.9) | 1 (0.3) | 23 (7.0) | 205 | 1 (0.5) | 0       | 2 (10) | 1032 | 15 (15.5) | 2 (0.2) | 21 (2.0) | 0 | 1 | 0 | 0 | 1 | 5 |
| Open SG with BR        | 175   | 36 (20.4) | 1 (0.11) | 102 (11.7) | 35 | 3 (8.6) | 0       | 4 (11.4) | 187 | 10 (5.3) | 0       | 13 (7.0) | 212 | 3 (14) | 1 (0.5) | 6 (2.8) | 38 | 106 | 6 | 2 | 83 | 29 |
| Open SG without BR     | 362   | 33 (9.1) | 0       | 44 (12.2) | 25 | 4 (16.0) | 0       | 4 (16.0) | 47 | 1 (2.1) | 0       | 4 (8.5) | 82 | 2 (24) | 0 | 3 (7.7) | 34 | 37 | 1 | 0 | 26 | 9 |
| Arch TEVAR with BR     | 18    | 0       | 0       | 85 | 0 | 5 (6.0) | 0       | 2 (24) | 47 | 0 | 0       | 0       | 298 | 2 (0.7) | 1 (0.3) | 5 (1.7) | 0 | 0 | 0 | 0 | 0 | 13 |
| Thoracoabdominal TEVAR with BR | 6    | 2 (33.3) | 0       | 2 (33.3) | 15 | 0 | 0       | 0       | 7 | 0 | 0       | 0       | 43 | 3 (7.0) | 0 | 5 (11.6) | 0 | 1 | 0 | 0 | 1 | 2 |
| Other                  | 21    | 9 (42.9) | 0       | 10 (47.6) | 3 | 1 (33.3) | 0       | 1 (33.3) | 2 | 0 | 0       | 0       | 8 | 1 (12.5) | 0 | 1 (12.5) | 0 | 0 | 0 | 0 | 1 | 3 |
| Total                  | 6157  | 398 (6.5) | 5 (0.8) | 646 (10.5) | 568 | 33 (5.8) | 1 (0.2) | 45 (7.9) | 1384 | 42 (3.0) | 1 (0.1) | 59 (4.3) | 2344 | 52 (2.2) | 6 (0.3) | 76 (3.2) | 336 | 757 | 43 | 26 | 498 | 282 |

(1). % mortality
As aorta, AVP aortic valve repair, AVR aortic valve replacement, MVP mitral valve repair, MVR mitral valve replacement, CABG coronary artery bypass grafting, TEVAR thoracic endovascular aortic (aneurysm) repair
Acute: within 2 weeks from the onset
Table 5 (continued)
(2) Non-dissection (total; 11,171)

| Replaced site | Unruptured Cases | 30-Day mortality Hospital After discharge | Hospital mortality | Ruptured Cases | 30-Day mortality Hospital After discharge | Hospital mortality | Concurrent operation |
|---------------|------------------|------------------------------------------|--------------------|---------------|------------------------------------------|--------------------|----------------------|
|               |                  | Hospital After discharge |                    | Hospital After discharge |                         |                    | AVP | AVR | MVP | MVR | CABG | Others |
| Ascending Ao  | 1366             | 29 (2.1)                  | 0                   | 45 (3.3)       | 53                         | 11 (20.8)           | 0   | 12 (22.6) | 68  | 974 | 111  | 48  | 183  | 252  |
| Aortic Root   | 1125             | 31 (2.8)                  | 0                   | 41 (3.6)       | 47                         | 9 (19.1)            | 0   | 11 (23.4) | 226 | 803 | 71   | 30  | 188  | 156  |
| Arch          | 2198             | 43 (2.0)                  | 0                   | 67 (3.0)       | 119                        | 19 (16.0)           | 1   | 26 (21.8) | 37  | 500 | 37   | 25  | 338  | 195  |
| Aortic root + Asc. Ao. + Arch | 275 | 11 (4.0) | 0   | 17 (6.2) | 3 | 0 | 0 | 1 (33.3) | 63 | 185 | 8 | 3 | 31  | 29  |
| Descending Ao | 294              | 6 (2.0)                   | 0                   | 10 (3.4)       | 53                         | 9 (17.0)            | 0   | 13 (24.5) | 1   | 8   | 2    | 0   | 14   | 9    |
| Thoracoabdominal | 387   | 30 (7.8) | 0 | 44 (11.4) | 38 | 5 (13.2) | 1 (26.3) | 8 (21.1) | 1   | 0   | 0    | 0   | 1    | 1    |
| Simple TEVAR  | 243              | 24 (1.1)                  | 0                   | 44 (2.1)       | 358                        | 37 (11.6)           | 0   | 61 (19.2) | 0   | 2   | 1    | 0   | 0    | 18   |
| Open SG with BR | 1004   | 20 (2.0) | 0 | 49 (4.9) | 69 | 16 (25.2) | 0 | 22 (31.9) | 9   | 93  | 8    | 2   | 161  | 69   |
| Open SG without BR | 339   | 10 (2.9) | 0 | 18 (5.3) | 34 | 6 (17.6) | 0 | 9 (26.5) | 11  | 45  | 2    | 0   | 47   | 23   |
| Arch TEVAR with BR | 1004 | 28 (2.8) | 0 | 40 (4.0) | 75 | 12 (16.0) | 0 | 17 (22.7) | 0   | 2   | 0    | 0   | 5    | 27   |
| Thoracoabdominal TEVAR with BR | 86 | 4 (4.7) | 0 | 4 (4.7) | 15 | 3 (20.0) | 0 | 4 (26.7) | 0   | 1   | 0    | 0   | 0    | 0    |
| Other         | 106              | 5 (4.7)                   | 0                   | 7 (6.6)        | 20                         | 5 (25.0)            | 0   | 6 (30.0) | 1   | 25  | 6    | 2   | 14   | 16   |
| Total         | 10,327           | 241 (2.3)                 | 0                   | 866 (3.7)      | 844                        | 132 (15.6)          | 2   | 110 (22.5) | 467 | 269 | 246  | 110 | 952  | 795  |

(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
Mitral valve repair constituted 63.3% of all mitral valve procedures. Hospital mortality rates for single valve replacement were 3.0% and 7.1% for aortic and mitral positions, respectively, but only 1.5% for mitral valve repair. Moreover, hospital mortality rates for redo valve surgery were 7.7% and 5.9% for the aortic and mitral positions, respectively. Finally, overall hospital mortality rates did not improve over the past 10 years (3.3% in 2008 [2], 3.1% in 2013 [3], and 3.5% in 2018).

Isolated CABG had been performed in 12,135 cases, accounting for only 68.3% of the number performed 10 years ago (n = 17,764) [2]. Among the aforementioned cases, 7197 (58.8%) underwent off-pump CABG, with a success rate of 97.4%. The percentage of intended off-pump CABG in 2018 was similar to that in 2017 when it fell below 60% for the first time since 2004 [4]. Hospital mortality associated with primary elective CABG procedures among 7707 cases was 1.3%, which did not differ from that in 2008 (1.5%) [2]. Nonetheless, hospital mortality for primary emergency CABG among 1667 cases still remained high (7.3%). The percentage of conversion from off-pump to on-pump CABG or on-pump beating-heart CABG was 2.6%, with a hospital mortality rate of 5.8%. Patients with end-stage renal failure on dialysis had higher hospital mortality rates than overall mortality, regardless of surgical procedure (on-pump arrest, on-pump beating, and off-pump). In this report, concomitant CABGs alongside other major procedures were not included under the ischemic heart disease category but rather under other categories, such as valvular heart disease and thoracic aortic aneurysm. Accordingly, the overall number of CABGs in 2018, including concomitant CABG with other major procedures, was 17,678.

Measures for arrhythmia were performed primarily as concomitant procedures in 5334 cases, with a hospital mortality rate of 3.2%. Pacemaker and implantable cardioverter–defibrillator implantation was not included in this category.

