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Management of Pararenal Aortic Aneurysms: A Literature Review

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Abstract

Abdominal aortic aneurysms (AAA) are the most common group of aortic aneurysms. Pararenal aortic aneurysm (PAA) is a classification of AAA where there is no normal aortic segment between the renal artery and the proximal border of the aneurysm. This group has a prevalence of around 20% of all AAA cases. In open repair (open surgery), PAA requires suprarenal clamps or even supraceliac which causes high morbidity. In endovascular procedures, PAA presents difficulties due to the absence of a landing zone to place the graft and the possibility of reintervention after action. A literature review is needed to discuss the strengths and weaknesses of each treatment. A review enrolling 7 focused on endovascular procedures for PAA and outcomes including mortality and morbidity with long-term follow-up.

Key words: pararenal, aortic aneurysm, open repair, endovascular procedures

Introduction

An aortic aneurysm is a blood vessel disease that causes disability and death. Based on the anatomical location, 62.3% of aortic aneurysms are found in the abdominal aorta, an abdominal aortic aneurysm (AAA).¹ An aortic aneurysm is called a pararenal aortic aneurysm (PAA) if there is no normal segment of the aorta below the renal artery or if the aneurysm involves at least one orifice of the renal artery.² PAA is estimated to account for 20% of all AAA cases.² The PAA is a complex group to deal with, challenging to expose at the time of surgery, causing increased operating time and blood loss properly. Suprarenal aortic occlusion required during surgery poses a risk of renal parenchymal ischemia and myocardial damage due to increased cardiac output. The kidney disorders and hypertension that often accompany it also increase the risk of surgery or postoperative recovery.²

PAA also has difficulties to be managed with endovascular procedures. Endovascular procedures require at least a segment of the normal aortic neck proximal from the 15 mm long aneurysm called the "landing zone," which is not available on the PAA. No studies have compared open and endovascular surgical procedures for PAA. Currently, there is no research on PAA in Indonesia. A study on AAA conducted by Jamtani in 2017 revealed the anatomical characteristics of EVAR patients at Cipto Mangunkusumo General Hospital, a national referral hospital in Indonesia. The study provides data that AAA patients with short proximal neck aneurysms (10-15 mm) amounted to 12.7%.³ PAA can be a health problem that found more frequently in Indonesia and improved vascular surgical care. This article aimed to review the treatment of PAA, and the outcome based on previous studies.

We carried out a literature search on the current procedures of pararenal aortic aneurysms on some databases (PubMed, Cochrane, EBSCO, and ProQuest) using keywords "pararenal aortic aneurysm," "endovascular," "open surgical" until 2019. Eligible criteria were systematic reviews,

meta-analysis, randomized control trials, cohort studies, case reports, and case series with the subject patients of pararenal aortic aneurysms. They were assessed for the type of study, the subject's characteristics, the outcome and analyzed using the content analysis method. In addition, we reviewed the secondary data based on the findings and the advantages and disadvantages to find consideration of the options based on the outcome of the PAA procedures. Out of 158 articles found on searching, 15 articles met the criteria. The literature search proceeded as shown in figure 1 and summarized in table 1.

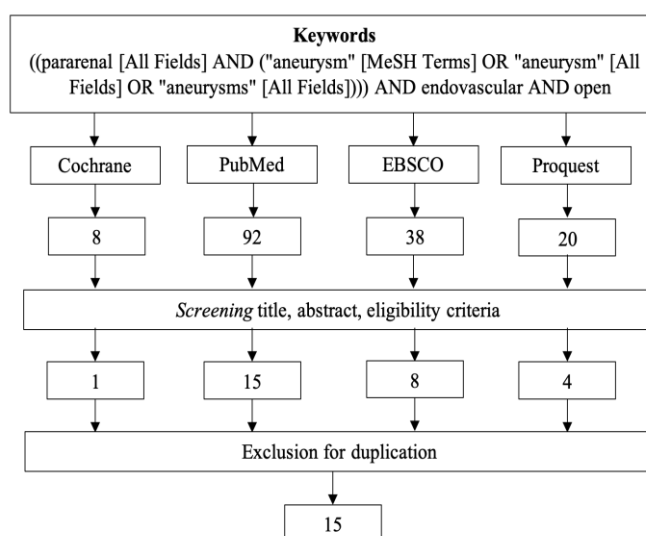


Figure 1. Literature search

Open Repair

The first study to report on PAA management is the case series report by Qvarfordt et al.² The study revealed that PAA is a problematic group of aneurysms to treat. The difficulty in exposing the surgical area leads to a prolonged operation time and an increased chance of blood loss. Suprarenal occlusion that must be done also creates a risk of kidney damage due to ischemia and myocardial damage due to increased afterload. Most of the approach chosen was the transabdominal approach (92%), with the rest (8%) was a thoracoretroperitoneal aortic

