**Supplemental Table 1.** Inclusion of missingness of individual complications by registry.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Australia** | **Denmark** | **Finland** | **Hungary** | **Malta** | **New Zealand** | **Sweden** | **US** |
| **Bleeding** | 0% | 1.8% | 0% | 0% | 1.6% | 0% | 3.1% | 0.8% |
| **Stroke** | 0% | 1.7% | 0% | 0% | 1.6% | 0% | 3.4% | 1.5% |
| **ACE** | 0% | 1.7% | 0% | 0% | 1.6% | 0% | 3.3% | 0.2% |
| **RRT** | 0% | 1.7% | 0% | 0% | 1.6% | 0% | 3.3% | 0.3% |
| **Respiratory** | 0% | NR | 0% | 0% | 1.6% | 0% | NR | 0.2% |
| **Bowel ischemia** | 0% | 1.8% | 0% | 0% | 1.6% | 0% | NR | 0.2% |

Shown as proportion of missingness or NR (not reported); ACE, acute cardiac event; RRT, renal replacement therapy; Registry data for Finland and Malta were not included in the volume-outcome analysis since only a single participating center was present for each registry.

**Supplemental Table 2.** Patient Characteristics by Hospital Volume Quartiles Stratified by Procedure Type. A: EVAR; B: Open.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Q1****1-22.5** | **Q2****22.5-37.7** | **Q3****37.7-63.7** | **Q4****63.7-121** | **P value** |
| 1. **EVAR**
 |  |  |  |  |  |
| **N total** | 369 | 416 | 367 | 476 |  |
| Age | 76.3(8.0) | 75.7(8.6) | 75.9(8.6) | 76.5(7.8) | 0.53 |
| Gender |  |  |  |  | 0.26 |
| Male | 291(78.9%) | 317(76.2%) | 267(72.8%) | 356(74.8%) |  |
| Female | 78(21.1%) | 99(23.8%) | 100(27.2%) | 120(25.2%) |  |
| Diabetes |  |  |  |  | 0.008 |
| No | 298(80.8%) | 329(79.1%) | 267(72.8%) | 368(77.3%) |  |
| Yes | 71(19.2%) | 87(20.9%) | 100(27.2%) | 104(21.8%) |  |
| Missing | 0(0.0%) | 0(0.0%) | 0(0.0%) | 4(0.8%) |  |
| Cardiac |  |  |  |  | 0.73 |
| No | 149(40.4%) | 179(43.0%) | 150(40.9%) | 188(39.5%) |  |
| Yes | 220(59.6%) | 237(57.0%) | 217(59.1%) | 287(60.3%) |  |
| Missing | 0(0.0%) | 0(0.0%) | 0(0.0%) | 1(0.2%) |  |
| High Cr |  |  |  |  | 0.05 |
| No | 297(80.5%) | 328(78.8%) | 304(82.8%) | 391(82.1%) |  |
| Yes | 64(17.3%) | 65(15.6%) | 57(15.5%) | 67(14.1%) |  |
| Missing | 8(2.2%) | 23(5.5%) | 6(1.6%) | 18(3.8%) |  |
| Procedure year |  |  |  |  | 0.56 |
| 10-13 | 191(51.8%) | 210(50.5%) | 181(49.3%) | 257(54.0%) |  |
| 14-16 | 178(48.2%) | 206(49.5%) | 186(50.7%) | 219(46.0%) |  |
| Maximum Aneurysm Diameter(cm) |  |  |  |  | 0.11 |
| Mean/SD | 5.8(1.5) | 6.0(1.3) | 6.0(1.5) | 5.9(1.5) |  |
| Missing | 4(1.1%) | 10(2.4%) | 6(1.6%) | 10(2.1%) |  |

