Systematic Review

# Spinal cord injury after open and endovascular repair of descending thoracic aneurysm and thoracoabdominal aortic aneurysm: an updated systematic review and meta-analysis

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**Background:** Spinal cord injury (SCI) is a rare but severe complication after open or endovascular repair of descending thoracic aneurysms (DTAs) or thoracoabdominal aortic aneurysms (TAAAs). This meta-analysis aims to provide a comprehensive assessment of SCI rates and factors associated with SCI.

**Methods:** A systematic literature search was performed in September 2022 looking for studies on open and/or endovascular repair of DTA and/or TAAA published after 2018, to update the results of our previously published meta-analysis. The primary outcome was permanent SCI. Secondary outcomes were temporary SCI, 30-day and in-hospital mortality, follow-up mortality, postoperative stroke, and cerebrospinal fluid (CSF) drain-related complications. Data were pooled as proportions using inverse-variance weighting.

**Results:** A total of 239 studies (71 new studies and 168 from our previous meta-analysis) and 61,962 patients were included. The overall pooled rate of permanent SCI was 3.3% [95% confidence interval (CI), 2.9–3.8%]. Open repair was associated with a permanent SCI rate of 4.0% (95% CI, 3.3–4.8%), and endovascular repair was associated with a permanent SCI rate of 2.9% (95% CI, 2.4–3.5%). Permanent SCI was 2.0% (95% CI, 1.2–3.3%) after DTA repair, and 4.7% (95% CI, 3.9–5.6%) after TAAA repair; permanent SCI rate was 3.8% (95% CI, 2.9–5.0%) for Crawford extent I, 13.4% (95% CI, 9.0–19.5%) for extent II, 7.1% (95% CI, 5.7–8.9%) for extent III, 2.3% (95% CI, 1.6–3.5%) for extent IV, and 6.7% (95% CI, 1.7–23.1%) for extent V TAAA aneurysms. The pooled rate of CSF drain related complications was 1.9% (95% CI, 0.8–4.7%) for severe, 0.4% (95% CI, 0.0–4.0%) for moderate, and 1.8% (95% CI, 0.6–5.6%) for minor complications.

**Conclusions:** Permanent SCI occurs after both endovascular and open DTA or TAAA repairs. Open repairs and TAAA repairs have higher risk of SCI compared with endovascular or DTA repairs. In particular, extent II aneurysms present the highest overall risk of SCI.

**Keywords:** Spinal cord injury (SCI); thoracoabdominal aortic aneurysm (TAAA); open; endovascular; cerebrospinal fluid drain

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## Introduction

Spinal cord injury (SCI) after descending thoracic aneurysm (DTA) or thoracoabdominal aortic aneurysm (TAAA) repair is a devastating complication of aortic surgery, and has been affecting the outcomes of open aortic repair since its introduction in the 1950's (1) and persisting despite the introduction of less invasive endovascular aortic repair techniques in the contemporary era (2). Despite advancements in the preoperative, intraoperative, and postoperative care of DTA/TAAA repairs, postoperative SCI remains a source of major morbidity. The origin of SCI is likely multifactorial, resulting from factors such as occlusion of intercostal and lumbar arteries by the aortic graft or endovascular stent, perioperative hypotension, or embolic events. Postoperative SCI can either be temporary or permanent. The incidence of SCI has been reported to be between 2% and 10% (3-5) after open or endovascular repair, although estimating the general incidence rate (IR) is challenging as most of the data are from retrospective, single-center observational studies with major limitations of sample size, disparate surgical techniques, complex patient anatomy and pathology, and preexisting comorbidities. In this meta-analysis, we provide a comprehensive systematic review and an update of a meta-analysis previously published by our group on SCI, mortality, and cerebrovascular events after open or endovascular repair of DTA/TAAA.

## Methods

### Search strategy

A medical librarian (MD) performed a comprehensive search to identify randomized trials and observational cohort studies of TAAA and DTA repair from July 2018 to September 2022. Searches were run on September 13, 2022, in the following databases: Ovid MEDLINE (ALL; July 1, 2018, to September 13, 2022); Ovid EMBASE (July 1, 2018 to September 13, 2022); and The Cochrane Library (Wiley; July 1, 2018 to September 13, 2022). The full search strategy for each database is available in Table S1.

### Study selection and data extraction

The search strategy retrieved 6,176 studies. Following de-duplication, three reviewers (TA, LH, KRA) independently screened a total of 4,100 titles and abstracts. Any discrepancies were resolved by the senior author (MG). Titles and abstracts were reviewed against the prespecified inclusion/exclusion criteria. Studies were included if they were written in English, if they were randomized trials or observational studies reporting outcomes of endovascular and/or open repair of TAAAs and/or DTAs, due to either a degenerative process or post-chronic dissection. Studies were excluded if they were animal studies, abstracts only, case reports, commentary, conference presentations, editorials, expert opinions, studies reporting repair of other aortic pathologies (acute dissection, traumatic aneurysms, aortic ruptures, aortic ulcers), studies reporting less than 10 patients, and studies not clearly defining the strategy used or using hybrid procedures. Only the largest national registry databases from (US, Japan, and Italy) were included. Two hundred fifty-two full text studies were evaluated to assess for eligibility. Reference lists for articles selected for inclusion in the study were also searched for relevant articles. The full Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (6) flow diagram outlining the study selection process is available in Figure S1.

All studies were reviewed by two independent investigators (TA, KRA), and disagreements were resolved by the senior author (MG). For studies with overlapping patient populations, the largest series were included. Seventy-one studies were included for data extraction. Three investigators (TA, LH, KRA) performed data extraction independently. The following variables were included: study data (institution, country, study period, number of patients, study design) (Table S2), patient demographics [age, sex, comorbidities (diabetes, hypertension, smoking, coronary artery disease, chronic renal failure, and chronic obstructive pulmonary disease)] (Tables S3,S4). Aneurysm characteristics and procedural details (previous aortic surgery, aortic dissection, acute dissection, cerebrospinal fluid (CSF) drain use, use of left heart bypass, selective renal perfusion, circulatory arrest, sequential cross-clamping, or clamp-and-sew technique, and mean cross-clamp time) were reported in (Tables S3,S4). The quality of the included studies was assessed using the Newcastle-Ottawa Scale (NOS) for observational studies and the Cochrane risk-of-bias (RoB 2) tool for randomized trials (Tables S5,S6).

### Outcomes

The primary outcome was the rate of permanent postoperative SCI. Secondary outcomes included temporary SCI, operative (30-day/in-hospital) mortality, follow-up mortality, postoperative stroke, and CSF drain-related complications using the individual studies' definitions. CSF drain-related complications were classified as severe (subdural hematoma, epidural hematoma, cerebellar hemorrhage, intracranial hemorrhage, subarachnoid hemorrhage, meningitis, and catheter/drainage-related neurologic deficit), moderate [spinal headache, CSF leak requiring intervention (i.e., blood patch or suturing), drain fracture requiring or not requiring surgical removal, cranial hypotension syndrome], or minor (puncture-site bleeding, bloody spinal fluid, CSF leak not requiring intervention, drain fracture left in place, and occluded/dislodged catheters, pale hemorrhagic discharge) based on a previous definition (7).

### Meta-analysis

Short-term binary outcomes were reported and pooled as proportions (%) with 95% confidence interval (CI) using the generic inverse-variance method. Events were extracted from the individual studies or calculated based on the proportion of patients with the corresponding outcome among all patients treated. For follow-up mortality, IR with Poisson model with a constant event rate was used to account for different length of follow-up among studies with the total number of events observed within a group, calculated out of the total person-time follow-up for that group based on each study's follow-up. Random effect meta-analysis was performed, and heterogeneity was considered low ($I^2$=0–25%), moderate ($I^2$=26–50%), or high ($I^2$>50%). Publication bias assessment was carried out using funnel plot and Egger's test (Figure S2). Leave one-out analysis for the primary outcome was performed as a sensitivity analysis. Subgroup analyses were performed for DTAs, TAAAs, open and endovascular repair, Crawford extent of TAAAs, studies reporting on patients operated after the year 2000, CSF drain use, and studies with the highest NOS scores (eight or nine stars). Meta-regression was used to explore the effects of study period, publication year, hospital volume, age, sex, patient variables [coronary artery disease, chronic renal failure, chronic obstructive pulmonary disease, acute/chronic dissection, aneurysm type (TAAA/DTA)], and operative variables (open *vs.* endovascular repair, use of clamp-and-sew technique, use of CSF drain, and use of circulatory arrest or left heart bypass) on the primary outcome. Statistical significance was set at the two-tailed 0.05 level, without multiplicity adjustments. All statistical analyses were performed using R (version 4.2.1) within R Studio using "metafor" and "meta" packages (*Table 1*).

## Results

### Study and patient characteristics

A total of 239 studies were included in the final analysis; 71 studies from the 252 studies that were retrieved for full-text review, and additional 168 studies were included from our group's previous meta-analysis (5), and one study (4) was excluded from the analysis due to overlapping patient population (Figure S1). The majority (84.1%) of the studies were retrospective (201/239), 15.5% (37/239) were prospective, and one was a randomized trial. Seventy-seven studies were conducted in the United States, 29 in China, 29 in Japan, 21 in Italy, 11 in the United Kingdom, and 5 multi-national studies (Table S2). The quality of the included studies according to the NOS and the ROB 2 tool are provided in Tables S5,S6. Overall, 61,962 patients were included in the final analysis, and the patient population of each individual study ranged from 10 to 14,235. The mean age range was 36 to 86 years, and the percentage of male patients ranged from 28.6% to 94.3%. Patient demographics of individual studies are reported in Table S3.

### Meta-analysis

#### *Primary outcome*

The overall pooled event rate of permanent SCI was 3.3% (95% CI, 2.9–3.8%). In subgroup analyses, the pooled rate of permanent SCI after open repair was 4.0% (95% CI, 3.3–4.8%), and 2.9% (95% CI, 2.4–3.5%) after endovascular repair (Figure S3). Permanent SCI rate was 2.0% (95% CI, 1.2–3.3%) for DTA repair and 4.7% (95% CI, 3.9–5.6%) for TAAA repair (Figure S4). For DTAs, open repair was associated with permanent SCI rate of 2.0% (95% CI, 1.0–4.3%), similar to the endovascular repair permanent SCI rate was 2.0% (95% CI, 1.1–3.8%) (Figure S5). TAAA repair was associated with a 5.6% SCI rate (95% CI, 4.4–7.2%) with the open technique and 3.9% (95% CI, 3.1–4.8%) with endovascular techniques (Figure S6). Pooled permanent SCI when stratified by aneurysm type (DTA and TAAA) showed no significant difference between open and endovascular repair (Figures S7,S8). In subgroup analysis based on TAAA Crawford extent, the pooled rate of permanent SCI was 3.8% (95% CI, 2.9–5.0%) for Crawford extent I, 13.4% (95% CI, 9.0–19.5%) for extent

 

**Table 1** Summery of outcomes

| Outcomes | Studies | Patient number | Effect estimate (%) (95% CI) | Heterogeneity ($I^2$) (%) | $P_{interaction}$ |
|---|---|---|---|---|---|
| Permanent spinal cord injury | 214 | 60,602 | 3.3 (2.9–3.8) | 81.1 | – |
| DTA | 22 | 2,714 | 2.0 (1.2–3.3) | 40.8 | 0.002 |
| TAAA | 107 | 37,202 | 4.7 (3.9–5.6) | 86.4 | |
| Open | 80 | 20,498 | 4.0 (3.3–4.8) | 83.0 | 0.02 |
| Endo | 134 | 40,104 | 2.9 (2.4–3.5) | 73.2 | |
| DTA open | 13 | 1,413 | 2.0 (1.0–4.3) | 43.0 | 0.01 |
| TAAA open | 53 | 11,270 | 5.6 (4.4–7.2) | 88.0 | |
| DTA endovascular | 9 | 1,301 | 2.0 (1.1–3.8) | 42.0 | 0.06 |
| TAAA endovascular | 54 | 25,932 | 3.9 (3.1–4.8) | 68.0 | |
| DTA open | 13 | 1,413 | 2.0 (1.0–4.3) | 43.0 | 0.98 |
| DTA endovascular | 9 | 1,301 | 2.0 (1.1–3.8) | 42.0 | |
| TAAA open | 53 | 11,270 | 5.6 (4.4–7.2) | 88.0 | 0.03 |
| TAAA endovascular | 54 | 25,932 | 3.9 (3.1–4.8) | 68.0 | |
| Extent I | 10 | 1,280 | 3.8 (2.9–5.0) | 0.0 | <0.001* |
| Endo | 2 | 21 | 15.2 (3.4–47.4) | 64.0 | 0.06 |
| Open | 8 | 1,259 | 3.7 (2.8–4.8) | 0.0 | |
| Extent II | 15 | 1,686 | 13.4 (9.0–19.5) | 70.6 | <0.001* |
| Endo | 4 | 79 | 21.5 (13.8–31.9) | 0.0 | 0.05 |
| Open | 11 | 1,607 | 11.8 (7.6–17.9) | 66.0 | |
| Extent III | 12 | 1,012 | 7.1 (5.7–8.9) | 0.0 | <0.001* |
| Endo | 3 | 93 | 5.4 (2.3–12.3) | 0.0 | 0.50 |
| Open | 9 | 919 | 7.3 (5.8–9.1) | 2.0 | |
| Extent IV | 12 | 1,031 | 2.3 (1.6–3.5) | 0.0 | <0.001* |
| Endo | 5 | 174 | 2.3 (0.9–6.0) | 0.0 | 0.98 |
| Open | 7 | 857 | 2.3 (1.5–3.6) | 0.0 | |
| Extent V | 3 | 30 | 6.7 (1.7–23.1) | 0.0 | <0.001* |
| Endo | – | – | – | – | – |
| Open | 3 | 30 | 6.7 (1.7–23.1) | 0.0 | – |
| CSF drain 100% patients | 24 | 3,577 | 3.5 (2.5–4.9) | 58.1 | 0.23 |
| CSF drain 0% patients | 8 | 362 | 1.5 (0.3–5.7) | 0.0 | |
| CSF drain ≥75% patients | 53 | 9,189 | 3.8 (3.0–4.9) | 82.9 | 0.62 |
| CSF drain <75% patients | 61 | 18,437 | 3.6 (3.0–4.3) | 68.3 | |
| CSF drain ≥50% patients | 76 | 12,748 | 3.9 (3.2–4.6) | 79.1 | 0.33 |
| CSF drain <50% patients | 38 | 14,878 | 3.3 (2.5–4.4) | 77.1 | |

**Table 1** (*continued*)

 

**Table 1** (*continued*)

| Outcomes | Studies | Patient number | Effect estimate (%) (95% CI) | Heterogeneity ($I^2$) (%) | $P_{interaction}$ |
|---|---|---|---|---|---|
| 30-day/in-hospital mortality | 210 | 65,067 | 4.8 (4.1–5.6) | 86.8 | – |
| Late mortality | 141 | – | 6.1 (5.3–7.1) | 93.0 | – |
| Stroke | 183 | 50,186 | 2.9 (2.3–3.6) | 82.6 | – |
| Temporary spinal cord injury | 114 | 22,597 | 3.1 (2.5–3.8) | 73.7 | – |
| Studies with highest NOS ratings | | | | | |
| Permanent spinal cord injury | 115 | 28,273 | 3.2 (2.7–3.9) | 78.1 | |
| Operative mortality | 111 | 21,339 | 4.6 (3.7–5.8) | 85.1 | |
| Late mortality | 90 | – | 6.7 (5.6–8.0) | 93.5 | |
| Stroke | 96 | 19,481 | 2.9 (2.0–3.9) | 84.9 | |

*, $P_{interaction}$ for Crawford extents. CI, confidence interval; DTA, descending thoracic aneurysm; TAAA, thoracoabdominal aortic aneurysm; CSF, cerebrospinal fluid; NOS, Newcastle-Ottawa Scale.

II, 7.1% (95% CI, 5.7–8.9%) for extent III, 2.3% (95% CI, 1.6–3.5%) for extent IV, and 6.7% (95% CI, 1.7–23.1%) for extent V (Figure S9A-S9E).

### *Secondary outcomes*

Temporary SCI was reported in 114 studies with a total of 22,597 patients, with the pooled rate at 3.1% (95% CI, 2.5–3.8%; Figure S10). The 30-day/in-hospital mortality was reported in 210 studies with 65,067 patients, with the pooled rate at 4.8% (95% CI, 4.1–5.6%; Figure S11). Follow-up mortality at a weighted median follow-up of 3.9 years was 6.1% (95% CI, 5.3–7.1%; Figure S12). The pooled rate of postoperative stroke from 183 studies and 50,186 patients was 2.9% (95% CI, 2.3–3.6%; Figure S13) (*Table 1*: summary of outcomes). CSF drain-related complications were reported in 13 studies (*Table 2*), with a total of 986 patients undergoing CSF drain placement. The pooled rate of severe complications was 1.95% (95% CI, 0.75–4.67%), moderate complications was 0.38% (95% CI, 0.03–3.97%), and minor complications was 1.81% (95% CI, 0.57–5.56%; Figure S14; Table S7). The pooled permanent SCI rate in the studies that reported CSF drain in ≥50% of the patient when compared to the studies that reported ≤50% of patients was not different, at 3.9% (95% CI, 3.2–4.6%) *vs.* 3.3% (95% CI, 2.5–4.4%, P=0.33; Figures S15-S17). Leave one-out analysis for the primary outcome was performed as a sensitivity analysis (Figure S18). We also noticed that there are no changes in permanent SCI over the last five years (Figure S19).

### Meta-regression

Meta-regression showed an association between DTA repair, endovascular repair, and clamp and saw technique with lower rate of permanent SCI (beta =−0.009, P=0.05), (beta =−0.336, P=0.02), (beta =−0.020, P=0.04), respectively (*Table 3*).

## Discussion

This study is an updated meta-analysis of one previously conducted by our group (5), which includes all relevant studies published from July 1, 2018 to September 13, 2022. The final analysis consists of a total of 239 studies and 61,962 patients. The overall pooled rate of permanent SCI after TAAA or DTA repair was 3.3% including both endovascular and open surgeries, with the permanent SCI rate being numerically higher after open repair compared with endovascular repair. Furthermore, the rate of SCI was found to be numerically higher after TAAA repair (4.7%, 95% CI, 3.9–5.6%) than DTA repair (2.0%, 95% CI, 1.2–3.3%; P=0.002). Of note, the highest rate of permanent SCI was observed in patients who underwent Crawford extent II repair, with a rate of 13.4% (95% CI, 9.0–19.5%).

Due to the anatomical and pathological complexity of the disease, in addition to the complicated patient population and surgical procedures, the current literature has reported varying IRs of SCI. Our data compares similarly to large contemporary national registry studies

 

**Table 2** Complications related to cerebrospinal fluid drain use

| Study* | No. of patients with drain | Severe complications | | | | | | | | | Moderate complications | | | | Minor complications | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Subdural hematoma | Subarachnoid bleeding | Epidural hematoma | Cerebellar hemorrhage | Intracranial bleeding | Meningitis | Para-lumbar infection | Intraspinal hematoma and subsequent paraplegia | Neurological symptom of bilateral thighs | Spinal headache | Persistent CSF leak | Fractured catheter | Cranial hypotension syndrome | Bleeding at spinal puncture side | Pale hemorrhagic discharge | Minor | Moderate | Severe |
| Abdelbaky 2021 | 100 | 2 | NR | NR | NR | NR | NR | NR | NR | NR | 5 | 7 | NR | NR | NR | 3 | 8 | 7 | 2 |
| Andersen 2014 | 9 | 1 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | 0 | 0 | 1 |
| Bisdas 2015 | 64 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | 4 | NR | NR | 4 | 0 | 0 |
| Dias 2015 | 64 | 2 | 3 | 1 | NR | NR | 2 | 1 | NR | NR | NR | NR | NR | NR | NR | NR | 0 | 0 | 9 |
| Ferreira 2008 | 11 | NR | NR | NR | NR | NR | NR | 1 | NR | NR | NR | NR | NR | NR | NR | NR | 0 | 0 | 1 |
| Hicks 2017 | 137 | NR | NR | NR | NR | NR | NR | NR | NR | NR | 4 | NR | NR | NR | NR | NR | 4 | 0 | 0 |
| Hiraoka 2018 | 55 | NR | NR | NR | NR | NR | NR | NR | 1 | NR | NR | NR | NR | NR | NR | NR | 0 | 0 | 1 |
| Katsargyris 2015 | 144 | 2 | NR | NR | NR | NR | NR | NR | NR | NR | 1 | NR | NR | NR | 2 | NR | 2 | 1 | 2 |
| Kitpanit 2021 | 78 | NR | 2 | NR | 1 | NR | NR | NR | NR | NR | 2 | NR | 1 | NR | 7 | NR | 20 | 0 | 6 |
| Marcondes 2023 | 22 | NR | NR | NR | NR | 1 | 1 | NR | NR | NR | NR | NR | NR | NR | NR | NR | 1 | 0 | 0 |
| Sugiura 2017 | 78 | 1 | NR | NR | NR | NR | 1 | NR | NR | 1 | 13 | NR | 1 | NR | NR | 3 | 3 | 14 | 3 |
| Van Calster 2019 | 197 | NR | NR | NR | NR | NR | NR | NR | NR | NR | 8 | NR | NR | NR | NR | NR | 0 | 8 | 0 |
| Yunoki 2015 | 27 | 1 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | 0 | 0 | 1 |

*, see Supplementary references. CSF, cerebrospinal fluid; NR, not reported.

 

**Table 3** Univariable meta-regression for permanent spinal cord injury

| Variable | Regression coefficient (beta) ± SD | P value |
|---|---|---|
| Study period | 0.002±0.011 | 0.86 |
| Publication year | 0.011±0.017 | 0.54 |
| Hospital volume | −0.0001±0.0004 | 0.74 |
| Age | 0.014±0.008 | 0.08 |
| Male gender | −0.003±0.005 | 0.56 |
| Coronary artery disease | 0.004±0.005 | 0.412 |
| Diabetes | 0.008±0.010 | 0.45 |
| Chronic renal failure | 0.008±0.005 | 0.10 |
| Chronic obstructive pulmonary disease | −0.002±0.001 | 0.11 |
| Acute dissection | −0.004±0.003 | 0.16 |
| Chronic/subacute dissection | 0.008±0.004 | 0.10 |
| DTA repair percent | −0.009±0.005 | 0.05* |
| Endovascular repair (*vs.* open) | −0.336±0.138 | 0.02* |
| Clamp-and-sew technique | −0.020±0.010 | 0.04* |
| Circulatory arrest | −0.002±0.006 | 0.75 |
| Left heart bypass | 0.007±0.004 | 0.13 |
| Cerebrospinal fluid drain use | 0.004±0.003 | 0.12 |

*, significant results. SD, standard deviation; DTA, descending thoracic aneurysm.

reporting on SCI injury after both open and endovascular procedures. Hoshina *et al.* (8), using data from the Japanese Committee for Stentgraft Management's national registry, reported a 3.7% paraplegia rate in 13,235 patients after endovascular repair of TAAA; similarly Scali *et al.* (9) using the Vascular Quality Initiative (VQI) database, reported a 2.1% permanent SCI after 6,529 thoracic endovascular aortic aneurysm repairs. In a population-based study using propensity-score matching including 664 patients, Rocha *et al.* (10) reported similar permanent paraplegia rates in patients with open *vs.* endovascular TAAA repair (4.1% *vs.* 4.6%; P>0.99). In the largest observational study of open TAAA repair comprising of 3,309 patients, including 1,066 patients with extent II repair, Coselli *et al.* (3) reported an SCI rate of 9.6%, whereas Gambardella *et al.* (11) and Girardi *et al.* (4) reported an SCI rate of 2.9% and 2.6%, respectively, after open DTA/TAAA repair. Rocha *et al.* (12) in a meta-analysis of eight comparative observational studies reported lower SCI after endovascular TAAA repair compared to open repair [relative risk (RR), 0.65; 95% CI, 0.42–1.01; P=0.05; $I^2$=28%]. In a more recent meta-analysis including 71 studies, 24 endovascular repairs and 47 open repairs of TAAA, Rocha *et al.* (13) reported higher SCI rates after endovascular repair 13.5% (95% CI, 10.5–16.7%) *vs.* open repair 7.4% (95% CI, 6.2–8.7%; P<0.01). In our group's previous meta-analysis including 169 studies and 22,634 patients, we reported a pooled overall permanent SCI rate of 4.5%, 3.5% for DTA and 7.6% for TAAA, 5.7% for open repairs and 3.9% for endovascular repairs. A pooled meta-analysis of 43 studies and 7,168 patients by Dijkstra *et al.* (14) reported a permanent SCI of 2.2% after endovascular repair of DTA and TAAA. In another meta-analysis of 46 studies and 4,936 patients, Wong *et al.* (15) reported an overall SCI rate of 3.9% in patients who underwent endovascular TAAA repair. A pooled SCI rate of 8.3% after open TAAA repair was reported in a meta-analysis of 30 articles and a total of 9,963 patients by Moulakakis *et al.* (16).

The decision to use a CSF drain in DTA/TAAA repairs is based on individual patient factors, such as prior aortic surgery, aneurysm size, stent or graft length, hypogastric artery patency, as well as reimplantation and occlusion of intercostal and lumbar vessels. While CSF drain use is common, there is limited evidence to support its effectiveness in preventing SCI (17). Coselli *et al.* (18) in a randomized clinical trial of 145 patients who underwent extent I or II TAAA open repair, found that prophylactic CSF drainage was associated with a significantly lower SCI rate when compared with no prophylactic CSF drainage (2.6% *vs.* 13%, P=0.03). Similarly, Cinà *et al.* (19) in a meta-analysis of three randomized trials and 11 cohort studies reporting effectiveness of CSF drainage after thoracic aneurysm and TAAA open repairs, found that patients with CSF drain have a pooled odds ratio of 0.35 (95% CI, 0.12–0.99; P=0.05) for paraplegia development. However, Wong *et al.* (15) in a meta-analysis of the effect of preoperative CSF drainage in patients who underwent thoracic endovascular aneurysm repair, including 46 studies and 4,936 patients, reported SCI rate of 3.2% in patients with routine prophylactic CSF drain placement and 3.5% in patients with no CSF drain placement. Gaudino *et al.* (5) in our group's previous meta-analysis reported nonsignificant difference in SCI rate in studies reporting greater use of CSF drain compared to studies with lower use of CSF drain (4.8% *vs.* 5.5%, P=0.58). In this study, CSF drain use was reported in 13 studies and a total of 986 patients had a CSF drain placed; permanent SCI in the studies that reported CSF drain use in ≥50% of the patients was not significantly different when compared with the SCI rate in studies reporting drain use in ≤50% of patients [3.9% (95% CI, 3.2–4.6%) *vs.* 3.3% (95% CI, 2.5–4.4%); P=0.33]. This noted difference in the effectiveness of CSF drain might be explained by differences in the surgical approach, as Coselli *et al.* (18) and Cinà *et al.* (19) included only open procedures, while Wong *et al.* (15) and Gaudino *et al.* (5) included both open and endovascular repair in their meta-analyses. As open repairs are more invasive, more physiologically stressful, and are associated with greater blood loss and greater risk for intraoperative hypotension, the benefit of prophylactic CSF drainage may be more pronounced in patients undergoing open repair compared with endovascular repair.

In this analysis, we also reported the pooled rate of severe, moderate, and minor CSF drain complications as 1.95%, 0.38%, and 1.81%, respectively, which is lower than our group's previously published meta-analysis (5) that reported 5.0% for severe, 4.0% for moderate, and 4.0% for minor complications. In another recent meta-analysis, Rong *et al.* (7) reported the pooled CSF drain-related complications were 2.5%, 3.7%, and 2.0%, respectively. These lower rates of complications in this study might be due to the low number of studies that reported the complications, with fewer reported events which can be potentially due to underreporting.

### Limitations

Although this is a comprehensive summary of current evidence on the incidence of SCI after DTA/TAAA repairs, it is important to interpret our analysis with caution due to methodological limitations intrinsic to pooled analyses of single-armed observational studies, and from the use of aggregated data, such as the ecological fallacy for meta-regression results (20). Moreover, the heterogeneity of the patient population, pathological and anatomical disease characteristics, presence of genetic connective tissues disorders, previous aortic surgical interventions, differences in surgical techniques, use of different types of endovascular grafts (fenestrated, branched, physician modified), variability in operators' volume and experience, and differences in perioperative and postoperative care protocols, all could impact surgical decision-making and outcomes. Even though our analysis showed low-to-moderate levels of heterogeneity among the included studies, not all primary and secondary outcomes were reported in all studies, which might have influenced the power of the subgroup analysis and the results of meta-regression.

## Conclusions

After analyzing 239 current studies and a total of 61,962 patients, we found that open repairs and TAAA repairs appear to be at higher risk of SCI compared with endovascular or DTA repairs. Notably, extent II aneurysms present the highest overall risk of SCI. Given the complexity of the disease and the surgical methods involved, as well as the scarcity of randomized controlled trials, more advanced and meticulous prospective data gathering, or ideally randomized controlled trials, should be undertaken to shed light on some of the unresolved issues.

## Acknowledgments

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## Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.



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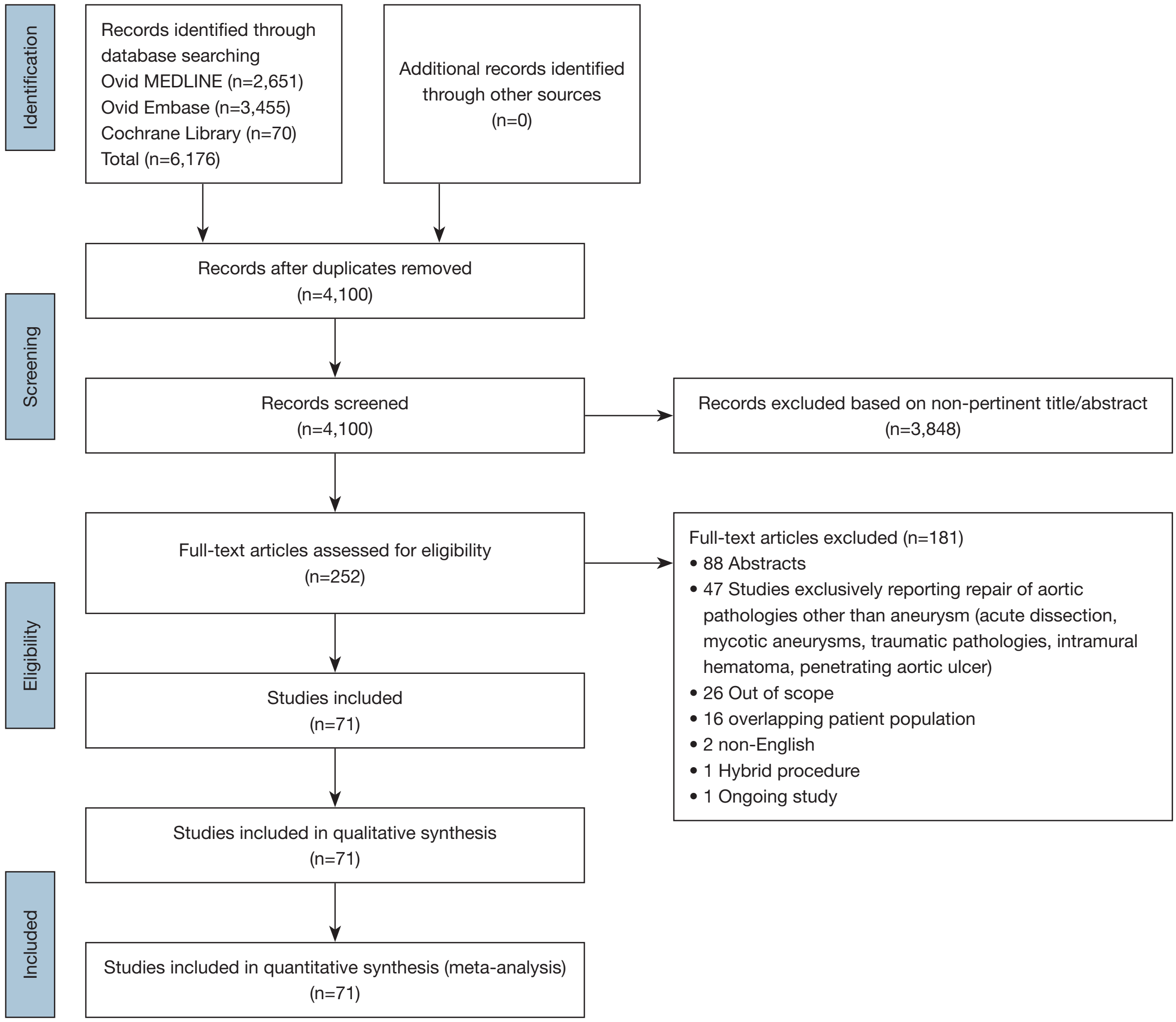


**Figure S1** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart of our analysis.

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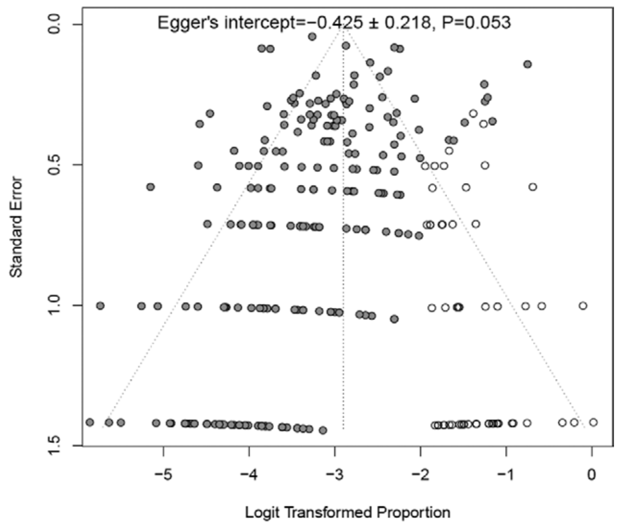
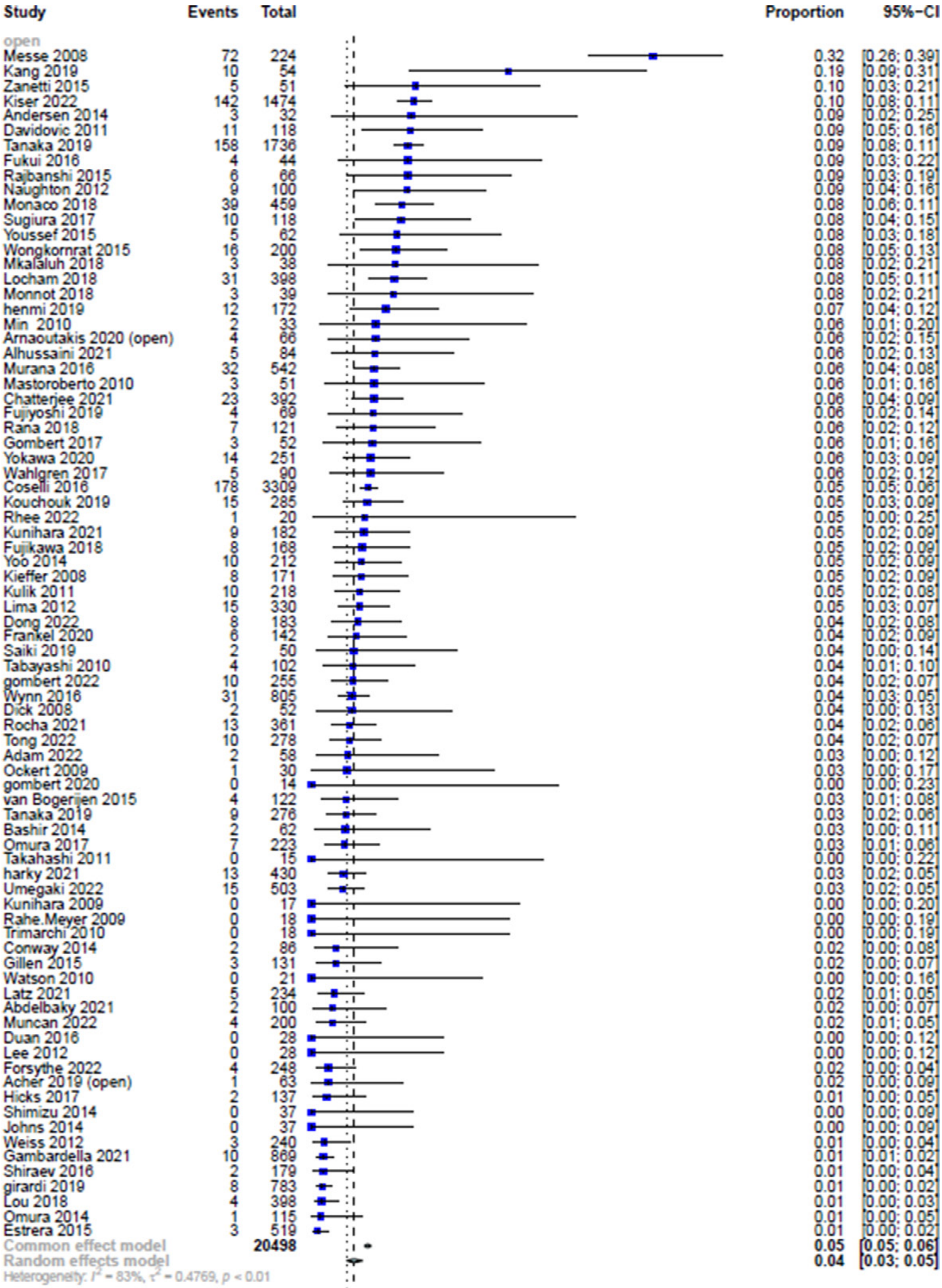
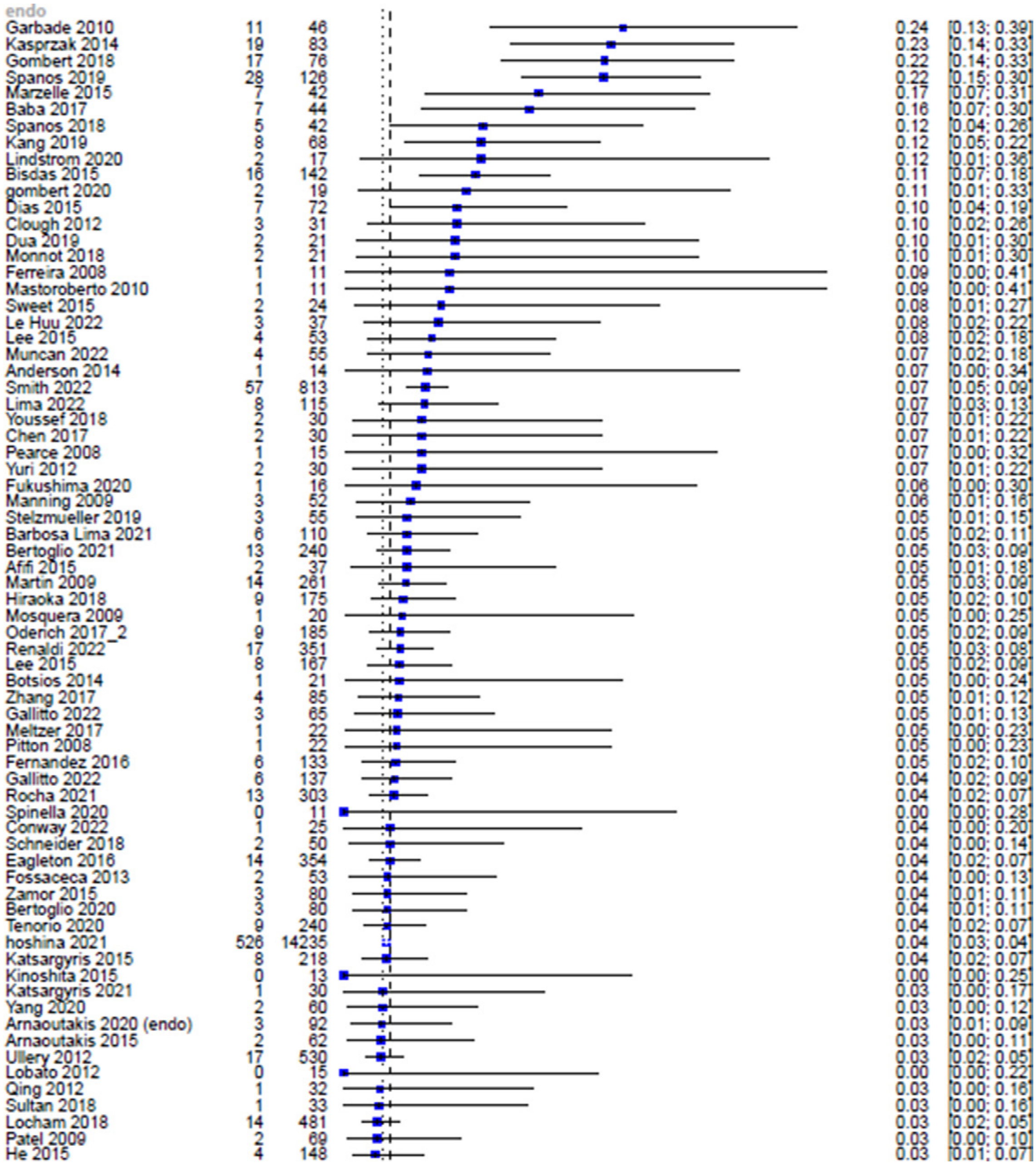



**Figure S2** Funnel plot for studies reporting the primary outcome. The gray circles represent each included study (logit transformed proportion, standard error), while the white circles represent the visual assessment of asymmetry using Trim and fill method in addition to statistical assessment using Egger's test.



