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# A New Type of Anesthesia for Endovascular Abdominal Aortic Aneurysm Repair: 3 Cases Report

**Xi You**[1,*], **Feng Jiang**[2]

[1]The Fourth People's Hospital of Shenzhen, People's Republic of China
[2]The First Naval Hospital of the Southern Theater Command of the People's Liberation Army, Zhanjiang, People's Republic of China

[*]**Corresponding Author**: Xi You, The Fourth People's Hospital of Shenzhen, People's Republic of China, China, Tel: +8613951353899, E-mail: 284663273@qq.com

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## Abstract

Choice of anesthetic approach for patients undergoing endovascular abdominal aortic aneurysm repair (EVAR) remains a challenge to the anesthetist, especially in emergency situations and for patients having multiple diseases. Although two main types of anesthetic techniques including general anesthetic (GA) and local anesthetic (LA) are used in EVAR, little is known about the effects of a combination method. Hence, we report a new combination anesthetic method used for 3 cases who are having multiple basic diseases (cardiovascular or lung) or with complex surgical procedure. The relevant anesthetic procedure was firstly anesthesia induction with midazolam, sufentanil, etomidate, rocuronium and methylprednisolone. After induction of GA and tracheal intubation, LA with 2% lidocaine combined with midazolam for sedation monitored anesthesia care (MAC) was maintained till to the end of the operation. Importantly, propofol and remifentanil were not injected with micropumps, muscle relaxants were not used, and anesthetics were not inhaled to maintain anesthesia. The depth of anesthesia was determined by Bis value and kept at the level of 40-60 during the operation. All patients cured and have completed one year follow-up. The benefits of using the method include: 1) increasing analgesic effect of LA mode and preventing patient body from moving and vasospasm occlusion caused by patient stress during LA procedure; 2) reducing the adverse reactions of GA drugs on cardiovascular and cerebrovascular systems therefore maintaining intraoperative hemodynamic stability. It is concluded that our method provides a new and valuable anesthetic consideration for emergency and complex endovascular repair surgery.

**Keywords:** Endovascular aneurysm repair (EVAR); Ruptured Abdominal Aortic Aneurysm (RAAA); Types of Anesthesia; Surgery

**List of Abbreviations:** EVAR: Endovascular Aneurysm Repair, MAC: monitored anesthesia care, GA: general anesthetic, LA: local anesthetic, RAAA: ruptured abdominal aortic aneurysm, DSA: Digital subtraction Angiography, CVP: Central Venous Pressure, ART: Arterial blood pressure, BIS: Bifrequency index.

## Introduction

Ruptured abdominal aortic aneurysm (RAAA) is a relatively dangerous disease in clinical practice [1]. Choice of anesthetic approach for patients undergoing endovascular abdominal aortic aneurysm repair (EVAR) remains a challenge to the anesthetist, especially in emergency situations and for patients having multiple diseases. There are three main types of anesthetic techniques using in clinic, those include general anesthetic (GA), regional anesthetic (RA) and local anesthetic (LA). One of anesthetic considerations for EVAR surgery is how to maintain hemodynamic stability and preserve organ function [2]. Recently, the monitored anesthesia care (MAC) in addition to LA instead of GA has become the standard of care in the endovascular aneurysm repair (EVAR) surgery of AAA patients at many institutions [3]. There are lots of reasons, e.g. MAC anesthesia is a type of sedation where patients remain aware of surroundings and stay calm [4] and LA mode in EVAR is associated with lower postoperative mortality and better surgical outcomes than GA [5-13]. In the other hand, some of research reports have shown that in patients undergoing fenestrated endograft aortic Repair (FEVAR)/ branched endograft aortic repair (BEVAR), GA and MAC seems not to affect procedural success, perioperative mortality and morbidity when pre-specificated haemodynamic targets are maintained will help to explore a safe and comfortable anesthesia method for EVAR surgery [14].

