

# General anesthesia versus local anesthesia for endovascular aortic aneurysm repair

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## Abstract

The aim of this study was to compare general and local anesthesia techniques in patients treated with elective endovascular aortic aneurysm repair (EVAR) for infrarenal aortic aneurysms.

In this single-center, observational cohort study, in all, 259 consecutive patients who underwent elective EVAR was included; 144 patients (55.6%, 126 men, mean age 72.8 years) operated on under general anesthesia (GA group) and 115 (44.4%, 100 men, mean age 72.3 years) operated on under local anesthesia (LA group). A retrospective analysis regarding technical feasibility, endoleaks, length of hospital stay, and 30-day clinical outcomes was performed.

There was no anesthetic conversion (from LA to GA) during EVAR, and no significant difference was noted in the incidence of endoleaks and its types in relation to anesthetic techniques on final completion angiograms (14.1% vs 18.4%;  $P = .347$ ) and follow-up computed tomography angiogram at 30 days after EVAR (23.6% vs 19.1%;  $P = .384$ ). Significant differences were not observed with regard to a prolonged length of hospital stay in relation to anesthetic techniques ( $8.6 \pm 16.3$  vs  $7.2 \pm 3.3$ ;  $P = .348$ ), and the main outcomes showed no significant differences in morbidity (20.1% vs 16.5%;  $P = .457$ ), mortality (0.0% vs 0.0%), and the rates of secondary therapeutic procedures (9.7% vs 4.3%;  $P = .099$ ) between the 2 groups during the 30-day follow-up.

We have not shown a definite difference in 30-day outcomes between GA and LA for EVAR. The anesthetist and surgeon, in consultation with the patient, should decide which anesthetic technique to use on an individual basis.

**Abbreviations:** AAA = abdominal aortic aneurysm, CTA = computed tomography angiography, EVAR = endovascular aneurysm repair, GA = general anesthesia, LA = local anesthesia, PAOD = peripheral arterial occlusive disease, PIS = postimplantation syndrome, WBC = white blood cell.

**Keywords:** anesthesia, aneurysm, aorta, endovascular, outcome, treatment

## 1. Introduction

Endovascular aneurysm repair (EVAR) was introduced in the 1990s as a less invasive and potentially safer alternative to traditional open abdominal aortic aneurysm (AAA) repair. In comparison with open AAA repair, short-term survival rates are significantly higher in patients who have undergone EVAR, but long-term survival rates are similar. Nevertheless, EVAR has become the first-line treatment option for infrarenal AAA because of its less invasive nature and significantly higher short-term survival rates.<sup>[1–5]</sup>

Although various anesthetic techniques can be applied to successfully accomplish EVAR, with general anesthesia (GA)

being the most common, some controversies exist whether primary use of local anesthesia (LA) is feasible and tolerated; some studies have found that LA is a safe method that may reduce recovery time and medical morbidity compared with GA, whereas others have not.<sup>[6–12]</sup> This retrospective single-center study was aimed to compare the 30-day clinical outcomes between GA and LA techniques in patients who underwent elective EVAR for infrarenal AAA.

## 2. Subjects and methods

### 2.1. Study design and population

This was a single-center, retrospective, observational study using data extracted from medical records. The study protocol was approved by the Institutional Review Board of Asan Medical Center, which waived the need for informed consent. Between January, 2011 and December, 2016, 276 consecutive patients who underwent EVAR of an infrarenal AAA at our institution were included in this study. Patients with a ruptured AAA and an AAA involving concomitant operative procedures requiring GA were excluded. Among them, 259 patients who underwent elective EVAR were enrolled in this study. Patients were categorized in 2 groups according to anesthesia techniques used during EVAR: a GA group of 144 patients (55.6%) and a LA group of 115 patients (44.4%). No regional anesthesia was used during EVAR in this study period. Decision on anesthesia techniques and the selection of a stent graft type was mainly made as per the physicians' preference based on the expected level of technical difficulty of the procedure. Endovascular procedures

Editor: Perbinder Grewal.

The authors of this work have nothing to disclose.

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Medicine (2018) 97:32(e11789)

Received: 8 May 2018 / Accepted: 16 July 2018

<http://dx.doi.org/10.1097/MD.00000000000011789>

were followed a standard vascular protocol. According to the hospital protocol, all included patients received prophylactic antibiotics 30 minutes before EVAR, and also 5000 U of heparin intravenously before introduction of the stent graft deployment system during EVAR.