Study Events Total Proportion 95%-CI
open
Messe 2008 72 224 0.32 [0.26; 0.39]
Kang 2019 10 54 0.19 [0.09; 0.31]
Zanetti 2015 5 51 0.10 [0.03; 0.21]
Kiser 2022 142 1474 0.10 [0.08; 0.11]
Andersen 2014 3 32 0.09 [0.02; 0.25]
Davidovic 2011 11 118 0.09 [0.05; 0.16]
Tanaka 2019 158 1736 0.09 [0.08; 0.11]
Fukui 2016 4 44 0.09 [0.03; 0.22]
Rajbanshi 2015 6 66 0.09 [0.03; 0.19]
Naughton 2012 9 100 0.09 [0.04; 0.16]
Monaco 2018 39 459 0.08 [0.06; 0.11]
Sugiura 2017 10 118 0.08 [0.04; 0.15]
Youssef 2015 5 62 0.08 [0.03; 0.18]
Wongkornrat 2015 16 200 0.08 [0.05; 0.13]
Mkalaluh 2018 3 38 0.08 [0.02; 0.21]
Locham 2018 31 398 0.08 [0.05; 0.11]
Monnot 2018 3 39 0.08 [0.02; 0.21]
henmi 2019 12 172 0.07 [0.04; 0.12]
Min 2010 2 33 0.06 [0.01; 0.20]
Arnaoutakis 2020 (open) 4 66 0.06 [0.02; 0.15]
Alhussaini 2021 5 84 0.06 [0.02; 0.13]
Murana 2016 32 542 0.06 [0.04; 0.08]
Mastoroberto 2010 3 51 0.06 [0.01; 0.16]
Chatterjee 2021 23 392 0.06 [0.04; 0.09]
Fujiyoshi 2019 4 69 0.06 [0.02; 0.14]
Rana 2018 7 121 0.06 [0.02; 0.12]
Gombert 2017 3 52 0.06 [0.01; 0.16]
Yokawa 2020 14 251 0.06 [0.03; 0.09]
Wahlgren 2017 5 90 0.06 [0.02; 0.12]
Coselli 2016 178 3309 0.05 [0.05; 0.06]
Kouchouk 2019 15 285 0.05 [0.03; 0.09]
Rhee 2022 1 20 0.05 [0.00; 0.25]
Kunihara 2021 9 182 0.05 [0.02; 0.09]
Fujikawa 2018 8 168 0.05 [0.02; 0.09]
Yoo 2014 10 212 0.05 [0.02; 0.09]
Kieffer 2008 8 171 0.05 [0.02; 0.09]
Kulik 2011 10 218 0.05 [0.02; 0.08]
Lima 2012 15 330 0.05 [0.03; 0.07]
Dong 2022 8 183 0.04 [0.02; 0.08]
Frankel 2020 6 142 0.04 [0.02; 0.09]
Saiki 2019 2 50 0.04 [0.00; 0.14]
Tabayashi 2010 4 102 0.04 [0.01; 0.10]
gombert 2022 10 255 0.04 [0.02; 0.07]
Wynn 2016 31 805 0.04 [0.03; 0.05]
Dick 2008 2 52 0.04 [0.00; 0.13]
Rocha 2021 13 361 0.04 [0.02; 0.06]
Tong 2022 10 278 0.04 [0.02; 0.07]
Adam 2022 2 58 0.03 [0.00; 0.12]
Ockert 2009 1 30 0.03 [0.00; 0.17]
gombert 2020 0 14 0.00 [0.00; 0.23]
van Bogerijen 2015 4 122 0.03 [0.01; 0.08]
Tanaka 2019 9 276 0.03 [0.02; 0.06]
Bashir 2014 2 62 0.03 [0.00; 0.11]
Omura 2017 7 223 0.03 [0.01; 0.06]
Takahashi 2011 0 15 0.00 [0.00; 0.22]
harky 2021 13 430 0.03 [0.02; 0.05]
Umegaki 2022 15 503 0.03 [0.02; 0.05]
Kunihara 2009 0 17 0.00 [0.00; 0.20]
Rahe.Meyer 2009 0 18 0.00 [0.00; 0.19]
Trimarchi 2010 0 18 0.00 [0.00; 0.19]
Conway 2014 2 86 0.02 [0.00; 0.08]
Gillen 2015 3 131 0.02 [0.00; 0.07]
Watson 2010 0 21 0.00 [0.00; 0.16]
Latz 2021 5 234 0.02 [0.01; 0.05]
Abdelbaky 2021 2 100 0.02 [0.00; 0.07]
Muncan 2022 4 200 0.02 [0.01; 0.05]
Duan 2016 0 28 0.00 [0.00; 0.12]
Lee 2012 0 28 0.00 [0.00; 0.12]
Forsythe 2022 4 248 0.02 [0.00; 0.04]
Acher 2019 (open) 1 63 0.02 [0.00; 0.09]
Hicks 2017 2 137 0.01 [0.00; 0.05]
Shimizu 2014 0 37 0.00 [0.00; 0.09]
Johns 2014 0 37 0.00 [0.00; 0.09]
Weiss 2012 3 240 0.01 [0.00; 0.04]
Gambardella 2021 10 869 0.01 [0.01; 0.02]
Shiraev 2016 2 179 0.01 [0.00; 0.04]
girardi 2019 8 783 0.01 [0.00; 0.02]
Lou 2018 4 398 0.01 [0.00; 0.03]
Omura 2014 1 115 0.01 [0.00; 0.05]
Estrera 2015 3 519 0.01 [0.00; 0.02]
Common effect model 20498 0.05 [0.05; 0.06]
Random effects model 0.04 [0.03; 0.05]
Heterogeneity: I^2 = 83%, τ^2 = 0.4769, p < 0.01





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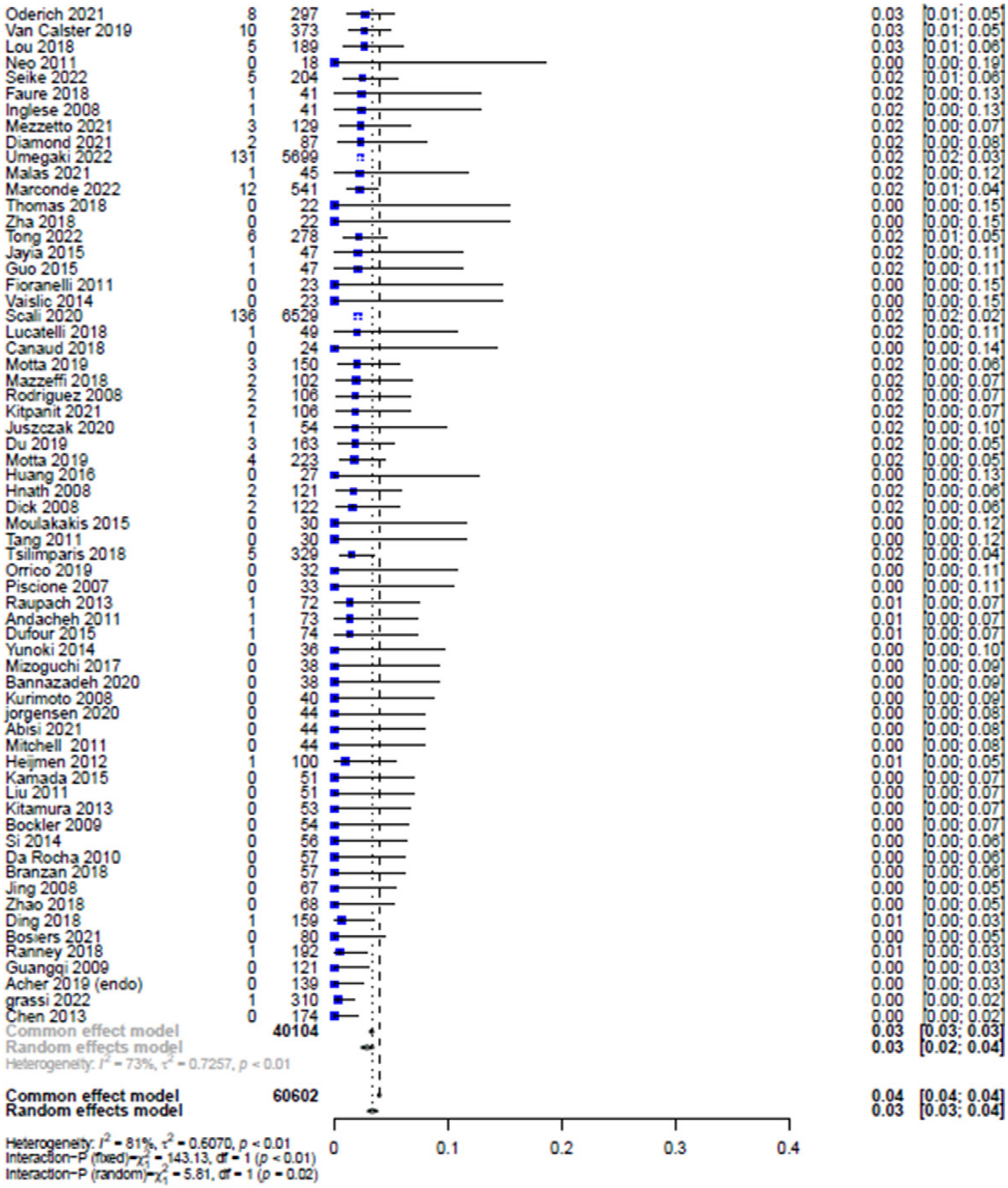

**Figure S3** Sub-group analysis of permanent spinal cord injury after open *vs.* endovascular aneurysm repair. CI, confidence interval.

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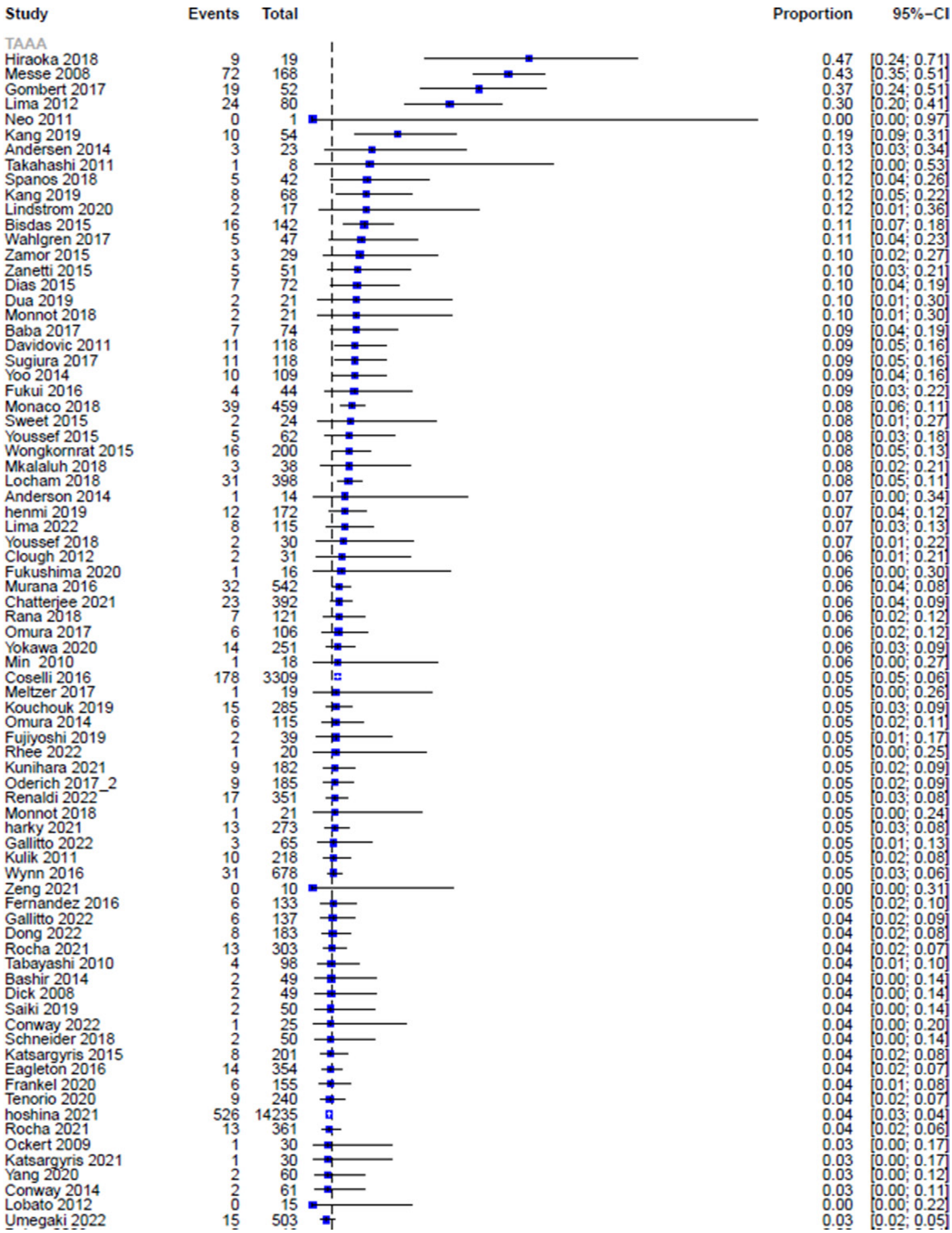


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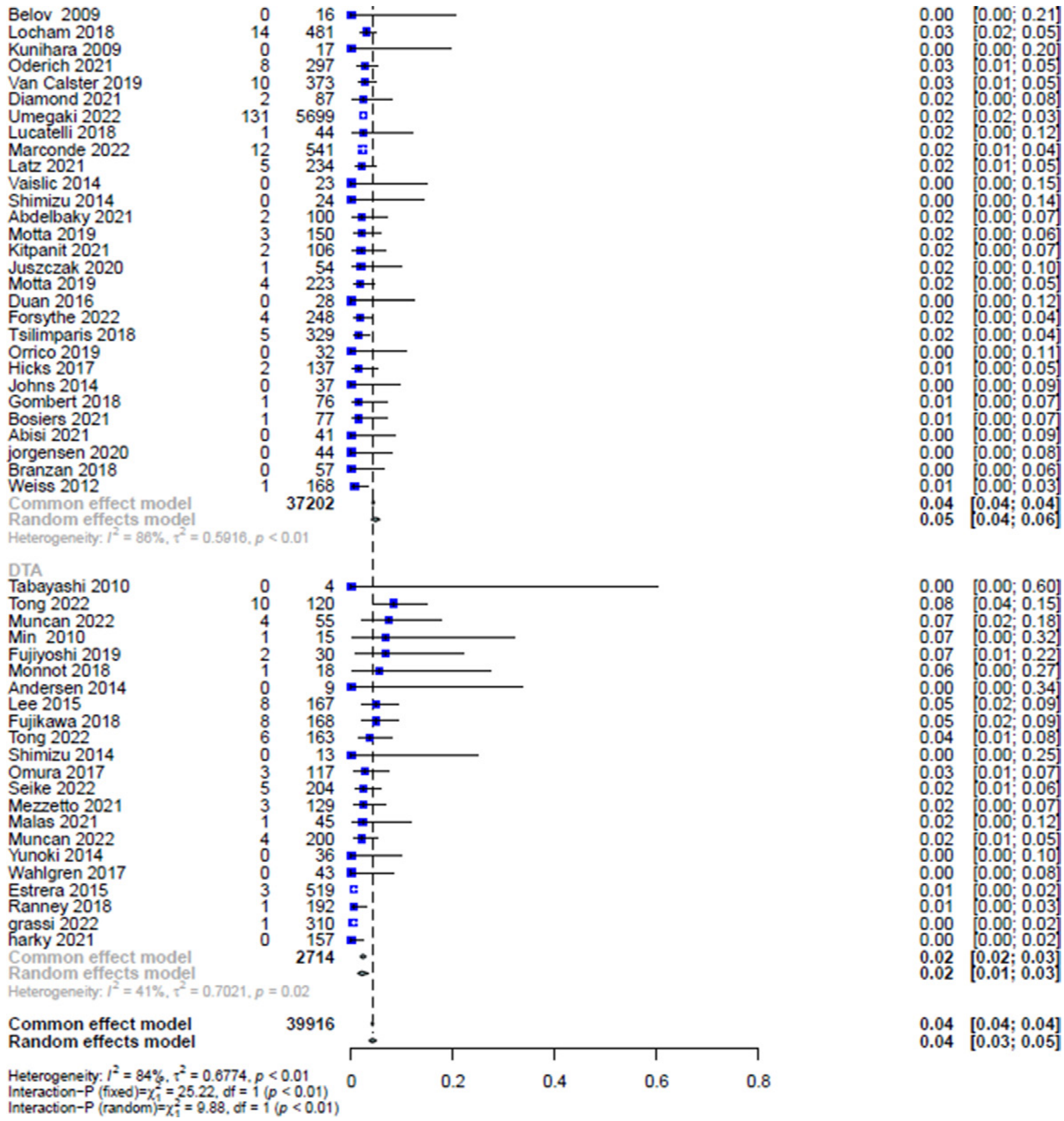


**Figure S4** Sub-group analysis of permanent spinal cord injury after repair of TAAA *vs.* DTA. CI, confidence interval; TAAA, thoracoabdominal aortic aneurysm; DTA, descending thoracic aneurysm.

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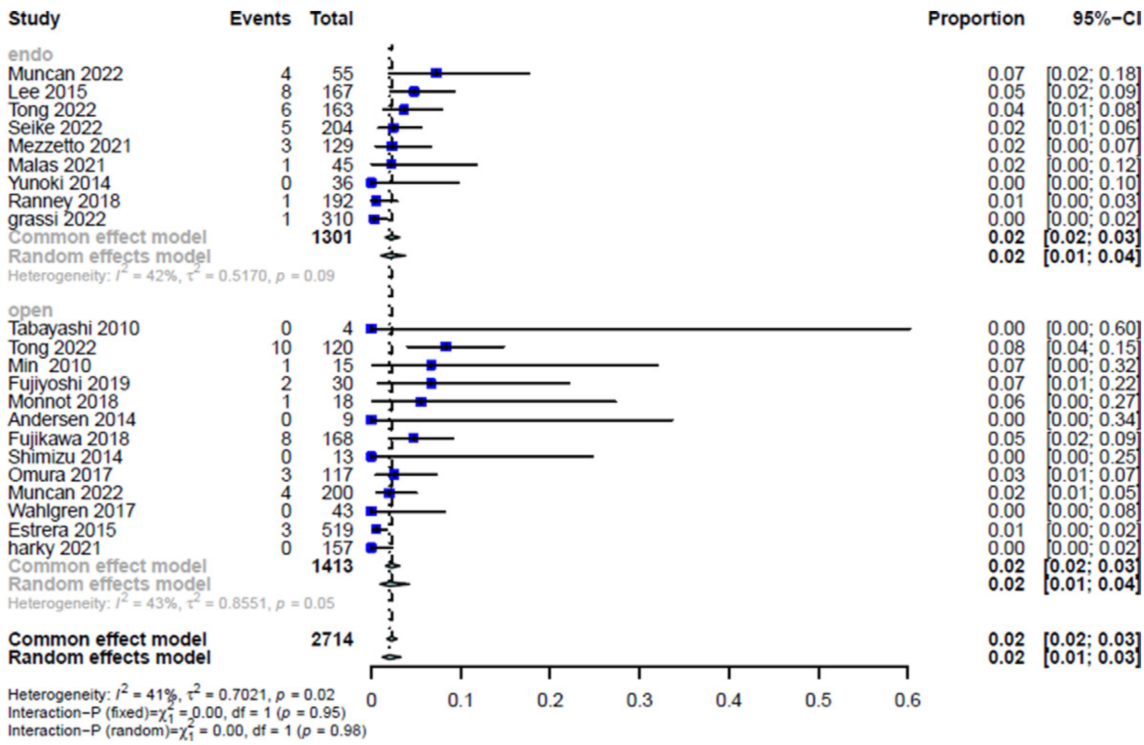


**Figure S5** Sub-group analysis of permanent spinal cord injury for endovascular *vs.* open repair of descending thoracic aneurysms. CI, confidence interval.


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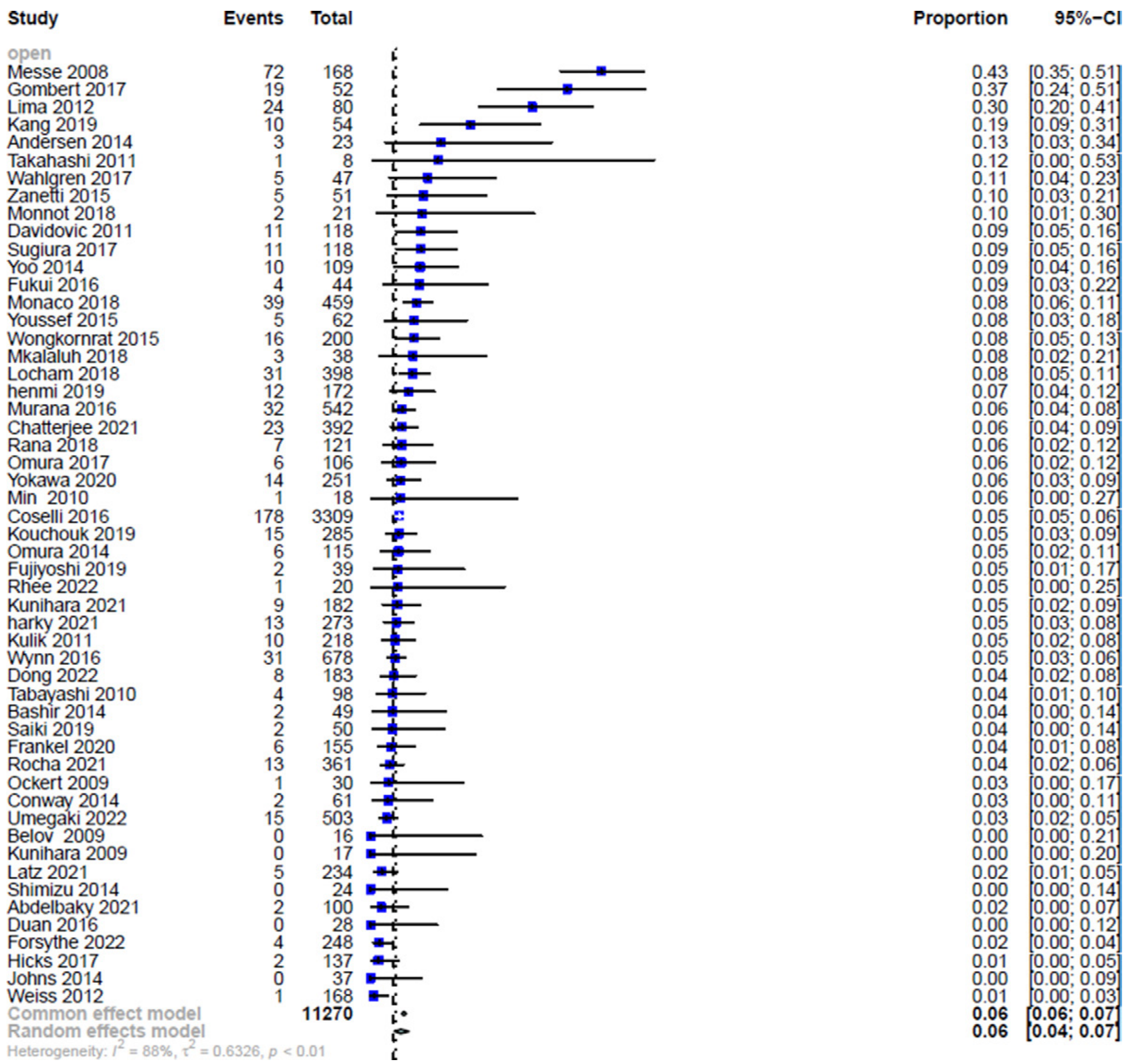


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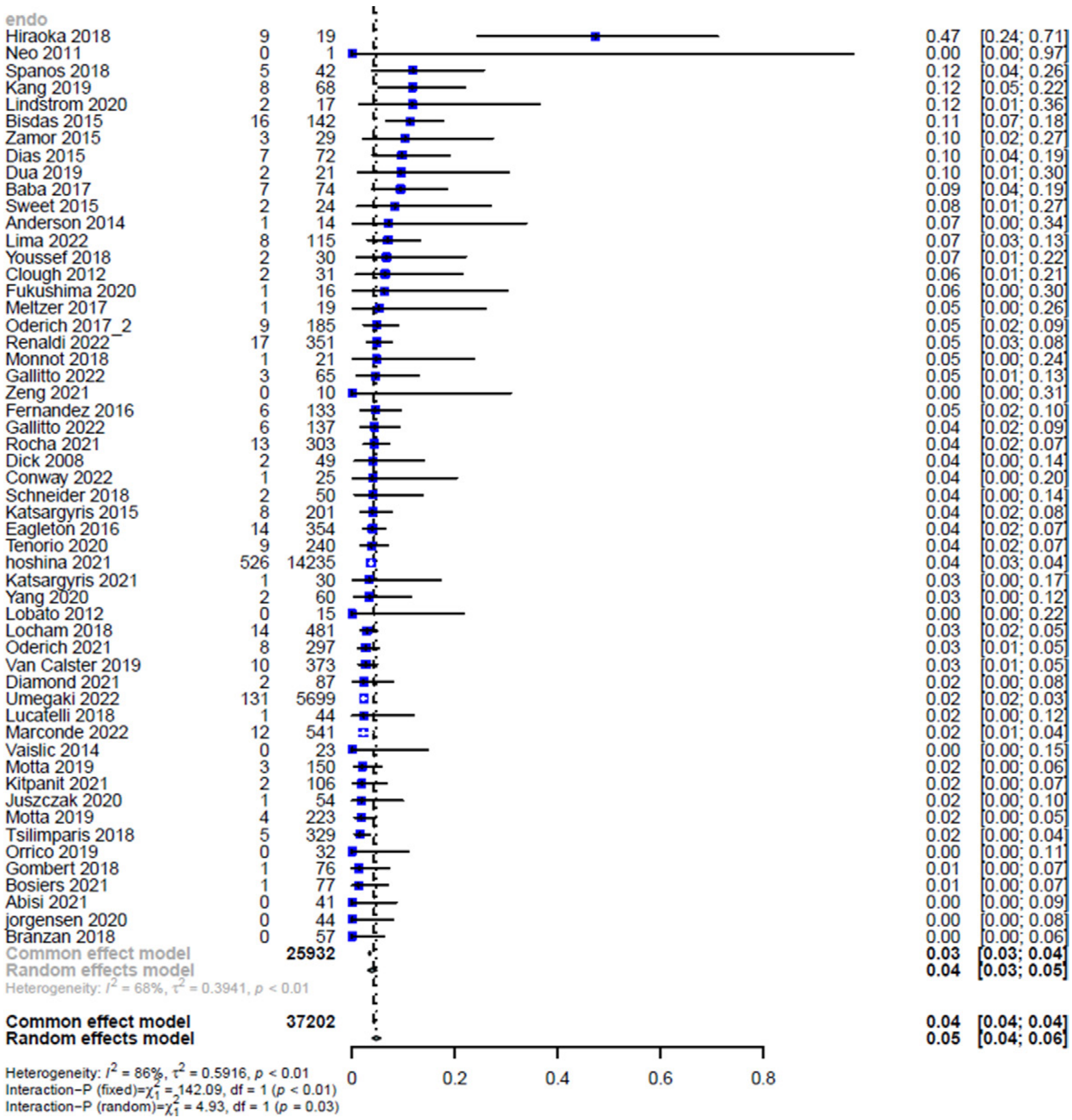


**Figure S6** Sub-group analysis of permanent spinal cord injury for open *vs.* endovascular repair of thoracoabdominal aortic aneurysms. CI, confidence interval.

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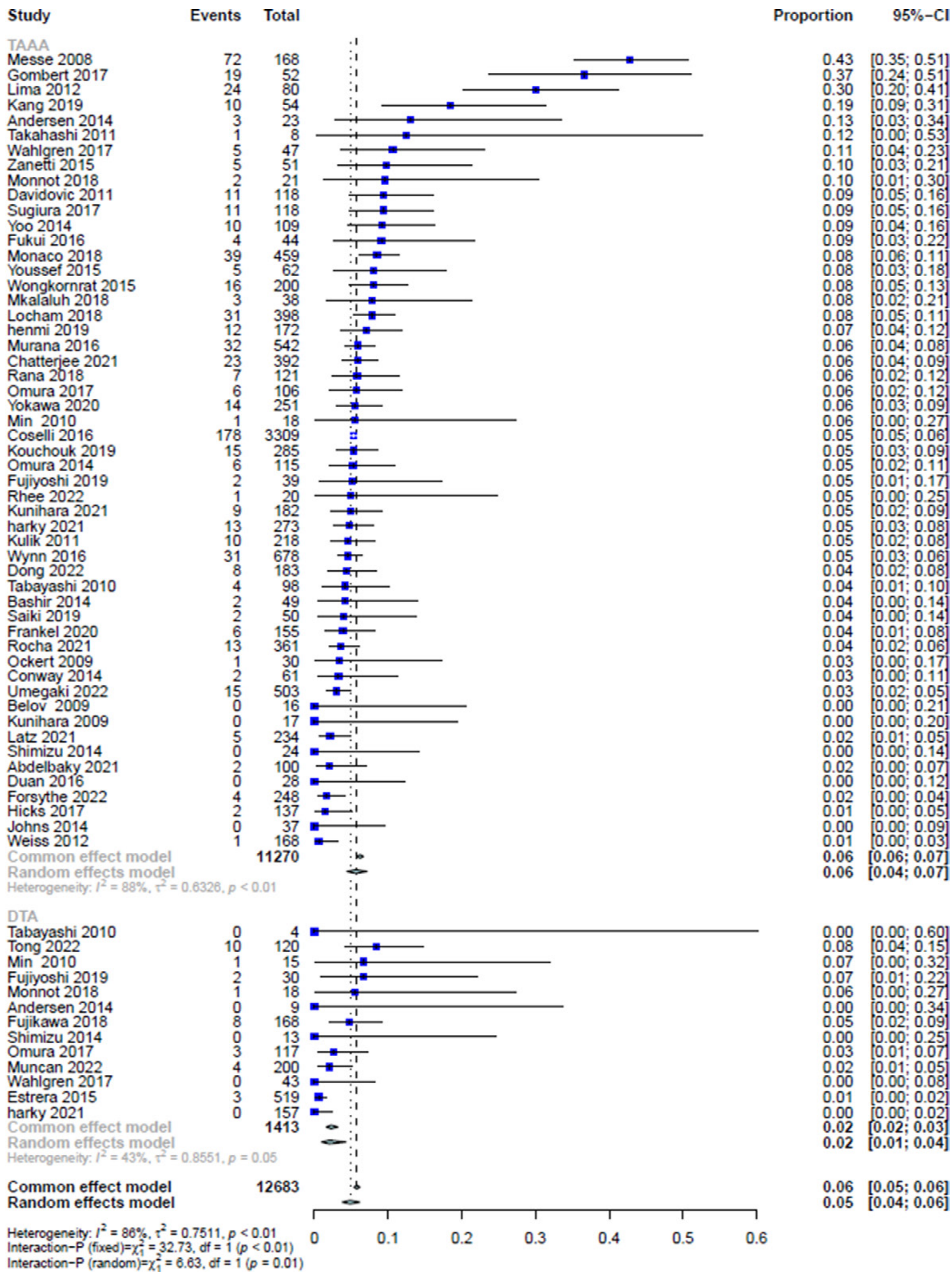


**Figure S7** Sub-group analysis of permanent spinal cord injury after open repair of TAAA *vs.* DTA. CI, confidence interval; TAAA, thoracoabdominal aortic aneurysm; DTA, descending thoracic aneurysm.

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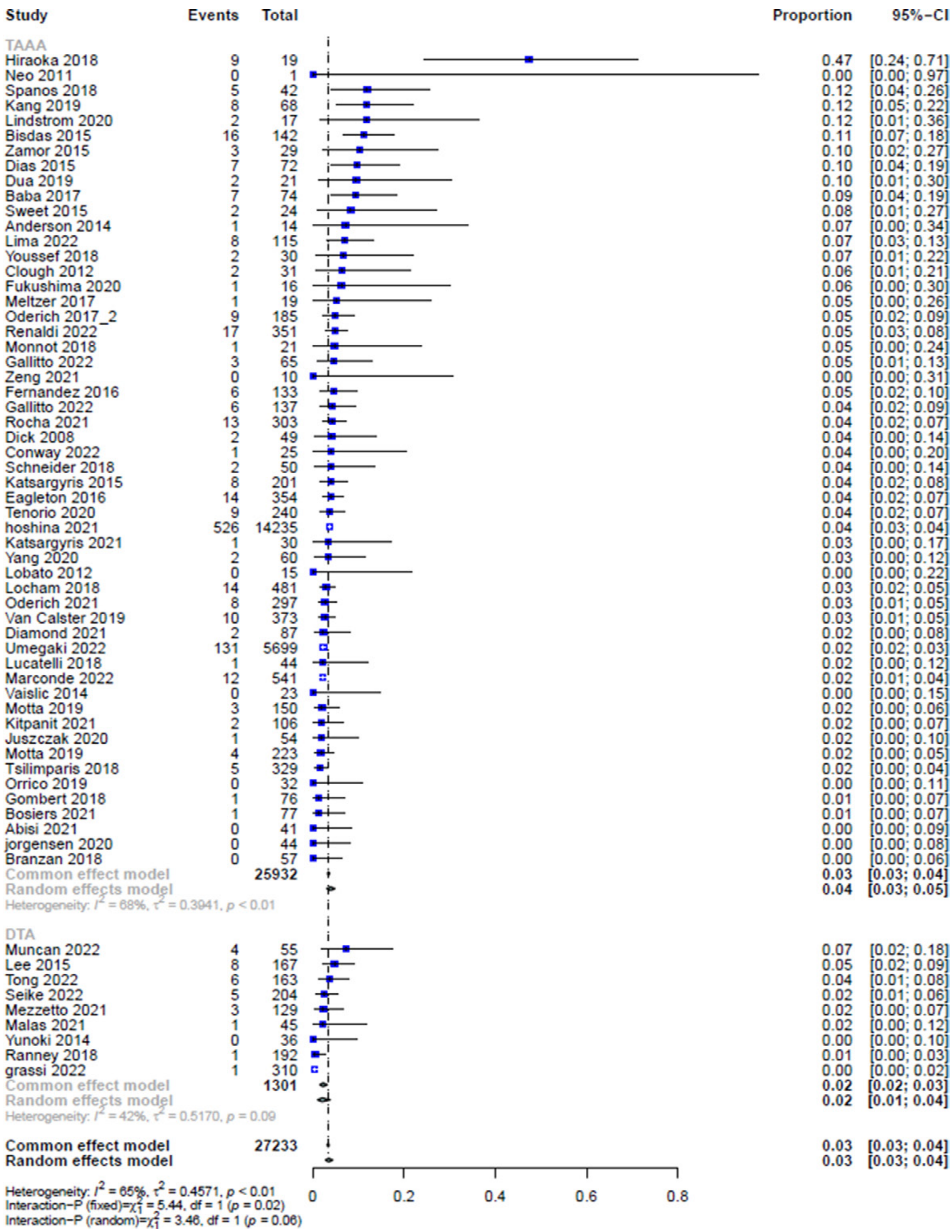


**Figure S8** Sub-group analysis of permanent spinal cord injury after endovascular repair of TAAA *vs.* DTA. CI, confidence interval; TAAA, thoracoabdominal aortic aneurysm; DTA, descending thoracic aneurysm.

