

Abdominal Aortic Aneurysm and EVAR: Systematic Review with SAIMSARA.

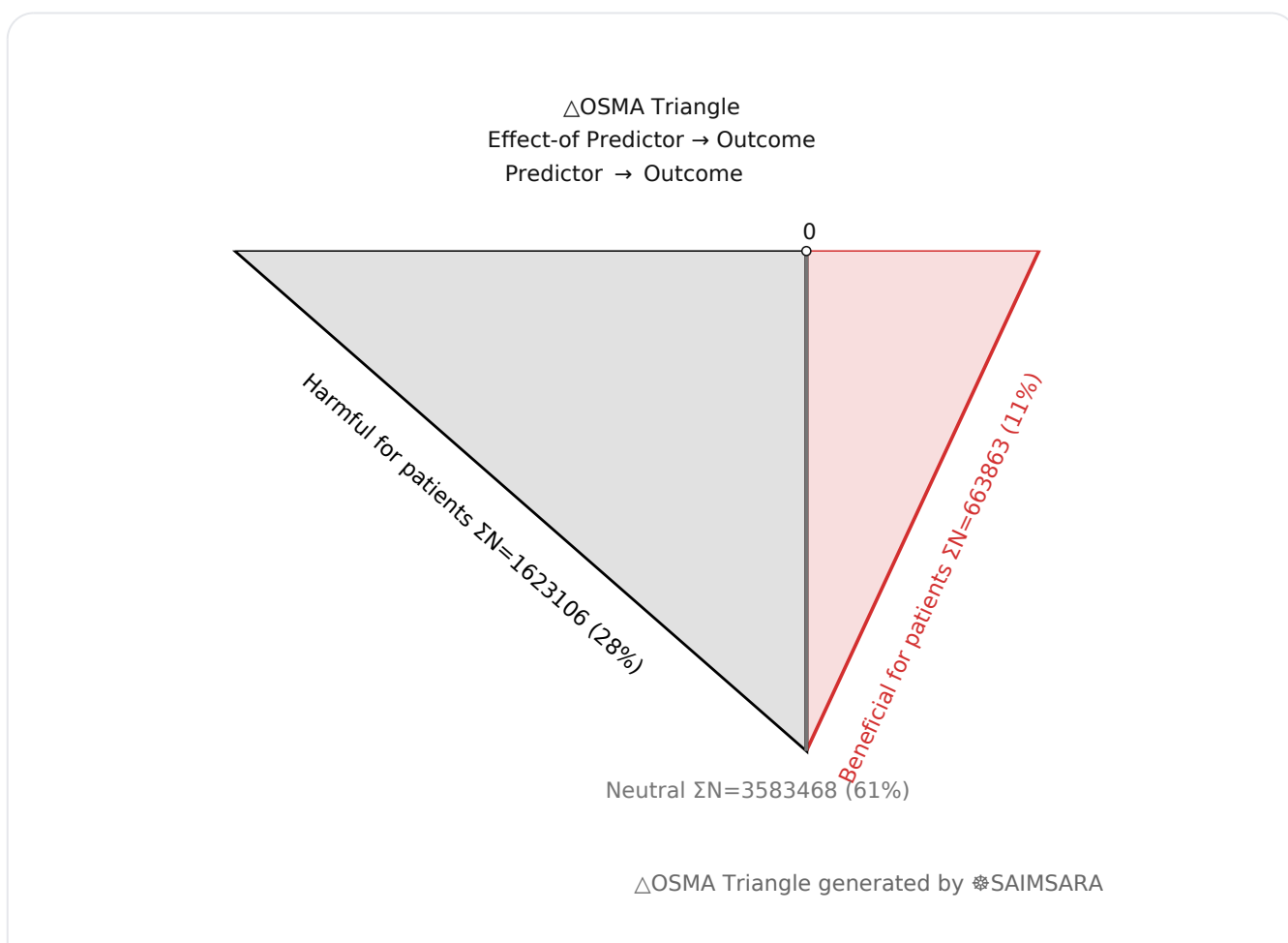
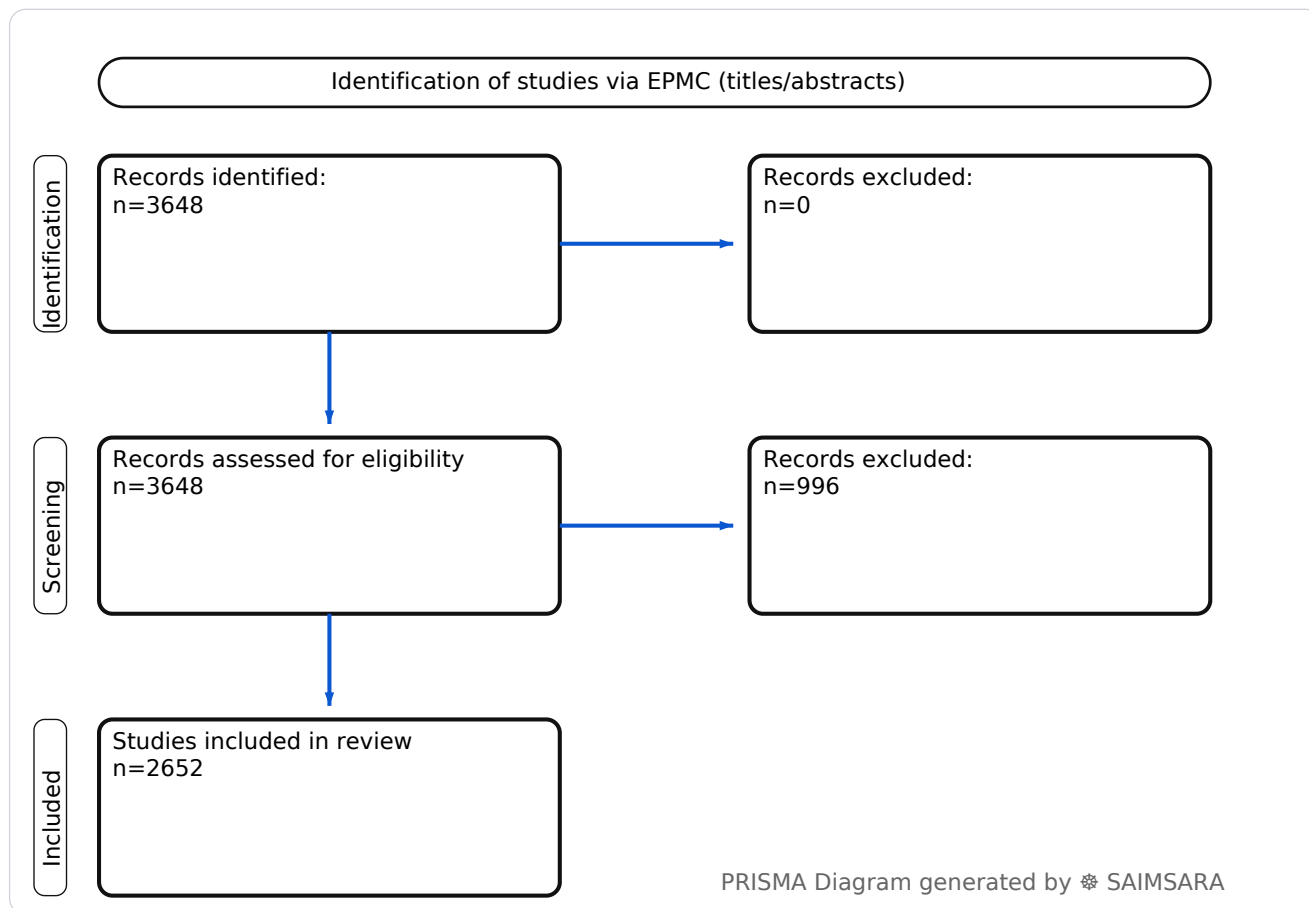
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Abstract: To systematically review and synthesize current evidence regarding the outcomes, complications, and advancements in endovascular aneurysm repair for abdominal aortic aneurysms. The review utilises 2652 studies with 5870437 total participants (naïve ΣN). This systematic review highlights the transformative impact of endovascular aneurysm repair (EVAR) on the management of abdominal aortic aneurysms (AAAs). EVAR generally offers a favorable short-term safety profile, with a median 30-day mortality rate of 2.9%, demonstrating significant advantages over open surgical repair in terms of perioperative mortality and morbidity. However, the procedure necessitates diligent, often lifelong, surveillance due to the persistent risk of endoleaks and the need for reinterventions. A key limitation remains the heterogeneity of study designs and outcome reporting, which complicates direct comparisons. Future research should focus on validating predictive models, standardizing outcome measures, and conducting long-term comparative studies to refine patient selection and optimize surveillance protocols, ultimately enhancing the durability and patient-centered outcomes of EVAR.