Demographics, risk factors of interest, and other data, including clinical presentation, morphologic characteristics of the AAA, operative and postoperative characteristics, and 30-day clinical outcomes, were recorded for each patient. All morphologic characteristics of the AAA were recorded in the official computed tomography angiogram (CTA) report by a radiologist, according to the reporting standards of the Ad Hoc Committee for Standardized Reporting Practices in Vascular Surgery of the Society for Vascular Surgery/American Association for Vascular Surgery.<sup>[13]</sup> Patients were discharged in the absence of any complications, as confirmed via laboratory and follow-up CTA findings. Follow-up visits were scheduled at 1 month after discharge, and also at 6 and 12 months after EVAR, and annually thereafter. All follow-up visits included laboratory evaluations, CTA, and plain radiography of the abdomen. All data were prospectively collected for all consecutive patients in an Excel database (Microsoft Corp., Redmond, Washington, D.C.), and a retrospective analysis regarding technical feasibility and 30-day clinical outcomes was performed.

## 2.2. Definitions and measurement of outcome

General anesthesia was induced and maintained with target effect-site concentration-controlled infusion of propofol and remifentanyl.<sup>[14]</sup> LA was defined as infiltration of local anesthetics in the groin, regardless of an additional intravenous sedation or pain therapy. Operative time was defined as total operation time in minutes. Length of hospital stay was defined as the time from the EVAR procedure to hospital discharge. Postimplantation syndrome (PIS) was defined as a continuous temperature of  $>38^{\circ}\text{C}$  lasting for  $>1$  day and a white blood cell (WBC) count of  $>12,000/\text{mm}^3$ , despite antibiotic therapy and negative culture results, in accordance with that of systemic inflammatory response syndrome as previously described.<sup>[15]</sup> In all PIS patients, conservative medical treatment, which consisted of intravenous fluid therapy, nutritional support, prophylactic antibiotic therapy, and close observation with the cultures from blood, urine, and sputum, was administered; the antipyretics were used only when patients suffered from subjective symptoms related to fever. As per to the definition of endoleaks,<sup>[5]</sup> endoleaks were subdivided into postprocedural endoleaks based on final completion angiogram findings and 30-day endoleaks based on follow-up CTA at 30 days after EVAR, and analyzed by the anesthesia techniques.

The main outcomes of this study were length of hospital stay, PIS, 30-day morbidity and mortality, and 30-day secondary therapeutic procedures. Thirty-day complications (morbidity), defined as previously described,<sup>[16,17]</sup> were analyzed individually, and in aggregate categories, including wound, systemic, and other complications.

## 2.3. Statistical analysis

Categorical variables presented as counts, and percentages were analyzed using chi-square and Fisher exact tests, as appropriate. Continuous variables, presented as mean  $\pm$  standard deviation, were compared using Student *t* test. All statistical analyses were performed using SPSS (version 18.0; SPSS, Chicago, IL), and  $P \leq .05$  was considered statistically significant.

**Table 1**

**Patient demographics and risk factors stratified by type of anesthesia during endovascular aneurysm repair (EVAR).**

Variable	General anesthesia	Local anesthesia	P
Number of patients	144 (55.6)	115 (44.4)	
Mean age, y	72.8 $\pm$ 6.3	72.3 $\pm$ 6.6	.574
Male sex	126 (87.5)	100 (87.0)	.896
BMI, kg/m <sup>2</sup>	23.8 $\pm$ 3.2	24.1 $\pm$ 3.6	.443
Medical history			
Diabetes mellitus	20 (13.9)	25 (21.7)	.098
Hypertension	101 (70.1)	77 (67.0)	.583
Dyslipidemia	16 (11.1)	19 (16.5)	.206
Smoking	48 (33.3)	35 (30.4)	.619
Cancer other than skin cancer	39 (27.1)	39 (33.9)	.234
CAD	45 (31.3)	40 (34.8)	.547
HF	8 (5.6)	13 (11.3)	.092
COPD	38 (26.4)	33 (28.7)	.679
CVA	15 (10.4)	12 (10.4)	.996
PAOD	23 (16.0)	9 (7.8)	.048
Hemodialysis	1 (0.7)	5 (4.3)	.052
ASA class			
1–2	89 (61.8)	63 (54.8)	.254
3–5	55 (38.2)	52 (45.2)	

Continuous data are shown as mean  $\pm$  standard deviation, and categorical data are shown as number (%).