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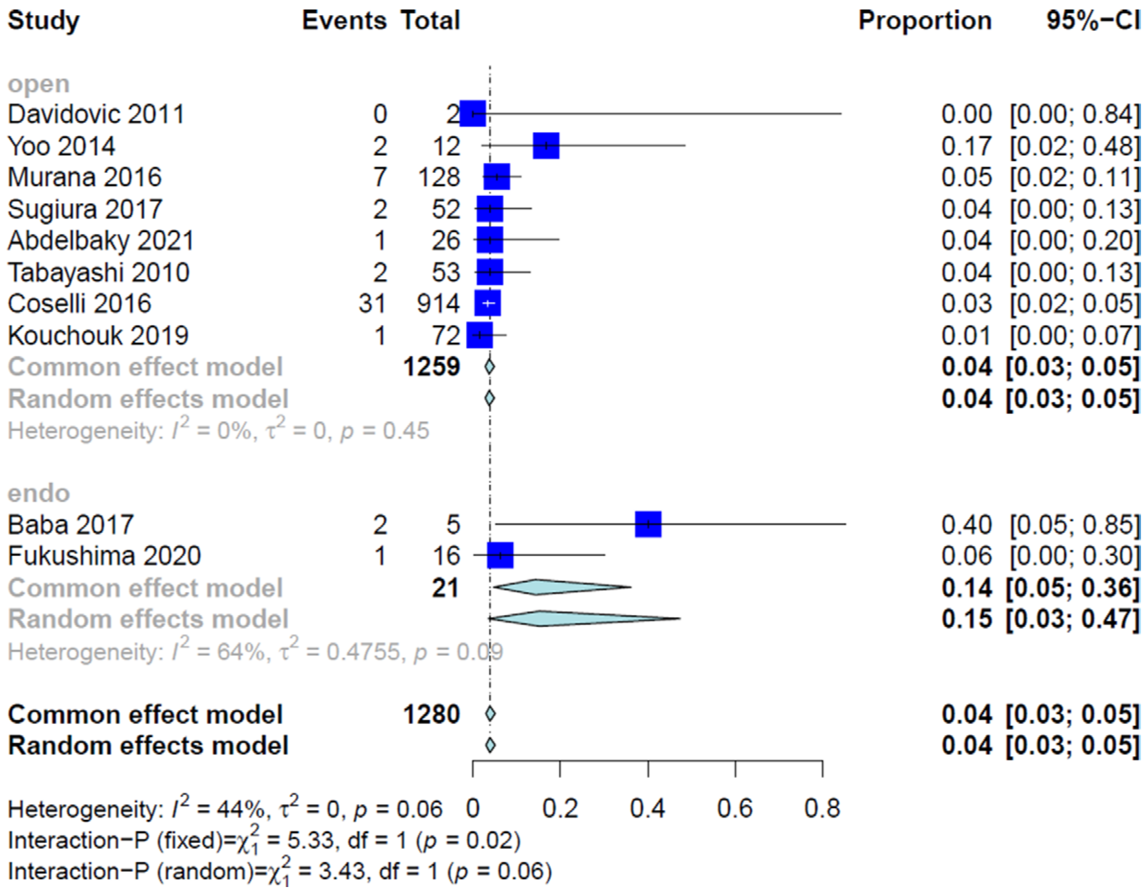


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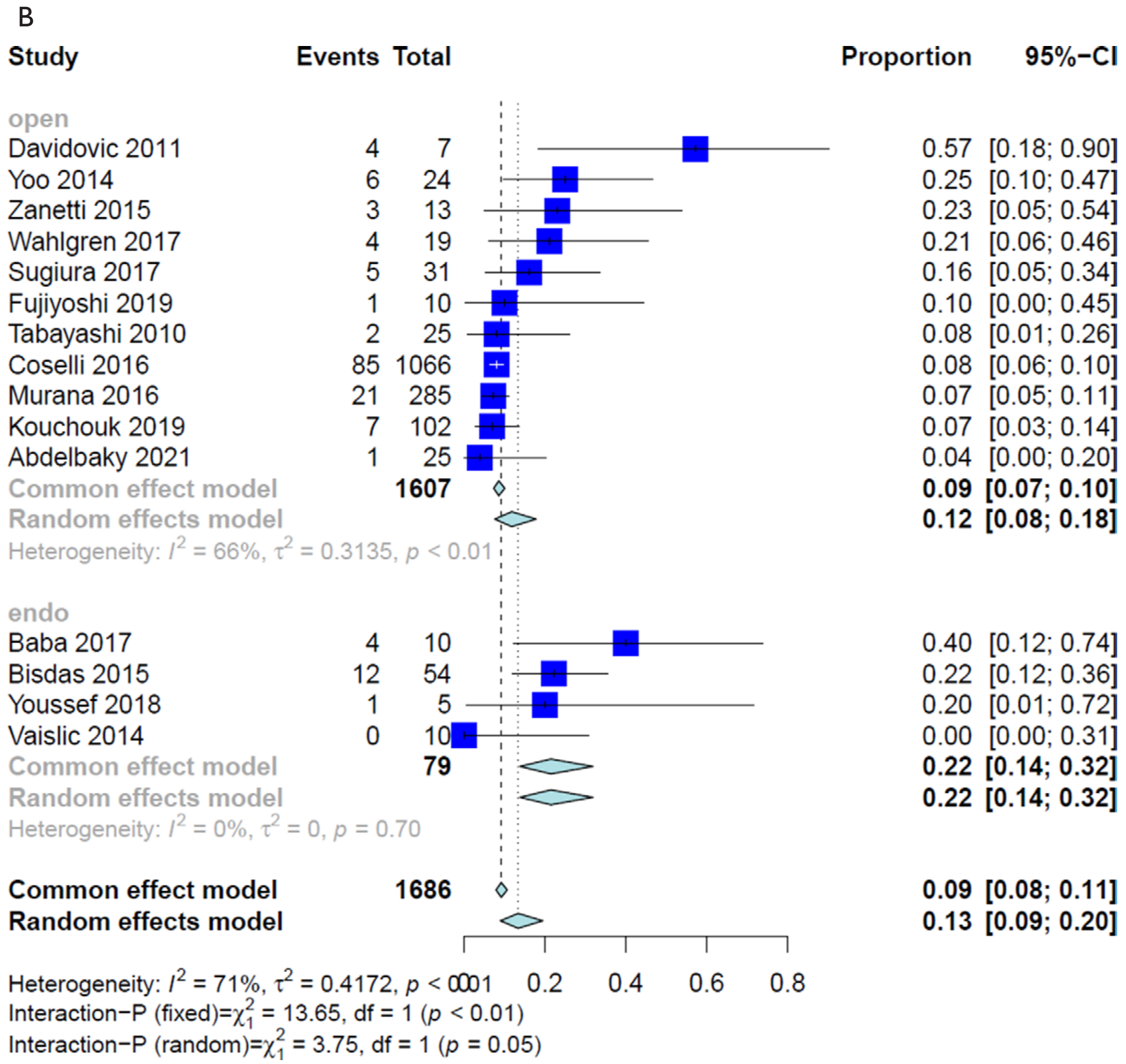



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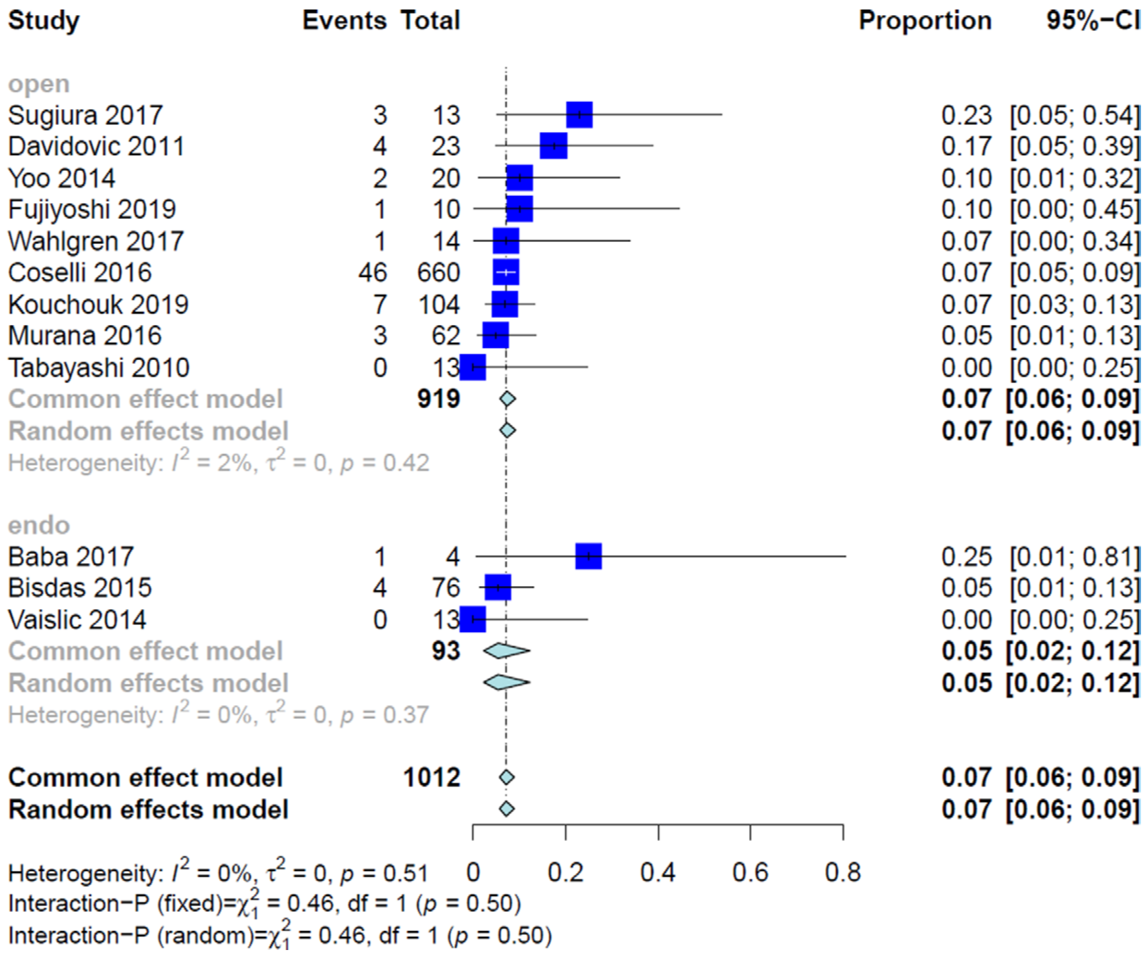



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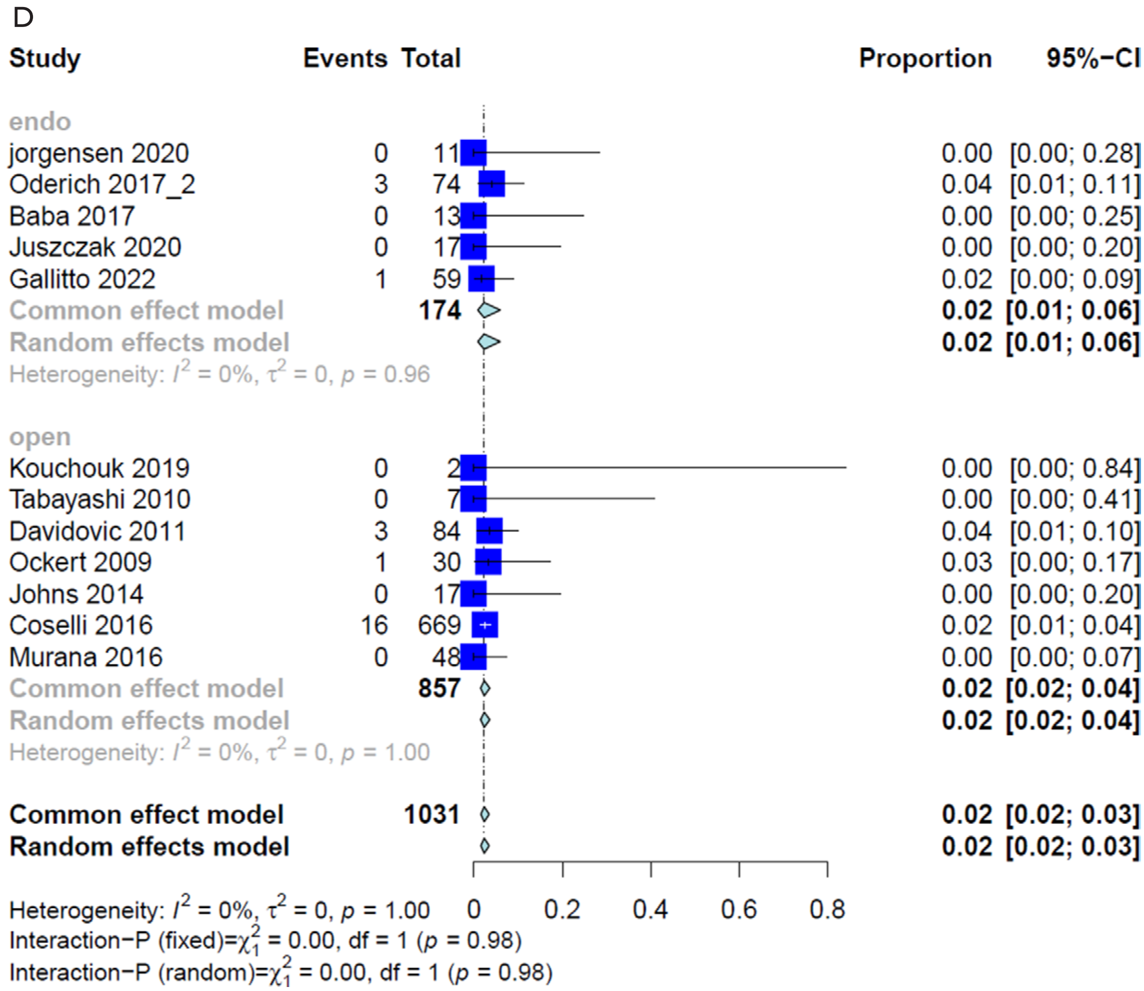


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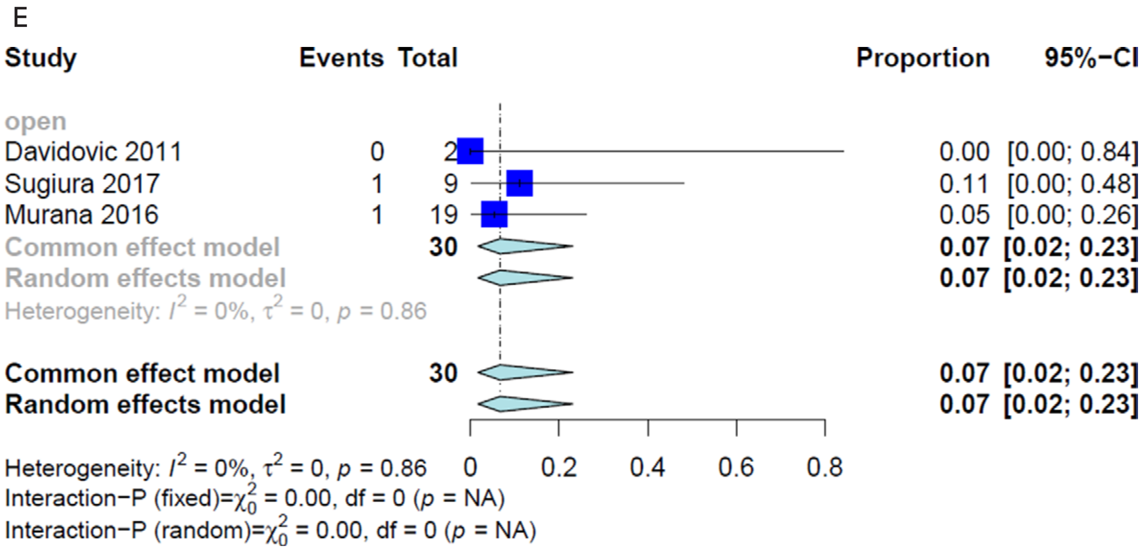


**Figure S9** Sub-group analysis of permanent spinal cord injury after repair of Crawford Extent I, II, III, IV, V aneurysms. (A) Sub-group analysis of permanent spinal cord injury after repair of Crawford Extent I aneurysms. (B) Sub-group analysis of permanent spinal cord injury after repair of Crawford Extent II aneurysms. (C) Sub-group analysis of permanent spinal cord injury after repair of Crawford Extent III aneurysms. (D) Sub-group analysis of permanent spinal cord injury after repair of Crawford Extent IV aneurysms. (E) Sub-group analysis of permanent spinal cord injury after repair of Crawford Extent V aneurysms. CI, confidence interval.


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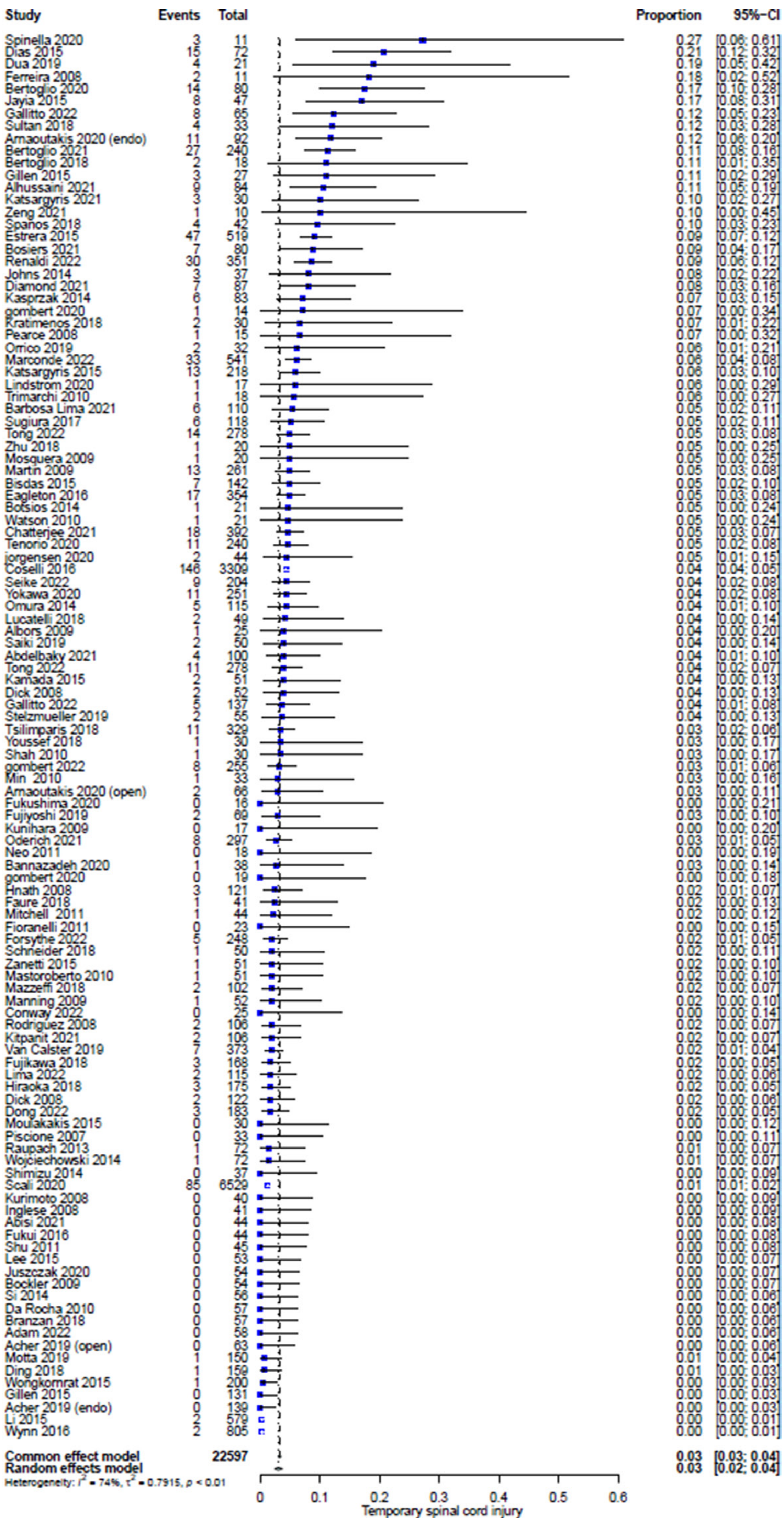


**Figure S10** Forest plot for pooled rate of temporary spinal cord injury. CI, confidence interval.


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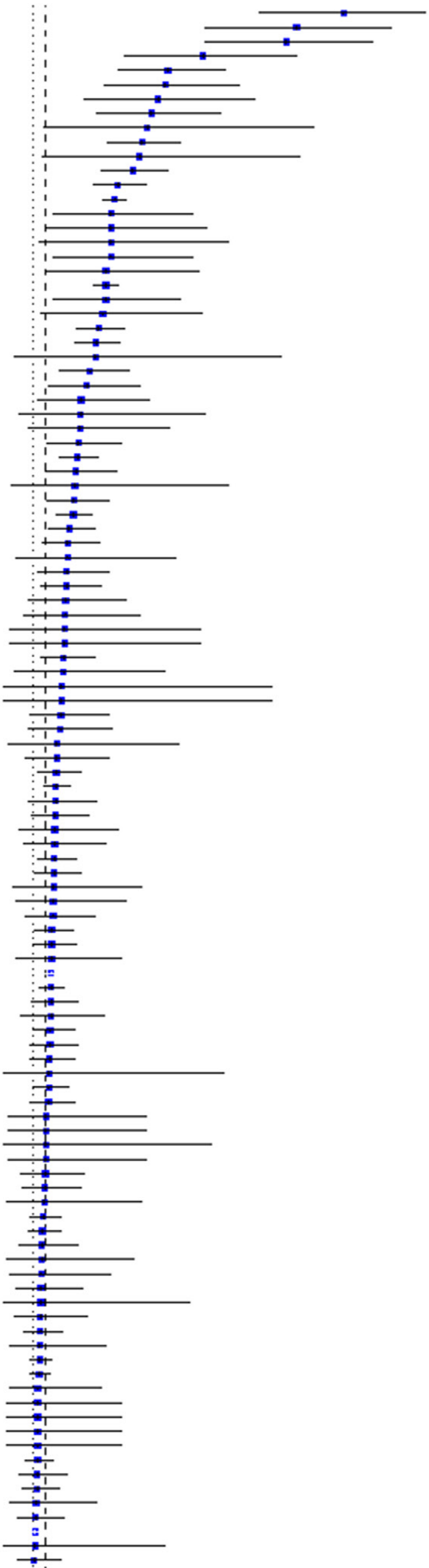


| Study | Events | Total | Proportion | 95%-CI |
|---|---|---|---|---|
| Gallitto 2022 | 34 | 65 | 0.52 | [0.40; 0.65] |
| Zanetti 2015 | 23 | 51 | 0.45 | [0.31; 0.60] |
| Bashir 2014 | 27 | 62 | 0.44 | [0.31; 0.57] |
| Dick 2008 | 16 | 52 | 0.31 | [0.19; 0.45] |
| Davidovic 2011 | 30 | 118 | 0.25 | [0.18; 0.34] |
| Gombert 2018 | 19 | 76 | 0.25 | [0.16; 0.36] |
| Garbade 2010 | 11 | 46 | 0.24 | [0.13; 0.39] |
| Kasprzak 2014 | 19 | 83 | 0.23 | [0.14; 0.33] |
| Trimarchi 2010 | 4 | 18 | 0.22 | [0.06; 0.48] |
| Messe 2008 | 48 | 224 | 0.21 | [0.16; 0.27] |
| gombert 2020 | 4 | 19 | 0.21 | [0.06; 0.46] |
| gombert 2022 | 51 | 255 | 0.20 | [0.15; 0.25] |
| Rocha 2021 | 64 | 361 | 0.18 | [0.14; 0.22] |
| Tanaka 2019 | 299 | 1736 | 0.17 | [0.15; 0.19] |
| Juszczak 2020 | 9 | 54 | 0.17 | [0.08; 0.29] |
| Marzelle 2015 | 7 | 42 | 0.17 | [0.07; 0.31] |
| Ockert 2009 | 5 | 30 | 0.17 | [0.06; 0.35] |
| Kang 2019 | 9 | 54 | 0.17 | [0.08; 0.29] |
| Baba 2017 | 7 | 44 | 0.16 | [0.07; 0.30] |
| Kiser 2022 | 234 | 1474 | 0.16 | [0.14; 0.18] |
| Acher 2019 (open) | 10 | 63 | 0.16 | [0.08; 0.27] |
| Monnot 2018 | 6 | 39 | 0.15 | [0.06; 0.31] |
| Locham 2018 | 59 | 398 | 0.15 | [0.11; 0.19] |
| harky 2021 | 62 | 430 | 0.14 | [0.11; 0.18] |
| gombert 2020 | 2 | 14 | 0.14 | [0.02; 0.43] |
| Kieffer 2008 | 23 | 171 | 0.13 | [0.09; 0.19] |
| Naughton 2012 | 13 | 100 | 0.13 | [0.07; 0.21] |
| Arnaoutakis 2020 (open) | 8 | 66 | 0.12 | [0.05; 0.22] |
| Conway 2022 | 3 | 25 | 0.12 | [0.03; 0.31] |
| Spanos 2018 | 5 | 42 | 0.12 | [0.04; 0.26] |
| Gallitto 2022 | 16 | 137 | 0.12 | [0.07; 0.18] |
| Umegaki 2022 | 58 | 503 | 0.12 | [0.09; 0.15] |
| Bisdas 2015 | 16 | 142 | 0.11 | [0.07; 0.18] |
| Rahe.Meyer 2009 | 2 | 18 | 0.11 | [0.01; 0.35] |
| Kunihara 2021 | 20 | 182 | 0.11 | [0.07; 0.16] |
| Murana 2016 | 59 | 542 | 0.11 | [0.08; 0.14] |
| Rocha 2021 | 31 | 303 | 0.10 | [0.07; 0.14] |
| Wongkomrat 2015 | 20 | 200 | 0.10 | [0.06; 0.15] |
| Katsargyris 2021 | 3 | 30 | 0.10 | [0.02; 0.27] |
| Yaffee 2015 | 13 | 132 | 0.10 | [0.05; 0.16] |
| Dong 2022 | 18 | 183 | 0.10 | [0.06; 0.15] |
| Dias 2015 | 7 | 72 | 0.10 | [0.04; 0.19] |
| Gombert 2017 | 5 | 52 | 0.10 | [0.03; 0.21] |
| Dua 2019 | 2 | 21 | 0.10 | [0.01; 0.30] |
| Monnot 2018 | 2 | 21 | 0.10 | [0.01; 0.30] |
| Yoo 2014 | 20 | 212 | 0.09 | [0.06; 0.14] |
| Andersen 2014 | 3 | 32 | 0.09 | [0.02; 0.25] |
| Ferreira 2008 | 1 | 11 | 0.09 | [0.00; 0.41] |
| Mastoroberto 2010 | 1 | 11 | 0.09 | [0.00; 0.41] |
| Abdelbaky 2021 | 9 | 100 | 0.09 | [0.04; 0.16] |
| Wahlgren 2017 | 8 | 90 | 0.09 | [0.04; 0.17] |
| Sweet 2015 | 2 | 24 | 0.08 | [0.01; 0.27] |
| Alhussaini 2021 | 7 | 84 | 0.08 | [0.03; 0.16] |
| Tong 2022 | 23 | 278 | 0.08 | [0.05; 0.12] |
| Wynn 2016 | 66 | 805 | 0.08 | [0.06; 0.10] |
| Dick 2008 | 10 | 122 | 0.08 | [0.04; 0.15] |
| henmi 2019 | 14 | 172 | 0.08 | [0.05; 0.13] |
| Youssef 2015 | 5 | 62 | 0.08 | [0.03; 0.18] |
| Diamond 2021 | 7 | 87 | 0.08 | [0.03; 0.16] |
| Renaldi 2022 | 28 | 351 | 0.08 | [0.05; 0.11] |
| Yokawa 2020 | 20 | 251 | 0.08 | [0.05; 0.12] |
| Mkalaluh 2018 | 3 | 38 | 0.08 | [0.02; 0.21] |
| Mastoroberto 2010 | 4 | 51 | 0.08 | [0.02; 0.19] |
| Omura 2014 | 9 | 115 | 0.08 | [0.04; 0.14] |
| Lima 2012 | 25 | 330 | 0.08 | [0.05; 0.11] |
| Tong 2022 | 21 | 278 | 0.08 | [0.05; 0.11] |
| Lee 2015 | 4 | 53 | 0.08 | [0.02; 0.18] |
| Coselli 2016 | 249 | 3309 | 0.08 | [0.07; 0.08] |
| Smith 2022 | 61 | 813 | 0.08 | [0.06; 0.10] |
| Bertoglio 2021 | 18 | 240 | 0.07 | [0.05; 0.12] |
| Bertoglio 2020 | 6 | 80 | 0.07 | [0.03; 0.16] |
| Kouchouk 2019 | 21 | 285 | 0.07 | [0.05; 0.11] |
| Kulik 2011 | 16 | 218 | 0.07 | [0.04; 0.12] |
| Forsythe 2022 | 18 | 248 | 0.07 | [0.04; 0.11] |
| Anderson 2014 | 1 | 14 | 0.07 | [0.00; 0.34] |
| Chatterjee 2021 | 28 | 392 | 0.07 | [0.05; 0.10] |
| Weiss 2012 | 17 | 240 | 0.07 | [0.04; 0.11] |
| Youssef 2018 | 2 | 30 | 0.07 | [0.01; 0.22] |
| Chen 2017 | 2 | 30 | 0.07 | [0.01; 0.22] |
| Pearce 2008 | 1 | 15 | 0.07 | [0.00; 0.32] |
| Yuri 2012 | 2 | 30 | 0.07 | [0.01; 0.22] |
| Rana 2018 | 8 | 121 | 0.07 | [0.03; 0.13] |
| Hicks 2017 | 9 | 137 | 0.07 | [0.03; 0.12] |
| Clough 2012 | 2 | 31 | 0.06 | [0.01; 0.21] |
| Monaco 2018 | 29 | 459 | 0.06 | [0.04; 0.09] |
| Van Calster 2019 | 23 | 373 | 0.06 | [0.04; 0.09] |
| Gillen 2015 | 8 | 131 | 0.06 | [0.03; 0.12] |
| Min 2010 | 2 | 33 | 0.06 | [0.01; 0.20] |
| Schneider 2018 | 3 | 50 | 0.06 | [0.01; 0.17] |
| Tabayashi 2010 | 6 | 102 | 0.06 | [0.02; 0.12] |
| Lindstrom 2020 | 1 | 17 | 0.06 | [0.00; 0.29] |
| Conway 2014 | 5 | 86 | 0.06 | [0.02; 0.13] |
| Tanaka 2019 | 16 | 276 | 0.06 | [0.03; 0.09] |
| Manning 2009 | 3 | 52 | 0.06 | [0.01; 0.16] |
| girardi 2019 | 45 | 783 | 0.06 | [0.04; 0.08] |
| Gambardella 2021 | 49 | 869 | 0.06 | [0.04; 0.07] |
| Stelzmueller 2019 | 3 | 55 | 0.05 | [0.01; 0.15] |
| Shimizu 2014 | 2 | 37 | 0.05 | [0.01; 0.18] |
| Le Huu 2022 | 2 | 37 | 0.05 | [0.01; 0.18] |
| Johns 2014 | 2 | 37 | 0.05 | [0.01; 0.18] |
| Afifi 2015 | 2 | 37 | 0.05 | [0.01; 0.18] |
| Locham 2018 | 26 | 481 | 0.05 | [0.04; 0.08] |
| Lee 2015 | 9 | 167 | 0.05 | [0.02; 0.10] |
| Martin 2009 | 14 | 261 | 0.05 | [0.03; 0.09] |
| Adam 2022 | 3 | 58 | 0.05 | [0.01; 0.14] |
| Hiraoka 2018 | 9 | 175 | 0.05 | [0.02; 0.10] |
| Umegaki 2022 | 285 | 5699 | 0.05 | [0.04; 0.06] |
| Mosquera 2009 | 1 | 20 | 0.05 | [0.00; 0.25] |
| Oderich 2017_2 | 9 | 185 | 0.05 | [0.02; 0.09] |

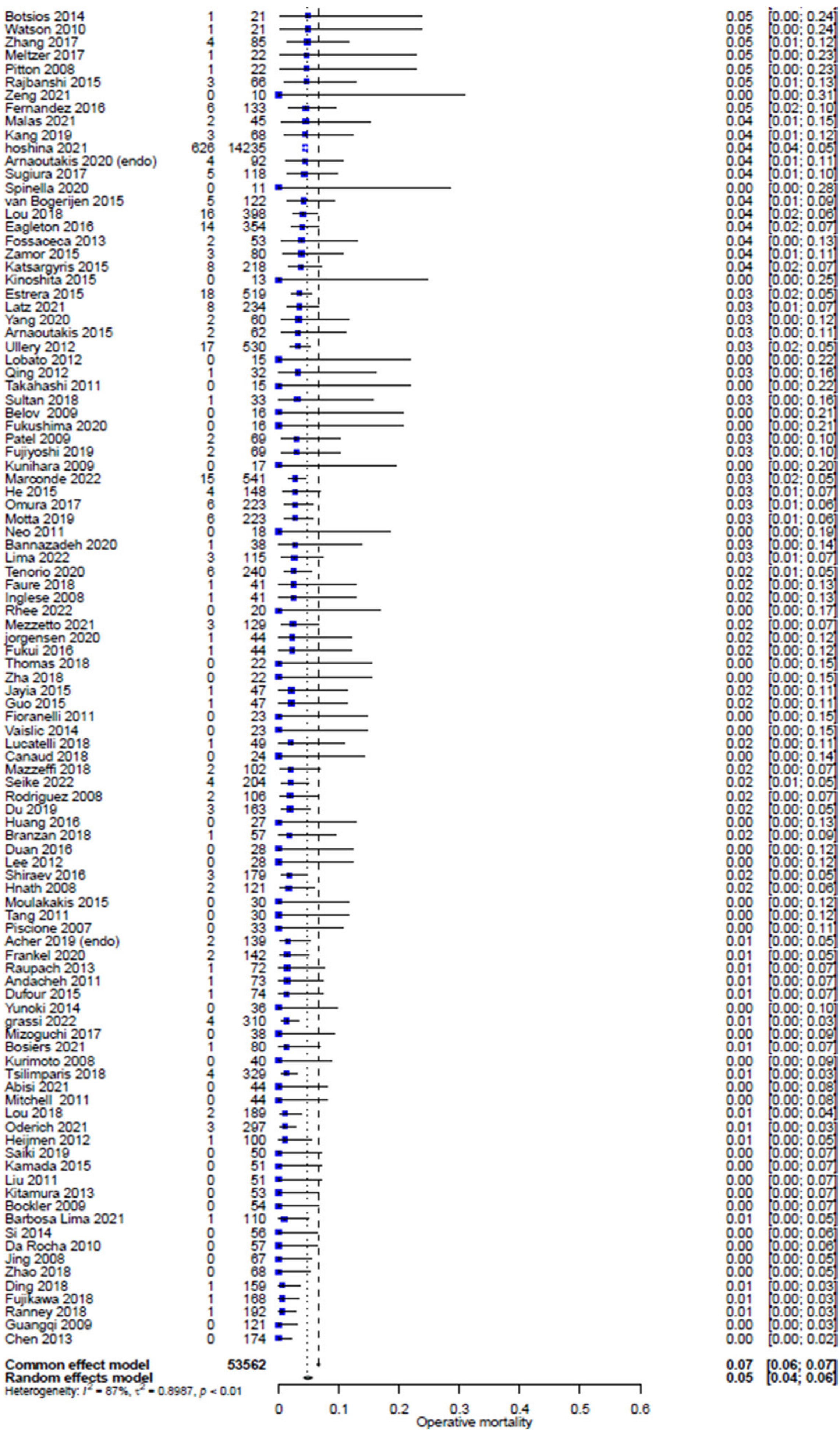
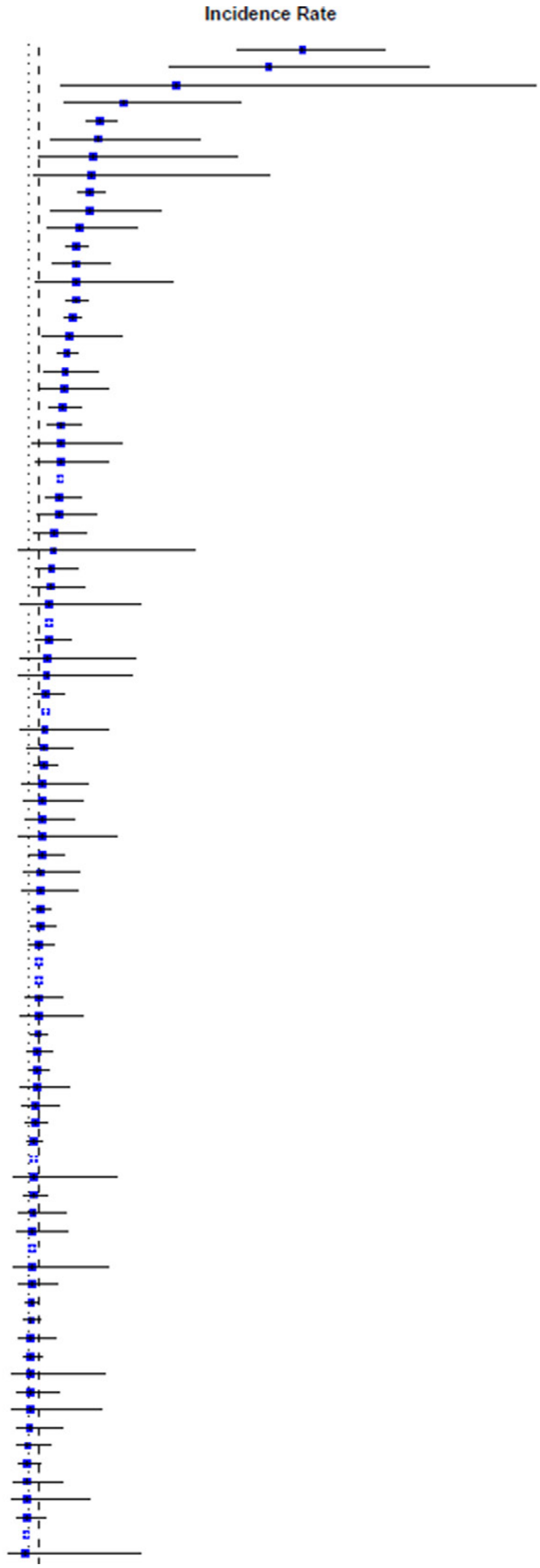