Keywords: Abdominal Aortic Aneurysm; Endovascular Aneurysm Repair; Endoleak; Aneurysm Rupture; Reintervention; Fenestrated EVAR; Branched EVAR; Open Surgical Repair; Aortic Morphology; Mortality

Review Stats

- Generated: 2026-02-17 02:51:17 CET
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- Source: Europe PMC
- Scope: Titles/Abstracts (tiab)
- Keyword Gate: Fuzzy ($\geq 60\%$ of required terms, minimum 2 terms matched in title/abstract)
- Total Abstracts/Papers: 3648
- Downloaded Abstracts/Papers: 3648
- Included original Abstracts/Papers: 2652
- Total study participants (naïve ΣN): 5870437



Outcome-Sentiment Meta-Analysis (OSMA): (LLM-only)

Frame: Effect-of Predictor → Outcome • *Source:* Europe PMC

Outcome: Outcome Typical timepoints: peri/post-op, 30-day. Reported metrics: %, CI, p.

Common endpoints: Common endpoints: mortality, complications, survival.

Predictor: Predictor — exposure/predictor. Doses/units seen: 60 ml, 10.0 g, 30 ml, 32 kg, 2 units, 3.1 µg.... Routes seen: oral, iv, subcutaneous, intravenous. Typical comparator: osr for abdominal aortic, dual antiplatelet therapy, open aortic repair, those undergoing oar....

- **1) Beneficial for patients** — Outcome with Predictor — [33], [38], [39], [43], [49], [50], [59], [118], [131], [194], [197], [203], [219], [238], [239], [242], [250], [256], [261], [292], [386], [389], [416], [419], [429], [430], [437], [438], [487], [512], [513], [515], [518], [524], [528], [531], [532], [533], [535], [536], [540], [541], [546], [549], [557], [561], [568], [590], [599], [600], [602], [621], [628], [631], [702], [713], [720], [725], [742], [810], [836], [846], [852], [861], [868], [869], [893], [898], [903], [904], [912], [934], [938], [942], [948], [1020], [1128], [1153], [1165], [1169], [1192], [1216], [1224], [1230], [1255], [1257], [1300], [1361], [1394], [1408], [1455], [1456], [1459], [1463], [1467], [1468], [1501], [1504], [1525], [1574], [1587], [1594], [1608], [1609], [1614], [1617], [1635], [1646], [1664], [1729], [1745], [1796], [1894], [1895], [1946], [1953], [1979], [2051], [2083], [2092], [2201], [2210], [2213], [2215], [2310], [2365], [2376], [2381], [2420], [2439], [2440], [2444], [2447], [2450], [2454], [2504], [2508], [2514], [2519], [2576], [2613], [2631], [2643], [2650] — ΣN=663863
- **2) Harmful for patients** — Outcome with Predictor — [6], [22], [40], [42], [45], [46], [47], [53], [54], [57], [58], [65], [81], [85], [104], [112], [121], [126], [138], [139], [145], [149], [155], [156], [165], [176], [177], [180], [202], [207], [208], [209], [210], [211], [217], [223], [235], [241], [247], [251], [254], [255], [259], [262], [264], [267], [268], [278], [281], [282], [300], [302], [308], [309], [310], [338], [359], [365], [375], [382], [385], [388], [407], [410], [417], [421], [424], [431], [436], [442], [446], [448], [450], [457], [460], [462], [470], [472], [478], [479], [490], [494], [497], [502], [503], [504], [516], [521], [522], [523], [525], [529], [534], [553], [555], [556], [558], [564], [565], [572], [585], [587], [589], [592], [593], [594], [595], [596], [598], [604], [605], [611], [614], [622], [624], [625], [629], [636], [640], [641], [642], [645], [647], [653], [659], [660], [664], [668], [676], [679], [689], [690], [693], [694], [699], [704], [705], [707], [709], [717], [744], [748], [754], [755], [762], [764], [766], [771], [773], [776], [777], [798], [805], [815], [820], [825], [826], [829], [833], [838], [841], [851], [858], [863], [866], [867], [882], [887], [889], [890], [897], [899], [905], [906], [908], [914], [918], [925], [936], [941], [949], [959], [960], [964], [965], [967], [970], [975], [977], [978], [979], [980], [987], [989], [991], [1017], [1021], [1040], [1042], [1061], [1064],

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- **3) No clear effect** — Outcome with Predictor — [1], [2], [3], [4], [5], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [23], [24], [25], [26], [27], [28], [29], [30], [31], [32], [34], [35], [36], [37], [41], [44], [48], [51], [52], [55], [56], [60], [61], [62], [63], [64], [66], [67], [68], [69], [70], [71], [72], [73], [74], [75], [76], [77], [78], [79], [80], [82], [83], [84], [86], [87], [88], [89], [90], [91], [92], [93], [94], [95], [96], [97], [98], [99], [100], [101], [102], [103], [105], [106], [107], [108], [109], [110], [111], [113], [114], [115], [116], [117], [119], [120], [122], [123], [124], [125], [127], [128], [129], [130], [132], [133], [134], [135], [136], [137], [140], [141], [142], [143], [144], [146], [147], [148], [150], [151], [152], [153], [154], [157], [158], [159], [160], [161], [162], [163], [164], [166], [167], [168], [169], [170], [171], [172], [173], [174], [175], [178], [179], [181], [182], [183], [184], [185], [186], [187], [188], [189], [190], [191], [192], [193], [195], [196], [198], [199], [200], [201], [204], [205], [206], [212], [213], [214], [215], [216], [218], [220], [221], [222], [224], [225], [226], [227], [228], [229], [230], [231], [232], [233], [234], [236], [237], [240], [243], [244], [245], [246], [248], [249], [252], [253], [257], [258], [260], [263], [265], [266], [269], [270], [271], [272], [273], [274], [275], [276], [277], [279], [280], [283], [284], [285], [286], [287], [288], [289], [290], [291], [293], [294], [295], [296], [297], [298], [299], [301],