In 2018, 21,624 procedures for thoracic and thoracoabdominal aortae diseases were performed, among which 10,453 and 11,171 were for aortic dissection and non-dissection, respectively. The number of surgeries for aortic dissection this year was 3.6% higher than that in the preceding year (n = 10,086). Hospital mortality rates for the 6157 Stanford type A acute aortic dissections remained high (10.5%). The number of procedures for non-dissected aneurysm increased by 4.8%, with a hospital mortality rate of 5.2% for all aneurysms and 3.7% and 22.5% for unruptured and ruptured aneurysms, respectively. The rate at which thoracic endovascular aortic repair (TEVAR) has been performed for aortic diseases has been increasing. A total of 3974 patients with aortic dissection underwent stent graft placement: 2151 TEVARs and 1823 open stent graftings, respectively. Moreover, 1373 and 294 cases underwent TEVAR and open stent grafting for type B chronic aortic dissection, accounting for 58.6% and 12.5% of the total number of cases, respectively.
mortality rates associated with simple TEVAR for type B aortic dissection were 7.0% and 2.0% for acute and chronic cases, respectively. A total of 5087 patients with non-dissected aortic aneurysm underwent stent graft placement, among which 3641 were TEVARs (a 10.6% increase compared to that in 2017, n = 3292) and 1446 were open stent graftings (a 6.0% increase compared to that in 2017, n = 1364). Hospital mortality rates for TEVARs were 2.7% and 20.4% for unruptured and ruptured aneurysms, respectively, whereas those for open stenting were 5.0% and 30.1% for unruptured and ruptured aneurysms, respectively.

(B) General thoracic surgery

The 2018 survey of general thoracic surgeries comprised 749 surgical units, with the bulk of the data submitted via a web-based collection system established by the NCD [1]. In total, 86,589 procedures had been reported by general thoracic surgery departments in 2018, twice the number of surgeries compared to 2000 and approximately 11,200 more procedures than that in 2013 (Fig. 2).

In 2018, 44,859 procedures for primary lung cancer had been performed, a number that has continued to increase annually. Accordingly, the number of procedures in 2018 was 2.4 times higher than that in 2000, with lung cancer procedures accounting for 52% of all general thoracic surgeries (Table 9).

Information regarding the number of video-assisted thoracoscopic surgery (VATS), defined as surgical procedures utilizing a skin incision over 8 cm and/or a minithoracotomy (hybrid) approach, has been available 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 presented in Tables 10, 11, 13, 16, 18, 19, 20, 21, 22, 23, 25, 26, 27, respectively.

In 2018, a total of 2342 procedures for benign pulmonary tumors had been conducted (Table 10). Hamartomas were the most frequent benign pulmonary tumors diagnosed, with 2222 patients (95%) undergoing VATS. 

Additional information on primary malignant pulmonary tumors is shown in Tables 11, 12. Accordingly, adenocarcinoma had been the most frequently diagnosed lung cancer subtype (71% of all lung cancers), followed by
squamoid cell carcinoma (18%). Sublobar resection was performed in 12,819 lung cancer cases (29% of all cases) and lobectomy in 31,365 cases (70% of all cases). Sleeve lobectomy was performed in 474 cases, while pneumonectomy was required in 324 cases (0.7% of all cases). VATS lobectomy for lung cancer was performed in 22,880 cases (73% of all lobectomy cases). The number of patients aged 80 years or older who underwent lung cancer surgery was 6115 (14%). Among those who died within 30 days following surgery, 107 died prior to hospital discharge, while 28 died after discharge. Overall, 135 patients died within 30 days after surgery (30-day mortality rate, 0.3%), while 242 died prior to discharge (hospital mortality rate, 0.5%). Moreover, 30-day mortality rates according to procedure were 0.1%, 0.2%, and 1.5% for segmentectomy, lobectomy, and pneumonectomy, respectively. Interstitial pneumonia had been the leading cause of death following lung cancer surgery, followed by pneumonia, cardiovascular events, and respiratory failure.

The procedures for metastatic pulmonary tumors, 8978 of which were performed in 2018, are shown in Table 13. Among such procedures, colorectal cancer had been the most frequent diagnosis (49% of all cases).

### Table 10 Benign pulmonary tumor

| Benign pulmonary tumor         | Cases | 30-Day mortality | Hospital mortality | After discharge | By VATS |
|--------------------------------|-------|------------------|--------------------|----------------|---------|
| Hamartoma                      | 527   | 0                | 0                  | 0              | 503     |
| Sclerosing hemangioma          | 109   | 0                | 0                  | 0              | 104     |
| Papilloma                      | 23    | 0                | 0                  | 0              | 22      |
| Macous gland adenoma bronchial | 4     | 0                | 0                  | 0              | 4       |
| Fibroma                        | 136   | 0                | 0                  | 0              | 123     |
| Lipoma                         | 8     | 0                | 0                  | 0              | 7       |
| Neurogenic tumor               | 18    | 0                | 0                  | 0              | 15      |
| Clear cell tumor               | 2     | 0                | 0                  | 0              | 2       |
| Leiomyoma                      | 12    | 0                | 0                  | 0              | 12      |
| Chondroma                      | 4     | 0                | 0                  | 0              | 4       |
| Inflammatory myofibroblastic tumor | 0       | 0                | 0                  | 0              | 0       |
| Pseudolymphoma                 | 26    | 0                | 0                  | 0              | 25      |
| Histiocytosis                  | 12    | 0                | 0                  | 0              | 12      |
| Teratoma                       | 7     | 0                | 0                  | 0              | 6       |
| Others                         | 1454  | 1 (0.04)         | 1 (0.04)           | 1 (0.04)       | 1383    |
| Total                          | 2342  | 1 (0.04)         | 1 (0.04)           | 1 (0.04)       | 2222    |

(0), mortality %

### Table 11 Primary malignant pulmonary tumor

| Primary malignant pulmonary tumor | Cases | 30-Day mortality | Hospital mortality | After discharge |
|-----------------------------------|-------|------------------|--------------------|----------------|
| Lung cancer                       | 44,859| 107 (0.2)        | 28 (0.1)           | 244 (0.5)      |
| Adenocarcinoma                    | 31,720| 52 (0.2)         | 11 (0.03)          | 92 (0.3)       |
| Squamous cell carcinoma           | 8265  | 40 (0.5)         | 13 (0.2)           | 106 (1.3)      |
| Large cell carcinoma              | 280   | 0                | 0                  | 1 (0.4)        |
| LCNEC                             | 543   | 2 (0.4)          | 0                  | 4 (0.7)        |
| Small cell carcinoma              | 785   | 3 (0.4)          | 2 (0.3)            | 10 (1.3)       |
| Adenosquamous carcinoma           | 560   | 2 (0.4)          | 0                  | 4              |
| Carcinoma with pleomorphic, sarcomatoid or sarcomatous elements | 511 | 4 (0.8) | 0 | 10 (2.0) |
| Carcinoid                         | 252   | 0                | 0                  | 0              |
| Carcinomas of salivary-gland type | 40    | 0                | 0                  | 1 (2.5)        |
| Unclassified                      | 46    | 0                | 0                  | 0              |
| Multiple lung cancer              | 1554  | 2 (0.1)          | 2 (0.1)            | 9 (0.6)        |
| Others                            | 302   | 2 (0.7)          | 0                  | 5              |
| Wedge resection                   | 7683  | 11 (0.1)         | 13 (0.2)           | 21 (0.3)       |
| Segmental excision                | 5136  | 5 (0.1)          | 1 (0.02)           | 17 (0.3)       |
| (Sleeve segmental excision)       | 12    | 0                | 0                  | 0              |
| Lobectomy                         | 31,365| 83 (0.3)         | 14 (0.04)          | 188 (0.6)      |
| (Sleeve lobectomy)                | 474   | 1 (0.2)          | 0                  | 3 (0.6)        |
| Pneumonectomy                     | 324   | 5 (1.5)          | 0                  | 10 (3.1)       |
| (Sleeve pneumonectomy)            | 9     | 0                | 0                  | 0              |
| Other bronchoplasty               | 34    | 1 (2.9)          | 0                  | 1 (2.9)        |
| Pleurepneumonectomy               | 2     | 0                | 0                  | 0              |
| Others                            | 515   | 2 (0.6)          | 0                  | 5 (1.6)        |
| Unknown                           | 0     | 0                | 0                  | 0              |
| Sarcoma                           | 51    | 0                | 0                  | 1 (2.0)        |
| AAH                               | 103   | 0                | 0                  | 0              |
| Others                            | 230   | 0                | 0                  | 1 (0.4)        |

(0), mortality %

A total of 59 procedures for malignant tracheal tumor were performed in 2018; however, 30 patients underwent sleeve resection and reconstruction (Table 14).

