

# Open and endovascular repair of juxtarenal abdominal aortic aneurysms: a systematic review

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This systematic review focuses on the 30-day mortality associated with open surgery and fenestrated endografts for short-necked (<15 mm) juxtarenal abdominal aortic aneurysms. A search for studies published in English and indexed in the PubMed and Medline electronic databases from 2002 to 2012 was performed, using “juxtarenal abdominal aortic aneurysm” and “treatment” as the main keywords. Among the 110 potentially relevant studies that were initially identified, eight were in accordance with the inclusion criteria in the analysis. Similar outcomes for open and endovascular repair were observed for 30-day mortality. No differences were observed regarding the secondary outcomes (duration of surgery, hospital stay, postoperative renal dysfunction and late mortality), except that the late mortality rate was significantly higher for the patients treated with open repair after a median follow-up of 24 months. Fenestrated endografting is a viable alternative to conventional surgery in juxtarenal abdominal aortic aneurysms with a proximal neck <15 mm.

**KEYWORDS:** Abdominal Aortic Aneurysm; Juxtarenal Aneurysm; Fenestrated Endograft; EVAR.

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## ■ INTRODUCTION

A juxtarenal aortic abdominal aneurysm (JRAAA) is an infrarenal aortic aneurysm extending to the renal arteries without involving them and its incidence has been estimated as approximately 16% of infrarenal aortic aneurysm (1). Open surgery (OS) is a well-established gold-standard JRAAA treatment for low-surgical-risk patients and the 30-day mortality is estimated as being approximately 3.6% (ranging from 0.0% to 8.6%) of the patients (2,3). For patients with severe comorbidities and/or a high-risk for OS, endovascular repair (EVAR) has been a better indication, with the 30-day mortality estimated as 1.7% (ranging from 0.8 to 4.1) of the patients (4,5). Both procedures are associated with early and late complications related to renal dysfunction (6).

An important concern regards the length of the proximal neck between the renal artery and the aneurysm. EVAR techniques should be used in cases of longer proximal necks (>15 mm) (2,7), whereas shorter necks (<15 mm) have been

considered a contraindication for such endovascular approaches (4).

Customized fenestrated endografts have allowed a proximal sealing zone of the grafts and thus enabled an increasing number of patients to be eligible for EVAR. Some centers have used such technology even for short-necked JRAAAs with promising results (8,9).

The lack of well-standardized and homogeneous studies on the treatment of short-necked JRAAAs confers remarkable limitations for effectively comparing OS and EVAR. We conducted this systematic review to analyze the outcomes of OS and EVAR specifically in patients with short-necked JRAAAs, focusing primarily on the 30-day mortality rate. The secondary outcomes included the duration of surgery, hospital stay, postoperative renal dysfunction and late mortality.

## ■ MATERIALS AND METHODS

Original articles published in English from 2002 to 2012 were searched in the Cochrane, PubMed and Medline electronic databases. The main keyword for this search was “juxtarenal aortic abdominal aneurysm”. References were selected when the title of the article clearly regarded the “treatment” of JRAAAs and all of the abstracts were read to select only original articles regarding OS or EVAR, excluding case reports, reviews and original articles involving series with less than 15 patients.

The inclusion criteria for this review included original articles reporting series greater than 15 patients with

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non-ruptured JRAAAs treated with OS or EVAR and, in this case, with proximal necks <15 mm. Publications reporting (a) replicate data, (b) infrarenal aneurysms or not referring to the length of the neck, (c) combined results with other anatomical locations of aneurysms (without clear references to the specific results observed in JRAAAs), and (d) outcomes incompatible with those defined for this review were excluded. Reports without clear patient data were excluded.

The outcome measures defined for this review included, primarily, the 30-day mortality rate and the secondary objectives referred to the duration of surgery (in minutes), hospital stay (in days), postoperative renal complications (represented by renal dysfunction) and late mortality rate (considering the mean follow-up in months).