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[1506], [1507], [1508], [1509], [1510], [1511], [1513], [1514], [1515], [1517], [1518], [1522], [1523], [1524], [1526], [1527], [1528], [1529], [1530], [1531], [1532], [1533], [1534], [1535], [1536], [1537], [1538], [1539], [1540], [1541], [1542], [1543], [1544], [1546], [1547], [1548], [1549], [1550], [1552], [1553], [1555], [1558], [1559], [1560], [1562], [1563], [1564], [1565], [1566], [1568], [1569], [1570], [1571], [1575], [1576], [1577], [1579], [1580], [1582], [1583], [1586], [1588], [1590], [1593], [1596], [1605], [1606], [1610], [1611], [1612], [1613], [1615], [1616], [1620], [1622], [1623], [1624], [1627], [1629], [1633], [1634], [1636], [1639], [1641], [1642], [1643], [1644], [1645], [1647], [1648], [1649], [1652], [1653], [1654], [1655], [1656], [1657], [1659], [1660], [1661], [1662], [1663], [1666], [1667], [1668], [1669], [1670], [1671], [1675], [1676], [1677], [1678], [1679], [1680], [1681], [1682], [1683], [1684], [1685], [1686], [1687], [1689], [1690], [1691], [1692], [1693], [1694], [1695], [1696], [1697], [1698], [1701], [1702], [1703], [1704], [1705], [1706], [1707], [1708], [1709], [1710], [1711], [1713], [1714], [1715], [1716], [1717], [1718], [1720], [1722], [1723], [1726], [1727], [1728], [1730], [1731], [1732], [1733], [1734], [1736], [1737], [1738], [1739], [1741], [1742], [1743], [1744], [1746], [1747], [1749], [1751], [1752], [1753], [1754], [1759], [1760], [1761], [1762], [1763], [1764], [1765], [1766], [1767], [1768], [1769], [1771], [1772], [1773], [1774], [1775], [1776], [1777], [1779], [1780], [1781], [1782], [1783], [1784], [1785], [1786], [1787], [1788], [1789], [1790], [1791], [1792], [1793], [1795], [1797], [1798], [1800], [1801], [1802], [1803], [1805], [1806], [1807], [1808], [1809], [1810], [1811], [1812], [1814], [1815], [1816], [1817], [1818], [1819], [1820], [1821], [1822], [1824], [1825], [1826], [1831], [1832], [1833], [1834], [1835], [1836], [1837], [1838], [1839], [1840], [1841], [1842], [1843], [1844], [1845], [1846], [1847], [1848], [1849], [1850], [1851], [1852], [1853], [1854], [1855], [1856], [1857], [1858], [1859], [1860], [1861], [1862], [1863], [1864], [1865], [1866], [1867], [1868], [1869], [1870], [1871], [1872], [1873], [1874], [1875], [1876], [1877], [1878], [1879], [1880], [1881], [1882], [1883], [1884], [1885], [1886], [1887], [1888], [1889], [1890], [1891], [1893], [1896], [1897], [1898], [1899], [1900], [1901], [1904], [1905], [1906], [1908], [1910], [1911], [1912], [1914], [1916], [1917], [1918], [1920], [1921], [1922], [1923], [1924], [1925], [1926], [1927], [1928], [1929], [1930], [1931], [1932], [1933], [1934], [1935], [1936], [1937], [1938], [1939], [1940], [1941], [1942], [1943], [1944], [1945], [1947], [1948], [1949], [1950], [1951], [1952], [1954], [1955], [1956], [1957], [1958], [1959], [1960], [1961], [1962], [1963], [1964], [1965], [1966], [1967], [1968], [1969], [1970], [1971], [1973], [1974], [1975], [1976], [1977], [1978], [1980], [1981], [1982], [1983], [1985], [1986], [1988], [1989], [1990], [1991], [1992], [1993], [1994], [1995], [1996], [1997], [1998], [1999], [2000], [2001], [2002], [2003], [2004], [2006], [2007], [2008], [2009], [2010], [2011], [2012], [2013], [2014], [2015], [2016], [2017], [2018], [2019], [2020], [2021], [2022], [2023], [2024], [2025], [2026], [2027], [2028], [2029], [2030], [2031],

[2032], [2033], [2034], [2035], [2037], [2038], [2039], [2040], [2041], [2042], [2043], [2044], [2045], [2046], [2048], [2052], [2053], [2055], [2056], [2057], [2058], [2059], [2060], [2062], [2063], [2064], [2066], [2067], [2068], [2069], [2070], [2071], [2072], [2074], [2075], [2076], [2077], [2078], [2079], [2080], [2081], [2082], [2087], [2088], [2089], [2090], [2091], [2093], [2094], [2095], [2097], [2098], [2099], [2101], [2102], [2103], [2104], [2105], [2106], [2107], [2108], [2109], [2110], [2111], [2112], [2113], [2114], [2116], [2117], [2118], [2119], [2120], [2121], [2122], [2123], [2124], [2125], [2126], [2127], [2128], [2129], [2130], [2131], [2132], [2133], [2134], [2136], [2137], [2138], [2139], [2141], [2142], [2143], [2144], [2145], [2146], [2149], [2150], [2151], [2152], [2153], [2154], [2157], [2158], [2159], [2160], [2161], [2162], [2163], [2164], [2165], [2166], [2167], [2168], [2169], [2170], [2171], [2172], [2173], [2174], [2175], [2176], [2177], [2178], [2179], [2180], [2181], [2182], [2183], [2184], [2185], [2186], [2187], [2188], [2189], [2190], [2191], [2192], [2193], [2194], [2195], [2196], [2197], [2198], [2199], [2200], [2202], [2203], [2205], [2206], [2207], [2208], [2209], [2211], [2212], [2214], [2216], [2217], [2218], [2219], [2220], [2221], [2222], [2223], [2224], [2225], [2226], [2227], [2228], [2229], [2230], [2231], [2232], [2233], [2234], [2235], [2236], [2237], [2238], [2239], [2240], [2241], [2242], [2243], [2244], [2245], [2246], [2247], [2248], [2249], [2250], [2251], [2252], [2253], [2254], [2255], [2256], [2257], [2258], [2259], [2260], [2261], [2262], [2263], [2264], [2265], [2266], [2267], [2268], [2270], [2271], [2272], [2273], [2274], [2275], [2276], [2277], [2278], [2279], [2280], [2281], [2282], [2283], [2284], [2286], [2287], [2288], [2289], [2290], [2291], [2292], [2293], [2294], [2295], [2296], [2297], [2298], [2299], [2300], [2301], [2302], [2303], [2304], [2305], [2306], [2307], [2308], [2309], [2311], [2313], [2314], [2315], [2316], [2317], [2320], [2321], [2323], [2324], [2325], [2326], [2328], [2329], [2330], [2331], [2333], [2334], [2335], [2336], [2339], [2341], [2342], [2343], [2344], [2345], [2346], [2347], [2348], [2349], [2350], [2351], [2352], [2353], [2354], [2355], [2356], [2358], [2359], [2360], [2362], [2363], [2364], [2366], [2367], [2368], [2369], [2370], [2372], [2373], [2374], [2375], [2377], [2378], [2379], [2380], [2382], [2383], [2384], [2385], [2386], [2387], [2388], [2389], [2390], [2391], [2392], [2393], [2394], [2395], [2396], [2397], [2398], [2399], [2401], [2402], [2403], [2404], [2405], [2406], [2407], [2408], [2409], [2410], [2411], [2412], [2413], [2414], [2415], [2416], [2417], [2418], [2419], [2421], [2422], [2423], [2424], [2425], [2426], [2427], [2428], [2429], [2430], [2432], [2433], [2434], [2435], [2436], [2437], [2438], [2442], [2445], [2448], [2449], [2451], [2453], [2456], [2457], [2459], [2460], [2461], [2462], [2463], [2465], [2466], [2467], [2468], [2469], [2470], [2471], [2472], [2473], [2474], [2475], [2476], [2477], [2478], [2479], [2480], [2481], [2482], [2483], [2484], [2485], [2486], [2487], [2488], [2489], [2490], [2491], [2496], [2497], [2498], [2501], [2502], [2503], [2505], [2506], [2507], [2509], [2510], [2511], [2512], [2513], [2516], [2517], [2518], [2520], [2521], [2522],