Overall, 664 pleural tumors had been diagnosed in 2018 (Table 15), with diffuse malignant pleural mesothelioma being the most frequent histologic diagnosis. Total pleurectomy was performed in 100 cases and extrapleural pneumonectomy in 64 cases. The 30-day mortality rate was 1% and 3% following total pleurectomy and extrapleural pneumonectomy, respectively, both of which had better outcomes than previously reported.
Overall, 656 chest wall tumor resections had been performed in 2018 (Table 16), among which 345 (53%) were benign. Among the 311 malignant chest wall tumors, 179 (58%) were metastatic.

A total of 5361 mediastinal tumors were resected in 2018, a slight increase compared to that in the previous year (Table 17). Thymic epithelial tumors—including 2098 thymomas, 325 thymic carcinomas, and 43 thymic carcinoids—were the most frequently diagnosed mediastinal tumor subtype in 2018.

In total, 499 patients underwent thymectomy for myasthenia gravis (Table 18), among which 348 procedures were associated with thymoma.

Overall, 22,996 patients underwent procedures for non-neoplastic disease. Accordingly, 2400 patients underwent lung resection for inflammatory lung diseases (Table 19), among which 22% and 14% were associated with mycobacterial infections and fungal infections, respectively. Procedures for inflammatory nodules were performed in cases where lung cancer was suspected prior to surgery (902 cases, 38%).

A total of 3103 procedures were performed for empyema (Table 20), among which 2402 (77%) were acute and 701 were chronic. Moreover, 509 patients with acute empyema and 325 patients with chronic empyema had developed bronchopleural fistulas. The hospital mortality rate was 13% among patients with acute empyema with fistula.

In 2018, 106 operations were performed for descending necrotizing mediastinitis (Table 21), with a hospital mortality rate of 6%. Furthermore, 376 procedures were
### Table 13  Metastatic pulmonary tumor

| Case Type                          | Cases   | 30-Day mortality | Hospital mortality | VATS  |
|------------------------------------|---------|------------------|--------------------|-------|
|                                    |         |                  | Hospital           | After discharge |
| Metastatic pulmonary tumor         | 8978    | 6 (0.1)          | 4 (0.04)           | 13 (0.1) |
| Colorectal                         | 4396    | 2 (0.05)         | 1 (0.02)           | 5 (0.1)  |
| Hepatobiliary/Pancreatic           | 433     | 0                | 0                  | 0       |
| Uterine                            | 504     | 0                | 1 (0.2)            | 0       |
| Mammary                            | 543     | 2 (0.4)          | 0                  | 3 (0.6) |
| Ovarian                            | 82      | 0                | 0                  | 0       |
| Testicular                         | 60      | 0                | 0                  | 0       |
| Renal                              | 690     | 0                | 0                  | 0       |
| Skeletal                           | 110     | 0                | 0                  | 0       |
| Soft tissue                        | 261     | 0                | 0                  | 0       |
| Otorhinolaryngological             | 471     | 0                | 1 (0.2)            | 0       |
| Pulmonary                          | 470     | 1 (0.2)          | 0                  | 2 (0.4) |
| Others                             | 958     | 1 (0.1)          | 1 (0.1)            | 3 (0.3) |

(), mortality %

### Table 14  Tracheal tumor

| Case Type                          | Cases   | 30-Day mortality | Hospital mortality |
|------------------------------------|---------|------------------|--------------------|
|                                    |         |                  | Hospital           | After discharge |
| Tracheal tumor                     | 127     | 5 (3.9)          | 1 (0.8)            | 6 (4.7) |
| A. Primary malignant tumor         |         |                  |                    | |
| Histological classification        |         |                  |                    | |
| Squamous cell carcinoma            | 17      | 1 (5.9)          | 0                  | 1 (5.9) |
| Adenoid cystic carcinoma           | 17      | 0                | 0                  | 0       |
| Mucoepidermoid carcinoma           | 6       | 0                | 0                  | 0       |
| Others                             | 19      | 0                | 0                  | 1 (5.3) |
| Total                              | 59      | 1 (1.7)          | 0                  | 2 (3.4) |
| B. Metastatic/invasive malignant tumor, e.g. invasion of thyroid cancer | 33 | 1 (3.0) | 1 (3.0) | 1 (3.0) |
| C. Benign tracheal tumor            |         |                  |                    | |
| Histological classification        |         |                  |                    | |
| Papilloma                          | 1       | 0                | 0                  | 0       |
| Adenoma                            | 2       | 0                | 0                  | 0       |
| Neurofibroma                       | 1       | 0                | 0                  | 0       |
| Chondroma                          | 0       | 0                | 0                  | 0       |
| Leiomyoma                          | 3       | 0                | 0                  | 0       |
| Others                             | 28      | 3 (10.7)         | 0                  | 3 (10.7) |
| Histology unknown                  | 0       | 0                | 0                  | 0       |
| Total                              | 35      | 3 (8.6)          | 0                  | 3 (8.6) |
| Operation                          |         |                  |                    | |
| Sleeve resection with reconstruction| 30      | 0                | 0                  | 0       |
| Wedge with simple closure          | 1       | 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                              | 35      | 0                | 0                  | 0       |

(), mortality %
conducted for bullous diseases (Table 22), while only 23 patients underwent lung volume reduction surgery. A total of 14,731 procedures were performed for spontaneous pneumothorax (Table 23). Among the 11,124 procedures for primary pneumothorax, 2825 (25%) were bullectomies alone, while 7632 (69%) required additional procedures. A total of 3607 procedures for secondary pneumothorax were conducted, with COPD being the most prevalent associated disease (2437 cases, 68%). The hospital mortality rate for secondary pneumothorax associated with COPD was 2.7%.

The 2018 survey reported 176 procedures for chest wall deformity (Table 24). However, this may have been underestimated given that 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.

Table 15 Tumor of pleural origin

| Histological classification                  | Cases | 30-Day mortality | Hospital mortality | After discharge | Hospital mortality | After discharge |
|---------------------------------------------|-------|------------------|--------------------|----------------|--------------------|----------------|
| Solitary fibrous tumor                      | 146   | 0                | 0                  | 0              | 0                  | 0              |
| Diffuse malignant pleural mesothelioma      | 264   | 4 (1.5)          | 1 (0.4)            | 13 (4.9)       |                    |                |
| Localized malignant pleural mesothelioma    | 32    | 0                | 0                  | 1 (3.1)        |                    |                |
| Others                                      | 222   | 1 (0.5)          | 0                  | 4 (1.8)        |                    |                |
| Total                                       | 664   | 5 (0.8)          | 1 (0.2)            | 18 (2.7)       |                    |                |

Overall, 30 patients underwent surgical treatment for diaphragmatic hernia (Table 25). This figure may have also been underestimated considering that procedures may have been classified as gastrointestinal surgery.

The survey reported 431 procedures for chest trauma, excluding iatrogenic injuries (Table 26), with a hospital mortality rate of 8%.

Table 27 summarizes the procedures for other diseases, including 84 and 103 cases of arteriovenous malformation and pulmonary sequestration, respectively.

A total of 71 lung transplantations were performed in 2018 (Table 28), among which 57 and 14 were from brain-dead and living related donors, respectively.

The number of VATS procedures has continued to increase annually, ultimately reaching 71,171 (82% of all general thoracic surgeries) in 2018 (Table 29).

