

## 1. Overall results

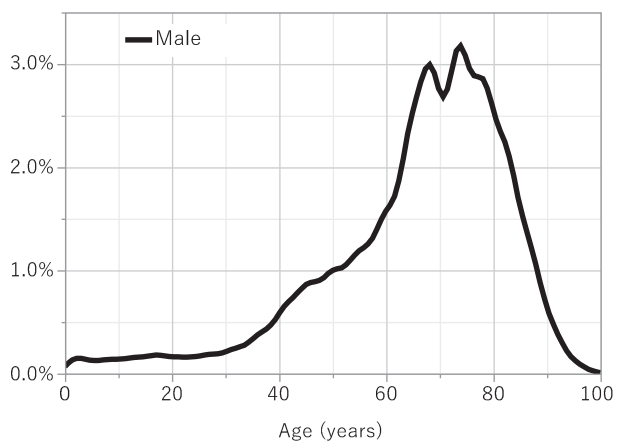
### 1.1 The number of surgeries in each category

| Category                  | 2015           | 2016           | 2017           | Total          |
|---------------------------|----------------|----------------|----------------|----------------|
| BTs                       | 20,809         | 20,291         | 20,635         | 61,735         |
| CVDs                      | 35,580         | 34,734         | 34,208         | 104,522        |
| Endovascular              | 26,978         | 29,456         | 32,901         | 89,335         |
| Head injuries             | 40,153         | 40,202         | 41,571         | 121,926        |
| Hydrocephalus / anomalies | 19,306         | 19,263         | 19,837         | 58,406         |
| Spine / peripheral        | 14,725         | 15,151         | 14,316         | 44,192         |
| Functional                | 5,635          | 5,477          | 5,849          | 16,961         |
| Radiosurgery              | 11,568         | 12,736         | 12,906         | 37,210         |
| Others                    | 8,160          | 8,295          | 8,546          | 25,001         |
| <b>Total</b>              | <b>182,914</b> | <b>185,605</b> | <b>190,769</b> | <b>559,288</b> |

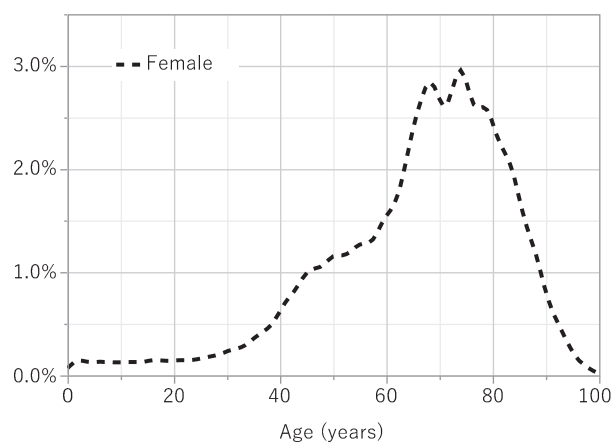
### 1.2 Sex and age at surgery

#### 1.2.1 Density plots of age by sex

n = 306,743



n = 252,545



### 1.2.2 Top 15 procedures according to sex and age groups\*

Overall

| Age group | 0 - 9                                     | 10 - 19                                   | 20 - 29                                   | 30 - 39                           | 40 - 49                                 | 50 - 59                                 | 60 - 69                           | 70 - 79                                 | 80 - 89                                     | 90 - 99                                   | 100 -                                    |
|-----------|-------------------------------------------|-------------------------------------------|-------------------------------------------|-----------------------------------|-----------------------------------------|-----------------------------------------|-----------------------------------|-----------------------------------------|---------------------------------------------|-------------------------------------------|------------------------------------------|
| 1         | Hydro-<br>cephalus<br>1,745               | Hydro-<br>cephalus<br>1,495               | BT removal<br>1,444                       | BT removal<br>3,081               | BT removal<br>5,950                     | Aneurysm,<br>open<br>8,850              | Aneurysm,<br>open<br>14,906       | CSDH<br>29,962                          | CSDH<br>38,374                              | CSDH<br>9,706                             | CSDH<br>192                              |
| 2         | BT removal<br>724                         | BT removal<br>1,127                       | Hydro-<br>cephalus<br>1,075               | Hydro-<br>cephalus<br>1,601       | Aneurysm,<br>open<br>5,920              | BT removal<br>7,449                     | CSDH<br>13,426                    | Hydro-<br>cephalus<br>15,274            | Hydro-<br>cephalus<br>9,262                 | Endovascular<br>recanalization<br>1,267   | Endovascular<br>recanalization<br>25     |
| 3         | Cranio-<br>cerebral<br>anomalies<br>699   | Craniotomy<br>for head<br>injuries<br>573 | Craniotomy<br>for head<br>injuries<br>586 | Aneurysm,<br>open<br>1,378        | Aneurysm<br>embolization<br>4,821       | Aneurysm<br>embolization<br>6,357       | BT removal<br>12,318              | Aneurysm,<br>open<br>12,278             | Endovascular<br>recanalization<br>5,795     | Craniotomy<br>for head<br>injuries<br>654 | Craniotomy<br>for head<br>injuries<br>10 |
| 4         | Revascula-<br>rization<br>645             | Revascula-<br>rization<br>488             | Epilepsy<br>577                           | Aneurysm<br>embolization<br>1,245 | Hydro-<br>cephalus<br>4,285             | Hydro-<br>cephalus<br>5,926             | Hydro-<br>cephalus<br>11,185      | Spinal<br>degeneration<br>11,531        | PTA<br>4,980                                | Hydro-<br>cephalus<br>619                 | ICH<br>10                                |
| 5         | Spinal<br>anomalies<br>470                | Epilepsy<br>477                           | Transnasal<br>519                         | Spinal<br>degeneration<br>1,181   | Spinal<br>degeneration<br>3,057         | Spinal<br>degeneration<br>4,581         | Spinal<br>degeneration<br>9,206   | PTA<br>10,930                           | ICH<br>4,725                                | ICH<br>381                                |                                          |
| 6         | Not<br>otherwise<br>classified<br>384     | AVM removal<br>301                        | Spinal<br>degeneration<br>393             | Transnasal<br>863                 | ICH<br>2,564                            | ICH<br>4,329                            | Spinal<br>degeneration<br>8,706   | BT removal<br>10,237                    | Spinal<br>degeneration<br>4,184             | Aneurysm<br>embolization<br>365           |                                          |
| 7         | Craniotomy<br>for head<br>injuries<br>319 | Not<br>otherwise<br>classified<br>265     | Not<br>otherwise<br>classified<br>322     | ICH<br>667                        | Radiotherapy<br>for metastasis<br>1,900 | Radiotherapy<br>for metastasis<br>3,802 | Aneurysm<br>embolization<br>8,555 | Radiotherapy<br>for metastasis<br>8,235 | Craniotomy<br>for head<br>injuries<br>4,125 | Aneurysm,<br>open<br>230                  |                                          |

| Age group | 0 - 9      | 10 - 19                               | 20 - 29                               | 30 - 39                               | 40 - 49                               | 50 - 59                               | 60 - 69                               | 70 - 79                               | 80 - 89                      | 90 - 99                     | 100 -                                 |
|-----------|------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|------------------------------|-----------------------------|---------------------------------------|
| 8         | Procedures | Epilepsy                              | Transnasal                            | Revascularization                     | Revascularization                     | CSDH                                  | CSDH                                  | ICH                                   | Aneurysm embolization        | Aneurysm, open              | Not otherwise classified              |
|           | Number     | 307                                   | 251                                   | 311                                   | 641                                   | 1,523                                 | 3,688                                 | 6,722                                 | 7,681                        | 3,674                       | 215                                   |
| 9         | Procedures | CCJ anomalies                         | AVM embolization                      | AVM removal                           | Craniotomy for head injuries          | Transnasal                            | Cranioplasty unrelated to head injury | PTA                                   | ICH                          | Aneurysm embolization       | PTA                                   |
|           | Number     | 164                                   | 234                                   | 274                                   | 586                                   | 1,438                                 | 1,700                                 | 5,895                                 | 7,273                        | 3,337                       | 213                                   |
| 10        | Procedures | Cranioplasty unrelated to head injury | Cranioplasty for head injuries        | AVM embolization                      | Not otherwise classified              | Not otherwise classified              | Not otherwise classified              | Endovascular recanalization           | Endovascular recanalization  | BT removal                  | Spinal degeneration                   |
|           | Number     | 154                                   | 228                                   | 246                                   | 585                                   | 1,379                                 | 1,652                                 | 3,198                                 | 5,998                        | 3,071                       | 156                                   |
| 11        | Procedures | Cranioplasty for head injuries        | BT biopsy                             | Cranioplasty for head injuries        | MVD                                   | Cranioplasty unrelated to head injury | MVD                                   | Not otherwise classified              | CEA                          | Radiotherapy for metastasis | Radiotherapy for metastasis           |
|           | Number     | 142                                   | 223                                   | 240                                   | 502                                   | 1,362                                 | 1,605                                 | 2,942                                 | 5,542                        | 2,761                       | 137                                   |
| 12        | Procedures | CSDH                                  | CCJ anomalies                         | Radiotherapy for primary BTs          | Cranioplasty unrelated to head injury | Revascularization                     | Transnasal                            | Craniotomy for head injuries          | Craniotomy for head injuries | Not otherwise classified    | Burr hole surgeries for head injuries |
|           | Number     | 100                                   | 223                                   | 231                                   | 496                                   | 1,329                                 | 1,524                                 | 2,906                                 | 4,212                        | 1,917                       | 124                                   |
| 13        | Procedures | Skull tumors                          | Radiotherapy for CVDs                 | Aneurysm, open                        | Radiotherapy for primary BTs          | MVD                                   | Radiotherapy for primary BTs          | CEA                                   | Not otherwise classified     | CEA                         | BT removal                            |
|           | Number     | 100                                   | 166                                   | 230                                   | 481                                   | 1,227                                 | 1,463                                 | 2,814                                 | 3,084                        | 1,573                       | 114                                   |
| 14        | Procedures | AVM removal                           | Spinal anomalies                      | ICH                                   | Epilepsy                              | Radiotherapy for primary BTs          | Craniotomy for head injuries          | Cranioplasty unrelated to head injury | Revascularization            | Spinal injuries             | Other intervention                    |
|           | Number     | 98                                    | 157                                   | 223                                   | 453                                   | 1,138                                 | 1,454                                 | 2,313                                 | 2,046                        | 867                         | 78                                    |
| 15        | Procedures | BT biopsy                             | Cranioplasty unrelated to head injury | Cranioplasty unrelated to head injury | Other intervention                    | Other intervention                    | Other intervention                    | Other intervention                    | Radiotherapy for primary BTs | Other intervention          | Spinal injuries                       |
|           | Number     | 98                                    | 154                                   | 208                                   | 428                                   | 1,137                                 | 1,314                                 | 2,195                                 | 1,976                        | 841                         | 76                                    |

\*Only procedures performed 10 times or more were shown.

| Male |            | 0 - 9                              | 10 - 19                                   | 20 - 29                                   | 30 - 39                            | 40 - 49                  | 50 - 59                  | 60 - 69                        | 70 - 79                        | 80 - 89                            | 90 - 99                            | 100 - |
|------|------------|------------------------------------|-------------------------------------------|-------------------------------------------|------------------------------------|--------------------------|--------------------------|--------------------------------|--------------------------------|------------------------------------|------------------------------------|-------|
| 1    | Procedures | Hydro-<br>cephalus                 | Hydro-<br>cephalus                        | BT removal                                | BT removal                         | BT removal               | Aneurysm,<br>open        | CSDH                           | CSDH                           | CSDH                               | CSDH                               | CSDH  |
|      | Number     | 967                                | 913                                       | 743                                       | 1,499                              | 2,663                    | 3,487                    | 10,508                         | 21,674                         | 25,182                             | 5,082                              | 73    |
| 2    | Procedures | Cranio-<br>cerebral<br>anomalies   | BT removal                                | Hydro-<br>cephalus                        | Spinal<br>degeneration             | Aneurysm,<br>open        | BT removal               | Spinal<br>degeneration         | PTA                            | PTA                                | Endovascular<br>recanalization     |       |
|      | Number     | 450                                | 661                                       | 656                                       | 840                                | 2,390                    | 3,330                    | 5,949                          | 9,253                          | 4,067                              | 304                                |       |
| 3    | Procedures | BT removal                         | Craniotomy<br>for head<br>injuries        | Craniotomy<br>for head<br>injuries        | Hydro-<br>cephalus                 | Hydro-<br>cephalus       | Spinal<br>degeneration   | BT removal                     | Hydro-<br>cephalus             | Hydro-<br>cephalus                 | Craniotomy<br>for head<br>injuries |       |
|      | Number     | 402                                | 441                                       | 456                                       | 836                                | 2,310                    | 3,208                    | 5,927                          | 6,952                          | 3,529                              | 297                                |       |
| 4    | Procedures | Revascula-<br>rization             | Epilepsy                                  | Epilepsy                                  | Aneurysm,<br>open                  | Spinal<br>degeneration   | Hydro-<br>cephalus       | Hydro-<br>cephalus             | Spinal<br>degeneration         | Endovascular<br>recanalization     | Hydro-<br>cephalus                 |       |
|      | Number     | 256                                | 259                                       | 318                                       | 655                                | 2,072                    | 3,105                    | 5,643                          | 6,859                          | 2,596                              | 166                                |       |
| 5    | Procedures | Spinal<br>anomalies                | AVM removal                               | Spinal<br>degeneration                    | Aneurysm<br>embolization           | Aneurysm<br>embolization | CSDH                     | Radiosurgery<br>for metastasis | Radiosurgery<br>for metastasis | Craniotomy<br>for head<br>injuries | PTA                                |       |
|      | Number     | 238                                | 176                                       | 261                                       | 510                                | 1,890                    | 2,978                    | 5,311                          | 5,092                          | 2,406                              | 145                                |       |
| 6    | Procedures | Not<br>otherwise<br>classified     | Cranio-<br>plasty<br>for head<br>injuries | Transnasal                                | Craniotomy<br>for head<br>injuries | ICH                      | ICH                      | PTA                            | BT removal                     | Spinal<br>degeneration             | ICH                                |       |
|      | Number     | 213                                | 173                                       | 210                                       | 458                                | 1,768                    | 2,821                    | 4,946                          | 4,955                          | 2,285                              | 133                                |       |
| 7    | Procedures | Craniotomy<br>for head<br>injuries | Not<br>otherwise<br>classified            | Cranio-<br>plasty<br>for head<br>injuries | ICH                                | CSDH                     | Aneurysm<br>embolization | Aneurysm,<br>open              | CEA                            | ICH                                | Not<br>otherwise<br>classified     |       |
|      | Number     | 201                                | 172                                       | 192                                       | 456                                | 1,187                    | 2,472                    | 4,761                          | 4,759                          | 2,098                              | 88                                 |       |

| Age group | 0 - 9      | 10 - 19                               | 20 - 29                               | 30 - 39                               | 40 - 49                               | 50 - 59                               | 60 - 69                               | 70 - 79                               | 80 - 89                               | 90 - 99                     | 100 -                                 |
|-----------|------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|-----------------------------|---------------------------------------|
| 8         | Procedures | Epilepsy                              | Revascularization                     | Not otherwise classified              | Transnasal                            | Craniotomy for head injuries          | Radiotherapy for metastasis           | ICH                                   | Radiotherapy for metastasis           | Spinal degeneration         |                                       |
|           | Number     | 163                                   | 166                                   | 191                                   | 388                                   | 887                                   | 1,850                                 | 4,379                                 | 3,971                                 | 1,647                       | 79                                    |
| 9         | Procedures | Cranioplasty for head injuries        | BT biopsy                             | CSDH                                  | Not otherwise classified              | Craniotomy for head injuries          | Craniotomy for head injuries          | Aneurysm embolization                 | Endovascular recanalization           | Radiotherapy for metastasis |                                       |
|           | Number     | 97                                    | 154                                   | 136                                   | 367                                   | 814                                   | 1,039                                 | 2,631                                 | 3,733                                 | 1,399                       | 71                                    |
| 10        | Procedures | CCJ anomalies                         | AVM embolization                      | AVM removal                           | CSDH                                  | Cranioplasty unrelated to head injury | Not otherwise classified              | CEA                                   | Aneurysm, open                        | CEA                         | Burr hole surgeries for head injuries |
|           | Number     | 91                                    | 130                                   | 135                                   | 310                                   | 709                                   | 921                                   | 2,469                                 | 2,867                                 | 1,351                       | 46                                    |
| 11        | Procedures | Cranioplasty unrelated to head injury | Transnasal                            | AVM embolization                      | Cranioplasty unrelated to head injury | Transnasal                            | PTA                                   | Endovascular recanalization           | Craniotomy for head injuries          | Not otherwise classified    | BT removal                            |
|           | Number     | 88                                    | 118                                   | 129                                   | 299                                   | 670                                   | 903                                   | 2,305                                 | 2,763                                 | 923                         | 41                                    |
| 12        | Procedures | CSDH                                  | Cranioplasty unrelated to head injury | Cranioplasty unrelated to head injury | Revascularization                     | Radiotherapy for metastasis           | Cranioplasty unrelated to head injury | Craniotomy for head injuries          | Aneurysm embolization                 | Aneurysm, open              | Other intervention                    |
|           | Number     | 74                                    | 107                                   | 127                                   | 271                                   | 662                                   | 893                                   | 2,086                                 | 1,744                                 | 540                         | 34                                    |
| 13        | Procedures | BT biopsy                             | Spinal degeneration                   | BT biopsy                             | Radiotherapy for primary BTs          | MVD                                   | Endovascular recanalization           | Not otherwise classified              | Aneurysm embolization                 | Brain abscess               |                                       |
|           | Number     | 54                                    | 102                                   | 121                                   | 260                                   | 571                                   | 749                                   | 1,689                                 | 1,704                                 | 516                         | 34                                    |
| 14        | Procedures | Skull tumors                          | CSDH                                  | ICH                                   | Epilepsy                              | Revascularization                     | Transnasal                            | Revascularization                     | Revascularization                     | Other intervention          | Aneurysm embolization                 |
|           | Number     | 54                                    | 95                                    | 114                                   | 250                                   | 560                                   | 722                                   | 1,468                                 | 1,462                                 | 361                         | 29                                    |
| 15        | Procedures | AVM removal                           | ICH                                   | Radiotherapy for primary BTs          | MVD                                   | Radiotherapy for primary BTs          | Revascularization                     | Cranioplasty unrelated to head injury | Cranioplasty unrelated to head injury | Spinal injuries             | Spinal injuries                       |
|           | Number     | 53                                    | 93                                    | 110                                   | 222                                   | 518                                   | 713                                   | 1,154                                 | 873                                   | 342                         | 25                                    |

\*Only procedures performed 10 times or more were shown.

## Female

| Age group | 0 - 9                            | 10 - 19                            | 20 - 29                | 30 - 39                  | 40 - 49                        | 50 - 59                        | 60 - 69                        | 70 - 79                  | 80 - 89                        | 90 - 99                            | 100 -                          |
|-----------|----------------------------------|------------------------------------|------------------------|--------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------|--------------------------------|------------------------------------|--------------------------------|
| 1         | Hydro-<br>cephalus               | Hydro-<br>cephalus                 | BT removal             | BT removal               | Aneurysm,<br>open              | Aneurysm,<br>open              | Aneurysm,<br>open              | Aneurysm,<br>open        | CSDH                           | CSDH                               | CSDH                           |
| Number    | 778                              | 582                                | 701                    | 1,582                    | 3,530                          | 5,363                          | 10,145                         | 9,411                    | 13,192                         | 4,624                              | 119                            |
| 2         | Revascula-<br>rization           | BT removal                         | Hydro-<br>cephalus     | Hydro-<br>cephalus       | BT removal                     | BT removal                     | BT removal                     | Hydro-<br>cephalus       | Hydro-<br>cephalus             | Endovascular<br>recanalization     | Endovascular<br>recanalization |
| Number    | 389                              | 466                                | 419                    | 765                      | 3,287                          | 4,119                          | 6,391                          | 8,322                    | 5,733                          | 963                                | 20                             |
| 3         | BT removal                       | Revascula-<br>rization             | Transnasal             | Aneurysm<br>embolization | Aneurysm<br>embolization       | Aneurysm<br>embolization       | Aneurysm<br>embolization       | CSDH                     | Endovascular<br>recanalization | Hydro-<br>cephalus                 |                                |
| Number    | 322                              | 322                                | 309                    | 735                      | 2,931                          | 3,885                          | 5,924                          | 8,288                    | 3,199                          | 453                                |                                |
| 4         | Cranio-<br>cerebral<br>anomalies | Epilepsy                           | Epilepsy               | Aneurysm,<br>open        | Hydro-<br>cephalus             | Hydro-<br>cephalus             | Hydro-<br>cephalus             | Aneurysm<br>embolization | Aneurysm,<br>open              | Craniotomy<br>for head<br>injuries |                                |
| Number    | 249                              | 218                                | 259                    | 723                      | 1,975                          | 2,821                          | 5,542                          | 5,937                    | 3,134                          | 357                                |                                |
| 5         | Spinal<br>anomalies              | CCJ<br>anomalies                   | Revascula-<br>rization | Transnasal               | Radiotherapy<br>for metastasis | Radiotherapy<br>for metastasis | Radiotherapy<br>for metastasis | BT removal               | Aneurysm<br>embolization       | Aneurysm<br>embolization           |                                |
| Number    | 232                              | 143                                | 227                    | 475                      | 1,238                          | 1,952                          | 3,895                          | 5,282                    | 2,821                          | 336                                |                                |
| 6         | Not<br>otherwise<br>classified   | Transnasal                         | AVM removal            | Revascula-<br>rization   | Spinal<br>degeneration         | ICH                            | CSDH                           | Spinal<br>degeneration   | ICH                            | ICH                                |                                |
| Number    | 171                              | 133                                | 139                    | 370                      | 985                            | 1,508                          | 2,918                          | 4,672                    | 2,627                          | 248                                |                                |
| 7         | Epilepsy                         | Craniotomy<br>for head<br>injuries | Spinal<br>degeneration | Spinal<br>degeneration   | ICH                            | Spinal<br>degeneration         | Spinal<br>degeneration         | ICH                      | Spinal<br>degeneration         | Aneurysm,<br>open                  |                                |
| Number    | 144                              | 132                                | 132                    | 341                      | 796                            | 1,373                          | 2,757                          | 3,302                    | 1,899                          | 208                                |                                |

| Age group | 0 - 9                                 | 10 - 19                      | 20 - 29                      | 30 - 39                               | 40 - 49                               | 50 - 59                               | 60 - 69                               | 70 - 79                               | 80 - 89                      | 90 - 99                               | 100 - |
|-----------|---------------------------------------|------------------------------|------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|------------------------------|---------------------------------------|-------|
| 8         | Craniotomy for head injuries          | AVM removal                  | Not otherwise classified     | Radiosurgery for metastasis           | Revascularization                     | MVD                                   | ICH                                   | Radiosurgery for metastasis           | Craniotomy for head injuries | Not otherwise classified              |       |
| Number    | 118                                   | 125                          | 131                          | 300                                   | 769                                   | 973                                   | 2,343                                 | 3,143                                 | 1,719                        | 127                                   |       |
| 9         | CCJ anomalies                         | AVM embolization             | Craniotomy for head injuries | MVD                                   | Transnasal                            | Radiosurgery for primary BTs          | MVD                                   | Endovascular recanalization           | BT removal                   | Burr hole surgeries for head injuries |       |
| Number    | 73                                    | 104                          | 130                          | 280                                   | 768                                   | 840                                   | 1,394                                 | 2,265                                 | 1,672                        | 78                                    |       |
| 10        | Cranioplasty unrelated to head injury | Not otherwise classified     | Aneurysm embolization        | Other intervention                    | MVD                                   | Cranioplasty unrelated to head injury | Other intervention                    | PTA                                   | Radiosurgery for metastasis  | Spinal degeneration                   |       |
| Number    | 66                                    | 93                           | 122                          | 244                                   | 656                                   | 807                                   | 1,270                                 | 1,677                                 | 1,114                        | 77                                    |       |
| 11        | Skull tumors                          | Radiosurgery for CVDs        | Radiosurgery for primary BTs | Radiosurgery for primary BTs          | Cranioplasty unrelated to head injury | Transnasal                            | Not otherwise classified              | Craniotomy for head injuries          | Not otherwise classified     | BT removal                            |       |
| Number    | 46                                    | 80                           | 121                          | 221                                   | 653                                   | 802                                   | 1,253                                 | 1,449                                 | 994                          | 73                                    |       |
| 12        | Cranioplasty for head injuries        | Spinal anomalies             | Aneurysm, open               | Not otherwise classified              | Other intervention                    | Other intervention                    | Radiosurgery for primary BTs          | Not otherwise classified              | PTA                          | PTA                                   |       |
| Number    | 45                                    | 74                           | 121                          | 218                                   | 628                                   | 782                                   | 1,201                                 | 1,380                                 | 913                          | 68                                    |       |
| 13        | AVM removal                           | BT biopsy                    | AVM embolization             | ICH                                   | Radiosurgery for primary BTs          | Not otherwise classified              | Cranioplasty unrelated to head injury | Radiosurgery for primary BTs          | Spinal injuries              | Radiosurgery for metastasis           |       |
| Number    | 45                                    | 69                           | 117                          | 211                                   | 620                                   | 731                                   | 1,159                                 | 1,160                                 | 525                          | 66                                    |       |
| 14        | BT biopsy                             | Radiosurgery for primary BTs | ICH                          | Epilepsy                              | Not otherwise classified              | CSDH                                  | Transnasal                            | Other intervention                    | Radiosurgery for primary BTs | Spinal injuries                       |       |
| Number    | 44                                    | 60                           | 109                          | 203                                   | 565                                   | 710                                   | 1,080                                 | 1,122                                 | 495                          | 51                                    |       |
| 15        | Transnasal                            | ICH                          | Radiosurgery for CVDs        | Cranioplasty unrelated to head injury | CSDH                                  | Revascularization                     | PTA                                   | Cranioplasty unrelated to head injury | Other intervention           | Other intervention                    |       |
| Number    | 40                                    | 59                           | 99                           | 197                                   | 336                                   | 548                                   | 949                                   | 1,022                                 | 480                          | 44                                    |       |

\*Only procedures performed 10 times or more were shown.