**Figure S11** Forest plot for pooled incidence rate of 30-day/in-hospital mortality. CI, confidence interval.


https://dx.doi.org/10.21037/acs-2023-scp-14

| Study | Events | Time | Rate | 95%-CI |
|---|---|---|---|---|
| Bertoglio 2020 | 63 | 1064.00 | 0.06 | [0.05; 0.08] |
| Gillen 2015 | 17 | 324.00 | 0.05 | [0.03; 0.08] |
| Ferreira 2008 | 3 | 88.00 | 0.03 | [0.01; 0.11] |
| Fioranelli 2011 | 8 | 340.40 | 0.02 | [0.01; 0.05] |
| Oderich 2021 | 145 | 7722.00 | 0.02 | [0.02; 0.02] |
| Monnot 2018 | 7 | 378.00 | 0.02 | [0.01; 0.04] |
| Heijmen 2012 | 4 | 230.00 | 0.02 | [0.01; 0.05] |
| Xiong 2013 | 3 | 176.80 | 0.02 | [0.01; 0.05] |
| Smith 2022 | 164 | 9756.00 | 0.02 | [0.01; 0.02] |
| Schneider 2018 | 10 | 600.00 | 0.02 | [0.01; 0.03] |
| Dua 2019 | 11 | 756.00 | 0.01 | [0.01; 0.03] |
| Rocha 2021 | 178 | 12726.00 | 0.01 | [0.01; 0.02] |
| Lima 2022 | 24 | 1725.00 | 0.01 | [0.01; 0.02] |
| Chen 2017 | 5 | 360.00 | 0.01 | [0.01; 0.03] |
| Van Calster 2019 | 150 | 10817.00 | 0.01 | [0.01; 0.02] |
| Rocha 2021 | 200 | 15162.00 | 0.01 | [0.01; 0.02] |
| Kang 2019 | 11 | 864.00 | 0.01 | [0.01; 0.02] |
| Marconde 2022 | 151 | 12443.00 | 0.01 | [0.01; 0.01] |
| Garbade 2010 | 20 | 1697.40 | 0.01 | [0.01; 0.02] |
| Diamond 2021 | 12 | 1044.00 | 0.01 | [0.01; 0.02] |
| Mezzetto 2021 | 47 | 4128.00 | 0.01 | [0.01; 0.02] |
| Motta 2019 | 42 | 3825.00 | 0.01 | [0.01; 0.01] |
| Thomas 2018 | 7 | 638.00 | 0.01 | [0.01; 0.02] |
| Bannazadeh 2020 | 10 | 912.00 | 0.01 | [0.01; 0.02] |
| Tanaka 2019 | 1029 | 95480.00 | 0.01 | [0.01; 0.01] |
| Tenorio 2020 | 36 | 3360.00 | 0.01 | [0.01; 0.01] |
| Andacheh 2011 | 14 | 1314.00 | 0.01 | [0.01; 0.02] |
| Arnaoutakis 2015 | 14 | 1469.40 | 0.01 | [0.01; 0.02] |
| Lobato 2012 | 2 | 212.55 | 0.01 | [0.00; 0.04] |
| Hicks 2017 | 18 | 1986.50 | 0.01 | [0.01; 0.01] |
| Fossaceca 2013 | 12 | 1356.80 | 0.01 | [0.01; 0.02] |
| Pitton 2008 | 3 | 345.40 | 0.01 | [0.00; 0.03] |
| girardi 2019 | 285 | 32886.00 | 0.01 | [0.01; 0.01] |
| Patel 2009 | 25 | 2891.10 | 0.01 | [0.01; 0.01] |
| Youssef 2018 | 3 | 360.00 | 0.01 | [0.00; 0.03] |
| Clough 2012 | 3 | 372.00 | 0.01 | [0.00; 0.03] |
| Kouchouk 2019 | 27 | 3420.00 | 0.01 | [0.01; 0.01] |
| Coselli 2016 | 1864 | 239571.60 | 0.01 | [0.01; 0.01] |
| Mastoroberto 2010 | 4 | 519.20 | 0.01 | [0.00; 0.02] |
| Le Huu 2022 | 12 | 1598.40 | 0.01 | [0.00; 0.01] |
| Arnaoutakis 2020 (endo) | 41 | 5520.00 | 0.01 | [0.01; 0.01] |
| Kurimoto 2008 | 6 | 820.00 | 0.01 | [0.00; 0.02] |
| Bosiers 2021 | 7 | 960.00 | 0.01 | [0.00; 0.02] |
| Botsios 2014 | 10 | 1378.86 | 0.01 | [0.00; 0.01] |
| Conway 2022 | 3 | 417.50 | 0.01 | [0.00; 0.02] |
| Bashir 2014 | 17 | 2380.80 | 0.01 | [0.00; 0.01] |
| Lee 2012 | 7 | 1008.00 | 0.01 | [0.00; 0.01] |
| Inglese 2008 | 7 | 1016.80 | 0.01 | [0.00; 0.01] |
| Motta 2019 | 55 | 8028.00 | 0.01 | [0.01; 0.01] |
| Arnaoutakis 2020 (open) | 27 | 3960.00 | 0.01 | [0.00; 0.01] |
| Tsilimparis 2018 | 26 | 3948.00 | 0.01 | [0.00; 0.01] |
| Yokawa 2020 | 85 | 12951.60 | 0.01 | [0.01; 0.01] |
| Latz 2021 | 92 | 14040.00 | 0.01 | [0.01; 0.01] |
| Zamor 2015 | 13 | 1992.00 | 0.01 | [0.00; 0.01] |
| Katsargyris 2021 | 5 | 780.00 | 0.01 | [0.00; 0.02] |
| Acher 2019 (endo) | 53 | 8340.00 | 0.01 | [0.00; 0.01] |
| Barbosa Lima 2021 | 25 | 3960.00 | 0.01 | [0.00; 0.01] |
| Forsythe 2022 | 37 | 5952.00 | 0.01 | [0.00; 0.01] |
| Lucatelli 2018 | 7 | 1156.40 | 0.01 | [0.00; 0.01] |
| Bockler 2009 | 10 | 1733.40 | 0.01 | [0.00; 0.01] |
| Dufour 2015 | 28 | 4884.00 | 0.01 | [0.00; 0.01] |
| Conrad 2017 | 54 | 9600.00 | 0.01 | [0.00; 0.01] |
| Tong 2022 | 186 | 33360.00 | 0.01 | [0.00; 0.01] |
| Tang 2011 | 2 | 360.00 | 0.01 | [0.00; 0.02] |
| Conway 2014 | 20 | 3715.20 | 0.01 | [0.00; 0.01] |
| Naguib 2016 | 6 | 1118.30 | 0.01 | [0.00; 0.01] |
| Ockert 2009 | 5 | 969.00 | 0.01 | [0.00; 0.01] |
| Ranney 2018 | 68 | 13248.00 | 0.01 | [0.00; 0.01] |
| Kinoshita 2015 | 2 | 390.00 | 0.01 | [0.00; 0.02] |
| Kang 2019 | 8 | 1564.00 | 0.01 | [0.00; 0.01] |
| gombert 2022 | 46 | 9180.00 | 0.01 | [0.00; 0.01] |
| henmi 2019 | 37 | 7430.40 | 0.00 | [0.00; 0.01] |
| Fujiyoshi 2019 | 8 | 1621.50 | 0.00 | [0.00; 0.01] |
| Wahlgren 2017 | 26 | 5292.00 | 0.00 | [0.00; 0.01] |
| Lindstrom 2020 | 2 | 408.00 | 0.00 | [0.00; 0.02] |
| Malas 2021 | 6 | 1242.00 | 0.00 | [0.00; 0.01] |
| Orrico 2019 | 2 | 416.00 | 0.00 | [0.00; 0.02] |
| Juszczak 2020 | 5 | 1069.20 | 0.00 | [0.00; 0.01] |
| Manning 2009 | 7 | 1630.20 | 0.00 | [0.00; 0.01] |
| Acher 2019 (open) | 16 | 3780.00 | 0.00 | [0.00; 0.01] |
| Kratimenos 2018 | 4 | 951.00 | 0.00 | [0.00; 0.01] |
| Moulakakis 2015 | 2 | 480.00 | 0.00 | [0.00; 0.02] |
| Piffaretti 2015 | 9 | 2240.00 | 0.00 | [0.00; 0.01] |
| Tong 2022 | 133 | 33360.00 | 0.00 | [0.00; 0.00] |
| Sweet 2015 | 1 | 264.00 | 0.00 | [0.00; 0.03] |




 https://dx.doi.org/10.21037/acs-2023-scp-14

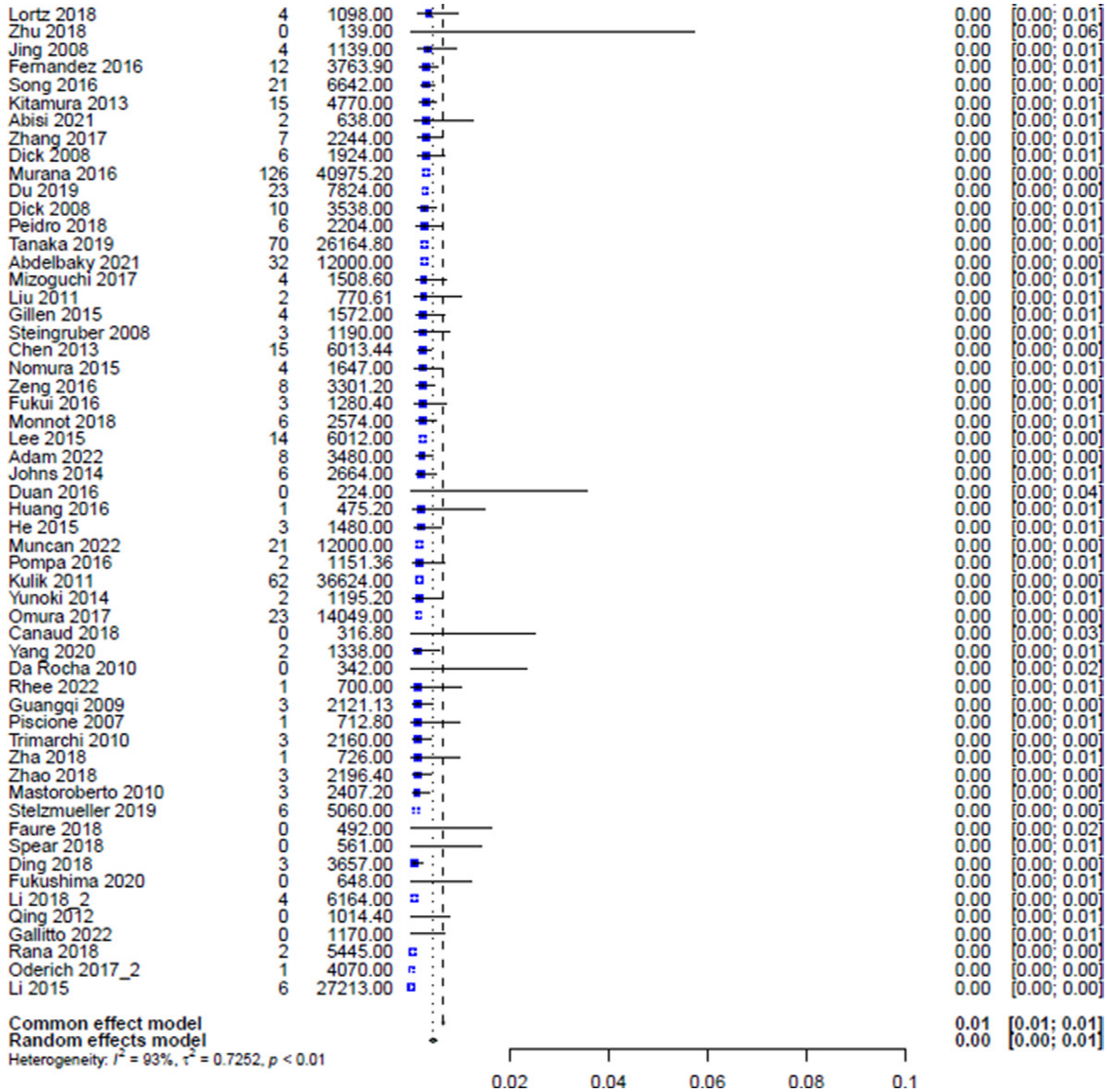
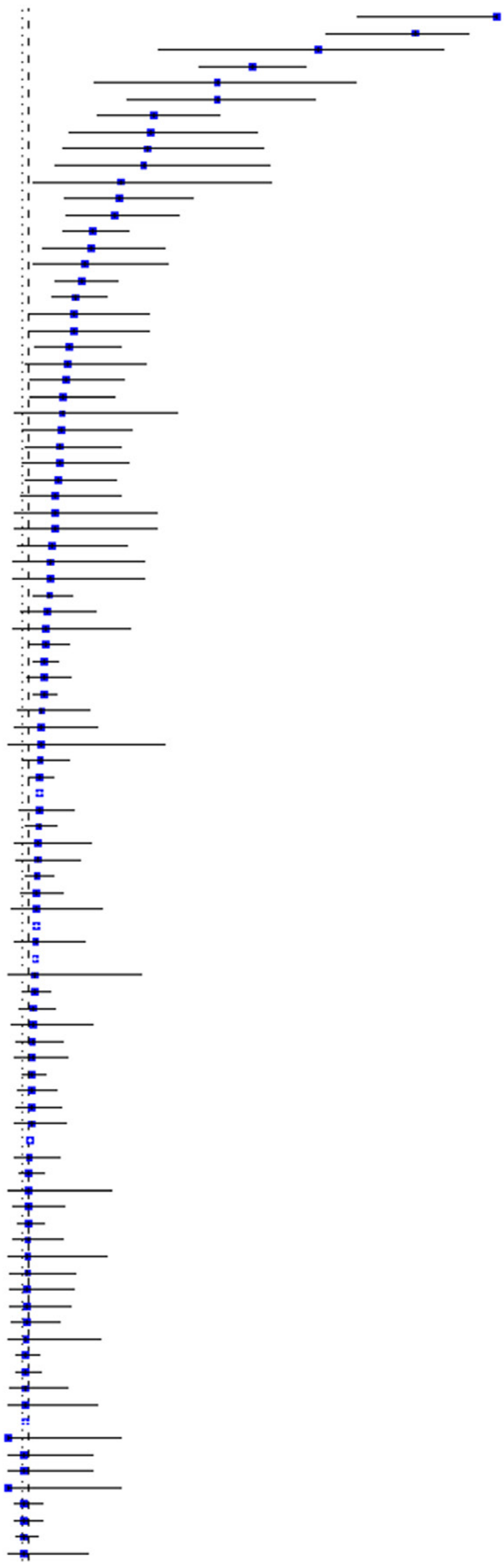



**Figure S12** Forest plot for pooled incidence rate of follow-up mortality. CI, confidence interval.

 https://dx.doi.org/10.21037/acs-2023-scp-14

| Study | Events | Total | Proportion | 95%-CI |
|---|---|---|---|---|
| Mastoroberto 2010 | 11 | 11 | 1.00 | [0.72; 1.00] |
| Youssef 2018 | 25 | 30 | 0.83 | [0.65; 0.94] |
| Al Adas 2018 | 7 | 11 | 0.64 | [0.31; 0.89] |
| Conway 2014 | 43 | 86 | 0.50 | [0.39; 0.61] |
| Anderson 2014 | 6 | 14 | 0.43 | [0.18; 0.71] |
| Lee 2012 | 12 | 28 | 0.43 | [0.24; 0.63] |
| Da Rocha 2010 | 17 | 57 | 0.30 | [0.18; 0.43] |
| Canaud 2018 | 7 | 24 | 0.29 | [0.13; 0.51] |
| Botsios 2014 | 6 | 21 | 0.29 | [0.11; 0.52] |
| Bertoglio 2018 | 5 | 18 | 0.28 | [0.10; 0.53] |
| Kinoshita 2015 | 3 | 13 | 0.23 | [0.05; 0.54] |
| Fukui 2016 | 10 | 44 | 0.23 | [0.11; 0.38] |
| Muncan 2022 | 12 | 55 | 0.22 | [0.12; 0.35] |
| Fernandez 2016 | 23 | 133 | 0.17 | [0.11; 0.25] |
| Faure 2018 | 7 | 41 | 0.17 | [0.07; 0.32] |
| Andersen 2014 | 5 | 32 | 0.16 | [0.05; 0.33] |
| Yaffee 2015 | 20 | 132 | 0.15 | [0.10; 0.22] |
| Ding 2018 | 22 | 159 | 0.14 | [0.09; 0.20] |
| Shimizu 2014 | 5 | 37 | 0.14 | [0.05; 0.29] |
| Afifi 2015 | 5 | 37 | 0.14 | [0.05; 0.29] |
| Clough 2018 | 8 | 64 | 0.12 | [0.06; 0.23] |
| Sultan 2018 | 4 | 33 | 0.12 | [0.03; 0.28] |
| Zanetti 2015 | 6 | 51 | 0.12 | [0.04; 0.24] |
| Bashir 2014 | 7 | 62 | 0.11 | [0.05; 0.22] |
| Neo 2011 | 2 | 18 | 0.11 | [0.01; 0.35] |
| Johns 2014 | 4 | 37 | 0.11 | [0.03; 0.25] |
| Jayia 2015 | 5 | 47 | 0.11 | [0.04; 0.23] |
| Mizoguchi 2017 | 4 | 38 | 0.11 | [0.03; 0.25] |
| Narayan 2011 | 5 | 49 | 0.10 | [0.03; 0.22] |
| Inglese 2008 | 4 | 41 | 0.10 | [0.03; 0.23] |
| Monnot 2018 | 2 | 21 | 0.10 | [0.01; 0.30] |
| Watson 2010 | 2 | 21 | 0.10 | [0.01; 0.30] |
| Piscione 2007 | 3 | 33 | 0.09 | [0.02; 0.24] |
| Fioranelli 2011 | 2 | 23 | 0.09 | [0.01; 0.28] |
| Vaislic 2014 | 2 | 23 | 0.09 | [0.01; 0.28] |
| Muncan 2022 | 17 | 200 | 0.08 | [0.05; 0.13] |
| Arnaoutakis 2015 | 5 | 62 | 0.08 | [0.03; 0.18] |
| Xiong 2013 | 2 | 26 | 0.08 | [0.01; 0.25] |
| Kieffer 2008 | 13 | 171 | 0.08 | [0.04; 0.13] |
| harky 2021 | 32 | 430 | 0.07 | [0.05; 0.10] |
| He 2015 | 11 | 148 | 0.07 | [0.04; 0.13] |
| Umegaki 2022 | 37 | 503 | 0.07 | [0.05; 0.10] |
| Adam 2022 | 4 | 58 | 0.07 | [0.02; 0.17] |
| Shu 2011 | 3 | 45 | 0.07 | [0.01; 0.18] |
| Lobato 2012 | 1 | 15 | 0.07 | [0.00; 0.32] |
| Hnath 2008 | 8 | 121 | 0.07 | [0.03; 0.13] |
| Locham 2018 | 26 | 398 | 0.07 | [0.04; 0.09] |
| Umegaki 2022 | 365 | 5699 | 0.06 | [0.06; 0.07] |
| Gallitto 2017 | 6 | 94 | 0.06 | [0.02; 0.13] |
| gombert 2022 | 16 | 255 | 0.06 | [0.04; 0.10] |
| Lucatelli 2018 | 3 | 49 | 0.06 | [0.01; 0.17] |
| Arnaoutakis 2020 (open) | 4 | 66 | 0.06 | [0.02; 0.15] |
| Rocha 2021 | 18 | 303 | 0.06 | [0.04; 0.09] |
| Gallitto 2022 | 8 | 137 | 0.06 | [0.03; 0.11] |
| Steingruber 2008 | 2 | 35 | 0.06 | [0.01; 0.19] |
| Tanaka 2019 | 99 | 1736 | 0.06 | [0.05; 0.07] |
| Naguib 2016 | 3 | 53 | 0.06 | [0.01; 0.16] |
| Kiser 2022 | 83 | 1474 | 0.06 | [0.05; 0.07] |
| Rahe.Meyer 2009 | 1 | 18 | 0.06 | [0.00; 0.27] |
| Tong 2022 | 15 | 278 | 0.05 | [0.03; 0.09] |
| henmi 2019 | 9 | 172 | 0.05 | [0.02; 0.10] |
| Monnot 2018 | 2 | 39 | 0.05 | [0.01; 0.17] |
| Abdelbaky 2021 | 5 | 100 | 0.05 | [0.02; 0.11] |
| Bertoglio 2020 | 4 | 80 | 0.05 | [0.01; 0.12] |
| Rocha 2021 | 18 | 361 | 0.05 | [0.03; 0.08] |
| Frankel 2020 | 7 | 142 | 0.05 | [0.02; 0.10] |
| Tabayashi 2010 | 5 | 102 | 0.05 | [0.02; 0.11] |
| Alhussaini 2021 | 4 | 84 | 0.05 | [0.01; 0.12] |
| hoshina 2021 | 654 | 14235 | 0.05 | [0.04; 0.05] |
| Arnaoutakis 2020 (endo) | 4 | 92 | 0.04 | [0.01; 0.11] |
| Kouchouk 2019 | 12 | 285 | 0.04 | [0.02; 0.07] |
| Sweet 2015 | 1 | 24 | 0.04 | [0.00; 0.21] |
| Dias 2015 | 3 | 72 | 0.04 | [0.01; 0.12] |
| Bertoglio 2021 | 10 | 240 | 0.04 | [0.02; 0.08] |
| Dufour 2015 | 3 | 74 | 0.04 | [0.01; 0.11] |
| Conway 2022 | 1 | 25 | 0.04 | [0.00; 0.20] |
| Schneider 2018 | 2 | 50 | 0.04 | [0.00; 0.14] |
| Kamada 2015 | 2 | 51 | 0.04 | [0.00; 0.13] |
| Kitamura 2013 | 2 | 53 | 0.04 | [0.00; 0.13] |
| Bosiers 2021 | 3 | 80 | 0.04 | [0.01; 0.11] |
| Huang 2016 | 1 | 27 | 0.04 | [0.00; 0.19] |
| Tanaka 2019 | 10 | 276 | 0.04 | [0.02; 0.07] |
| Yokawa 2020 | 9 | 251 | 0.04 | [0.02; 0.07] |
| Piffaretti 2015 | 2 | 56 | 0.04 | [0.00; 0.12] |
| Pompa 2016 | 1 | 28 | 0.04 | [0.00; 0.18] |
| Smith 2022 | 29 | 813 | 0.04 | [0.02; 0.05] |
| Mishra 2008 | 0 | 14 | 0.00 | [0.00; 0.23] |
| Ockert 2009 | 1 | 30 | 0.03 | [0.00; 0.17] |
| Tang 2011 | 1 | 30 | 0.03 | [0.00; 0.17] |
| gombert 2020 | 0 | 14 | 0.00 | [0.00; 0.23] |
| Kunihara 2021 | 6 | 182 | 0.03 | [0.01; 0.07] |
| Dong 2022 | 6 | 183 | 0.03 | [0.01; 0.07] |
| Tong 2022 | 9 | 278 | 0.03 | [0.01; 0.06] |
| Qing 2012 | 1 | 32 | 0.03 | [0.00; 0.16] |

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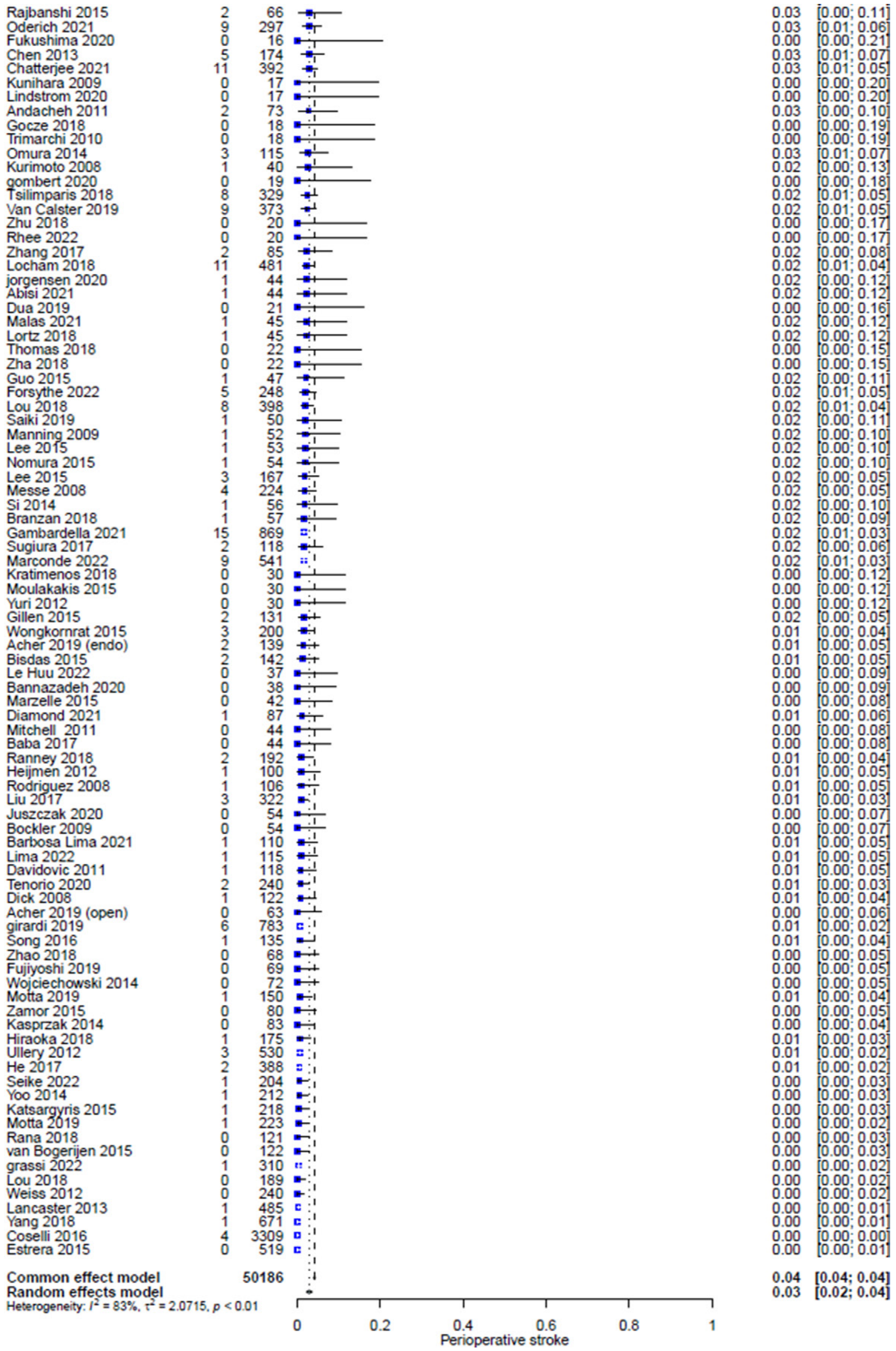
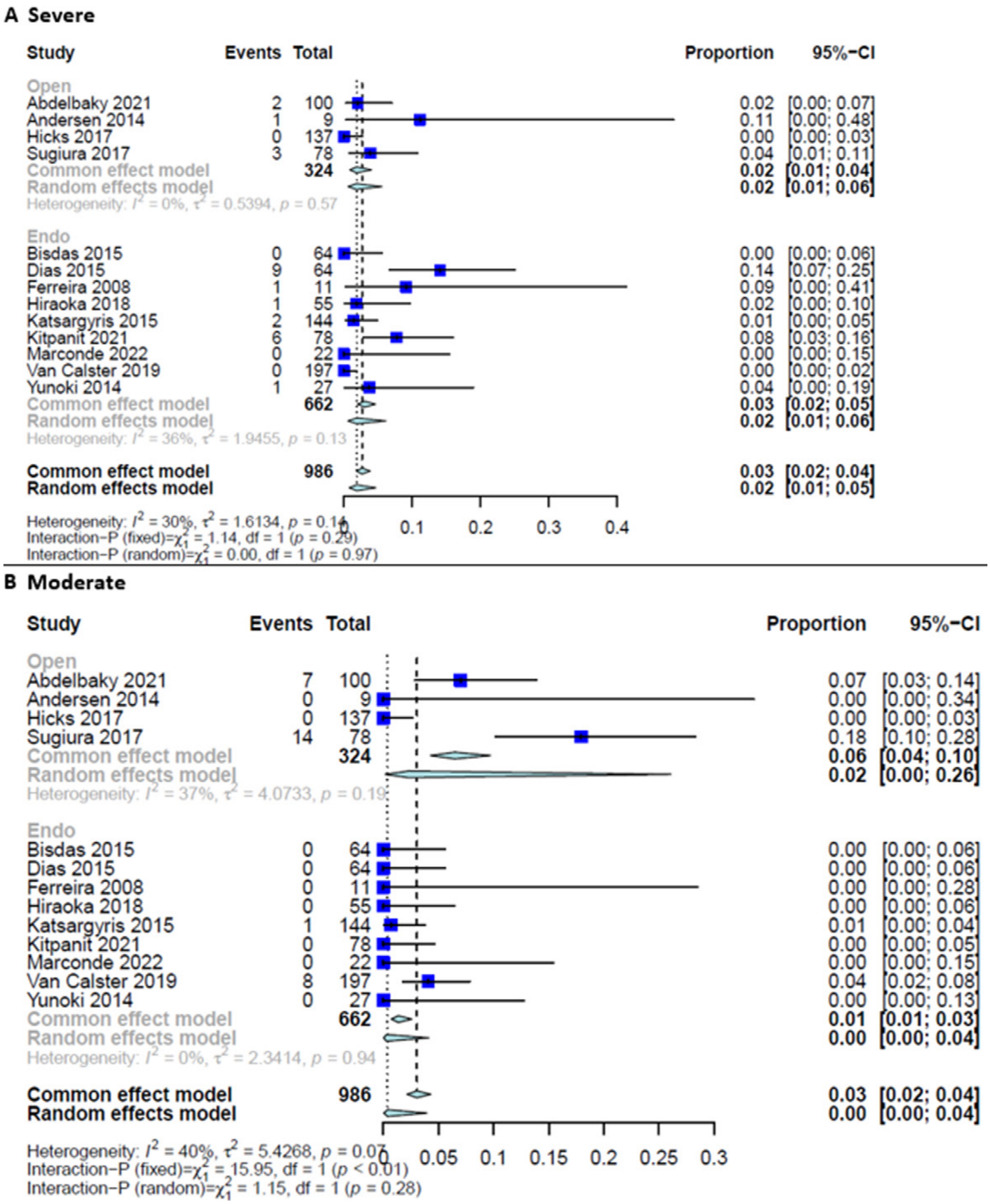



**Figure S13** Forest plot for pooled rate of post-operative stroke. CI, confidence interval.





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**C Minor**

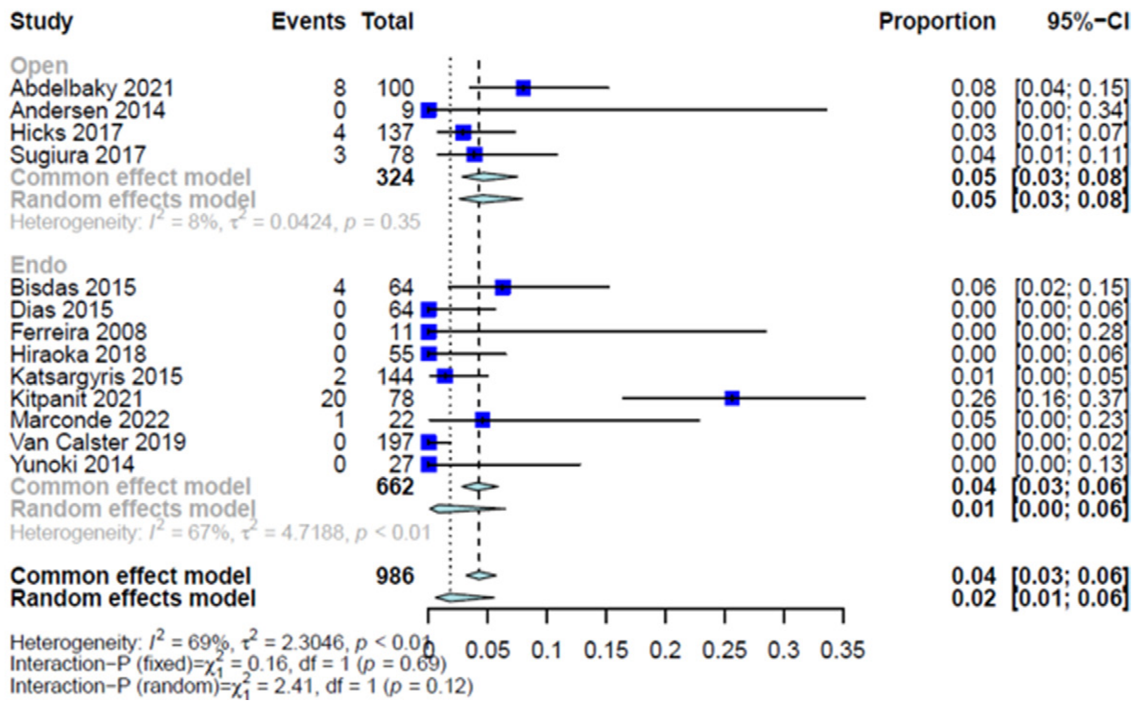



**Figure S14** Forest plots of pooled complication rates related to CSF drain use. (A) Severe complications. (B) Moderate complications. (C) Minor complications. CI, confidence interval; CSF, cerebrospinal fluid.

 https://dx.doi.org/10.21037/acs-2023-scp-14

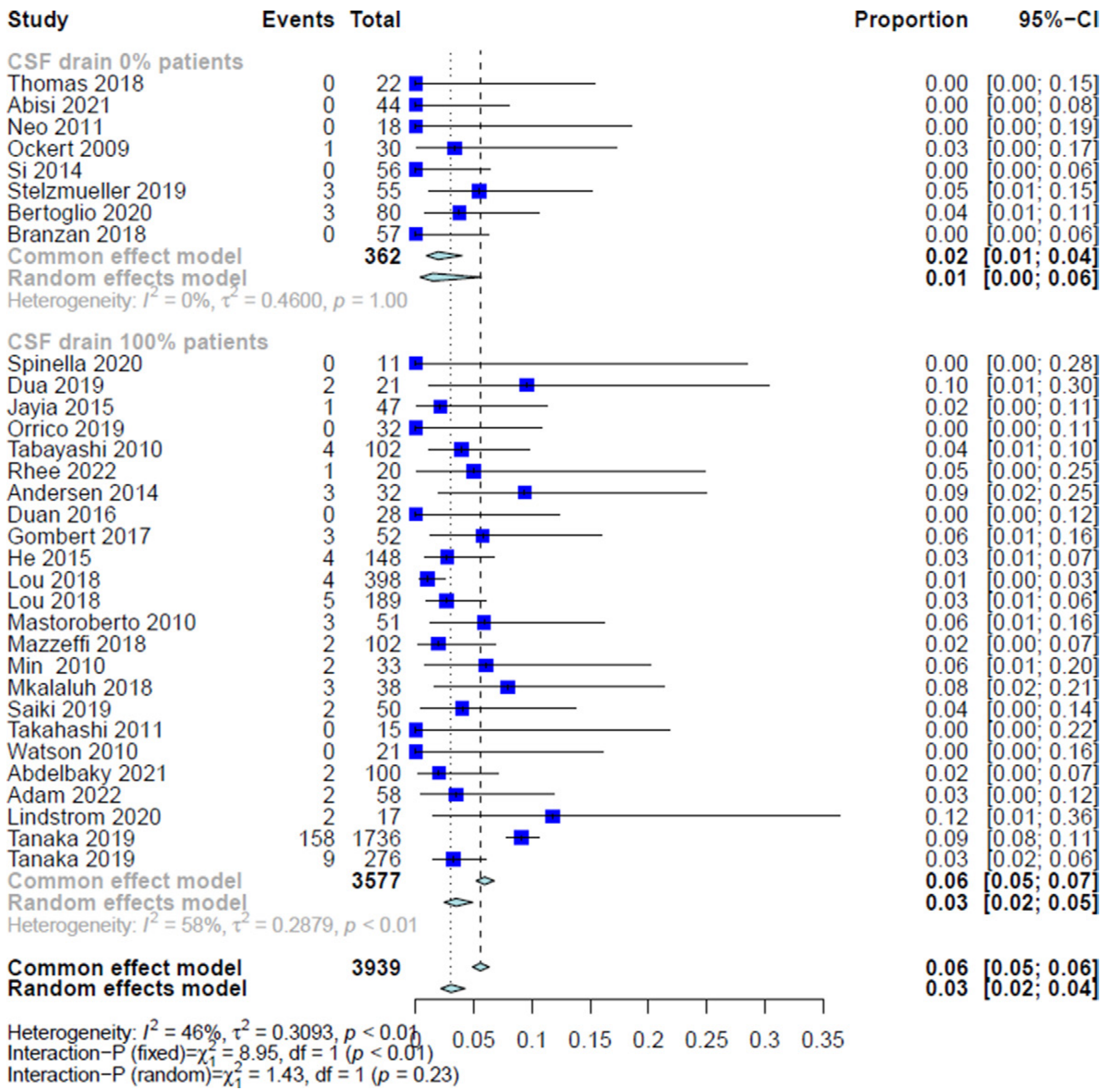
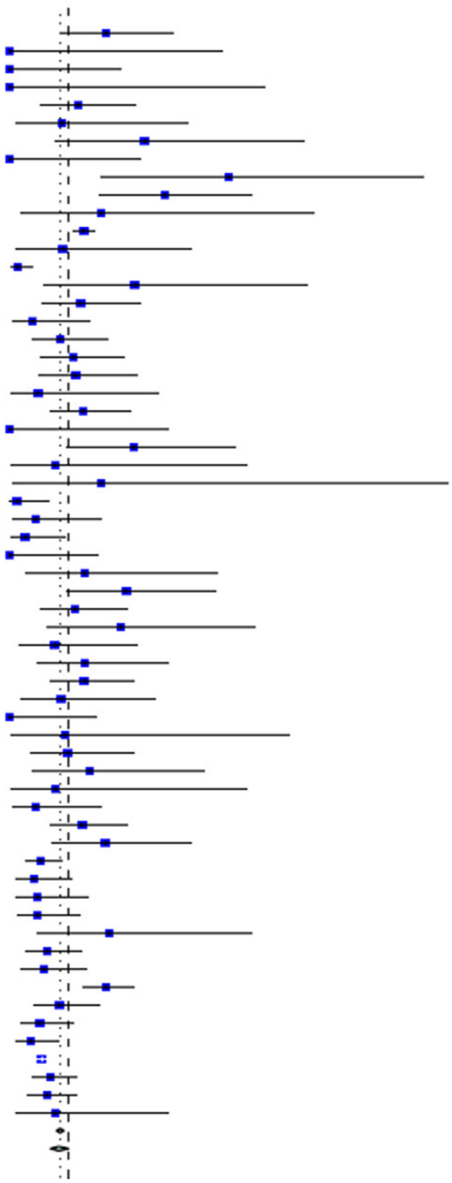



**Figure S15** Sub-group analysis of permanent spinal cord injury of studies reporting median CSF drain use in 0% patient's *vs.* 100% patients. CI, confidence interval; CSF, cerebrospinal fluid.