Table 16 Chest wall tumor

| Operative procedure                  | Cases | 30-Day mortality | Hospital mortality | VATS |
|--------------------------------------|-------|------------------|--------------------|------|
| Extrapleural pneumonectomy           | 64    | 2 (3.1)          | 0                  | 71   |
| Total pleurectomy                    | 100   | 1 (1.0)          | 0                  | 84   |
| Others                               | 100   | 1 (1.0)          | 1 (1.0)            | 265  |
| Total                                | 264   | 4 (1.5)          | 1 (0.4)            | 420  |

(), mortality %
| Table 17 Mediastinal tumor | Cases | 30-Day mortality | Hospital mortality | By VATS |
|---------------------------|-------|------------------|--------------------|--------|
|                           |       | Hospital         | After discharge    |        |
| Mediastinal tumor         | 5361  | 2 (0.04)         | 1 (0.02)           | 6 (0.1)| 4009   |
| Thymoma*                  | 2098  | 0                | 0                  | 2 (0.1)| 1379   |
| Thymic cancer             | 325   | 1 (0.3)          | 0                  | 1 (0.3)| 171    |
| Thymus carcinoid          | 43    | 0                | 0                  | 0      | 22     |
| Germ cell tumor           | 81    | 0                | 0                  | 0      | 44     |
| Benign                    | 58    | 0                | 0                  | 0      | 35     |
| Malignant                 | 23    | 0                | 0                  | 0      | 9      |
| Neurogenic tumor          | 492   | 1 (0.2)          | 0                  | 1 (0.2)| 461    |
| Congenital cyst           | 1224  | 0                | 0                  | 0      | 1129   |
| Goiter                    | 98    | 0                | 0                  | 1 (1.0)| 40     |
| Lymphatic tumor           | 172   | 0                | 0                  | 1 (0.6)| 122    |
| Excision of pleural recurrence of thymoma | 20 | 0 | 0 | 0 | 15 |
| Thymolipoma               | 20    | 0                | 0                  | 0      | 17     |
| Others                    | 788   | 0                | 1 (0.1)            | 0      | 609    |

(\()\), mortality %

| Table 18 Thymectomy for myasthenia gravis | Cases | 30-Day mortality | Hospital mortality | By VATS |
|-------------------------------------------|-------|------------------|--------------------|--------|
|                                           |       | Hospital         | After discharge    |        |
| Thymectomy for myasthenia gravis         | 499   | 0                | 0                  | 0      | 319    |
| With thymoma                             | 348   | 0                | 0                  | 0      | 209    |

(\()\), mortality %

| Table 19 Operations for non-neoplastic diseases | Cases | 30-Day mortality | Hospital mortality |
|-------------------------------------------------|-------|------------------|--------------------|
| Operations for non-neoplastic diseases           | 22,996| 229 (1.0)        | 30 (0.1)           |

| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|------|
|       | Hospital         | After discharge    |      |
| A. Inflammatory pulmonary disease               | 2400  | 8 (0.3)           | 4 (0.2)| 18 (0.8)| 2102 |
| Tuberculous infection                          | 54    | 1 (1.9)           | 0     | 1 (1.9)| 46   |
| Mycobacterial infection                        | 526   | 2 (0.4)           | 0     | 3 (0.6)| 465  |
| Fungal infection                               | 325   | 1 (0.3)           | 2 (0.6)| 6 (1.8)| 241  |
| Bronchiectasis                                 | 64    | 0                | 0     | 0      | 48   |
| Tuberculous nodule                             | 70    | 0                | 0     | 0      | 65   |
| Inflammatory pseudotumor                       | 902   | 0                | 0     | 3 (0.3)| 838  |
| Interpulmonary lymph node                      | 59    | 0                | 0     | 0      | 58   |
| Others                                         | 400   | 4 (1.0)           | 2 (0.5)| 5 (1.3)| 341  |

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

| Cases | 30-day mortality | Hospital mortality | by VATS |
|-------|------------------|--------------------|--------|
|       |                   | hospital | After discharge |        |
| Acute empyema | 2402 | 57 (2.4) | 4 (0.2) | 124 (5.2) | 2013 |
| With fistula | 509 | 34 (6.7) | 1 (0.2) | 66 (13.0) | 270 |
| Without fistula | 1876 | 22 (1.2) | 3 (0.2) | 54 (2.9) | 1729 |
| Unknown | 17 | 1 (5.9) | 0 | 4 (23.5) | 14 |
| Chronic empyema | 701 | 23 (3.3) | 1 (0.1) | 63 (9.0) | 407 |
| With fistula | 325 | 14 (4.3) | 0 | 36 (11.1) | 125 |
| Without fistula | 324 | 8 (2.5) | 1 (0.3) | 25 (7.7) | 241 |
| Unknown | 52 | 1 (1.9) | 0 | 2 (3.8) | 41 |
| Total | 3103 | 80 (2.6) | 5 (0.2) | 187 (6.0) | 2420 |

(), mortality %

### Table 21 C. Descending necrotizing mediastinitis

| Cases | 30-day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|------|
|       |                   | hospital | After discharge |       |
| C. Descending necrotizing mediastinitis | 106 | 4 (3.8) | 1 (0.9) | 6 (5.7) | 81 |

(), mortality %

### Table 22 D. Bullous diseases

| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|------|
|       |                   | hospital | After discharge |       |
| D. Bullous diseases | 376 | 0 | 0 | 0 | 349 |
| Emphysematous bulla | 270 | 0 | 0 | 0 | 258 |
| Bronchogenic cyst | 21 | 0 | 0 | 0 | 18 |
| Emphysema with LVRS | 23 | 0 | 0 | 0 | 19 |
| Others | 62 | 0 | 0 | 0 | 54 |

(), mortality %

*LVRS* lung volume reduction surgery
### Table 23  E. Pneumothorax

#### Cases 30-day mortality

| Cases | 30-Day mortality | Hospital mortality | VATS |
|-------|------------------|--------------------|------|
|       | Hospital         | After discharge    |      |
| 14,731 | 81 (0.5)         | 19 (0.1)           | 146 (1.0) | 14,379 |

#### Spontaneous pneumothorax

| Operative procedure | Cases | 30-Day mortality | Hospital mortality | VATS |
|---------------------|-------|------------------|--------------------|------|
|                     |       | Hospital         | After discharge    |      |
| Bullectomy          | 2825  | 7 (0.2)          | 4 (0.1)            | 11 (0.4) | 2,770 |
| Bullectomy with additional procedure | 7632 | 5 (0.1)          | 1 (0.01)           | 10 (0.1) | 7,535 |
| Coverage with artificial material | 7383 | 5 (0.1)          | 1 (0.01)           | 10 (0.1) | 7,291 |
| Parietal pleurectomy | 27   | 0                | 0                  | 0     | 27    |
| Coverage and parietal pleurectomy | 57   | 0                | 0                  | 0     | 54    |
| Others              | 165   | 0                | 0                  | 0     | 163   |
| Others              | 657   | 3 (0.5)          | 2 (0.3)            | 5 (0.8) | 610   |
| Unknown             | 10    | 0                | 0                  | 0     | 9     |
| Total               | 11,124 | 15 (0.1)         | 7 (0.1)            | 26 (0.2) | 10,924 |

#### Secondary pneumothorax

| Associated disease | Cases | 30-Day mortality | Hospital mortality | VATS |
|--------------------|-------|------------------|--------------------|------|
|                    |       | Hospital         | After discharge    |      |
| COPD               | 2,437 | 33 (1.4)         | 8 (0.3)            | 65 (2.7) | 2,359 |
| Tumorous disease   | 128   | 9 (7.0)          | 1 (0.8)            | 14 (10.9) | 123   |
| Catamenal          | 199   | 0                | 0                  | 1 (0.5) | 194   |
| LAM                | 39    | 0                | 0                  | 0     | 38    |
| Others (excluding pneumothorax by trauma) | 804 | 24 (3.0)         | 3 (0.4)            | 40 (5.0) | 741   |
| Unknown            | 0     | 0                | 0                  | 0     | 0     |
| Total              | 3,607 | 66 (1.8)         | 12 (0.3)           | 120 (3.3) | 3,455 |

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

| Cases | 30-Day mortality | Hospital mortality |
|-------|------------------|-------------------|
|       | Hospital | After discharge |       | Hospital | After discharge |       | Hospital | After discharge |       | Hospital | After discharge |       |
| F. Chest wall deformity | 176 | 0 | 0 | 1 (0.6) | Funnel chest | 165 | 0 | 0 | 1 (0.6) | Others | 11 | 0 | 0 | 0 |