It would be for sure that LA is more attractive than GA mode. LA is associated with fewer endoleaks on completion angiogram and similar rates of endoleak and sacregression at 1-year follow-up, also LA decreased rates of type 1a and type 1b endoleaks at 1-year follow-up. Long term reintervention and mortality rates were similar between LA and GA. LA provides a safe setting for accurate deployment of endografts, is associated with durable results, and should be considered with increasing frequency when selecting anesthetic modality for EVAR [15]. Interestingly, Brett (2024) reported that in older patients with asymptomatic abdominal aortic aneurysms, outcomes were slightly better with local anesthesia than general mode [16], the benefits include shorter lengths of stay (mean, 1.8 vs. 2.6 days), more likely to be discharged to home (89% vs. 87%) and slightly less likely to have postoperative pulmonary or cardiovascular complications.

However, the disadvantages of local anesthesia are many as well including 1) MAC can be challenging for surgical teams due to patient and procedure-related factors. In fact, even with patients may also be because of the pain and discomfort, cerebral hypoperfusion, appear restless in the process of operation, and in the airway is not always directly into the environment, may need more depth of sedation [16]. LA requires the patient to fully cooperate during the procedure, lying still, and staying awake during the procedure may cause significant discomfort to the patient. In many actual surgical operations, it has been found that the more unfavorable situation in the operation caused by local anesthesia is that the patient has vasospasm occlusion due to nerve tension, and the limb is pale and bloodless due to vascular occlusion, leading the surgeon to find no filling blood vessels for puncture during the operation, and there is no available blood vessel. Failure of the patient to cooperate well under LA can also have a fatal impact in F/B EVAR surgery, that is, even a small body movement can constitute a major technical problem that potentially affects the patient and surgical outcome. 2) In addition, the risk of adverse cardiovascular events might be increased due to stress pain and anxiety during the procedure. Therefore, for patients with complex conditions, hypertension or other cardiovascular and cerebrovascular diseases, and poorly controlled blood pressure, it is safer to complete the operation under GA. GA has a good analgesic and sedative effect, which can reduce the change of blood pressure caused by tense or painful stimulation. Also one can use the methods such as vascular active drug, blood transfusion, rehydration to control and maintain patients' blood pressure stability. Nevertheless, GA was associated with higher number of patients who needed inotropes/-vasopressors to treat intraoperative hypotension. 3) If anesthetist selects LA mode for patient who receives very complicated EVAR procedures, then they need multiple venipuncture catheters, called “Open More Windows” . When patients are awake during anesthesia operation, it not only increases the patients' stress pain, but also need a large dose of local anesthetic drugs, what will increase the risk of local anesthetics poisoning.

General anesthesia overcomes most of the MAC-related disadvantage, but it is associated with hypotension, which in turn, may

negatively impact on organs' perfusion and patient prognosis.

Little is known about the effects of a combination method. Local plus sedoanalgesia or spinal analgesia (SA) in endovascular aortic aneurysm repair for 36 patients those required percutaneous implantation has been reported [17], the experience was positive, i.e. LA-SA provides a safe anesthesia method with stable hemodynamics, less invasive intervention and shorter operation times than neuraxial anesthesia.

Under the comprehensive consideration of the advantages and disadvantages of LA and GA reported by the latest literature and our own experiences on anesthesia for EVAR, the authors have developed a new anesthetic procedure and used it for 3 patients with RAAA in the report. After induction of GA and tracheal intubation, LA with 2% lidocaine combined with midazolam for sedation monitored anesthesia care was maintained till to the end of the operation. Importantly, propofol and remifentanil were not injected with micropumps, muscle relaxants were not used, and anesthetics were not inhaled to maintain anesthesia. The benefits of using the method include: 1) increasing analgesic effect of LA mode and preventing patient body from moving and vasospasm occlusion caused by patient stress during LA procedure; 2) reducing the adverse reactions of GA drugs on cardiovascular and cerebrovascular systems therefore maintaining intraoperative hemodynamic stability. Clearly, as the combination anesthesia for EVAR is the most contemporary and evolving clinical problem, there should be several limitations in our case report, such as the small sample size and potential biases e.g. the inclusion and exclusion criteria for the patient selection. This can to some degree be improved by getting an understanding of the merits and limitations of the method in the future.

