

# Late open conversion after endovascular abdominal aortic aneurysm repair

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**Objective:** This study determined the incidence, the surgical details, and the outcome of late open conversion after failed endovascular aneurysm repair (EVAR) for abdominal aortic aneurysm.

**Methods:** A review of English-language medical literature from 1991 to 2014 was conducted using the PubMed and EMBASE databases to find all studies involving late conversion after EVAR for abdominal aortic aneurysm. The search identified 26 articles encompassing 641 patients (84% men; median age, 73.5 years).

**Results:** Mean interval from the initial implantation was  $38.5 \pm 10.7$  months. The cumulative single-center open conversion rate was 3.7%. The indications for late open conversion included endoleak in 62.4%, infection in 9.5%, migration in 5.5%, and thrombosis in 6.7%. Operations were urgent in 22.5% of the patients. The 30-day mortality was 9.1%. Mortality rates were different between elective (3.2%) and nonelective patients (29.2%). Five aneurysm-related deaths (1.5%) and two graft infections (0.6%) occurred during a median follow-up of 26.4 months (range, 5-50.2 months).

**Conclusions:** The number of patients with failed EVAR and without further options for endovascular salvage is growing. Endoleak remains the most important weakness of EVAR as the leading cause of late open conversion. Such procedures, although technically demanding, are associated with relatively low mortality rates when performed electively. Open repair still represents a valuable solution for many patients with failed EVAR. (*J Vasc Surg* 2015;61:1350-6.)

Endovascular abdominal aortic aneurysm (AAA) repair (EVAR) has gained widespread acceptance as the preferred method of treatment of suitable patients with infrarenal AAA, accounting for >70% of all AAA repairs in most large referral centers.<sup>1</sup> The technique is associated with significantly lower short-term and midterm mortality and reduced hospital stay, but also with increased late reintervention rates compared with open surgical repair.<sup>2</sup> Long-term results have been challenged by the presence of endoleaks, persistent aneurysm sac growth, and other aneurysm-related or graft-related complications. In some cases, conversion to open repair may be eventually needed despite reinterventions.

Late open conversion after EVAR has been estimated initially near 2%. This incidence will possibly rise with the increasing numbers of patients treated endovascularly nowadays.<sup>3</sup> New techniques, including custom-made fenestrated devices and chimney grafts, have been lately added in endovascular salvage of failed EVAR, with promising results.<sup>4,5</sup> However, fenestration is usually restricted

to centers of expertise and is characterized by delays in availability due to complex manufacturing, whereas despite the initial technical success, chimney grafts lack medium-term and long-term follow-up data. Moreover, clinicians have continued to push the limits of the technique to treat more anatomically difficult aneurysms, even in off-label conditions, challenging the durability of the method. The reports of late open conversion after EVAR have increased in frequency in recent years, revealing an increasing population without further options for endovascular salvage that should be thoroughly studied.

We therefore conducted a systematic review of the literature and analyzed the reported cases of late open conversion after EVAR to determine the incidence, the surgical details, and the outcome of these patients.

## METHODS

Our Institutional Review Committee approved the study.

**Eligibility criteria.** The objectives, the methodology of the systematic review and analysis, and the inclusion criteria for study enrollment were prespecified. Standard Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines<sup>6</sup> were followed and documented in advance in a formal protocol. Studies considered for inclusion and full-text review fulfilled the following criteria: (1) reported open conversion after EVAR, (2) included at least five patients, and (3) provided outcome and perioperative data separately for late open conversion. Two reviewers (G.K., A.K.) assessed the eligibility of studies for inclusion in this review independently in an unblinded standardized manner. Disagreements between reviewers were arbitrated by discussion.

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Author conflict of interest: none.