( ), mortality %

Table 25  G. Diaphragmatic hernia

| Cases | 30-Day mortality | Hospital mortality |
|-------|------------------|-------------------|
|       | Hospital | After discharge |       | Hospital | After discharge |       | VATS |
| G. Diaphragmatic hernia | 30 | 1 (3.3) | 0 | 3 (10.0) | 21 |
| Congenital | 5 | 0 | 0 | 2 (40.0) | 4 |
| Traumatic | 4 | 0 | 0 | 0 | 3 |
| Others | 21 | 1 (4.8) | 0 | 1(4.8) | 14 |

( ), mortality %

Table 26  H. Chest trauma

| Cases | 30-Day mortality | Hospital mortality |
|-------|------------------|-------------------|
|       | Hospital | After discharge |       | Hospital | After discharge |       | VATS |
| H. Chest trauma | 431 | 21 (4.9) | 0 | 33 (7.7) | 280 |

( ), mortality %

Table 27  I. Other respiratory surgery

| Cases | 30-Day mortality | Hospital mortality |
|-------|------------------|-------------------|
|       | Hospital | After discharge |       | Hospital | After discharge |       | VATS |
| I. Other respiratory surgery | 1643 | 34 (2.1) | 1 (0.1) | 71 (4.3) | 1258 |
| Arteriovenous malformation* | 84 | 0 | 0 | 0 | 79 |
| Pulmonary sequestration | 103 | 0 | 0 | 0 | 92 |
| Postoperative bleeding - air leakage | 481 | 17 (3.5) | 0 | 36 (7.5) | 329 |
| Chylothorax | 73 | 0 | 0 | 3 (4.1) | 61 |
| Others | 902 | 17 (1.9) | 1 (0.1) | 32 (3.5) | 697 |

( ), mortality %

Table 28  Lung transplantation

| Cases | 30-Day mortality | Hospital mortality |
|-------|------------------|-------------------|
|       | Hospital | After discharge |       | Hospital | After discharge |       |
| Single lung transplantation from brain-dead donor | 30 | 0 | 0 | 0 |
| Bilateral lung transplantation from brain-dead donor | 27 | 0 | 0 | 0 |
| Lung transplantation from living donor | 14 | 0 | 0 | 1 (7.1) |
| Total lung transplantation | 71 | 0 | 0 | 1 (1.4) |
| Donor of living donor lung transplantation | 23 | 0 | 0 | 0 |

( ), mortality %

Table 29  Video-assisted thoracic surgery

| Cases | 30-Day mortality | Hospital mortality |
|-------|------------------|-------------------|
|       | hospital | After discharge |       | Hospital | After discharge |       | VATS |
| Video-assisted thoracic surgery | 71,171 | 229 (0.3) | 48 (0.1) | 474 (0.7) |

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

|                      | Cases | 30-Day mortality | Hospital mortality | After discharge |
|----------------------|-------|------------------|--------------------|-----------------|
| Tracheobronchoplasty | 747   | 8 (1.1)          | 1 (0.1)            | 11 (1.5)        |
| Trachea              | 46    | 1 (2.2)          | 0                  | 1 (2.2)         |
| Sleeve resection with reconstruction | 32 | 0 | 0 | 0 |
| 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               | 9     | 1 (11.1)         | 0                  | 1 (11.1)        |
| Carinal reconstruction | 35 | 0 | 0 | 1 (2.9) |
| Sleeve pneumonectomy | 10 | 0 | 0 | 0 |
| Sleeve lobectomy     | 464   | 1 (0.2)          | 0                  | 2 (0.4)         |
| Sleeve segmental excision | 15 | 0 | 0 | 0 |
| Bronchoplasty without lung resection | 23 | 1 (4.3) | 1 (4.3) | 1 (4.3) |
| Others               | 154   | 5 (3.2)          | 0                  | 6 (3.9)         |

( ), mortality %

### Table 31 Pediatric surgery

|                      | Cases | 30-Day mortality | Hospital mortality | After discharge |
|----------------------|-------|------------------|--------------------|-----------------|
| Pediatric surgery    | 287   | 7 (2.4)          | 1 (0.3)            | 11 (3.8)        |

( ), mortality %

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

|                      | Cases | 30-Day mortality | Hospital mortality | After discharge |
|----------------------|-------|------------------|--------------------|-----------------|
| Combined resection of neighboring organ(s) | 1,043 | 9 (1.2) | 2 (0.2) | 7 (0.7) |

| Organ resected | Cases | 30-Day mortality | Hospital mortality | After discharge |
|----------------|-------|------------------|--------------------|-----------------|
| A. Primary lung cancer |       |                  |                    |                 |
| Aorta           | 10    | 1 (10.0)         | 0                  | 1 (10.0)        |
| Superior vena cava | 21   | 0                | 0                  | 1 (4.8)         |
| Brachiocephalic vein | 8    | 0                | 0                  | 1 (12.5)        |
| Pericardium     | 122   | 1 (0.8)          | 0                  | 4 (3.3)         |
| Pulmonary artery | 146   | 1 (0.7)          | 0                  | 2 (1.4)         |
| Left atrium     | 18    | 0                | 0                  | 0               |
| Diaphragm       | 74    | 1 (1.4)          | 0                  | 1 (1.4)         |
| Chest wall (including ribs) | 330   | 5 (1.5)        | 0                  | 9 (2.7)         |
| Vertebral       | 8     | 0                | 0                  | 0               |
| Esophagus       | 4     | 0                | 0                  | 0               |
| Total           | 741   | 9 (1.2)          | 2 (0.2)            | 7 (0.7)         |

( ), mortality %

B. Mediastinal tumor

| Organ resected | Cases | 30-Day mortality | Hospital mortality | After discharge |
|----------------|-------|------------------|--------------------|-----------------|
| Aorta          | 6     | 1 (16.7)         | 0                  | 1 (16.7)        |
| Superior vena cava | 53    | 0                | 0                  | 1 (1.9)         |
| Brachiocephalic vein | 112  | 0                | 0                  | 1 (0.9)         |
| Pericardium    | 336   | 0                | 1 (0.3)            | 1 (0.3)         |
| Pulmonary artery | 4    | 1 (25.0)         | 0                  | 25 (25.0)       |
| Left atrium    | 2     | 0                | 0                  | 0               |
| Diaphragm      | 30    | 0                | 0                  | 0               |
| Chest wall (including ribs) | 4     | 0                | 0                  | 0               |
| Vertebral      | 5     | 0                | 0                  | 0               |
| Esophagus      | 4     | 0                | 0                  | 0               |
| Lung           | 487   | 1 (0.2)          | 1 (0.2)            | 2 (0.4)         |
| Total          | 1,043 | 3 (0.3)          | 2 (0.2)            | 7 (0.7)         |

( ), mortality %

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

|                      | Cases | 30-Day mortality | Hospital mortality | After discharge |
|----------------------|-------|------------------|--------------------|-----------------|
| 15. Operation of lung cancer invading the chest wall of the apex | 772 | 6 (0.8) | 0 | 9 (1.2) |

( ), mortality %

Includes tumors invading the anterior apical chest wall and posterior apical chest wall (superior sulcus tumor, so called Pancoast type)
Details regarding tracheobronchoplasty, pediatric surgery, and combined resection of neighboring organs are presented in Tables 30, 31, 32, 33.

(C) Esophageal surgery

In 2018, the data collection method for esophageal surgery had been modified from self-reports using questionnaire sheets according to each institution belonging to the Japanese Association for Thoracic Surgery to an automatic package downloaded from the NCD in Japan. Consequently, data for non-surgical cases with esophageal diseases had been excluded from the registry. Furthermore, data regarding the histological classification of malignant tumors, multiple primary cancers, and mortality rates for cases with combined resection of other organs could not be registered given that they were not included in the NCD. Instead, detailed data regarding postoperative surgical and non-surgical complications were collected from the NCD. Moreover, data regarding surgeries for corrosive esophageal strictures and salvage surgeries for esophageal cancer had been exceptionally registered by participating institutions.