### 1.3 Resident prefectures

|    | Prefecture                      | 2015           | 2016           | 2017           | Total          |
|----|---------------------------------|----------------|----------------|----------------|----------------|
| 1  | Hokkaido                        | 9,947          | 10,344         | 9,617          | 29,908         |
| 2  | Aomori                          | 1,787          | 1,837          | 1,645          | 5,269          |
| 3  | Iwate                           | 928            | 806            | 963            | 2,697          |
| 4  | Miyagi                          | 1,824          | 1,609          | 1,861          | 5,294          |
| 5  | Akita                           | 1,466          | 1,781          | 1,763          | 5,010          |
| 6  | Yamagata                        | 1,586          | 1,262          | 1,477          | 4,325          |
| 7  | Fukushima                       | 2,297          | 2,425          | 2,355          | 7,077          |
| 8  | Ibaraki                         | 4,722          | 4,526          | 4,606          | 13,854         |
| 9  | Tochigi                         | 2,205          | 1,576          | 1,648          | 5,429          |
| 10 | Gunma                           | 2,519          | 2,508          | 2,187          | 7,214          |
| 11 | Saitama                         | 9,095          | 9,743          | 10,010         | 28,848         |
| 12 | Chiba                           | 8,799          | 9,531          | 9,919          | 28,249         |
| 13 | Tokyo                           | 17,742         | 17,870         | 17,837         | 53,449         |
| 14 | Kanagawa                        | 10,722         | 11,632         | 12,206         | 34,560         |
| 15 | Niigata                         | 2,604          | 2,952          | 2,854          | 8,410          |
| 16 | Toyama                          | 1,214          | 1,213          | 1,372          | 3,799          |
| 17 | Ishikawa                        | 1,169          | 1,168          | 1,338          | 3,675          |
| 18 | Fukui                           | 1,021          | 1,125          | 1,141          | 3,287          |
| 19 | Yamanashi                       | 1,091          | 1,096          | 1,205          | 3,392          |
| 20 | Nagano                          | 3,629          | 3,654          | 3,666          | 10,949         |
| 21 | Gifu                            | 2,051          | 2,367          | 2,463          | 6,881          |
| 22 | Shizuoka                        | 6,330          | 5,884          | 6,678          | 18,892         |
| 23 | Aichi                           | 10,610         | 11,099         | 11,805         | 33,514         |
| 24 | Mie                             | 3,538          | 3,599          | 3,619          | 10,756         |
| 25 | Shiga                           | 2,396          | 2,499          | 2,605          | 7,500          |
| 26 | Kyoto                           | 3,144          | 3,722          | 3,587          | 10,453         |
| 27 | Osaka                           | 15,881         | 16,053         | 16,066         | 48,000         |
| 28 | Hyogo                           | 9,199          | 9,730          | 10,104         | 29,033         |
| 29 | Nara                            | 2,627          | 2,807          | 2,983          | 8,417          |
| 30 | Wakayama                        | 2,091          | 2,030          | 2,069          | 6,190          |
| 31 | Tottori                         | 722            | 676            | 513            | 1,911          |
| 32 | Shimane                         | 942            | 934            | 696            | 2,572          |
| 33 | Okayama                         | 2,380          | 2,826          | 2,944          | 8,150          |
| 34 | Hiroshima                       | 4,395          | 4,239          | 4,562          | 13,196         |
| 35 | Yamaguchi                       | 1,748          | 1,892          | 1,874          | 5,514          |
| 36 | Tokushima                       | 787            | 941            | 968            | 2,696          |
| 37 | Kagawa                          | 1,325          | 1,285          | 1,485          | 4,095          |
| 38 | Ehime                           | 1,850          | 1,909          | 1,975          | 5,734          |
| 39 | Kochi                           | 1,141          | 1,153          | 1,151          | 3,445          |
| 40 | Fukuoka                         | 9,183          | 8,190          | 8,180          | 25,553         |
| 41 | Saga                            | 2,048          | 1,891          | 2,060          | 5,999          |
| 42 | Nagasaki                        | 2,069          | 1,897          | 2,150          | 6,116          |
| 43 | Kumamoto                        | 2,097          | 2,282          | 2,642          | 7,021          |
| 44 | Oita                            | 1,148          | 974            | 871            | 2,993          |
| 45 | Miyazaki                        | 910            | 821            | 848            | 2,579          |
| 46 | Kagoshima                       | 2,150          | 1,974          | 2,565          | 6,689          |
| 47 | Okinawa                         | 1,668          | 1,713          | 2,048          | 5,429          |
| 48 | Unknown or<br>foreign countries | 2,117          | 1,560          | 1,588          | 5,265          |
|    | <b>Total</b>                    | <b>182,914</b> | <b>185,605</b> | <b>190,769</b> | <b>559,288</b> |



## 1.4 Emergency transfer and surgery

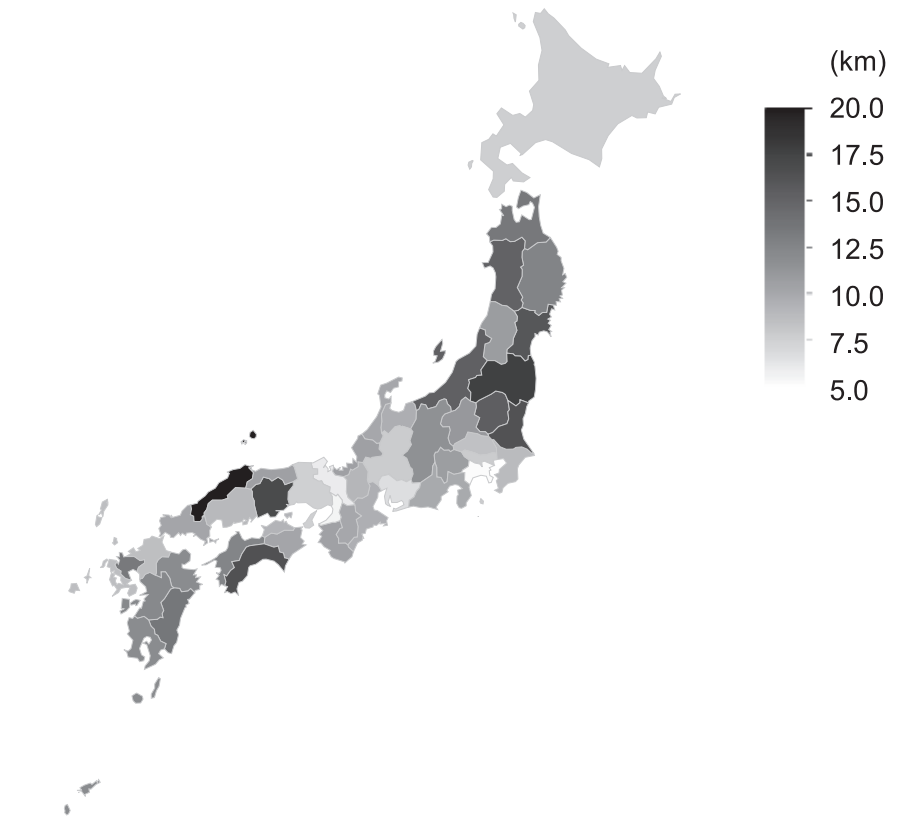
### 1.4.1 Emergency transfer and surgery

|                       | Non-emergency surgery | Emergency surgery | Total   |
|-----------------------|-----------------------|-------------------|---------|
| No emergency transfer | 291,181               | 55,682            | 346,866 |
| Emergency transfer    | 71,052                | 141,366           | 212,419 |
| Total                 | 362,233               | 197,048           | 559,288 |

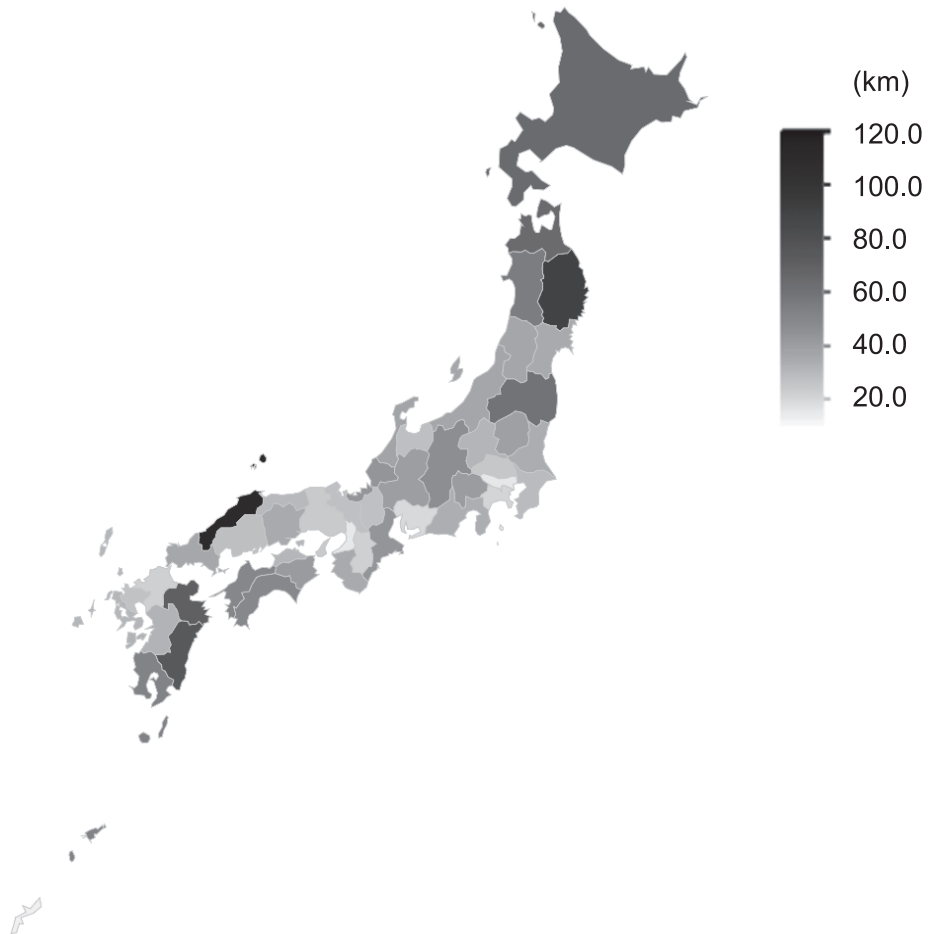
### 1.4.2 Transfer distance in each resident area

|    | Prefecture | Median (km) | 90 percentile (km) |
|----|------------|-------------|--------------------|
| 1  | Hokkaido   | 6.8         | 80.9               |
| 2  | Aomori     | 11.3        | 80.5               |
| 3  | Iwate      | 13.0        | 103.1              |
| 4  | Miyagi     | 11.6        | 46.7               |
| 5  | Akita      | 12.4        | 70.7               |
| 6  | Yamagata   | 9.6         | 47.9               |
| 7  | Fukushima  | 13.9        | 76.2               |
| 8  | Ibaraki    | 13.4        | 44.9               |
| 9  | Tochigi    | 11.4        | 51.3               |
| 10 | Gunma      | 9.6         | 40.9               |
| 11 | Saitama    | 8.7         | 32.9               |
| 12 | Chiba      | 9.1         | 38.7               |
| 13 | Tokyo      | 5.0         | 19.0               |
| 14 | Kanagawa   | 5.6         | 27.0               |
| 15 | Niigata    | 12.1        | 48.0               |
| 16 | Toyama     | 8.4         | 36.3               |
| 17 | Ishikawa   | 7.9         | 49.2               |
| 18 | Fukui      | 9.5         | 57.4               |
| 19 | Yamanashi  | 9.9         | 53.0               |
| 20 | Nagano     | 9.7         | 60.9               |
| 21 | Gifu       | 8.6         | 52.4               |
| 22 | Shizuoka   | 8.1         | 44.2               |
| 23 | Aichi      | 6.0         | 25.0               |
| 24 | Mie        | 9.5         | 57.5               |
| 25 | Shiga      | 7.9         | 35.7               |
| 26 | Kyoto      | 5.8         | 35.8               |
| 27 | Osaka      | 5.0         | 18.6               |
| 28 | Hyogo      | 7.0         | 31.5               |
| 29 | Nara       | 9.0         | 28.6               |
| 30 | Wakayama   | 8.4         | 46.3               |
| 31 | Tottori    | 8.6         | 39.3               |
| 32 | Shimane    | 19.2        | 115.8              |
| 33 | Okayama    | 11.8        | 46.7               |
| 34 | Hiroshima  | 7.7         | 36.5               |
| 35 | Yamaguchi  | 9.4         | 47.4               |
| 36 | Tokushima  | 8.9         | 53.9               |
| 37 | Kagawa     | 8.6         | 40.6               |
| 38 | Ehime      | 10.9        | 64.7               |
| 39 | Kochi      | 13.3        | 64.4               |
| 40 | Fukuoka    | 7.0         | 28.9               |
| 41 | Saga       | 10.4        | 35.0               |
| 42 | Nagasaki   | 8.2         | 40.5               |
| 43 | Kumamoto   | 9.8         | 42.0               |
| 44 | Oita       | 15.8        | 86.8               |
| 45 | Miyazaki   | 11.5        | 90.5               |
| 46 | Kagoshima  | 10.5        | 66.9               |
| 47 | Okinawa    | 4.5         | 15.6               |

Median



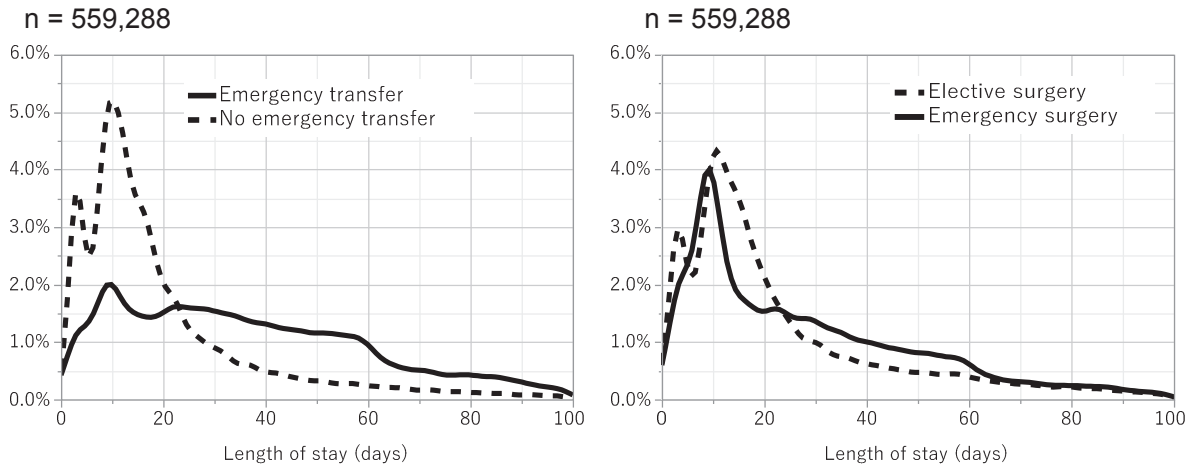
90 percentile



## 1.4.3 Procedures frequently performed as emergency surgery

| Procedure                             | 2015   | 2016   | 2017   | Total  |
|---------------------------------------|--------|--------|--------|--------|
| CSDH                                  | 23,314 | 23,795 | 25,198 | 72,307 |
| ICH                                   | 7,603  | 7,906  | 7,799  | 23,308 |
| Aneurysm, open                        | 7,903  | 7,626  | 7,227  | 22,756 |
| Hydrocephalus                         | 6,355  | 6,348  | 6,491  | 19,194 |
| Endovascular recanalization           | 4,365  | 5,878  | 7,564  | 17,807 |
| Craniotomy for head injuries          | 5,166  | 5,049  | 5,189  | 15,404 |
| Aneurysm embolization                 | 4,217  | 4,479  | 4,718  | 13,414 |
| Craniectomy for brain ischemia        | 1,491  | 1,449  | 1,561  | 4,501  |
| Not otherwise classified              | 1,147  | 1,229  | 1,249  | 3,625  |
| PTA                                   | 1,084  | 1,202  | 1,326  | 3,612  |
| Other intervention                    | 787    | 834    | 749    | 2,370  |
| BT removal                            | 786    | 716    | 681    | 2,183  |
| Burr hole surgeries for head injuries | 694    | 602    | 546    | 1,842  |
| Brain abscess                         | 492    | 499    | 463    | 1,454  |
| Other CVD surgeries                   | 365    | 366    | 325    | 1,056  |
| AVM removal                           | 271    | 279    | 283    | 833    |
| Revascularization                     | 230    | 207    | 244    | 681    |
| Spinal degeneration                   | 196    | 190    | 204    | 590    |
| Cranioplasty unrelated to head injury | 209    | 167    | 165    | 541    |

**1.5 Density plots of length of hospital stay by emergency transfer or surgery**

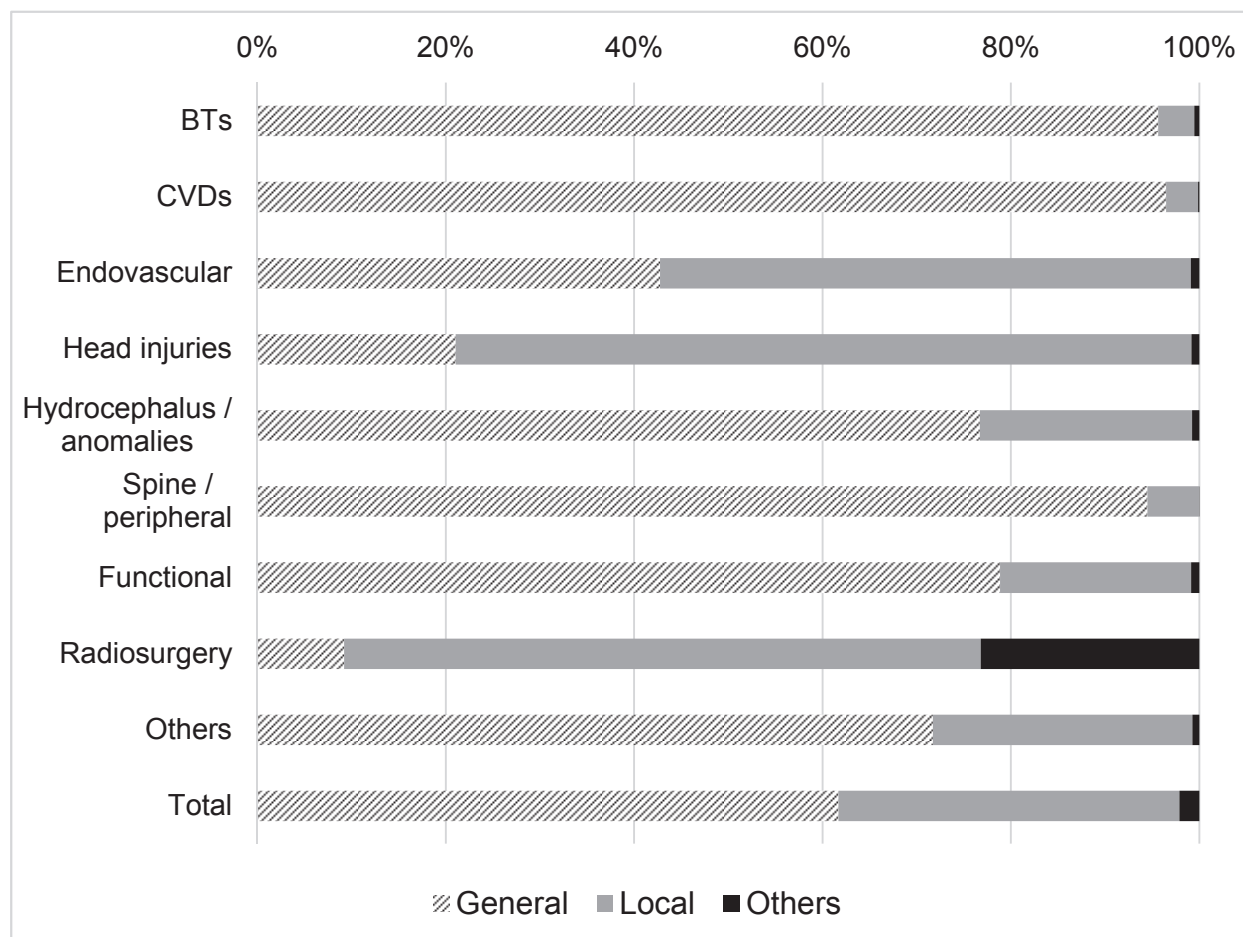


**1.6 Use of microscope, first surgery for the same lesion, and non-neurological surgeries simultaneously performed**

|                                                            | BTs    | CVDs    | Endo-vascular | Head injuries | Hydrocephalus / anomalies | Spine / peripheral | Functional | Radio-surgery | Others |
|------------------------------------------------------------|--------|---------|---------------|---------------|---------------------------|--------------------|------------|---------------|--------|
| Total number                                               | 61,735 | 104,522 | 89,335        | 121,926       | 58,406                    | 44,192             | 16,961     | 37,210        | 25,001 |
| Use of microscope (rate)                                   | 76.4%  | 80.6%   | 1.7%          | 4.0%          | 6.7%                      | 79.4%              | 54.6%      | 0.4%          | 8.6%   |
| First surgery for the same lesion (rate)                   | 82.4%  | 93.8%   | 89.9%         | 86.9%         | 70.8%                     | 91.6%              | 75.8%      | 77.3%         | 57.6%  |
| Non-neurological surgeries simultaneously performed (rate) | 0.3%   | 0.2%    | 0.2%          | 0.2%          | 0.5%                      | 0.2%               | 0.09%      | 0.0%          | 0.9%   |

## 1.7 Types of anesthesia

### 1.7.1 Types of anesthesia in each category



### 1.7.2 Ranking of awake surgery

Top 2 procedures performed as awake surgery\*

|   | Procedure  | 2016 | 2017 | Total |
|---|------------|------|------|-------|
| 1 | BT removal | 105  | 185  | 290   |
| 2 | Epilepsy   | 13   | 7    | 20    |

\*Only indications written in the guideline by the Japan Awake Surgery Conference were shown.

Top 3 diagnoses in BT removal performed as awake surgery

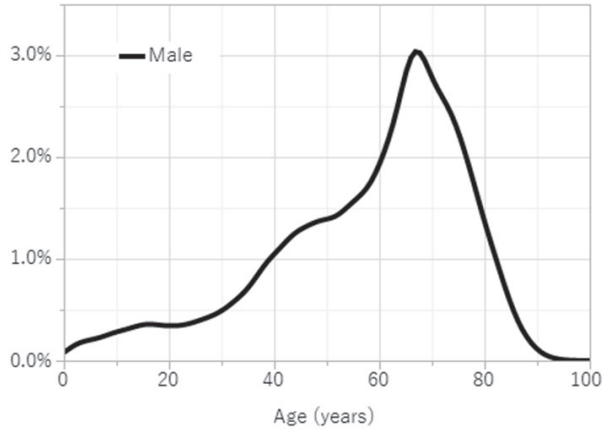
|   | BT diagnosis          | 2016 | 2017 | Total |
|---|-----------------------|------|------|-------|
| 1 | Neuroepithelial tumor | 87   | 161  | 248   |
| 2 | Metastasis            | 8    | 8    | 16    |
| 3 | Meningioma            | 3    | 8    | 11    |

## 2. Brain tumors

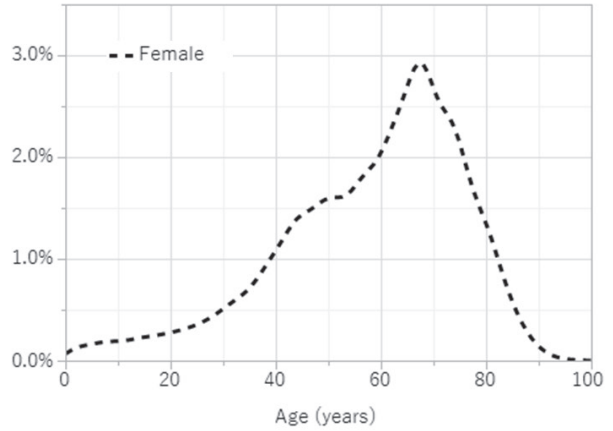
### 2.1 Overall results

#### 2.1.1 Density plots of age by sex

Male (n = 29,777)



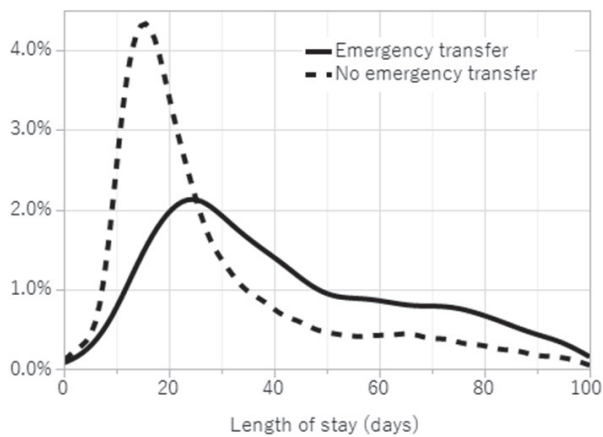
Female (n = 31,958)



#### 2.1.2 Density plots of length of hospital stay by emergency transfer or surgery

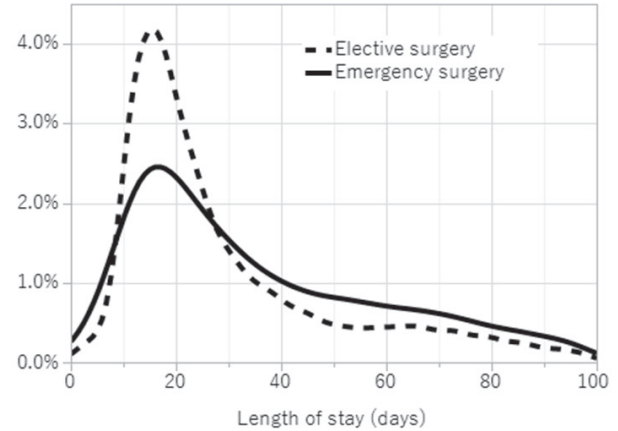
Emergency transfer (n = 5,133)

No emergency transfer (n = 56,602)



Emergency surgery (n = 3,069)

Elective surgery (n = 58,666)



## 2.2 BTs - characteristics and outcomes of each procedure

| Variables               | BT removal | BT biopsy | Transnasal | Extended removal of skull base tumors | Skull tumors | Intraorbital tumors | Scalp tumors | Others |
|-------------------------|------------|-----------|------------|---------------------------------------|--------------|---------------------|--------------|--------|
| Number of surgeries     |            |           |            |                                       |              |                     |              |        |
| total                   | 45,695     | 4,445     | 8,503      | 865                                   | 730          | 291                 | 238          | 968    |
| 2015                    | 15,262     | 1,486     | 3,016      | 304                                   | 238          | 110                 | 75           | 318    |
| 2016                    | 15,067     | 1,464     | 2,766      | 286                                   | 233          | 87                  | 89           | 299    |
| 2017                    | 15,366     | 1,495     | 2,721      | 275                                   | 259          | 94                  | 74           | 351    |
| Emergency transfer      | 9%         | 13%       | 2%         | 3%                                    | 2%           | 1%                  | 3%           | 14%    |
| Emergency surgery       | 5%         | 8%        | 3%         | 1%                                    | 3%           | 3%                  | 4%           | 25%    |
| Age                     |            |           |            |                                       |              |                     |              |        |
| median                  | 63         | 66        | 57         | 56                                    | 55           | 56                  | 61           | 64     |
| mean                    | 59         | 60        | 54         | 54                                    | 47           | 55                  | 57           | 59     |
| lower quartile          | 48         | 51        | 43         | 43                                    | 25           | 44                  | 45           | 50     |
| upper quartile          | 71         | 75        | 68         | 67                                    | 68           | 68                  | 71           | 72     |
| Female patients         | 52%        | 42%       | 52%        | 57%                                   | 60%          | 49%                 | 40%          | 50%    |
| Length of hospital stay |            |           |            |                                       |              |                     |              |        |
| median                  | 24         | 32        | 16         | 27                                    | 12           | 16                  | 6            | 27     |
| mean                    | 36         | 48        | 23         | 40                                    | 15           | 18                  | 15           | 40     |
| lower quartile          | 16         | 15        | 13         | 20                                    | 8            | 12                  | 3            | 14     |
| upper quartile          | 44         | 67        | 21         | 43                                    | 17           | 21                  | 15           | 51     |
| Use of microscope       | 90%        | 30%       | 37%        | 93%                                   | 24%          | 91%                 | 7%           | 18%    |
| First surgery           | 81%        | 95%       | 84%        | 71%                                   | 94%          | 86%                 | 91%          | 64%    |
| General anesthesia      | 99%        | 70%       | 100%       | 100%                                  | 86%          | 98%                 | 39%          | 53%    |
| Preoperative mRS        |            |           |            |                                       |              |                     |              |        |
| median                  | 2          | 3         | 1          | 1                                     | 1            | 1                   | 1            | 3      |
| mean                    | 2          | 3         | 1          | 2                                     | 1            | 1                   | 1            | 3      |
| lower quartile          | 1          | 2         | 1          | 1                                     | 0            | 1                   | 0            | 2      |
| upper quartile          | 3          | 4         | 2          | 2                                     | 1            | 2                   | 1            | 4      |
| mRS at discharge        |            |           |            |                                       |              |                     |              |        |
| median                  | 1          | 2         | 1          | 1                                     | 0            | 1                   | 0            | 2      |
| mean                    | 2          | 3         | 1          | 2                                     | 1            | 1                   | 1            | 3      |
| lower quartile          | 0          | 1         | 0          | 1                                     | 0            | 1                   | 0            | 1      |
| upper quartile          | 2          | 4         | 1          | 2                                     | 1            | 2                   | 1            | 4      |
| mRS improved            | 34%        | 28%       | 39%        | 21%                                   | 24%          | 26%                 | 21%          | 33%    |
| mRS unchanged           | 52%        | 55%       | 58%        | 59%                                   | 70%          | 66%                 | 74%          | 51%    |
| mRS worsened            | 13%        | 13%       | 4%         | 19%                                   | 5%           | 8%                  | 4%           | 8%     |
| Dead                    | 1.9%       | 4.7%      | 0.2%       | 0.6%                                  | 1.0%         | 0.3%                | 0.0%         | 8.1%   |



## 2.3 BTs - diagnoses and approaches

### 2.3.1 Pathological diagnosis

2015

| Diagnosis                      | Removal       | Biopsy       | Total         |
|--------------------------------|---------------|--------------|---------------|
| Meningioma                     | 4,821         | 15           | 4,836         |
| Neuroepithelial tumor          | 3,392         | 468          | 3,860         |
| Metastasis                     | 2,787         | 132          | 2,919         |
| Schwannoma                     | 1,297         | 5            | 1,302         |
| Lymphoma                       | 426           | 508          | 934           |
| Pituitary adenoma              | 517           | 4            | 521           |
| Hemangioblastoma               | 374           | 4            | 378           |
| Craniopharyngioma              | 243           | 11           | 254           |
| Germ cell tumor / pineal tumor | 133           | 88           | 221           |
| Dermoid / epidermoid           | 167           | 1            | 168           |
| Cystic lesions*                | 104           | 10           | 114           |
| Chordoma / chondrosarcoma      | 52            | 0            | 52            |
| Other tumors                   | 949           | 240          | 1,189         |
| <b>Total</b>                   | <b>15,262</b> | <b>1,486</b> | <b>16,748</b> |

\*Excluding Rathke's cleft cyst, dermoid, epidermoid, and arachnoid cyst

| Diagnosis                         | Transnasal   |
|-----------------------------------|--------------|
| Non-functioning pituitary adenoma | 1,566        |
| Functioning pituitary adenoma     | 705          |
| Rathke's cleft cyst               | 252          |
| Craniopharyngioma                 | 154          |
| Chordoma / chondrosarcoma         | 66           |
| Other tumors                      | 273          |
| <b>Total</b>                      | <b>3,016</b> |

2016

| Diagnosis                         | Removal | Biopsy | Transnasal | Total  |
|-----------------------------------|---------|--------|------------|--------|
| Meningioma                        | 4,801   | 17     | 72         | 4,890  |
| Neuroepithelial tumor             | 3,459   | 471    | 15         | 3,945  |
| Metastasis                        | 2,812   | 121    | 14         | 2,947  |
| Non-functioning pituitary adenoma | 398     | 3      | 1,444      | 1,845  |
| Schwannoma                        | 1,215   | 11     | 0          | 1,226  |
| Lymphoma                          | 451     | 490    | 10         | 951    |
| Functioning pituitary adenoma     | 117     | 2      | 630        | 749    |
| Craniopharyngioma                 | 214     | 20     | 137        | 371    |
| Hemangioblastoma                  | 317     | 4      | 0          | 321    |
| Rathke's cleft cyst               | 57      | 2      | 228        | 287    |
| Germ cell tumor                   | 68      | 67     | 12         | 147    |
| Dermoid / epidermoid              | 132     | 0      | 1          | 133    |
| Chordoma / chondrosarcoma         | 50      | 1      | 59         | 110    |
| Cystic lesions*                   | 55      | 9      | 21         | 85     |
| Other pineal tumors               | 50      | 24     | 0          | 74     |
| Other tumors                      | 871     | 222    | 123        | 1,216  |
| Total                             | 15,067  | 1,464  | 2,766      | 19,297 |

\*Excluding Rathke's cleft cyst, dermoid, epidermoid, and arachnoid cyst

2017

| Diagnosis                         | Removal | Biopsy | Transnasal | Total  |
|-----------------------------------|---------|--------|------------|--------|
| Meningioma                        | 4,846   | 24     | 78         | 4,948  |
| Neuroepithelial tumor             | 3,477   | 499    | 4          | 3,980  |
| Metastasis                        | 2,835   | 105    | 13         | 2,953  |
| Non-functioning pituitary adenoma | 460     | 2      | 1,338      | 1,800  |
| Schwannoma                        | 1,322   | 8      | 6          | 1,336  |
| Lymphoma                          | 419     | 522    | 5          | 946    |
| Functioning pituitary adenoma     | 147     | 0      | 635        | 782    |
| Craniopharyngioma                 | 207     | 17     | 174        | 398    |
| Hemangioblastoma                  | 353     | 1      | 0          | 354    |
| Rathke's cleft cyst               | 80      | 5      | 229        | 314    |
| Germ cell tumor                   | 81      | 70     | 20         | 171    |
| Dermoid / epidermoid              | 144     | 2      | 3          | 149    |
| Chordoma / chondrosarcoma         | 55      | 1      | 84         | 140    |
| Other cystic lesions*             | 77      | 0      | 20         | 97     |
| Other pineal tumors               | 50      | 23     | 1          | 74     |
| Other tumors                      | 813     | 216    | 111        | 1,140  |
| Total                             | 15,366  | 1,495  | 2,721      | 19,582 |