The statistical analysis was performed by comparing the outcomes of OS with those of EVAR. The equality of the

medians was analyzed using the Mann-Whitney Test and Fishers Exact Test was applied for comparing the frequencies of higher or lower medians reported in the studies. The frequencies of the outcomes were compared with the Chi-square Test. The mean follow-ups reported in the papers were correlated with 30-day mortality, postoperative (PO) renal dysfunction and late mortality with the application of the Spearman Correlation Coefficient. The *p*-values were two-sided and the differences were significant with *p*≤0.05.

## ■ RESULTS

In the search using the “juxtarenal abdominal aortic aneurysm” keyword in the specified electronic databases, 134 articles were found (PubMed: 90; Medline: 41; Cochrane: 3). Thirteen articles were not published in English remaining and 121 articles remained. In eleven

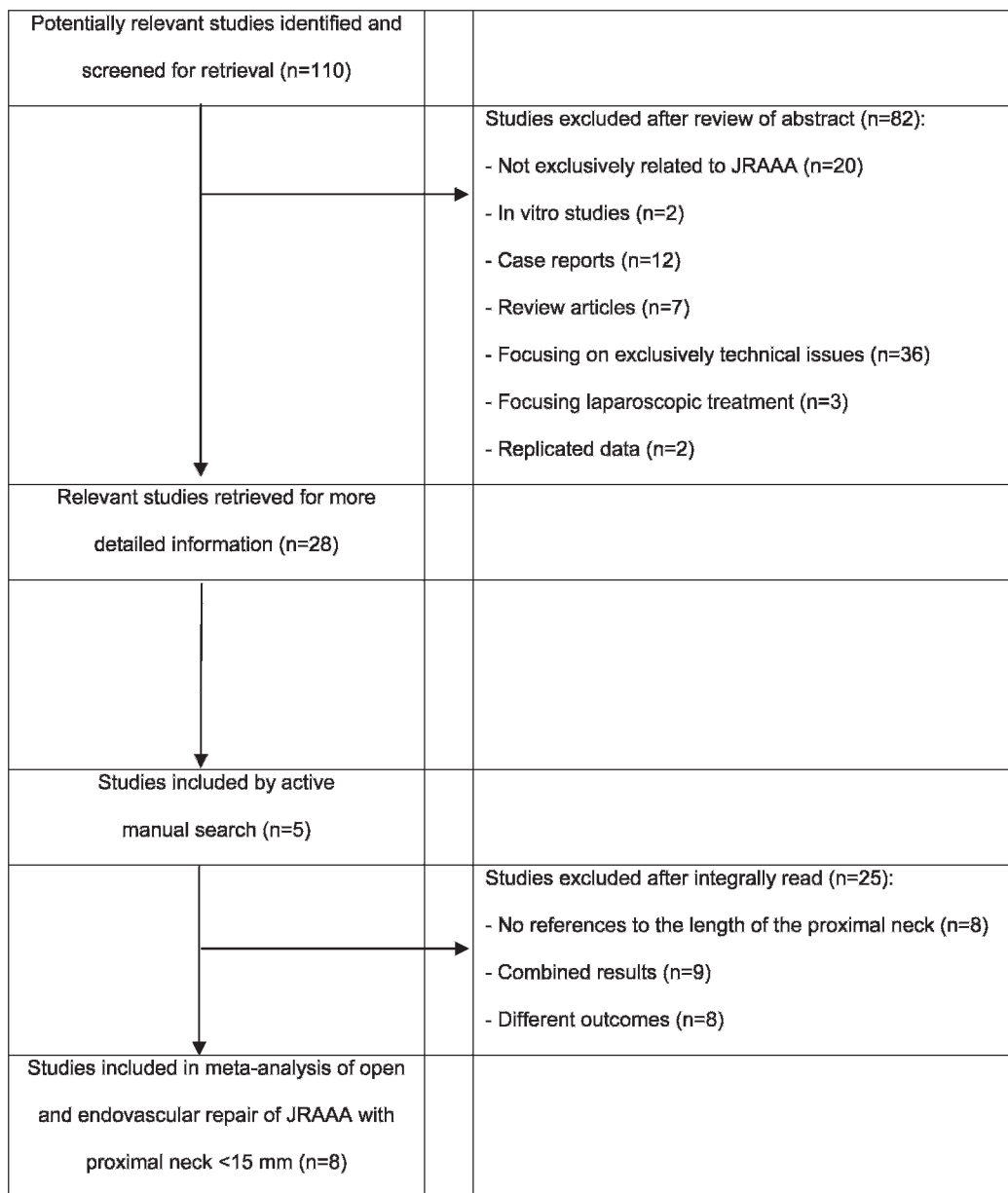


Figure 1 - PRISMA flow diagram for the meta-analysis of open and endovascular repair of JRAAA with proximal neck <15 mm.



articles, the titles referred to issues other than the JRAAA treatment. A total of 110 articles were identified as potentially relevant studies to be screened for retrieval after reading their abstracts and 28 papers remained to be entirely read. Five articles were included in the active manual search. Eight articles did not report the length of the proximal neck of the JRAAA; nine articles presented combined results (including different abdominal aortic aneurysm sites, ruptured and non-ruptured aneurysms and infected and non-infected aneurysms) (Figure 1).

Rigorously considering the inclusion and exclusion criteria, eight studies were eligible for this systematic review (Table 1), involving a total of 776 patients (483 for OS and 293 for EVAR). Four retrospective studies refer to the OS and three refer to the endovascular treatment of JRAAAs (one prospective study). One prospective study reports OS and EVAR. The EVAR studies refer to the use of fenestrated endografts. The outcomes as reported by the authors are presented in Table 2.