exposure approach. The majority of subjects were performed suprarenal aortic occlusion. Blood vessel reconstruction was performed in the form of aortic reconstruction (infrarenal aortic graft, infrarenal aortic prosthetic graft plus transaortic endarterectomy).² The mortality in the study was 1.3%, while the morbidity was 22%, with the leading cause being decreased renal function.

Table.1. Studies' Characteristics

No.	Author/Year	Sample	Study Design	Intervention	Output	Level of Evidence	Results	Note
1	Qvarfordt et al, 1986 ²	77	Case series	Open surgery	Perioperative mortality, perioperative morbidity, decreased renal function	4	Mortality 1.3% Morbidity 28% Decreased of renal function 23%	
2	West et al, 2006 ⁴	247	Case series	Open surgery	30-day mortality of cardiac, pulmonary, and renal complications	4	30-day mortality 2.5% Heart complications 13% Pulmonary complications 16% Decreased renal function 22%	3 patients died of mesenteric ischemia
3	Sultan et al, 2011 ³	118	Retrospective cohort	Endovascular vs open surgeries	3 year survival without aneurysm-related death, 3 years-free of major adverse clinical events	2b	EVAR vs open surgery - Mortality 0 vs 4.5% (p = 0.122) - Morbidity 30 days 15% vs 30% (p = 0.059) - Decreased renal function 3.8% vs 15.2% (p = 0.044)	
4	Tallarita et al, 2011 ⁶	2228	Case series	Open surgery	Morbidity and early mortality at 2 periods	4	- Decreased mortality - Decreased renal function 14%	This study compared mortality in 2 study periods
5	Quinones-Baldrich et al, 2013 ⁷	31	Case series	Endovascular (Fenestrated technique)	Technical success, survival, endoleak	4	- Technical success 94% - 30 days survival 100% - Survival over 30 days occurred in 3 patients (cause is not related to aneurysm) - Endoleak 26% (type II)	
6	Belczak et al, 2014 ⁸	8 studies	Systematic review	Open vs endovascular surgeries	30 days mortality, postoperative renal failure	2a	Open surgery vs EVAR - 30-day mortality 2.5% vs 1% - Postoperative renal failure 12% vs 9.6%	
7	Kabbani et al, 2014 ⁹	245	Retrospective cohort	Open surgery	30 day mortality, Postoperative acute kidney injury	2b	- 30-day mortality 3.3% - Postoperative acute renal failure 60%	
8	Usai, et al, 2015 ¹⁰	7 studies	Systematic review	Endovascular (Chimney graft technique)	Occlusion of the renovisceral vessels	2a	Post-action occlusion occurred in 4.5%	
9	Ferrante et al, 2016 ¹¹	200	Retrospective cohort	Open surgery	Mortality and complications	2b	30-day mortality 2.5% Postoperative acute renal failure 11%	
10	Orr et al, 2016 ¹²	1005	Retrospective cohort	Open vs endovascular surgeries	Mortality and morbidity rates	2b	EVAR vs open surgery: - 30-day mortality 2.7% vs 5.7% (p = 0.126) - 30-day morbidity 16% vs 35% (p = 0.001)	
11	Vanlammeren et al, 2016 ¹³	214	Case series	Open surgery	30-day mortality and morbidity	4	30-day mortality 3.4%, 30-day morbidity 27.1%	
12	Stella et al, 2017 ¹⁴	1	Case report	Endovascular (Chimney technique)	Technical success and vessel patency	5	Patent graft in the absence of endoleak	
13	Sugimoto et al, 2017 ¹⁵	451	Retrospective cohort	Open surgery	Hemodialysis cases	2b	Early output: - Acute kidney injury mass care 18.7% - Hemodialysis 0.9% Further output: - Chronic renal failure 15.9%	
14	Fiorucci et al, 2018 ¹⁶	200	Retrospective cohort	Open vs endovascular surgeries (fenestrated technique)	Survival rates and perioperative complications	2b	Open surgery vs EVAR - Major Adverse Event 21.3% vs 9.8% (p = 0.033) - Acute kidney injury 5.6% vs 4.3% (p > 0.99)	In endovascular procedures, there were 4 cases of leg ischemia and 2 cases of visceral artery occlusion. Whereas in open surgery there were 2 cases of leg ischemia
15	Locham et al, 2018 ¹⁷	1191	Retrospective cohort	Open vs endovascular surgeries (fenestrated technique and chimney technique)	Mortality and morbidity	2b	FEVAR vs CEVAR vs Open surgery: - Mortality 2.47% vs 7.32% vs 6.13% (p = 0.13)	The research subjects in this study were patients with juxtarenal, pararenal, and suprarenal aortic aneurysms.