Throughout 2018, a total of 7324 patients underwent surgery for esophageal diseases (1068 and 6256 for benign and malignant esophageal diseases, respectively) from 552 institutions across Japan. Among them, 329 (63.0%) and 441 (79.9%) institutions performed surgeries for benign and malignant esophageal diseases, respectively. Among institutions performing surgeries for malignant esophageal diseases, 82 (18.6%) had 20 or more patients who underwent esophageal surgeries within 2018, while 271 (61.5%) had less than 10 patients (i.e., 1–9 patients) who underwent the same procedure within the same year. This distribution was quite different from that in 2017 [125 (29.2%) and 215 (50.2%), respectively], suggesting the differences between the two data collection methods, as mentioned previously (Table 34). Annual trends among registered in-patients with esophageal diseases have remained unchanged for the past 5 years (Fig. 3).

With regard to benign esophageal diseases (Table 35), thoracoscopic and/or laparoscopic surgeries were

Table 34 Distribution of number of esophageal operations in 2018 in each institution

| Number of operations in 2018 | Benign esophageal diseases | Malignant Esophageal disease | Benign + Malignant |
|-----------------------------|---------------------------|-----------------------------|-------------------|
| 0                           | 224                       | 111                         | 63                |
| 1–4                         | 271                       | 179                         | 193               |
| 5–9                         | 43                        | 92                          | 101               |
| 10–19                       | 10                        | 88                          | 95                |
| 20–29                       | 0                         | 36                          | 38                |
| 30–39                       | 1                         | 10                          | 21                |
| 40–49                       | 2                         | 13                          | 14                |
| ≥ 50                        | 1                         | 23                          | 27                |
| Total                       | 552                       | 552                         | 552               |

Fig. 3 Annual trend of in-patients with esophageal diseases

Springer
| Operation (+)                      | Cases | Hospital mortality | T/L*3 |
|-----------------------------------|-------|--------------------|-------|
|                                   | ~ 30 days | 31–90 days | Total (including after 91 days mortality) | ~ 30 days | 31–90 days | Total (including after 91 days mortality) |
| 1. Achalasia                      | 206   | 0      | 0      | 102   | 0      | 0      |
| 2. Benign tumor                   | 64    | 0      | 0      | 33    | 0      | 0      |
| 3. Diverticulum                   | 41    | 0      | 0      | 13    | 0      | 0      |
| 4. Hiatal hernia                  | 475   | 8 (1.7) | 5 (1.1) | 13 (2.7)| 387   | 3 (0.8) | 3 (0.8) | 6 (1.6) |
| 5. Spontaneous rupture of the esophagus | 129   | 2 (1.6) | 0      | 2 (1.6) | 14    | 0      | 0      | 0      |
| 6. Esophago-tracheal fistula      | 2     | 0      | 0      | 1     | 0      | 0      |
| 7. Esophagitis, Esophageal ulcer  | 129   | 0      | 0      | 115   | 0      | 0      |
| 8. Corrosive stricture of the esophagus | 22    | 0      | 0      | 8     | 0      | 0      |
| Total                            | 1068  | 10 (0.9) | 5 (0.5) | 15 (1.4) | 673   | 3 (0.4) | 3 (0.4) | 6 (0.9) |

(*), mortality %
T/L Thoracoscopic and/or laparoscopic
## Table 36 Malignant esophageal disease

| Location | Operation (+) | Thoracoscopic and/or laparoscopic procedure |
|----------|---------------|------------------------------------------|
|          | Cases | Hospital mortality | Thoracoscopic and/or laparoscopic procedure |
|          | ~ 30 days | 31–90 days | Total (including after 91days mortality) | Cases | Conversion to thoracotomy | Hospital mortality |
|          | ~ 30 days | 31–90 days | Total (including after 91days mortality) |
| (1) Cervical esophagus | 172 | 2 (1.2) | 2 (1.2) | 3 (1.7) | 67 | 0 | 1 (1.5) | 1 (1.5) | 2 (3.0) |
| (2) Thoracic esophagus | 5244 | 41 (0.8) | 27 (0.5) | 69 (1.3) | 3848 | 42 (1.1) | 28 (0.7) | 15 (0.4) | 43 (1.1) |
| (3) Abdominal esophagus | 499 | 1 (0.2) | 2 (0.4) | 3 (0.6) | 272 | 2 (0.7) | 1 (0.4) | 0 | 1 (0.4) |
| Total | 5915 | 44 (0.7) | 31 (0.5) | 75 (1.3) | 4187 | 44 (1.1) | 30 (0.7) | 16 (0.4) | 46 (1.1) |

### Tumor depth

**A. Superficial cancer (T1)**

| Location | Operation (+) | Thoracoscopic and/or laparoscopic procedure |
|----------|---------------|------------------------------------------|
|          | Cases | Hospital mortality | Thoracoscopic and/or laparoscopic procedure |
|          | ~ 30 days | 31–90 days | Total (including after 91days mortality) | Cases | Conversion to thoracotomy | Hospital mortality |
|          | ~ 30 days | 31–90 days | Total (including after 91days mortality) |
| (1) Transhiatal esophagectomy | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (2) Mediastinoscopic esophagectomy and reconstruction | 90 | 0 | 0 | 0 | 90 | 0 | 0 | 0 | 0 |
| (3) Transthoracic (rt.) esophagectomy and reconstruction | 1908 | 8 (0.4) | 6 (0.3) | 14 (0.7) | 1534 | 12 (0.8) | 7 (0.5) | 4 (0.3) | 11 (0.7) |
| (4) Transthoracic (lt.) esophagectomy and reconstruction | 43 | 0 | 1 (2.3) | 1 (2.3) | 19 | 0 | 0 | 0 | 0 |
| (5) Cervical esophageal resection and reconstruction | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (6) Robot-assisted esophagectomy and reconstruction | 172 | 1 (0.6) | 0 | 1 (0.6) | 174 | 0 | 2 (1.1) | 0 | 2 (1.1) |
| (7) Others | 58 | 0 | 0 | 0 | 14 | 1 (7.1) | 0 | 0 | 0 |
| (8) Esophagectomy without reconstruction | 233 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Subtotal | 2538 | 9 (0.4) | 7 (0.3) | 16 (0.6) | 1852 | 13 (0.7) | 9 (0.5) | 4 (0.2) | 13 (0.7) |

**B. Advanced cancer (T2–T4)**

| Location | Operation (+) | Thoracoscopic and/or laparoscopic procedure |
|----------|---------------|------------------------------------------|
|          | Cases | Hospital mortality | Thoracoscopic and/or laparoscopic procedure |
|          | ~ 30 days | 31–90 days | Total (including after 91days mortality) | Cases | Conversion to thoracotomy | Hospital mortality |
|          | ~ 30 days | 31–90 days | Total (including after 91days mortality) |
| (1) Transhiatal esophagectomy | 32 | 1 (3.1) | 0 | 1 (3.1) | 0 | 0 | 0 | 0 | 0 |
| (2) Mediastinoscopic esophagectomy and reconstruction | 83 | 2 (2.4) | 0 | 2 (2.4) | 82 | 0 | 2 (2.4) | 0 | 2 (2.4) |
| (3) Transthoracic (rt.) esophagectomy and reconstruction | 3045 | 30 (1.0) | 18 (0.6) | 49 (1.6) | 2017 | 29 (1.4) | 19 (0.9) | 10 (0.5) | 29 (1.4) |
| (4) Transthoracic (lt.) esophagectomy and reconstruction | 94 | 0 | 1 (1.1) | 1 (1.1) | 25 | 0 | 0 | 0 | 0 |
| (5) Cervical esophageal resection and reconstruction | 66 | 0 | 1 (1.5) | 0 | 0 | 0 | 0 | 0 | 0 |
| (6) Robot-assisted esophagectomy and reconstruction | 156 | 0 | 0 | 0 | 156 | 1 (0.6) | 0 | 0 | 0 |
| (7) Others | 92 | 1 (1.1) | 1 (1.1) | 2 (2.2) | 23 | 0 | 0 | 0 | 0 |
| (8) Esophagectomy without reconstruction | 150 | 4 (2.7) | 8 (5.3) | 12 (8.0) | 8 | 0 | 0 | 2 (25.0) | 2 (25.0) |
| Subtotal | 3718 | 38 (1.0) | 29 (0.8) | 67 (1.8) | 2311 | 30 (1.3) | 21 (0.9) | 12 (0.5) | 33 (1.4) |
| Total | 6256 | 47 (0.8) | 36 (0.6) | 83 (1.3) | 4143 | 43 (1.0) | 30 (0.7) | 16 (0.4) | 46 (1.1) |

