



Clinical Research

Midterm Outcomes of Endovascular Aortic Aneurysm Repair with Carbon Dioxide—Guided Angiography

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Background: Although iodinated contrast (IC) agents are commonly used in endovascular aneurysm repair (EVAR), perioperative use in patients with renal dysfunction or IC allergies is avoided. Carbon dioxide (CO₂)-guided angiography is a promising alternative. We aimed to evaluate short-term and midterm outcomes of EVAR using CO₂-guided angiography.

Methods: Three hundred eighty-one patients who underwent EVAR from January 2012 to September 2016 were retrospectively reviewed and divided into an IC-EVAR group ($n = 351$) and CO₂-EVAR group ($n = 30$). Subjects in the CO₂-EVAR group had severe renal dysfunction ($n = 27$) and IC allergy ($n = 4$). Intraoperative, postoperative, and follow-up variables were compared.

Results: Compared with the IC-EVAR group, preoperative serum creatinine level was significantly higher (2.0 vs. 0.92 mg/dL, $P < 0.0001$) and mean IC dose was significantly lower (18 vs. 55 mL, $P < 0.0001$) in the CO₂-EVAR group. The fluoroscopy time, operative time, number of stent grafts placed, and technical success rates of the groups were similar; no type I and/or type III endoleaks were detected on completion angiography. There was no acute kidney injury and one case of intestinal necrosis in the CO₂-EVAR group, potentially due to cholesterol embolism. Postoperative endoleak, enlargement of aneurysms, survival, freedom from secondary intervention, and renal function change up to 3 months, postoperatively, were similar between the groups.

Conclusions: CO₂-EVAR is technically feasible and exhibits prominent renal protection. However, consideration of the aortic lumen status remains an important challenge.

Funding: This report did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sector.

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Ann Vasc Surg 2018; ■: 1–7

<https://doi.org/10.1016/j.avsg.2018.02.036>

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Manuscript received: June 28, 2017; manuscript accepted: February 19, 2018; published online: ■ ■ ■

INTRODUCTION

Endovascular aneurysm repair (EVAR) has lower short-term morbidity and mortality than open surgery.^{1,2} Intra-arterial contrast agents are an important component of successful EVAR as the tool of choice for preoperative evaluation of aortic aneurysm morphology as well as precise sizing and intraoperative visualization of the ostia of the renal and hypogastric arteries for graft replacement. Although iodinated contrast (IC) is overwhelmingly the most common contrast agent, the perioperative use of IC agents is not recommended in patients with renal dysfunction or allergies to IC.^{3,4} Many strategies have been proposed with the aim of reducing IC

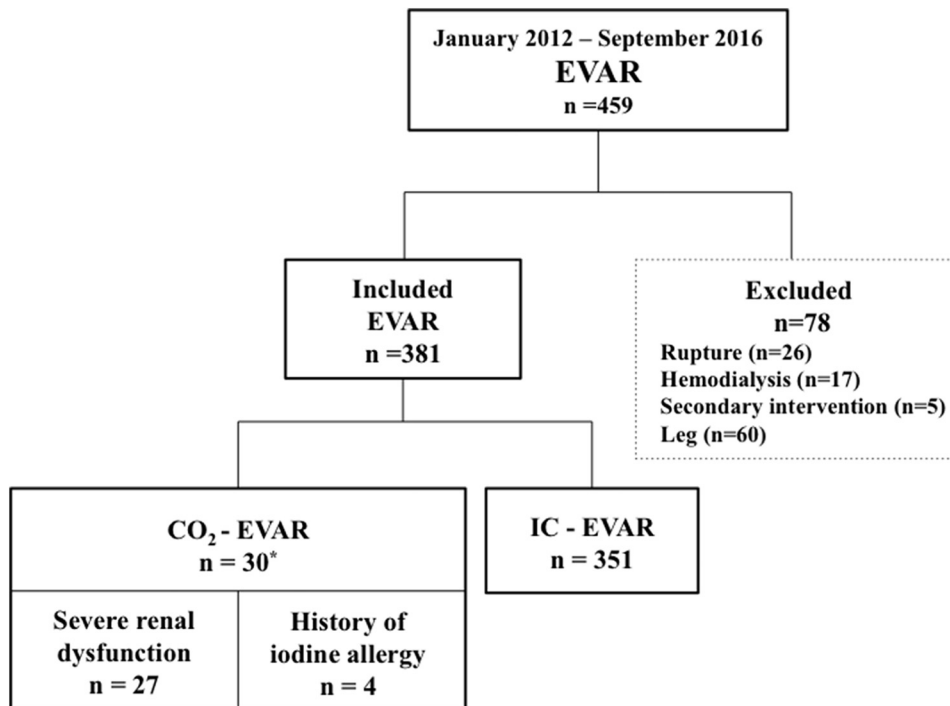


Fig. 1. Flow diagram showing the patients analyzed retrospectively. *One patient had both severe renal dysfunction and history of iodine allergy.

exposure. Alternatives have been developed, such as the use of intravascular ultrasound,^{5–7} high-quality 3-dimensional imaging techniques, and fusion of preoperative and intraoperative imaging.⁸ However, despite reports of various methods of renal protection, including the use of perioperative hydration, acetylcysteine, mannitol, dopamine, and fenoldopam, the effects of these methods are controversial.^{9–11}

Carbon dioxide (CO₂)-guided angiography is an alternative contrast approach first described for diagnostic purposes by Hawkins.¹² Although many studies have demonstrated the safety and effectiveness of CO₂-EVAR and its noninferiority to IC-EVAR,^{13–17} the midterm and long-term outcomes of CO₂-EVAR have not been reported to date. The aim of this study was to evaluate the short-term and midterm outcomes of patients who underwent CO₂-EVAR and to compare them with those of patients who underwent conventional IC-EVAR.

METHODS

We retrospectively analyzed data from patients who underwent EVAR at Yamaguchi University (Yamaguchi, Japan) and Saiseikai Shimonoseki General Hospital (Yamaguchi, Japan) from January 2012 to

September 2016. Of the 459 patients who underwent EVAR using commercially available devices, 381 were included in the present study (Fig. 1). The reasons for exclusion of the remaining 78 patients were rupture in 26 patients and hemodialysis in 17 patients because the evaluation of renal function differs quite substantially in these patients from that in elective surgeries and nonhemodialysis patients. In addition, patients undergoing secondary EVAR ($n = 5$) and those in whom only one limb placement was performed ($n = 60$) were also excluded because the operative procedure in these patients tended to be simpler than that in other cases, which may have biased the evaluation of intraoperative variables. More than 40 variables pertaining to patient demographics, comorbidity, medication, anatomy, device used, perioperative outcome, and midterm outcome (including transition of renal function, aneurysm size, types of endoleak, and secondary intervention) were collected.

The Risk/Injury/Failure/Loss/End-stage (RIFLE) classification was used to evaluate the presence of acute kidney injury. The RIFLE classification consists of international criteria to define and stage acute kidney injury within the first 7 postoperative days.¹⁸ Serum creatinine, glomerular filtration rate, and urine volume should be used for this classification; however, we substituted these

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