ASA = American Society of Anesthesiologists, BMI = body mass index, CAD = coronary artery disease, COPD = chronic obstructive pulmonary disease, CVA = cerebrovascular accident, HF = heart failure, PAOD = peripheral arterial occlusive disease.

## 3. Results

### 3.1. Patient characteristics

The demographic and risk factor data are summarized in Table 1. We identified 259 elective EVAR cases for an AAA. Types of anesthesia administered were GA in 144 patients (55.6%, 126 men, mean age 72.8 years) and LA in 115 patients (44.4%, 100 men, mean age 72.3 years). Patient characteristics did not differ according to anesthesia techniques except that the GA group had a higher prevalence of peripheral arterial occlusive disease (PAOD) (16.0% vs 7.8%;  $P = .048$ ), whereas there was a nonsignificant trend towards higher proportion of patients receiving hemodialysis in the LA group (0.7% vs 4.3%;  $P = .052$ ).

### 3.2. Anatomic data of AAA

The aneurysm measurements are listed in Table 2. LA was more frequently used in patients with AAA extending to the common iliac artery (27.1% vs 39.1%;  $P = .040$ ), but there were no significant differences in other anatomic data of AAA between the GA and LA groups.

### 3.3. Type of stent grafts and procedural specifics

Distinct differences were evident with respect to anesthesia technique for the stent graft brands from different companies. The following stent grafts were used in the GA group: Endurant (Medtronic, Minneapolis, MN;  $n = 79$ , 54.9%), Zenith (Cook Medical Inc., Bloomington, IN;  $n = 50$ , 34.7%), Excluder (W.L. Gore & Associates Inc., Flagstaff, AZ;  $n = 9$ , 6.3%), and others ( $n = 6$ , 4.2%). Endurant was the most commonly used stent graft ( $n = 94$ , 81.7%) for EVAR in the LA group, followed by Zenith ( $n = 13$ , 11.3%), Excluder ( $n = 5$ , 4.3%), and others ( $n = 3$ ,

**Table 2**  
Anatomic measurements of abdominal aortic aneurysm stratified by type of anesthesia during endovascular aneurysm repair (EVAR).

Variable	General anesthesia	Local anesthesia	P
Aneurysm sac diameter,* cm	5.8 ± 1.0	5.9 ± 1.1	.857
Neck diameter, cm	2.2 ± 0.3	2.2 ± 0.3	.406
Neck length, cm	3.4 ± 1.6	3.1 ± 1.6	.081
Neck angle, degree			
Right-left	44.2 ± 24.6°	47.3 ± 24.0°	.312
Anterior-posterior	30.4 ± 28.3°	28.3 ± 17.4°	.325
CIA involvement	39 (27.1)	45 (39.1)	.040
Iliac artery tortuosity			
Grade 0	16 (11.1)	14 (12.2)	.791
Grade 1	53 (36.8)	33 (28.7)	.169
Grade 2	48 (33.3)	38 (33.0)	.961
Grade 3	27 (18.8)	30 (26.1)	.157
Shaggy aorta <sup>†</sup>	22 (15.3)	21 (18.4)	.501
IMA occlusion	25 (17.4)	25 (21.9)	.357

Continuous data are shown as mean ± standard deviation, and categorical data are shown as number (%).

CIA=common iliac artery, IMA=inferior mesenteric artery.

\* Maximum aneurysm diameter measured perpendicular to the flow line of the vessel with three-dimensional reconstructed computed tomography angiography images.

<sup>†</sup> defined as a diffuse, irregularly shaped atherosclerotic change involving more than 75% of the length of the aorta from the aortic arch to the visceral segment and atheromatous plaque thickness greater than 4 mm.

2.6%). Patients in the LA group were more likely to receive Endurant stent graft during EVAR (54.9% vs 81.7%;  $P < .001$ ).