| Study | Events | Total | Proportion | 95%-CI |
|---|---|---|---|---|
| CSF drain <75% patients | | | | |
| henmi 2019 | 12 | 172 | 0.07 | [0.04; 0.12] |
| Thomas 2018 | 0 | 22 | 0.00 | [0.00; 0.15] |
| Abisi 2021 | 0 | 44 | 0.00 | [0.00; 0.08] |
| Neo 2011 | 0 | 18 | 0.00 | [0.00; 0.19] |
| Kunihara 2021 | 9 | 182 | 0.05 | [0.02; 0.09] |
| Fossaceca 2013 | 2 | 53 | 0.04 | [0.00; 0.13] |
| Zanetti 2015 | 5 | 51 | 0.10 | [0.03; 0.21] |
| Johns 2014 | 0 | 37 | 0.00 | [0.00; 0.09] |
| Baba 2017 | 7 | 44 | 0.16 | [0.07; 0.30] |
| Bisdas 2015 | 16 | 142 | 0.11 | [0.07; 0.18] |
| Chen 2017 | 2 | 30 | 0.07 | [0.01; 0.22] |
| Coselli 2016 | 178 | 3309 | 0.05 | [0.05; 0.06] |
| Dick 2008 | 2 | 52 | 0.04 | [0.00; 0.13] |
| Estrera 2015 | 3 | 519 | 0.01 | [0.00; 0.02] |
| Fukui 2016 | 4 | 44 | 0.09 | [0.03; 0.22] |
| Hiraoka 2018 | 9 | 175 | 0.05 | [0.02; 0.10] |
| Hnath 2008 | 2 | 121 | 0.02 | [0.00; 0.06] |
| Katsargyris 2015 | 8 | 218 | 0.04 | [0.02; 0.07] |
| Kulik 2011 | 10 | 218 | 0.05 | [0.02; 0.08] |
| Lee 2015 | 8 | 167 | 0.05 | [0.02; 0.09] |
| Lucatelli 2018 | 1 | 49 | 0.02 | [0.00; 0.11] |
| Martin 2009 | 14 | 261 | 0.05 | [0.03; 0.09] |
| Moulakakis 2015 | 0 | 30 | 0.00 | [0.00; 0.12] |
| Naughton 2012 | 9 | 100 | 0.09 | [0.04; 0.16] |
| Ockert 2009 | 1 | 30 | 0.03 | [0.00; 0.17] |
| Pearce 2008 | 1 | 15 | 0.07 | [0.00; 0.32] |
| Ranney 2018 | 1 | 192 | 0.01 | [0.00; 0.03] |
| Rodriguez 2008 | 2 | 106 | 0.02 | [0.00; 0.07] |
| Shiraev 2016 | 2 | 179 | 0.01 | [0.00; 0.04] |
| Si 2014 | 0 | 56 | 0.00 | [0.00; 0.06] |
| Stelzmueller 2019 | 3 | 55 | 0.05 | [0.01; 0.15] |
| Sugiura 2017 | 10 | 118 | 0.08 | [0.04; 0.15] |
| Yoo 2014 | 10 | 212 | 0.05 | [0.02; 0.09] |
| Youssef 2015 | 5 | 62 | 0.08 | [0.03; 0.18] |
| Arnaoutakis 2020 (endo) | 3 | 92 | 0.03 | [0.01; 0.09] |
| Barbosa Lima 2021 | 6 | 110 | 0.05 | [0.02; 0.11] |
| Bertoglio 2021 | 13 | 240 | 0.05 | [0.03; 0.09] |
| Bertoglio 2020 | 3 | 80 | 0.04 | [0.01; 0.11] |
| Branzan 2018 | 0 | 57 | 0.00 | [0.00; 0.06] |
| Conway 2022 | 1 | 25 | 0.04 | [0.00; 0.20] |
| Frankel 2020 | 6 | 142 | 0.04 | [0.02; 0.09] |
| Fujiyoshi 2019 | 4 | 69 | 0.06 | [0.02; 0.14] |
| Katsargyris 2021 | 1 | 30 | 0.03 | [0.00; 0.17] |
| Kitpanit 2021 | 2 | 106 | 0.02 | [0.00; 0.07] |
| Kouchouk 2019 | 15 | 285 | 0.05 | [0.03; 0.09] |
| Lima 2022 | 8 | 115 | 0.07 | [0.03; 0.13] |
| Marconde 2022 | 12 | 541 | 0.02 | [0.01; 0.04] |
| Motta 2019 | 4 | 223 | 0.02 | [0.00; 0.05] |
| Motta 2019 | 3 | 150 | 0.02 | [0.00; 0.06] |
| Muncan 2022 | 4 | 200 | 0.02 | [0.01; 0.05] |
| Muncan 2022 | 4 | 55 | 0.07 | [0.02; 0.18] |
| Oderich 2021 | 8 | 297 | 0.03 | [0.01; 0.05] |
| Seike 2022 | 5 | 204 | 0.02 | [0.01; 0.06] |
| Smith 2022 | 57 | 813 | 0.07 | [0.05; 0.09] |
| Tong 2022 | 10 | 278 | 0.04 | [0.02; 0.07] |
| Tong 2022 | 6 | 278 | 0.02 | [0.01; 0.05] |
| Tsilimparis 2018 | 5 | 329 | 0.02 | [0.00; 0.04] |
| Umegaki 2022 | 131 | 5699 | 0.02 | [0.02; 0.03] |
| Umegaki 2022 | 15 | 503 | 0.03 | [0.02; 0.05] |
| Van Calster 2019 | 10 | 373 | 0.03 | [0.01; 0.05] |
| Yang 2020 | 2 | 60 | 0.03 | [0.00; 0.12] |
| **Common effect model** | | **18437** | **0.04** | **[0.03; 0.04]** |
| **Random effects model** | | | **0.04** | **[0.03; 0.04]** |

Heterogeneity: $I^2 = 68\%$, $\tau^2 = 0.2970$, $p < 0.01$

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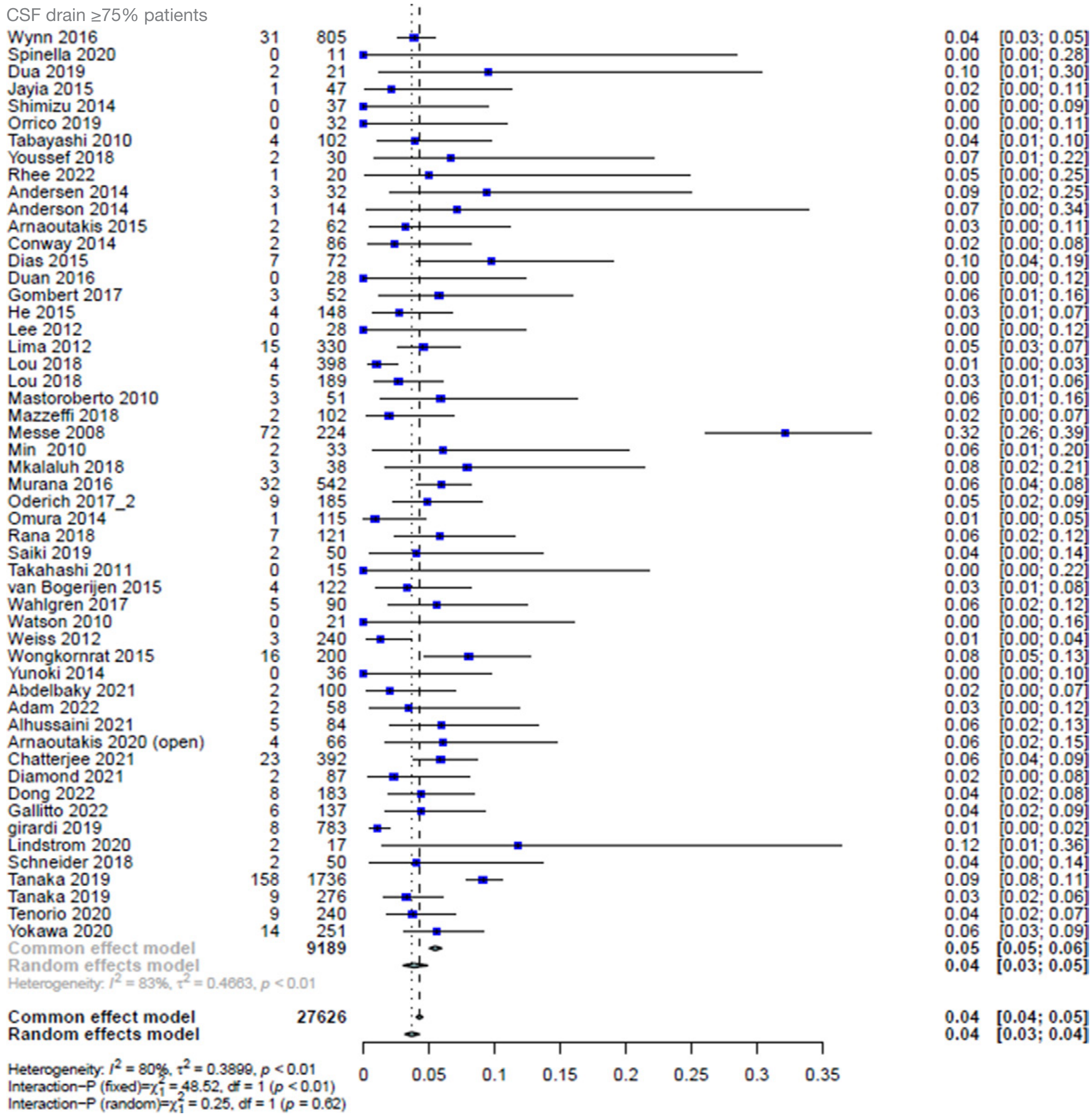
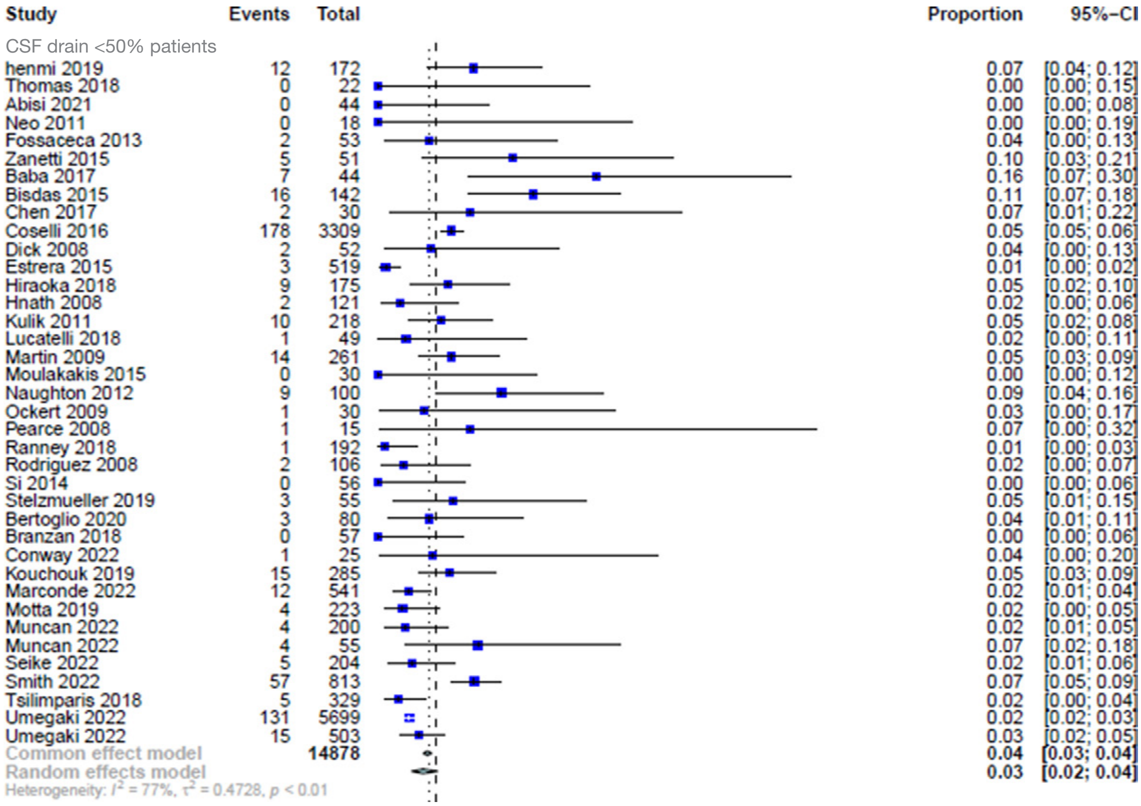



**Figure S16** Sub-group analysis of permanent spinal cord injury of studies reporting median CSF drain use in <75% patients *vs.* ≥75% patients. CI, confidence interval; CSF, cerebrospinal fluid.


https://dx.doi.org/10.21037/acs-2023-scp-14




 https://dx.doi.org/10.21037/acs-2023-scp-14

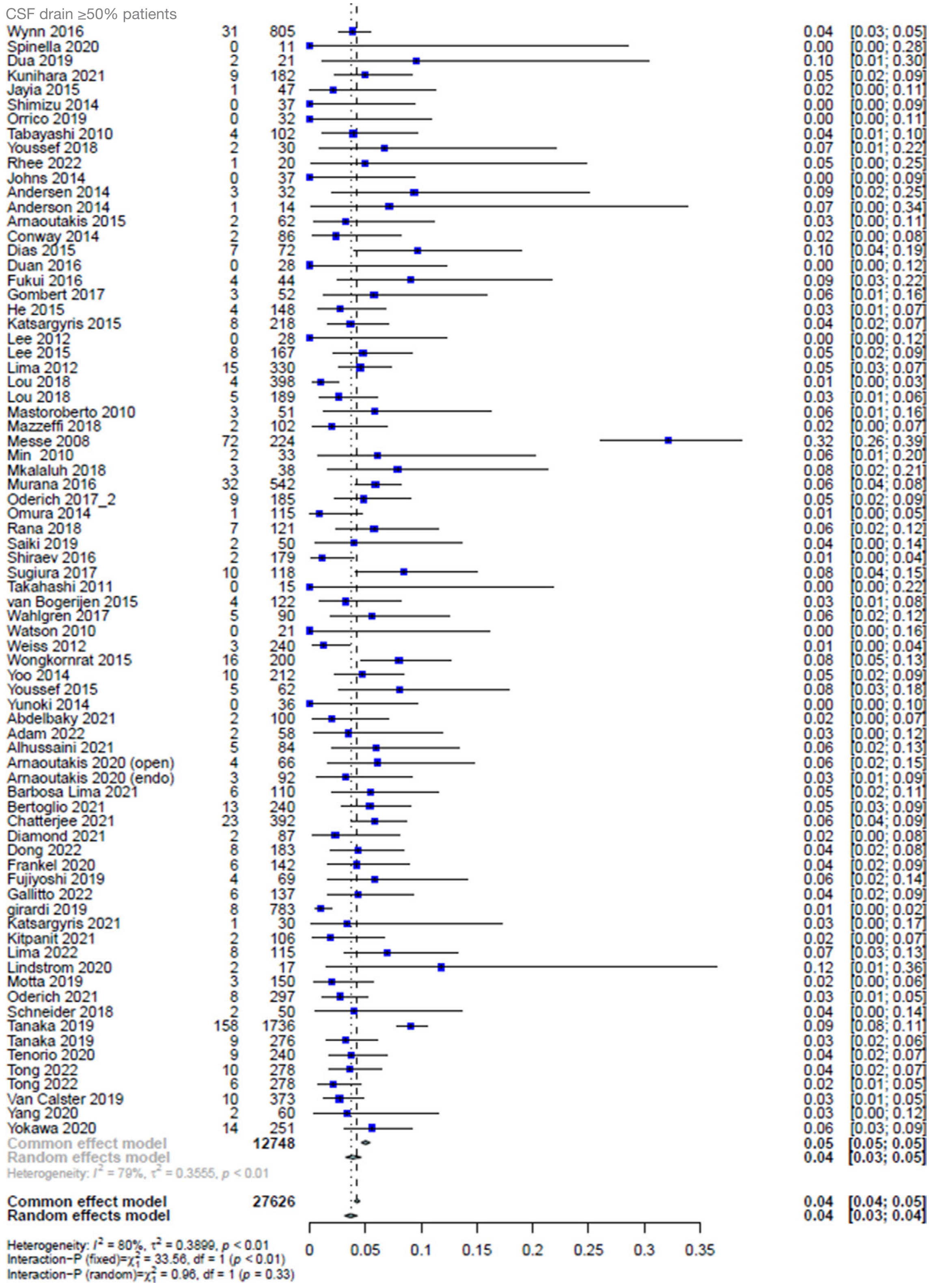
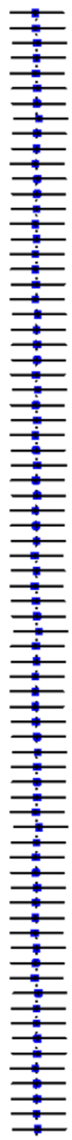


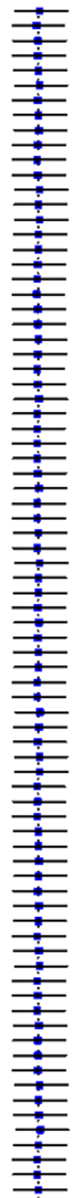

**Figure S17** Sub-group analysis of permanent spinal cord injury of studies reporting median CSF drain use in <50% patients *vs.* ≥50% patients. CI, confidence interval; CSF, cerebrospinal fluid.

 https://dx.doi.org/10.21037/acs-2023-scp-14



| Study | Proportion | 95%-CI | P-value | Tau2 | Tau | I2 |
|---|---|---|---|---|---|---|
| Omitting henmi 2019 | 0.03 | [0.03; 0.04] | . | 0.6105 | 0.7813 | 81% |
| Omitting hoshina 2021 | 0.03 | [0.03; 0.04] | . | 0.6147 | 0.7840 | 80% |
| Omitting jorgensen 2020 | 0.03 | [0.03; 0.04] | . | 0.6033 | 0.7767 | 81% |
| Omitting Juszczak 2020 | 0.03 | [0.03; 0.04] | . | 0.6081 | 0.7798 | 81% |
| Omitting Wynn 2016 | 0.03 | [0.03; 0.04] | . | 0.6143 | 0.7838 | 81% |
| Omitting Kurimoto 2008 | 0.03 | [0.03; 0.04] | . | 0.6038 | 0.7770 | 81% |
| Omitting Thomas 2018 | 0.03 | [0.03; 0.04] | . | 0.6059 | 0.7784 | 81% |
| Omitting grassi 2022 | 0.03 | [0.03; 0.04] | . | 0.5862 | 0.7656 | 81% |
| Omitting Abisi 2021 | 0.03 | [0.03; 0.04] | . | 0.6033 | 0.7767 | 81% |
| Omitting Neo 2011 | 0.03 | [0.03; 0.04] | . | 0.6063 | 0.7787 | 81% |
| Omitting Sweet 2015 | 0.03 | [0.03; 0.04] | . | 0.6095 | 0.7807 | 81% |
| Omitting Mitchell 2011 | 0.03 | [0.03; 0.04] | . | 0.6033 | 0.7767 | 81% |
| Omitting Raupach 2013 | 0.03 | [0.03; 0.04] | . | 0.6065 | 0.7788 | 81% |
| Omitting Spinella 2020 | 0.03 | [0.03; 0.04] | . | 0.6069 | 0.7790 | 81% |
| Omitting Dua 2019 | 0.03 | [0.03; 0.04] | . | 0.6089 | 0.7803 | 81% |
| Omitting Malas 2021 | 0.03 | [0.03; 0.04] | . | 0.6087 | 0.7802 | 81% |
| Omitting Clough 2012 | 0.03 | [0.03; 0.04] | . | 0.6085 | 0.7801 | 81% |
| Omitting Kunihara 2021 | 0.03 | [0.03; 0.04] | . | 0.6130 | 0.7830 | 81% |
| Omitting Fossaceca 2013 | 0.03 | [0.03; 0.04] | . | 0.6109 | 0.7816 | 81% |
| Omitting Zanetti 2015 | 0.03 | [0.03; 0.04] | . | 0.6074 | 0.7794 | 81% |
| Omitting Bockler 2009 | 0.03 | [0.03; 0.04] | . | 0.6021 | 0.7759 | 81% |
| Omitting Jayia 2015 | 0.03 | [0.03; 0.04] | . | 0.6086 | 0.7801 | 81% |
| Omitting Shimizu 2014 | 0.03 | [0.03; 0.04] | . | 0.6041 | 0.7773 | 81% |
| Omitting Orrico 2019 | 0.03 | [0.03; 0.04] | . | 0.6048 | 0.7777 | 81% |
| Omitting Tabayashi 2010 | 0.03 | [0.03; 0.04] | . | 0.6122 | 0.7825 | 81% |
| Omitting Da Rocha 2010 | 0.03 | [0.03; 0.04] | . | 0.6017 | 0.7757 | 81% |
| Omitting Youssef 2018 | 0.03 | [0.03; 0.04] | . | 0.6103 | 0.7812 | 81% |
| Omitting Zha 2018 | 0.03 | [0.03; 0.04] | . | 0.6059 | 0.7784 | 81% |
| Omitting Le Huu 2022 | 0.03 | [0.03; 0.04] | . | 0.6097 | 0.7808 | 81% |
| Omitting Rhee 2022 | 0.03 | [0.03; 0.04] | . | 0.6095 | 0.7807 | 81% |
| Omitting Johns 2014 | 0.03 | [0.03; 0.04] | . | 0.6041 | 0.7773 | 81% |
| Omitting Afifi 2015 | 0.03 | [0.03; 0.04] | . | 0.6107 | 0.7815 | 81% |
| Omitting Andacheh 2011 | 0.03 | [0.03; 0.04] | . | 0.6064 | 0.7787 | 81% |
| Omitting Andersen 2014 | 0.03 | [0.03; 0.04] | . | 0.6088 | 0.7802 | 81% |
| Omitting Anderson 2014 | 0.03 | [0.03; 0.04] | . | 0.6091 | 0.7805 | 81% |
| Omitting Arnaoutakis 2015 | 0.03 | [0.03; 0.04] | . | 0.6106 | 0.7814 | 81% |
| Omitting Baba 2017 | 0.03 | [0.03; 0.04] | . | 0.5975 | 0.7730 | 81% |
| Omitting Bashir 2014 | 0.03 | [0.03; 0.04] | . | 0.6106 | 0.7814 | 81% |
| Omitting Bisdas 2015 | 0.03 | [0.03; 0.04] | . | 0.6013 | 0.7755 | 81% |
| Omitting Botsios 2014 | 0.03 | [0.03; 0.04] | . | 0.6096 | 0.7808 | 81% |
| Omitting Canaud 2018 | 0.03 | [0.03; 0.04] | . | 0.6057 | 0.7783 | 81% |
| Omitting Chen 2013 | 0.03 | [0.03; 0.04] | . | 0.5888 | 0.7673 | 81% |
| Omitting Chen 2017 | 0.03 | [0.03; 0.04] | . | 0.6103 | 0.7812 | 81% |
| Omitting Conway 2014 | 0.03 | [0.03; 0.04] | . | 0.6094 | 0.7806 | 81% |
| Omitting Coselli 2016 | 0.03 | [0.03; 0.04] | . | 0.6130 | 0.7830 | 81% |
| Omitting Davidovic 2011 | 0.03 | [0.03; 0.04] | . | 0.6063 | 0.7787 | 81% |
| Omitting Dias 2015 | 0.03 | [0.03; 0.04] | . | 0.6067 | 0.7789 | 81% |
| Omitting Dick 2008 | 0.03 | [0.03; 0.04] | . | 0.6109 | 0.7816 | 81% |
| Omitting Dick 2008 | 0.03 | [0.03; 0.04] | . | 0.6069 | 0.7790 | 81% |
| Omitting Ding 2018 | 0.03 | [0.03; 0.04] | . | 0.5984 | 0.7736 | 81% |
| Omitting Du 2019 | 0.03 | [0.03; 0.04] | . | 0.6078 | 0.7796 | 81% |
| Omitting Duan 2016 | 0.03 | [0.03; 0.04] | . | 0.6052 | 0.7780 | 81% |
| Omitting Dufour 2015 | 0.03 | [0.03; 0.04] | . | 0.6063 | 0.7787 | 81% |
| Omitting Eagleton 2016 | 0.03 | [0.03; 0.04] | . | 0.6139 | 0.7835 | 81% |
| Omitting Esfrera 2015 | 0.03 | [0.03; 0.04] | . | 0.5868 | 0.7660 | 81% |
| Omitting Faure 2018 | 0.03 | [0.03; 0.04] | . | 0.6090 | 0.7804 | 81% |
| Omitting Fernandez 2016 | 0.03 | [0.03; 0.04] | . | 0.6129 | 0.7829 | 81% |
| Omitting Ferreira 2008 | 0.03 | [0.03; 0.04] | . | 0.6087 | 0.7802 | 81% |
| Omitting Fioranelli 2011 | 0.03 | [0.03; 0.04] | . | 0.6058 | 0.7783 | 81% |
| Omitting Fujikawa 2018 | 0.03 | [0.03; 0.04] | . | 0.6131 | 0.7830 | 81% |
| Omitting Fukui 2016 | 0.03 | [0.03; 0.04] | . | 0.6087 | 0.7802 | 81% |
| Omitting Garbade 2010 | 0.03 | [0.03; 0.04] | . | 0.5796 | 0.7613 | 81% |
| Omitting Gillen 2015 | 0.03 | [0.03; 0.04] | . | 0.6096 | 0.7808 | 81% |
| Omitting Gombert 2017 | 0.03 | [0.03; 0.04] | . | 0.6113 | 0.7818 | 81% |
| Omitting Gombert 2018 | 0.03 | [0.03; 0.04] | . | 0.5769 | 0.7595 | 81% |
| Omitting Guangqi 2009 | 0.03 | [0.03; 0.04] | . | 0.5942 | 0.7709 | 81% |
| Omitting Guo 2015 | 0.03 | [0.03; 0.04] | . | 0.6086 | 0.7801 | 81% |
| Omitting He 2015 | 0.03 | [0.03; 0.04] | . | 0.6110 | 0.7817 | 81% |
| Omitting Heijmen 2012 | 0.03 | [0.03; 0.04] | . | 0.6039 | 0.7771 | 81% |
| Omitting Hicks 2017 | 0.03 | [0.03; 0.04] | . | 0.6058 | 0.7783 | 81% |
| Omitting Hiraoka 2018 | 0.03 | [0.03; 0.04] | . | 0.6129 | 0.7829 | 81% |
| Omitting Hnath 2008 | 0.03 | [0.03; 0.04] | . | 0.6070 | 0.7791 | 81% |
| Omitting Huang 2016 | 0.03 | [0.03; 0.04] | . | 0.6053 | 0.7780 | 81% |
| Omitting Inglese 2008 | 0.03 | [0.03; 0.04] | . | 0.6090 | 0.7804 | 81% |
| Omitting Jing 2008 | 0.03 | [0.03; 0.04] | . | 0.6004 | 0.7749 | 81% |

 https://dx.doi.org/10.21037/acs-2023-scp-14



| | | | | | | |
|---|---|---|---|---|---|---|
| Omitting Kamada 2015 | 0.03 | [0.03; 0.04] | . | 0.6024 | 0.7762 | 81% |
| Omitting Kasprzak 2014 | 0.03 | [0.03; 0.04] | . | 0.5746 | 0.7580 | 80% |
| Omitting Katsargyris 2015 | 0.03 | [0.03; 0.04] | . | 0.6132 | 0.7831 | 81% |
| Omitting Kieffer 2008 | 0.03 | [0.03; 0.04] | . | 0.6131 | 0.7830 | 81% |
| Omitting Kinoshita 2015 | 0.03 | [0.03; 0.04] | . | 0.6067 | 0.7789 | 81% |
| Omitting Kitamura 2013 | 0.03 | [0.03; 0.04] | . | 0.6022 | 0.7760 | 81% |
| Omitting Kulik 2011 | 0.03 | [0.03; 0.04] | . | 0.6134 | 0.7832 | 81% |
| Omitting Kunihara 2009 | 0.03 | [0.03; 0.04] | . | 0.6064 | 0.7787 | 81% |
| Omitting Lee 2012 | 0.03 | [0.03; 0.04] | . | 0.6052 | 0.7780 | 81% |
| Omitting Lee 2015 | 0.03 | [0.03; 0.04] | . | 0.6130 | 0.7830 | 81% |
| Omitting Lee 2015 | 0.03 | [0.03; 0.04] | . | 0.6101 | 0.7811 | 81% |
| Omitting Lima 2012 | 0.03 | [0.03; 0.04] | . | 0.6137 | 0.7834 | 81% |
| Omitting Liu 2011 | 0.03 | [0.03; 0.04] | . | 0.6024 | 0.7762 | 81% |
| Omitting Lobato 2012 | 0.03 | [0.03; 0.04] | . | 0.6066 | 0.7788 | 81% |
| Omitting Lou 2018 | 0.03 | [0.03; 0.04] | . | 0.5980 | 0.7733 | 81% |
| Omitting Lou 2018 | 0.03 | [0.03; 0.04] | . | 0.6112 | 0.7818 | 81% |
| Omitting Lucatelli 2018 | 0.03 | [0.03; 0.04] | . | 0.6084 | 0.7800 | 81% |
| Omitting Manning 2009 | 0.03 | [0.03; 0.04] | . | 0.6113 | 0.7818 | 81% |
| Omitting Martin 2009 | 0.03 | [0.03; 0.04] | . | 0.6129 | 0.7829 | 81% |
| Omitting Marzelle 2015 | 0.03 | [0.03; 0.04] | . | 0.5964 | 0.7723 | 81% |
| Omitting Mastoroberto 2010 | 0.03 | [0.03; 0.04] | . | 0.6112 | 0.7818 | 81% |
| Omitting Mastoroberto 2010 | 0.03 | [0.03; 0.04] | . | 0.6087 | 0.7802 | 81% |
| Omitting Mazzeffi 2018 | 0.03 | [0.03; 0.04] | . | 0.6083 | 0.7800 | 81% |
| Omitting Meltzer 2017 | 0.03 | [0.03; 0.04] | . | 0.6096 | 0.7808 | 81% |
| Omitting Messe 2008 | 0.03 | [0.03; 0.04] | . | 0.5404 | 0.7351 | 76% |
| Omitting Min  2010 | 0.03 | [0.03; 0.04] | . | 0.6105 | 0.7813 | 81% |
| Omitting Mizoguchi 2017 | 0.03 | [0.03; 0.04] | . | 0.6040 | 0.7772 | 81% |
| Omitting Mkalaluh 2018 | 0.03 | [0.03; 0.04] | . | 0.6099 | 0.7809 | 81% |
| Omitting Monaco 2018 | 0.03 | [0.03; 0.04] | . | 0.6064 | 0.7787 | 81% |
| Omitting Monnot 2018 | 0.03 | [0.03; 0.04] | . | 0.6100 | 0.7810 | 81% |
| Omitting Monnot 2018 | 0.03 | [0.03; 0.04] | . | 0.6089 | 0.7803 | 81% |
| Omitting Mosquera 2009 | 0.03 | [0.03; 0.04] | . | 0.6095 | 0.7807 | 81% |
| Omitting Moulakakis 2015 | 0.03 | [0.03; 0.04] | . | 0.6050 | 0.7778 | 81% |
| Omitting Murana 2016 | 0.03 | [0.03; 0.04] | . | 0.6121 | 0.7824 | 81% |
| Omitting Naughton 2012 | 0.03 | [0.03; 0.04] | . | 0.6073 | 0.7793 | 81% |
| Omitting Ockert 2009 | 0.03 | [0.03; 0.04] | . | 0.6095 | 0.7807 | 81% |
| Omitting Oderich 2017_2 | 0.03 | [0.03; 0.04] | . | 0.6131 | 0.7830 | 81% |
| Omitting Omura 2014 | 0.03 | [0.03; 0.04] | . | 0.6024 | 0.7762 | 81% |
| Omitting Omura 2017 | 0.03 | [0.03; 0.04] | . | 0.6125 | 0.7827 | 81% |
| Omitting Patel 2009 | 0.03 | [0.03; 0.04] | . | 0.6103 | 0.7812 | 81% |
| Omitting Pearce 2008 | 0.03 | [0.03; 0.04] | . | 0.6092 | 0.7805 | 81% |
| Omitting Piscione 2007 | 0.03 | [0.03; 0.04] | . | 0.6046 | 0.7776 | 81% |
| Omitting Pitton 2008 | 0.03 | [0.03; 0.04] | . | 0.6096 | 0.7808 | 81% |
| Omitting Qing 2012 | 0.03 | [0.03; 0.04] | . | 0.6095 | 0.7807 | 81% |
| Omitting Rahe.Meyer 2009 | 0.03 | [0.03; 0.04] | . | 0.6063 | 0.7787 | 81% |
| Omitting Rajbanshi 2015 | 0.03 | [0.03; 0.04] | . | 0.6080 | 0.7797 | 81% |
| Omitting Rana 2018 | 0.03 | [0.03; 0.04] | . | 0.6121 | 0.7824 | 81% |
| Omitting Ranney 2018 | 0.03 | [0.03; 0.04] | . | 0.5955 | 0.7717 | 81% |
| Omitting Rodriguez 2008 | 0.03 | [0.03; 0.04] | . | 0.6081 | 0.7798 | 81% |
| Omitting Saiki 2019 | 0.03 | [0.03; 0.04] | . | 0.6109 | 0.7816 | 81% |
| Omitting Shiraev 2016 | 0.03 | [0.03; 0.04] | . | 0.6026 | 0.7763 | 81% |
| Omitting Si 2014 | 0.03 | [0.03; 0.04] | . | 0.6018 | 0.7758 | 81% |
| Omitting Spanos 2018 | 0.03 | [0.03; 0.04] | . | 0.6049 | 0.7778 | 81% |
| Omitting Stelzmueller 2019 | 0.03 | [0.03; 0.04] | . | 0.6114 | 0.7819 | 81% |
| Omitting Sugiura 2017 | 0.03 | [0.03; 0.04] | . | 0.6080 | 0.7798 | 81% |
| Omitting Sultan 2018 | 0.03 | [0.03; 0.04] | . | 0.6094 | 0.7807 | 81% |
| Omitting Takahashi 2011 | 0.03 | [0.03; 0.04] | . | 0.6066 | 0.7788 | 81% |
| Omitting Tang 2011 | 0.03 | [0.03; 0.04] | . | 0.6050 | 0.7778 | 81% |
| Omitting Trimarchi 2010 | 0.03 | [0.03; 0.04] | . | 0.6063 | 0.7787 | 81% |
| Omitting Ullery 2012 | 0.03 | [0.03; 0.04] | . | 0.6135 | 0.7833 | 81% |
| Omitting Vaislic 2014 | 0.03 | [0.03; 0.04] | . | 0.6058 | 0.7783 | 81% |
| Omitting van Bogerijen 2015 | 0.03 | [0.03; 0.04] | . | 0.6119 | 0.7822 | 81% |
| Omitting Wahlgren 2017 | 0.03 | [0.03; 0.04] | . | 0.6120 | 0.7823 | 81% |
| Omitting Watson 2010 | 0.03 | [0.03; 0.04] | . | 0.6060 | 0.7785 | 81% |
| Omitting Weiss 2012 | 0.03 | [0.03; 0.04] | . | 0.6029 | 0.7765 | 81% |
| Omitting Wongkornrat 2015 | 0.03 | [0.03; 0.04] | . | 0.6083 | 0.7799 | 81% |
| Omitting Yoo 2014 | 0.03 | [0.03; 0.04] | . | 0.6133 | 0.7831 | 81% |
| Omitting Youssef 2015 | 0.03 | [0.03; 0.04] | . | 0.6095 | 0.7807 | 81% |
| Omitting Yunoki 2014 | 0.03 | [0.03; 0.04] | . | 0.6043 | 0.7774 | 81% |
| Omitting Yuri 2012 | 0.03 | [0.03; 0.04] | . | 0.6103 | 0.7812 | 81% |
| Omitting Zamor 2015 | 0.03 | [0.03; 0.04] | . | 0.6117 | 0.7821 | 81% |
| Omitting Zhang 2017 | 0.03 | [0.03; 0.04] | . | 0.6122 | 0.7824 | 81% |
| Omitting Zhao 2018 | 0.03 | [0.03; 0.04] | . | 0.6003 | 0.7748 | 81% |
| Omitting Abdelbaky 2021 | 0.03 | [0.03; 0.04] | . | 0.6085 | 0.7801 | 81% |
| Omitting Acher 2019 (open) | 0.03 | [0.03; 0.04] | . | 0.6073 | 0.7793 | 81% |
| Omitting Acher 2019 (endo) | 0.03 | [0.03; 0.04] | . | 0.5923 | 0.7696 | 81% |
| Omitting Adam 2022 | 0.03 | [0.03; 0.04] | . | 0.6108 | 0.7815 | 81% |
| Omitting Alhussaini 2021 | 0.03 | [0.03; 0.04] | . | 0.6117 | 0.7821 | 81% |
| Omitting Arnaoutakis 2020 (open) | 0.03 | [0.03; 0.04] | . | 0.6114 | 0.7819 | 81% |
| Omitting Arnaoutakis 2020 (endo) | 0.03 | [0.03; 0.04] | . | 0.6114 | 0.7819 | 81% |

 https://dx.doi.org/10.21037/acs-2023-scp-14

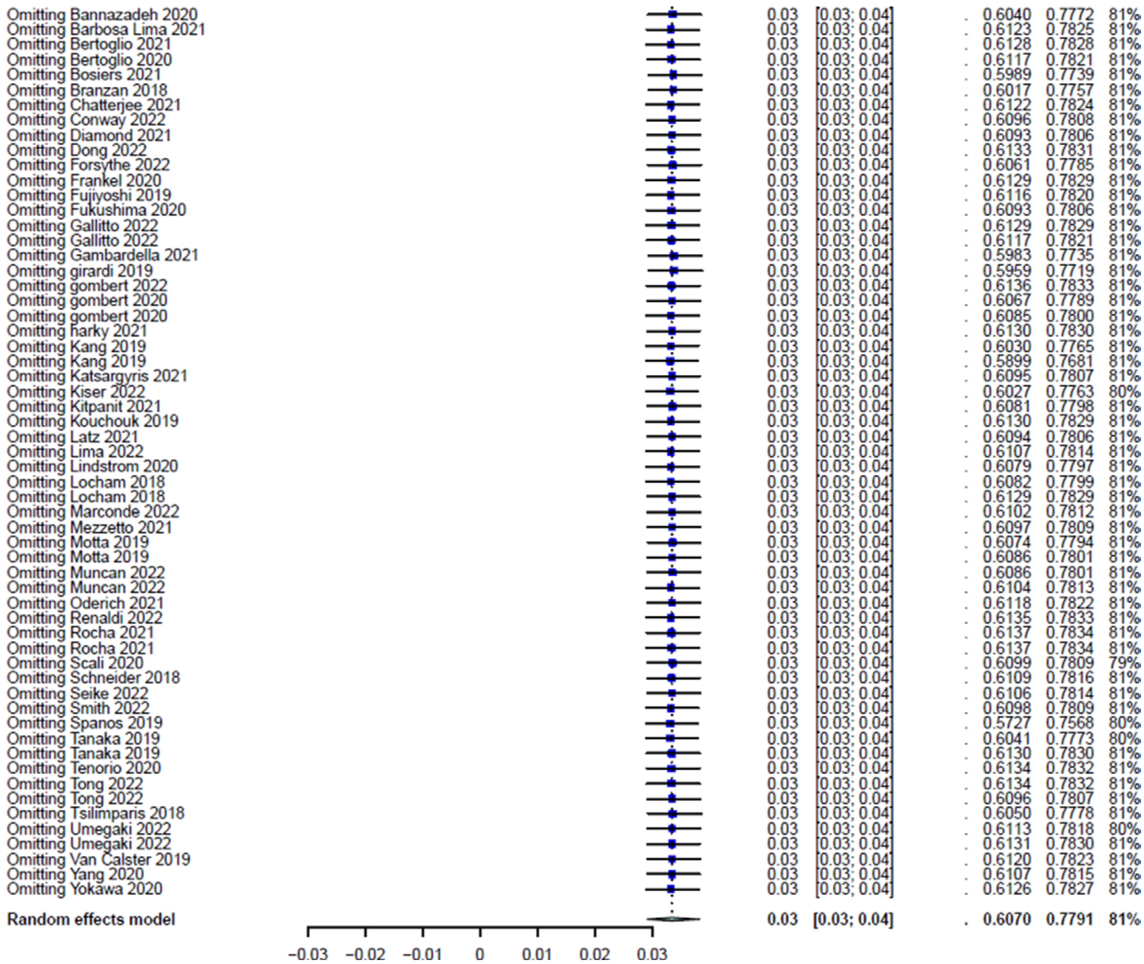
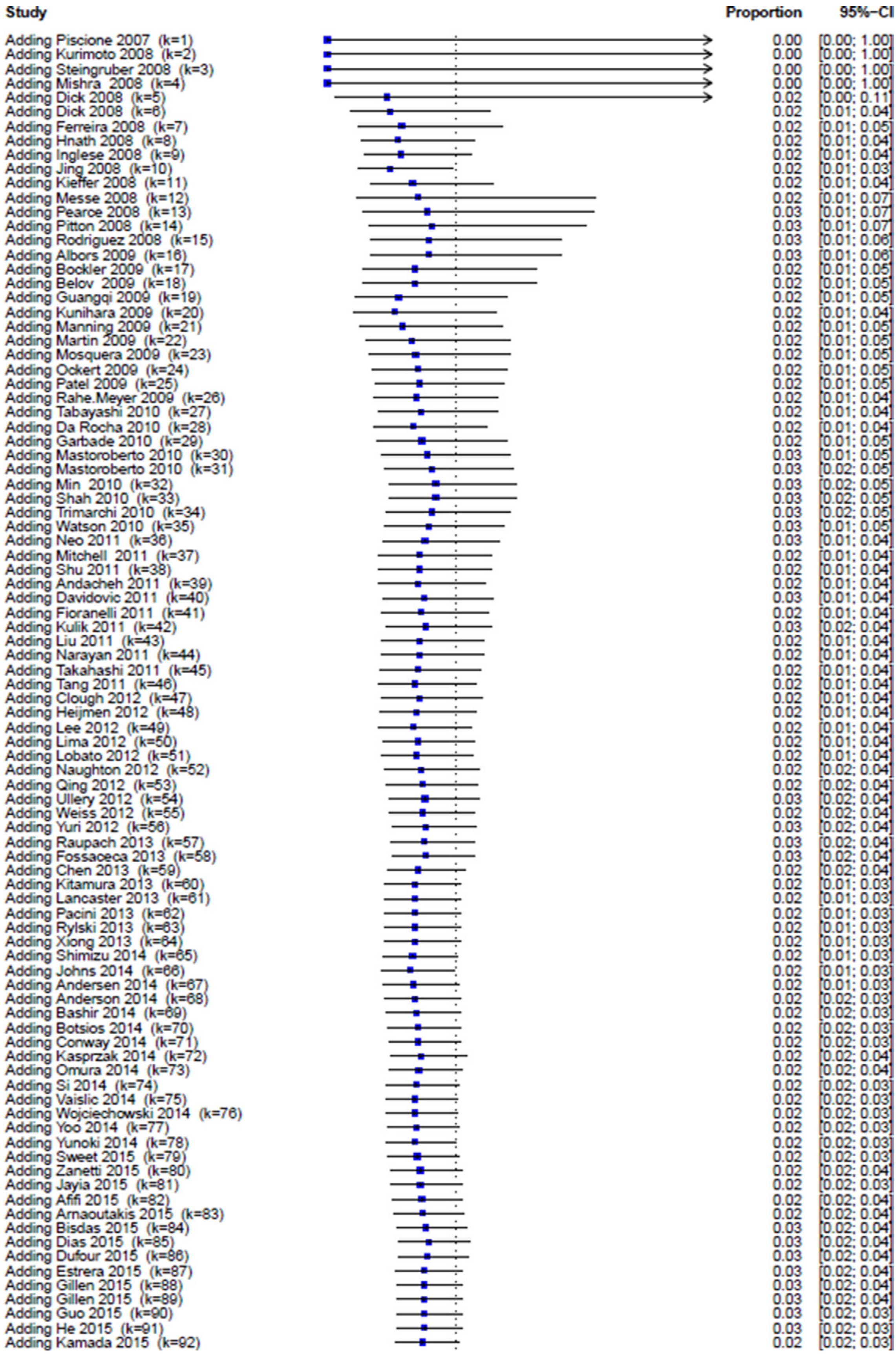