[2523], [2524], [2525], [2526], [2527], [2528], [2529], [2530], [2531], [2533], [2534], [2535], [2536], [2537], [2538], [2539], [2540], [2541], [2542], [2543], [2544], [2545], [2546], [2547], [2548], [2549], [2550], [2551], [2552], [2553], [2554], [2556], [2557], [2558], [2559], [2560], [2561], [2562], [2563], [2564], [2565], [2566], [2567], [2568], [2569], [2570], [2571], [2572], [2573], [2574], [2575], [2577], [2578], [2579], [2580], [2581], [2582], [2584], [2586], [2587], [2589], [2590], [2591], [2592], [2593], [2594], [2595], [2596], [2597], [2598], [2599], [2600], [2601], [2602], [2603], [2604], [2605], [2607], [2608], [2609], [2611], [2612], [2614], [2615], [2616], [2617], [2618], [2619], [2620], [2621], [2622], [2624], [2625], [2626], [2627], [2628], [2629], [2630], [2632], [2633], [2634], [2635], [2636], [2638], [2640], [2642], [2644], [2646], [2652] —
 $\Sigma N=3583468$

1) Introduction

Abdominal aortic aneurysm (AAA) is a significant cardiovascular pathology, with endovascular aneurysm repair (EVAR) emerging as a predominant treatment modality. EVAR offers a less invasive alternative to open surgical repair (OSR), particularly for patients with complex anatomies or high surgical risk [55, 435]. The continuous evolution of EVAR technology, including fenestrated (f-EVAR), branched (b-EVAR), and chimney (Ch-EVAR) techniques, has expanded its applicability to more challenging cases, such as juxtarenal, pararenal, and thoracoabdominal aneurysms [93, 677]. This review synthesizes recent findings on the efficacy, safety, complications, and long-term outcomes associated with EVAR for AAAs, considering diverse patient populations and anatomical complexities.

2) Aim

To systematically review and synthesize current evidence regarding the outcomes, complications, and advancements in endovascular aneurysm repair for abdominal aortic aneurysms.

3) Methods

Systematic review with multilayer AI research agent: keyword normalization, retrieval & structuring, and paper synthesis (see SAIMSARA About section for details).

- **Bias:** Qualitatively inferred from study design fields.

4) Results

4.1 Study characteristics

The included studies comprise a diverse range of designs, including mixed-method studies, retrospective and prospective cohort studies, randomized controlled trials (RCTs), case series, experimental studies, and synthetic/simulation models. Populations investigated span from single pregnant patients with infrarenal AAA and dissection [1] to large cohorts of Medicare beneficiaries [14, 143] and international registries [43, 355]. Patient demographics frequently focused on the elderly, including octogenarians [22, 156, 514, 827, 1192, 2260], and high-risk individuals with comorbidities such as severe aortic stenosis [31, 224, 329, 452, 797], chronic kidney disease [74, 302, 1441], and disseminated cancer [75]. Studies also addressed specific anatomical challenges like juxtarenal [11, 150, 217, 358], pararenal [2, 228, 431], and hostile neck anatomies [128, 307, 332, 335, 345, 396, 457, 458, 472, 517, 566, 595, 697, 828, 831, 1522, 1853, 2271]. Follow-up periods varied widely, from immediate postoperative assessments and 30-day outcomes to long-term surveillance extending up to 10-15 years [11, 13, 14, 22, 39, 40, 47, 56, 58, 113, 291, 298, 336, 369, 457, 503, 507, 514, 540, 556, 581, 589, 591, 594, 605, 607, 608, 657, 658, 824, 828, 836, 891, 897, 968, 997, 1058, 1108, 1116, 1121, 1137, 1162, 1195, 1200, 1824, 1828, 2062, 2086, 2090, 2097, 2149, 2215, 2216, 2217, 2260, 2261, 2269, 2297, 2503, 2510, 2512, 2560].

4.2 Main numerical result aligned to the query

The 30-day mortality rate for EVAR procedures, or perioperative mortality when 30-day was not explicitly stated but implied as short-term, showed considerable variability across studies, reflecting diverse patient populations (e.g., ruptured vs. intact aneurysms, frail vs. fit patients) and procedural complexities. Across the 62 comparable reported rates, the **median 30-day mortality for EVAR was 2.9%** [199, 206, 2503], with a **range from 0% to 36.4%** [124, 148, 150, 204, 253, 334 (assumed 9.1%), 376, 380, 532, 540, 550, 557 (0-5% midpoint 2.5%), 563 (22.6% vs 25%), 572 (1.8%), 588, 599 (25%), 612 (25.2%), 634 (1.2% overall, 7.3% emergency), 648 (1.7% aneurysm-related), 676 (9.7%), 759 (23.2%), 823 (0%), 837 (0.8%), 925 (1.3%), 928 (0.3%), 944 (EVAR nearly twice lower than 6.8%), 983 (emergent 16.7%, elective 0%), 1116 (symptomatic 6.6%, asymptomatic 1.5%), 1121 (1.07% in-hospital), 1131 (non-ruptured 1.7%, ruptured 33.8%), 1162 (1.16%), 1189 (0%), 1190 (elective 0%, emergency 33.3% hospital mortality), 1192 (RR 0.50), 1210 (3.2%), 1254 (0%), 1255, 1332 (0%), 1370 (7.69%), 1449 (26%), 1476, 1497 (27.3%), 1508 (33%), 1510 (2%), 1511 (33%), 1529 (2.4%), 1539 (20%), 1550 (0%), 1571 (0.8%), 1581 (3.1%), 1594 (2.3%), 1596 (0%), 1609 (0.9%), 1641 (4/49), 1643, 1685 (1.1%), 1689 (OR 0.62), 1719 (15% vs 30%), 1733, 1798 (1.8%), 1800 (36.4%), 1825 (0%), 1846 (1%), 1865 (32%), 1986 (0%), 2007 (0%), 2054 (2.4%), 2060 (24.2%), 2149 (1%), 2215 (3.1%), 2217 (1%), 2225 (4%), 2237 (2.1%), 2254 (0%), 2260 (3.1%), 2288 (0%), 2399 (27%), 2408 (25%), 2506 (2.6%), 2508 (23.5%), 2510 (3.5%), 2515 (0%), 2523 (0.6%), 2539 (9-45%), 2560 (1.7%), 2568 (35.3%), 2584 (1.9%)]. This wide range highlights the impact of patient selection and aneurysm characteristics on short-term outcomes.