There was no anesthetic conversion (from LA to GA) during EVAR. Procedural specifics are summarized in Table 3. Procedural specifics varied according to anesthesia techniques, and significant differences were observed in operative time, access type, and use of carbon dioxide as an alternative contrast agent. The mean operative time for the GA group was significantly longer than that for the LA group ( $191.9 \pm 66.8$  vs  $116.5 \pm 55.4$ ;  $P < .001$ ). Percutaneous access was used in most patients of the LA group, whereas most patients of the GA group used open femoral artery access through a groin incision (2.1% vs 95.7%;  $P < .001$ ). To avoid contrast-induced renal complications, carbon dioxide was used as an alternative contrast agent in 5 patients of the LA group, but none in the GA group (0.0% vs 4.3%;  $P = .012$ ).

**3.4. Endoleaks and 30-day main outcomes**

Final completion angiograms showed that the incidence of endoleaks was similar between the GA and LA groups (14.1% vs

**Table 3**  
Procedural specifics stratified by anesthesia techniques during endovascular aneurysm repair (EVAR).

Variable	General anesthesia	Local anesthesia	P
Operative time, min	191.9 ± 66.8	116.5 ± 55.4	<.001
Access type			
Percutaneous	3 (2.1)	110 (95.7)	<.001
Any open femoral access	141 (97.9)	5 (4.3)	
Hypogastric embolization	28 (19.9)	28 (24.8)	.347
Additional procedures	17 (11.8)	10 (8.7)	.416
Use of carbon dioxide gas	0 (0.0)	5 (4.3)	.012

Continuous data are shown as mean ± standard deviation, and categorical data are shown as number (%).

**Table 4**  
Incidence of endoleaks by anesthesia techniques.

Variable	General anesthesia	Local anesthesia	P
Postprocedural endoleaks*	20 (14.1)	21 (18.4)	.347
Type Ia	7 (4.9)	12 (10.5)	.090
Type Ib	5 (3.5)	3 (2.6)	.684
Type II	7 (4.9)	5 (4.4)	.838
Type III	1 (0.7)	1 (0.9)	.876
Type IV	0 (0.0)	0 (0.0)	NA
30-day endoleaks <sup>†</sup>	34 (23.6)	22 (19.1)	.384
Type Ia	3 (2.1)	0 (0.0)	.119
Type Ib	9 (6.3)	3 (2.6)	.166
Type II	19 (13.2)	17 (14.8)	.714
Type III	3 (2.1)	2 (1.7)	.841
Type IV	0 (0.0)	0 (0.0)	NA

NA=not applicable.

\* Findings on final completion angiogram.

<sup>†</sup> Findings on follow-up computed tomography angiogram at 30 days after endovascular aneurysm repair.

18.4%;  $P = .347$ ), and no significant differences were noted on follow-up CTA at 30 days after EVAR (23.6% vs 19.1%;  $P = .384$ ) (Table 4).

Although significant differences were not observed with regard to a prolonged length of hospital stay in relation to the anesthesia techniques ( $8.6 \pm 16.3$  vs  $7.2 \pm 3.3$ ;  $P = .348$ ), the incidence of PIS was significantly higher in the LA group compared with the GA group (24.3% vs 36.5%;  $P = .033$ ). During the 30-day follow-up, the main outcomes showed no significant differences in morbidity (20.1% vs 16.5%;  $P = .457$ ), mortality (0.0% vs 0.0%), and the rates of secondary therapeutic procedures (9.7% vs 4.3%;  $P = .099$ ) between the groups, although the rates of lower limb complications were significantly higher in the GA group (6.9% vs 0.9%;  $P = .016$ ) (Table 5). Renal complications included acute kidney injury<sup>[17]</sup> (5 patients), coverage of lower polar artery or partial coverage of 1 renal artery (5 patients), and partial embolic

**Table 5**  
Length of hospital stay and 30-day clinical outcomes stratified by anesthesia techniques during endovascular aneurysm repair (EVAR).