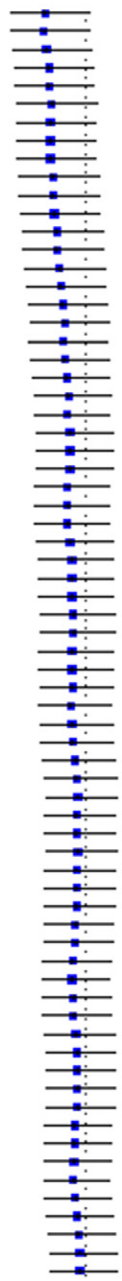

**Figure S18** Leave one out analysis for the primary outcome of permanent spinal cord injury. CI, confidence interval.

 https://dx.doi.org/10.21037/acs-2023-scp-14




 https://dx.doi.org/10.21037/acs-2023-scp-14

| | | |
|---|---|---|
| Adding Katsargyns 2015 (k=93) | 0.03 | [0.02; 0.03] |
| Adding Kinoshita 2015 (k=94) | 0.02 | [0.02; 0.03] |
| Adding Lee 2015 (k=95) | 0.03 | [0.02; 0.03] |
| Adding Lee 2015 (k=96) | 0.03 | [0.02; 0.04] |
| Adding Li 2015 (k=97) | 0.03 | [0.02; 0.04] |
| Adding Marzelle 2015 (k=98) | 0.03 | [0.02; 0.04] |
| Adding Moulakakis 2015 (k=99) | 0.03 | [0.02; 0.04] |
| Adding Nomura 2015 (k=100) | 0.03 | [0.02; 0.04] |
| Adding Piffaretti 2015 (k=101) | 0.03 | [0.02; 0.04] |
| Adding Rajbanshi 2015 (k=102) | 0.03 | [0.02; 0.04] |
| Adding Rossi 2015 (k=103) | 0.03 | [0.02; 0.04] |
| Adding van Bogerijen 2015 (k=104) | 0.03 | [0.02; 0.04] |
| Adding Wongkornrat 2015 (k=105) | 0.03 | [0.02; 0.04] |
| Adding Yaffee 2015 (k=106) | 0.03 | [0.02; 0.04] |
| Adding Youssef 2015 (k=107) | 0.03 | [0.02; 0.04] |
| Adding Zamor 2015 (k=108) | 0.03 | [0.02; 0.04] |
| Adding Wynn 2016 (k=109) | 0.03 | [0.02; 0.04] |
| Adding Coselli 2016 (k=110) | 0.03 | [0.02; 0.04] |
| Adding Duan 2016 (k=111) | 0.03 | [0.02; 0.04] |
| Adding Eagleton 2016 (k=112) | 0.03 | [0.02; 0.04] |
| Adding Fernandez 2016 (k=113) | 0.03 | [0.02; 0.04] |
| Adding Fukui 2016 (k=114) | 0.03 | [0.02; 0.04] |
| Adding Huang 2016 (k=115) | 0.03 | [0.02; 0.04] |
| Adding Murana 2016 (k=116) | 0.03 | [0.02; 0.04] |
| Adding Naguib 2016 (k=117) | 0.03 | [0.02; 0.04] |
| Adding Pompa 2016 (k=118) | 0.03 | [0.02; 0.04] |
| Adding Shiraev 2016 (k=119) | 0.03 | [0.02; 0.04] |
| Adding Song 2016 (k=120) | 0.03 | [0.02; 0.04] |
| Adding Zeng 2016 (k=121) | 0.03 | [0.02; 0.04] |
| Adding Baba 2017 (k=122) | 0.03 | [0.02; 0.04] |
| Adding Chen 2017 (k=123) | 0.03 | [0.02; 0.04] |
| Adding Conrad 2017 (k=124) | 0.03 | [0.02; 0.04] |
| Adding Gallitto 2017 (k=125) | 0.03 | [0.02; 0.04] |
| Adding Gombert 2017 (k=126) | 0.03 | [0.02; 0.04] |
| Adding He 2017 (k=127) | 0.03 | [0.02; 0.04] |
| Adding Hicks 2017 (k=128) | 0.03 | [0.02; 0.04] |
| Adding Liu 2017 (k=129) | 0.03 | [0.02; 0.04] |
| Adding Meltzer 2017 (k=130) | 0.03 | [0.02; 0.04] |
| Adding Mizoguchi 2017 (k=131) | 0.03 | [0.02; 0.04] |
| Adding Oderich 2017_2 (k=132) | 0.03 | [0.02; 0.04] |
| Adding Omura 2017 (k=133) | 0.03 | [0.02; 0.04] |
| Adding Sugiura 2017 (k=134) | 0.03 | [0.02; 0.04] |
| Adding Wahlgren 2017 (k=135) | 0.03 | [0.03; 0.04] |
| Adding Zhang 2017 (k=136) | 0.03 | [0.03; 0.04] |
| Adding Thomas 2018 (k=137) | 0.03 | [0.03; 0.04] |
| Adding Zhu 2018 (k=138) | 0.03 | [0.03; 0.04] |
| Adding Youssef 2018 (k=139) | 0.03 | [0.03; 0.04] |
| Adding Zha 2018 (k=140) | 0.03 | [0.03; 0.04] |
| Adding Al Adas 2018 (k=141) | 0.03 | [0.03; 0.04] |
| Adding Bertoglio 2018 (k=142) | 0.03 | [0.03; 0.04] |
| Adding Canaud 2018 (k=143) | 0.03 | [0.02; 0.04] |
| Adding Clough 2018 (k=144) | 0.03 | [0.02; 0.04] |
| Adding Ding 2018 (k=145) | 0.03 | [0.02; 0.04] |
| Adding Faure 2018 (k=146) | 0.03 | [0.02; 0.04] |
| Adding Fujikawa 2018 (k=147) | 0.03 | [0.02; 0.04] |
| Adding Gocze 2018 (k=148) | 0.03 | [0.02; 0.04] |
| Adding Gombert 2018 (k=149) | 0.03 | [0.03; 0.04] |
| Adding Hiraoka 2018 (k=150) | 0.03 | [0.03; 0.04] |
| Adding Kratimenos 2018 (k=151) | 0.03 | [0.03; 0.04] |
| Adding Li 2018_2 (k=152) | 0.03 | [0.03; 0.04] |
| Adding Lortz 2018 (k=153) | 0.03 | [0.03; 0.04] |
| Adding Lou 2018 (k=154) | 0.03 | [0.02; 0.04] |
| Adding Lou 2018 (k=155) | 0.03 | [0.02; 0.04] |
| Adding Lucatelli 2018 (k=156) | 0.03 | [0.02; 0.04] |
| Adding Mazzeffi 2018 (k=157) | 0.03 | [0.02; 0.04] |
| Adding Mkalaluh 2018 (k=158) | 0.03 | [0.03; 0.04] |
| Adding Monaco 2018 (k=159) | 0.03 | [0.03; 0.04] |
| Adding Monnot 2018 (k=160) | 0.03 | [0.03; 0.04] |
| Adding Monnot 2018 (k=161) | 0.03 | [0.03; 0.04] |
| Adding Peidro 2018 (k=162) | 0.03 | [0.03; 0.04] |



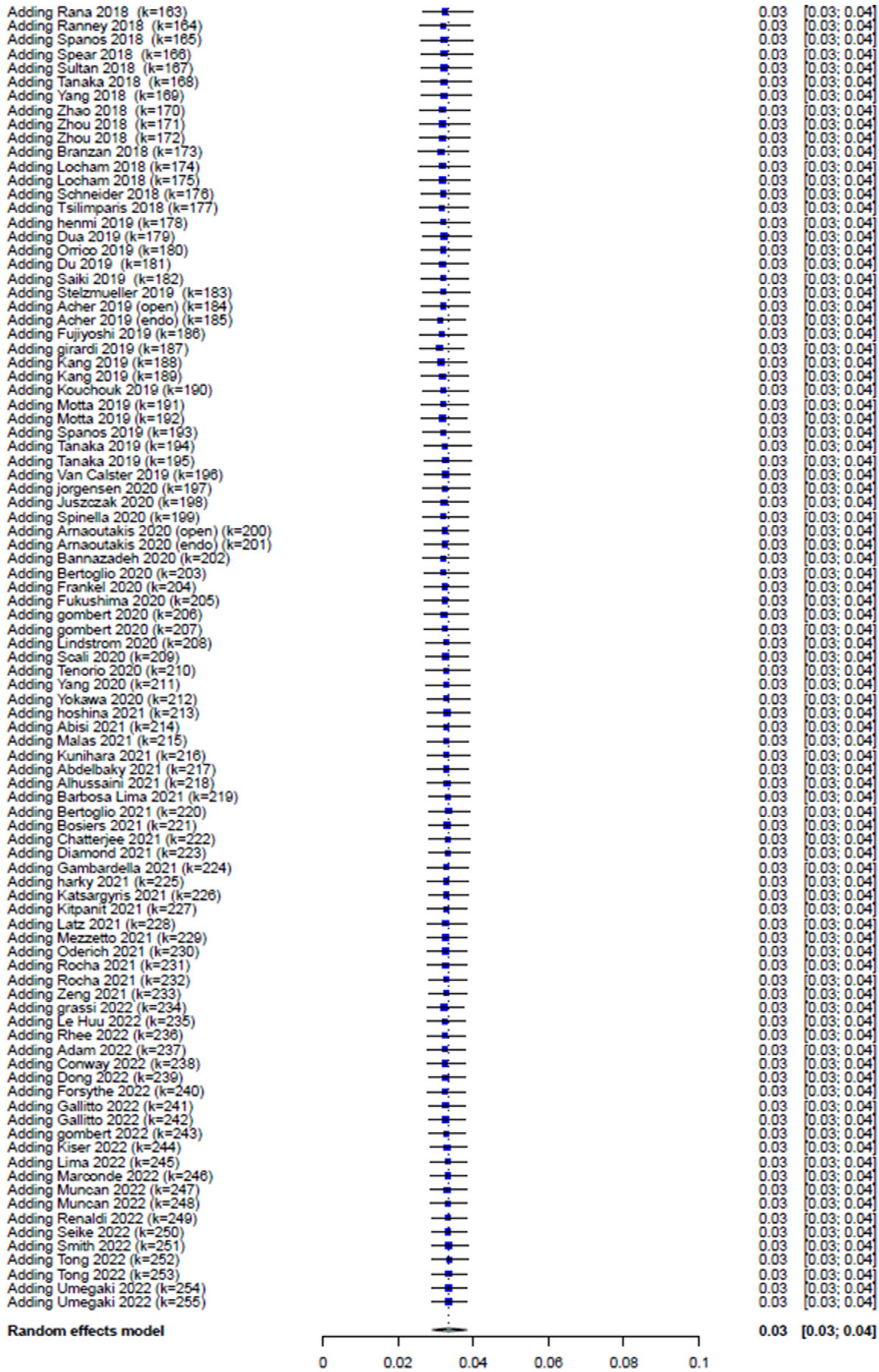



**Figure S19** Permanent SCI trend based on years. SCI, spinal cord injury.


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**Table S1** Full search strategy

| Ovid MEDLINE ALL (July 1, 2018 to September 13, 2022) | |
|---|---|
| Searched on September 13, 2022 | |
| Line # | Search |
| 1 | Aneurysm/ and (Aorta, Thoracic/ or Aorta, Abdominal/ or Aorta/) |
| 2 | Aortic Aneurysm/ |
| 3 | Aortic Aneurysm, Thoracic/ |
| 4 | Aortic Aneurysm, Abdominal/ |
| 5 | ((aneurysm* or aneurism* or aneurysma*) adj2 (aorta* or aortic*)).tw. |
| 6 | Marfan Syndrome/ |
| 7 | (Marfan syndrome or Marfan's syndrome or Marfans syndrome or marfan abiotrophy or Marfan disease or Marfan's disease or Marfans disease or Marfan achard syndrome or Marfan's achard syndrome or Marfans achard syndrome or Marfan hallez syndrome or Marfan's hallez syndrome or Marfans hallez syndrome).tw. |
| 8 | Loeys-Dietz Syndrome/ |
| 9 | (Loeys-Dietz Syndrome or LoeysDietz Syndrome).tw. |
| 10 | or/1-9 |
| 11 | (TEVAR or TAAA or TAA).tw. |
| 12 | ((thoracic or thoracoabdominal) adj2 (aorta* or aortic*)).tw. |
| 13 | 11 or 12 |
| 14 | 10 and 13 |
| 15 | limit 14 to (english language and yr="2008 -Current") |

| Ovid EMBASE (July 1, 2018 to September 13, 2022) | |
|---|---|
| Searched on September 13, 2022 | |
| Line # | Search |
| 1 | aneurysm/ and (thoracic aorta/ or abdominal aorta/ or aorta/) |
| 2 | thoracic aorta aneurysm/ |
| 3 | thoracoabdominal aorta aneurysm/ or abdominal aorta aneurysm/ |
| 4 | aortic aneurysm/ |
| 5 | ((aneurysm* or aneurism* or aneurysma*) adj2 (aorta* or aortic*)).tw. |
| 6 | Marfan syndrome/ |
| 7 | (Marfan syndrome or Marfan's syndrome or Marfans syndrome or marfan abiotrophy or Marfan disease or Marfan's disease or Marfans disease or Marfan achard syndrome or Marfan's achard syndrome or Marfans achard syndrome or Marfan hallez syndrome or Marfan's hallez syndrome or Marfans hallez syndrome).tw. |
| 8 | Loeys Dietz syndrome/ |
| 9 | (Loeys-Dietz Syndrome or LoeysDietz Syndrome).tw. |
| 10 | or/1-9 |
| 11 | (TEVAR or TAAA or TAA).tw. |
| 12 | ((thoracic or thoracoabdominal) adj2 (aorta* or aortic*)).tw. |
| 13 | 11 or 12 |
| 14 | 10 and 13 |
| 15 | limit 14 to (english language and yr="2008 -Current") |

| Cochrane Library (Wiley; July 1, 2018 to September 13, 2022) | |
|---|---|
| Searched on September 13, 2022 | |
| Line # | Search |
| #1 | MeSH descriptor: [Aneurysm] this term only |
| #2 | MeSH descriptor: [Aorta, Thoracic] this term only |
| #3 | MeSH descriptor: [Aorta, Abdominal] this term only |
| #4 | MeSH descriptor: [Aorta] this term only |
| #5 | #2 or #3 or #4 |
| #6 | #1 and #5 |
| #7 | MeSH descriptor: [Aortic Aneurysm] this term only |
| #8 | MeSH descriptor: [Aortic Aneurysm, Thoracic] this term only |
| #9 | MeSH descriptor: [Aortic Aneurysm, Abdominal] this term only |
| #10 | ((aneurysm or aneurism or aneurysma) near/2 (aorta or aortic)):ti,ab,kw |
| #11 | MeSH descriptor: [Marfan Syndrome] this term only |
| #12 | (Marfan syndrome or Marfan's syndrome or Marfans syndrome or marfan abiotrophy or Marfan disease or Marfan's disease or Marfans disease or Marfan achard syndrome or Marfan's achard syndrome or Marfans achard syndrome or Marfan hallez syndrome or Marfan's hallez syndrome or Marfans hallez syndrome):ti,ab,kw |
| #13 | MeSH descriptor: [Loeys-Dietz Syndrome] this term only |
| #14 | (Loeys-Dietz Syndrome or LoeysDietz Syndrome):ti,ab,kw |
| #15 | #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 |
| #16 | (TEVAR or TAAA or TAA):ti,ab,kw |
| #17 | ((thoracic or thoracoabdominal) near/2 (aorta or aortic)):ti,ab,kw |
| #18 | #16 or #17 |
| #19 | #15 and #18 |

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**Table S2** Summary of the included studies

| Study | Institution | Country | Study period | No. of patients | Type of study | Surgical approach reported |
|---|---|---|---|---|---|---|
| Abdelbaky 2021 | Yale University | United States | 2006–2017 | 100 | Retrospective | Open |
| Abisi 2021 | Guy's and St. Thomas' Hospital | United Kingdom | 2018–2020 | 44 | Retrospective | Endovascular |
| Acher 2019 | University of Wisconsin | United States | 1984–2014 | 202 | Retrospective | Both |
| Adam 2022 | University of Birmingham | United Kingdom | 1999–2019 | 58 | Retrospective | Open |
| Afifi 2015 | University of Texas Medical School | United States | 2001–2014 | 37 | Retrospective | Endovascular |
| Al Adas 2018 | Henry Ford Hospital | United States | 2003–2012 | 11 | Retrospective | Endovascular |
| Albors 2009 | Hospital Clinico Universitario | Spain | 2003–2008 | 25 | Retrospective | Endovascular |
| Alhussaini 2021 | University of Florida | United States | 2008–2018 | 84 | Retrospective | Open |
| Andacheh 2011 | Harbor-UCLA Medical Center | United States | 2002–2010 | 73 | Prospective | Endovascular |
| Andersen 2014 | Duke University | United States | 2005–2013 | 32 | Retrospective | Open |
| Anderson 2014 | University of South Dakota | United States | 2012–2014 | 14 | Retrospective | Endovascular |
| Arnaoutakis 2015 | Johns Hopkins | United States | 2002–2013 | 62 | Retrospective | Endovascular |
| Arnaoutakis 2020 | University of Florida | United States | 2002–2018 | 158 | Retrospective | Both |
| Baba 2017 | Jikei University School of Medicine | Japan | 2006–2015 | 44 | Retrospective | Endovascular |
| Bannazadeh 2020 | Mount Sinai West Hospital | United States | 2014–2017 | 38 | Retrospective | Endovascular |
| Barbosa Lima 2021 | University of Texas Health Science Center | United States | 2013–2020 | 110 | Prospective | Endovascular |
| Bashir 2014 | Liverpool Heart & Chest Hospital | United Kingdom | 1998–2014 | 62 | Retrospective | Endovascular |
| Belov 2009 | National Research Center of Surgery | Russia | 2000–2007 | 16 | Retrospective | Open |
| Bertoglio 2018 | San Raffaele Scientific Institute | Italy | 2015–2017 | 18 | Retrospective | Open |
| Bertoglio 2020 | Vita Salute University | Italy | 2013–2018 | 80 | Prospective | Endovascular |
| Bertoglio 2021 | Multicenter | Italy | 2007–2019 | 240 | Retrospective | Endovascular |
| Bisdas 2015 | St. Franziskus Hospital | Germany | 2010–2014 | 142 | Retrospective | Endovascular |
| Böckler 2009 | Ruprecht-Karls University | Germany | 1997–2008 | 54 | Retrospective | Endovascular |
| Bosiers 2021 | St Franziskus Hospital | Germany | 2012–2015 | 80 | Retrospective | Endovascular |
| Botsios 2014 | University Witten/Herdecke & St.-Johannes Hospital Dortmund | Germany | 2001–2011 | 21 | Retrospective | Endovascular |
| Branzan 2018 | University Hospital Leipzig | Germany | 2014–2017 | 57 | Retrospective | Endovascular |
| Canaud 2018 | Multicenter | Multi-national | 2013–2017 | 24 | Retrospective | Endovascular |
| Chatterjee 2021 | Baylor College of Medicine | United States | 2006–2016 | 392 | Retrospective | Open |

**Table S2** *(continued)*

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Table S2 (*continued*)

| Study | Institution | Country | Study period | No. of patients | Type of study | Surgical approach reported |
|---|---|---|---|---|---|---|
| Chen 2013 | Nanjing Medical University | China | 2000–2011 | 174 | Prospective | Endovascular |
| Chen 2017 | Eastern Virginia Medical School | United States | 2008–2014 | 30 | Retrospective | Endovascular |
| Clough 2012 | Guy's and St Thomas' NHS Foundation Trust | United Kingdom | 2008–2011 | 31 | Retrospective | Endovascular |
| Clough 2018 | Universite Paris Sud | France | NA | 64 | Retrospective | Endovascular |
| Conrad 2017 | Massachusetts General Hospital | United States | 2006–2009 | 160 | Prospective | Endovascular |
| Conway 2014 | Lenox Hill Hospital | United States | 1999–2010 | 86 | Retrospective | Open |
| Conway 2022 | VQI (Lenox Hill) | United States | 2003–2021 | 25 | Retrospective | Endovascular |
| Coselli 2016 | Baylor College of Medicine | United States | 1986–2014 | 3309 | Retrospective | Open |
| Da Rocha 2010 | University of Barcelona | Spain | 2006–2009 | 57 | Retrospective | Endovascular |
| Davidovic 2011 | University of Belgrade & Clinical Center of Serbia | Serbia | 1999–2009 | 118 | Retrospective | Open |
| Diamond 2021 | University of Massachussetts | United States | 2010–2018 | 87 | Retrospective | Endovascular |
| Dias 2015 | Skane University Hospital | Sweden | 2008–2014 | 72 | Retrospective | Endovascular |
| Dick 2008 | University of Bern | switzerland | 2001–2005 | 174 | Prospective | Both |
| Ding 2018 | Guangdong Academy of Medical Sciences | China | 2012–2017 | 159 | Retrospective | Endovascular |
| Dong 2022 | Anzhen Hospital | China | 2011–2019 | 183 | Retrospective | Open |
| Du 2019 | People's Hospital of Xinjiang Uygur Autonomous Region | China | 2004–2016 | 163 | Retrospective | Endovascular |
| Dua 2019 | Stanford Hospitals | United States | 2015–2018 | 21 | Retrospective | Endovascular |
| Duan 2016 | Capital Medical University | China | 2014–2015 | 28 | Retrospective | Open |
| Dufour 2015 | Louis Pradel University Hospital | France | 1999–2007 | 74 | Retrospective | Endovascular |
| Eagleton 2016 | Cleveland Clinic | United States | 2004–2013 | 354 | Prospective | Endovascular |
| Estrera 2015 | University of Texas Medical School | United States | 1991–2014 | 519 | Retrospective | Open |
| Faure 2018 | Georges Pompidou European Hospital | France | 2011–2017 | 41 | Retrospective | Open |
| Fernandez 2016 | University of California at San Francisco | United States | 2005–2014 | 133 | Prospective | Endovascular |
| Ferreira 2008 | Servico Integrado de Tecnicas Endovasculares | Brazil | 2006–2008 | 11 | Retrospective | Endovascular |
| Fioranelli 2011 | Hospital de Sao Paulo | Brazil | 2004–2007 | 23 | Retrospective | Endovascular |
| Forsythe 2022 | Royal Infirmary of Edinburgh | United Kingdom | 1999–2021 | 248 | Retrospective | Endovascular |
| Fossaceca 2013 | A. Avogadro University & Maggiore Della Carita Hospital | Italy | 2005–2011 | 53 | Retrospective | Open |

Table S2 (*continued*)


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Table S2 (*continued*)

| Study | Institution | Country | Study period | No. of patients | Type of study | Surgical approach reported |
|---|---|---|---|---|---|---|
| Frankel 2020 | GenTAC Registry | United States | 2006–2014 | 142 | Retrospective | Endovascular |
| Fujikawa 2018 | Kawasaki Aortic Center | Japan | 2015–2016 | 168 | Retrospective | Open |
| Fujiyoshi 2019 | Tokyo Medical University Hospital | Japan | 2011–2018 | 69 | Retrospective | Open |
| Fukui 2016 | Sakakibara Heart Institute | Japan | 2009–2015 | 44 | Retrospective | Open |
| Fukushima 2020 | Jikei University School of Medicine | Japan | 2010–2017 | 16 | Retrospective | Open |
| Gallitto 2017 | University of Bologna | Italy | 2010–2015 | 94 | Prospective | Endovascular |
| Gallitto 2022 | University of Bologna | Italy | 2010–2020 | 137 | Retrospective | Endovascular |
| Gallitto 2022 | University of Bologna | Italy | 2010–2020 | 65 | Retrospective | Endovascular |
| Gambardella 2021 | Weill Cornell Medicine | United States | 1997–2019 | 869 | Retrospective | Open |
| Garbade 2010 | University of Leipzig | Germany | 2000–2008 | 46 | Retrospective | Endovascular |
| Gillen 2015 | University of Virginia | United States | 2005–2012 | 158 | Retrospective | Both |
| Girardi 2019 | Weill Cornell Medicine | United States | 1997–2017 | 783 | Retrospective | open |
| Gocze 2018 | University Hospital Regensburg | Germany | 2013–2017 | 18 | Prospective | Endovascular |
| Gombert 2017 | RWTH University Hospital Aachen | Germany | 2006–2016 | 52 | Retrospective | Open |
| Gombert 2018 | RWTH University Hospital Aachen | Germany | 2014–2015 | 76 | Prospective | Endovascular |
| Gombert 2020 | University Hospital RWTCH | Germany | 2017–2018 | 33 | Retrospective | Both |
| Gombert 2022 | University Hospital RWTCH | Germany | 2006–2019 | 255 | Retrospective | Open |
| Grassi 2022 | Opsedale maggiore policlinico | Italy | 2010–2016 | 310 | Retrospective | Endovascular |
| Guangqi 2009 | Hospital of Sun Yat-sen University | China | 2001–2006 | 121 | Retrospective | Endovascular |
| Guo 2015 | Zhongshan Hospital, Fudan University | China | 2011–2012 | 47 | Prospective | Endovascular |
| Harky 2021 | Liverpool Heart and Chest Hospital | United Kingdom | 1998–2019 | 430 | Retrospective | Open |
| He 2015 | Third Xiangya Hospital of Central South University | China, USA | 2010–2013 | 148 | Retrospective | Endovascular |
| He 2017 | General Hospital of Shenyang Military Region | China | 2007–2014 | 388 | Retrospective | Endovascular |
| Heijmen 2012 | Multicenter | Multi-national | 2009–2010 | 100 | Prospective | Endovascular |
| Henmi 2019 | Kobe University Graduate School of Medicine | Japan | 1999–2018 | 172 | Retrospective | Open |
| Hicks 2017 | Johns Hopkins | United States | 2006–2015 | 137 | Retrospective | Open |
| Hiraoka 2018 | Kurashiki Central Hospital | Japan | 2008–2014 | 175 | Retrospective | Endovascular |
| Hnath 2008 | Albany Medical College | United States | 2004–2006 | 121 | Prospective | Endovascular |
| Hoshina 2021 | University of Tokyo | Japan | 2006–2016 | 14235 | Retrospective | Endovascular |

Table S2 (*continued*)

**Table S2** (*continued*)

| Study | Institution | Country | Study period | No. of patients | Type of study | Surgical approach reported |
|---|---|---|---|---|---|---|
| Huang 2016 | Affiliated Hospital of Nantong University | China | 2011–2014 | 27 | Retrospective | Endovascular |
| Inglese 2008 | San Donato Milanese Hospital | Italy | 2002–2007 | 41 | Retrospective | Endovascular |
| Jayia 2015 | Royal Free Hospital NHS Trust | United Kingdom | 2008–2014 | 47 | Retrospective | Endovascular |
| Jing 2008 | Shenyang Northern Hospital | China | 2002–2007 | 67 | Prospective | Endovascular |
| Johns 2014 | Royal Infirmary of Edinburgh | United Kingdom | 1999–2013 | 37 | Retrospective | Open |
| Jorgensen 2020 | University of South Dakota | United States | 2015–2019 | 44 | Prospective | Endovascular |
| Juszczak 2020 | University Hospitals Birmingham | United Kingdom | 2009–2018 | 54 | Retrospective | Endovascular |
| Kamada 2015 | Iwate Medical University | Japan | 2002–2014 | 51 | Retrospective | Endovascular |
| Kang 2019 | University of Washington | United States | 2009–2017 | 122 | Retrospective | Both |
| Kasprzak 2014 | University Hospital Regensburg | Germany | 2009–2012 | 83 | Retrospective | Endovascular |
| Katsargyris 2015 | Paracelsus Medical University | Germany | 2004–2014 | 218 | Prospective | Endovascular |
| Katsargyris 2021 | General Hospital Nuremberg, Paracelsus Medical University | Germany | 2010–2020 | 30 | Retrospective | Endovascular |
| Kieffer 2008 | Pitie-Salpetriere University Hospital | France | 1991–2006 | 171 | Retrospective | Open |
| Kinoshita 2015 | Tokushima University Graduate School | Japan | 2008–2012 | 13 | Retrospective | Endovascular |
| Kiser 2022 | Memorial Hermann Hospital | United States | 1991–2017 | 1474 | Retrospective | Open |
| Kitamura 2013 | Kitasato University School of Medicine | Japan | 1998–2012 | 53 | Retrospective | Endovascular |
| Kitpanit 2021 | Weill Cornell Medicine | United States | 2014–2019 | 106 | Prospective | Endovascular |
| Kouchoukos 2019 | Missouri Baptist Medical Center | United States | 1986–2015 | 285 | Retrospective | Open |
| Kratimenos 2018 | Evangelismos General Hospital of Athens | Greece | 2014–2017 | 30 | Retrospective | Endovascular |
| Kulik 2011 | Missouri Baptist Medical Center | United States | 1986–2008 | 218 | Retrospective | Open |
| Kunihara 2009 | Hokkaido University Hospital | Japan | 1998–2006 | 17 | Retrospective | Open |
| Kunihara 2021 | The Jikei University School of Medicine | Japan | 1996–2016 | 182 | Retrospective | Open |
| Kurimoto 2008 | Sapporo Medical University | Japan | 2001–2005 | 40 | Retrospective | Endovascular |
| Lancaster 2013 | Massachusetts General Hospital | United States | 1987–2011 | 485 | Retrospective | Open |
| Latz 2021 | Massachusetts General Hospital | United States | 1989–2015 | 234 | Retrospective | Open |
| Le Huu 2022 | Baylor College of Medicine | United States | 2002–2020 | 37 | Retrospective | Endovascular |

**Table S2** (*continued*)


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**Table S2** (*continued*)

| Study | Institution | Country | Study period | No. of patients | Type of study | Surgical approach reported |
|---|---|---|---|---|---|---|
| Lee 2012 | Yonsei University College of Medicine | South Korea | 2006–2013 | 28 | Retrospective | Open |
| Lee 2015 | Yonsei University College of Medicine | South Korea | 2006–2013 | 167 | Retrospective | Both |
| Li 2015 | Beijing Anzhen Hospital, Capital Medical University | China | 2009–2013 | 579 | Retrospective | Endovascular |
| Li 2018 | Second Xiangya Hospital of Central South University | China | 2013–2014 | 134 | Retrospective | Endovascular |
| Lima 2012 | Cleveland Clinic | United States | 2002–2010 | 330 | Prospective | Open |
| Lima 2022 | The University of Texas Health Science Center at Houston | United States | 2013–2020 | 115 | Prospective | Endovascular |
| Lindstrom 2020 | Karolinska University Hospital | Sweden | 2009–2018 | 17 | Retrospective | Endovascular |
| Liu 2011 | Shanghai Jiao Tong University School of Medicine | China | 2004–2009 | 51 | Retrospective | Endovascular |
| Liu 2017 | Changhai Hospital, Second Military Medical University | China | 1998–2014 | 322 | Retrospective | Endovascular |
| Lobato 2012 | Hospital de Sao Paulo | Brazil | 2008–2012 | 15 | Prospective | Endovascular |
| Locham 2018 | National database | United States | 2009–2015 | 879 | Retrospective | Both |
| Lortz 2018 | University of Duisburg-Essen | Germany | 2006–2016 | 45 | Retrospective | Endovascular |
| Lou 2018 | Emory University School of Medicine | United States | 2000–2016 | 587 | Retrospective | Both |
| Lucatelli 2018 | Azienda Ospedaliera Universitaria Senese | Italy | 2011–2017 | 49 | Retrospective | Endovascular |
| Malas 2021 | Multicenter | United States | 2014–2018 | 45 | Prospective | Endovascular |
| Manning 2009 | Malmo University Hospital UMAS | Sweden | 2001–2008 | 52 | Retrospective | Endovascular |
| Marcondes 2022 | Multicenter | Multi-national | 2012–2021 | 541 | Retrospective | Endovascular |
| Martin 2009 | University of Florida | United States | 2000–2007 | 261 | Retrospective | Endovascular |
| Marzelle 2015 | University Paris XII | France | 2009–2012 | 42 | Randomized clinical trial | Endovascular |
| Mastroroberto 2010 | University Magna Grecia | Italy | 2001–2008 | 62 | Retrospective | Both |
| Mazzeffi 2018 | University of Maryland | United States | 2011–2015 | 102 | Retrospective | Endovascular |
| Meltzer 2017 | Weill Cornell Medicine | United States | NA | 22 | Prospective | Endovascular |
| Messe 2008 | University of Pennsylvania | United States | 2000–2005 | 224 | Retrospective | Open |
| Mezzetto 2021 | Multicenter | Italy | 2005–2019 | 129 | Prospective | Endovascular |
| Min 2010 | Samsung Medical Center | South Korea | 2006–2009 | 33 | Retrospective | Open |
| Mishra 2008 | Rikshopitalet Radiumhospitalet Medical Center | Norway | NA | 14 | Prospective | Open |

**Table S2** (*continued*)

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Table S2 (*continued*)

| Study | Institution | Country | Study period | No. of patients | Type of study | Surgical approach reported |
|---|---|---|---|---|---|---|
| Mitchell 2011 | University of Mississippi | United States | 2007–2010 | 44 | Retrospective | Endovascular |
| Mizoguchi 2017 | Yamaguchi Prefecture Grand Medical Center | Japan | 2007–2015 | 38 | Retrospective | Endovascular |
| Mkalaluh 2018 | University of Heidelberg | Germany | 2007–2017 | 38 | Retrospective | Open |
| Monaco 2018 | San Raffaele Scientific Institute | Italy | 2009–2016 | 459 | Retrospective | Open |
| Monnot 2018 | Rouen University Hospital | France | 2007–2015 | 60 | Retrospective | Both |
| Mosquera 2009 | Juan Canalejo Hospital | Spain | 2000–2008 | 20 | Retrospective | Endovascular |
| Motta 2019 | University of North Carolina | United States | 2012–2017 | 223 | Prospective | Endovascular |
| Motta 2019 | University of North Carolina | United States | 2012–2017 | 150 | Prospective | Endovascular |
| Moulakakis 2015 | Multicenter | Greece | 2010–2013 | 30 | Prospective | Endovascular |
| Muncan 2022 | Stony Brook University Hospital | United States | 2010–2020 | 255 | Retrospective | Both |
| Murana 2016 | St Antonius Hospital | Netherlands | 1994–2014 | 542 | Retrospective | Open |
| Naguib 2016 | Frankfurt University | Germany | 2002–2010 | 53 | Retrospective | Endovascular |
| Narayan 2011 | Bristol Heart Institute | United Kingdom | 1996–2009 | 49 | Retrospective | Endovascular |
| Naughton 2012 | Northwestern | United States | 2001–2010 | 100 | Retrospective | Open |
| Neo 2011 | Tan Tock Seng Hospital | Singapore | 2004–2009 | 18 | Retrospective | Endovascular |
| Nomura 2015 | Kobe University Graduate School of Medicine | Japan | 2008–2014 | 54 | Retrospective | Endovascular |
| Ockert 2009 | University of Heidelberg | Germany | 1997–2004 | 30 | Retrospective | Open |
| Oderich 2017 | Mayo Clinic Rochester | United States | 2007–2016 | 185 | Retrospective | Endovascular |
| Oderich 2021 | University of Texas Health Science Center at Houston | United States | 2013–2020 | 297 | Prospective | Endovascular |
| Omura 2014 | Kobe Univeristy Graduate School of Medicine | Japan | 1999–2012 | 115 | Retrospective | Open |
| Omura 2017 | National Cerebral and Cardiovascular Center | Japan | 2003–2014 | 223 | Retrospective | Open |
| Orrico 2019 | San Camillo Forlanini Hospital | Italy | 2015–2017 | 32 | Retrospective | Endovascular |
| Pacini 2013 | Multicenter | Italy | 2000–2008 | 93 | Retrospective | Endovascular |
| Patel 2009 | University of Michigan Hospitals | United States | 1997–2008 | 69 | Retrospective | Endovascular |
| Pearce 2008 | University of Alabama | United States | 2005–2007 | 15 | Retrospective | Endovascular |
| Peidro 2018 | Hopital Nord, Aix-Marseille University | France | 2007–2015 | 76 | Retrospective | Endovascular |
| Piffaretti 2015 | Multicenter | Multi-national | 2000–2012 | 56 | Retrospective | Endovascular |
| Piscione 2007 | “Federico II” University, Naples | Italy | 2002–2004 | 33 | Retrospective | Endovascular |
| Pitton 2008 | University Hospital of Mainz | Germany | 1995–2007 | 22 | Retrospective | Endovascular |

Table S2 (*continued*)