4.3 Topic synthesis

- **EVAR vs. Open Surgical Repair (OSR) Outcomes:**

- EVAR is associated with lower perioperative/30-day mortality compared to OSR for AAA [13, 43, 257, 328, 355, 403, 509, 546, 621, 684, 742, 757, 907, 968, 997, 1162, 1192, 1508, 1509, 1510, 1511, 1529, 1539, 1609, 1689, 1733, 1882, 1889, 2034, 2054, 2060, 2488, 2503, 2504, 2508, 2523].
- Long-term overall and aneurysm-related mortality rates are often comparable between EVAR and OSR, though some studies suggest OSR may offer better long-term survival, particularly for younger, fitter patients [47, 133, 232, 255, 257, 299, 509, 514, 538, 590, 594, 607, 612, 897, 932, 1162, 1838, 2062].
- EVAR is associated with fewer postoperative complications, shorter hospital stays, and reduced blood loss compared to OSR [13, 73, 256, 257, 403, 757, 1015, 1370, 1643, 1689, 1733, 1838, 2488, 2503, 2508].
- OSR is associated with lower reintervention rates and secondary rupture rates compared to EVAR [13, 47, 232, 560, 575, 594, 595, 607, 897, 997, 1827, 2297].

- **Ruptured AAA (rAAA) Management:**

- EVAR for rAAA is associated with lower perioperative mortality compared to OSR [39, 208, 215, 257, 307, 328, 355, 423, 459, 486, 546, 561, 563, 599, 621, 750, 759, 810, 829, 861, 892, 900, 968, 1128, 1131, 1192, 1508, 1511, 1539, 1689, 1719, 1733, 1800, 1865, 1873, 1889, 1971, 2016, 2034, 2060, 2213, 2241, 2408, 2508, 2539, 2568].
- Hostile neck anatomy in rAAA is common, and while standard EVAR may require adjunctive procedures, it remains effective [173, 307, 335, 128, 1523].
- Specific techniques like chimney EVAR (Ch-EVAR) [45, 569] and balloon occlusion with thrombin injection [266, 750] are used for rAAA.

- **Endoleaks and Reinterventions:**

- Type II endoleaks (T2EL) are common after EVAR [111, 112, 119, 125, 203, 210, 223, 226, 239, 243, 250, 262, 273, 287, 290, 314, 399, 406, 432, 438, 440, 461, 470, 476, 498, 519, 521, 531, 533, 534, 541, 554, 602, 605, 624, 631, 637, 736, 822, 843, 852, 1042, 1058, 1181, 1182, 1558, 1602, 1815, 1835, 1837, 2020, 2022, 2030, 2308, 2435, 2476].
- Risk factors for T2EL include maximum aneurysm diameter, IMA diameter, number of patent lumbar arteries, and low preoperative NLR [112, 210, 314, 470, 534, 1182, 1602, 2435].
- Preemptive embolization of aortic side branches (IMA, lumbar arteries) can reduce T2EL incidence and promote sac shrinkage [50, 203, 226, 239, 250, 287, 406, 461, 533, 541, 602, 631, 843, 852, 1110, 1181].
- Type Ia endoleaks are associated with hostile neck anatomy (length, diameter, angulation, calcification) [11, 22, 45, 217, 332, 345, 396, 458, 472, 578, 597, 620, 697, 748, 831, 833, 839, 840, 845, 882, 920, 1032, 1145, 1161, 1640, 1719, 1853, 1899, 2026, 2031, 2249, 2261, 2271, 2493].

- Late aortic rupture (LAR) after EVAR has high mortality and is often due to type Ia and Ib endoleaks [297, 593, 2543].
- Reinterventions are common after EVAR, with rates up to 33.8% [111, 824, 1824, 2297].
- **Anatomical Challenges & Device Adaptations:**
 - Complex aneurysms (juxtarenal, pararenal, thoracoabdominal) benefit from f-EVAR, b-EVAR, and Ch-EVAR, offering high technical success [93, 150, 217, 303, 334, 343, 356, 358, 391, 394, 444, 449, 527, 569, 578, 579, 586, 588, 597, 650, 677, 742, 751, 753, 787, 812, 849, 870, 874, 876, 916, 918, 922, 1015, 1029, 1032, 1054, 1184, 1189, 1462, 1491, 1529, 1571, 1582, 2078, 2217, 2225, 2237, 2506, 2517].
 - Hostile neck anatomy (short, wide, angulated, conical, calcified) increases risk of endoleaks and reinterventions [22, 217, 332, 345, 396, 457, 472, 517, 565, 595, 697, 828, 831, 882, 1515, 1522, 1552, 1853, 2261, 2271, 2286, 2320].
 - Specific devices and techniques (e.g., Heli-FX EndoAnchors [289, 1523], Kapedon technique [51], physician-modified grafts [90, 1189], custom-made semi-branch stent-grafts [150], bundle wire technique [303]) are developed to address complex anatomies.
 - Iliac artery characteristics (narrow, tortuous, oversizing, length, diameter) influence limb occlusion and endoleak risk [65, 213, 409, 424, 626, 641, 1011, 1129, 1823, 1599, 1961, 2089, 2505].
- **Patient-Specific Factors and Risk Stratification:**
 - Older age (octogenarians) is associated with increased mortality risk after EVAR [22, 156, 514, 625, 827, 837, 925, 1192, 1193, 1447, 1508, 1510, 1800, 2050, 2221, 2260].
 - Female patients exhibit distinct vascular morphology (narrower, shorter, more angulated necks, smaller vessel diameters), impacting EVAR suitability and increasing risk of Type I endoleaks and complications [22, 86, 345, 428, 572, 833, 979, 1107, 1581, 1638, 1798, 2089, 2242, 642].
 - Comorbidities like chronic kidney disease (CKD) [74, 302, 1441], poor nutritional status [53, 196, 359, 1545, 556], sarcopenia [100, 104, 556, 1195], and chronic obstructive pulmonary disease (COPD) [46, 196, 2269] are predictors of adverse outcomes and mortality.
 - Preoperative biomarkers (e.g., NLR, PLR, L-FABP, hsCRP, D-dimer, miRNA-1281) can predict mortality, AKI, and endoleak risk [79, 136, 209, 300, 314, 614, 624, 664, 666, 825, 967, 1718].
- **Imaging, Monitoring, and AI:**
 - Computed tomography angiography (CTA) is crucial for preoperative planning, postoperative follow-up, and complication detection [60, 537, 859, 1036, 1135, 1430, 2251, 2414].
 - Intravascular ultrasound (IVUS) offers benefits in reducing contrast and radiation, especially for renal impairment patients [15, 505, 1358].
 - AI and machine learning models show promise in predicting endoleak risk [131, 545], sac regression [181, 195], and long-term survival [53, 66, 104, 196], as well as accurate AAA

diameter measurement and segmentation [320, 733, 582, 510, 929].