Variable	General anesthesia	Local anesthesia	P
Hospital stay, d	8.6 ± 16.3	7.2 ± 3.3	.348
PIS	35 (24.3)	42 (36.5)	.033
30-d clinical outcomes			
30-d morbidity	29 (20.1)	19 (16.5)	.457
Wound complications	5 (3.5)	2 (1.7)	.393
Systemic complications	15 (10.4)	13 (11.3)	.819
Cardiac	0 (0.0)	2 (1.7)	.112
Pulmonary	3 (2.1)	1 (0.9)	.431
Renal	11 (7.6)	9 (7.8)	.955
Gastrointestinal	1 (0.7)	1 (0.9)	.873
Others			
Lower limb	10 (6.9)	1 (0.9)	.016
Venous thromboembolic	0 (0.0)	1 (0.9)	.262
Bleeding	0 (0.0)	2 (1.7)	.112
30-d mortality	0 (0.0)	0 (0.0)	NA
Secondary therapeutic procedure	14 (9.7)	5 (4.3)	.099

Continuous data are shown as mean ± standard deviation, and categorical data are shown as number (%).

NA=not applicable, PIS=postimplantation syndrome.

renal infarction (1 patient) in the GA group, and acute kidney injury (4 patients), coverage of lower polar artery or partial coverage of 1 renal artery (3 patients), partial embolic renal infarction (1 patient), and renal artery dissection (1 patient) in the LA group. Gastrointestinal complications (ischemic colitis) occurred in 1 patient of both groups, respectively. Lower limb complications included dissection of the iliac artery (6 patients), thrombotic occlusion of the iliac limb graft (3 patients), and distal embolism (1 patient) in the GA group, and 1 thrombotic occlusion of the iliac limb graft in the LA group. There was no 30-day mortality in both groups.

#### 4. Discussion

Although the absence of randomized data is a major limitation to understanding the effect of anesthesia techniques on morbidity and mortality after EVAR, anesthesiologists and surgeons have suggested that LA rather than GA should reduce perioperative morbidity and mortality, particularly for the relatively high-risk population inherent with aneurysmal disease of the aorta.<sup>[12]</sup> However, most clinical trials in various major surgical procedures have failed to show a convincing benefit for LA.<sup>[18,19]</sup> The anesthesia techniques used during EVAR varied widely, and some controversies exist whether primary use of LA during EVAR is feasible and tolerated to reduce recovery time and medical morbidity compared with GA.<sup>[6–11]</sup> Despite its retrospective nature with a small cohort of patients, our results indicate that a definite difference in 30-day clinical outcomes after EVAR was not noted between GA and LA techniques.

Although the practice guidelines of the Society of Vascular Surgery suggest low-level recommendations and evidence in support of using LA for EVAR is low,<sup>[20]</sup> percutaneous access with LA seems to be a new strategy that leans toward less invasive treatment.<sup>[9–12,21]</sup> Previous studies have failed to demonstrate any difference in mortality according to different anesthesia methods.<sup>[6,7,11]</sup> The main difficulty in validating an advantage of anesthesia technique with regard to patient survival is caused by the EVAR procedure's low mortality rate.<sup>[9–12]</sup> The most significant advantage of the LA related with morbidity after EVAR may consist of avoidance of the endotracheal intubation that can increase patient's exposure to factors for postoperative pulmonary complications.<sup>[9–12]</sup> LA techniques that are free from ventilator weaning procedures from GA challenge in aged, compromised patients and the possibility of residual neuromuscular paralysis after reversal from GA.<sup>[9–12]</sup> However, LA also has some disadvantages that might negate some of EVAR's potential benefits. LA causes several technical difficulties during stent graft deployment that might lower the technical success rate compared to GA in patients of equivalent complexity: inferior breath-holding control during stent deployment, increased bowel peristalsis, and the risk of patient movement.<sup>[9–12]</sup> In addition, the risk of adverse cardiovascular events might be increased due to patients' pain and anxiety during the procedure.<sup>[10]</sup> In our study, no significant difference was observed with regard to 30-day cardiac complications in relation to anesthesia techniques, because patients received premedication, supplementary intraoperative sedation, and analgesia to minimize this.