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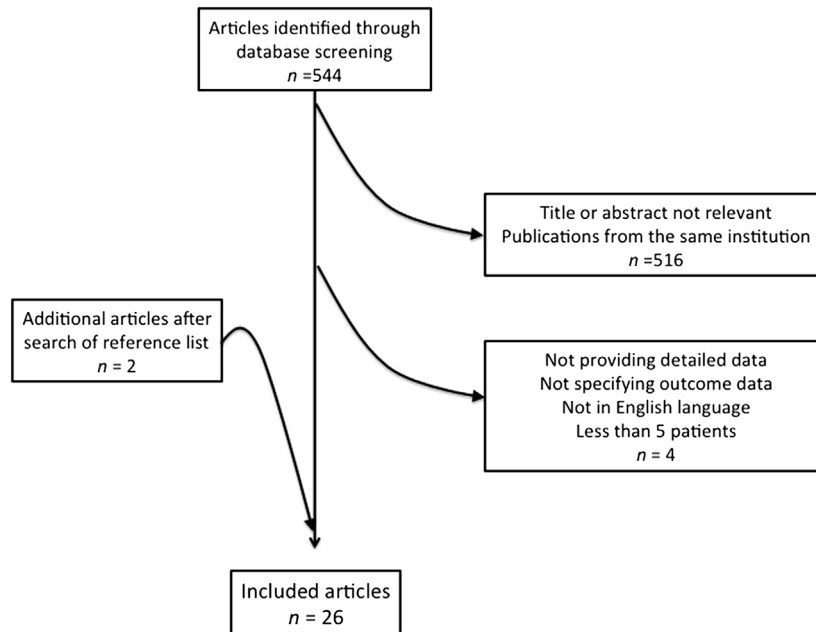


Fig 1. Literature search strategy.

**Search.** An electronic search was conducted of the English-language medical literature from 1991 to July 2014 using the PubMed and EMBASE databases to find all studies relevant to open conversion after EVAR for AAA. Search terms included “open conversion,” or “surgical conversion” or “explantation” and “EVAR” and “abdominal aneurysm.” Related articles suggested by the PubMed search engine and reviews on this subject were searched for additional relevant articles. Further articles were also identified via examination of the references cited in the initially identified reports. When more than one publication on the same topic came from the same institution, only the most recent study was included in the analysis. The reviewers extracted the following from each study: publication year, country of origin, number of patients, time from implantation, AAA diameter initially and at conversion, cause of conversion, type of endograft, intraoperative variations, 30-day mortality, mean follow-up, and outcome during follow-up. Means of outcome parameters were weighted and data were pooled after significant outcome heterogeneity was excluded. Data analysis was performed using SPSS 20 software (IBM Corp, Armonk, NY).

## RESULTS

The initial search identified 544 articles potentially suitable for inclusion in the review (Fig 1). After articles whose titles had no relevance to the area of concern of this review and subsequent publications on the same topic from the same institution were excluded, the full texts of 28 articles were retrieved and assessed for eligibility. The manual search of the reference list of the selected articles added

another two citations. Four articles were excluded because they did not provide data separately for the patients treated with open conversion.<sup>7-10</sup> The final analysis included 26 articles.<sup>11-35</sup>

Characteristics of the studies included are summarized in Table I. One study was a prospective review from multiple centers, three studies were retrospective reviews from multiple centers, and 22 studies were retrospective reviews from a single center. None of the single-center reports were included in any of the multicenter studies. The studies were published between 2001 and 2014, and the study cohorts ranged from 5 to 100 patients. The population of this review comprised 641 patients (84% males) who were a median age of 73.5 years.

Mean duration of the open conversion from the initial implantation was  $38.5 \pm 10.7$  months (Fig 2). Detailed data on reinterventions before conversion were available from 14 studies and included 219 procedures in 381 patients (57.5%). The open conversion rate for each center was clearly reported in 19 studies and averaged 3.7% (range, 0.9%-22.8%). Procedures were elective in 497 patients (77.5%) and were urgent in 144 (22.5%).

**Indications.** The indications for late open conversion are shown in Fig 3. The most common included endoleak in 400 patients (62.4%), infection in 61 (9.5%), migration in 35 (5.5%), and thrombosis in 43 (6.7%). Forty-eight patients (7.5%) underwent emergency operations due to aneurysm rupture. The endoleak group included 168 type I (42%), 107 type II (26.8%), 36 type III (9%), 2 type IV (0.5%), and 24 type V (6%). Thirty-eight patients (9.5%) presented with more than one different concomitant endoleaks, whereas in 25 (6.2%) the type of

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