\*Excluding Rathke's cleft cyst, dermoid, epidermoid, and arachnoid cyst

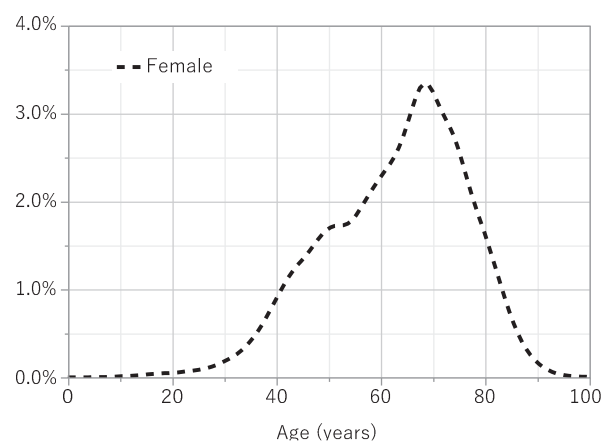
### 2.3.2 Density plots of age by sex in popular tumors (2016 and 2017 only)

#### Meningioma

Male (n = 3,078)

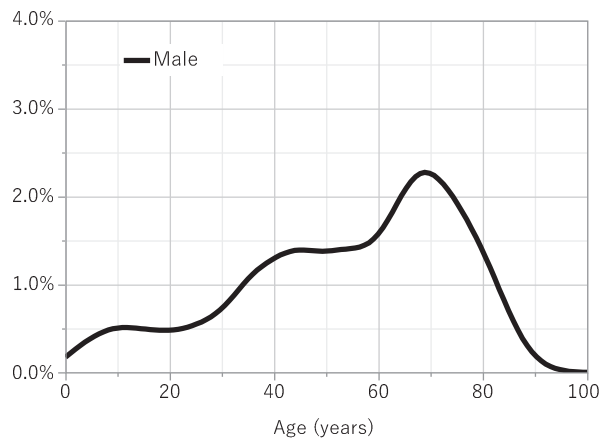


Female (n = 6,569)

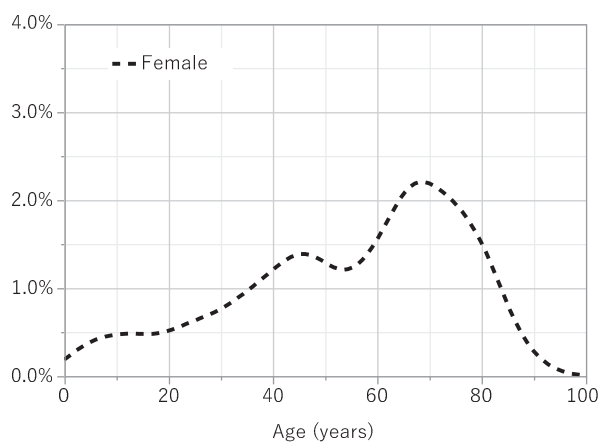


#### Neuroepithelial tumor

Male (n = 3,945)

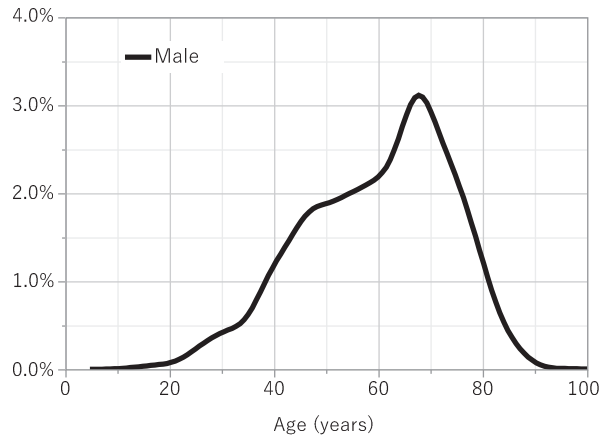


Female (n = 2,991)

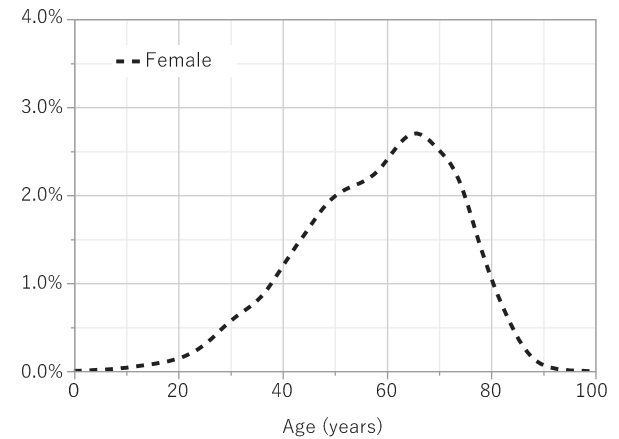


#### Non-functioning pituitary adenoma

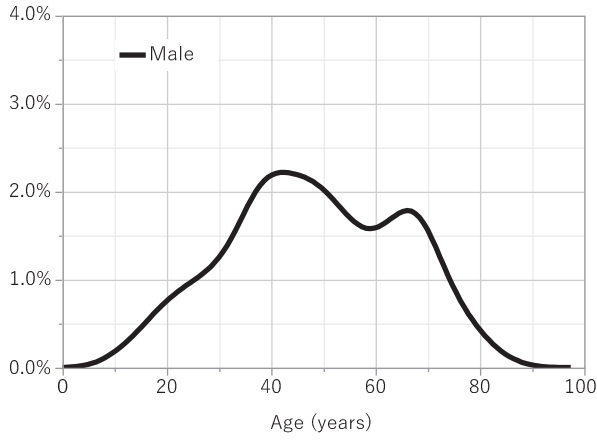
Male (n = 446)



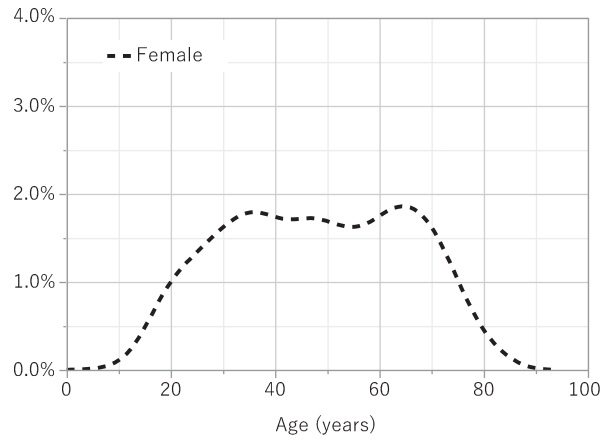
Female (n = 412)



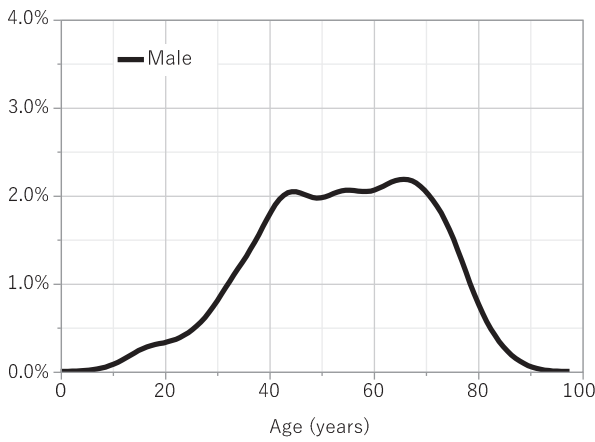
Functioning pituitary adenoma  
Male (n = 136)



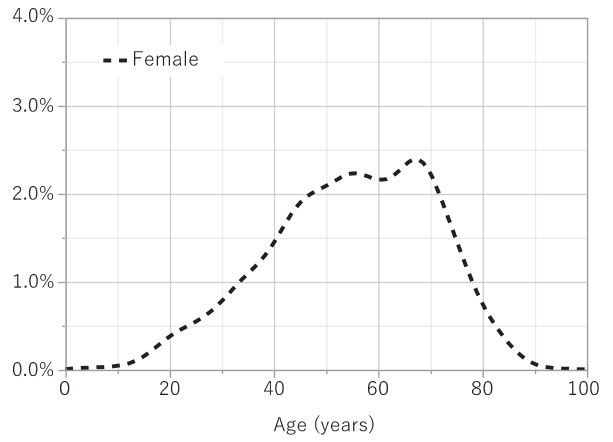
Female (n = 128)



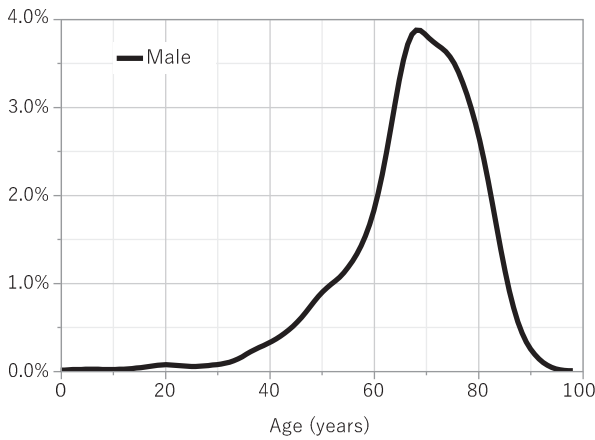
Schwannoma  
Male (n = 1,181)



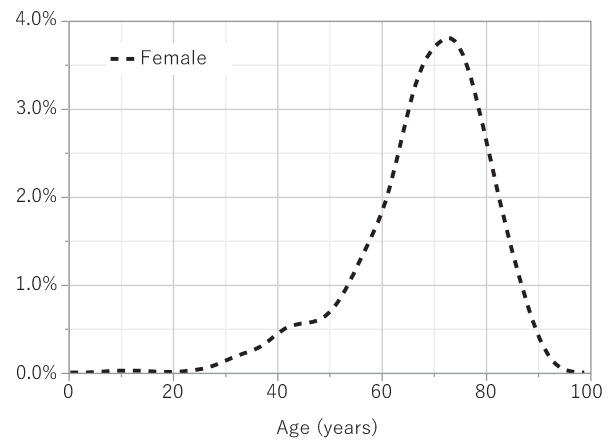
Female (n = 1,356)



Lymphoma  
Male (n = 509)

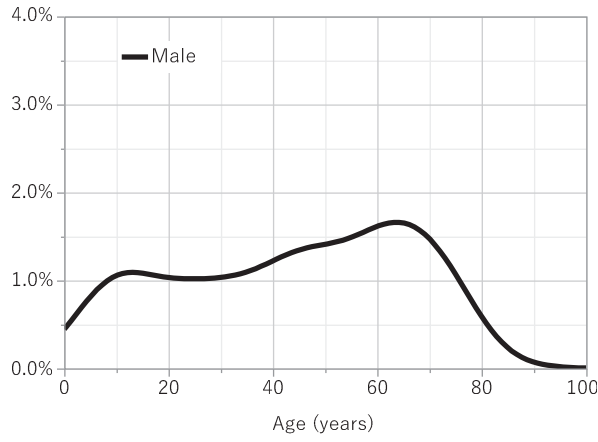


Female (n = 361)

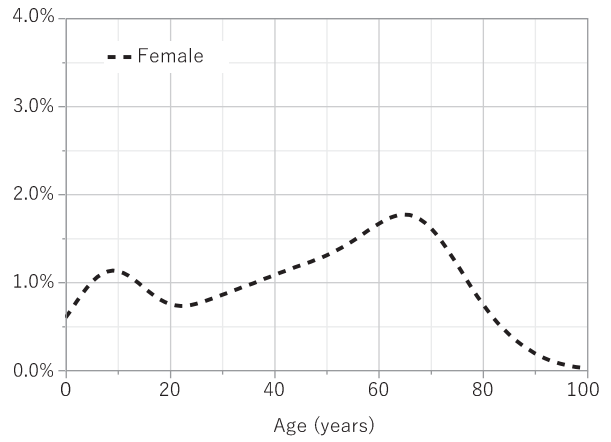


### Craniopharyngioma

Male (n = 224)

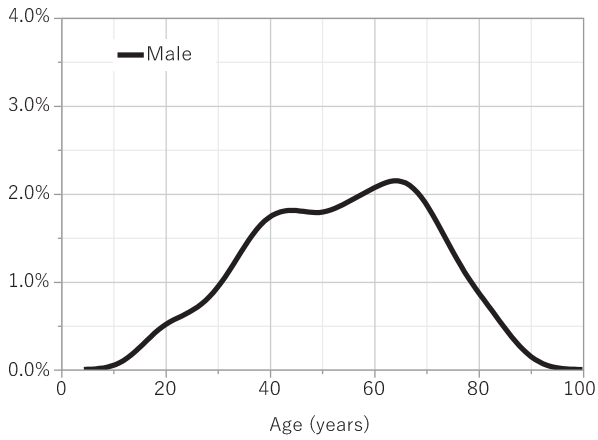


Female (n = 197)

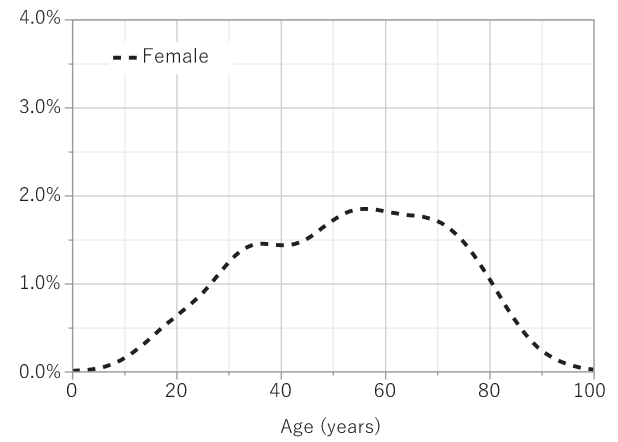


### Hemangioblastoma

Male (n = 380)

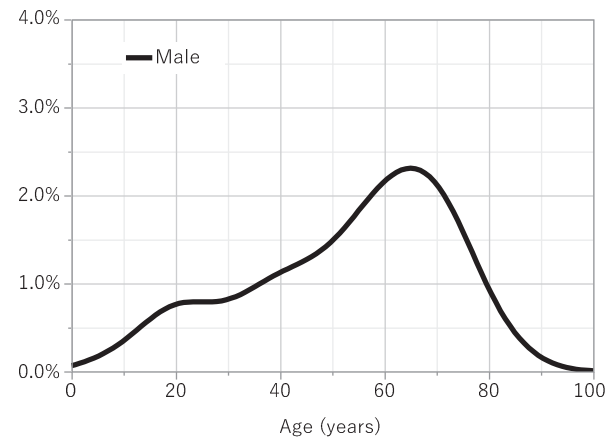


Female (n = 290)

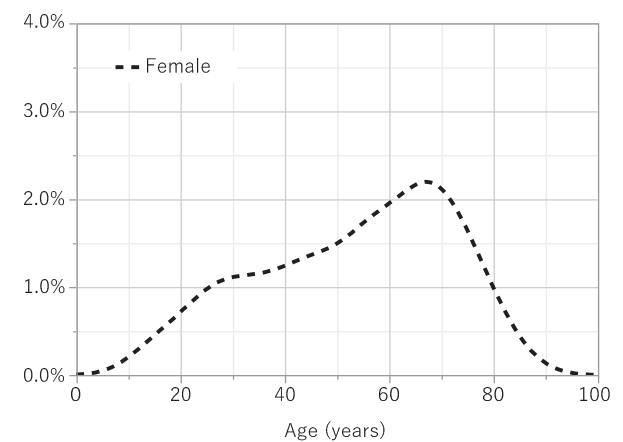


### Rathke's cleft cyst

Male (n = 43)

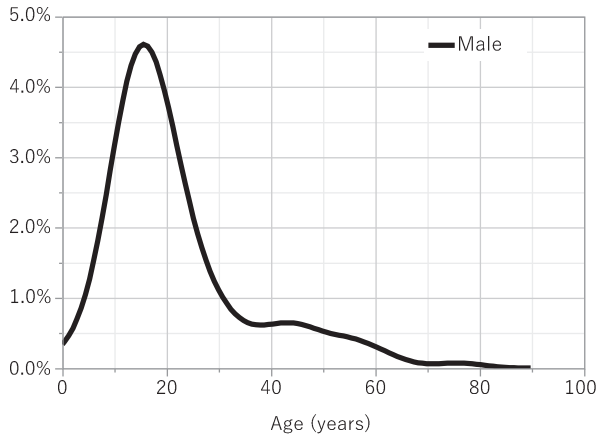


Female (n = 94)

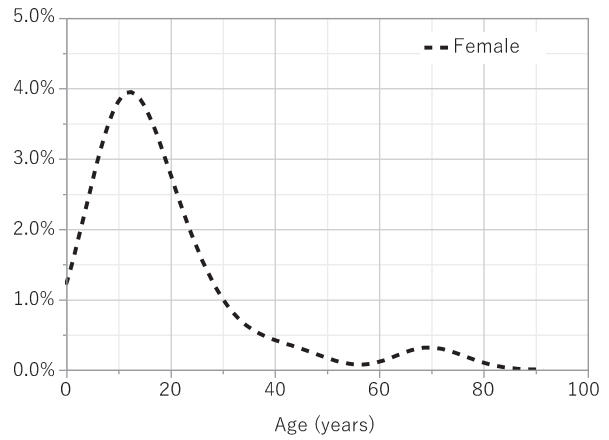


Germ cell tumor

Male (n = 116)

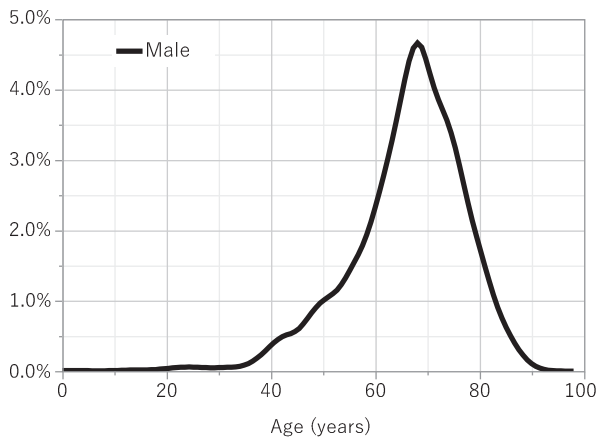


Female (n = 33)

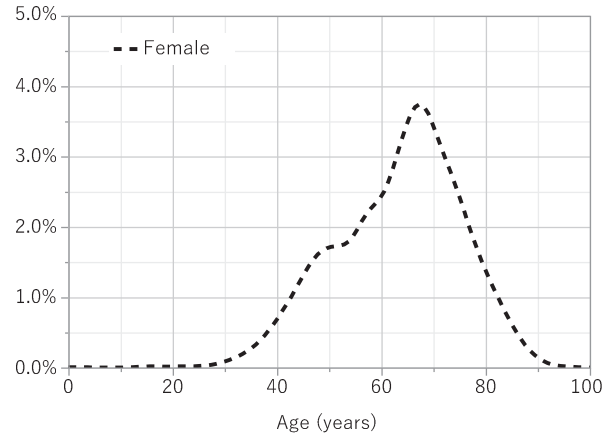


Metastasis

Male (n = 3,128)



Female (n = 2,519)



2.3.3 Approaches in BT removal

| Approach*  | 2,015  | 2,016  | 2,017  | Total  |
|------------|--------|--------|--------|--------|
| Craniotomy | 14,708 | 14,487 | 14,645 | 43,840 |
| Endoscopic | 548    | 616    | 788    | 1,952  |
| Others     | 121    | 105    | 95     | 321    |
| Total      | 15,262 | 15,067 | 15,366 | 45,695 |

\*multiple selection allowed

## 2.3.4 Use of microscope and first surgery in BT removal (2016 and 2017 only)

| Diagnosis                         | n      | Use of microscope | rate  | First surgery | rate  |
|-----------------------------------|--------|-------------------|-------|---------------|-------|
| Meningioma                        | 9,647  | 9,034             | 93.6% | 7,506         | 77.8% |
| Neuroepithelial tumor             | 6,936  | 6,531             | 94.2% | 5,259         | 75.8% |
| Non-functioning pituitary adenoma | 858    | 387               | 45.1% | 716           | 83.4% |
| Functioning pituitary adenoma     | 264    | 116               | 43.9% | 230           | 87.1% |
| Schwannoma                        | 2,537  | 2,464             | 97.1% | 2,254         | 88.8% |
| Craniopharyngioma                 | 421    | 347               | 82.4% | 273           | 64.8% |
| Lymphoma                          | 870    | 703               | 80.8% | 835           | 96.0% |
| Hemangioblastoma                  | 670    | 630               | 94.0% | 540           | 80.6% |
| Germ cell tumor                   | 149    | 109               | 73.2% | 110           | 73.8% |
| Other pineal tumors               | 100    | 87                | 87.0% | 63            | 63.0% |
| Dermoid / epidermoid              | 276    | 260               | 94.2% | 217           | 78.6% |
| Rathke's cleft cyst               | 137    | 66                | 48.2% | 110           | 80.3% |
| Other cystic lesions*             | 132    | 96                | 72.7% | 110           | 83.3% |
| Chordoma / chondrosarcoma         | 105    | 69                | 65.7% | 52            | 49.5% |
| Metastasis                        | 5,647  | 4,985             | 88.3% | 5,063         | 89.7% |
| Other tumors                      | 1,684  | 1,441             | 85.6% | 1,407         | 83.6% |
| Total                             | 30,433 | 27,325            | 89.8% | 24,745        | 81.3% |

\*Excluding Rathke's cleft cyst, dermoid, epidermoid, and arachnoid cyst

## 2.3.5 Approaches in BT biopsy

| Approach*    | 2015  | 2016  | 2017  | Total |
|--------------|-------|-------|-------|-------|
| Craniotomy   | 494   | 513   | 487   | 1,494 |
| Endoscopic   | 295   | 286   | 302   | 883   |
| Stereotactic | 685   | 641   | 674   | 2,000 |
| Others       | 50    | 49    | 68    | 167   |
| Total        | 1,486 | 1,464 | 1,495 | 4,445 |

\*multiple selection allowed



## 2.3.6 Approaches of transnasal surgeries (2016 and 2017 only)

| Diagnosis                                     | Microscope alone | Endoscope alone | Combination | Total |
|-----------------------------------------------|------------------|-----------------|-------------|-------|
| Non-functioning pituitary adenoma             | 369              | 2,100           | 307         | 2,782 |
| Functioning pituitary adenoma                 | 82               | 1,047           | 135         | 1,265 |
| Rathke's cleft cyst                           | 43               | 353             | 60          | 457   |
| Craniopharyngioma                             | 12               | 283             | 16          | 311   |
| Other tumors                                  | 22               | 176             | 34          | 234   |
| Meningioma                                    | 7                | 138             | 5           | 150   |
| Chordoma / chondrosarcoma                     | 8                | 127             | 8           | 143   |
| Other cystic lesions excluding arachnoid cyst | 6                | 32              | 3           | 41    |
| Germ cell tumor                               | 4                | 27              | 1           | 32    |
| Metastasis                                    | 1                | 24              | 2           | 27    |
| Neuroepithelial tumor                         | 0                | 18              | 1           | 19    |
| Lymphoma                                      | 1                | 11              | 2           | 15    |

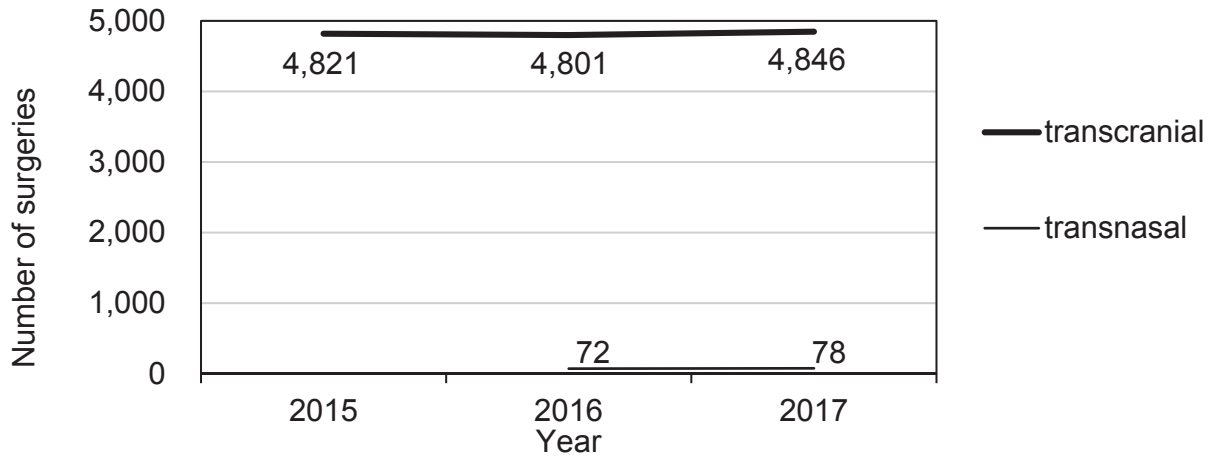
## 2.3.7 Diagnoses for extended removal of skull base tumors with reconstruction

| Diagnosis                                                         | 2015 | 2016 | 2017 | Total |
|-------------------------------------------------------------------|------|------|------|-------|
| Chordoma / chondrosarcoma                                         | 12   | 7    | 7    | 26    |
| Other primary skull base tumors including nasopharyngeal invasion | 197  | 191  | 194  | 582   |
| Other tumors                                                      | 95   | 88   | 74   | 257   |
| Total                                                             | 304  | 286  | 275  | 865   |

## 2.3.8 Diagnoses of skull tumors

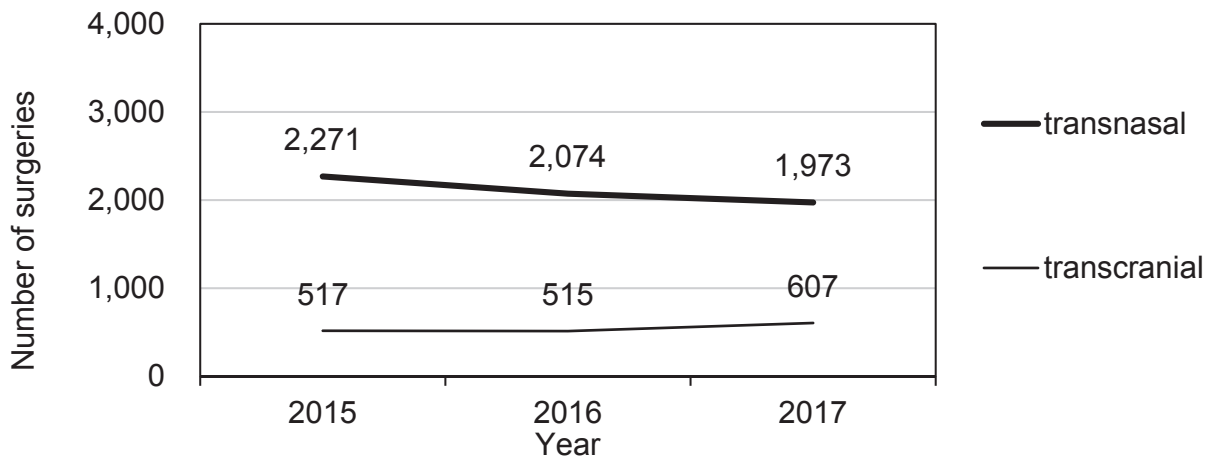
| Diagnosis    | 2015 | 2016 | 2017 | Total |
|--------------|------|------|------|-------|
| Malignant    | 84   | 81   | 107  | 272   |
| Benign       | 139  | 141  | 134  | 414   |
| Other tumors | 15   | 11   | 18   | 44    |
| Total        | 238  | 233  | 259  | 730   |

2.3.9 Trends in approaches for meningioma\*

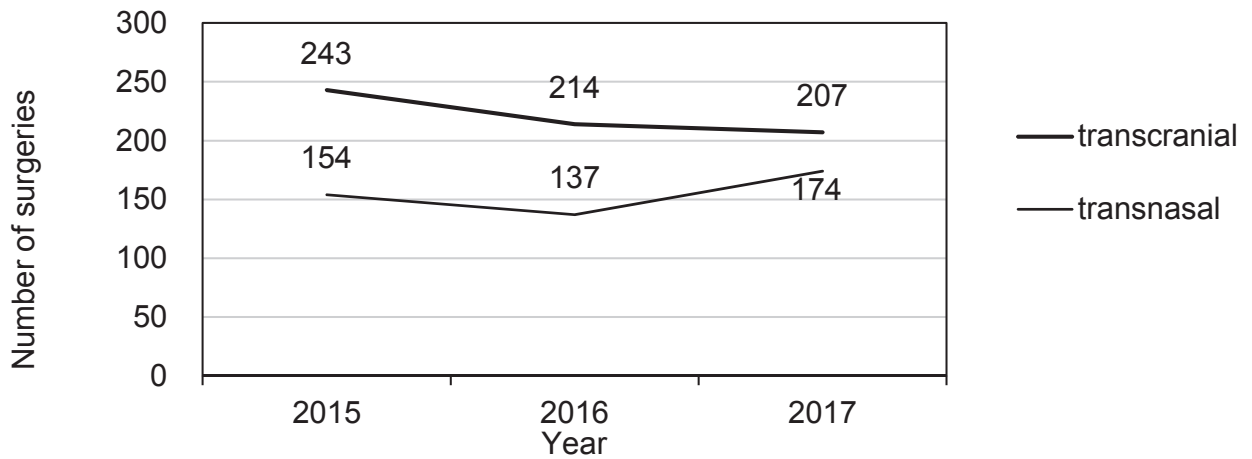


\*Classification of transnasal approach for meningioma added from 2016.