The percentages of male patients (83% and 90% for OS and EVAR, respectively) as well as their mean ages (72 and 71, respectively) were similar for both groups. The range in the 30-day mortality and the follow-up was significantly ( $p=0.04$ ) wider in the OS group (2.5%, ranging from 0.8% to 8.6% and 28 months, ranging from 6 to 56 months, respectively) compared with that in the EVAR studies (0.9%, ranging from 0.0% to 2.0% and 21 months, ranging from 13 to 24 months, respectively).

The distribution of the studies according to the medians calculated from the reported results showed the frequency of higher medians in the OS studies for the 30-day and late mortality (Figure 2), although such differences were not significant.

Considering the distribution of the patients according to the type of repair they experienced, no differences were shown in the rates of the 30-day mortality and PO renal dysfunction; however, late mortality rates were significantly higher in the OS compared with the EVAR series (Figure 3).

A significant positive correlation between the mean follow-up and late mortality was observed in the OS repair ( $r=0.99$ ) group, whereas non-significant low correlations were observed between the follow-up and PO renal dysfunction for the types of JRAAA repair ( $r=0.27$  for OS and  $r=0.40$  for EVAR) and late mortality for EVAR ( $r=0.38$ ) (Table 3).

The technical success (defined as target vessel perfusion) in the fenestrated endografting of JRAAAs ranged from 97.7% to 99.7%. Endoleaks were reported in 7/293 patients

(2.4%) for Type I, in 24/193 patients (12.4%) for Type II and in 4/193 patients (2.1%) for Type 3. In one of the studies, which involved a series of 100 patients, Type II and III endoleak data were not available.

**DISCUSSION**

In the years since EVAR was proposed as an alternative treatment of aortic abdominal aneurysms, approximately 75% of patients have been amenable to such an approach (16). Approximately 40%-60% of these patients are candidates for infrarenal EVAR (17) and of these, 16% of the patients have JRAAAs (1).