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Table S2 (*continued*)

| Study | Institution | Country | Study period | No. of patients | Type of study | Surgical approach reported |
|---|---|---|---|---|---|---|
| Pompa 2016 | Sapienza University of Rome | Italy | 2010–2012 | 28 | Retrospective | Endovascular |
| Qing 2012 | The University of Hong Kong-Queen Mary Hospital | Hong Kong | NA | 32 | Retrospective | Endovascular |
| Rahe.Meyer 2009 | Hannover Medical School | Germany | NA | 18 | Retrospective | Open |
| Rajbanshi 2015 | Yale University | United States | 2000–2014 | 66 | Retrospective | Open |
| Rana 2018 | Mayo Clinic Rochester | United States | 1999–2011 | 121 | Retrospective | Open |
| Ranney 2018 | Duke University | United States | 2005–2016 | 192 | Retrospective | Endovascular |
| Raupach 2013 | Faculty Hospital Hradec Kralove | Czech Republic | 1999–2012 | 72 | Retrospective | Endovascular |
| Rinaldi 2022 | Multicenter | Italy | 2008–2017 | 351 | Retrospective | Endovascular |
| Rhee 2022 | Asan Medical Center | South Korea | 2015–2019 | 20 | Retrospective | Open |
| Rocha 2021 | University of Toronto | Canada | 2006–2017 | 664 | Retrospective | Both |
| Rodriguez 2008 | Arizona Heart Institute | United States | 2000–2006 | 106 | Retrospective | Endovascular |
| Rossi 2015 | St Thomas Hospital | United Kingdom | 2008–2014 | 69 | Retrospective | Endovascular |
| Rylski 2013 | University Heart Center Freiburg | Germany | 2000–2011 | 36 | Retrospective | Endovascular |
| Saiki 2019 | Tohoku University | Japan | 2011–2015 | 50 | Retrospective | Open |
| Scali 2020 | University of Florida | United States | 2014–2019 | 6529 | Retrospective | Endovascular |
| Schneider 2018 | Weill Cornell Medicine, NewYork-Presbyterian Hospital | United States | 2014–2017 | 50 | Prospective | Endovascular |
| Seike 2022 | National Cerebral and Cardiovascular Center | Japan | 2009–2020 | 204 | Retrospective | Endovascular |
| Shah 2010 | New York University | United States | 2004–2008 | 30 | Retrospective | Endovascular |
| Shimizu 2014 | Keio University Hospital | Japan | 2008–2012 | 37 | Prospective | Open |
| Shiraev 2016 | (2) Royal Prince Alfred Hospital, St George Hospital | Australia | 2003–2013 | 179 | Retrospective | Open |
| Shu 2011 | Second Xiangya Hospital of Central South University | China | 2002–2009 | 45 | Retrospective | Endovascular |
| Si 2014 | Zhongshan Hospital, Fudan University | China | 2009–2010 | 56 | Prospective | Endovascular |
| Smith 2022 | Case Western Reserve University School of Medicine, University Hospitals Cleveland Medical Center | United States | 2012–2020 | 813 | Retrospective | Endovascular |
| Song 2016 | Shanghai Hospital | China | 1999–2015 | 135 | Retrospective | Endovascular |
| Spanos 2018 | University Hospital Hamburg-Eppendorf & Hamburg University Heart Center | Germany | 2014–2017 | 42 | Retrospective | Endovascular |
| Spanos 2019 | German Aortic Center Hamburg | Germany | 2011–2017 | 126 | Retrospective | Endovascular |

Table S2 (*continued*)


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Table S2 (*continued*)

| Study | Institution | Country | Study period | No. of patients | Type of study | Surgical approach reported |
|---|---|---|---|---|---|---|
| Spear 2018 | Aortic Center, CHRU, Lille | France | 2011–2017 | 22 | Retrospective | Endovascular |
| Spinella 2020 | University of Genoa | Italy | 2017–2019 | 11 | Retrospective | Endovascular |
| Steingruber 2008 | Innsbruck Medical University | Austria | 1996–2007 | 35 | Retrospective | Endovascular |
| Stelzmueller 2019 | University of Vienna | Austria | 2001–2016 | 55 | Retrospective | Endovascular |
| Sugiura 2017 | Nagoya University Graduate School of Medicine | Japan | 2002–2015 | 118 | Retrospective | Open |
| Sultan 2018 | University of Pittsburgh | United States | 2013–2016 | 33 | Retrospective | Endovascular |
| Sweet 2015 | University of Washington | United States | 2011–2015 | 24 | Prospective | Endovascular |
| Tabayashi 2010 | Tohoku University | Japan | 1998–2007 | 102 | Retrospective | Open |
| Takahashi 2011 | Hiroshima University Hospital | Japan | 2005–2008 | 15 | Retrospective | Open |
| Tanaka 2018 | The University of Texas Health Science Center at Houston | United States | 2005–2014 | 88 | Retrospective | Endovascular |
| Tanaka 2019 | University of Texas Health Science Center at Houston (UTHealth) | United States | 1991–2017 | 2012 | Retrospective | Open |
| Tang 2011 | TongJi University | China | 2007–2008 | 30 | Retrospective | Endovascular |
| Tenorio 2020 | Multicenter | United States | 2014–2017 | 240 | Retrospective | Endovascular |
| Thomas 2018 | University Hospital, Klinikum Oldenburg AoR | Germany | 2011–2017 | 22 | Retrospective | Endovascular |
| Tong 2022 | Cleveland Clinic | United States | 2000–2010 | 556 | Retrospective | Both |
| Trimarchi 2010 | University of Milan | Italy | 1988–2002 | 18 | Retrospective | Open |
| Tsilimparis 2018 | Multicenter | Germany | 2004–2013 | 329 | Prospective | Endovascular |
| Ullery 2012 | University of Pennsylvania | United States | 2001–2010 | 530 | Retrospective | Endovascular |
| Umegaki 2022 | Multicenter | Japan | 2010–2019 | 6202 | Retrospective | Both |
| Vaislic 2014 | Multicenter | France | 2010–2011 | 23 | Prospective | Endovascular |
| van Bogerijen 2015 | University of Michigan Hospitals | United States | 1993–2013 | 122 | Retrospective | Open |
| Van Calster 2019 | Aortic Center of CHU | France | 2004–2016 | 373 | Retrospective | Endovascular |
| Wahlgren 2017 | Karolinska University Hospital | Sweden | 2004–2015 | 90 | Retrospective | Open |
| Watson 2010 | Riverside Methodist Hospital | United States | 2002–2008 | 21 | Prospective | Open |
| Weiss 2012 | Mount Sinai School of Medicine | United States | 2002–2008 | 240 | Retrospective | Open |
| Wojciechowski 2014 | Medical University of Gdansk | Poland | 2004–2012 | 72 | Retrospective | Endovascular |
| Wongkornrat 2015 | Kawasaki Aortic Center | Japan | 2007–2011 | 200 | Retrospective | Open |
| Wynn 2016 | University of Wisconsin | United States | 1989–2013 | 805 | Retrospective | Open |
| Xiong 2013 | Chinese PLA General Hospital | China | 2004–2010 | 26 | Retrospective | Endovascular |
| Yaffee 2015 | New York University Langone Medical Center | United States | 2010–2011 | 132 | Retrospective | Open |

Table S2 (*continued*)

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Table S2 (*continued*)

| Study | Institution | Country | Study period | No. of patients | Type of study | Surgical approach reported |
|---|---|---|---|---|---|---|
| Yang 2018 | Shenzhen Second Hospital, Sichuan Provincial People's Hospital | China | 2010–2015 | 671 | Retrospective | Endovascular |
| Yang 2020 | Nanjing Drum Tower Hospital | China | 2016–2019 | 60 | Retrospective | Endovascular |
| Yokawa 2020 | Kobe University School of Medicine | Japan | 1999–2016 | 251 | Retrospective | Open |
| Yoo 2014 | Asan Medical Center, University of Ulsan College of Medicine | South Korea | 1994–2011 | 212 | Retrospective | Open |
| Youssef 2015 | University Medical Center, Johannes-Gutenberg University | Germany | 1998–2012 | 62 | Retrospective | Open |
| Youssef 2018 | University Medical Center, Johannes-Gutenberg University | Germany | 2012–2016 | 30 | Retrospective | Endovascular |
| Yunoki 2014 | Osaka University Graduate School of Medicine | Japan | 2008–2011 | 36 | Retrospective | Endovascular |
| Yuri 2012 | Saitama Medical Center of Jichi Medical University | Japan | 2006–2009 | 30 | Retrospective | Endovascular |
| Zamor 2015 | Northwestern | United States | 2001–2013 | 80 | Retrospective | Endovascular |
| Zanetti 2015 | Policlinic of Monza | Italy | 1994–2014 | 51 | Retrospective | Open |
| Zeng 2016 | West China Hospital, Sichuan University | China | NA | 131 | Retrospective | Endovascular |
| Zeng 2021 | Changhai Hospital | China | 2017–2020 | 10 | Prospective | Endovascular |
| Zha 2018 | Anhui Medical University | China | 2012–2016 | 22 | Retrospective | Endovascular |
| Zhang 2017 | General Hospital of People's Liberation Army | China | 2011–2013 | 85 | Retrospective | Endovascular |
| Zhao 2018 | First Affiliated Hospital, Sun Yat-sen University | China | 2013–2014 | 68 | Retrospective | Endovascular |
| Zhou 2018 | Qingdao University | China | 2012–2016 | 66 | Retrospective | Endovascular |
| Zhu 2018 | General Hospital of Tianjin Medical University | China | 2015–2016 | 20 | Retrospective | Endovascular |


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**Table S3** Demographics of patients in the included studies

| Study | Age | Male (%) | Diabetes (%) | HTN (%) | Smoking history (%) | Preop CAD (%) | CRF (%) | COPD (%) | Previous aortic surgery (%) | Dissection (%) | Acute dissection (%) | CSF drain use (%) | Left Heart Bypass (%) | Selective renal perfusion (%) | Circulatory arrest (%) | Sequential Cross Clamp (%) | Clamp & Sew (%) | Mean Cross clamp time (minutes) ± st dev | Number of intercostals implanted | % of patients undergoing reimplantation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abdelbaky 2021(1) | 65.4±11.7 | 60 | 15 | 97 | 66 | 32 | 16 | 23 | 66 | 43 | 2 | 100 | 98 | NR | NR | NR | NR | NR | NR | 72 |
| Abisi 2021 (2) | 77 | 83 | 14 | 74 | 12 | NA | 33 | 17 | NR | NR | NR | 0 | NR | NR | NR | NR | NR | NR | NR | NR |
| Acher 2019 (3) | 69 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Acher 2019 (3) | 73 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Adam 2022 (4) | 41±9.62 | 57 | 1.7 | 60.3 | NA | 3.4 | 1.7 | 10.3 | 79 | 57 | 0 | 100 | 100 | NA | 53.4 | NR | NR | NR | 5±0.74 | 48.2 |
| Afifi 2015 (5) | 61.3±15.3 | 67.6 | NR | NR | NR | NR | NR | NR | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Al Adas 2018 (6) | NR | NR | NR | NR | NR | NR | NR | NR | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Albors 2009 (7) | 63 | 84 | 4 | 84 | 64 | 12 | 8 | 28 | NR | 52 | 24 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Alhussaini 2021 (8) | 56.6±13.7 | 76 | 17.8 | 76.2 | 55.9 | 16 | 14.8 | 10.7 | 71.4 | 60.6 | 7.1 | 78.5 | 45 | NA | 54.7 | NR | NR | NR | NR | 19 |
| Andacheh 2011 (9) | 58 | 71.2 | NR | NR | NR | NR | NR | NR | NR | 100 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Andersen 2014 (10) | 63 | 84.4 | 3.1 | 90.6 | 62.5 | 27.6 | 13.8 | 18.7 | 65.6 | 100 | 0 | 100 | NR | NR | NR | NR | NR | NR | NR | NR |
| Anderson 2014 (11) | 73.2 | NR | 28.6 | 92.9 | 100 | 28.6 | 78.6 | 64.3 | 35.7 | NR | NR | 92.9 | NR | NR | NR | NR | NR | NR | NR | NR |
| Arnaoutakis 2015 (12) | 67.6±12.9 | 53.2 | 16.1 | 88.7 | 58.1 | 33.9 | NR | 25.8 | NR | 17.7 | NR | 75.8 | NR | NR | NR | NR | NR | NR | NR | NR |
| Arnaoutakis 2020 (13) | 59±12 | 73 | 8 | 91 | NR | 36 | 50 | 24 | 27 | 52 | 0 | 94 | 4 | NR | 6 | NR | 38 | NR | NR | 30 |
| Arnaoutakis 2020 (13) | 72±8 | 62 | 18 | 98 | NR | 42 | 38 | 57 | 4 | 8 | 0 | 74 | NR | NR | NR | NR | NR | NR | NR | NR |
| Baba 2017 (14) | 75.3 | 77.3 | 27.3 | 88.6 | NR | 59.1 | NR | 25 | 59.1 | 0 | 0 | 31.8 | NR | NR | NR | NR | NR | NR | NR | NR |
| Bannazadeh 2020 (15) | 76.5 | 60.5 | 10.5 | 81.5 | 86.3 | 39.4 | 10.5 | 18.4 | NR | 0 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Barbosa Lima 2021 (16) | 73±8 | 50 | 13 | 94 | 72 | 32 | 44 | 28 | NR | 23 | 0 | 74 | NR | NR | NR | NR | NR | NR | NR | NR |
| Bashir 2014 (17) | 52.4±14.4 | 72.6 | 0 | 59.7 | 16.1 | 3.2 | 9.7 | 8.1 | NR | 100 | 0 | NR | 19.4 | NR | NR | NR | NR | NR | NR | NR |
| Belov 2009 (18) | 45.1 | 62.5 | 12.5 | 81.2 | NR | NR | NR | 25 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Bertoglio 2018 (19) | 74.7 | 77.8 | 0 | 94.4 | 88.9 | NR | 27.8 | 77.7 | 94.4 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Bertoglio 2020 (20) | 74.1±8.14 | 70 | 15 | 96 | 69 | 60 | 48 | 32 | 36 | NR | NR | 0 | NR | NR | NR | NR | NR | NR | NR | NR |
| Bertoglio 2021 (21) | 73±6.66 | 76 | 27 | 97 | 72 | NR | 34 | NR | 10 | 14 | 0 | 54 | NR | NR | NR | NR | NR | NR | NR | NR |
| Bisdas 2015 (22) | 70.0±7.0 | 78.9 | 12 | 93.7 | 58.4 | 44.4 | 5.6 | 27.5 | 47.2 | 9.1 | NR | 45.1 | NR | NR | NR | NR | NR | NR | NR | NR |
| Böckler 2009 (23) | 57 | 74.1 | NR | NR | NR | NR | NR | NR | NR | 100 | 42.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Bosiers 2021 (24) | 71±7.4 | 70 | 10 | 83.8 | 52.5 | 35 | 30 | 22.5 | NR | 0 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Botsios 2014 (25) | 66.1±12.4 | 71.5 | 9.5 | 80.9 | 19 | 23.8 | 28.5 | 9.5 | 14.2 | 42.9 | 42.9 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Branzan 2018 (26) | 69.6±7.6 | 75 | 36 | 100 | 68 | 38 | 35 | 33 | 12.2 | 0 | 0 | 0 | NR | NR | NR | NR | NR | NR | NR | NR |
| Canaud 2018 (27) | 68.9±9.0 | 70.8 | 25 | 91.6 | NR | 20.8 | 8.4 | 12.5 | NR | 37.5 | 37.5 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Chatterjee 2021 (28) | 68.7±6.24 | 60.5 | 15.6 | 94.9 | 82.6 | 42.6 | 43.8 | 37.2 | 20.1 | 31.3 | 3.3 | 77.3 | 46.9 | 35.2 | NR | NR | NR | 52.3 | NR | 37.7 |
| Chen 2013 (29) | 56.3 | 89.1 | 5.7 | 86.8 | 62.6 | 27.6 | 4.6 | 2.9 | NR | 100 | 67.8 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Chen 2017 (30) | 62.5 | 70 | 13.3 | 90 | 63.3 | 16.7 | 13.3 | 13.3 | NR | 100 | 100 | 43.3 | NR | NR | NR | NR | NR | NR | NR | NR |
| Clough 2012 (31) | 71 | 67.7 | 6.5 | 80.6 | NR | 32.3 | 45.1 | 16.1 | 19.4 | 3.2 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |

**Table S3** (*continued*)



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**Table S3** *(continued)*

| Study | Age | Male (%) | Diabetes (%) | HTN (%) | Smoking history (%) | Preop CAD (%) | CRF (%) | COPD (%) | Previous aortic surgery (%) | Dissection (%) | Acute dissection (%) | CSF drain use (%) | Left Heart Bypass (%) | Selective renal perfusion (%) | Circulatory arrest (%) | Sequential Cross Clamp (%) | Clamp & Sew (%) | Mean Cross clamp time (minutes) ± st dev | Number of intercostals implanted | % of patients undergoing reimplantation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Clough 2018 (32) | 58.5±12.7 | 79.7 | 9.9 | 75 | NR | 4.7 | 0 | NR | 0 | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Conrad 2017 (33) | 72.2±9.1 | 59.4 | 21.2 | 93.7 | 44.4 | 44.4 | 16.2 | 35.6 | NR | NR | NR | 53.7 | NR | NR | NR | NR | NR | NR | NR | NR |
| Conway 2014 (34) | 57 | 68.6 | NR | 94.2 | NR | NR | 12.8 | 25.6 | 33.7 | 100 | 0 | 87.2 | 43 | NR | 41.9 | 7 | NR | 47 | NR | 55 |
| Conway 2022 (35) | 75±11.85 | 80 | 24 | 84 | 21 | NR | NR | NR | 8 | NR | NR | 24 | NR | NR | NR | NR | NR | NR | NR | NR |
| Coselli 2016 (36) | 67 | 61.7 | 7.9 | 84.8 | 79.1 | 37.2 | 3 | 36.7 | 25.9 | 35.8 | 8.3 | 44.8 | 44.7 | 58.4 | 1.5 | NR | NR | 48 | NR | NR |
| Coselli 2020 (37) | 65±12.6 | 64.5 | 6.4 | 86.5 | 77.3 | 31.1 | 39.6 | 30.3 | 17.5 | 50.6 | 5.4 | 62.7 | 83.1 | 64.3 | 2 | NR | 15 | 67±20 | NR | 86.1 |
| Da Rocha 2010 (38) | 71.1 | 40 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Davidovic 2011 (39) | 64.4 | 90.7 | NR | NR | NR | NR | NR | 67.8 | 2.5 | 5.9 | NR | NR | 8.8 | NR | NR | NR | 11.7 | 68.1±19.2 | NR | NR |
| Diamond 2021 (40) | 72±9.1 | 55 | 10 | 98 | 86 | 38 | 4.6 | 40 | 22 | 11 | NR | 82 | NR | NR | NR | NR | NR | NR | NR | NR |
| Dias 2015 (41) | 68 | 73.7 | 18.1 | 84.7 | 44.4 | 33.3 | 41.7 | 43.1 | 56.9 | NR | NR | 88.9 | NR | NR | NR | NR | NR | NR | NR | NR |
| Dick 2008 (42) | 68.8±10.1 | 43 | 8 | 41 | 26 | 18 | 12 | 11 | 16 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Dick 2008 (42) | 61.6±15.2 | 59 | 3 | 53 | 40 | 34 | NR | 12 | NR | NR | NR | 36 | NR | NR | 45 | NR | NR | NR | NR | 83 |
| Ding 2018 (43) | 54.0±11.0 | 88.6 | 7.5 | 81.8 | 30.2 | 15.7 | 11.9 | 2.5 | 1.3 | 100 | 63.5 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Dong 2022 (44) | 38.3±9.8 | 67.2 | 1.6 | 42.9 | NR | 2.2 | NR | NR | 60.7 | NR | NR | 80.9 | NR | NR | NR | NR | NR | NR | NR | 84.7 |
| Du 2019 (45) | 51.1±10.8 | 83.4 | 4.3 | 74.8 | 31.9 | 14.7 | 7.4 | NR | 0 | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Dua 2019 | 72.8 | 52 | NR | NR | NR | NR | NR | NR | NR | 14 | NR | 100 | NR | NR | NR | NR | NR | NR | NR | NR |
| Duan 2016 (46) | 36.1±12.0 | 71.4 | NR | 50 | NR | NR | NR | NR | 57.1 | 85.7 | NR | 100 | NR | NR | NR | NR | NR | 17.5±4.4 | 5.9±1.3 | NR |
| Dufour 2015 (47) | 60.0±18.0 | 77 | 8.1 | 37.8 | 51.3 | NR | NR | 9.5 | NR | 17.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Eagleton 2016 (48) | 73.5±8.4 | 76.3 | 14.7 | NR | 91.9 | 43.8 | 18.6 | 30.8 | 43.2 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Estrera 2015 (49) | 64.2±13.8 | 0.6 | NR | 83 | 78.9 | 27.4 | NR | 714 | 5.9 | 35.2 | 81 | 83.3 | 93.1 | NR | NR | NR | NR | 46.9±25.7 | NR | 20 |
| Faure 2018 (50) | 61 | 82.9 | NR | 65.8 | NR | NR | NR | NR | 21.9 | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Fernandez 2016 (51) | 73.0±8.0 | 75.2 | 11.3 | 94.7 | 90.2 | NR | 3 | NR | NR | 6.8 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Ferreira 2008 (52) | 72 | 13 | NR | NR | NR | 4 | NR | 3 | 4 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Fioranelli 2011 (53) | 58.8±11.4 | 78.3 | 13 | 100 | 65.2 | 17.4 | 13 | 4.3 | NR | 100 | 43.5 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Forsythe 2022 (54) | 70±6.66 | 78.2 | 13.7 | 72.6 | 85.1 | 36.7 | NR | 24.2 | NR | 0 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Fossaceca 2013 (55) | 71 | 84.9 | 56.6 | 71.6 | 56.6 | 50.9 | 9.4 | 56.6 | NR | 3.8 | NR | 35.8 | NR | NR | NR | NR | NR | NR | NR | NR |
| Frankel 2020 (56) | 42±14 | 59 | 6 | 21 | 32 | 7 | NR | NR | 5 | 65 | 5 | 56 | 41 | 45 | 16 | NR | NR | NR | NR | NR |
| Fujikawa 2018 (57) | 69.0±21.8 | 72.6 | 5.9 | 73.2 | 57.1 | 17.9 | 12 | 25 | 58.9 | 63.1 | 4.8 | NR | 88.6 | NR | 9 | NR | NR | 95.0±45.8 | NR | NR |
| Fujiyoshi 2019 (58) | 64±45.92 | 81.2 | 8.7 | 84 | NR | 24.6 | 5.8 | 11.6 | 55.1 | NR | NR | 68.1 | 0 | NR | 100 | NR | NR | NR | NR | NR |
| Fukui 2016 (59) | 65.6±14.4 | 65.9 | 9.1 | 95.5 | 65.9 | NR | 6.8 | 4.5 | 59.1 | 40.9 | NR | 72.7 | NR | NR | 40.9 | 100 | NR | NR | NR | NR |
| Fukushima 2020 (60) | 77.6±7.4 | 75 | 6.3 | 87.5 | NR | 18.9 | 25 | 31.3 | 25 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Gallitto 2017 (61) | 73.0±6.0 | 90 | 20 | 100 | 30 | 40 | 40 | 40 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Gallitto 2022 (62) | 73±7 | 77 | 12 | 98 | 65 | 37 | 47 | 40 | 52 | NR | NR | 88 | NR | NR | NR | NR | NR | NR | NR | NR |

**Table S3** *(continued)*


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**Table S3** *(continued)*

| Study | Age | Male (%) | Diabetes (%) | HTN (%) | Smoking history (%) | Preop CAD (%) | CRF (%) | COPD (%) | Previous aortic surgery (%) | Dissection (%) | Acute dissection (%) | CSF drain use (%) | Left Heart Bypass (%) | Selective renal perfusion (%) | Circulatory arrest (%) | Sequential Cross Clamp (%) | Clamp & Sew (%) | Mean Cross clamp time (minutes) ± st dev | Number of intercostals implanted | % of patients undergoing reimplantation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gallitto 2022 (63) | 73±7 | 71 | 11 | 100 | NR | 32 | 52 | 42 | 48 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Gambardella 2021 (64) | 68±18 | 54.3 | 10.1 | 95.9 | 71.3 | NR | 0.272 | NR | NR | NR | NR | NR | 0.284 | NR | 7.9 | NR | 64 | 33 | 360 | 41.4 |
| Garbade 2010 (65) | 65 | 69.6 | 19.6 | 87 | NR | NR | NR | 19.5 | 13 | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Gillen 2015 (66) | 67 | 74 | 10 | 84.7 | NR | 62 | 27 | 35 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Gillen 2015 (66) | 58 | 14 | 0 | 24 | NR | 7 | 5 | 5 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Girardi 2019 (67) | 64.7±14.6 | 59 | 9.2 | 96 | 76 | NR | 25.3 | 40.4 | NR | 42.5 | 8 | 84.8 | 0.272 | NR | 8.3 | NR | 64.5 | 65 | 318 | 40.6 |
| Gocze 2018 (68) | 70.1 | 72.2 | 16.7 | 88.9 | 61.1 | 50 | 0 | NR | NR | 0 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Gombert 2017 (69) | 70.5±6.2 | 73.9 | 17.4 | 87 | 52.2 | 34.8 | 21.7 | NR | NR | 0 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Gombert 2018 (70) | 55.2±14.2 | 69.7 | NR | 79.5 | 61.7 | 25.9 | 13.5 | 13.5 | 19.7 | 0 | 0 | 100 | NR | NR | NR | NR | NR | NR | NR | NR |
| Gombert 2020 (71) | 50.1±16.4 | 42.8 | 14.3 | 57 | 28.6 | 28.6 | 21.4 | 14.3 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | 35 | NR |
| Gombert 2020 (71) | 72.5±7.1 | 52.6 | 21 | 79 | 42.1 | 52.6 | 10.5 | 57.9 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Gombert 2022 (72) | 56.2±13 | 73 | 9 | 83 | 38 | 29 | 53 | 29 | 51 | 58 | NR | NR | NR | NR | NR | NR | NR | NR | 92 | 36 |
| Grassi 2022 (73) | 70±11 | 58.1 | 19.2 | 88 | 56.9 | 29.3 | 20.8 | 25.7 | 19 | NR | NR | NR | NR | NR | NR | NR | NR | NR | 0 | 0 |
| Guangqi 2009 (74) | 56.7 | 91.7 | NR | 97.5 | NR | NR | 4.1 | NR | NR | 100 | 59.5 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Guo 2015 (75) | 57.4 | 74.5 | 23.4 | 83 | 44.7 | NR | NR | NR | NR | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Harky 2021 (76) | 63.26±15.11 | 66 | 5.5 | 59.7 | 17.9 | NR | NR | 15.5 | 33 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| He 2015 (77) | 42.8 | 82.4 | 8.1 | 97.3 | NR | 12.8 | 6.1 | 9.5 | 14.2 | 100 | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR |
| He 2017 (78) | 54.1 | 79.9 | 4.4 | 86.9 | 61.1 | 35.8 | NR | NR | NR | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Heijmen 2012 (79) | 64.6±12.0 | 81 | 11 | 84 | 55 | 20 | 19 | 18 | 9 | 42 | 0.2 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Henmi 2019 (80) | 60.3 | 74.4 | 9.9 | 83.1 | 50.6 | NR | 56.4 | 19.2 | 26.2 | 61 | NR | 9.2 | NR | NR | 17.4 | NR | NR | NR | 475 | NR |
| Hicks 2017 (81) | 62.1±1.3 | 64.2 | 5.8 | 81 | 65.7 | 20.4 | 10.2 | 19.7 | 45.6 | 24.1 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Hiraoka 2018 (82) | 72.1±9.9 | 74.9 | 13.7 | 92 | 8.5 | NR | 2.3 | 12 | 43.4 | 36.6 | NR | 31.4 | NR | NR | NR | NR | NR | NR | NR | NR |
| Hnath 2008 (83) | 60.6 | 51.1 | NR | 77.9 | NR | 41.9 | 17.5 | 33.1 | 33.9 | NR | NR | 46.3 | NR | NR | NR | NR | NR | NR | NR | NR |
| Hoshina 2021 (84) | 75.2±8.3 | 75.9 | NR | 72.8 | | 15.4 | 3.4 | 22.1 | 12.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Huang 2016 (85) | 73.5 | 70.4 | 3.7 | 66.7 | NR | NR | 3.7 | 7.4 | NR | 100 | 92.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Inglese 2008 (86) | 69.3±9.7 | 80.5 | 12.2 | 100 | 70.7 | 31.7 | 41.5 | 51.2 | NR | 14.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Jayia 2015 (87) | 72.1 | 68.1 | 10.6 | 80.8 | 23.4 | 36.2 | 19.1 | NR | 21.3 | NR | NR | 100 | NR | NR | NR | NR | NR | NR | NR | NR |
| Jing 2008 (88) | 86.6 | 68.4 | 20.9 | 77.6 | 62.7 | 13.4 | 9 | 9 | NR | 100 | 47.8 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Johns 2014 (89) | 56 | 83.8 | 2.7 | NR | 83.8 | 29.7 | 13.5 | 16.2 | NR | 27 | 0 | 54.1 | 54 | NR | NR | NR | NR | NR | NR | NR |
| Jorgensen 2020 (90) | NR | 77.3 | 13.6 | 88.6 | 95.5 | 54.5 | 6.8 | 50 | 45.5 | NR | NR | NR | NR | NR | NR | NR | NR | NR | 0 | 0 |
| Juszczak 2020 (91) | 73±25.6 | 68.5 | 7.4 | 68.5 | NR | 33.3 | 24 | 25.9 | 48.1 | 4 | 0 | NR | NR | NR | NR | NR | NR | NR | 0 | 0 |
| Kamada 2015 (92) | 72.0±10.6 | 74.5 | 11.8 | 86.3 | NR | NR | NR | NR | 37.3 | 21.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Kang 2019 (93) | 74.9±7.6 | 75 | NR | NR | NR | NR | NR | NR | 44.1 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |

**Table S3** *(continued)*


https://dx.doi.org/10.21037/acs-2023-scp-14

**Table S3** *(continued)*

| Study | Age | Male (%) | Diabetes (%) | HTN (%) | Smoking history (%) | Preop CAD (%) | CRF (%) | COPD (%) | Previous aortic surgery (%) | Dissection (%) | Acute dissection (%) | CSF drain use (%) | Left Heart Bypass (%) | Selective renal perfusion (%) | Circulatory arrest (%) | Sequential Cross Clamp (%) | Clamp & Sew (%) | Mean Cross clamp time (minutes) ± st dev | Number of intercostals implanted | % of patients undergoing reimplantation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kang 2019 (93) | 62±20.4 | 66.7 | NR | NR | NR | NR | NR | NR | 38.9 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Kasprzak 2014 (94) | 72.6 | 66.3 | NR | 92.8 | 62.6 | 51.8 | 31.3 | 28.9 | 33.7 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Katsargyris 2015 (95) | 68.8±7.5 | 76.6 | 8.5 | 80.6 | 63.7 | 62.7 | 8 | 53.2 | NR | NR | NR | 71.6 | NR | NR | NR | NR | NR | NR | NR | NR |
| Katsargyris 2021 (96) | 67.5±6.9 | 60 | 6.7 | 93.3 | NR | 46.7 | NR | 50 | 23.3 | NR | NR | 50 | NR | NR | NR | NR | NR | NR | NR | NR |
| Kieffer 2008 (97) | 65.0±10.9 | 87.1 | 13 | 121 | NR | 72 | 58 | 81 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Kinoshita 2015 (98) | 58.9±12.6 | 92.3 | NR | NR | NR | NR | NR | NR | NR | 100 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Kiser 2022 (99) | 67.66±13.1 | 63 | NR | 88 | NR | 27 | 6 | 39 | 22 | 37 | 4 | NR | 100 | NR | 0 | NR | NR | NR | NR | NR |
| Kitamura 2013 (100) | 55.5±13.1 | 94.3 | NR | NR | NR | NR | 7.5 | NR | 20.8 | 100 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Kitpanit 2021 (101) | 75.67±7.7 | NR | 9.4 | 87.7 | 22.6 | 43.3 | 36.8 | 21.7 | 50.9 | NR | NR | 73.6 | NR | NR | NR | NR | NR | NR | NR | NR |
| Kouchoukos 2019 (102) | 64 | NR | 6 | 77.2 | 54.4 | 37.8 | NR | 38.6 | NR | 26.4 | 1.1 | 39.3 | NR | NR | NR | NR | NR | NR | NR | 46.3 |
| Kratimenos 2018 (103) | 73.7±6.3 | 80 | 16.7 | 56.7 | 70 | 26.7 | 13.3 | 23.3 | 3.3 | 0 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Kulik 2011 (104) | 63.0±14.0 | 49.5 | 6 | 76.6 | 62.8 | 39.9 | 13.8 | 40.8 | 73.4 | 25.2 | 1.4 | 25.2 | NR | NR | 100 | NR | NR | NR | NR | 56 |
| Kunihara 2009 (105) | 64.0±15.0 | 58.8 | NR | NR | NR | NR | 1 | NR | 8 | 7 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Kunihara 2021 (106) | 68 | 66.4 | 10.4 | 88.5 | NR | 46.7 | 27.5 | 33 | 56.6 | 29.7 | NR | 62.1 | NR | 34.6 | NR | NR | NR | 53±111.1 | NR | 64.8 |
| Kurimoto 2008 (107) | 71.6 | 90 | NR | NR | NR | NR | NR | NR | NR | 20 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Lancaster 2013 (108) | 69.8 | 45.2 | 8.4 | 89 | 81.5 | 41.9 | 10 | 21 | NR | 21.3 | NR | 100 | 29.4 | NR | NR | NR | 79.4 | 78.6 | NR | 53 |
| Latz 2021(109) | 73.4±7.4 | 63.6 | 11.1 | 85.4 | 82 | 46.1 | 15.3 | 24.7 | 29.9 | 3 | NR | NR | NR | 86 | NR | NR | NR | 77.27±19 | NR | NR |
| Le Huu 2022 (110) | 46.5 | 54.1 | 2.7 | 83.8 | 35.1 | 16.2 | 13.5 | 21.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Lee 2012 (111) | 62.6±12.8 | 28.6 | 7.1 | 85.7 | 60.7 | 28.6 | NR | NR | NR | 39.3 | 17.9 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Lee 2015 (112) | 65.5±12.9 | 76.3 | 8.8 | 73.7 | 40.4 | 11.4 | 33 | NR | NR | 47.4 | NR | 58.8 | NR | NR | NR | NR | NR | NR | NR | NR |
| Lee 2015 (112) | 60.1±15.9 | 69.8 | 13.2 | 75.5 | 30.2 | 13.2 | 15.1 | NR | NR | 28.3 | NR | 79.2 | 37.7 | NR | 58.5 | NR | NR | NR | NR | NR |
| Li 2015 (113) | 53.1±10.5 | 84.8 | 3.8 | 74.2 | NR | 4.3 | 1.2 | 0.5 | NR | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Li 2018 (114) | 52.5±10.8 | 85.1 | NR | NR | NR | NR | NR | NR | NR | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Lima 2012 (115) | 62 | 37 | NR | 89.4 | NR | NR | 8.8 | 37 | NR | 47.3 | 1.8 | 93.2 | NR | NR | NR | NR | NR | NR | NR | NR |
| Lima 2022 (116) | 73.8±8.3 | 65 | 16 | 89 | 70 | 33 | 53 | 28 | 35 | 16 | NR | 53.9 | NR | NR | NR | NR | NR | NR | NR | NR |
| Lindstrom 2020 (117) | 72.9±5.1 | 41.2 | 11.8 | 64.7 | NR | 11.8 | NR | 52.9 | NR | NR | NR | 100 | NR | NR | NR | NR | NR | NR | NR | NR |
| Liu 2011 (118) | 58.9±12.7 | 88.2 | 5.9 | 86.3 | 41.2 | 5.9 | 11.8 | NR | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Liu 2017 (119) | 56.1±12.9 | 83.9 | 6.5 | 74.2 | NR | 6.8 | 4.7 | 3.4 | 0 | 100 | 26.7 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Lobato 2012 (120) | NR | NR | NR | NR | NR | NR | NR | NR | 20 | 0 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Locham 2018 (121) | 66.5±10.9 | 58.8 | 14.3 | 80.7 | 56.8 | NR | 20.6 | 44.7 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Locham 2018 (121) | 71.2±10 | 52.2 | 15.8 | 87.1 | 56.8 | NR | 20.4 | 43.9 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Lortz 2018 (122) | 64.3 | 44.4 | 15.6 | 88.9 | 48.9 | 37.8 | 28.9 | NR | 17.8 | 100 | 71.1 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Lou 2018 (123) | 39.4 | 58.2 | 8.5 | 67.2 | 29.1 | NR | 3.7 | 8.5 | NR | 100 | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR |