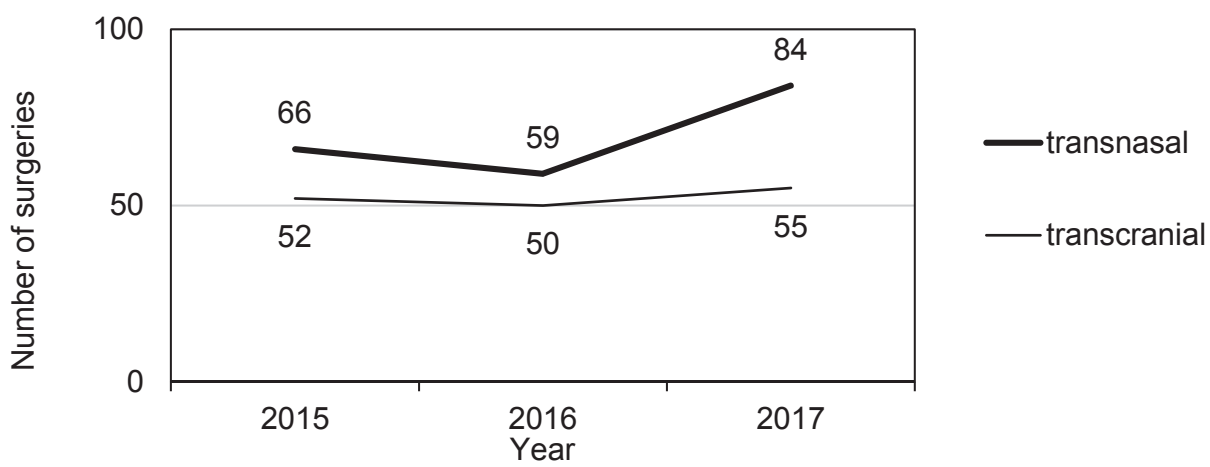
2.3.10 Trends in approaches for pituitary adenoma



2.3.11 Trends in approaches for craniopharyngioma



## 2.3.12 Trends in approaches for chordoma / chondrosarcoma

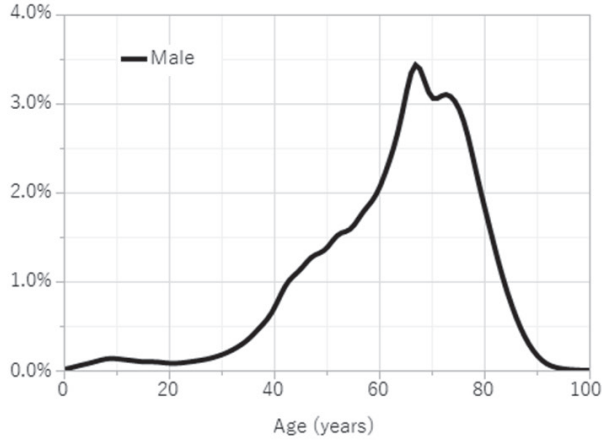


### 3. Cerebrovascular diseases

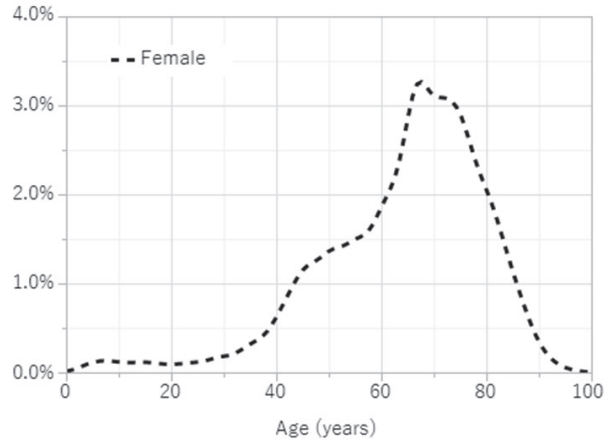
#### 3.1 Overall results

##### 3.1.1 Density plots of age by sex

Male (n = 50,391)



Female (n = 53,991)



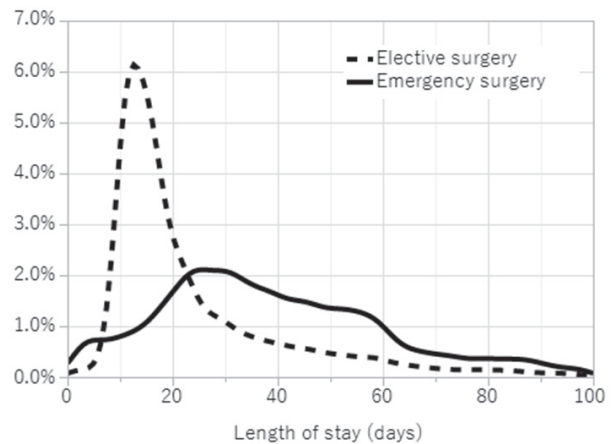
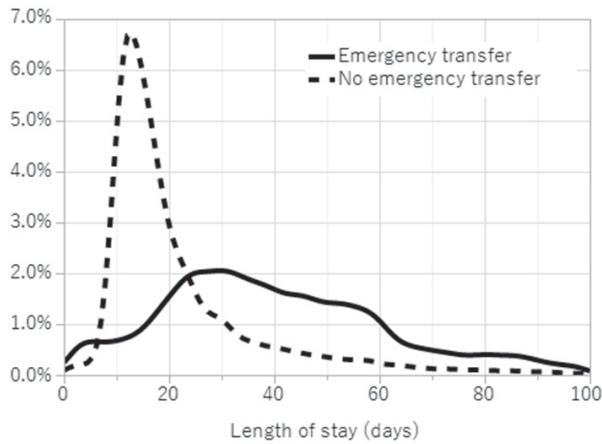
##### 3.1.2 Density plots of length of hospital stay by emergency transfer or surgery

Emergency transfer (n = 56,005)

Emergency surgery (n = 53,574)

No emergency transfer (n = 48,517)

Elective surgery (n = 50,948)



## 3.2 CVDs - characteristics and outcomes of each procedure

| Variables               | Aneurysm   |          |        | AVMs  | Cavernous malformations | CEA    | Revascula-<br>rization | ICH    | Craniectomy<br>for brain<br>ischemia | Others |
|-------------------------|------------|----------|--------|-------|-------------------------|--------|------------------------|--------|--------------------------------------|--------|
|                         | Unruptured | Ruptured | Others |       |                         |        |                        |        |                                      |        |
| Number of surgeries     |            |          |        |       |                         |        |                        |        |                                      |        |
| total                   | 22,949     | 24,355   | 338    | 2,629 | 584                     | 10,466 | 9,285                  | 27,215 | 4,907                                | 1,793  |
| 2015                    | 8,147      | 8,477    | 135    | 870   | 194                     | 3,371  | 3,173                  | 8,944  | 1,642                                | 626    |
| 2016                    | 7,532      | 8,215    | 106    | 897   | 187                     | 3,502  | 2,997                  | 9,134  | 1,574                                | 590    |
| 2017                    | 7,270      | 7,663    | 97     | 862   | 203                     | 3,593  | 3,115                  | 9,137  | 1,691                                | 577    |
| Emergency transfer      | 5%         | 86%      | 36%    | 57%   | 18%                     | 12%    | 16%                    | 89%    | 84%                                  | 60%    |
| Emergency surgery       | 4%         | 89%      | 46%    | 32%   | 10%                     | 4%     | 7%                     | 86%    | 92%                                  | 59%    |
| Age                     |            |          |        |       |                         |        |                        |        |                                      |        |
| median                  | 66         | 64       | 65     | 48    | 44                      | 73     | 59                     | 68     | 67                                   | 68     |
| mean                    | 64         | 63       | 63     | 47    | 45                      | 72     | 53                     | 66     | 64                                   | 65     |
| lower quartile          | 57         | 52       | 54     | 29    | 29                      | 68     | 42                     | 57     | 54                                   | 56     |
| upper quartile          | 72         | 74       | 73     | 65    | 60                      | 78     | 70                     | 77     | 75                                   | 76     |
| Female patients         | 68%        | 69%      | 55%    | 42%   | 53%                     | 14%    | 44%                    | 41%    | 46%                                  | 45%    |
| Length of hospital stay |            |          |        |       |                         |        |                        |        |                                      |        |
| median                  | 15         | 37       | 23     | 32    | 23                      | 16     | 20                     | 37     | 51                                   | 31     |
| mean                    | 21         | 46       | 32     | 39    | 31                      | 24     | 30                     | 45     | 58                                   | 41     |
| lower quartile          | 12         | 25       | 15     | 20    | 16                      | 12     | 15                     | 24     | 27                                   | 15     |
| upper quartile          | 21         | 56       | 45     | 50    | 38                      | 26     | 36                     | 54     | 72                                   | 54     |
| Use of microscope       | 97%        | 96%      | 91%    | 93%   | 95%                     | 82%    | 92%                    | 60%    | 23%                                  | 48%    |
| First surgery           | 98%        | 97%      | 89%    | 69%   | 93%                     | 99%    | 93%                    | 92%    | 77%                                  | 81%    |
| General anesthesia      | 100%       | 100%     | 99%    | 99%   | 99%                     | 100%   | 99%                    | 89%    | 99%                                  | 77%    |
| Preoperative mRS        |            |          |        |       |                         |        |                        |        |                                      |        |
| median                  | 0          | 4        | 2      | 3     | 2                       | 1      | 1                      | 5      | 5                                    | 4      |
| mean                    | 0          | 4        | 2      | 3     | 2                       | 1      | 2                      | 4      | 5                                    | 3      |
| lower quartile          | 0          | 2        | 1      | 1     | 1                       | 0      | 0                      | 4      | 5                                    | 1      |
| upper quartile          | 0          | 5        | 3      | 5     | 3                       | 2      | 2                      | 5      | 5                                    | 5      |
| mRS at discharge        |            |          |        |       |                         |        |                        |        |                                      |        |
| median                  | 0          | 2        | 1      | 2     | 1                       | 0      | 1                      | 4      | 5                                    | 3      |
| mean                    | 1          | 3        | 2      | 2     | 1                       | 1      | 1                      | 4      | 5                                    | 3      |
| lower quartile          | 0          | 1        | 0      | 1     | 0                       | 0      | 0                      | 4      | 4                                    | 1      |
| upper quartile          | 1          | 4        | 3      | 4     | 2                       | 1      | 2                      | 5      | 5                                    | 5      |
| mRS improved            | 9%         | 58%      | 41%    | 45%   | 44%                     | 22%    | 26%                    | 42%    | 33%                                  | 31%    |
| mRS unchanged           | 78%        | 23%      | 46%    | 44%   | 48%                     | 70%    | 65%                    | 39%    | 41%                                  | 42%    |
| mRS worsened            | 13%        | 11%      | 11%    | 8%    | 7%                      | 7%     | 8%                     | 7%     | 6%                                   | 14%    |
| Dead                    | 0.4%       | 7.6%     | 2.4%   | 3.3%  | 0.3%                    | 0.6%   | 0.9%                   | 12.5%  | 20.3%                                | 13.3%  |

### 3.3 CVDs - diagnoses and approaches

#### 3.3.1 Approaches in open surgeries for cerebral aneurysms

| Approach*       | Unruptured    | Ruptured      | Others     | Total         |
|-----------------|---------------|---------------|------------|---------------|
| Neck clipping   | 21,748        | 23,110        | 174        | 45,032        |
| Feeder clipping | 448           | 898           | 31         | 1,377         |
| Wrapping        | 753           | 339           | 8          | 1,100         |
| STA-MCA         | 507           | 310           | 108        | 925           |
| OA-PICA         | 87            | 149           | 4          | 240           |
| Other bypasses  | 268           | 223           | 15         | 506           |
| Others          | 91            | 178           | 22         | 291           |
| <b>Total</b>    | <b>22,949</b> | <b>24,355</b> | <b>338</b> | <b>47,642</b> |

\*multiple selection allowed

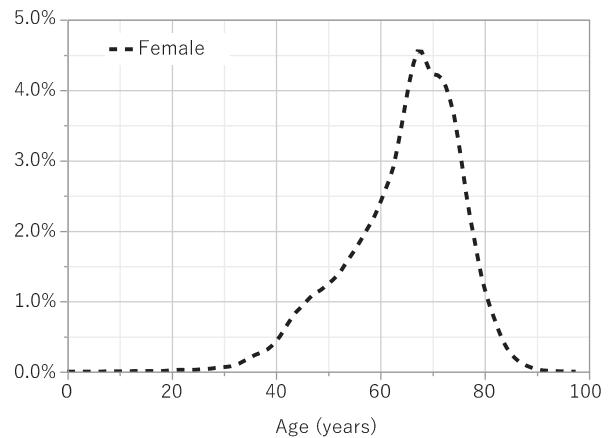
#### 3.3.2 Density plots of age by sex in cerebral aneurysms

Unruptured

Male (n = 7,256)

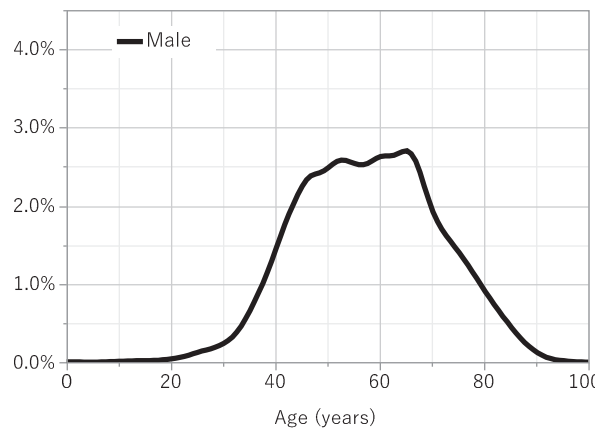


Female (n = 15,693)

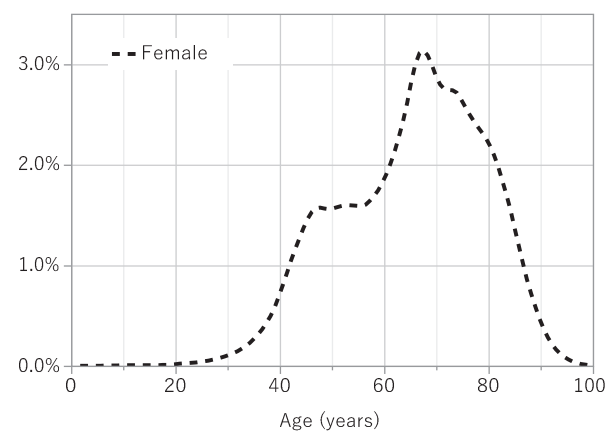


Ruptured

Male (n = 7,497)



Female (n = 16,858)



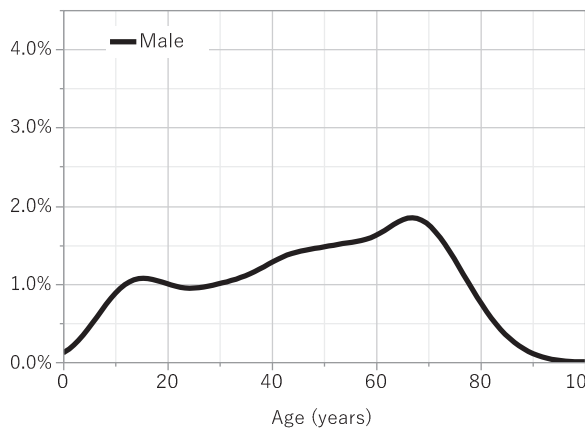
3.3.3 Details of AVM removal

| Diagnosis  | 2015 | 2016 | 2017 | Total |
|------------|------|------|------|-------|
| Unruptured | 207  | 201  | 209  | 617   |
| Ruptured   | 645  | 676  | 635  | 1,956 |
| Others     | 18   | 20   | 18   | 56    |
| Total      | 870  | 897  | 862  | 2,629 |

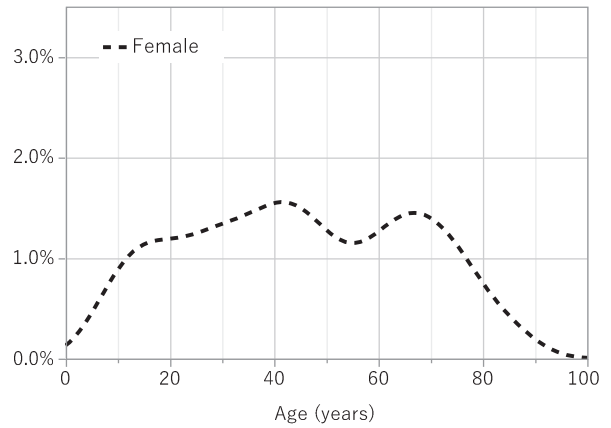
3.3.4 Density plots of age by sex in AVM by CEA

AVM

Male (n = 1,513)

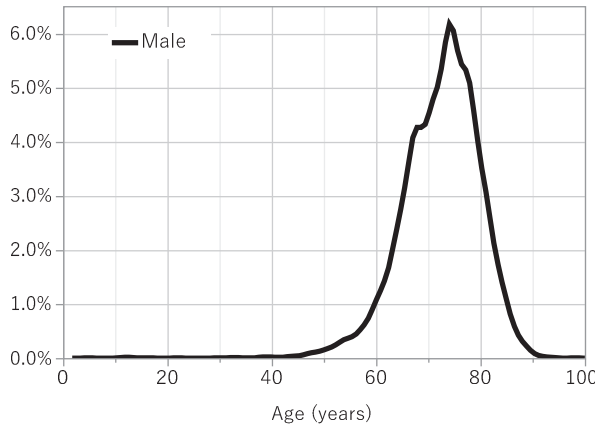


Female (n = 1,116)

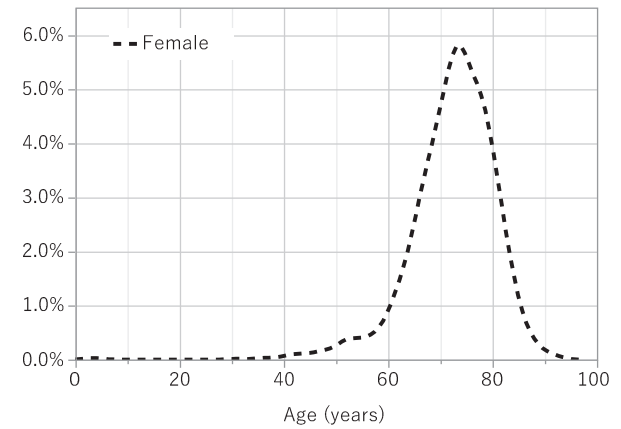


CEA

Male (n = 9,026)



Female (n = 1,440)



## 3.3.5 Approaches in revascularization

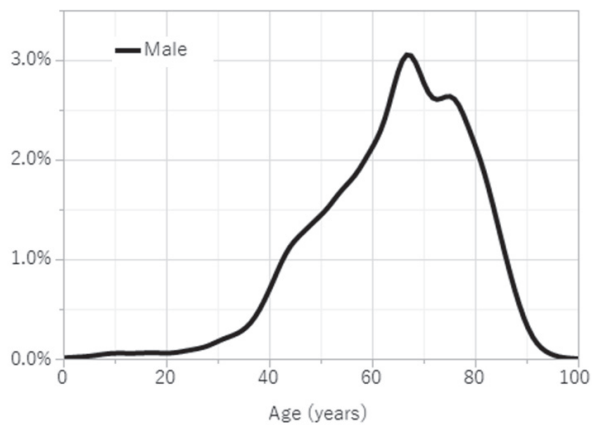
| Approach*                  | Moyamoya disease | Other brain ischemia | Others | Total |
|----------------------------|------------------|----------------------|--------|-------|
| STA-MCA                    | 3,059            | 5,030                | 286    | 8,375 |
| Indirect revascularization | 1,665            | 77                   | 14     | 1,756 |
| Others                     | 71               | 205                  | 103    | 379   |
| Total                      | 3,629            | 5,263                | 393    | 9,285 |

\*multiple selection allowed

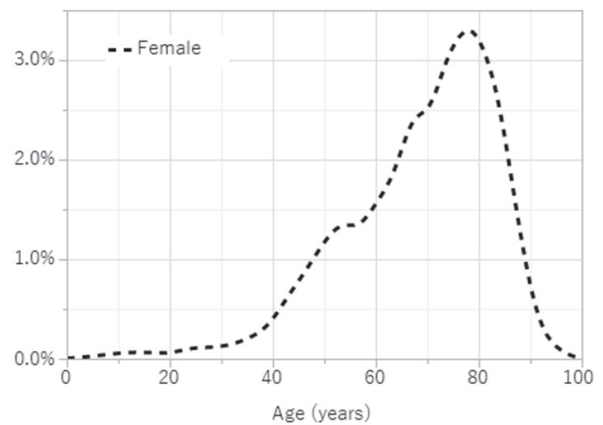
## 3.3.6 Density plots of age by sex in ICH evacuation

## Craniotomy

Male (n = 12,014)

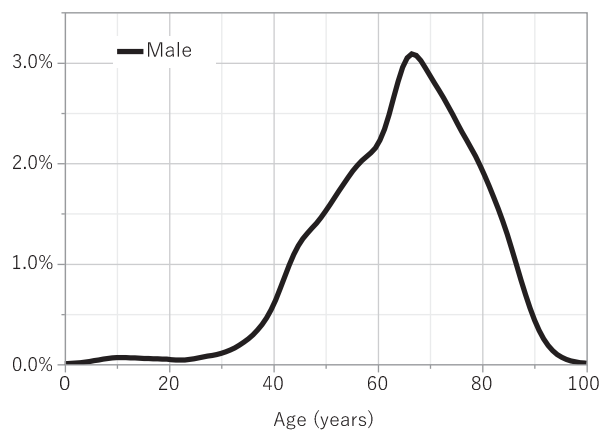


Female (n = 8,540)

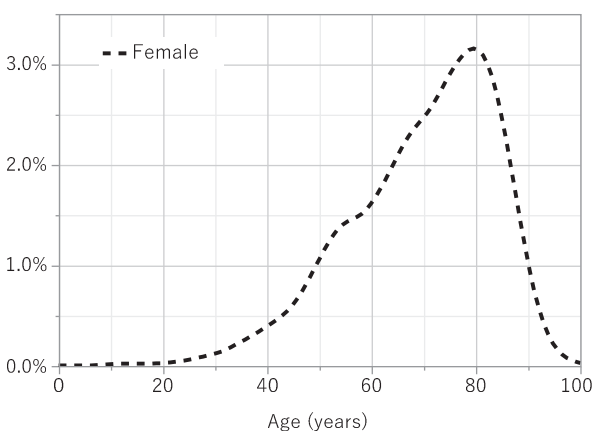


## Endoscopic

Male (n = 2,883)

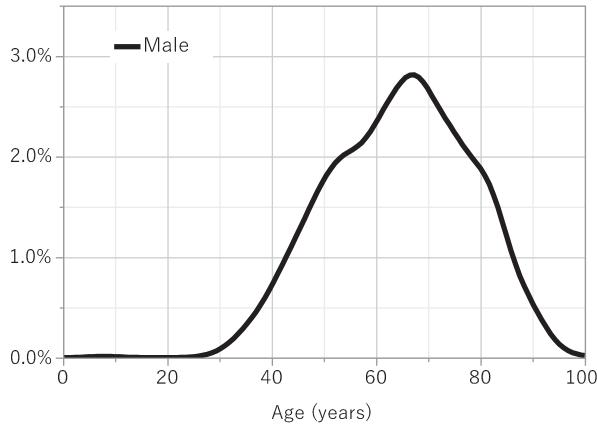


Female (n = 2,052)

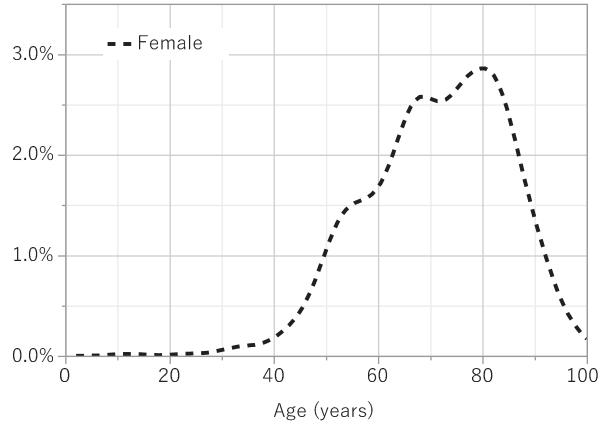




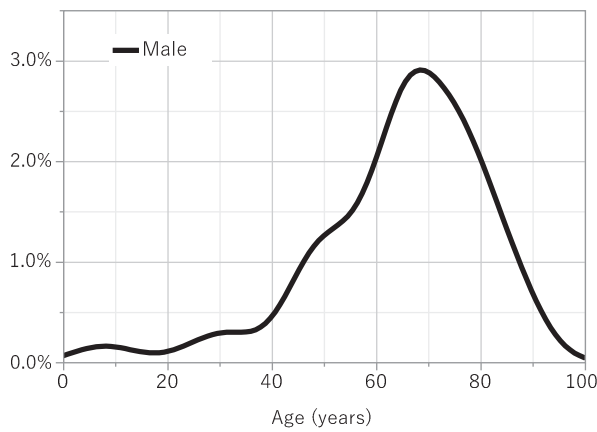
Stereotactic  
Male (n = 1,055)



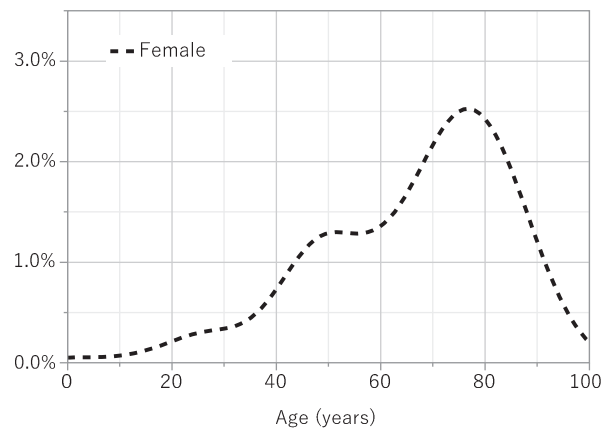
Female (n = 637)



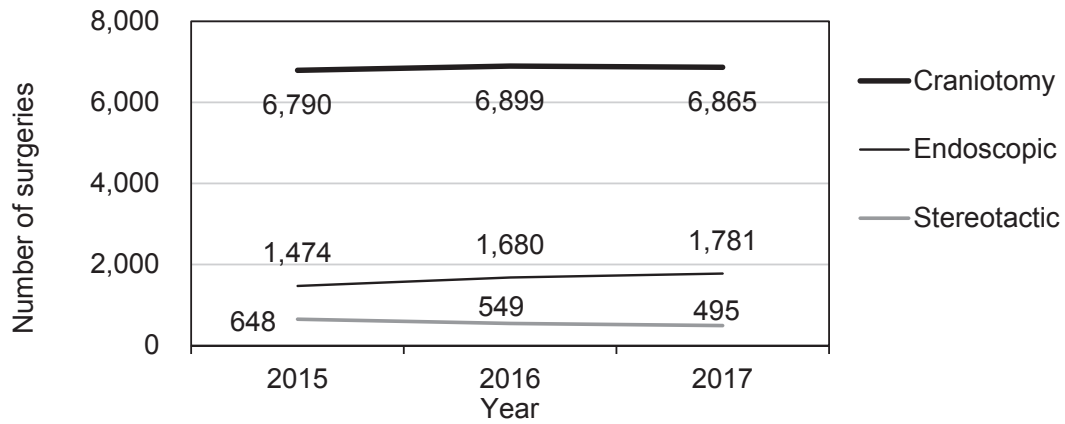
Others  
Male (n = 207)



Female (n = 158)



3.3.7 Trends in approaches to evacuate ICH

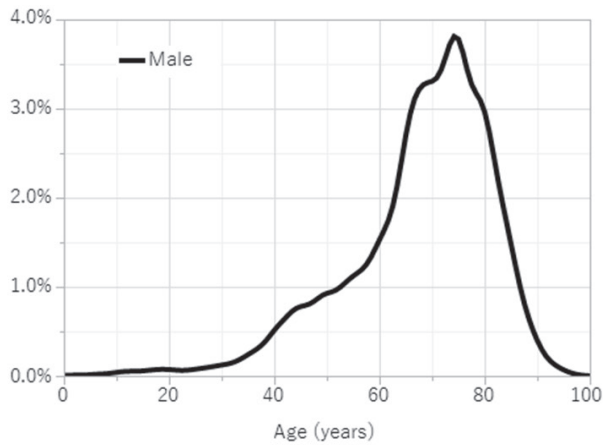


## 4. Endovascular intervention

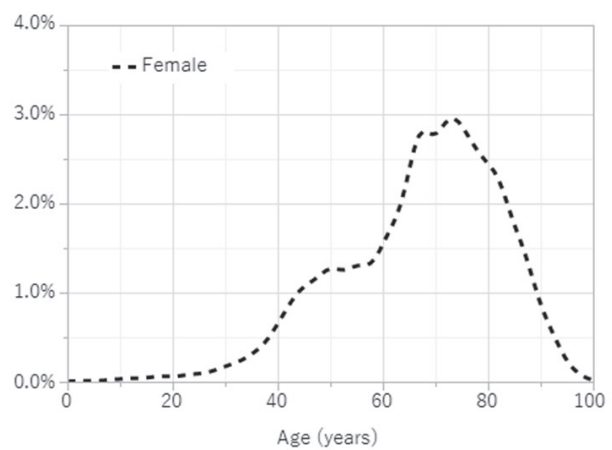
### 4.1 Overall results

#### 4.1.1 Density plots of age by sex

Male (n = 46,740)



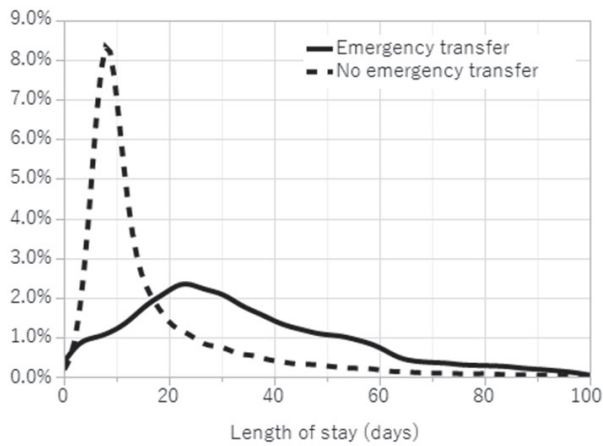
Female (n = 42,595)