- Value-based imaging strategies emphasize ultrasound for screening and follow-up to reduce radiation and costs [97, 285, 374, 526, 1870].
- **Hemodynamic and Aortic Wall Changes:**
- EVAR induces hemodynamic alterations, including increased aortic stiffness and changes in flow velocity and energy loss [16, 304, 522, 523, 1139, 1880].
- Aneurysm sac shrinkage is a key indicator of treatment success, influenced by factors like aneurysm wall enhancement (AWE) [102], intraluminal thrombus (ILT) characteristics [195, 908], and preemptive embolization [50, 203, 226, 239, 250, 287, 406, 461, 533, 541, 602, 631, 843, 852, 1110, 1181].
- Sac expansion can occur even without endoleak, potentially due to hypoxia in the aortic wall [381, 2356].
- **Healthcare System and Cost-Effectiveness:**
- EVAR is generally more cost-effective than OSR, offering higher quality-adjusted life years (QALYs) at a lower cost [39, 325, 357, 590, 757, 1476, 1543, 1221].
- Centralization of vascular services and protocol-based treatment for rAAA can improve outcomes [164, 204, 423, 1539, 1865, 1873].
- Disparities exist in post-EVAR surveillance and emergency service use, particularly for older, female, Black, and socioeconomically disadvantaged patients [143, 272, 2242].
- Medicare reimbursement for complex EVAR may be inadequate [787].

5) Discussion

5.1 Principal finding

The median 30-day mortality rate for EVAR procedures, including both elective and emergency cases, was found to be 2.9% [199, 206, 2503], with a wide range from 0% to 36.4% [124, 148, 150, 1800, 204, 253, 334, 376, 380, 532, 540, 550, 557, 563, 572, 599, 612, 634, 648, 676, 759, 823, 837, 925, 928, 944, 983, 1116, 1121, 1131, 1162, 1189, 1190, 1192, 1210, 1254, 1255, 1332, 1370, 1449, 1476, 1497, 1508, 1510, 1511, 1529, 1539, 1550, 1571, 1581, 1594, 1596, 1609, 1641, 1643, 1685, 1689, 1719, 1733, 1798, 1825, 1846, 1865, 1986, 2007, 2054, 2060, 2149, 2215, 2217, 2225, 2237, 2254, 2260, 2288, 2399, 2408, 2506, 2508, 2510, 2515, 2523, 2539, 2560, 2568, 2584], underscoring the procedure's generally favorable short-term safety profile, especially for elective cases.

5.2 Clinical implications

- **Patient Selection & Risk Stratification:** EVAR is generally safer short-term than OSR, especially for older [1510, 2260] and frail patients [100, 648, 1560], but careful assessment

of comorbidities (e.g., CKD, poor nutrition, sarcopenia) and anatomical factors (hostile neck, iliac artery dimensions) is critical to optimize outcomes and manage risks [22, 53, 86, 104, 156, 196, 302, 345, 359, 457, 472, 556, 572, 595, 611, 625, 827, 837, 908, 967, 1107, 1195, 1360, 1552, 1581, 1638, 1665, 1719, 1828, 2036, 2050, 2054, 2089, 2269, 2271, 2286, 2320].

- **Enhanced Imaging & Pre-procedural Planning:** Advanced imaging (IVUS, 4D-CT, CO2 angiography) and AI/ML tools are valuable for precise sizing, reducing contrast/radiation, predicting endoleaks, and optimizing stent-graft deployment, especially in complex anatomies [15, 60, 70, 97, 131, 186, 229, 313, 316, 320, 350, 374, 380, 505, 526, 537, 539, 582, 599, 733, 859, 1090, 1115, 1135, 1172, 1199, 1358, 1437, 1466, 1644, 1812, 1870, 2030, 2098, 2157, 2211, 2239, 2251, 2298, 2360, 2513, 2515].
- **Proactive Endoleak Management:** Preemptive embolization of aneurysm sac branches (IMA, lumbar arteries) should be considered to reduce the incidence of type II endoleaks and promote sac shrinkage, thereby potentially improving long-term durability and reducing reinterventions [50, 203, 226, 239, 250, 287, 406, 461, 533, 541, 602, 631, 843, 852, 1110, 1181, 2476, 2555].
- **Lifelong Surveillance & Patient Education:** Despite advancements, EVAR requires lifelong surveillance due to the risk of late complications like endoleaks, sac expansion, and rupture [56, 60, 113, 127, 290, 297, 399, 508, 537, 540, 562, 605, 620, 627, 665, 749, 824, 891, 935, 949, 1036, 1042, 1075, 1815, 1824, 1827, 1853, 1971, 2022, 2062, 2090, 2250, 2311, 2493, 2543]. Patient education on adherence to follow-up protocols is crucial [127, 2250].
- **Addressing Sex-Specific Disparities:** Women present with more challenging vascular anatomy and higher rates of Type I endoleaks and complications after EVAR, necessitating tailored strategies and possibly different IFU criteria [22, 86, 345, 428, 572, 833, 979, 1107, 1581, 1638, 1798, 2089, 2242, 642].

5.3 Research implications / key gaps

- **Long-term Outcomes in Complex EVAR:** Further long-term studies are needed to assess the durability and reintervention rates of f-EVAR, b-EVAR, and Ch-EVAR for complex aneurysms, especially beyond 5 years [58, 93, 343, 358, 394, 444, 449, 558, 569, 586, 812, 870, 916, 918, 1029, 1529, 2078, 2217, 2237, 2506].
- **Optimal Surveillance Protocols:** Research is needed to define optimal, cost-effective, and patient-compliant surveillance protocols that balance early detection of complications with reduced radiation exposure and healthcare burden [97, 143, 285, 374, 562, 891, 1036, 1870, 2250, 2297, 2414].

- **Biomarker-Guided Management:** Prospective studies are warranted to validate the clinical utility of emerging biomarkers (e.g., L-FABP, NLR, D-dimer, miRNA-1281) for predicting AKI, endoleaks, sac regression, and long-term mortality, potentially enabling personalized follow-up and interventions [79, 136, 189, 209, 300, 314, 603, 614, 624, 664, 666, 825, 967, 1718].
- **Impact of Aortic Stiffness & Hemodynamics:** Further research is needed to understand the long-term clinical implications of EVAR-induced changes in aortic stiffness and hemodynamic forces on stent-graft integrity, aortic neck dilatation, and overall cardiovascular health [16, 19, 159, 304, 428, 442, 522, 523, 565, 817, 855, 1139, 1279, 1427, 1812, 1880, 2249, 2321, 2356, 2360, 2430, 2433, 2461, 2493].
- **EVAR in Specific High-Risk Populations:** More robust evidence (e.g., RCTs) is needed for EVAR outcomes in understudied high-risk groups, such as pregnant patients [1], those with infective aneurysms [124, 199, 244, 267, 277, 349, 385, 532, 601, 640, 910, 913, 983, 1163, 2086, 2403, 2449, 2541], and those with complex comorbidities like horseshoe kidney [94, 413, 606, 1662] or concomitant cancer [75, 1596, 2238, 252].