## Case Presentation

### Inclusion and Exclusion Criteria for the Patient Selection

Inclusion criteria: 1) the EVAR surgery procedure was complex as covered additional procedures, e.g. for patient C; 2) long predicted operation time; 3) the patient fears the operation and was unable to cooperate, thereafter resulted in vasospasm and difficult vessel puncture; 4) the vasoactive drug application was needed to control hemodynamic change.

Quantitative Criteria: In clinical practice, the anesthetist will have a comprehensive judgment based on the mental state of the patient who is admitted to the hospital. If the hemodynamic parameters are to be quantifiable, the hypotension standard can be 90/60 mmHg. The duration of the operation is 2-3 hours, after 2 hours, a little muscle relaxant can be added to meet the need and to maintain the stability of the intubation. The recovery time may be within 10-30 minutes after discontinuation of imidazole or propofol, which is related to the total duration of the operation and the total amount of imidazole or propofol added during the operation.

Exclusion criteria = failure to adhere to inclusive criteria requirements in the study.

Complications: We haven't had any complications related to the new combination anesthesia in the report. One thing should be pay attention, it would be hypotension. Thus, the vasoactive drugs, e.g. norepinephrine or dopamine application with a micropump was needed; accordingly the blood pressure can be controlled unless a sudden massive bleeding. The most potential complication unrelated to anesthesia would be thrombus, which is pulmonary embolism and cerebral infarction, thus heparin thrombolysis should be given during the operation (the procedure in detail see case A).

### Presenting Concerns

Case A. A 66-year-old male patient weighed 75 kg. Came to the emergency department of our hospital because of "sudden lumbar and abdominal pain for 4 hours ". Aortic computed tomography angiography（CTA）and head CT were performed in the emergency department, and the results showed that 1. considering the localized dissection and rupture of the lower segment of

the abdominal aorta, massive exudation and blood accumulation at the lower margin of the liver, right perirenal and right abdominal cavity, interwall hematoma of the abdominal aorta and mural thrombosis; 2. atherosclerotic changes of left subclavian artery, right brachiocephalic artery, thoracoabdominal aorta, abdominal trunk, superior mesenteric artery and bilateral iliac artery; 3. inferior vena cava, right renal vein and the proximal segment of left renal vein were not well developed in venous stage, and only thin linear contrast agent filling was observed; 4. multiple flaky slightly low-density shadows under bilateral fronto-parietal cortex and adjacent to bilateral ventricles; 5. bilateral maxillary sinusitis; 6. intracranial arteriosclerosis; 7. multiple diverticula of ascending colon, cyst of right kidney and multiple calculus of both kidneys. Electrocardiogram showed sinus rhythm, HR 91bpm,blood routine showed white blood cells $15.83*10^9$/L, no obvious abnormalities in five coagulation, eight renal and liver functions. His medical history was remarkable for known of hypertension for 10 years, and his blood pressure was controlled at 130/90mmHg by long-term oral administration of Nifedipine sustained-release tablets. Diabetes mellitus was found for 1 year. Metformin was taken orally and fasting blood glucose was controlled at 7mmol/L. Deny the history of hepatitis, tuberculosis and other infectious diseases, deny the history of trauma, blood transfusion, deny the history of food and drug allergies.

In this case, the patient suffered from rupture and hemorrhage of the right posterior wall of the tumor. Due to the limitation of the encapsulation of the posterior peritoneum, the amount of blood loss was limited, and blood extravasation was gradually reduced, which was an important condition for the recovery of circulating blood volume after intraoperative rescue and dilatation. The results of an emergent computed tomography angiography (CTA) scan of his abdomen and pelvis demonstrated an 47.6mm*45.4mm AAA with a large retroperitoneal hematoma (Figure 1).