#### 4.1.2 Density plots of length of hospital stay by emergency transfer or surgery

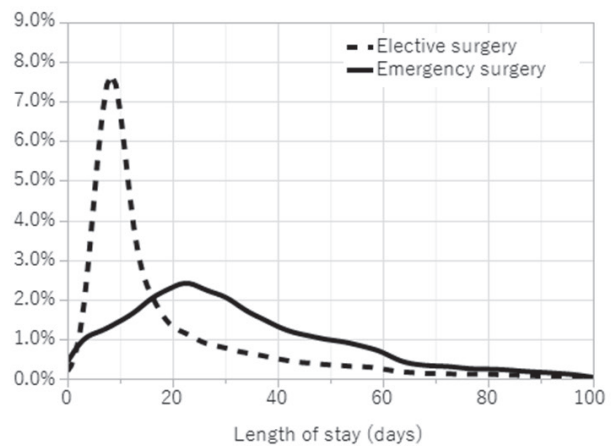
Emergency transfer (n = 39,191)

No emergency transfer (n = 50,144)



Emergency surgery (n = 37,737)

Elective surgery (n = 51,598)



#### 4.2 Endovascular intervention - characteristics and outcomes of each procedure

| Variables               | Aneurysm   |          |        | AVM embolization | Dural AVF embolization | Spinal AVM embolization | PTA    | Acute endovascular recanalization | Other intervention |
|-------------------------|------------|----------|--------|------------------|------------------------|-------------------------|--------|-----------------------------------|--------------------|
|                         | Unruptured | Ruptured | Others |                  |                        |                         |        |                                   |                    |
| Number of surgeries     |            |          |        |                  |                        |                         |        |                                   |                    |
| total                   | 17,651     | 14,719   | 342    | 1,940            | 4,032                  | 242                     | 23,917 | 18,261                            | 8,231              |
| 2015                    | 5,487      | 4,695    | 123    | 646              | 1,261                  | 88                      | 7,555  | 4,490                             | 2,633              |
| 2016                    | 5,827      | 4,898    | 97     | 625              | 1,253                  | 78                      | 7,851  | 6,008                             | 2,819              |
| 2017                    | 6,337      | 5,126    | 122    | 669              | 1,518                  | 76                      | 8,511  | 7,763                             | 2,779              |
| Emergency transfer      | 5%         | 86%      | 30%    | 36%              | 14%                    | 19%                     | 22%    | 88%                               | 36%                |
| Emergency surgery       | 3%         | 86%      | 27%    | 12%              | 7%                     | 10%                     | 15%    | 98%                               | 29%                |
| Age                     |            |          |        |                  |                        |                         |        |                                   |                    |
| median                  | 65         | 64       | 61     | 43               | 69                     | 61                      | 74     | 76                                | 64                 |
| mean                    | 63         | 63       | 60     | 43               | 66                     | 55                      | 72     | 75                                | 61                 |
| lower quartile          | 54         | 51       | 49     | 27               | 60                     | 45                      | 68     | 68                                | 51                 |
| upper quartile          | 72         | 75       | 72     | 60               | 76                     | 70                      | 79     | 83                                | 73                 |
| Female patients         | 72%        | 67%      | 58%    | 44%              | 49%                    | 44%                     | 17%    | 44%                               | 58%                |
| Length of hospital stay |            |          |        |                  |                        |                         |        |                                   |                    |
| median                  | 9          | 32       | 13     | 25               | 12                     | 21                      | 12     | 26                                | 28                 |
| mean                    | 14         | 40       | 21     | 35               | 20                     | 30                      | 23     | 33                                | 38                 |
| lower quartile          | 7          | 22       | 8      | 11               | 8                      | 10                      | 8      | 15                                | 17                 |
| upper quartile          | 12         | 51       | 30     | 48               | 23                     | 38                      | 28     | 41                                | 47                 |
| First surgery           | 90%        | 92%      | 52%    | 71%              | 77%                    | 75%                     | 91%    | 98%                               | 79%                |
| General anesthesia      | 80%        | 85%      | 75%    | 82%              | 63%                    | 64%                     | 18%    | 6%                                | 20%                |
| Preoperative mRS        |            |          |        |                  |                        |                         |        |                                   |                    |
| median                  | 0          | 4        | 1      | 1                | 1                      | 3                       | 1      | 5                                 | 2                  |
| mean                    | 0          | 3        | 2      | 2                | 2                      | 3                       | 2      | 4                                 | 2                  |
| lower quartile          | 0          | 2        | 0      | 0                | 1                      | 1                       | 0      | 4                                 | 1                  |
| upper quartile          | 0          | 5        | 3      | 4                | 2                      | 4                       | 3      | 5                                 | 4                  |
| mRS at discharge        |            |          |        |                  |                        |                         |        |                                   |                    |
| median                  | 0          | 2        | 1      | 1                | 1                      | 2                       | 1      | 4                                 | 1                  |
| mean                    | 0          | 3        | 1      | 2                | 1                      | 2                       | 1      | 3                                 | 2                  |
| lower quartile          | 0          | 1        | 0      | 0                | 0                      | 1                       | 0      | 2                                 | 0                  |
| upper quartile          | 0          | 4        | 2      | 3                | 2                      | 3                       | 2      | 5                                 | 3                  |
| mRS improved            | 7%         | 54%      | 28%    | 29%              | 33%                    | 33%                     | 25%    | 53%                               | 36%                |
| mRS unchanged           | 86%        | 25%      | 63%    | 56%              | 61%                    | 57%                     | 68%    | 26%                               | 51%                |
| mRS worsened            | 6%         | 9%       | 7%     | 13%              | 5%                     | 8%                      | 6%     | 9%                                | 9%                 |
| Dead                    | 0.7%       | 11.4%    | 1.8%   | 1.8%             | 0.8%                   | 0.8%                    | 1.7%   | 11.6%                             | 3.4%               |

### 4.3 Endovascular intervention - diagnoses and approaches

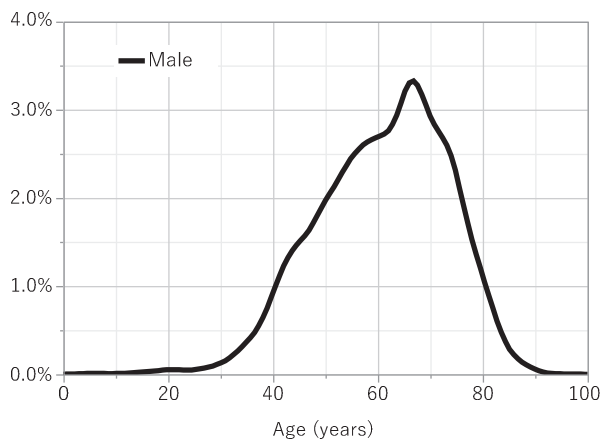
#### 4.3.1 Use of stent in aneurysm embolization

| Approach      | Unruptured    | Ruptured      | Others     | Total         |
|---------------|---------------|---------------|------------|---------------|
| Without stent | 12,438        | 13,416        | 246        | 26,100        |
| With stent    | 5,213         | 1,303         | 96         | 6,612         |
| <b>Total</b>  | <b>17,651</b> | <b>14,719</b> | <b>342</b> | <b>32,712</b> |

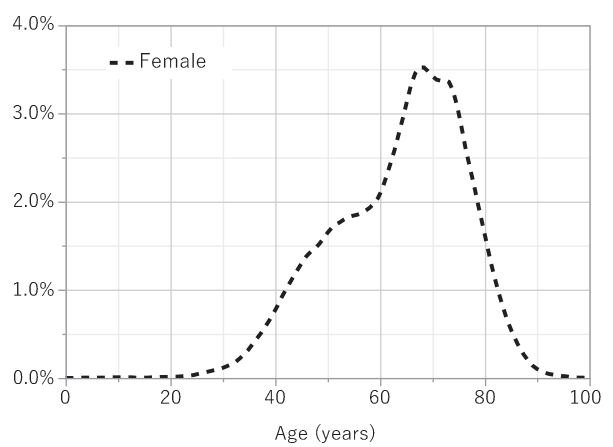
#### 4.3.2 Density plots of age by sex in aneurysm embolization

##### Unruptured

Male (n = 4,936)

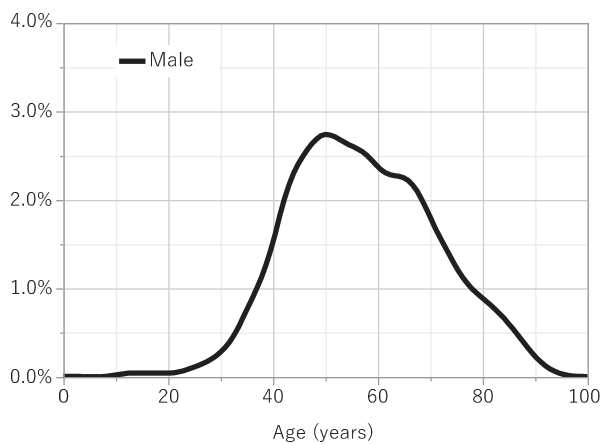


Female (n = 12,715)

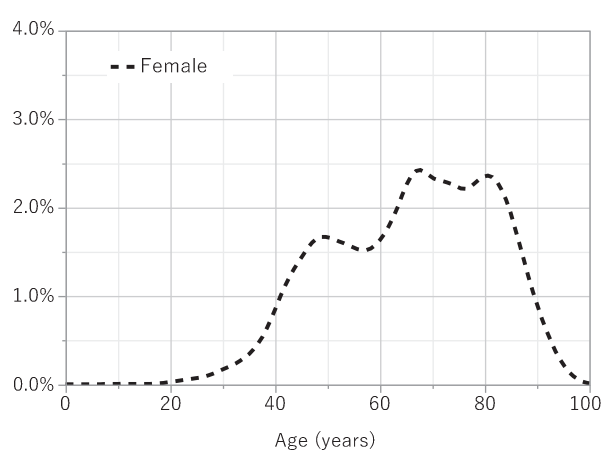


##### Ruptured

Male (n = 4,870)



Female (n = 9,849)



#### 4.3.3 Details of AVM embolization

| Diagnosis    | 2015       | 2016       | 2017       | Total        |
|--------------|------------|------------|------------|--------------|
| Unruptured   | 278        | 246        | 281        | 805          |
| Ruptured     | 353        | 363        | 375        | 1,091        |
| Others       | 15         | 16         | 13         | 44           |
| <b>Total</b> | <b>646</b> | <b>625</b> | <b>669</b> | <b>1,940</b> |

4.3.4 Details of PTA

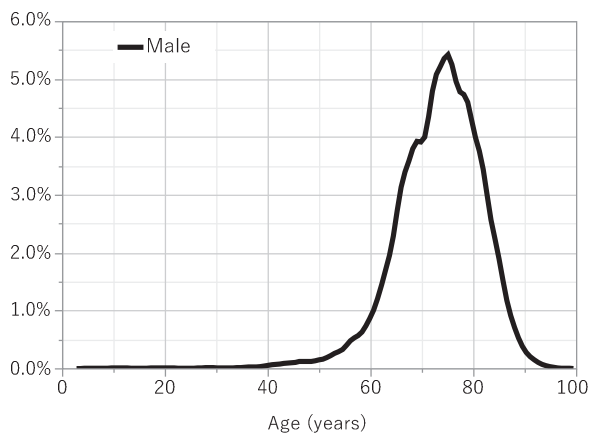
| Approach      | Extracranial carotid artery | Intracranial artery | Extracranial non-carotid artery | Total         |
|---------------|-----------------------------|---------------------|---------------------------------|---------------|
| Without stent | 1,397                       | 1,954               | 248                             | 3,599         |
| With stent    | 18,398*                     | 877                 | 1,043                           | 20,318        |
| <b>Total</b>  | <b>19,795</b>               | <b>2,831</b>        | <b>1,291</b>                    | <b>23,917</b> |

\*This number represents the number for CAS.

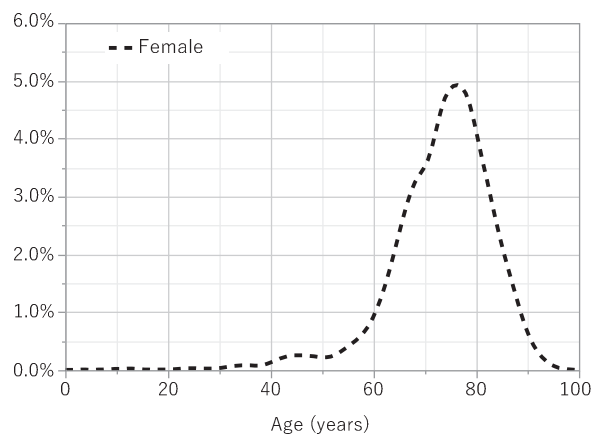
4.3.5 Density plots of age by sex in PTA

Extracranial carotid artery

Male (n = 16,988)

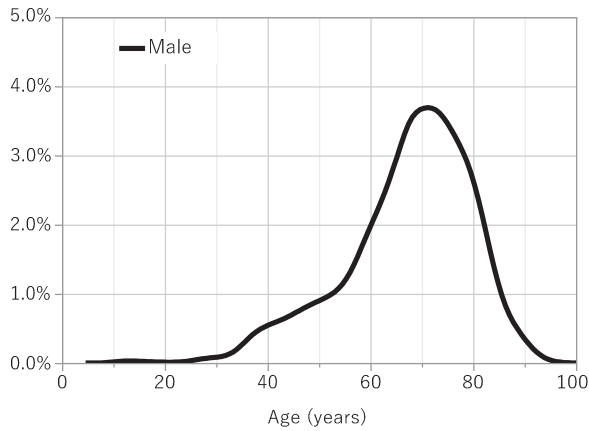


Female (n = 2,807)

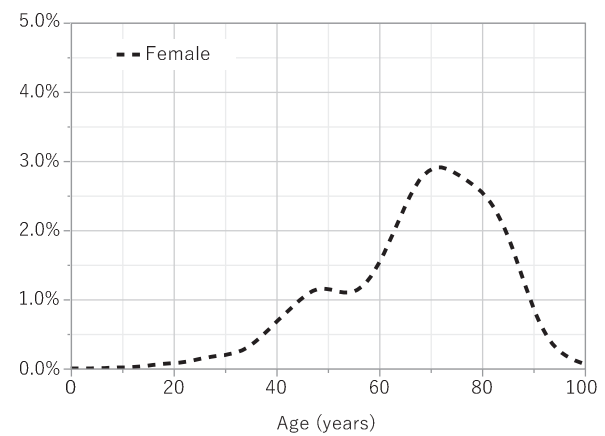


Intracranial artery

Male (n = 1,819)

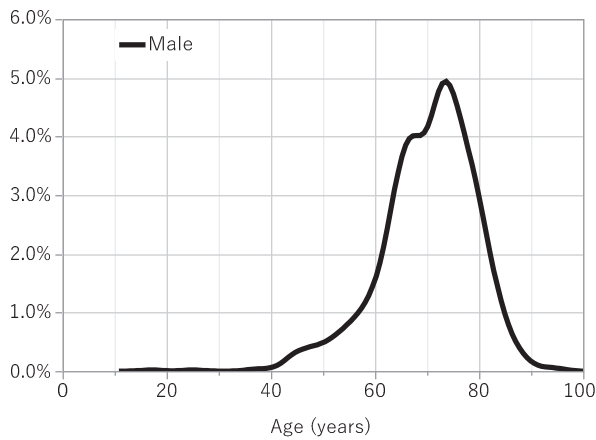


Female (n = 1,012)

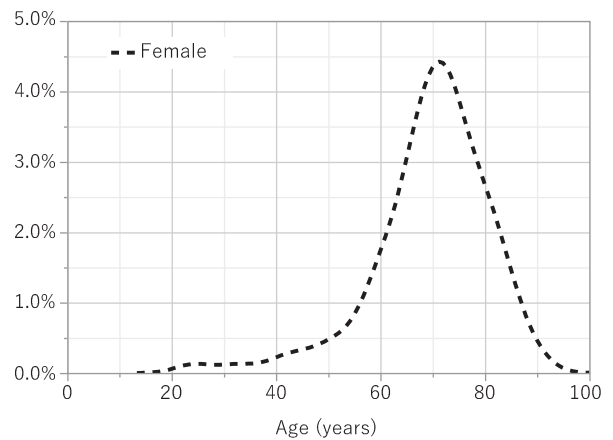


Extracranial non-carotid artery

Male (n = 987)



Female (n = 304)



4.3.6 Approaches of acute endovascular recanalization

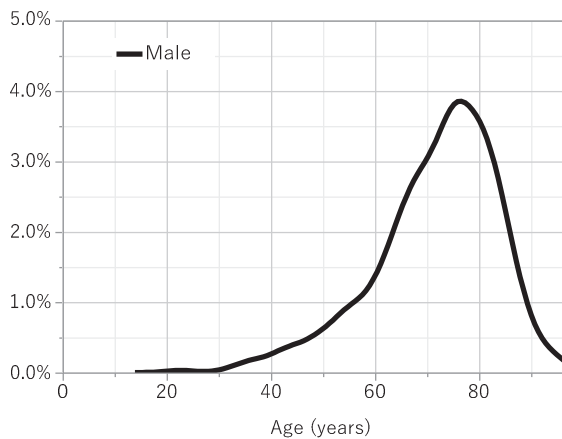
| Approach*                  | 2015  | 2016  | 2017  | Total  |
|----------------------------|-------|-------|-------|--------|
| Intraarterial thrombolysis | 529   | 519   | 632   | 1,680  |
| Mechanical thrombectomy    | 4,110 | 5,665 | 7,393 | 17,168 |
| Others                     | 88    | 96    | 109   | 293    |
| Total                      | 4,490 | 6,008 | 7,763 | 18,261 |

\*multiple selection allowed

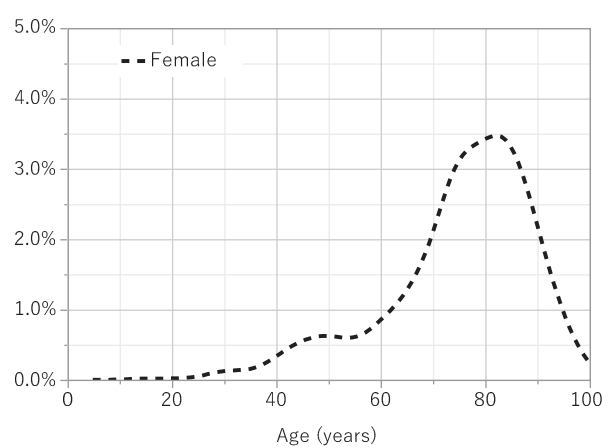
4.3.7 Density plots of age by sex in acute endovascular recanalization

Intraarterial thrombolysis

Male (n = 950)

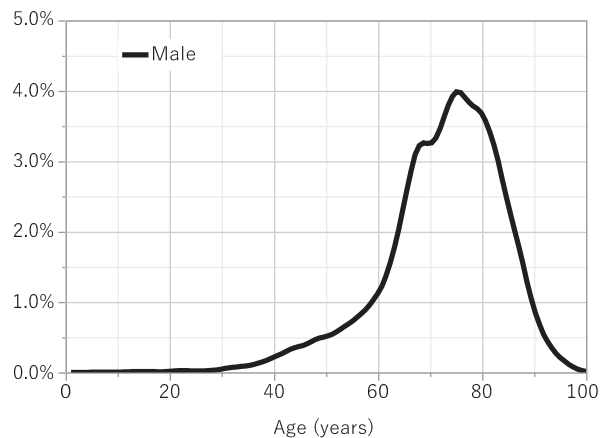


Female (n = 730)

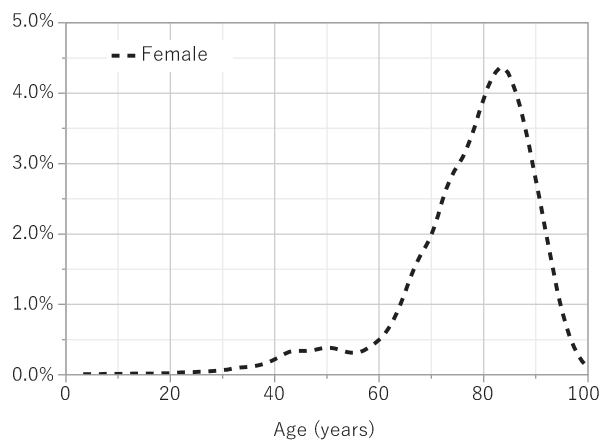


### Mechanical thrombectomy

Male (n = 9,617)

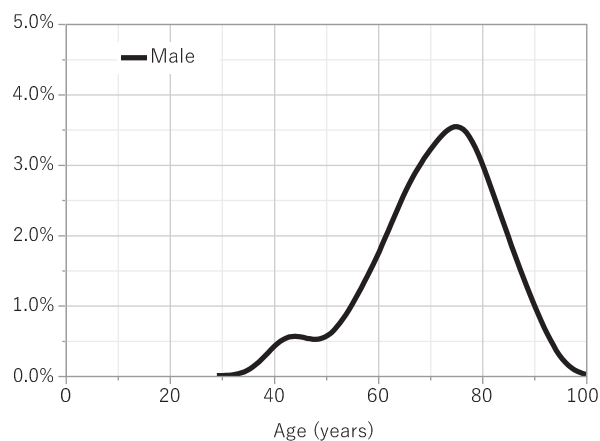


Female (n = 7,551)

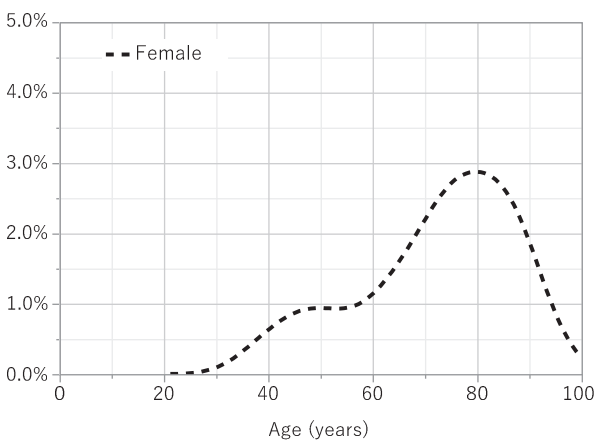


### Others

Male (n = 191)



Female (n = 102)



#### 4.3.8 Details of other interventional procedures

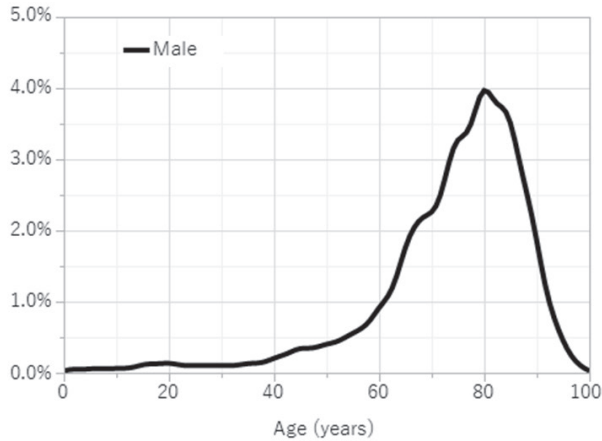
| Approach                           | 2015         | 2016         | 2017         | Total        |
|------------------------------------|--------------|--------------|--------------|--------------|
| Embolization of intracranial tumor | 1,151        | 1,304        | 1,381        | 3,836        |
| Embolizaion of other lesions       | 561          | 549          | 553          | 1,663        |
| Intervention for vasospasm         | 708          | 754          | 633          | 2,095        |
| Others                             | 213          | 212          | 212          | 637          |
| <b>Total</b>                       | <b>2,633</b> | <b>2,819</b> | <b>2,779</b> | <b>8,231</b> |

## 5. Head injuries

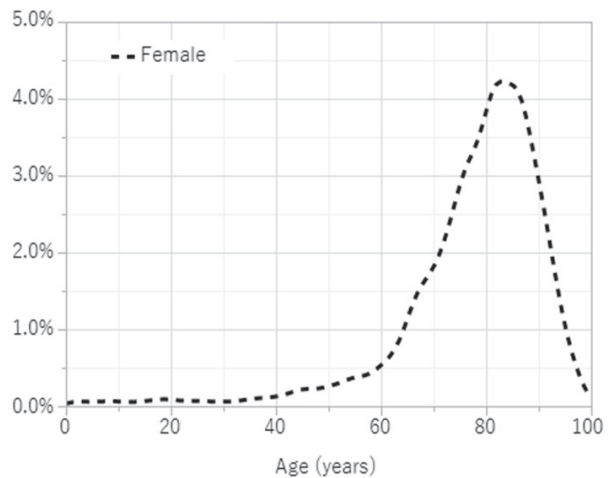
### 5.1 Overall results

#### 5.1.1 Density plots of age by sex

Male (n = 83,475)



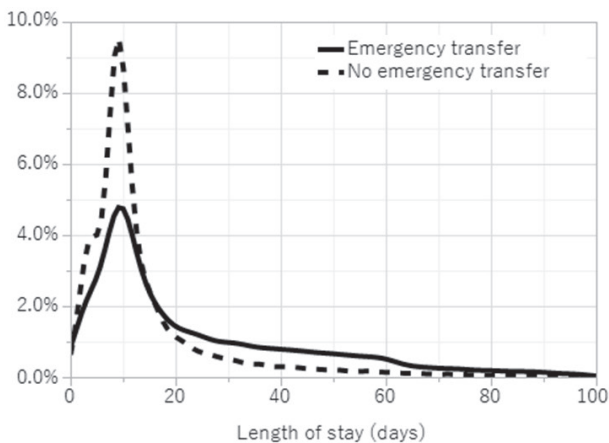
Female (n = 38,451)



#### 5.1.2 Density plots of length of hospital stay by emergency transfer or surgery

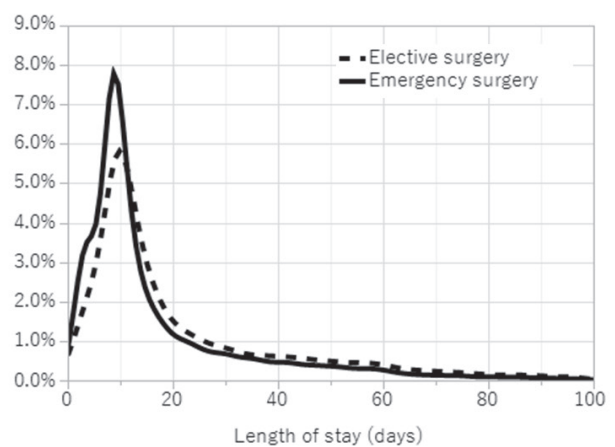
Emergency transfer (n = 51,587)

No emergency transfer (n = 70,339)



Emergency surgery (n = 90,933)

Elective surgery (n = 30,993)





## 5.2 Head injuries - characteristics and outcomes of each procedure

| Variables               | Craniotomy | Burr hole surgeries | CSDH   | Cranioplasty | CSF leakage | Foreign bodies | Others |
|-------------------------|------------|---------------------|--------|--------------|-------------|----------------|--------|
| Number of surgeries     |            |                     |        |              |             |                |        |
| total                   | 16,703     | 2,085               | 98,027 | 3,197        | 843         | 255            | 816    |
| 2015                    | 5,607      | 792                 | 32,036 | 1,035        | 262         | 92             | 329    |
| 2016                    | 5,470      | 677                 | 32,325 | 1,111        | 284         | 73             | 262    |
| 2017                    | 5,626      | 616                 | 33,666 | 1,051        | 297         | 90             | 225    |
| Emergency transfer      | 85%        | 84%                 | 33%    | 71%          | 37%         | 42%            | 60%    |
| Emergency surgery       | 92%        | 88%                 | 74%    | 14%          | 36%         | 44%            | 62%    |
| Age                     |            |                     |        |              |             |                |        |
| median                  | 72         | 73                  | 79     | 61           | 56          | 65             | 70     |
| mean                    | 66         | 67                  | 78     | 55           | 54          | 57             | 62     |
| lower quartile          | 56         | 58                  | 72     | 40           | 42          | 41             | 47     |
| upper quartile          | 81         | 82                  | 85     | 73           | 69          | 75             | 81     |
| Female patients         | 33%        | 36%                 | 31%    | 30%          | 40%         | 33%            | 32%    |
| Length of hospital stay |            |                     |        |              |             |                |        |
| median                  | 32         | 25                  | 10     | 45           | 37          | 23             | 17     |
| mean                    | 40         | 32                  | 18     | 52           | 46          | 35             | 40     |
| lower quartile          | 15         | 7                   | 8      | 20           | 20          | 10             | 9      |
| upper quartile          | 54         | 47                  | 17     | 67           | 59          | 49             | 41     |
| Use of microscope       | 18%        | 2%                  | 1%     | 3%           | 31%         | 15%            | 11%    |
| First surgery           | 88%        | 92%                 | 89%    | 43%          | 58%         | 70%            | 81%    |
| General anesthesia      | 93%        | 39%                 | 5%     | 95%          | 91%         | 74%            | 54%    |
| Preoperative mRS        |            |                     |        |              |             |                |        |
| median                  | 5          | 5                   | 3      | 4            | 2           | 3              | 2      |
| mean                    | 4          | 4                   | 3      | 3            | 3           | 3              | 3      |
| lower quartile          | 4          | 4                   | 2      | 2            | 1           | 1              | 1      |
| upper quartile          | 5          | 5                   | 4      | 5            | 4           | 4              | 4      |
| mRS at discharge        |            |                     |        |              |             |                |        |
| median                  | 4          | 5                   | 1      | 3            | 1           | 2              | 1      |
| mean                    | 4          | 4                   | 2      | 3            | 2           | 2              | 2      |
| lower quartile          | 2          | 3                   | 0      | 1            | 0           | 0              | 0      |
| upper quartile          | 5          | 6                   | 3      | 5            | 3           | 4              | 4      |
| mRS improved            | 47%        | 37%                 | 75%    | 36%          | 49%         | 35%            | 43%    |
| mRS unchanged           | 28%        | 26%                 | 21%    | 59%          | 44%         | 56%            | 49%    |
| mRS worsened            | 5%         | 5%                  | 3%     | 4%           | 5%          | 5%             | 4%     |
| Dead                    | 19.8%      | 31.8%               | 1.3%   | 1.3%         | 2.5%        | 3.5%           | 4.4%   |