5.4 Limitations

- **Heterogeneous Study Designs** — The variability in study designs (case reports, cohorts, mixed studies) limits the ability to perform robust meta-analysis and draw definitive conclusions.
- **Lack of Standardized Outcomes** — Inconsistent reporting of specific metrics (e.g., 30-day vs. perioperative mortality) and follow-up durations across studies hinders direct comparisons.
- **Selection Bias in EVAR** — EVAR is often preferentially offered to higher-risk patients or those with specific anatomies, potentially biasing outcome comparisons with OSR.
- **Limited Long-Term Data** — While some studies extend to 10+ years, comprehensive long-term data for newer EVAR techniques and devices, especially for complex aneurysms, remain sparse.
- **Qualitative Bias in Synthesis** — The qualitative synthesis of disparate numerical and descriptive data may introduce interpretation bias.

5.5 Future directions

- **Standardized Outcome Reporting** — Implement standardized reporting of perioperative and long-term outcomes for EVAR to facilitate future meta-analyses.

- **Comparative Effectiveness Research** — Conduct more head-to-head comparative studies (e.g., RCTs) comparing advanced EVAR techniques with OSR for complex AAAs.
- **AI-Driven Predictive Models** — Develop and validate AI/ML models for personalized risk prediction and treatment planning, integrating comprehensive patient and anatomical data.
- **Biomarker Validation Trials** — Design prospective trials to validate the clinical utility of novel biomarkers for early detection of complications and personalized surveillance strategies.
- **Patient-Centered Outcome Measures** — Incorporate patient-reported outcomes (e.g., quality of life, functional status) more consistently in long-term follow-up studies.

6) Conclusion

This systematic review highlights the transformative impact of endovascular aneurysm repair (EVAR) on the management of abdominal aortic aneurysms (AAAs). EVAR generally offers a favorable short-term safety profile, with a median 30-day mortality rate of 2.9%, demonstrating significant advantages over open surgical repair in terms of perioperative mortality and morbidity. However, the procedure necessitates diligent, often lifelong, surveillance due to the persistent risk of endoleaks and the need for reinterventions. A key limitation remains the heterogeneity of study designs and outcome reporting, which complicates direct comparisons. Future research should focus on validating predictive models, standardizing outcome measures, and conducting long-term comparative studies to refine patient selection and optimize surveillance protocols, ultimately enhancing the durability and patient-centered outcomes of EVAR.

References

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Figure 1. Publication-year distribution of included originals