### Location

| Location | Overall morbidity | Morbidity ≥ CD III |
|----------|-------------------|-------------------|
| (1) Cervical esophagus | 172 | 105 (61.0) | 49 (28.5) | 13 (7.6) | 5 (2.9) | 11 (6.4) | 17 (9.9) | 14 (8.1) | 3 (1.7) |
| (2) Thoracic esophagus | 5244 | 3001 (58.4) | 1108 (22.7) | 360 (6.9) | 206 (3.9) | 463 (8.8) | 738 (14.1) | 785 (15.0) | 66 (1.3) |
| (3) Abdominal esophagus | 499 | 236 (47.5) | 93 (18.6) | 21 (4.2) | 11 (2.2) | 43 (8.6) | 65 (13.0) | 29 (5.8) | 4 (0.8) |
| Total | 5915 | 3402 (57.5) | 1330 (22.5) | 394 (6.7) | 222 (3.8) | 517 (8.7) | 820 (13.9) | 828 (14.0) | 73 (1.2) |
| Cases | Overall morbidity | Mortality ≥ CD III | Surgical complications |
|-------|------------------|--------------------|------------------------|
|       |                  |                    | Surgical site infection | Anastomotic leakage | Recurrent nerve palsy | Wound dehiscence |
|       |                  |                    | Superficial incision | Deep incision | Organ space |
|-------|------------------|--------------------|-----------------|--------------|---------------|
|       |                  |                    |                 |              |              |                |

### Tumor depth

**A) Superficial cancer (T1)**

1. **Transhiatal esophagectomy**
   - 15 cases: 10 (66.7), 7 (46.7), 2 (13.3), 3 (20.0), 5 (33.3), 1 (6.7), 0
   - 20 (22.2), 7 (7.8), 2 (2.2), 8 (8.9), 18 (20.0), 22 (24.4), 0
   - 10 (66.7), 7 (46.7), 2 (13.3), 3 (20.0), 5 (33.3), 1 (6.7), 0

2. **Mediastinoscopic esophagectomy and reconstruction**
   - 90 cases: 54 (60.0), 20 (22.2), 7 (7.8), 2 (2.2), 8 (8.9), 18 (20.0), 22 (24.4), 0
   - 1100 (57.7), 421 (22.1), 129 (6.8), 75 (3.9), 171 (9.0), 294 (15.4), 274 (14.4), 29 (1.5)

3. **Transthoracic (rt.) esophagectomy and reconstruction**
   - 1908 cases: 1100 (57.7), 421 (22.1), 129 (6.8), 75 (3.9), 171 (9.0), 294 (15.4), 274 (14.4), 29 (1.5)

4. **Transthoracic (lt.) esophagectomy and reconstruction**
   - 43 cases: 19 (44.2), 9 (20.9), 2 (4.7), 1 (2.3), 4 (9.3), 5 (11.6), 1 (2.3), 0

5. **Cervical esophageal resection and reconstruction**
   - 19 cases: 15 (78.9), 3 (15.8), 1 (5.3), 0, 1 (5.3), 2 (10.5), 1 (6.7), 0

6. **Robot-assisted esophagectomy and reconstruction**
   - 172 cases: 99 (57.6), 35 (20.3), 6 (3.5), 2 (1.2), 13 (7.6), 25 (14.5), 25 (14.5), 1 (0.6)

7. **Others**
   - 58 cases: 30 (51.7), 9 (15.5), 0, 0, 14 (8.6), 11 (19.0), 0, 0

8. **Esophagectomy without reconstruction**
   - 23 cases: 15 (63.0), 5 (21.7), 0, 0, 1 (4.3), 0, 0, 0

**Subtotal**
- 2538 cases: 1359 (53.5), 514 (20.3), 147 (5.8), 82 (3.2), 205 (8.1), 360 (14.2), 326 (12.8), 30 (1.2)

**B) Advanced cancer (T2-T4)**

1. **Transhiatal esophagectomy**
   - 32 cases: 18 (56.3), 9 (28.1), 0, 4 (12.5), 4 (12.5), 6 (18.8), 2 (6.3), 0

2. **Mediastinoscopic esophagectomy and reconstruction**
   - 83 cases: 55 (66.3), 21 (25.3), 4 (4.8), 2 (2.2), 6 (7.2), 16 (19.3), 20 (24.1), 0

3. **Transthoracic (rt.) esophagectomy and reconstruction**
   - 3045 cases: 1749 (57.4), 696 (22.9), 221 (7.3), 121 (4.0), 266 (8.7), 386 (12.7), 422 (13.9), 38 (1.2)

4. **Transthoracic (lt.) esophagectomy and reconstruction**
   - 94 cases: 51 (54.3), 23 (24.5), 4 (43), 6 (6.4), 9 (9.6), 10 (10.6), 7 (7.4), 0

5. **Cervical esophageal resection and reconstruction**
   - 66 cases: 41 (62.1), 15 (22.7), 9 (13.6), 3 (4.5), 1 (1.5), 4 (6.1), 7 (10.6), 0

6. **Robot-assisted esophagectomy and reconstruction**
   - 156 cases: 87 (55.8), 25 (16.0), 6 (3.8), 2 (1.3), 7 (4.5), 17 (10.9), 36 (23.1), 0

7. **Others**
   - 92 cases: 45 (48.9), 19 (20.7), 0, 0, 11 (12.0), 13 (14.1), 4 (4.3), 2 (2.2)

8. **Esophagectomy without reconstruction**
   - 150 cases: 77 (51.3), 38 (25.3), 1 (0.7), 0, 1 (0.7), 0, 0, 1

**Subtotal**
- 3718 cases: 2123 (57.1), 846 (22.8), 138 (3.7), 306 (8.2), 452 (12.2), 498 (13.4), 41 (1.1), 0

**Total**
- 6256 cases: 3482 (55.7), 1360 (21.7), 377 (6.4), 308 (5.0), 812 (13.0), 824 (13.2), 71 (1.1), 0

### Location

| Cases | Pneumonia | Unplanned intubation | Prolonged ventilation >48h | Pulmonary embolism | Pneumonia | Esophageal leakage | Renal failure | CNS events | Cardiac events | Septic shock | Readmission within 30 days | Reoperation within 30 days |
|-------|-----------|----------------------|----------------------------|-------------------|-----------|------------------|--------------|------------|---------------|-------------|--------------------------|--------------------------|
|       |           |                      |                            |                   |           |                  |              |            |               |             |                          |                          |

### Tumor depth

**A) Superficial cancer (T1)**

1. **Transhiatal esophagectomy**
   - 15 cases: 5 (33.3), 0, 0, 0, 2 (13.3), 0, 0, 0, 1 (6.7), 1 (6.7), 3 (20.0)

2. **Mediastinoscopic esophagectomy and reconstruction**
   - 90 cases: 10 (11.1), 6 (6.7), 8 (8.9), 0, 3 (3.3), 1 (1.1), 0, 1 (1.1), 2 (2.2), 5 (5.6)

3. **Transthoracic (rt.) esophagectomy and reconstruction**
   - 1908 cases: 281 (14.7), 84 (4.4), 105 (5.5), 20 (1.0), 97 (5.1), 10 (0.5), 9 (0.5), 6 (0.3), 13 (0.7), 44 (2.3), 123 (6.4)

4. **Transthoracic (lt.) esophagectomy and reconstruction**
   - 43 cases: 4 (9.3), 2 (4.7), 3 (7.0), 0, 3 (7.0), 0, 0, 0, 1 (2.3), 2 (4.7)