### 5.3 Head injuries - diagnoses and approaches

#### 5.3.1 Details of craniotomy or craniectomy for head injuries

| Approach*                 | AEDH  | ASDH   | Traumatic ICH and contusion | Others | Total  |
|---------------------------|-------|--------|-----------------------------|--------|--------|
| Removal of hematoma       | 3,748 | 10,180 | 2,729                       | 665    | 17,322 |
| Decompressive craniectomy | 599   | 3,474  | 1,598                       | 268    | 5,939  |
| Placement of ICP monitor  | 224   | 1,142  | 565                         | 53     | 1,984  |
| Others                    | 31    | 93     | 68                          | 109    | 301    |
| Total                     | 3,813 | 10,655 | 3,122                       | 963    | 16,703 |

\*multiple selection allowed

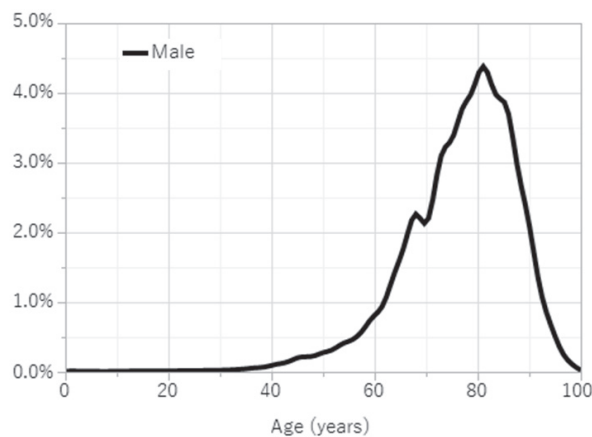
#### 5.3.2 Details of burr hole surgeries for head injuries

| Approach*                 | AEDH | ASDH  | Traumatic ICH and contusion | Others | Total |
|---------------------------|------|-------|-----------------------------|--------|-------|
| Removal of hematoma       | 105  | 1,081 | 148                         | 134    | 1,468 |
| Decompressive craniectomy | 3    | 13    | 3                           | 3      | 22    |
| Placement of ICP monitor  | 37   | 336   | 360                         | 80     | 813   |
| Others                    | 13   | 133   | 81                          | 135    | 362   |
| Total                     | 149  | 1,354 | 493                         | 322    | 2,085 |

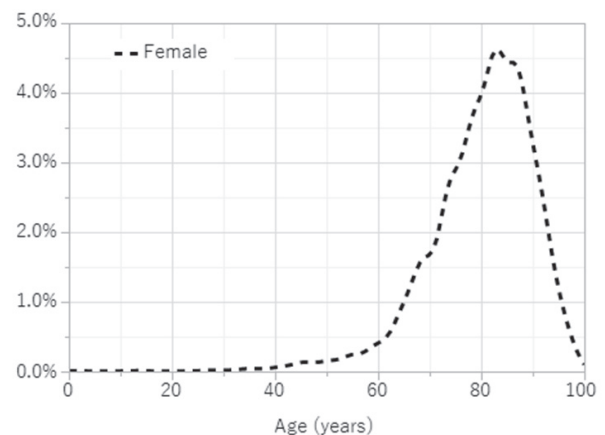
\*multiple selection allowed

#### 5.3.3 Density plots of age by sex in CSDH

Male (n = 67,535)



Female (n = 30,492)

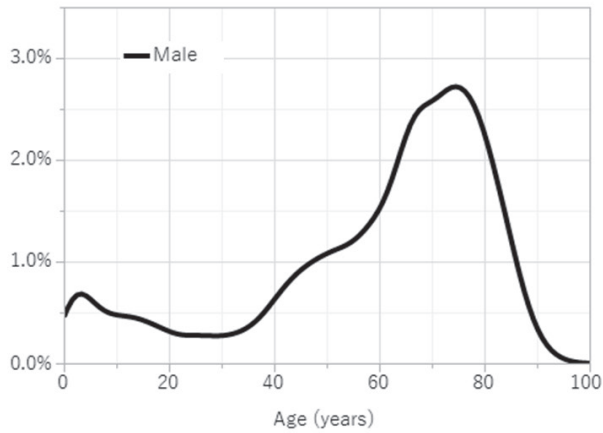


## 6. Hydrocephalus and developmental anomalies

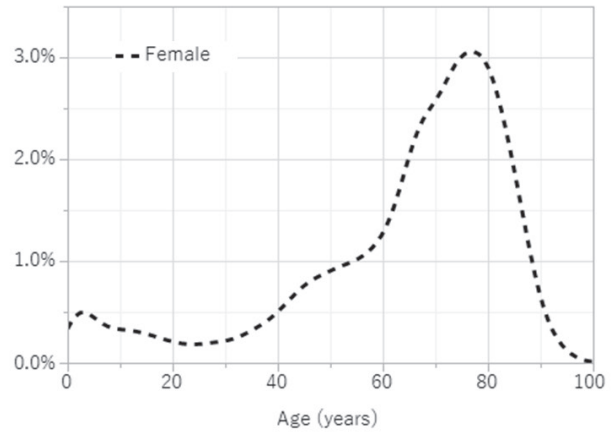
### 6.1 Overall results

#### 6.1.1 Density plots of age by sex

Male (n = 28,029)



Female (n = 30,377)



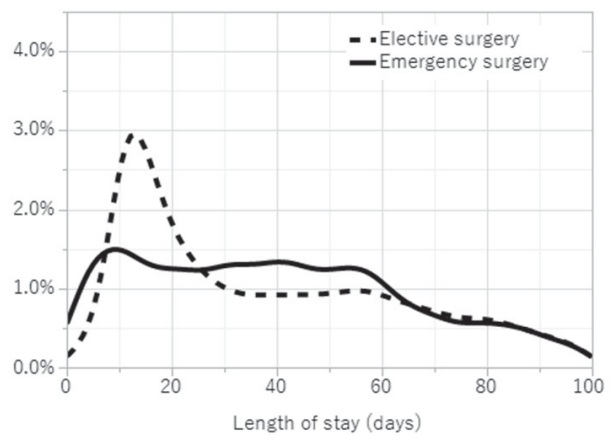
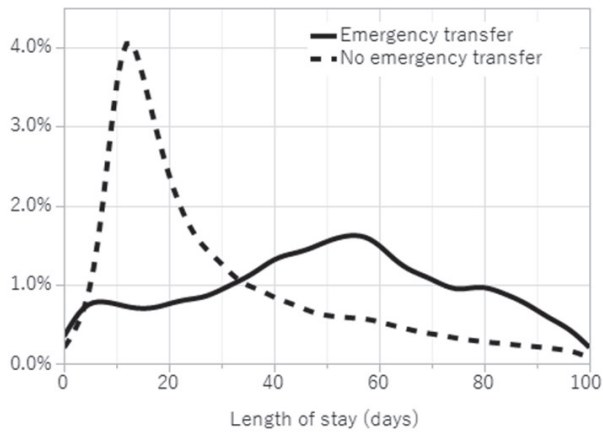
#### 6.1.2 Density plots of length of hospital stay by emergency transfer or surgery

Emergency transfer (n = 28,899)

Emergency surgery (n = 19,495)

No emergency transfer (n = 29,507)

Elective surgery (n = 38,911)



## 6.2 Hydrocephalus and developmental anomalies - characteristics and outcomes of each procedure

| Variables               | Hydrocephalus | Developmental craniocerebral anomalies | Developmental anomalies in CCJ | Developmental spinal anomalies |
|-------------------------|---------------|----------------------------------------|--------------------------------|--------------------------------|
| Number of surgeries     |               |                                        |                                |                                |
| total                   | 54,508        | 1,439                                  | 907                            | 1,552                          |
| 2015                    | 18,017        | 520                                    | 262                            | 507                            |
| 2016                    | 17,999        | 450                                    | 326                            | 488                            |
| 2017                    | 18,492        | 469                                    | 319                            | 557                            |
| Emergency transfer      | 53%           | 5%                                     | 1%                             | 7%                             |
| Emergency surgery       | 35%           | 5%                                     | 2%                             | 14%                            |
| Age                     |               |                                        |                                |                                |
| median                  | 69            | 4                                      | 23                             | 6                              |
| mean                    | 63            | 16                                     | 27                             | 10                             |
| lower quartile          | 55            | 2                                      | 12                             | 2                              |
| upper quartile          | 77            | 14                                     | 41                             | 12                             |
| Female patients         | 52%           | 42%                                    | 66%                            | 53%                            |
| Length of hospital stay |               |                                        |                                |                                |
| median                  | 43            | 16                                     | 14                             | 16                             |
| mean                    | 54            | 24                                     | 24                             | 24                             |
| lower quartile          | 19            | 11                                     | 11                             | 12                             |
| upper quartile          | 71            | 29                                     | 19                             | 26                             |
| Use of microscope       | 3%            | 21%                                    | 68%                            | 91%                            |
| First surgery           | 70%           | 77%                                    | 89%                            | 87%                            |
| General anesthesia      | 75%           | 99%                                    | 100%                           | 100%                           |
| Preoperative mRS        |               |                                        |                                |                                |
| median                  | 4             | 1                                      | 1                              | 1                              |
| mean                    | 4             | 2                                      | 2                              | 2                              |
| lower quartile          | 3             | 1                                      | 1                              | 1                              |
| upper quartile          | 5             | 2                                      | 2                              | 2                              |
| mRS at discharge        |               |                                        |                                |                                |
| median                  | 4             | 1                                      | 1                              | 1                              |
| mean                    | 3             | 1                                      | 1                              | 2                              |
| lower quartile          | 2             | 0                                      | 1                              | 0                              |
| upper quartile          | 5             | 2                                      | 2                              | 2                              |
| mRS improved            | 40%           | 23%                                    | 35%                            | 18%                            |
| mRS unchanged           | 47%           | 75%                                    | 63%                            | 80%                            |
| mRS worsened            | 5%            | 2%                                     | 1%                             | 2%                             |
| Dead                    | 8.6%          | 0.3%                                   | 0.1%                           | 0.2%                           |

## 6.3 Hydrocephalus and developmental anomalies - diagnoses and approaches

### 6.3.1 Approaches for hydrocephalus

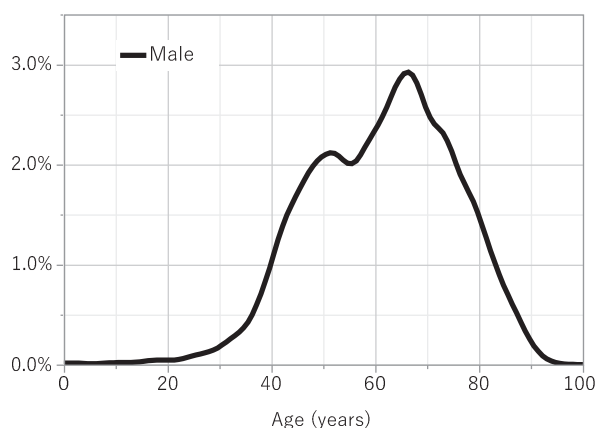
| Approach*             | Hydrocephalus after SAH | iNPH         | Congenital hydrocephalus |                            |                  | Others        | Total         |
|-----------------------|-------------------------|--------------|--------------------------|----------------------------|------------------|---------------|---------------|
|                       |                         |              | aqueductal stenosis      | caused by myelomeningocele | other congenital |               |               |
| VP shunt              | 8,885                   | 4,593        | 161                      | 425                        | 885              | 6,538         | 21,487        |
| LP shunt              | 3,576                   | 4,164        | 5                        | 4                          | 17               | 1,646         | 9,412         |
| VA shunt              | 217                     | 234          | 4                        | 15                         | 48               | 203           | 721           |
| Third ventriculostomy | 77                      | 36           | 164                      | 34                         | 135              | 1,186         | 1,632         |
| Ventricular drainage  | 4,890                   | 274          | 45                       | 89                         | 214              | 10,623        | 16,135        |
| Shunt removal         | 1,023                   | 352          | 31                       | 76                         | 197              | 1,183         | 2,862         |
| Others                | 1,026                   | 273          | 41                       | 108                        | 247              | 1,784         | 3,479         |
| <b>Total</b>          | <b>19,380</b>           | <b>9,812</b> | <b>424</b>               | <b>704</b>                 | <b>1,617</b>     | <b>22,571</b> | <b>54,508</b> |

\*multiple selection allowed

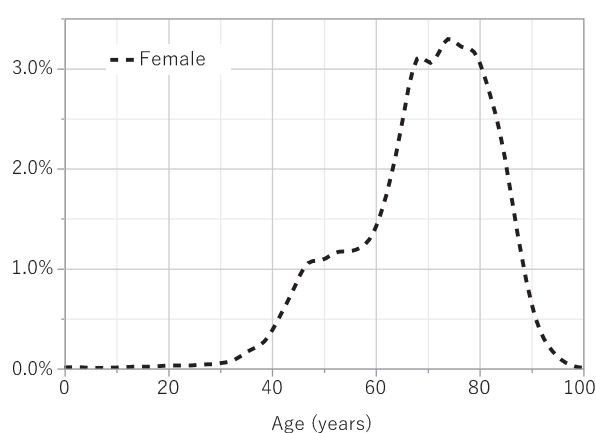
### 6.3.2 Density plots of age by sex in hydrocephalus

Hydrocephalus after SAH

Male (n = 6,567)

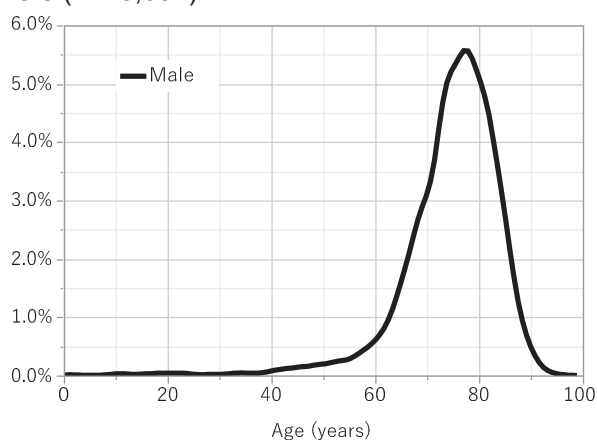


Female (n = 12,813)

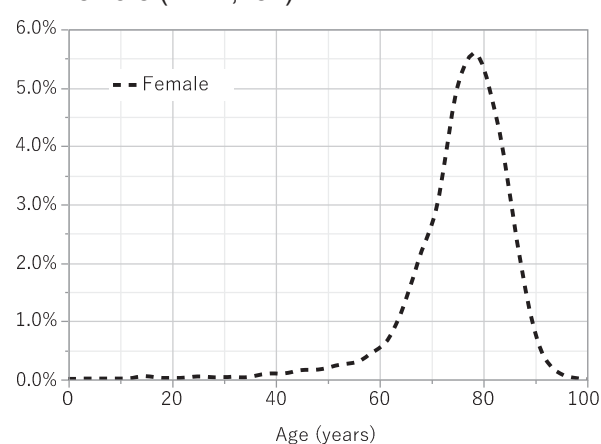


iNPH

Male (n = 5,631)

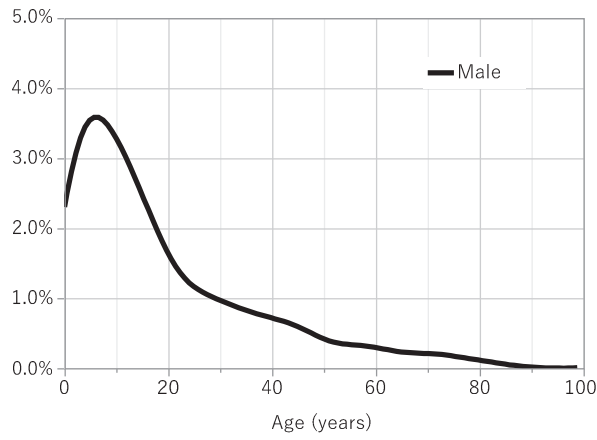


Female (n = 4,181)

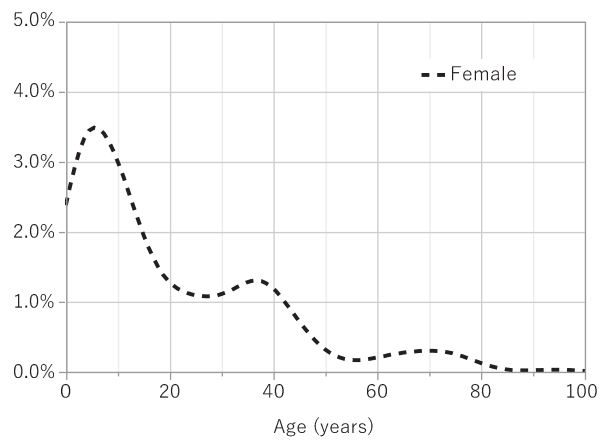


**Congenital hydrocephalus**

**Male (n = 1,417)**

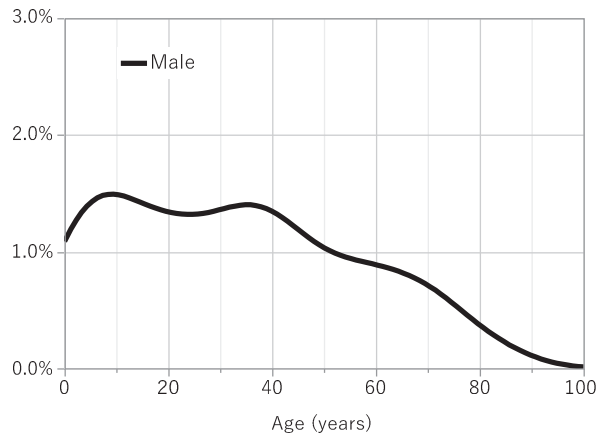


**Female (n = 1,328)**

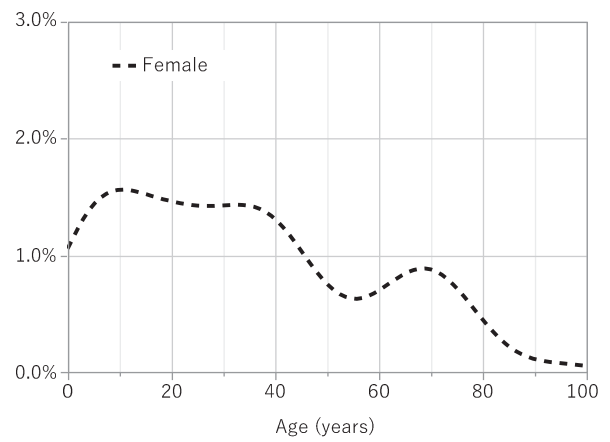


**Aqueductal stenosis**

**Male (n = 234)**

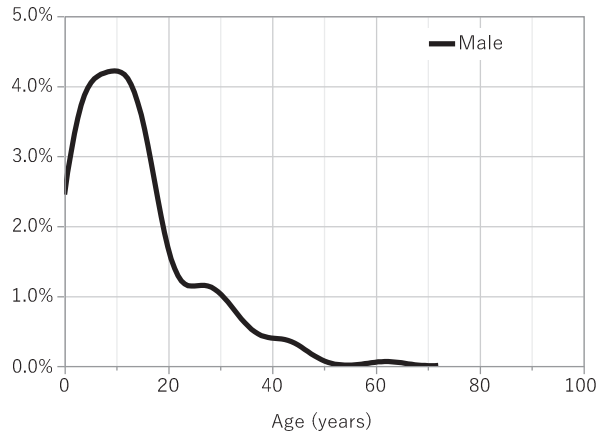


**Female (n = 190)**

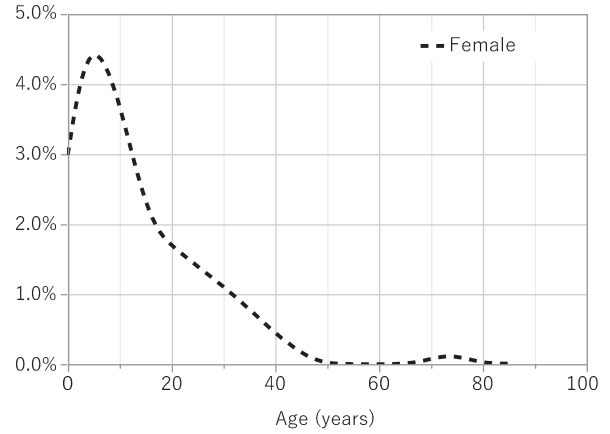


**Hydrocephalus caused by myelomeningocele**

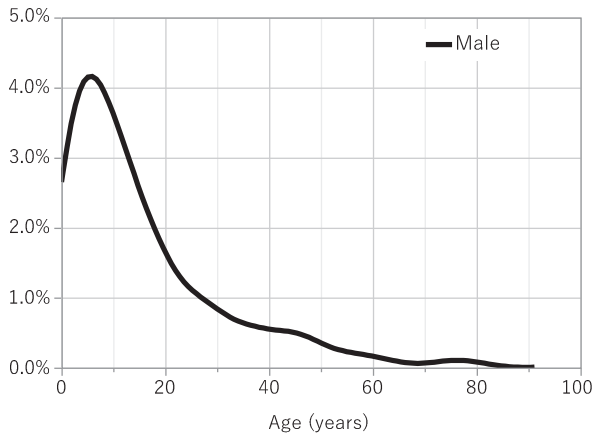
**Male (n = 343)**



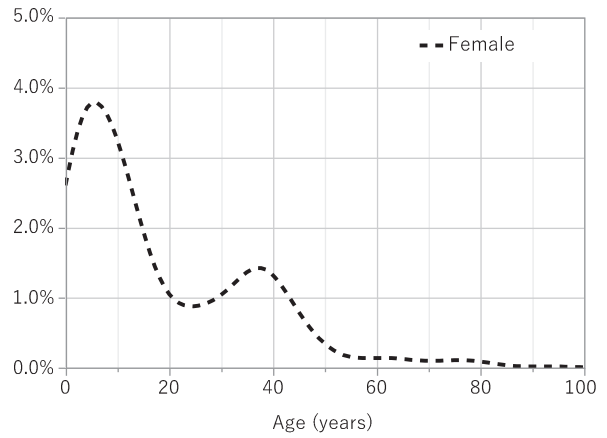
**Female (n = 361)**



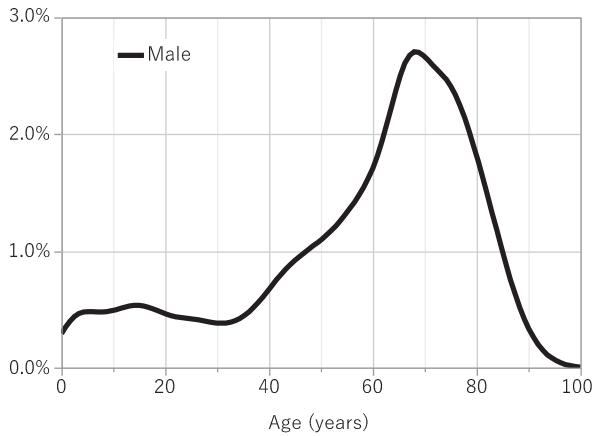
Other congenital hydrocephalus  
Male (n = 840)



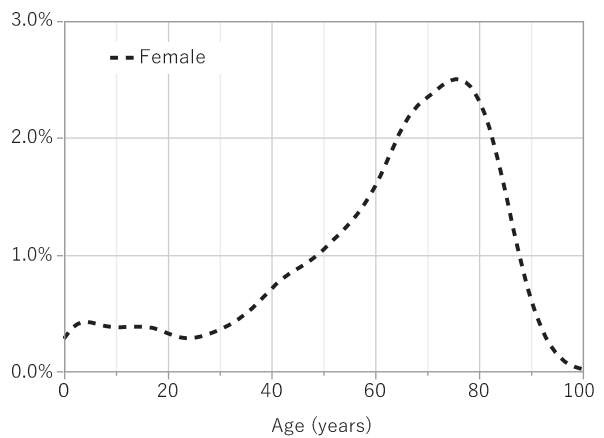
Female (n = 777)



Other hydrocephalus  
Male (n = 12,540)



Female (n = 10,031)



6.3.3 Approaches for developmental craniocerebral anomalies

Craniosynostosis

|                                   | Total      |
|-----------------------------------|------------|
| With cranial vault distraction    | 315        |
| Without cranial vault distraction | 402        |
| <b>Total</b>                      | <b>717</b> |

Arachnoid cyst

| Approach*               | Total      |
|-------------------------|------------|
| Open fenestration       | 198        |
| Endoscopic fenestration | 115        |
| Cystoperitoneal shunt   | 41         |
| Others                  | 50         |
| <b>Total</b>            | <b>391</b> |

Encephalocele

| Approach*    | Total      |
|--------------|------------|
| Repair       | 143        |
| Others       | 16         |
| <b>Total</b> | <b>158</b> |

\*multiple selection allowed

\*multiple selection allowed

## 6.3.4 Approaches for developmental anomalies in CCJ

| Approach*                    | Diagnosis*                 |                             |        | Total |
|------------------------------|----------------------------|-----------------------------|--------|-------|
|                              | Chiari malformation type I | Chiari malformation type II | Others |       |
| Foramen magnum decompression | 752                        | 31                          | 63     | 843   |
| Syringosubarachnoid shunt    | 31                         | 2                           | 6      | 38    |
| Fixation                     | 4                          | 0                           | 4      | 8     |
| Others                       | 30                         | 2                           | 13     | 44    |
| Total                        | 793                        | 35                          | 83     | 907   |

\*multiple selection allowed

## 6.3.5 Approaches for myelomeningocele and spina bifida

| Approach* | Total |
|-----------|-------|
| Closure   | 345   |
| Others    | 56    |
| Total     | 400   |

\*multiple selection allowed

## 6.3.6 Approaches for developmental spinal anomalies

| Approach*   | Spinal lipoma | Others | Total |
|-------------|---------------|--------|-------|
| Untethering | 845           | 151    | 996   |
| Others      | 66            | 113    | 179   |
| Total       | 895           | 257    | 1,175 |

\*multiple selection allowed

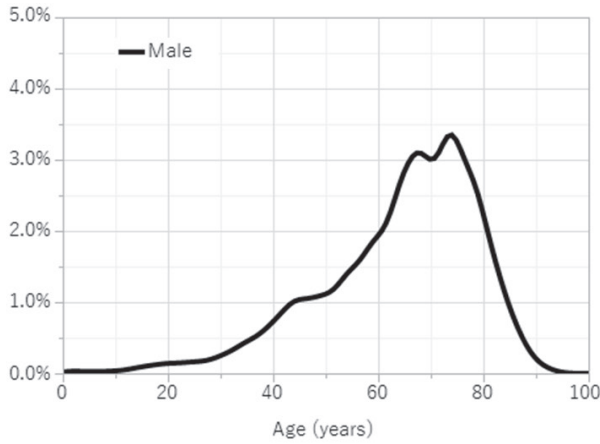


## 7. Spine and peripheral nerves

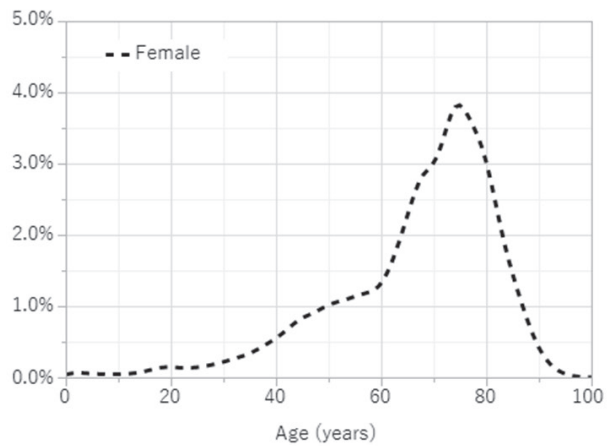
### 7.1 Overall results

#### 7.1.1 Density plots of age by sex

Male (n = 27,001)



Female (n = 17,191)



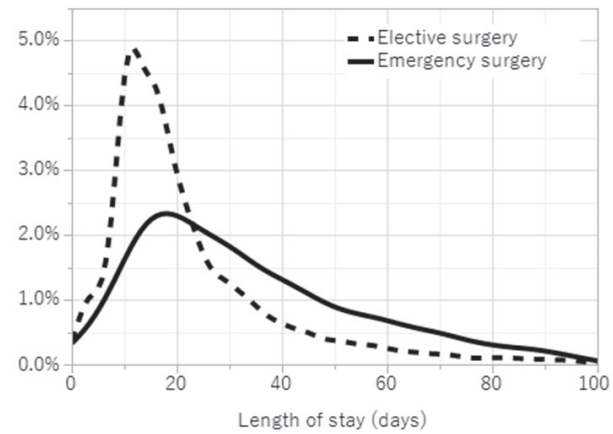
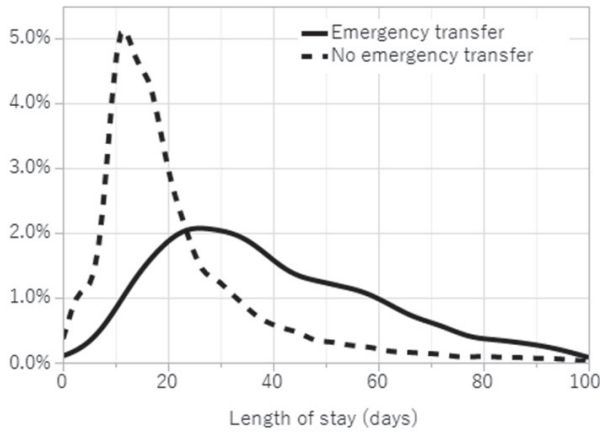
#### 7.1.2 Density plots of length of hospital stay by emergency transfer or surgery

Emergency transfer (n = 3,382)

Emergency surgery (n = 1,676)

No emergency transfer (n = 40,810)

Elective surgery (n = 42,516)