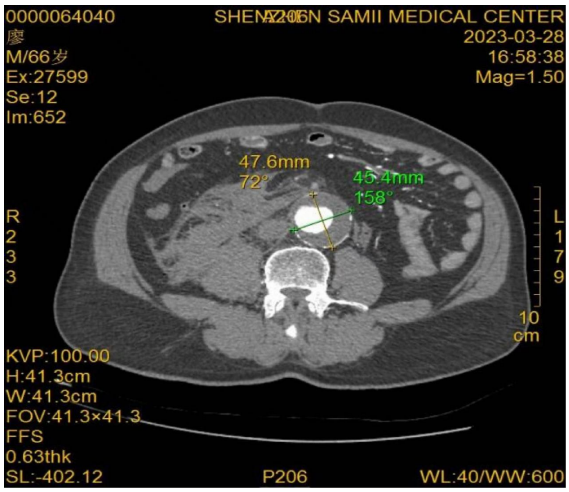


**Figure 1:** Computed tomography angiography (CTA) shows ruptured abdominal aortic aneurysm (AAA). Transverse diameter (major axis) = 47.6mm of AAA; vertical diameter (minor axis) = 45.5mm of AAA.

## Therapeutic Intervention and Treatment

At the time of entry, the patient was listless, vital signs: HR 98bpm, BP 147/95 mmHg, SpO2 95%. Electrocardiogram showed ventricular premature onset. After the patient entered the room, right radial artery puncture was performed to continuously monitor arterial blood pressure, and central venous catheterization was performed to ensure intravenous infusion. When the patient was ready for anesthesia induction, the right lower abdominal pain occurred. The patient's blood pressure decreased to 53/41mmHg (1mmHg = 0.133kpa), heart rate 118bpm, SpO2 99% (pure oxygen inhalation), and a single intravenous bolus of 4ug norepinephrine was immediately given, followed by a continuous infusion of low-dose norepinephrine using a micropump. Anesthesia induction was administered with midazolam 2mg, etomidate 10mg, sufentanil 20ug, rocuronium 50mg, and methylprednisolone 80mg. The patient was successfully intubated after induction. Since the patient's blood pressure fluctuated between 75-100/50-60mmHg, after tracheal intubation, on the basis of continuous pumping of norepinephrine with a small

dose by a micro pump, intravenous injection of 4ug norepinephrine and intravenous infusion of hydroxyethyl were given intermittently to maintain the hemodynamic stability of the patient. Arterial blood gas analysis showed PH 7.25, $BE^-$7 mmol/L, $HCO3^-$18.7 mmol/L, $K^+$4.4mmol/L, Hb 78g/L, and Glu 6.9 mmol/L. An infusion of 250ml of 5% sodium bicarbonate and 2U of isotype red blood cell suspension was given immediately. Intraoperative anesthesia was maintained only with local anesthesia, and intermittent intravenous injection of midazolam 2mg for sedation, and BIS value was maintained at 40-60. During the operation, the patient's blood pressure could not be maintained and dropped to 53/30mmHg. Norepinephrine 150ug/kg/min was pumping with using a micropump to maintain blood pressure at the level of 90-100/50-60 mmHg.

After the main body of the stent was released and covered the right internal iliac artery, arterial blood gas analysis was performed, and the results showed that PH 7.30, $BE^-$ 5 mmol/L, $HCO_3^-$ 23.1 mmol/l, $K^+$ 4.5mmol/L, Hb 82g/L, Glu 10.2 mmol/L. At this point, 500ml hydroxyethyl, 1000ml lactate Ringer's solution have been infused, the amount of bleeding was about 150ml, and the urine volume is about 50ml. After the left internal iliac artery stent was placed in place, both renal arteries were well developed. Arterial blood gas analysis showed that PH 7.32, $Ca^{2+}$ 2.02mmol /L, $K^+$ 4.6mmol /L, Hb 85g/L, $BE^-$ 3mmol/L. Calcium gluconate 2g was given. Heparin 2500u was given for anticoagulation. The operation lasted for 2 hours and 23 minutes. The bleeding was about 200ml-250ml. A total of 2000ml of fluid, 7.5U of red suspension, 250ml of 5% sodium bicarbonate, calcium gluconate 2g, urination >100ml. Blood pressure and heart rate gradually stabilized, oxygen saturation maintained at 99-100%, and the patient was returned to ICU with catheter after surgery. After 5 days of treatment, the patient was transferred back to vascular surgery. After receiving anti-inflammatory, atomizing, nourishing myocardium, antiplatelet, antihypertensive and hypoglycemic supportive treatment, the patient recovered and was rehabilitation discharged 8 days later (Figure 2).