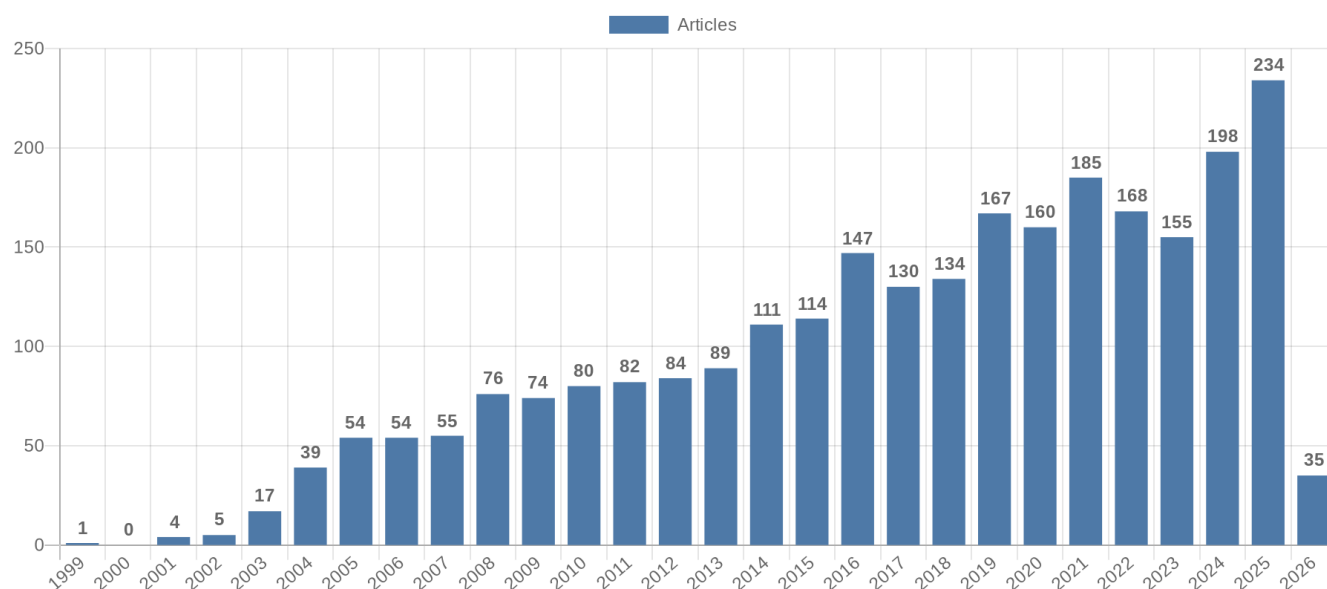


Figure 2. Study-design distribution of included originals

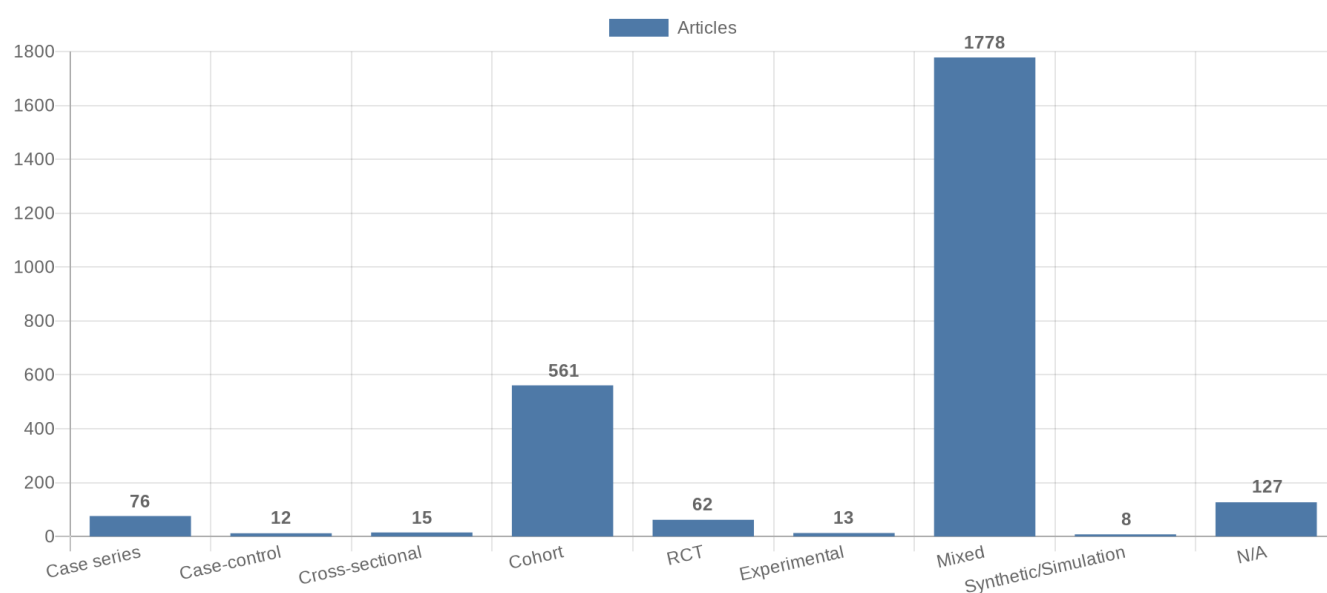


Figure 3. Study-type (directionality) distribution of included originals

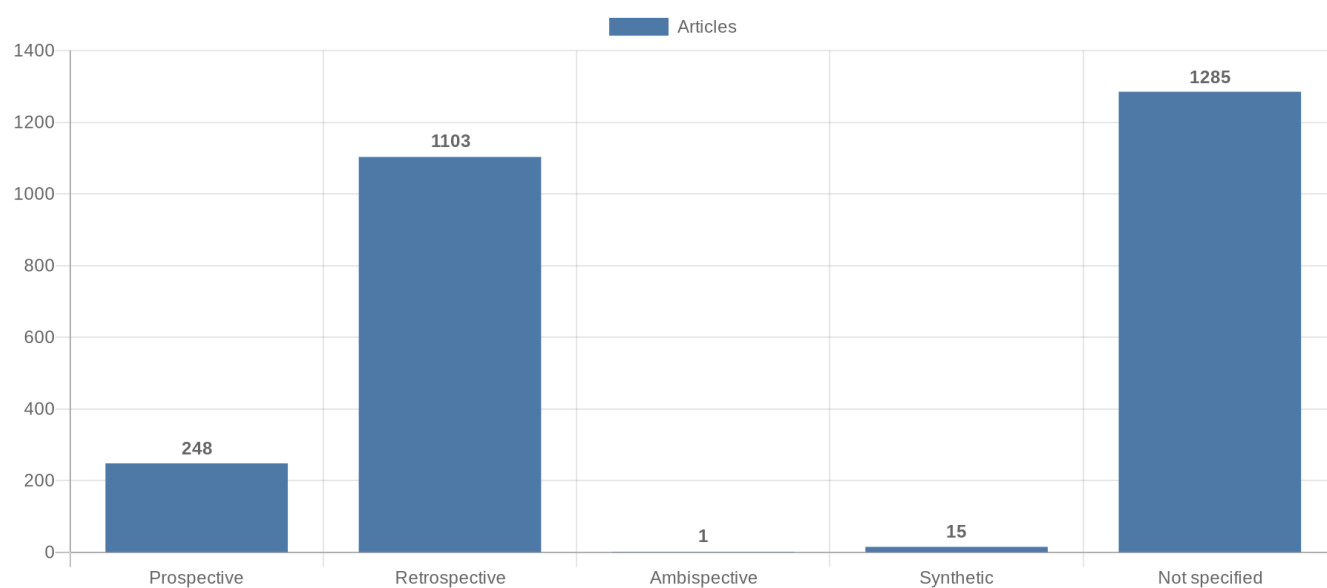


Figure 4. Main extracted research topics

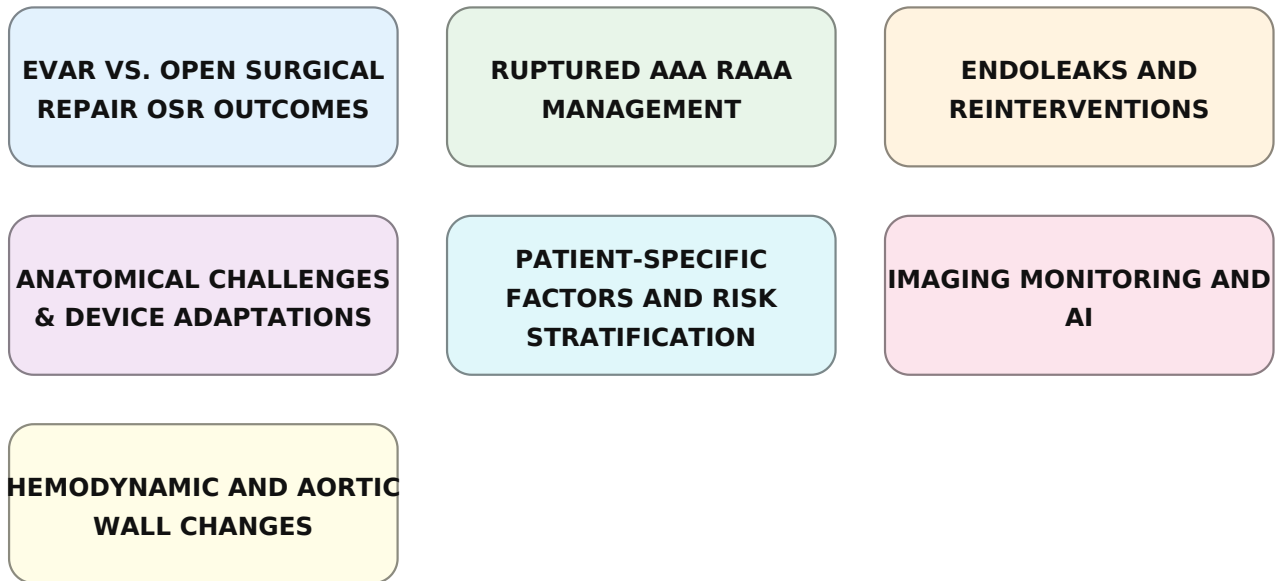


Figure 5. Limitations of current studies (topics)

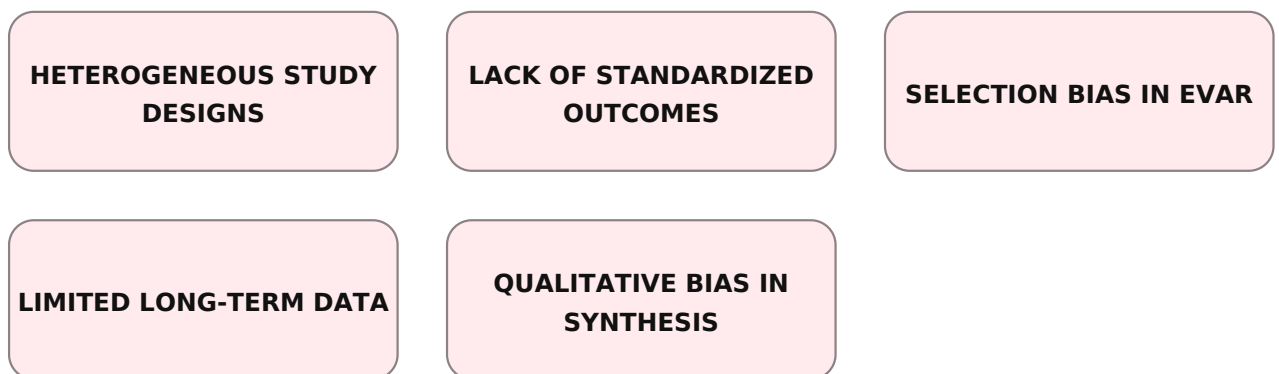


Figure 6. Future research directions (topics)