## 7.2 Spine and peripheral nerves - characteristics and outcomes of each procedure

| Variables               | Spinal degeneration | Spinal tumors | Syringomyelia unrelated to Chiari malformation | Spinal vascular diseases | Spinal injuries | Spinal infection | Peripheral nerve disorders | Other spinal surgeries |
|-------------------------|---------------------|---------------|------------------------------------------------|--------------------------|-----------------|------------------|----------------------------|------------------------|
| Number of surgeries     |                     |               |                                                |                          |                 |                  |                            |                        |
| total                   | 34,052              | 2,919         | 203                                            | 647                      | 3,143           | 415              | 1,858                      | 955                    |
| 2015                    | 11,582              | 1,011         | 67                                             | 238                      | 860             | 143              | 536                        | 288                    |
| 2016                    | 11,601              | 992           | 68                                             | 226                      | 1,165           | 127              | 639                        | 333                    |
| 2017                    | 10,869              | 916           | 68                                             | 183                      | 1,118           | 145              | 683                        | 334                    |
| Emergency transfer      | 5%                  | 5%            | 1%                                             | 30%                      | 40%             | 27%              | 0%                         | 13%                    |
| Emergency surgery       | 2%                  | 6%            | 1%                                             | 36%                      | 11%             | 34%              | 1%                         | 18%                    |
| Age                     |                     |               |                                                |                          |                 |                  |                            |                        |
| median                  | 68                  | 59            | 50                                             | 67                       | 74              | 69               | 69                         | 66                     |
| mean                    | 66                  | 55            | 47                                             | 63                       | 69              | 66               | 66                         | 60                     |
| lower quartile          | 58                  | 42            | 34                                             | 56                       | 64              | 58               | 58                         | 48                     |
| upper quartile          | 76                  | 71            | 64                                             | 75                       | 81              | 77               | 77                         | 75                     |
| Female patients         | 36%                 | 50%           | 47%                                            | 32%                      | 47%             | 26%              | 60%                        | 41%                    |
| Length of hospital stay |                     |               |                                                |                          |                 |                  |                            |                        |
| median                  | 17                  | 21            | 22                                             | 28                       | 27              | 57               | 4                          | 18                     |
| mean                    | 24                  | 31            | 37                                             | 33                       | 35              | 70               | 9                          | 28                     |
| lower quartile          | 12                  | 14            | 16                                             | 18                       | 15              | 36               | 2                          | 11                     |
| upper quartile          | 27                  | 37            | 37                                             | 44                       | 46              | 96               | 10                         | 39                     |
| Use of microscope       | 85%                 | 94%           | 88%                                            | 86%                      | 33%             | 47%              | 65%                        | 35%                    |
| First surgery           | 94%                 | 90%           | 72%                                            | 84%                      | 87%             | 55%              | 97%                        | 54%                    |
| General anesthesia      | 99%                 | 99%           | 100%                                           | 98%                      | 90%             | 85%              | 21%                        | 74%                    |
| Preoperative mRS        |                     |               |                                                |                          |                 |                  |                            |                        |
| median                  | 2                   | 2             | 3                                              | 4                        | 4               | 4                | 2                          | 2                      |
| mean                    | 3                   | 3             | 3                                              | 3                        | 3               | 3                | 2                          | 2                      |
| lower quartile          | 2                   | 2             | 2                                              | 2                        | 3               | 3                | 1                          | 1                      |
| upper quartile          | 3                   | 4             | 4                                              | 4                        | 4               | 4                | 2                          | 4                      |
| mRS at discharge        |                     |               |                                                |                          |                 |                  |                            |                        |
| median                  | 1                   | 2             | 2                                              | 2                        | 2               | 3                | 1                          | 1                      |
| mean                    | 1                   | 2             | 2                                              | 2                        | 2               | 3                | 1                          | 2                      |
| lower quartile          | 1                   | 1             | 1                                              | 1                        | 1               | 1                | 1                          | 1                      |
| upper quartile          | 2                   | 3             | 4                                              | 4                        | 3               | 4                | 1                          | 2                      |
| mRS improved            | 73%                 | 47%           | 35%                                            | 59%                      | 70%             | 56%              | 48%                        | 47%                    |
| mRS unchanged           | 25%                 | 45%           | 61%                                            | 37%                      | 28%             | 36%              | 51%                        | 48%                    |
| mRS worsened            | 1%                  | 7%            | 3%                                             | 3%                       | 1%              | 5%               | 1%                         | 3%                     |
| Dead                    | 0.2%                | 1.4%          | 0.0%                                           | 0.8%                     | 1.0%            | 3.4%             | 0.0%                       | 1.6%                   |

### 7.3 Spine and peripheral nerves - diagnoses and approaches

#### 7.3.1 Details of spinal degenerative diseases

| Approach*               | CCJ (C0-C1-C2) | Mid- to lower cervical | Thoracic     | Lumbo-sacral  | Other locations | Total         |
|-------------------------|----------------|------------------------|--------------|---------------|-----------------|---------------|
| Anterior decompression  | 47             | 3,628                  | 26           | 106           | 3               | 3,810         |
| Posterior decompression | 388            | 8,782                  | 745          | 14,135        | 23              | 24,073        |
| Fusion                  | 401            | 4,286                  | 274          | 4,183         | 33              | 9,177         |
| Others                  | 79             | 517                    | 117          | 1,264         | 107             | 2,084         |
| <b>Total</b>            | <b>753</b>     | <b>14,501</b>          | <b>1,014</b> | <b>17,625</b> | <b>158</b>      | <b>34,052</b> |

\*multiple selection allowed

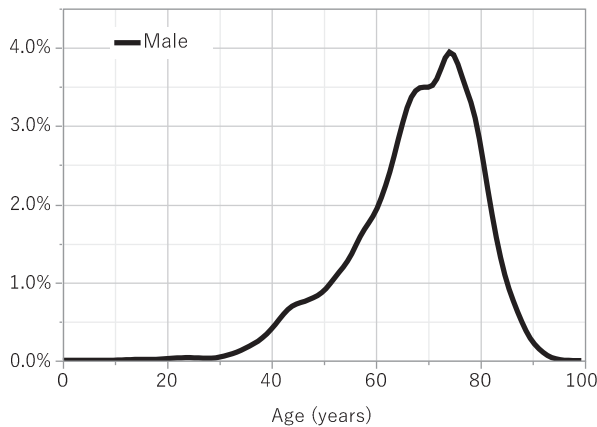
#### 7.3.2 Use of fixation implant

| Procedure           | 2015          |              |             | 2016          |              |             | 2017          |              |             |
|---------------------|---------------|--------------|-------------|---------------|--------------|-------------|---------------|--------------|-------------|
|                     | Total         | Used         | Rate of use | Total         | Used         | Rate of use | Total         | Used         | Rate of use |
| Spinal degeneration | 11,581        | 4,576        | 40%         | 11,601        | 4,466        | 38%         | 10,869        | 4,564        | 42%         |
| Spinal tumors       | 1,011         | 151          | 15%         | 992           | 150          | 15%         | 916           | 139          | 15%         |
| Spinal injuries     | 860           | 393          | 46%         | 1,165         | 583          | 50%         | 1,118         | 484          | 43%         |
| Spinal infection    | 143           | 28           | 20%         | 127           | 31           | 24%         | 145           | 29           | 20%         |
| <b>Total</b>        | <b>13,595</b> | <b>5,148</b> | <b>38%</b>  | <b>13,885</b> | <b>5,230</b> | <b>38%</b>  | <b>13,048</b> | <b>5,216</b> | <b>40%</b>  |

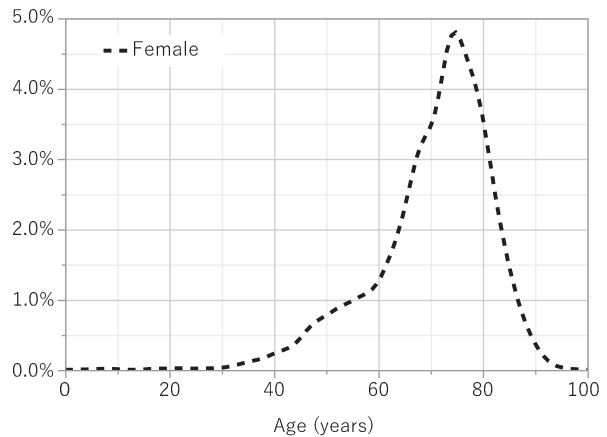
#### 7.3.3 Density plots of age by sex in spinal degenerative diseases (2016 and 2017 only)

##### Spondylosis

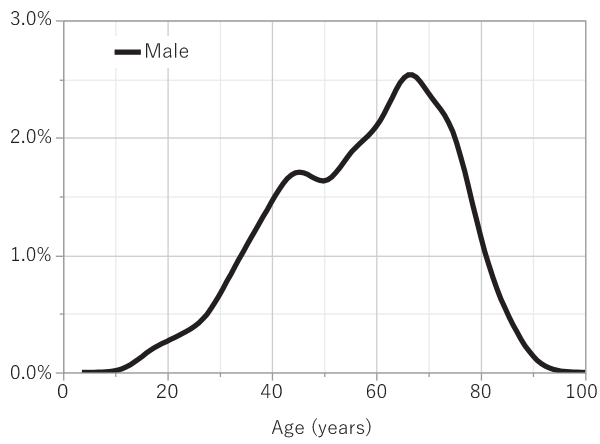
Male (n = 9,134)



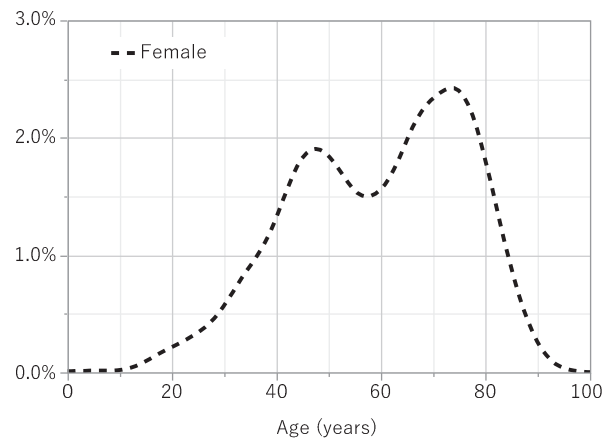
Female (n = 5,621)



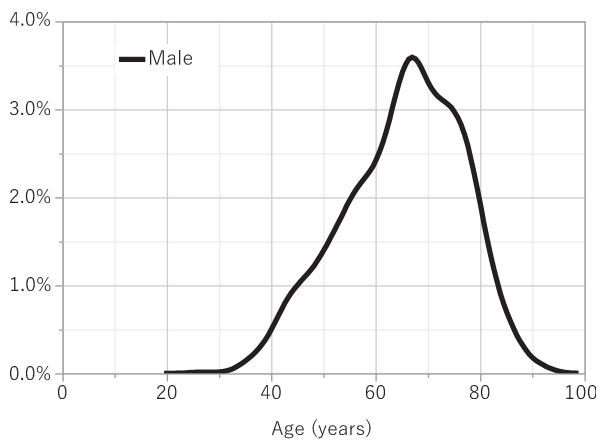
**Disc herniation**  
Male (n = 3,457)



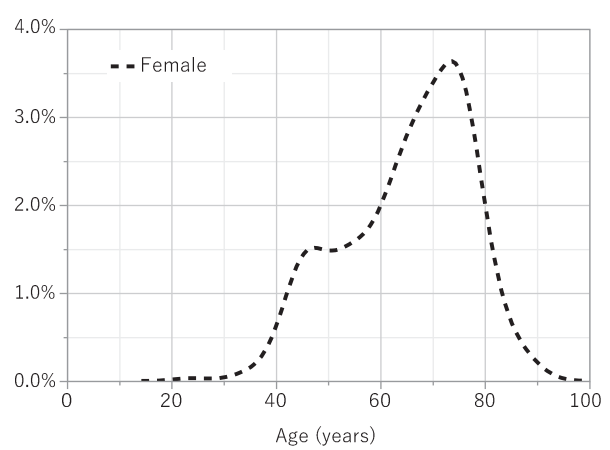
Female (n = 1,783)



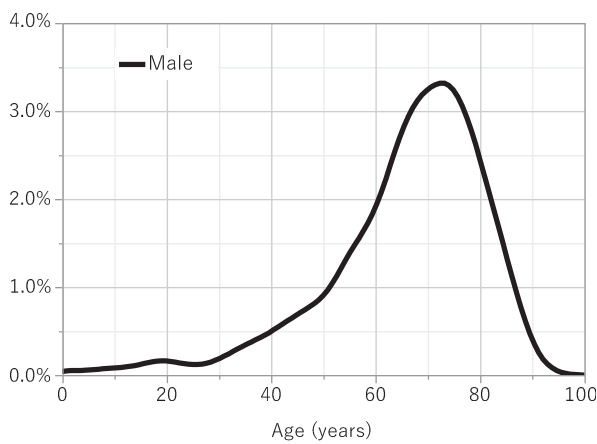
**OPLL**  
Male (n = 1,121)



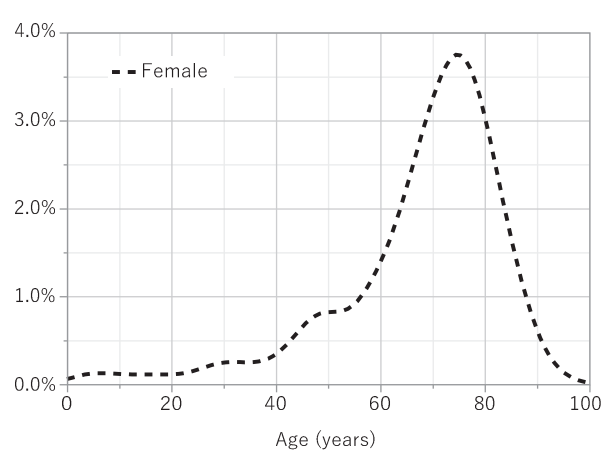
Female (n = 404)



**Others**  
Male (n = 1,419)



Female (n = 901)



## 7.3.4 Details of spinal tumor removal

| Diagnosis                                                       | Total or subtotal removal | Partial removal | Biopsy | Others | Total |
|-----------------------------------------------------------------|---------------------------|-----------------|--------|--------|-------|
| Intramedullary tumor                                            | 565                       | 138             | 87     | 8      | 798   |
| Intradural extramedullary tumor                                 | 1,072                     | 109             | 14     | 5      | 1,200 |
| Extramedullary tumor with extradural or paravertebral extension | 476                       | 202             | 22     | 13     | 713   |
| Primary vertebral tumor                                         | 23                        | 20              | 18     | 2      | 63    |
| Others                                                          | 48                        | 35              | 29     | 33     | 145   |
| Total                                                           | 2,184                     | 504             | 170    | 61     | 2,919 |

## 7.3.5 Details of syringomyelia unrelated to Chiari malformation

| Diagnosis*             | Syrinx shunt | Decompression | Others | Total |
|------------------------|--------------|---------------|--------|-------|
| Adhesive arachnoiditis | 68           | 20            | 26     | 104   |
| Traumatic              | 8            | 3             | 1      | 11    |
| Others                 | 49           | 32            | 9      | 88    |
| Total                  | 125          | 55            | 36     | 203   |

\*multiple selection allowed

## 7.3.6 Details of spinal vascular diseases

| Diagnosis              | Approaches*    |         |        | Total |
|------------------------|----------------|---------|--------|-------|
|                        | Closure of AVF | Removal | Others |       |
| Dural AVF              | 214            | 27      | 18     | 257   |
| Perimedullary AVF      | 44             | 10      | 3      | 54    |
| Extradural AVF         | 29             | 4       | 5      | 38    |
| Intramedullary AVM     | 8              | 11      | 4      | 23    |
| Cavernous malformation | 0              | 31      | 0      | 31    |
| Epidural hematoma      | 0              | 149     | 73     | 214   |
| Others                 | 1              | 16      | 13     | 30    |
| Total                  | 296            | 248     | 116    | 647   |

\*multiple selection allowed

## 7.3.7 Details of spinal injuries

| Diagnosis            | Approaches*            |                         |        |                             |        | Total |
|----------------------|------------------------|-------------------------|--------|-----------------------------|--------|-------|
|                      | Anterior decompression | Posterior decompression | Fusion | Percutaneous vertebroplasty | Others |       |
| Without bone injury  | 52                     | 227                     | 78     | 4                           | 26     | 326   |
| Dislocation fracture | 54                     | 80                      | 231    | 4                           | 29     | 297   |
| Other fractures      | 69                     | 198                     | 795    | 1222                        | 165    | 2,198 |
| Others               | 21                     | 74                      | 44     | 27                          | 186    | 322   |
| Total                | 196                    | 579                     | 1148   | 1257                        | 406    | 3,143 |

\*multiple selection allowed

## 7.3.8 Details of spinal infection

| Diagnosis       | Approaches*            |                         |        |        | Total |
|-----------------|------------------------|-------------------------|--------|--------|-------|
|                 | Anterior decompression | Posterior decompression | Fusion | Others |       |
| With abscess    | 22                     | 126                     | 41     | 112    | 269   |
| Without abscess | 8                      | 40                      | 52     | 67     | 146   |
| Total           | 30                     | 166                     | 93     | 179    | 415   |

\*multiple selection allowed

## 7.3.9 Details of peripheral nerve disorders

| Diagnosis               | Neurolysis | Others | Total |
|-------------------------|------------|--------|-------|
| Carpal tunnel syndrome  | 831        | 398    | 1,229 |
| Cubital tunnel syndrome | 77         | 35     | 112   |
| Tarsal tunnel syndrome  | 143        | 8      | 151   |
| Brachial plexus injury  | 52         | 12     | 64    |
| Others                  | 264        | 38     | 302   |
| Total                   | 1,367      | 491    | 1,858 |

## 7.3.10 Details of other spinal surgeries

|                                | 2015 | 2016 | 2017 | Total |
|--------------------------------|------|------|------|-------|
| Correction of spinal deformity | 8    | 5    | 9    | 22    |
| Others                         | 280  | 328  | 325  | 933   |
| Total                          | 288  | 333  | 334  | 955   |

## 7.3.11 Complications of spinal surgery

| Procedures                                     | Total number | Complications* |               |               |                                                        |               |               | Total           |
|------------------------------------------------|--------------|----------------|---------------|---------------|--------------------------------------------------------|---------------|---------------|-----------------|
|                                                |              | radiculopathy  | myelopathy    | C5 palsy      | complications related to construction and implantation | infection     | Others        |                 |
| Spinal degenerative diseases                   | 34,052       | 229<br>(0.7%)  | 227<br>(0.7%) | 136<br>(0.4%) | 62<br>(0.2%)                                           | 175<br>(0.5%) | 286<br>(0.8%) | 1,089<br>(3.2%) |
| Spinal tumors                                  | 2,919        | 41<br>(1.4%)   | 123<br>(4.2%) | 5<br>(0.2%)   | 3<br>(0.1%)                                            | 17<br>(0.6%)  | 33<br>(1.1%)  | 218<br>(7.5%)   |
| Syringomyelia unrelated to Chiari malformation | 203          | 1<br>(0.5%)    | 4<br>(2.0%)   | 0<br>(0.0%)   | 0<br>(0.0%)                                            | 0<br>(0.0%)   | 6<br>(3.0%)   | 11<br>(5.4%)    |
| Spinal vascular diseases                       | 647          | 4<br>(0.6%)    | 23<br>(3.6%)  | 0<br>(0.0%)   | 0<br>(0.0%)                                            | 1<br>(0.2%)   | 4<br>(0.6%)   | 31<br>(4.8%)    |
| Spinal injuries                                | 3,143        | 8<br>(0.3%)    | 41<br>(1.3%)  | 9<br>(0.3%)   | 15<br>(0.5%)                                           | 16<br>(0.5%)  | 22<br>(0.7%)  | 109<br>(3.5%)   |
| Spinal infection                               | 415          | 1<br>(0.2%)    | 3<br>(0.7%)   | 1<br>(0.2%)   | 1<br>(0.2%)                                            | 20<br>(4.8%)  | 4<br>(1.0%)   | 26<br>(6.3%)    |
| Peripheral nerve disorders                     | 1,858        | 9<br>(0.5%)    | 15<br>(0.8%)  | 0<br>(0.0%)   | 0<br>(0.0%)                                            | 15<br>(0.8%)  | 9<br>(0.5%)   | 45<br>(2.4%)    |
| Other spinal surgeries                         | 955          | 3<br>(0.3%)    | 12<br>(1.3%)  | 0<br>(0.0%)   | 3<br>(0.3%)                                            | 14<br>(1.5%)  | 8<br>(0.8%)   | 37<br>(3.9%)    |
| Total                                          | 44,192       | 296<br>(0.7%)  | 448<br>(1.0%) | 151<br>(0.3%) | 84<br>(0.2%)                                           | 258<br>(0.6%) | 372<br>(0.8%) | 1,566<br>(3.5%) |

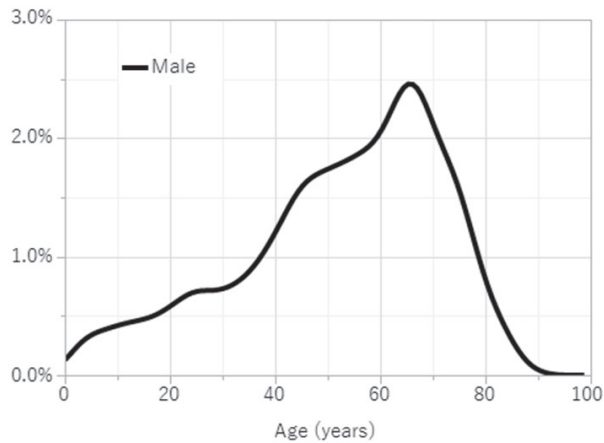
\*multiple selection allowed

## 8. Functional disorders

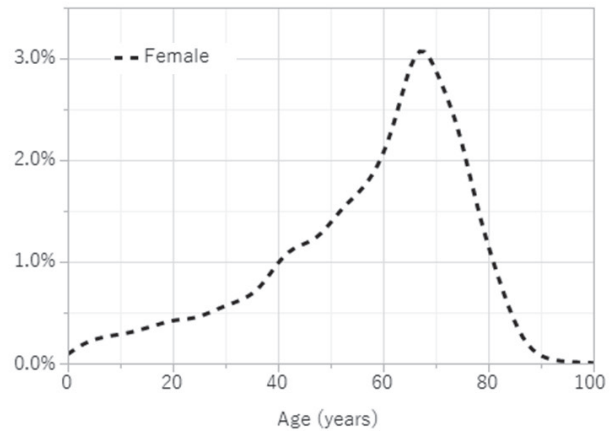
### 8.1 Overall results

#### 8.1.1 Density plots of age by sex

Male (n = 7,937)



Female (n = 9,024)



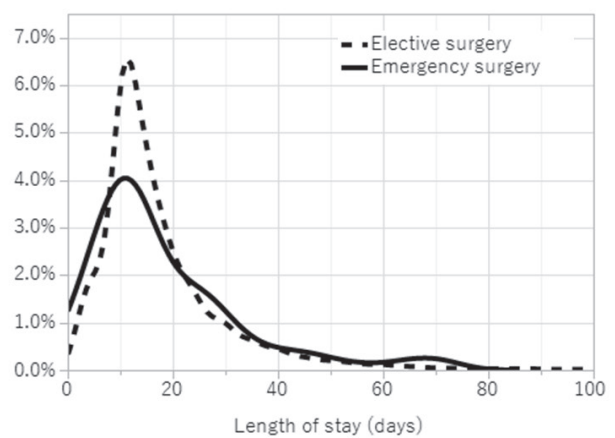
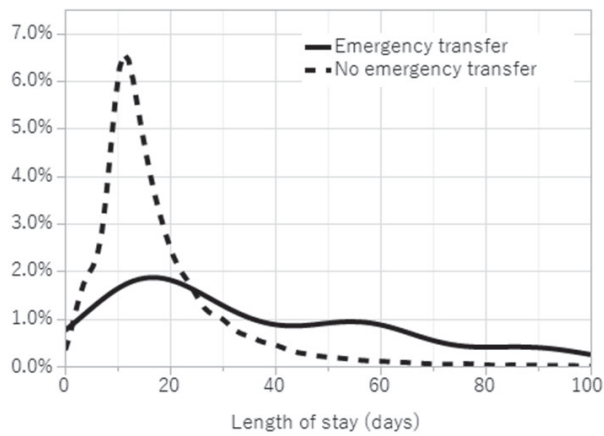
#### 8.1.2 Density plots of length of hospital stay by emergency transfer or surgery

Emergency transfer (n = 109)

Emergency surgery (n = 184)

No emergency transfer (n = 16,852)

Elective surgery (n = 16,777)





## 8.2 Functional disorders - characteristics and outcomes of each procedure

| Variables               | Epilepsy surgeries | MVD   | Functional stereotactic surgeries | Implantation of drug pump | Implantation of spinal cord stimulator | Other functional surgeries |
|-------------------------|--------------------|-------|-----------------------------------|---------------------------|----------------------------------------|----------------------------|
| Number of surgeries     |                    |       |                                   |                           |                                        |                            |
| total                   | 2,440              | 7,221 | 2,498                             | 511                       | 898                                    | 3,393                      |
| 2015                    | 868                | 2,393 | 892                               | 159                       | 318                                    | 1,005                      |
| 2016                    | 889                | 2,369 | 742                               | 167                       | 249                                    | 1,061                      |
| 2017                    | 683                | 2,459 | 864                               | 185                       | 331                                    | 1,327                      |
| Emergency transfer      | 1%                 | 0%    | 0%                                | 5%                        | 1%                                     | 1%                         |
| Emergency surgery       | 1%                 | 1%    | 1%                                | 1%                        | 1%                                     | 3%                         |
| Age                     |                    |       |                                   |                           |                                        |                            |
| median                  | 26                 | 60    | 63                                | 51                        | 66                                     | 66                         |
| mean                    | 28                 | 59    | 58                                | 49                        | 63                                     | 61                         |
| lower quartile          | 16                 | 49    | 52                                | 35                        | 54                                     | 54                         |
| upper quartile          | 39                 | 69    | 69                                | 65                        | 74                                     | 73                         |
| Female patients         | 45%                | 63%   | 48%                               | 28%                       | 45%                                    | 48%                        |
| Length of hospital stay |                    |       |                                   |                           |                                        |                            |
| median                  | 20                 | 13    | 20                                | 22                        | 18                                     | 11                         |
| mean                    | 25                 | 15    | 23                                | 36                        | 23                                     | 14                         |
| lower quartile          | 12                 | 10    | 11                                | 15                        | 12                                     | 7                          |
| upper quartile          | 31                 | 16    | 29                                | 40                        | 27                                     | 18                         |
| Use of microscope       | 80%                | 97%   | 2%                                | 1%                        | 5%                                     | 5%                         |
| First surgery           | 75%                | 95%   | 80%                               | 85%                       | 68%                                    | 33%                        |
| General anesthesia      | 98%                | 100%  | 54%                               | 96%                       | 35%                                    | 47%                        |
| Preoperative mRS        |                    |       |                                   |                           |                                        |                            |
| median                  | 1                  | 1     | 2                                 | 4                         | 2                                      | 3                          |
| mean                    | 2                  | 1     | 3                                 | 4                         | 2                                      | 3                          |
| lower quartile          | 1                  | 1     | 2                                 | 3                         | 2                                      | 2                          |
| upper quartile          | 3                  | 1     | 3                                 | 5                         | 3                                      | 4                          |
| mRS at discharge        |                    |       |                                   |                           |                                        |                            |
| median                  | 1                  | 0     | 2                                 | 4                         | 2                                      | 3                          |
| mean                    | 2                  | 0     | 2                                 | 4                         | 2                                      | 3                          |
| lower quartile          | 1                  | 0     | 1                                 | 3                         | 1                                      | 2                          |
| upper quartile          | 2                  | 1     | 3                                 | 5                         | 3                                      | 4                          |
| mRS improved            | 17%                | 60%   | 44%                               | 15%                       | 22%                                    | 12%                        |
| mRS unchanged           | 80%                | 38%   | 53%                               | 83%                       | 75%                                    | 86%                        |
| mRS worsened            | 3%                 | 2%    | 3%                                | 2%                        | 3%                                     | 2%                         |
| Dead                    | 0.0%               | 0.1%  | 0.1%                              | 0.6%                      | 0.2%                                   | 0.1%                       |

### 8.3 Functional disorders - diagnoses and approaches

#### 8.3.1 Details of epilepsy surgeries

| Approach*                                       | 2015       | 2016       | 2017       | Total        |
|-------------------------------------------------|------------|------------|------------|--------------|
| Selective amygdalo-hippocampectomy              | 118        | 89         | 79         | 286          |
| Lobectomy                                       | 88         | 122        | 74         | 284          |
| Lesionectomy, corticectomy, and focus resection | 170        | 163        | 139        | 472          |
| Hemispherotomy and hemispherectomy              | 24         | 26         | 10         | 60           |
| Corpus callosotomy                              | 83         | 85         | 62         | 230          |
| MST                                             | 9          | 6          | 6          | 21           |
| Intracranial electrode                          | 149        | 167        | 146        | 462          |
| Vagus nerve stimulation                         | 228        | 212        | 151        | 591          |
| Others                                          | 48         | 48         | 43         | 139          |
| <b>Total</b>                                    | <b>868</b> | <b>889</b> | <b>683</b> | <b>2,440</b> |

\*multiple selection allowed

#### 8.3.2 Details of MVD

| Diagnosis            | 2015         | 2016         | 2017         | Total        |
|----------------------|--------------|--------------|--------------|--------------|
| Hemifacial spasm     | 1,419        | 1,362        | 1,404        | 4,185        |
| Trigeminal neuralgia | 942          | 976          | 1,003        | 2,921        |
| Others               | 32           | 31           | 52           | 115          |
| <b>Total</b>         | <b>2,393</b> | <b>2,369</b> | <b>2,459</b> | <b>7,221</b> |

#### 8.3.3 Details of functional stereotactic surgeries

| Diagnosis                   | Stimulation  | Coagulation | Others     | Total        |
|-----------------------------|--------------|-------------|------------|--------------|
| Parkinson's disease         | 1,429        | 38          | 121        | 1,588        |
| Essential tremor            | 119          | 194         | 28         | 341          |
| Dystonia                    | 137          | 215         | 32         | 384          |
| Other involuntary movements | 35           | 16          | 10         | 61           |
| Spasticity                  | 0            | 9           | 0          | 9            |
| Pain                        | 5            | 6           | 1          | 12           |
| Others                      | 8            | 78          | 17         | 103          |
| <b>Total</b>                | <b>1,733</b> | <b>556</b>  | <b>209</b> | <b>2,498</b> |