Another study by Ferrante et al. reported 20 years of experience with open aneurysms. The approach taken was the Williams-Sicard left flank incision (77%), with the rest being a transperitoneal and thoracophrenolaparotomy approach.¹¹ Proximal aortic control was performed with suprarenal clamping in 80% of patients, supra celiac clamping in 17.5% of patients, and supra mesenteric clamping in 2.5% patients. The 30-day mortality was 2.5%, with the leading causes being intraoperative bleeding (aortic rupture at clamping site and renal artery

rupture) and acute myocardial infarction. The study concluded that 30-day mortality was associated with duration of surgery, duration of visceral ischemia, total aortic clamp, supra visceral clamp site, intraoperative blood loss, intraoperative blood transfusion, and cardiac complications. As many as 51% of subject patients experienced at least one complication. The most common complications were a respiratory failure (14%), cardiac complication (13%), and postoperative acute kidney failure (11%). In long-term follow-up, the mean survival was 50

months, with the leading cause being cardiovascular disease. Age, history of AMI, COPD, CrCl <40 mL/minute preoperatively, postoperative cardiac complications, and peripheral artery disease (PAD) were predictors associated with death in long-term follow-up.

The study by van Lammeren et al. enrolled 214 patients who underwent elective surgery for PAA. The aortic clamp was positioned on the crus diaphragm (16.8%), suprarenal (58.4%), and juxta renal (24.8%). The 30-day mortality was 3.4%, with causes of death including intestinal ischemia, myocardial infarction, and subsequent cardiac failure, rebleeding, pneumonia, and multiple organ failure. The 30-day morbidity was 27.1%, with the majority [of the cause] due to pneumonia. There were 2.8% of patients who eventually needed permanent haemodialysis. In long-term follow-up, the 5-year survival rate was 74.2%.

Sugimoto et al. conducted a study in 2018 involving 108 patients. The median duration of surgery was 268 minutes. Proximal clamps were applied in supra celiac (5.6%), suprarenal (31.5%), and inter-renal (62.9%). The median renal ischemic duration was 33 minutes, with 22.2% of patients had left renal vein separated to visualize the proximal clamping sites better. The median length of stay was 13 days. Mortality was noted due to postoperative multiple organ failure. There were 15.7% of patients who eventually developed chronic kidney dysfunction and required permanent hemodialysis. This has been shown to occur in patients who had previously been diagnosed with stage 3-4 of CKD.

Endovascular Procedures

The use of conventional EVAR in the PAA case has a reintervention rate of 26.9% and a conversion rate of 6.9%. From the findings of the article obtained, the endovascular methods that are often discussed are the chimney endovascular aneurysm repair (cEVAR), fenestrated endovascular aneurysm repair (fEVAR), and branched endovascular aneurysm repair (bEVAR) techniques.¹⁸

The chimney technique has become an option for PAA management. Chimney grafts are located between the wall of the aorta and the endovascular prosthesis so that it is still possible to keep the graft-covered visceral artery supplied with blood. If it leads to the cranial, it is called a chimney, whereas if it leads to the caudal, it is called a periscope. With this technique, PAA can be managed with endovascular procedures by revascularization of the superior mesenteric artery and both renal arteries. This procedure begins with catheterization of the visceral arteries with stiff wires and covered stents, then the stents and endovascular prosthesis are simultaneously dilated (kissing balloon) to prevent collapse and provide a landing zone for the aortic stent graft. An issue discussed was a type I endoleak because the landing zone was not optimal. A study by Donas et al. reported that type Ia endoleak occurred in 6 of 72 patients.¹⁹ No mortality occurred, besides there was no difference in the number of prostheses to patient outcome.²⁰