|  |
| --- |
| **Supplemental Table 2. (Continued)** |
|  | **Q1****1-11** | **Q2****11-23** | **Q3****23-43** | **Q4****43-116** | **P value** |
| 1. **Open**
 |  |  |  |  |  |
| **N total** | 740 | 640 | 548 | 144 |  |
| Age | 71.9(8.6) | 71.9(8.0) | 72.1(7.7) | 72.0(9.1) | 0.96 |
| Gender |  |  |  |  | 0.08 |
| Male | 542(73.2%) | 457(71.4%) | 406(74.1%) | 118(81.9%) |  |
| Female | 198(26.8%) | 183(28.6%) | 142(25.9%) | 26(18.1%) |  |
| Diabetes |  |  |  |  | 0.92 |
| No | 616(83.2%) | 531(83.0%) | 454(82.8%) | 118(81.9%) |  |
| Yes | 123(16.6%) | 109(17.0%) | 94(17.2%) | 26(18.1%) |  |
| Missing | 1(0.1%) | 0(0.0%) | 0(0.0%) | 0(0.0%) |  |
| Cardiac |  |  |  |  | 0.78 |
| No | 367(49.6%) | 326(50.9%) | 272(49.6%) | 67(46.5%) |  |
| Yes | 373(50.4%) | 313(48.9%) | 276(50.4%) | 77(53.5%) |  |
| Missing | 0(0.0%) | 1(0.2%) | 0(0.0%) | 0(0.0%) |  |
| High Cr |  |  |  |  | <0.001 |
| No | 603(81.5%) | 536(83.8%) | 465(84.9%) | 91(63.2%) |  |
| Yes | 75(10.1%) | 79(12.3%) | 59(10.8%) | 13(9.0%) |  |
| Missing | 62(8.4%) | 25(3.9%) | 24(4.4%) | 40(27.8%) |  |
| Procedure year |  |  |  |  | <0.001 |
| 10-13 | 352(47.6%) | 295(46.1%) | 299(54.6%) | 46(31.9%) |  |
| 14-16 | 388(52.4%) | 345(53.9%) | 249(45.4%) | 98(68.1%) |  |
| Maximum Aneurysm Diameter(cm) |  |  |  |  | 0.62 |
| Mean/SD | 6.1(1.8) | 6.2(1.6) | 6.2(1.5) | 6.1(1.3) |  |
| Missing | 9(1.2%) | 6(0.9%) | 4(0.7%) | 0(0.0%) |  |

|  |
| --- |
| **Supplemental Table 3.** Model Results for Endovascular and Open AAA Repair Failure to Rescue Analysis within the ICVR. |
| ***Effect*** | ***Univariable*** |  | ***Multivariable*** |  |
| ***OR (95% CI)*** | ***P-value*** | ***OR (95% CI)*** | ***P-value*** |
| ***EVAR*** |  |  |  |  |
| Volume comparison |  |  |  |  |
| Q2 vs. Q1 | 0.77(0.49-1.20) | 0.25 | 0.76(0.49-1.19) | 0.23 |
| Q3 vs. Q1 | 0.91(0.58-1.41) | 0.67 | 0.85(0.54-1.34) | 0.49 |
| Q4 vs. Q1 | 0.56(0.35-0.89) | 0.01 | 0.54(0.34-0.87) | 0.01 |
| Age 1-year increase | 1.03(1.01-1.05) | 0.006 | 1.03(1.00-1.05) | 0.02 |
| Sex: Female vs. Male | 1.59(1.12-2.26) | 0.009 | 1.57(1.09-2.25) | 0.01 |
| Diabetes mellitus vs. No | 1.12(0.77-1.64) | 0.55 | 1.12(0.76-1.65) | 0.57 |
| Cardiac history vs. No | 1.25(0.89-1.74) | 0.2 | 1.29(0.91-1.82) | 0.15 |
| High Creatinine (>1.8mg/dL) vs. No | 1.89(1.28-2.79) | 0.001 | 1.74(1.17-2.59) | 0.006 |
| Small AAA1 vs. Non-Small AAA | 0.55(0.36-0.83) | 0.004 | 0.62(0.40-0.94) | 0.02 |
| Year  |  |  |  |  |
| 2011 vs. 2010 | 1.65(0.66-4.09) | 0.28 | 1.68(0.68-4.17) | 0.26 |
| 2012 vs. 2010 | 1.29(0.52-3.20) | 0.58 | 1.26(0.52-3.09) | 0.61 |
| 2013 vs. 2010 | 1.42(0.57-3.51) | 0.45 | 1.40(0.58-3.39) | 0.46 |
| 2014 vs. 2010 | 1.52(0.62-3.73) | 0.36 | 1.50(0.63-3.59) | 0.36 |
| 2015 vs. 2010 | 1.80(0.73-4.45) | 0.2 | 1.74(0.72-4.21) | 0.22 |
| 2016 vs. 2010 | 1.97(0.80-4.87) | 0.14 | 1.93(0.80-4.69) | 0.15 |
| ***Open*** |  |  |  |  |
| Volume comparison |  |  |  |  |
| Q2 vs. Q1 | 0.65(0.48-0.88) | 0.005 | 0.64(0.47-0.87) | 0.004 |
| Q3 vs. Q1 | 0.72(0.53-0.98) | 0.04 | 0.74(0.54-1.01) | 0.06 |
| Q4 vs. Q1 | 0.24(0.12-0.47) | <0.001 | 0.22(0.11-0.44) | <0.001 |
| Age 1-year increase | 1.05(1.03-1.06) | <0.001 | 1.05(1.03-1.06) | <0.001 |
| Sex: Female vs. Male | 1.27(0.97-1.65) | 0.08 | 1.18(0.89-1.55) | 0.25 |
| Diabetes mellitus vs. No | 1.31(0.97-1.78) | 0.08 | 1.25(0.91-1.72) | 0.16 |
| Cardiac history vs. No | 1.63(1.27-2.08) | <0.001 | 1.54(1.20-1.99) | <0.001 |
| High Creatinine (>1.8mg/dL) vs. No | 1.26(0.88-1.81) | 0.2 | 1.18(0.81-1.72) | 0.4 |
| Small AAA1 vs. Non-Small AAA | 0.74(0.55-1.01) | 0.05 | 0.85(0.62-1.16) | 0.3 |
| Year  |  |  |  |  |
| 2011 vs. 2010 | 1.95(1.07-3.55) | 0.03 | 1.99(1.08-3.66) | 0.03 |
| 2012 vs. 2010 | 2.25(1.25-4.06) | 0.007 | 2.27(1.25-4.14) | 0.007 |
| 2013 vs. 2010 | 1.90(1.06-3.41) | 0.03 | 1.96(1.08-3.54) | 0.03 |
| 2014 vs. 2010 | 1.72(0.95-3.10) | 0.07 | 1.90(1.04-3.47) | 0.04 |
| 2015 vs. 2010 | 2.44(1.37-4.33) | 0.002 | 2.54(1.41-4.57) | 0.002 |
| 2016 vs. 2010 | 2.24(1.25-4.01) | 0.007 | 2.37(1.31-4.30) | 0.004 |
| *1AAA, abdominal aortic aneurysm; Small AAA, male <5.5cm, female <5.0cm* |