Indications for EVAR incorporating fenestrations and branches typically include proximal necks of at least 15 mm (2,4). In addition, renal or visceral target vessels <4 mm in diameter are relative contraindications because of the increased risk for arterial complications (18). More recently, a number of studies have shown that fenestrated grafts represent a promising approach for short-necked JRAAAs (8,9,14,15), including those with a neck <4 mm (7).

The early advantages of this type of approach (lower 30-day mortality and shorter length of hospital stay) do not always avoid longer-term morbidity, reintervention and postoperative mortality (6); many authors continue to recommend OS for such cases (11,12,19).

Despite rates of technical success greater than 90%, fenestrated endografting for short-necked JRAAAs involves higher costs, longer time in the operating room and more human resources for the pre-, intra- and postoperative management of the patients compared with OS (18).

Many recent cohort and review studies have focused on the endovascular treatment of JRAAAs; however, in most cases, the length of the proximal neck is not mentioned (5,20,22). Most likely, the reported results combine the outcomes of JRAAAs with sufficient proximal necks with those that are short-necked, which could explain the wide variation in 30-day mortality, PO renal complications and late mortality in the different publications.

In our systematic search for publications on OS and on EVAR for JRAAAs (excluding other anatomic aneurysm sites), we found eight papers amenable for analysis (four on OS, three on EVAR and one on both).

Similar 30-day mortality rates were observed in the OS and EVAR studies. There was a significantly wider range in the 30-day mortality in the OS (0.8% to 8.6%) studies compared with that in the EVAR (0.0% to 2.0%) studies. In reports on EVAR for JRAAAs that did not mention the length of the proximal necks, the range of the 30-day

**Table 1 - Publications on the treatment of juxtarenal aortic abdominal aneurysms systematically selected for this review.**

Type of repair	References	Study design	N	♂	Age	
					Mean	Range
Open surgery	Ockert et al., 2007 (10)	Retrospective	35	86%	68	NR
	Knott et al., 2008 (11)	Retrospective	126	78%	74	55-93
	Speziale et al., 2010 (12)	Retrospective	92	94%	72	53-85
	Tsai et al., 2012 (13)	Retrospective	199	71%	74	51-93
	Donas et al., 2012 (9)	Prospective	31	87%	71	NR
EVAR*	O'Neill et al., 2006 (14)	Prospective	119	82%	65	46-102
	Scurr et al., 2008 (15)	Retrospective	45	91%	73	53-85
	Verhoeven et al., 2010 (8)	Retrospective	100	87%	73	50-91
	Donas et al., 2012 (9)	Prospective	29	100.0%	74	NR

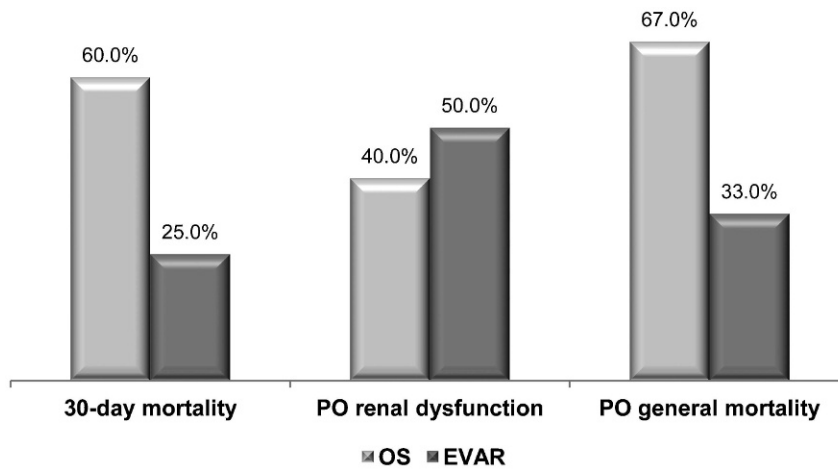
NR: Not reported.