The fenestrated stent graft is a prosthesis with a 5-8 mm gap, adapted to each patient's anatomical variation. During the procedure, a stent-graft will be used to connect the slits to the visceral arteries. The fenestrated graft should be designed with 3D vascular software to obtain precise measurements. These slits are best suited to be used for healthy segments of the aorta so that they are in direct contact with the walls of the aorta and then the branches of the visceral blood vessels to prevent endoleaks. In contrast, branched prostheses are said to be suitable for cases where the visceral arteries are in the segment of the aneurysm. These branches are used to bridge the gap between the stent graft and the wall of the aorta. This system can be separate or consist of several module parts. In addition, these branches can be either inside or outside of the prosthesis. In this review, there were limited studies on endovascular procedures that have specifically addressed PAA. Other studies that were excluded

discussed endovascular procedures of complex aortic aneurysms with a small proportion of PAA. The studies found were in the form of 1 case report, 1 case series, and 1 systematic review, showing no clear indication of the choice of endovascular procedures. The study also failed to reveal the outcome of endovascular procedures due to the study design and sample size. However, the systematic review obtained successfully revealed the risk of occlusion after the chimney graft procedure. Usai et al. performed a systematic review of graft occlusion in patients undergoing cEVAR. Chimney graft occlusion is a rare complication and is generally temporary.¹⁰ The exact mechanism is unknown, but most of them are due to thrombosis, whereas stent deformation or fracture is rarely the cause. Several possibilities are an insufficient expansion of chimney grafts which can cause blood flow disruption that leads to occlusion. In addition, congenital hyper coagulopathy may also affect the patency of the chimney graft. The study found that one patient died due to intestinal ischemia.

Open surgery vs. Endovascular Procedures

Five studies have compared open surgery and endovascular procedures. The study by Sultan et al. in 2007 involved 118 patients. The study showed no perioperative mortality in the endovascular method group compared to the open surgery method, which had perioperative mortality of 4.5%. There was no aneurysm rupture in either method, but the aneurysm-related survival in patients with the endovascular method was higher than in open surgery (100% vs. 92.4%), but comorbidity was more common in EVAR (overall survival 57.1% vs. 84.8%).⁵ Another study from Orr et al. in 2016 enrolled 1005 patients with aneurysms. In this study, it was found that there was no significant difference in mortality rates between endovascular procedures and open surgery (2.7% vs. 5.7%). Endovascular procedures have a shorter ICU length of stay and an overall hospital length of stay. The 30-day morbidity was significantly better with the endovascular procedures when compared with open surgery (16% vs. 35%, $p < 0.001$). The main cause of morbidity being heart or respiratory failure (7.6% vs 21%, $p = 0.001$), levels of kidney insufficiency or failure (3.8% vs 9.9%, $p = 0.009$), and levels of pneumonia (1.5% vs 6, 8%, $p = 0.004$).¹²

A study by Fiorucci et al. in 2019 compared open surgery with fenestrated EVAR methods. This study found that patients who underwent fEVAR were significantly older and had a higher frequency of coronary artery disease and a history of the previous stroke. In addition, open surgery had a higher risk of perioperative morbidity (OR 2.5, 95% CI 1.09 to 5.71, $p = 0.033$). This finding was confirmed in a trend-adjusted analysis, in which cardiac complications were also higher after open surgery (OR 12.8, 95% CI 0.07–0.21, $p = 0.02$). We identified no difference in perioperative mortality (2.2% for fEVAR vs. 1.9% for open surgery). The mean follow-up time was 50 months (range 0–119).¹⁶

A study by Locham et al. enrolled 1191 patients who underwent repair of abdominal aortic aneurysms. This study found no significant difference in 30-day mortality in the three groups (fEVAR: 2.47% vs. cEVAR: 7.32% vs. open surgery: 6.13%, $p = 0.13$) but with complications such as renal failure. Kidney failure complications in open surgery 9.36% vs. cEVAR group 6.10% vs. fEVAR group 1.85%, $p = 0.003$, whereas cardiopulmonary complications in open surgery had a prevalence 19.77% vs. cEVAR group 3.66% vs. fEVAR group 4.94%, $p < 0.001$. This study found that open surgery is associated with a two to five-fold increase in mortality compared to other groups.¹⁷ A study by Belczak et al. in 2014 revealed that open surgery has higher mortality and decreased/impaired kidney function without significant differences.⁸

Summary

Endovascular treatment has benefits in lower mortality, shorter ICU length of stay and overall length of stay, better morbidity, and suitable for an older patient with more comorbidity than open surgery. In addition, open surgery has higher cardiopulmonary and kidney complications that were increasing morbidity and mortality, although some studies show insignificant differences. Based on the existing literature, we concluded that endovascular treatment is recommended for PAA.

Disclosure

Authors declare no conflict of interest

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