**Supplemental Table 4.** Sensitivity Analyses among Patients < 75 Years Old and Excluding Outliers with High Complication Rates but Low Failure to Rescue Rates.

|  |  |  |
| --- | --- | --- |
|  | **EVAR**OR (95% CI) | **Open**OR (95% CI) |
| **Patients <75 years** |  |  |
| Q1 | Ref | Ref |
| Q2 | 0.68(0.32-1.44) | 0.70(0.45-1.09) |
| Q3 | 0.56(0.25-1.29) | 0.99(0.64-1.52) |
| Q4 | 0.62(0.29-1.35) | 0.16(0.05-0.52) |
| **Excluding outliers\*** |  |  |
| Q1 | NA | Ref |
| Q2 | NA | 0.61(0.45-0.82) |
| Q3 | NA | 0.70(0.51-0.95) |
| Q4 | NA | 0.20(0.10-0.40) |

\*Outlier defined as having at least 10 cases, ≥ 40% complication rate, but ≤ 10% FtR.

 No outliers were identified for EVAR.

**Supplemental Table 5.** Sensitivity analysis examining the impact of both center volume and the proportion of EVAR procedures for intact AAA repair on Failure to Rescue.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Volume Category** |  | **Percentage EVAR Category\*** |
|  | OR(95% CI) | P value |  | OR(95% CI) | P value |
| **EVAR Intact** |  |  |  |  |  |
| Q1 | Ref |  |  | Ref |  |
| Q2 | 0.67(0.41-1.08) | 0.1 |  | 0.86(0.39-1.87) | 0.70 |
| Q3 | 0.83(0.52-1.31) | 0.42 |  | 1.38(0.67-2.86) | 0.38 |
| Q4 | 0.50(0.31-0.81) | 0.005 |  | 1.38(0.67-2.87) | 0.38 |
| **Open Intact** |  |  |  |  |  |
| Q1 | Ref |  |  | Ref |  |
| Q2 | 0.69(0.50-0.95) | 0.02 |  | 1.03(0.71-1.50) | 0.86 |
| Q3 | 0.90(0.61-1.32) | 0.58 |  | 1.60(1.05-2.43) | 0.03 |
| Q4 | 0.26(0.13-0.55) | <0.001 |  | 1.16(0.68-2.00) | 0.58 |

\*Percentage of EVAR category signifies the proportion of all intact AAA repairs in a center performed with endovascular repair: Q1 [0%, 58%), Q2 [58%-77.6%), Q3 [77.6%-87.9%), Q4 [87.9%-100%].

**Supplemental Table 6.** Association between Type of Complication and Subsequent Risk of Failure to Rescue in Patients Experiencing only a Single Complication.

|  |  |  |
| --- | --- | --- |
|  | **EVAR** | **Open** |
|  | **Adjusted predicted risks of FtR** |
| Bleeding | 8% (4-16%) | 25% (15-38%) |
| Stroke | 4% (1-15%) | 5% (1-21%) |
| Cardiac | 2% (2-3%) | 8% (5-14%) |
| Renal | 11% (5-21%) | 8% (3-17%) |
| Respiratory | 11% (7-18%) | 12% (7-20%) |
| Bowel | 27% (14-45%) | 30% (17-46%) |