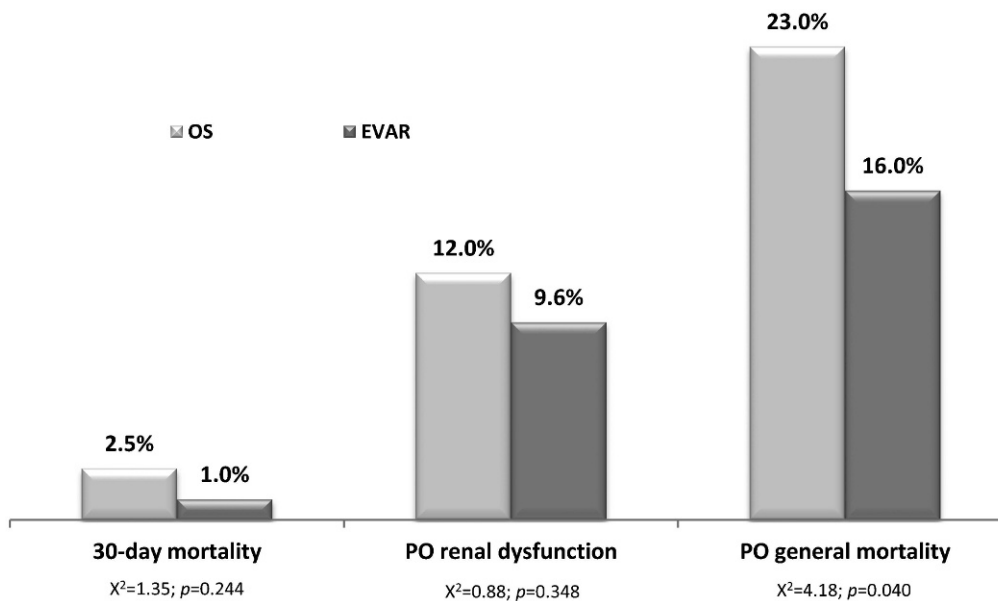
**Table 2** - Outcomes reported in the studies on OS or EVAR of the juxtarenal aortic abdominal aneurysms.

Type of repair	References	Outcomes					
		Duration of surgery	Hospital stay	30-day mortality	Mean follow-up	Renal dysfunction	Late mortality
Open surgery	Ockert et al., 2007 (10)	215 m	4 d	8.6%	28 m	17.1%	20.0%
	Knott et al., 2008 (11)	319 m	17 d	0.8%	48 m	18.0%	NR
	Speziale et al., 2010 (12)	205 m	NR	1.1%	6 m	10.9%	9.8%
	Tsai et al., 2012 (13)	NR	10 d	2.5%	56 m	8.5%	29.6%
	Donas et al., 2012 (9)	NR	7 d	6.4%	14 m	6.5%	NR
EVAR	O'Neill et al., 2006 (14)	227 m	NR	0.8%	19 m	15.9%	12.6%
	Scurr et al., 2008 (15)	350 m	6 d	2.0%	24 m	15.6%	11.0%
	Verhoeven et al., 2010 (8)	180 m	4 d	1.0%	24 m	2.0%	22.0%
	Donas et al., 2012 (9)	290 m	4 d	0.0%	13 m	0.0%	NR

NR: Not reported.



**Figure 2** - Distribution of the studies on OS and EVAR reporting higher medians than the median calculated for all nine studies on the treatment of juxtarenal aortic abdominal aneurysms.



**Figure 3** - Distribution of the patients treated with OS (in five studies) and EVAR (in four studies) according to 30-day mortality, PO renal dysfunction and PO general mortality rates.

**Table 3** - Analysis of the median data regarding the outcomes reported in studies on open surgery and endovascular repair of short-necked juxtarenal aortic abdominal aneurysms.