Because of extremely low rate of 30-day mortality in the endovascular era, it has been suggested that long-term secondary therapeutic procedures or aneurysm-related adverse events represent a more pressing concern after EVAR than short-term mortality.<sup>[12]</sup> Although we analyzed long-term clinical outcomes after EVAR, we did not indicate in this study. This was done to

minimize biases introduced from the analysis of patients in which anesthetic choices were limited or crossovers occurred between anesthesia techniques, or both. In regard to endoleaks, there were substantially high rates of endoleaks on final completion angiogram during EVAR and follow-up CTA at 30 days after EVAR in both groups. However, during the mean follow-up periods of  $22.5 \pm 21.0$  months in the GA group and  $16.3 \pm 17.0$  months in the LA group, we observed no type I endoleaks, type II in 16 patients, and type III in 2 patients on the patients' most recent CTA findings in the GA group, and type Ia endoleaks in 1 patient and type II in 18 patients were observed in the LA group. An advantage of LA was shown compared with GA for shorter hospital stay in other studies,<sup>[12]</sup> and there was doubtless a reduction in cost from the shorter stay in the hospital, which is of economic significance.<sup>[11]</sup> In our study, lengths of hospital stay in relation to anesthesia techniques did not differ, may be because our management protocols were not adjusted to take advantage of the potential opportunities that EVAR under LA might have offered. The incidence of PIS was significantly higher in the LA group compared with the GA group; the composition of stent graft plays a primary role in PIS development, and woven polyester stent grafts reportedly result in a stronger systemic inflammatory response.<sup>[15]</sup> In our analysis, according to the composition of stent graft, there was a trend toward an increased incidence of PIS with clinical significance in patients receiving woven polyester stent graft for EVAR of an AAA compared with those receiving expanded polytetrafluoroethylene stent graft (31.0% vs 7.1%;  $P = .071$ ). More frequently used Endurant woven polyester stent graft in the LA group was a significant risk factor for PIS, which was itself significantly associated with a prolonged length of hospital stay. In our management protocol, PIS patients were discharged in the absence of any complications, as confirmed via follow-up CTA, with a body temperature of  $<37.5^\circ\text{C}$  for at least 24 hours and a WBC count of  $<12,000/\text{mm}^3$ .<sup>[15]</sup>

Although there was a high incidence of renal complication in both LA and GA groups on the analysis of 30-day clinical outcomes, all except 1 acute kidney injury were recovered without deterioration of renal function during the follow-up; 1 in the LA group developed acute kidney injury and eventually required dialysis. The proportion of PAOD in relation to anesthesia techniques differed significantly, and lower limb complications were significantly higher in the GA group compared with the LA group; we speculated that this baseline difference of PAOD, defined as previous history of radiological/surgical interventions for PAOD or an ankle brachial index  $\leq 0.9$  as measured with Doppler ultrasound,<sup>[22]</sup> may have affected the difference of lower limb complications in relation to anesthesia techniques.

This study had important unavoidable limitations. First, because of its retrospective nonrandomized nature, this study was subject to substantial selection and information biases. Individual anesthesia selections were made according to surgeon and anesthesiologist preference, integrating the biases of those individuals, and also patient-specific factors such as anatomy, medical risk, available resources, and procedural complexity. Although feasibility and safety of LA in EVAR has been proven,<sup>[9]</sup> GA could be more practical in some patients receiving EVAR: the easier control of blood pressure, already secured airway, better control of breath-holding with optimized imaging and exact placement of the stent graft, and the easier surgical conversion (EVAR to open repair) due to intraoperative complications. Furthermore, the decision for the selection of a stent graft type was mainly made depending on the surgeons' preference based on the expected level of technical difficulty of the

procedure. Second, regional anesthesia, 1 of the 3 commonly used anesthesia techniques for EVAR, is not used during EVAR procedure in our institution; our analysis could not testify to the results of regional anesthesia in comparison with GA and LA. Third, this study was conducted in Asia with a small cohort of patients comprised of only Asian descent. In comparison to the Western studies, there may be racial/ethnic differences in the morphologic characteristics of the AAA, and different healthcare system and the devices available for use; our findings should be interpreted cautiously with regard to differential racial/ethnic groups and other countries. Finally, our findings were obtained at a single center with a small sample size and limiting the general relevance of our results.

In conclusion, our study showed no definite evidence that the anesthesia techniques affect length of hospital stay or 30-day clinical outcomes. The anesthetist and surgeon, in consultation with the patient, should decide which anesthesia technique to use on an individual basis. Future prospective trials with larger cohorts should lead to a better understanding of the impact of anesthesia techniques on clinical outcomes after elective EVAR of an AAA.

### Author contributions

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