### 8.3.4 Details of implantation of drug pump, implantation of spinal cord stimulator, and other functional surgeries

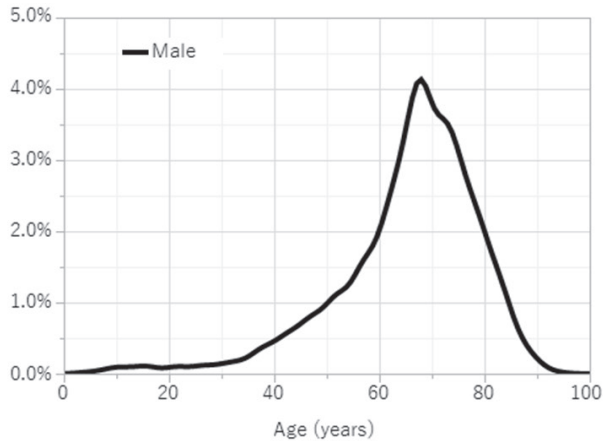
| Diagnosis                   | Implantation of drug pump | Implantation of spinal cord stimulator | Other functional surgeries | Total |
|-----------------------------|---------------------------|----------------------------------------|----------------------------|-------|
| Parkinson's disease         | 2                         | 65                                     | 2,047                      | 2,114 |
| Essential tremor            | 0                         | 4                                      | 134                        | 138   |
| Dystonia                    | 11                        | 15                                     | 310                        | 336   |
| Other involuntary movements | 8                         | 2                                      | 44                         | 54    |
| Spasticity                  | 460                       | 17                                     | 204                        | 681   |
| Pain                        | 7                         | 755                                    | 306                        | 1,068 |
| Others                      | 23                        | 40                                     | 348                        | 411   |
| Total                       | 511                       | 898                                    | 3,393                      | 4,802 |

## 9. Stereotactic radiosurgery

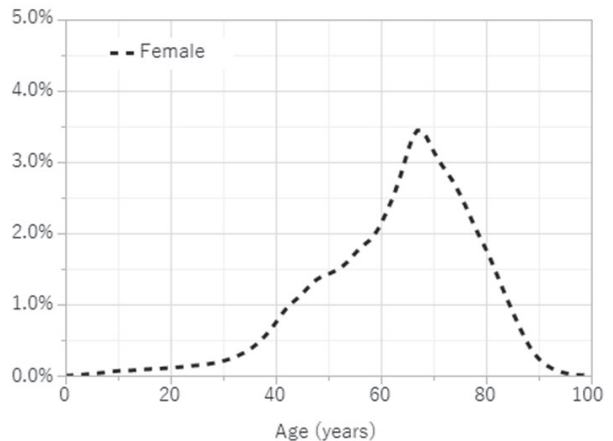
### 9.1 Overall results

#### 9.1.1 Density plots of age by sex

Male (n = 19,609)



Female (n = 17,601)



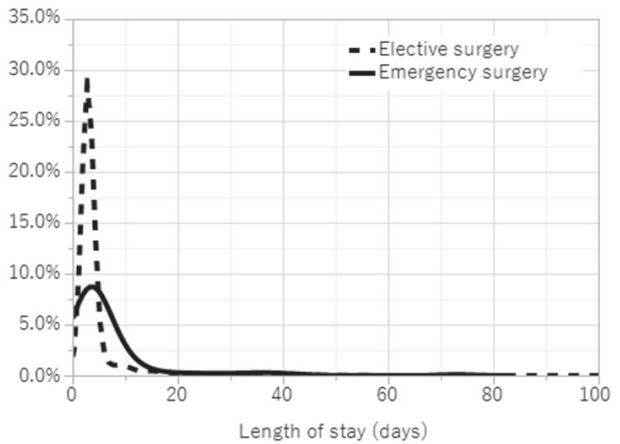
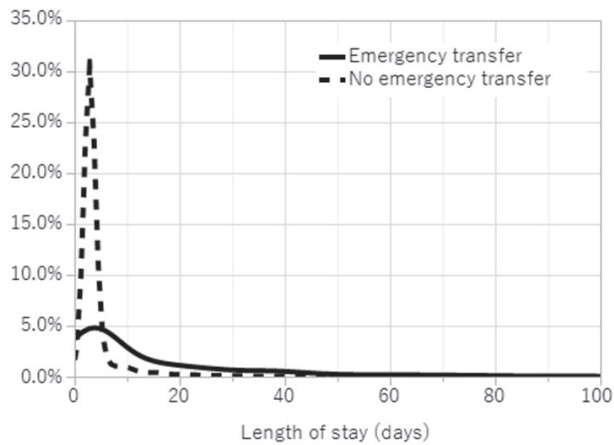
#### 9.1.2 Density plots of length of hospital stay by emergency transfer or surgery

Emergency transfer (n = 579)

Emergency surgery (n = 113)

No emergency transfer (n = 36,631)

Elective surgery (n = 37,097)



## 9.2 Stereotactic radiosurgery - characteristics and outcomes of each category

| Variables               | Metastatic<br>BTs | Primary BTs | CVDs  | Functional<br>disorders | Others |
|-------------------------|-------------------|-------------|-------|-------------------------|--------|
| Number of surgeries     |                   |             |       |                         |        |
| total                   | 26,586            | 8,544       | 1,350 | 571                     | 159    |
| 2015                    | 8,292             | 2,662       | 397   | 132                     | 85     |
| 2016                    | 9,183             | 2,816       | 457   | 238                     | 42     |
| 2017                    | 9,111             | 3,066       | 496   | 201                     | 32     |
| Emergency transfer      | 2%                | 1%          | 2%    | 1%                      | 0%     |
| Emergency surgery       | 0%                | 0%          | 0%    | 0%                      | 0%     |
| Age                     |                   |             |       |                         |        |
| median                  | 68                | 64          | 43    | 76                      | 65     |
| mean                    | 66                | 61          | 43    | 74                      | 61     |
| lower quartile          | 60                | 50          | 26    | 69                      | 51     |
| upper quartile          | 74                | 73          | 58    | 81                      | 72     |
| Female patients         | 44%               | 56%         | 47%   | 59%                     | 50%    |
| Length of hospital stay |                   |             |       |                         |        |
| median                  | 3                 | 3           | 3     | 3                       | 7      |
| mean                    | 6                 | 7           | 6     | 3                       | 13     |
| lower quartile          | 3                 | 3           | 3     | 3                       | 3      |
| upper quartile          | 3                 | 4           | 3     | 3                       | 12     |
| First surgery           | 79%               | 69%         | 84%   | 88%                     | 78%    |
| General anesthesia      | 10%               | 7%          | 7%    | 5%                      | 1%     |
| Preoperative mRS        |                   |             |       |                         |        |
| median                  | 1                 | 1           | 1     | 1                       | 2      |
| mean                    | 2                 | 1           | 1     | 2                       | 2      |
| lower quartile          | 0                 | 0           | 0     | 1                       | 1      |
| upper quartile          | 2                 | 2           | 1     | 2                       | 3      |
| mRS at discharge        |                   |             |       |                         |        |
| median                  | 1                 | 1           | 1     | 1                       | 2      |
| mean                    | 2                 | 1           | 1     | 2                       | 2      |
| lower quartile          | 0                 | 0           | 0     | 1                       | 1      |
| upper quartile          | 2                 | 2           | 1     | 2                       | 3      |
| mRS improved            | 2%                | 2%          | 2%    | 3%                      | 3%     |
| mRS unchanged           | 96%               | 96%         | 96%   | 97%                     | 97%    |
| mRS worsened            | 1%                | 2%          | 1%    | 0%                      | 0%     |
| Dead                    | 0.4%              | 0.4%        | 0.1%  | 0.0%                    | 0.0%   |

### 9.3 Diagnoses for stereotactic radiosurgery

#### 9.3.1 Metastatic BTs

|                    | 2015  | 2016  | 2017  | Total  |
|--------------------|-------|-------|-------|--------|
| Respiratory origin | 5,652 | 6,280 | 6,242 | 18,174 |
| Intestinal origin  | 800   | 808   | 880   | 2,488  |
| Breast origin      | 1,057 | 1,226 | 1,119 | 3,402  |
| Urogenital origin  | 404   | 449   | 453   | 1,306  |
| Other origin       | 379   | 420   | 417   | 1,216  |
| Total              | 8,292 | 9,183 | 9,111 | 26,586 |

#### 9.3.2 Primary BTs

|                       | 2015  | 2016  | 2017  | Total |
|-----------------------|-------|-------|-------|-------|
| Schwannoma            | 657   | 699   | 733   | 2,089 |
| Meningioma            | 1,092 | 1,182 | 1,276 | 3,550 |
| Pituitary adenoma     | 233   | 263   | 231   | 727   |
| Neuroepithelial tumor | 295   | 282   | 423   | 1,000 |
| Others                | 385   | 390   | 403   | 1,178 |
| Total                 | 2,662 | 2,816 | 3,066 | 8,544 |

#### 9.3.3 CVDs

|                        | 2015 | 2016 | 2017 | Total |
|------------------------|------|------|------|-------|
| Cerebral AVM           | 350  | 389  | 426  | 1,165 |
| Dural AVF              | 28   | 41   | 40   | 109   |
| Cavernous malformation | 16   | 23   | 21   | 60    |
| Others                 | 3    | 4    | 9    | 16    |
| Total                  | 397  | 457  | 496  | 1,350 |

#### 9.3.4 Functional disorders

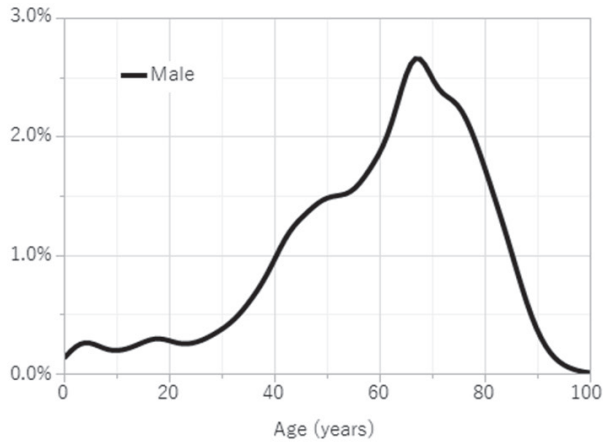
|                      | 2015 | 2016 | 2017 | Total |
|----------------------|------|------|------|-------|
| Trigeminal neuralgia | 108  | 210  | 192  | 510   |
| Parkinson's disease  | 6    | 3    | 1    | 10    |
| Epilepsy             | 0    | 0    | 2    | 2     |
| Others               | 18   | 25   | 6    | 49    |
| Total                | 132  | 238  | 201  | 571   |

## 10. Others

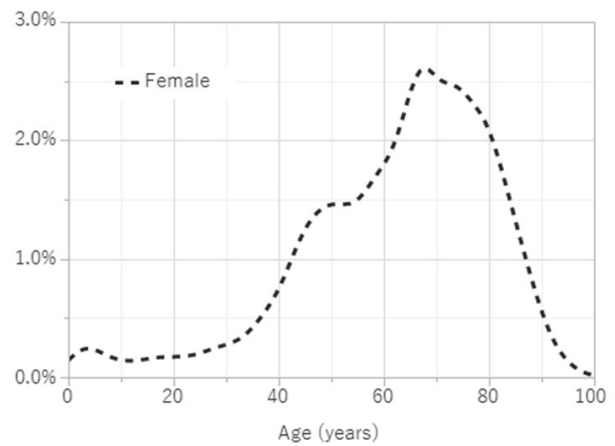
### 10.1 Overall results

#### 10.1.1 Density plots of age by sex

Male (n = 13,614)



Female (n = 11,335)



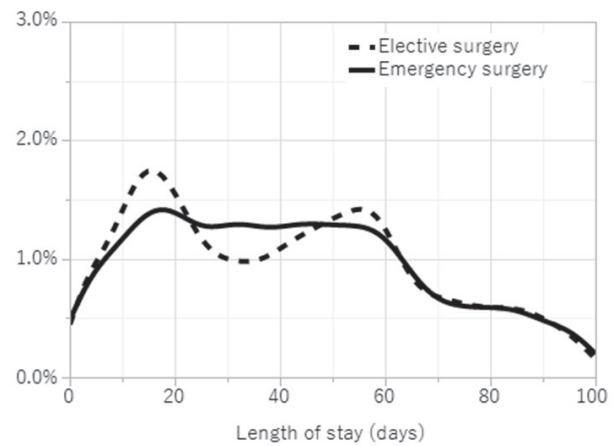
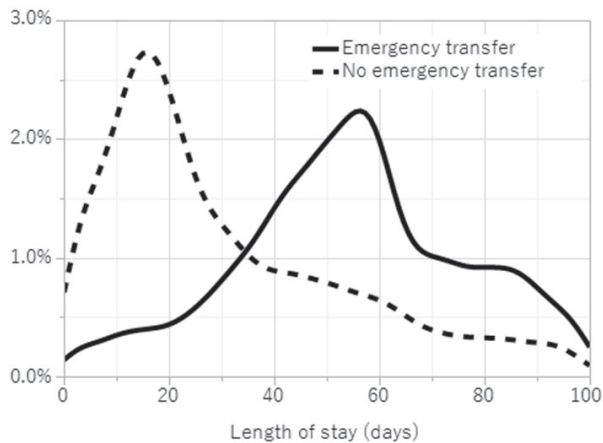
#### 10.1.2 Density plots of length of hospital stay by emergency transfer or surgery

Emergency transfer (n = 12,152)

Emergency surgery (n = 5,620)

No emergency transfer (n = 12,797)

Elective surgery (n = 19,329)



**10.2 Others - characteristics and outcomes of each procedure**

| Variables               | Cranioplasty unrelated to head injury | Brain abscess | Not otherwise classified |
|-------------------------|---------------------------------------|---------------|--------------------------|
| Number of surgeries     |                                       |               |                          |
| total                   | 9,089                                 | 2,950         | 12,908                   |
| 2015                    | 3,002                                 | 989           | 4,116                    |
| 2016                    | 2,992                                 | 1,009         | 4,293                    |
| 2017                    | 3,095                                 | 952           | 4,499                    |
| Emergency transfer      | 62%                                   | 42%           | 41%                      |
| Emergency surgery       | 6%                                    | 49%           | 28%                      |
| Age                     |                                       |               |                          |
| median                  | 62                                    | 66            | 66                       |
| mean                    | 59                                    | 62            | 62                       |
| lower quartile          | 49                                    | 52            | 51                       |
| upper quartile          | 72                                    | 76            | 76                       |
| Female patients         | 50%                                   | 37%           | 44%                      |
| Length of hospital stay |                                       |               |                          |
| median                  | 54                                    | 50            | 37                       |
| mean                    | 62                                    | 61            | 51                       |
| lower quartile          | 28                                    | 31            | 16                       |
| upper quartile          | 78                                    | 75            | 65                       |
| Use of microscope       | 4%                                    | 19%           | 10%                      |
| First surgery           | 43%                                   | 65%           | 67%                      |
| General anesthesia      | 98%                                   | 74%           | 53%                      |
| Preoperative mRS        |                                       |               |                          |
| median                  | 4                                     | 4             | 4                        |
| mean                    | 4                                     | 3             | 3                        |
| lower quartile          | 3                                     | 2             | 1                        |
| upper quartile          | 5                                     | 5             | 5                        |
| mRS at discharge        |                                       |               |                          |
| median                  | 4                                     | 3             | 3                        |
| mean                    | 3                                     | 3             | 3                        |
| lower quartile          | 2                                     | 1             | 1                        |
| upper quartile          | 5                                     | 4             | 5                        |
| mRS improved            | 26%                                   | 44%           | 25%                      |
| mRS unchanged           | 68%                                   | 44%           | 63%                      |
| mRS worsened            | 4%                                    | 5%            | 5%                       |
| Dead                    | 1.6%                                  | 6.3%          | 6.6%                     |



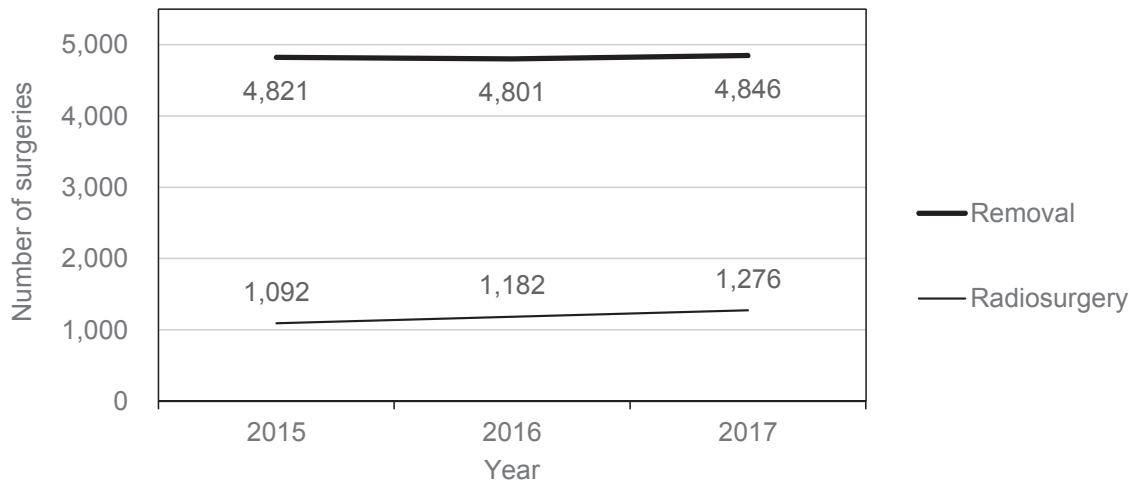
**10.3 Others - approaches**

## 10.3.1 Approaches for brain abscess

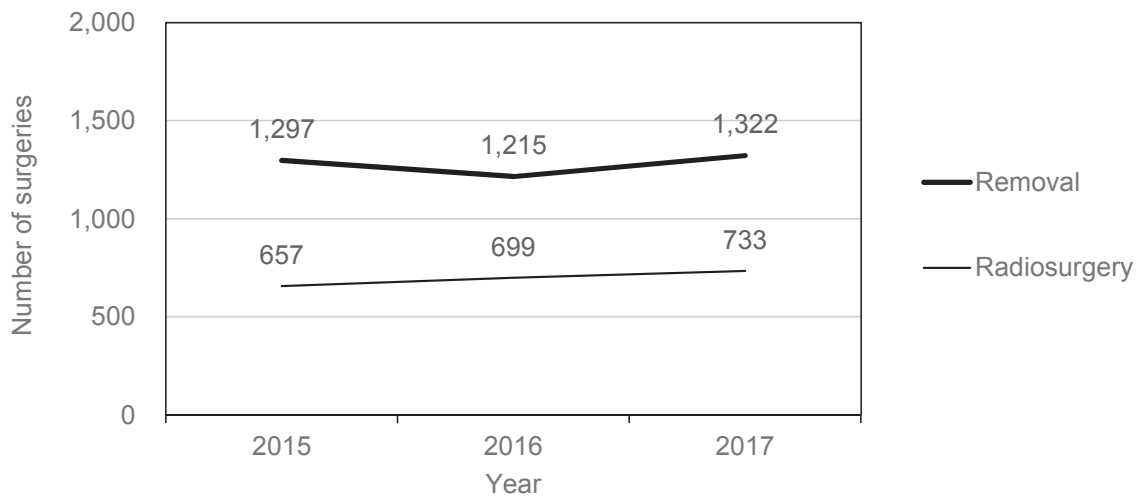
|                | 2015 | 2016  | 2017 | Total |
|----------------|------|-------|------|-------|
| Open resection | 307  | 300   | 288  | 895   |
| Drainage       | 622  | 643   | 592  | 1,857 |
| Others         | 60   | 66    | 72   | 198   |
| Total          | 989  | 1,009 | 952  | 2,950 |

## 11. Therapeutic trends in diseases with multiple options

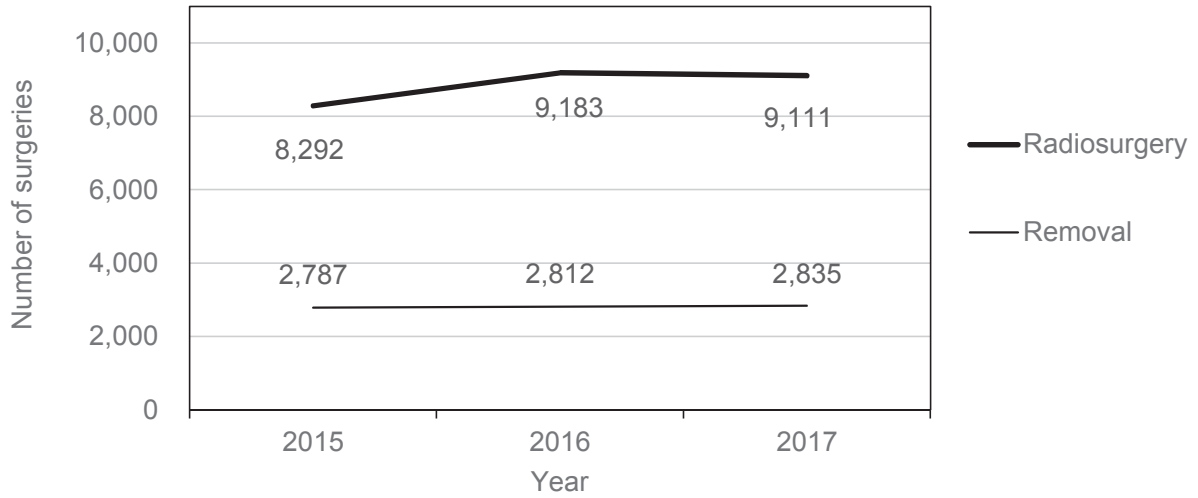
### 11.1 Meningioma



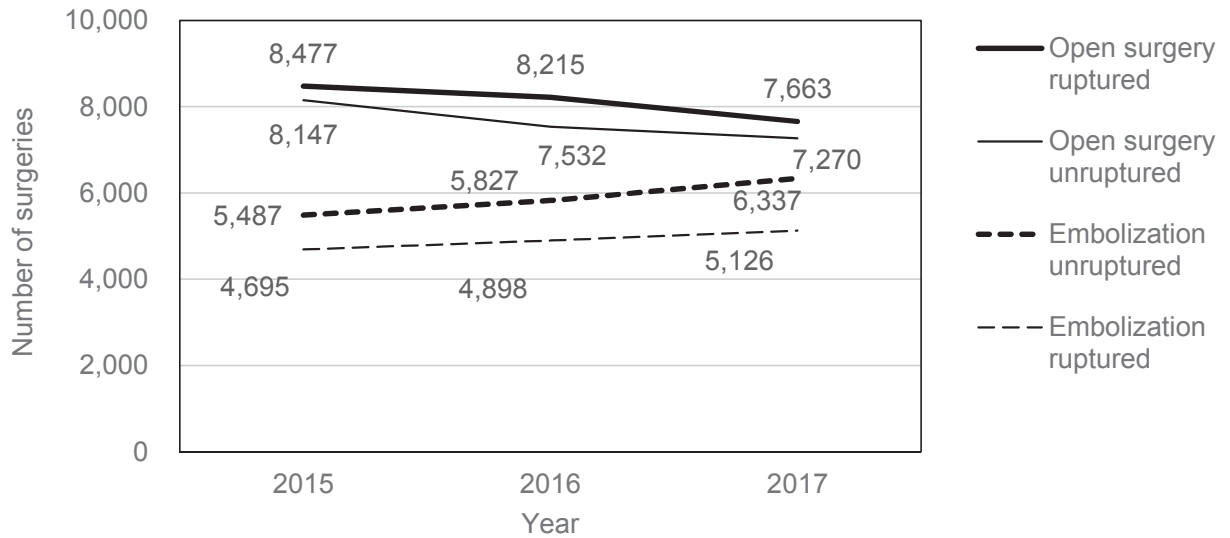
### 11.2 Schwannoma



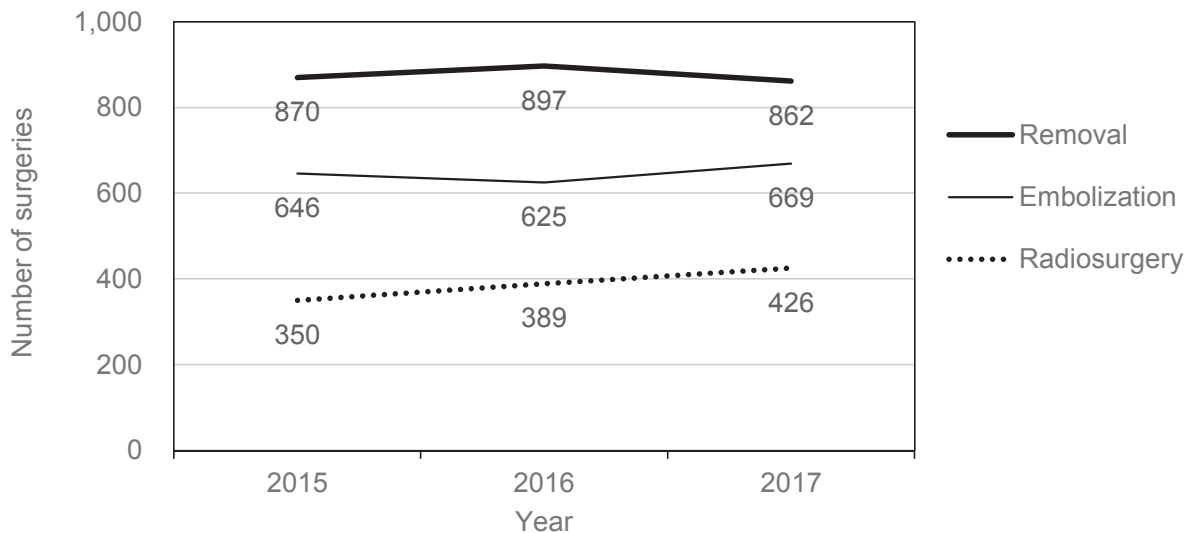
11.3 Metastatic brain tumor



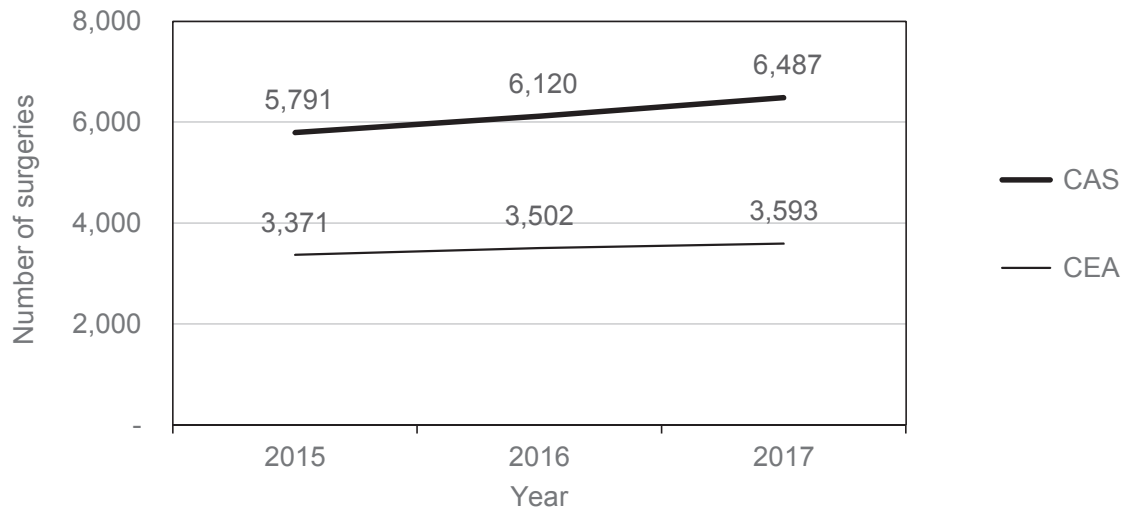
11.4 Intracranial aneurysm



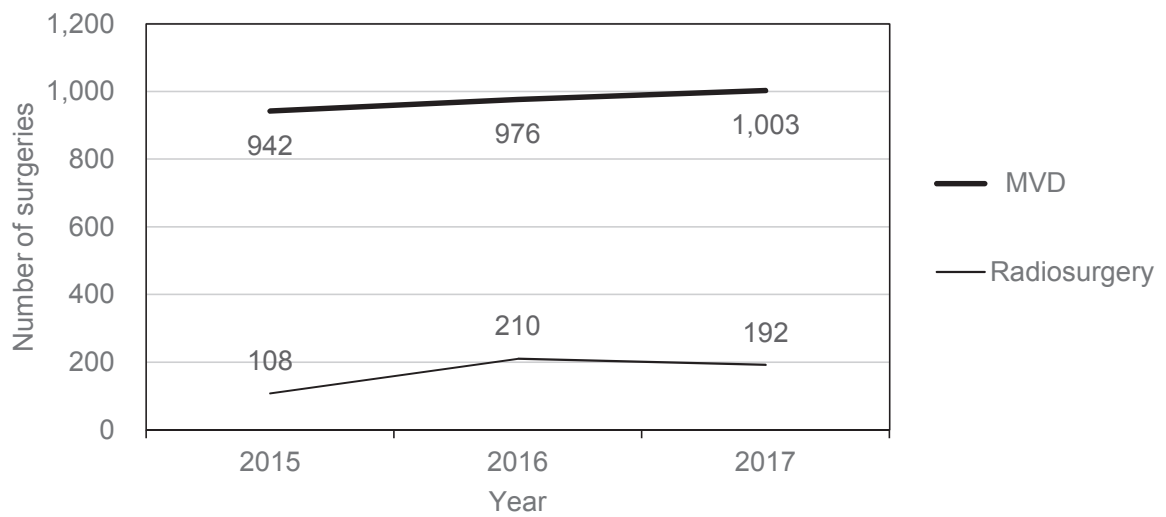
11.5 Arteriovenous malformation



## 11.6 Cervical carotid stenosis



## 11.7 Trigeminal neuralgia



## 12. Appendix

The number of surgeries in each category according to conventional annual reports of the Japan Neurosurgical Society

| Category                  | 2015           | 2016           | 2017           | Total          |
|---------------------------|----------------|----------------|----------------|----------------|
| BTs                       | 25,016         | 25,649         | 24,972         | 75,637         |
| CVDs                      | 44,640         | 44,043         | 42,755         | 131,438        |
| Endovascular              | 40,733         | 45,200         | 50,136         | 136,069        |
| Head injuries             | 52,577         | 52,885         | 53,452         | 158,914        |
| Hydrocephalus / anomalies | 20,516         | 21,579         | 21,411         | 63,506         |
| Spine / peripheral        | 18,791         | 19,271         | 20,397         | 58,459         |
| Functional                | 6,692          | 7,015          | 7,180          | 20,887         |
| Radiosurgery              | 20,240         | 20,799         | 19,719         | 60,758         |
| Others                    | 12,447         | 12,920         | 12,900         | 38,267         |
| <b>Total</b>              | <b>243,667</b> | <b>251,377</b> | <b>254,939</b> | <b>743,935</b> |