Outcomes	OS + EVAR studies	OS studies	EVAR studies	p-values
Duration of the surgery in minutes	227 (180 – 350)	215 (205 – 319)	258 (180 – 350)	<i>p</i> = 0.514
Hospital stay in days	6 (4 – 17)	8.5 (4 – 17)	4 (4 – 6)	<i>p</i> = 0.114
30-day mortality rate	1.1% (0 – 20.0%)	2.5% (0.8% – 8.6%)	0.9% (0 – 20.0%)	<i>p</i> = 0.317
Follow-up in months	24 (6 – 56)	28 (6 – 56)	21 (13 – 24)	<i>p</i> = 0.119
PO renal dysfunction rate	11.0% (0 – 17.1%)	11.0% (6.5% – 17.1%)	9.0% (0 – 15.9%)	<i>p</i> = 0.476
Late mortality rate	16.3% (9.8% – 29.6%)	20.0% (9.8% – 29.6%)	12.6% (11.0% – 22.0%)	<i>p</i> = 0.450

mortality rates is wider than that observed in this systematic review, varying from 0.8% (22) to 4.1% (5). The combination of the results observed for JRAAAs and infrarenal aneurysms could explain such observations.

Regarding the secondary objectives, differences were not evidenced between the groups. The mean duration of the surgery was longer, whereas the mean hospital stay was shorter in the EVAR than in the OS studies, which was in agreement with information published elsewhere (6,11,12,19); however, such differences were not significant. The late mortality rate in a median follow-up of 24 months was significantly higher (*p* = 0.04) in the OS studies (23%; 75/326) than in the EVAR studies (16.0%; 42/264).

These findings impose reflections on two main concerns because inverse results were expected. First, the main indication for endovascular repair of JRAAAs refers to the high surgical risk for older patients presenting important comorbidities and such indications appear to have been respected in the studies systematically selected for this review. Second, the expected higher postoperative mortality in EVAR is the point most focused on by the authors who support OS for JRAAAs (11,12,19). The selected studies are more recent and it is possible to hypothesize that the learning curve and experience with fenestrated endografting have improved.

A significant positive correlation was found between the mean follow-up and late mortality in the OS studies and not in the EVAR studies, which could indicate that late mortality in EVAR studies could be higher with a longer follow-up. This type of analysis should be emphasized in further studies comparing this outcome for the two types of JRAAA treatment.

Although our selection did not include the surgical techniques for the open repair, Tsai et al. (13) reported several cases with supraceliac clamping, which could have affected the results of OS because it increases the risks of cardiac stress and renal and/or visceral ischemia/reperfusion.

Higher rates of endoleaks were reported in a study published six years ago (14) that involved 119 patients, whereas lower rates were reported in a very well designed prospective study published in 2012 (9) that involved 29 patients. These observations appear to contribute to the concept that better experience with endovascular techniques for JRAAA repair could result in better outcomes.

A specific limitation of this study is that some information have not been reported in some publications. The technical variations reported in the OS and EVAR studies did not allow us to explore their influence on the outcomes in a deeper analysis. Most of the publications refer to retrospective studies because prospective randomized trials have not been performed, resulting in the evidence being of low quality. Because only relatively small series from single

centers have been reported, establishing a substantial cohort would most likely take time. These limitations support the need for more standardized prospective studies on OS and EVAR for JRAAAs.

This study is the first attempt at a systematic review that focuses on the EVAR outcomes for only short-necked JRAAAs (excluding any other anatomic aneurysm site or combined results) and compares them with outcomes of OS. Even considering the limitations of this study, we could conclude that the outcomes of fenestrated endografting of JRAAAs are very similar to those observed in OS, ensuring that EVAR is a very promising alternative. We suggest that fenestrated endografts involve more expensive devices, more delayed and longer procedures and more human resources for postoperative patient management (18), which are significant considerations to be carefully analyzed in EVAR selection.

## ■ AUTHOR CONTRIBUTIONS

Belczak SQ performed the data search and analysis and writing. Lanzotti L and Botelho Y performed the data search and analysis. Aun R, da Silva ES, Puech-Leão P and De Luccia N conducted the review.

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