5. **Cervical esophageal resection and reconstruction**
   - 19 cases: 3 (15.8), 1 (5.3), 1 (5.3), 0, 2 (10.5), 0, 1 (5.3), 0, 0, 0, 1 (5.3)

6. **Robot-assisted esophagectomy and reconstruction**
   - 172 cases: 21 (12.2), 5 (2.9), 9 (5.2), 3 (1.7), 3 (1.7), 3 (1.7), 2 (1.2), 0, 0, 3 (1.7), 3 (1.7)
### Table 36 (continued)

| (7) Others | 58 | 7 (12.1) | 1 (1.7) | 1 (1.7) | 1 (1.7) | 5 (8.6) | 0 | 0 | 0 | 0 | 2 (3.4) | 4 (6.9) |
| (8) Esophagectomy without reconstruction | 233 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 (1.7) | 0 |
| **Subtotal** | 2538 | 331 (13.0) | 99 (3.9) | 127 (5.0) | 24 (0.9) | 115 (4.5) | 14 (0.6) | 12 (0.5) | 7 (0.3) | 15 (0.6) | 57 (2.2) | 141 (5.6) |

#### B Advanced cancer (T2–T4)

| (1) Transhiatal esophagectomy | 32 | 1 (3.1) | 1 (3.1) | 3 (9.4) | 0 | 1 (3.1) | 0 | 0 | 1 (3.1) | 0 | 0 | 3 (9.4) |
| (2) Mediastinoscopic esophagectomy and reconstruction | 83 | 7 (8.4) | 3 (3.6) | 6 (7.2) | 1 (1.2) | 2 (2.4) | 1 (1.2) | 0 | 1 (1.2) | 1 (1.2) | 1 (1.2) | 5 (6.0) |
| (3) Transsthoracic (rt.) esophagectomy and reconstruction | 3045 | 474 (15.6) | 177 (5.8) | 213 (7.0) | 15 (0.5) | 200 (6.6) | 15 (0.5) | 14 (0.5) | 13 (0.4) | 26 (0.9) | 89 (2.9) | 202 (6.6) |
| (4) Transsthoracic (lt.) esophagectomy and reconstruction | 94 | 15 (16.0) | 4 (4.3) | 6 (6.4) | 2 (2.1) | 6 (6.4) | 1 (1.1) | 2 (2.1) | 0 | 0 | 5 (5.3) | 6 (6.4) |
| (5) Cervical esophageal resection and reconstruction | 66 | 6 (9.1) | 4 (6.1) | 3 (4.5) | 1 (1.5) | 0 | 0 | 1 (1.5) | 1 (1.5) | 0 | 0 | 5 (7.6) |
| (6) Robot-assisted esophagectomy and reconstruction | 156 | 19 (12.2) | 5 (3.2) | 7 (4.5) | 2 (1.3) | 7 (4.5) | 0 | 0 | 1 (0.6) | 0 | 3 (1.9) | 6 (3.8) |
| (7) Others | 92 | 8 (8.7) | 3 (3.3) | 6 (6.5) | 0 | 9 (9.8) | 0 | 0 | 0 | 1 (1.1) | 3 (3.3) | 6 (6.5) |
| (8) Esophagectomy without reconstruction | 150 | 3 (2.0) | 2 (1.3) | 3 (2.0) | 0 | 1 (0.7) | 0 | 1 (0.7) | 0 | 2 (1.3) | 6 (4.0) | 3 (2.0) |
| **Subtotal** | 3718 | 533 (14.3) | 199 (5.4) | 247 (6.6) | 21 (0.6) | 226 (6.1) | 17 (0.5) | 18 (0.5) | 17 (0.5) | 30 (0.8) | 107 (2.9) | 236 (6.3) |
| **Total** | 6256 | 864 (13.8) | 298 (4.8) | 374 (6.0) | 45 (0.7) | 341 (5.5) | 31 (0.5) | 30 (0.5) | 24 (0.4) | 45 (0.7) | 164 (2.6) | 377 (6.0) |

### Table 37 Salvage surgery

| Operation (+) | Cases | Hospital mortality | Total (including after 91days mortality) | Thoracoscopic and/or laparoscopic procedure | EMR or ESD |
|---------------|-------|---------------------|------------------------------------------|---------------------------------------------|-------------|
|               | ~ 30 days | 31–90 days | Conversion to thoracotomy | ~ 30 days | 31–90 days | Total (including after 91days mortality) |
| Salvage surgery | 570 | 3 (0.5) | 6 (1.1) | 9 (1.6) | 272 | 4 (1.5) | 1 (0.4) | 3 (1.1) | 4 (1.5) | 245 |
performed in 89.1% (115/129), 81.5% (387/475), 51.6% (33/64), and 49.5% (102/206) of patients with esophagitis (including esophageal ulcer), hiatal hernia, benign tumors, and achalasia, respectively. On the other hand, 89.1% (115/129) of patients with spontaneous rupture of the esophagus underwent open surgery. Hospital mortality rates after surgery for benign esophageal diseases had only been recorded for those with hiatal hernia and spontaneous rupture of the esophagus, with 8 (1.7%) and 2 (1.6%) patients succumbing to mortality within 30 days following surgery, respectively. Only 3 (0.4%) among the 673 patients who underwent thoracoscopic and/or laparoscopic surgery died within 30 postoperative days, all of whom had hiatal hernia.

The most common tumor location for malignant esophageal diseases was the thoracic esophagus (Table 36). Among 6256 cases with esophageal malignancies, 2538 (40.6%) and 3718 (59.4%) underwent esophagectomy for superficial and advanced cancers, respectively. The 30-day and hospital mortality rates following esophagectomy were 0.4% and 0.6% for patients with superficial cancer and 1.0% and 1.8% for those with advanced cancer, respectively.

Among esophagectomy procedures, transthoracic esophagectomy via right thoracotomy or right thoracoscopy was most commonly adopted for patients with a superficial cancer (1908/2538, 75.2%) and advanced cancer (3045/3718, 81.9%) (Table 36). Transhiatal esophagectomy, which is commonly performed in Western countries, was adopted in only 15 (0.6%) and 32 (0.9%) patients with superficial and advanced cancer who underwent esophagectomy in Japan, respectively. Thoracoscopic and/or laparoscopic esophagectomy was utilized in 1832 (72.2%) and 2311 (62.2%) patients with superficial and advanced cancer, respectively. The number of patients who underwent thoracoscopic and/or laparoscopic surgery for superficial or advanced cancer has been increasing, whereas that of open surgery, especially for advanced cancer, has been decreasing annually (Fig. 4). Mediastinoscopic and robot-assisted esophagectomy and reconstruction were performed for 173 and 328 patients in 2018, respectively. The 30-day and hospital mortality rates following thoracoscopic and/or laparoscopic esophagectomy were 0.5% and 0.7% for patients with superficial cancer and 0.9% and 1.4% or those with advanced cancer, respectively (Table 36).

Detailed data collection regarding postoperative surgical and non-surgical complications have been initiated this year (Table 36). Overall, 1360 (21.7%) of 6256 patients developed grade III or higher complications based on the Clavien–Dindo classification. Among surgical complications, anastomotic leakage and recurrent nerve palsy occurred in 13.0% and 13.2% of the patients and in approximately 20% and 24% of those who underwent mediastinoscopic esophagectomy, respectively. Among non-surgical postoperative complications, pneumonia occurred in 13.8% of the patients, 4.8% of whom underwent unplanned intubation. Mediastinoscopic esophagectomy seemed to be less likely to promote postoperative pneumonia compared to transthoracic (rt.) esophagectomy. Postoperative pulmonary embolism occurred in 0.7% of the patients.

Salvage surgery following definitive (chemo) radiotherapy was performed in 570 patients, with a 30-day and hospital mortality rate of 0.5% and 1.6%, respectively. Thoracoscopic and/or laparoscopic esophagectomy were performed in 272 (47.7%) patients, both of which had comparable mortality rates (Table 37).

We aim to continue our efforts in collecting comprehensive survey data through more active collaboration with the Japan Esophageal Society and other related institutions.

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