**Table S3** *(continued)*

**Table S3** *(continued)*

| Study | Age | Male (%) | Diabetes (%) | HTN (%) | Smoking history (%) | Preop CAD (%) | CRF (%) | COPD (%) | Previous aortic surgery (%) | Dissection (%) | Acute dissection (%) | CSF drain use (%) | Left Heart Bypass (%) | Selective renal perfusion (%) | Circulatory arrest (%) | Sequential Cross Clamp (%) | Clamp & Sew (%) | Mean Cross clamp time (minutes) ± st dev | Number of intercostals implanted | % of patients undergoing reimplantation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lou 2018 (123) | 53.4±10.9 | 76.3 | 8.8 | 98.3 | 44.1 | NR | 5.1 | 11.9 | NR | 100 | 100 | 100 | 57.6 | NR | 42.4 | NR | NR | NR | NR | NR |
| Lucatelli 2018 (124) | 71.3±9.5 | 69.4 | 14.3 | 73.5 | 75.5 | NR | 20.4 | NR | 42.9 | 10.2 | 0 | 22.4 | NR | NR | NR | NR | NR | NR | NR | NR |
| Malas 2021 (125) | 73.5±7.2 | 69 | 18 | 96 | 84 | 56 | 27 | 31 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Manning 2009 (126) | 67 | 73.1 | NR | NR | NR | NR | NR | NR | NR | 100 | 98.1 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Marcondes 2022 (127) | 71±9 | 66 | 14 | 81 | 57 | 38 | 41 | 37 | 75 | 14 | NR | 4 | NR | NR | NR | NR | NR | NR | NR | NR |
| Martin 2009 (128) | 66.2±15.2 | 67.4 | NR | NR | NR | NR | NR | NR | NR | 21.1 | NR | 11.9 | NR | NR | NR | NR | NR | NR | NR | NR |
| Marzelle 2015 (129) | 68.4±10.7 | 81 | 9.5 | 83.3 | NR | 31 | 42.9 | 35.7 | 57.1 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Mastroroberto 2010 (130) | 74.3±8.4 | 53.8 | 7.7 | 76.9 | NR | 7.7 | NR | 61.6 | 7.7 | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Mastroroberto 2010 (130) | 70.2±7.8 | 72.7 | 18.2 | 81.8 | NR | 9.1 | NR | 63.6 | 9.1 | 100 | 100 | 100 | 0 | NR | NR | NR | NR | NR | NR | NR |
| Mazzeffi 2018 (131) | 68 | 60.8 | 16.7 | 90.3 | 39.8 | 16.7 | 6.9 | 14.7 | 29.4 | 29.4 | NR | 100 | NR | NR | NR | NR | NR | NR | NR | NR |
| Meltzer 2017 (132) | 75.1±8.9 | 77.3 | 18.2 | 90.9 | 81.8 | NR | 18.2 | 13.6 | 45.5 | 4.5 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Messe 2008 (133) | 65.5±14.0 | 54.5 | 7.6 | 81.7 | 32.6 | 26.3 | 23.7 | 31.7 | 40.6 | 30.8 | NR | 82.1 | 75 | NR | 30.8 | NR | NR | 73.0±31.0 | NR | 34 |
| Mezzetto 2021 (134) | 74.9±7.4 | 89.1 | 15.5 | 66.6 |  | 31.7 | 13.9 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Min 2010 (135) | 50.7±15.2 | 72.7 | 6.1 | NR | NR | 12.1 | 3 | 15.2 | 33.3 | 69.7 | 0 | 100 | 0 | NR | 0 | NR | NR | NR | DTA 1.0 (0–4), TAAA 2.3 (0–7) | NR |
| Mishra 2008 (136) | 62 | 71.4 | 7.1 | 92.9 | NR | 21.4 | 21.4 | 42.9 | NR | 21.4 | 0 | NR | NR | NR | 14.3 | NR | 64.3 | NR | NR | NR |
| Mitchell 2011 (137) | 49 | 59.1 | NR | NR | NR | NR | NR | NR | NR | 9.1 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Mizoguchi 2017 (138) | 65 | 78.9 | NR | 100 | 76.3 | 15.8 | 21.1 | 18.4 | NR | 100 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Mkalaluh 2018 (139) | 54.4±13.4 | 42.1 | 2.6 | 78.9 | 44.7 | 2.6 | 23.7 | NR | 65.8 | 63.2 | 0 | 100 | 0 | NR | 15.8 | NR | NR | NR | 2.0 ±1.1 | 60.5 |
| Monaco 2018 (140) | 65.7 | 73.2 | 6.8 | 74.7 | 43.6 | 7 | 12.2 | 16.1 | 35.3 | 0 | 0 | NR | 74.3 | NR | NR | NR | NR | 52.9 | NR | NR |
| Monnot 2018 (141) | 68.9±10.4 | 83.3 | 16.7 | 66.7 | 61.1 | 22.2 | 27.8 | 50 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Monnot 2018 (141) | 66.3±6.7 | 81 | 28.6 | 85.7 | 85.7 | 19 | 23.8 | 28.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Mosquera 2009 (142) | 63.5±13.6 | 75 | NR | 65 | NR | 15 | 10 | 10 | 10 | 40 | 30 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Motta 2019 (143) | 72±8 | 72 | 19 | 92 | 95 | 53 | 42 | 59 | 35 | NR | NR | 35 | NR | NR | NR | NR | NR | NR | NR | NR |
| Motta 2019 (144) | 71 | 69 | 17 | 91 | 93 | 51 | 43 | 58 | NR | 9 | NR | 51 | NR | NR | NR | NR | NR | NR | NR | NR |
| Moulakakis 2015 (145) | 68.8±5.9 | 93.3 | NR | 76.7 | 60 | 30 | NR | 53.3 | NR | NR | NR | 13.3 | NR | NR | NR | NR | NR | NR | NR | NR |
| Muncan 2022 (146) | 39.2±15.3 | 47.8 | 5 | 48.5 | NR | NR | 5 | NR | 5 | 42.8 | NR | 5.6 | NR | NR | NR | NR | NR | NR | NR | NR |
| Muncan 2022 (146) | 48.7±13.9 | 58.7 | 18.1 | 80 | NR | NR | 18.1 | NR | 23.6 | 77.8 | NR | 18.5 | NR | NR | NR | NR | NR | NR | NR | NR |
| Murana 2016 (147) | 65.0±10.5 | 53.9 | 5.5 | 90.4 | NR | NR | 8.9 | 21 | 57.9 | 29.5 | 0 | 86.7 | 87.3 | NR | 12.7 | 76.2 | NR | NR | NR | NR |
| Naguib 2016 (148) | 58.8±14.0 | 75.5 | NR | 62.3 | NR | NR | NR | NR | NR | 47.2 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Narayan 2011 (149) | 57.5 | 69.4 | 2 | 46.9 | 46.9 | NR | 12.2 | 8.2 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Naughton 2012 (150) | 66.7±14.9 | 58.3 | 16.7 | 8.3 | 50 | NR | NR | 12.5 | 33.3 | NR | NR | 29.2 | 100 | NR | NR | NR | NR | NR | NR | NR |

**Table S3** *(continued)*

**Table S3** *(continued)*

| Study | Age | Male (%) | Diabetes (%) | HTN (%) | Smoking history (%) | Preop CAD (%) | CRF (%) | COPD (%) | Previous aortic surgery (%) | Dissection (%) | Acute dissection (%) | CSF drain use (%) | Left Heart Bypass (%) | Selective renal perfusion (%) | Circulatory arrest (%) | Sequential Cross Clamp (%) | Clamp & Sew (%) | Mean Cross clamp time (minutes) ± st dev | Number of intercostals implanted | % of patients undergoing reimplantation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neo 2011 (151) | 64.3 | 77.8 | 5.6 | 66.7 | NR | 16.7 | 5.6 | 5.6 | NR | 11.1 | NR | 0 | NR | NR | NR | NR | NR | NR | NR | NR |
| Nomura 2015 (152) | 76.2±7.9 | 74.1 | 25.9 | 85.2 | 66.7 | 9.3 | 24.1 | 24.1 | 16.7 | NR | NR | 44.4 | NR | NR | NR | NR | NR | NR | NR | NR |
| Ockert 2009 (153) | 62.1 | 70 | NR | 83.3 | 50 | 53.3 | 36.7 | 23.3 | NR | NR | NR | 0 | NR | NR | NR | NR | NR | NR | NR | 13.3 |
| Oderich 2017 (154) | 75.0±7.0 | 72.4 | 16.8 | 88.6 | 85.9 | 60.5 | 32.4 | 47.6 | 37.3 | NR | NR | 79.5 | NR | NR | NR | NR | NR | NR | NR | NR |
| Oderich 2021 (155) | 73.9±8 | 68.3 | 14.1 | 90.9 | 79.4 | 48.1 | 46.8 | 30.3 | NR | 12.7 | NR | 62.9 | NR | NR | NR | NR | NR | NR | NR | NR |
| Omura 2014 (156) | 63.0±15.0 | 72.2 | 11.3 | 80.9 | 56.5 | NR | 10.4 | 8.7 | 23.5 | 53.9 | NR | 82.6 | NR | NR | 32.1 | NR | NR | NR | 3.0±1.4 | 100 |
| Omura 2017 (157) | 55.0±16.0 | 69.1 | NR | NR | NR | NR | 3.1 | 13 | 20.2 | NR | NR | NR | NR | NR | NR | NR | NR | NR | 1.5 | 57.4 |
| Orrico 2019 (158) | 69.9±19.9 | 75 | 25 | 87 | 66 | NR | 3 | 44 | NR | NR | NR | 100 | NR | NR | NR | NR | NR | NR | NR | NR |
| Pacini 2013 (159) | 64.6±14.6 | 74.2 | 4.3 | 72 | NR | 3.2 | 7.5 | 21.5 | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Patel 2009 (160) | 57.3±12.1 | 78.2 | 13 | 82.6 | NR | 13 | 43.4 | 15.9 | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Pearce 2008 (161) | 61.0±11.5 | 80 | NR | 100 | NR | NR | NR | NR | NR | NR | NR | 2 | NR | NR | NR | NR | NR | NR | NR | NR |
| Peidro 2018 (162) | 54.0±22.0 | 76.3 | NR | NR | NR | NR | NR | NR | NR | 34.2 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Piffaretti 2015 (163) | 62.5 | 71.4 | 23.2 | NR | NR | 28.6 | 14.3 | 28.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Piscione 2007 (164) | 58.4±17.8 | 84.8 | NR | NR | NR | 36.4 | 18.2 | NR | NR | 51.5 | 51.5 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Pitton 2008 (165) | 58.9 | 40.9 | NR | NR | NR | NR | NR | NR | NR | 59.1 | 9.1 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Pompa 2016 (166) | 47.4±5.1 | 67.9 | NR | 71.4 | NR | NR | NR | NR | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Qing 2012 (167) | 56.4 | NR | NR | NR | NR | NR | NR | NR | NR | 100 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Rahe.Meyer 2009 (168) | 56.9 | 66.7 | 11.1 | 72.2 | NR | 16.7 | 5.6 | 44.4 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Rajbanshi 2015 (169) | 72.3±7.5 | 65.1 | 19.7 | 89.4 | 37.9 | 78.8 | 21.2 | 31.8 | 66.7 | 4.5 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Rana 2018 (170) | 69.0±11.0 | 68.6 | NR | 78.5 | 82.6 | 58.7 | 29.7 | NR | NR | NR | NR | 82.6 | 25.6 | 72.7 | 0 | NR | 53.7 | NR | NR | 54 |
| Ranney 2018 (171) | 71.1±10.4 | 55.8 | 21.9 | 91.7 | 67.2 | 38.5 | 20.3 | 32.8 | 41.1 | 0 | 0 | 12.5 | NR | NR | NR | NR | NR | NR | NR | NR |
| Raupach 2013 (172) | 59.8 | 73.6 | NR | NR | NR | NR | NR | NR | NR | 31.9 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Rinaldi 2022 (173) | 73±7 | 78.6 | 25.4 | 96.3 | 72.1 | 48.1 | 34.8 | 60.7 | NR | 10.5 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Rhee 2022 (174) | 40 | 75 | NR | 35 | NR | NR | 15 | NR | 90 | 80 | NR | 100 | 100 | NR | 100 | NR | NR | NR | NR | NR |
| Rocha 2021 (175) | 71.3±9.4 | 74.5 | 26.4 | 88.4 | NR | 23.1 | 13.2 | 41.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Rocha 2021 (175) | 67.5±11.2 | 67.7 | 24.1 | 87.5 | NR | 26.6 | 15.5 | 38.2 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Rodriguez 2008 (176) | 55 | 70 | 7.5 | 100 | 58.5 | 35.8 | 19.8 | 45.3 | NR | 44.3 | 36.8 | 1.9 | NR | NR | NR | NR | NR | NR | NR | NR |
| Rossi 2015 (177) | 73 | 75.4 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Rylski 2013 (178) | NR | NR | NR | NR | NR | NR | NR | NR | NR | 0 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Saiki 2019 (179) | 58.3±11.5 | 72 | NR | NR | NR | NR | NR | NR | NR | 76 | NR | 100 | NR | NR | NR | NR | NR | NR | 2.0±1.2 | 100 |
| Scali 2020 (180) | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Schneider 2018 (181) | 75.6±7.5 | 76 | 8 | 92 | 84 | 48 | 54 | 20 | 48 | 6 | NR | 86 | NR | NR | NR | NR | NR | NR | NR | NR |
| Seike 2021 (182) | 76±7.4 | 78.7 | NR | NR | 38.2 | 41.2 | 20.6 | 11.8 | 72.7 | NR | NR | 33.1 | NR | NR | NR | NR | NR | NR | NR | NR |

**Table S3** *(continued)*

 

**Table S3** *(continued)*

| Study | Age | Male (%) | Diabetes (%) | HTN (%) | Smoking history (%) | Preop CAD (%) | CRF (%) | COPD (%) | Previous aortic surgery (%) | Dissection (%) | Acute dissection (%) | CSF drain use (%) | Left Heart Bypass (%) | Selective renal perfusion (%) | Circulatory arrest (%) | Sequential Cross Clamp (%) | Clamp & Sew (%) | Mean Cross clamp time (minutes) ± st dev | Number of intercostals implanted | % of patients undergoing reimplantation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seike 2022 (183) | 76.5 | 77 | NR | NR | 42.1 | NR | 22.5 | NR | 30.4 | NR | NR | 43.6 | NR | NR | NR | NR | NR | NR | NR | NR |
| Shah 2010 (184) | 65.4 | 100 | 23.3 | 56.7 | 63.3 | 30 | 13.3 | 33.3 | NR | 3.3 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Shimizu 2014 (185) | 63.8 | 73 | 8.1 | NR | NR | 13.5 | NR | 10.8 | 43.2 | 62.2 | NR | 83.8 | NR | 59.5 | NR | 97.3 | NR | 142.0±69.0 | NR | 75.7 |
| Shiraev 2016 (186) | 55.9±17.2 | 58.33 | 0 | 58.3 | 66.7 | 25 | NR | NR | 8.3 | NR | NR | 50 | NR | NR | NR | NR | NR | NR | NR | NR |
| Shu 2011 (187) | 42.6 | 73.3 | 17.8 | 22.2 | NR | 13.3 | 15.6 | 13.3 | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Si 2014 (188) | 55.8 | 85.7 | 5.4 | 78.6 | 30.4 | 3.6 | 14.3 | 16.1 | NR | 85.7 | NR | 0 | NR | NR | NR | NR | NR | NR | NR | NR |
| Smith 2022 (189) | 71.76±9 | 65.3 | 16.2 | 90 | NR | 27.6 | 2.8 | 40.9 | 43.1 | NR | NR | 49.8 | NR | NR | NR | NR | NR | NR | NR | NR |
| Song 2016 (190) | 53.9±12.7 | 81.5 | 8.1 | 78.5 | 41.2 | 1.5 | 5.9 | NR | NR | 100 | 41.5 | 1.5 | NR | NR | NR | NR | NR | NR | NR | NR |
| Spanos 2018 (191) | 73.3±7.0 | 61.9 | 7.1 | 78.6 | 38.1 | 30.9 | 35.7 | 23.8 | 47.6 | 4.8 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Spanos 2019 (192) | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Spear 2018 (193) | 61.5 | 90.9 | 4.5 | 95.4 | NR | 9.1 | 9.1 | 13.6 | 86.4 | 100 | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Spinella 2020 (194) | 76.5 | 90.9 | 0.09 | 100 | NR | 63 | 27 | 54 | 45 | NR | NR | 100 | NR | NR | NR | NR | NR | NR | NR | NR |
| Steingruber 2008 (195) | 64 | 77.1 | NR | NR | NR | NR | NR | NR | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Stelzmueller 2019 (196) | 52.0±13.0 | 72.7 | 5.5 | 78.2 | NR | 5.5 | 5.5 | 5.5 | 7.3 | 100 | 100 | 0 | NR | NR | NR | NR | NR | NR | NR | NR |
| Sugiura 2017 (197) | 63 | 72.9 | NR | 79.7 | NR | NR | 31.4 | 8.5 | 34.7 | 52.5 | NR | 66.1 | NR | NR | NR | NR | NR | NR | CSFD group: 2.1±2.4, No CSFD group: 1.2±2.1 | CSFD group: 56.4, No CSFD group: 37.5 |
| Sultan 2018 (198) | 63.8 | 81.8 | NR | 81.8 | 60.6 | NR | 3 | NR | 18.2 | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Sweet 2015 (199) | 73 | 75 | 12.5 | 91.7 | 50 | 54.2 | 29.2 | 41.7 | 50 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Tabayashi 2010 (200) | 63 | 74.5 | NR | NR | NR | NR | NR | NR | NR | NR | NR | 100 | 56.9 | NR | NR | NR | NR | NR | No SCI group (n=98): 2.6±1.6 SCI group (n=4): 3.7±1.5 | 100 |
| Takahashi 2011 (201) | 72.7±7.6 | 73.3 | 20 | 86.7 | 26.7 | 26.7 | 13.3 | 6.7 | 10.8 | 26.7 | NR | 100 | NR | NR | NR | NR | NR | 77.0±31.0 | NR | 20 |
| Tanaka 2018 (202) | 75 | 46.6 | 9.1 | 96.6 | 75 | 45.5 | 38.6 | 56.8 | 46.6 | 12.5 | 0 | 78.4 | NR | NR | NR | NR | NR | NR | NR | NR |
| Tanaka 2019 (203) | 71±9.63 | 63 | NR | 86 | 83 | 31 | NR | 42 | 49 | 30 | 4 | 100 | NR | NR | NR | 100 | NR | 40±20.74 | NR | NR |
| Tanaka 2019 (203) | 39±11.1 | 67 | NR | 71 | 51 | 7 | NR | 9 | 65 | 68 | 4 | 100 | NR | NR | NR | 100 | NR | 44±29.62 | NR | NR |
| Tang 2011 (204) | 64.0±19.0 | 76.7 | 23.3 | 80 | 66.7 | 30 | 3.3 | 13.3 | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Tenorio 2020 (205) | 72±9 | 57 | 13 | 95 | 73 | 42 | 45 | 45 | 71 | 20 | NR | 92 | NR | NR | NR | NR | NR | NR | NR | NR |
| Thomas 2018 (206) | 73.7 | 72.7 | 13.6 | 95.5 | 40.9 | NR | NR | NR | NR | 40.9 | 31.8 | 0 | NR | NR | NR | NR | NR | NR | NR | NR |
| Tong 2022 (207) | 66±11 | 62 | 11 | 91 | NR | 18 | NR | 36 | NR | NR | NR | 61 | NR | NR | NR | NR | NR | NR | NR | NR |
| Tong 2022 (207) | 66±13 | 63 | 10 | 89 | NR | 22 | NR | 36 | NR | NR | NR | 62 | NR | NR | NR | NR | NR | NR | NR | NR |
| Trimarchi 2010 (208) | 60 | 88.9 | NR | NR | NR | NR | NR | NR | NR | 100 | 100 | NR | 0 | NR | 0 | NR | 100 | NR | NR | NR |
| Tsilimparis 2018 (209) | 72.7±9.9 | 61.7 | NR | 86.9 | 81.9 | 35.5 | 1.8 | 35.7 | NR | NR | NR | 40.1 | NR | NR | NR | NR | NR | NR | NR | NR |

**Table S3** *(continued)*

**Table S3** *(continued)*

| Study | Age | Male (%) | Diabetes (%) | HTN (%) | Smoking history (%) | Preop CAD (%) | CRF (%) | COPD (%) | Previous aortic surgery (%) | Dissection (%) | Acute dissection (%) | CSF drain use (%) | Left Heart Bypass (%) | Selective renal perfusion (%) | Circulatory arrest (%) | Sequential Cross Clamp (%) | Clamp & Sew (%) | Mean Cross clamp time (minutes) ± st dev | Number of intercostals implanted | % of patients undergoing reimplantation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ullery 2012 (210) | 71.3 | 59.4 | 18.5 | 97.7 | 47.9 | 44.3 | 11.3 | 24 | NR | 15.3 | 15.3 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Umegaki 2022 (211) | 73±10.6 | 74.2 | NR | NR | NR | NR | NR | NR | NR | 28.8 | NR | 6.3 | NR | NR | NR | NR | NR | NR | NR | NR |
| Umegaki 2022 (211) | 65±12.6 | 76.7 | NR | NR | NR | NR | NR | NR | NR | 44.7 | NR | 16.3 | NR | NR | NR | NR | NR | NR | NR | NR |
| Vaislic 2014 (212) | 75.8±10.8 | 82.6 | 8.7 | 87 | 65.2 | 26.1 | 30.4 | NR | 65.2 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| van Bogerijen 2015 (213) | 56.4±12.8 | 77.8 | 8.9 | 90 | 62.2 | 12.2 | NR | 2.2 | 31.1 | 83.3 | 0 | 86.7 | 21.1 | NR | 77.8 | NR | NR | 75 | NR | NR |
| Van Calster 2019 (214) | 71.6±8.89 | 94.2 | 19.8 | NR | 87.3 | 44.7 | 23.9 | 36.7 | NR | NR | NR | 52.8 | NR | NR | NR | NR | NR | NR | NR | NR |
| Wahlgren 2017 (215) | 60 | 78.9 | NR | 83.3 | 52.2 | 10 | 4.4 | 8.9 | 57.8 | NR | NR | 76.7 | 63.3 | NR | 36.7 | NR | NR | NR | LHB group: 2.7, HCA group: 1.4 | LHB group: 56, HCA group: 45 |
| Watson 2010 (216) | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR | 100 | NR | 100 | NR | NR | NR | NR | NR | NR |
| Weiss 2012 (217) | 62.6±13.2 | 55.8 | NR | NR | 62.9 | NR | 10 | 16.3 | 37.9 | 40 | 3.8 | 80 | NR | NR | 32.1 | NR | NR | 46 | NR | NR |
| Wojciechowski 2014 (218) | 72.0±14.4 | 72.2 | 12.5 | 62.5 | NR | 18.1 | 8.3 | NR | 9.7 | 11.1 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Wongkornrat 2015 (219) | 65.1±12.0 | 73.5 | NR | NR | NR | NR | 8 | NR | 26 | 50.5 | NR | 82 | 100 | 61.5 | NR | 38 | NR | 78.8 | NR | 38 |
| Wynn 2016 (220) | 70 | 57.9 | NR | NR | NR | NR | NR | NR | 29.2 | 10.6 | NR | 75.7 | NR | NR | 4.7 | NR | 95.3 | NR | NR | 32.9 |
| Xiong 2013 (221) | 52.8±13.1 | 88.5 | NR | NR | NR | NR | NR | NR | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Yaffee 2015 (222) | 60.7±14.0 | 64.4 | 9.8 | NR | NR | 3 | 5.3 | 12.1 | NR | 29.5 | 16.7 | NR | NR | NR | NR | NR | NR | 101.9 | NR | NR |
| Yang 2018 (223) | 44.0±15.0 | 86.4 | 6.3 | 85.2 | NR | NR | NR | NR | NR | 100 | 81.4 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Yang 2020 (224) | 74.4±8.7 | 85 | 11 | 80 | 85 | 13 | 3 | NR | NR | NR | NR | 60 | NR | NR | NR | NR | NR | NR | NR | NR |
| Yokawa 2020 (225) | 62.6±14 | 72.1 | 9.6 | 82.5 | NR | 19.5 | 54.6 | 18.2 | 45 | NR | NR | 81.5 | 100 | NR | 12.7 | NR | NR | NR | 192 | 76.5 |
| Yoo 2014 (226) | 53.5 | 76.9 | 6.1 | 51.9 | NR | 2.8 | NR | NR | NR | 46.2 | 9 | 59.4 | 2.4 | NR | 37.3 | NR | NR | NR | NR | NR |
| Youssef 2015 (227) | 66.0±10.0 | 64.5 | 4.8 | 98.4 | 77.4 | 25.8 | 22.6 | NR | 22.6 | 27.4 | NR | 56.5 | 17.7 | NR | NR | NR | NR | NR | NR | NR |
| Youssef 2018 (228) | 72 | 60 | 30 | 96.7 | 73.3 | 40 | NR | 20 | 50 | 10 | 0 | 80 | NR | NR | NR | NR | NR | NR | NR | NR |
| Yunoki 2014 (229) | 74.8±10.0 | 66.7 | NR | 94.4 | NR | 44.4 | 13.9 | 13.9 | 27.8 | NR | NR | 75 | NR | NR | NR | NR | NR | NR | NR | NR |
| Yuri 2012 (230) | 70.1±14.1 | 83.3 | 13.3 | 40 | NR | NR | 10 | 20 | NR | NR | 0 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Zamor 2015 (231) | 59.9 | 70 | 16.3 | 78.8 | 53.8 | 30 | 26.3 | 11.3 | NR | 40 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Zanetti 2015 (232) | 62 | 74.5 | NR | 78.4 | 68.6 | 15.7 | 19.6 | 29.4 | NR | 45.1 | NR | 11.8 | 51 | NR | 19.6 | NR | 13.7 | 53.5 | 1.33 | NR |
| Zeng 2016 (233) | 51.0±13.0 | 74 | NR | 80.9 | 42.7 | NR | 0 | NR | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Zeng 2021 (234) | 56.3±14.6 | 90 | 10 | 80 | 70 | NR | 10 | NR | 20 | 10 | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Zha 2018 (235) | 54.9 | 77.3 | NR | NR | NR | NR | NR | NR | NR | 100 | 36.4 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Zhang 2017 (236) | 63.9 | 69.4 | 12.9 | 83.5 | 54.1 | NR | 4.7 | 3.5 | NR | 100 | 70.6 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Zhao 2018 (237) | 52.1 | 91.2 | 7.4 | 82.4 | NR | 2.9 | 4.4 | NR | NR | 100 | 7.4 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Zhou 2018 (238) | 57.0±11.0 | 81.6 | 2.6 | 86.8 | NR | 13.2 | NR | NR | NR | 100 | 57.9 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Zhou 2018 (238) | 49.7±11.6 | 93.9 | 7.6 | 69.7 | 69.7 | 6.1 | NR | 0 | NR | 100 | 68.2 | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Zhu 2018 (239) | 53 | 80 | 5 | 90 | NR | 35 | 15 | 10 | NR | 100 | 100 | NR | NR | NR | NR | NR | NR | NR | NR | NR |

HTN, hypertension; CAD, coronary artery disease; CVA, cerebrovascular accident; CRF, chronic renal failure; COPD, chronic obstructive pulmonary disease; CSF, cerebrospinal fluid; HCA, hypothermic circulatory arrest; LHB, left heart bypass; NR, not reported.

**Table S4** Proportion of studies that reported preoperative, intraoperative, and postoperative variables of interest

| Variable | Reported endovascular repair (%) | Reported open repair (%) |
|---|---|---|
| Gender | 94.7 | 96.4 |
| Diabetes | 73.1 | 67.9 |
| Hypertension | 80.1 | 79.8 |
| Smoking | 55 | 54.8 |
| Coronary artery disease | 65.5 | 64.3 |
| Chronic renal failure | 70.2 | 67.9 |
| Chronic obstructive pulmonary disease | 63.2 | 72.6 |
| Aortic dissection | 50.9 | 59.5 |
| Cerebrospinal fluid drain use | 36.3 | 67.9 |
| Left heart bypass | NA | 45.2 |
| Renal perfusion | NA | 10.7 |
| Circulatory arrest | NA | 39.3 |
| Postoperative cerebrovascular accident | 70.8 | 73.8 |
| Follow-up mortality | 66.7 | 54.8 |

NA, not applicable.


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**Table S5** Summary of critical appraisal of included observational studies using the Newcastle-Ottawa Quality Assessment Scale

| Author | Selection | Comparability | Outcome |
|---|---|---|---|
| Abdelbaky 2021 | **** | ** | *** |
| Abisi 2021 | *** | ** | ** |
| Acher 2019 | *** | ** | *** |
| Adam 2022 | *** | ** | *** |
| Afifi 2015 | **** | ** | ** |
| Al Adas 2018 | *** | * | *** |
| Albors 2009 | *** | * | ** |
| Alhussaini 2021 | *** | * | ** |
| Andacheh 2011 | *** | ** | *** |
| Andersen 2014 | **** | * | *** |
| Anderson 2014 | **** | ** | *** |
| Arnaoutakis 2015 | **** | ** | *** |
| Arnaoutakis 2020 | **** | ** | *** |
| Baba 2017 | *** | * | *** |
| Bannazadeh 2020 | *** | ** | *** |
| Barbosa Lima 2021 | *** | ** | *** |
| Bashir 2014 | **** | * | *** |
| Belov 2009 | *** | * | ** |
| Bertoglio 2018 | *** | * | ** |
| Bertoglio 2020 | *** | * | *** |
| Bertoglio 2021 | *** | ** | ** |
| Bisdas 2015 | **** | * | ** |
| Bockler 2009 | *** | * | ** |
| Bosiers 2021 | *** | ** | *** |
| Botsios 2014 | *** | * | ** |
| Branzan 2018 | *** | ** | ** |
| Canaud 2018 | **** | * | *** |
| Chatterjee 2021 | *** | ** | *** |
| Chen 2013 | **** | ** | *** |
| Chen 2017 | **** | * | ** |
| Clough 2012 | **** | * | *** |
| Clough 2018 | **** | ** | *** |
| Conrad 2017 | **** | ** | *** |
| Conway 2014 | **** | ** | *** |
| Conway 2022 | *** | ** | *** |
| Coselli 2016 | **** | ** | *** |
| Da Rocha 2010 | **** | * | ** |
| Davidovic 2011 | **** | * | ** |
| Diamond 2021 | *** | * | ** |
| Dias 2015 | **** | ** | *** |
| Dick 2008 | **** | ** | *** |
| Ding 2018 | **** | * | *** |
| Dong 2022 | *** | ** | ** |
| Du 2019 | **** | * | *** |
| Dua 2019 | *** | ** | *** |
| Duan 2016 | *** | * | ** |
| Dufour 2015 | **** | ** | *** |
| Eagleton 2016 | **** | ** | *** |
| Estrera 2015 | **** | ** | *** |
| Faure 2018 | *** | * | *** |
| Fernandez 2016 | **** | * | *** |
| Ferreira 2008 | *** | ** | *** |
| Fioranelli 2011 | **** | ** | *** |
| Forsythe 2022 | *** | ** | *** |
| Fossaceca 2013 | *** | * | ** |
| Frankel 2020 | ** | ** | *** |
| Fujikawa 2018 | **** | ** | *** |
| Fujikawa 2019 | *** | * | *** |
| Fujiyoshi 2019 | *** | ** | *** |
| Fukui 2016 | **** | ** | *** |
| Fukushima 2020 | *** | * | *** |
| Gallitto 2017 | **** | * | ** |
| Gallitto 2022 | *** | ** | ** |
| Gallitto 2022 | *** | ** | *** |
| Gambardella 2021 | *** | * | ** |
| Garbade 2010 | **** | ** | *** |
| Gillen 2015 | **** | ** | *** |

**Table S5** (*continued*)


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Table S5 (continued)

| Author | Selection | Comparability | Outcome |
|---|---|---|---|
| girardi 2019 | **** | ** | *** |
| Gocze 2018 | **** | ** | *** |
| Gombert 2017 | **** | ** | *** |
| Gombert 2018 | **** | ** | *** |
| gombert 2020 | *** | * | ** |
| gombert 2022 | *** | ** | *** |
| grassi 2022 | *** | ** | ** |
| Guangqi 2009 | **** | * | *** |
| Guo 2015 | **** | ** | ** |
| harky 2021 | *** | ** | ** |
| He 2015 | *** | * | *** |
| He 2017 | **** | ** | ** |
| Heijmen 2012 | **** | ** | ** |
| henmi 2019 | *** | ** | *** |
| Hicks 2017 | **** | ** | *** |
| Hiraoka 2018 | *** | ** | *** |
| Hnath 2008 | **** | * | ** |
| hoshina 2021 | **** | * | ** |
| Huang 2016 | **** | ** | ** |
| Inglese 2008 | **** | ** | *** |
| Jayia 2015 | **** | * | *** |
| Jing 2008 | *** | ** | *** |
| Johns 2014 | *** | * | *** |
| jorgensen 2020 | *** | ** | ** |
| Juszczak 2020 | *** | ** | ** |
| Kamada 2015 | **** | ** | *** |
| Kang 2019 | *** | ** | *** |
| Kasprzak 2014 | **** | ** | ** |
| Katsargyris 2015 | *** | ** | *** |
| Katsargyris 2021 | *** | ** | *** |
| Kieffer 2008 | **** | * | *** |
| Kinoshita 2015 | *** | * | *** |
| Kiser 2022 | **** | ** | *** |
| Kitamura 2013 | **** | ** | *** |

Table S5 (continued)

Table S5 (continued)

| Author | Selection | Comparability | Outcome |
|---|---|---|---|
| Kitpanit 2021 | *** | ** | ** |
| Kouchouk 2019 | *** | ** | *** |
| Kratimenos 2018 | **** | * | *** |
| Kulik 2011 | *** | ** | *** |
| Kunihara 2009 | *** | * | *** |
| Kunihara 2021 | *** | * | ** |
| Kurimoto 2008 | **** | ** | *** |
| Lancaster 2013 | *** | * | *** |
| Latz 2021 | *** | ** | *** |
| Le Huu 2022 | *** | ** | *** |
| Lee 2012 | *** | ** | *** |
| Lee 2015 | **** | * | ** |
| Li 2015 | **** | ** | *** |
| Li 2018 | **** | ** | *** |
| Lima 2012 | **** | ** | *** |
| Lima 2022 | *** | ** | *** |
| Lindstrom 2020 | *** | ** | *** |
| Liu 2011 | *** | * | *** |
| Liu 2017 | **** | ** | *** |
| Lobato 2012 | *** | ** | *** |
| Locham 2018 | *** | ** | ** |
| Lortz 2018 | ** | ** | ** |
| Lou 2018 | *** | ** | ** |
| Lucatelli 2018 | *** | ** | ** |
| Malas 2021 | **** | * | *** |
| Manning 2009 | *** | ** | ** |
| Marconde 2022 | *** | ** | *** |
| Martin 2009 | ** | ** | *** |
| Mastroroberto 2010 | *** | ** | *** |
| Mazzeffi 2018 | ** | ** | *** |
| Meltzer 2017 | *** | ** | ** |
| Messe 2008 | ** | * | *** |
| Mezzetto 2021 | *** | ** | *** |
| Min 2010 | *** | ** | *** |

Table S5 (continued)


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**Table S5** (*continued*)

| Author | Selection | Comparability | Outcome |
|---|---|---|---|
| Mishra 2008 | *** | ** | *** |
| Mitchell 2011 | **** | ** | ** |
| Mizoguchi 2017 | ** | ** | *** |
| Mkalaluh 2018 | *** | ** | ** |
| Monaco 2018 | **** | ** | *** |
| Monnot 2018 | *** | ** | ** |
| Mosquera 2009 | *** | * | *** |
| Motta 2019 | *** | * | *** |
| Motta 2019 | *** | ** | *** |
| Moulakakis 2015 | *** | ** | ** |
| Muncan 2022 | *** | ** | *** |
| Murana 2016 | *** | ** | *** |
| Naguib 2016 | ** | ** | *** |
| Narayan 2011 | **** | ** | ** |
| Naughton 2012 | ** | ** | *** |
| Neo 2011 | ** | ** | *** |
| Nomura 2015 | *** | * | *** |
| Ockert 2009 | *** | ** | ** |
| Oderich 2017 | *** | ** | *** |
| Oderich 2021 | *** | * | *** |
| Omura 2014 | **** | * | ** |
| Omura 2017 | ** | ** | *** |
| Orrico 2019 | *** | * | *** |
| Pacini 2013 | ** | ** | ** |
| Patel 2009 | *** | ** | *** |
| Pearce 2008 | *** | * | ** |
| Peidro 2018 | *** | ** | *** |
| Piffaretti 2015 | *** | * | ** |
| Piscione 2007 | **** | * | ** |
| Pitton 2008 | ** | ** | ** |
| Pompa 2016 | ** | ** | ** |
| Qing 2012 | *** | ** | *** |
| Rahe.Meyer 2009 | *** | ** | ** |
| Rajbanshi 2015 | **** | ** | *** |

**Table S5** (*continued*)

**Table S5** (*continued*)

| Author | Selection | Comparability | Outcome |
|---|---|---|---|
| Rana 2018 | ** | ** | *** |
| Ranney 2018 | *** | * | *** |
| Raupach 2013 | *** | * | *** |
| Renaldi 2022 | *** | ** | ** |
| Rhee 2022 | *** | ** | *** |
| Rocha 2021 | *** | ** | *** |
| Rodriguez 2008 | *** | ** | *** |
| Rossi 2015 | ** | * | ** |
| Rylski 2013 | ** | ** | *** |
| Saiki 2019 | *** | ** | ** |
| Scali 2020 | *** | ** | *** |
| Schneider 2018 | *** | ** | ** |
| Seike 2022 | *** | * | ** |
| Shah 2010 | *** | ** | *** |
| Shimizu 2014 | *** | ** | ** |
| Shiraev 2016 | **** | * | *** |
| Shu 2011 | ** | * | *** |
| Si 2014 | **** | * | *** |
| Smith 2022 | **** | ** | *** |
| Song 2016 | **** | ** | *** |
| Spanos 2018 | ** | ** | *** |
| Spanos 2019 | *** | ** | ** |
| Spear 2018 | ** | ** | *** |
| Spinella 2020 | *** | * | ** |
| Steingruber 2008 | *** | ** | ** |
| Stelzmueller 2019 | *** | * | *** |
| Sugiura 2017 | *** | * | ** |
| Sultan 2018 | ** | ** | *** |
| Sweet 2015 | ** | * | *** |
| Tabayashi 2010 | *** | ** | *** |
| Takahashi 2011 | **** | ** | ** |
| Tanaka 2018 | ** | ** | *** |
| Tanaka 2019 | *** | ** | *** |
| Tanaka 2019 | *** | ** | *** |

**Table S5** (*continued*)



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**Table S5** (*continued*)

| Author | Selection | Comparability | Outcome |
|---|---|---|---|
| Tang 2011 | **** | ** | *** |
| Tenorio 2020 | *** | * | *** |
| Thomas 2018 | *** | ** | *** |
| Tong 2022 | *** | ** | *** |
| Trimarchi 2010 | ** | * | *** |
| Tsilimparis 2018 | *** | ** | *** |
| Ullery 2012 | *** | * | *** |
| Umegaki 2022 | *** | ** | ** |
| Vaislic 2014 | ** | ** | *** |
| van Bogerijen 2015 | ** | ** | ** |
| Van Calster 2019 | *** | ** | *** |
| Wahlgren 2017 | ** | ** | *** |
| Watson 2010 | *** | ** | *** |
| Weiss 2012 | **** | ** | *** |
| Wojciechowski 2014 | ** | ** | *** |
| Wongkornrat 2015 | *** | * | ** |
| Wynn 2016 | *** | ** | ** |
| Xiong 2013 | **** | ** | *** |
| Yaffee 2015 | *** | ** | ** |

**Table S5** (*continued*)

**Table S5** (*continued*)

| Author | Selection | Comparability | Outcome |
|---|---|---|---|
| Yang 2018 | **** | ** | *** |
| Yang 2020 | *** | * | *** |
| Yokawa 2020 | *** | ** | *** |
| Yoo 2014 | ** | ** | *** |
| Youssef 2015 | *** | ** | *** |
| Youssef 2018 | *** | * | *** |
| Yunoki 2014 | *** | * | *** |
| Yuri 2012 | **** | ** | *** |
| Zamor 2015 | *** | ** | ** |
| Zanetti 2015 | **** | * | ** |
| Zeng 2016 | ** | * | *** |
| Zeng 2021 | *** | ** | ** |
| Zha 2018 | *** | ** | *** |
| Zhang 2017 | *** | * | ** |
| Zhao 2018 | ** | ** | *** |
| Zhou 2018 | **** | ** | *** |
| Zhu 2018 | **** | ** | *** |


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**Table S6** The Cochrane Collaboration's tool for assessing risk of bias in randomized trials

| | Random sequence generation | Allocation concealment | Blinding of participants | Blinding of outcome assessment | Incomplete outcome data | Selective reporting | Other sources of bias |
|---|---|---|---|---|---|---|---|
| Marzelle 2015 (129) | + | ? | – | – | + | + | ? |
| | + | Low risk | | | | | |
| | ? | Uncertain | | | | | |
| | – | High risk | | | | | |

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Table S7 Pooled rates of CSF drain use related complication

| Outcomes | Studies | Patient number | Effect estimate % [95% CI (%)] | Heterogeneity ($I^2$, P value) | $P_{interaction}$ |
|---|---|---|---|---|---|
| Severe complications | 13 | 986 | 1.95 [0.75; 4.67] | 69.00, P<0.001 | – |
| Endovascular | 9 | 662 | 3.02 [1.96; 4.64] | 36.4% | 0.97 |
| Open | 4 | 324 | 1.85 [0.83; 4.06] | 0.0% | 0.97 |
| Moderate complications | 13 | 986 | 0.38 [0.03; 3.97] | 40.0%, P=0.07 | – |
| Endovascular | 9 | 662 | 0.29 [0.02; 4.13] | 0.0% | 0.28 |
| Open | 4 | 324 | 2.28 [0.15; 26.11] | 37.0% | 0.28 |
| Minor complications | 13 | 986 | 1.81 [0.57; 5.56] | 30.0%, P=0.14 | – |
| Endovascular | 9 | 662 | 0.84 [0.10; 6.50] | 67.0% | 0.12 |
| Open | 4 | 324 | 4.56 [2.58; 7.94] | 8.0% | 0.12 |

CSF, cerebrospinal fluid.


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