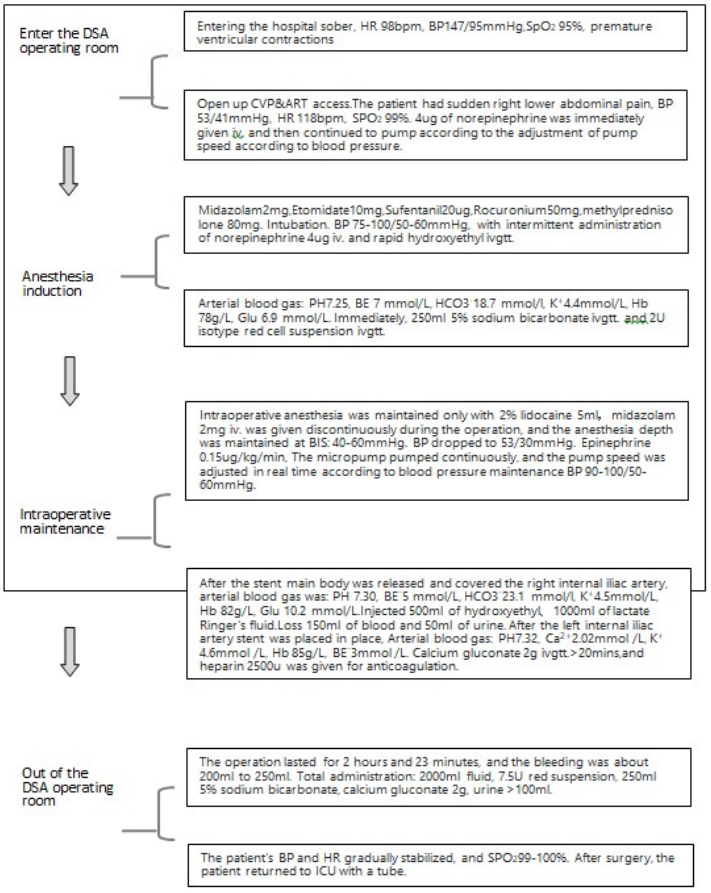


**Figure 2:** The anesthetic procedures used for the EVAR surgery. DSA= Digital subtraction Angiography; CVP=Central Venous Pressure; ART=Arterial blood pressure, BIS= Bifrequency index.

### Follow-up and Outcomes

The patient was treated with ERAP in time after admission, and was successfully transferred to ICU for treatment, and then transferred to ward and discharged from hospital. The patient was still alive and living independently after one year of follow-up.

In view of this successful case, we continued to use this anesthesia method to do EVAR in the coming two similar patients B and C, both of them were successfully rescued and had a good outcome. (Figure 3)

| | Patient B | Patient C |
|---|---|---|
| AGE | 68 years old | 71 years old |
| Gender | male | male |
| History of present illness | 06:00:sudden lower abdominal discomfort: paroxysmal colic, pain and discomfort intermittently occurred, accompanied by more than 10 times of diarrhea, chest tightness and shortness of breath. 16:00 :"abdominal pain and diarrhea of abdominal aortic aneurysm unknown",Admission to hospital | Abdominal aortic aneurysm was found during physical examination in another hospital 2 months ago. She had felt abdominal fluctuations for many years, accompanied by cough and expectoration,The patient was admitted to the hospital because of "abdominal aortic aneurysm without mention of rupture" |
| Past medical history | Bilateral abdominal hernia surgery (name and procedure unknown) 2 years ago, chronic obstructive pulmonary disease for 1 year, and history of hyperemia was unknown | History of tachyarrhythmia syndrome, paroxysmal atrial fibrillation, frequent atrial premature beats, sinus arrest, and hepatitis B virus carrier |
| diagnosis | 1, abdominal aortic aneurysm,2, hypertension grade 2 (high risk),3, hematochezia,4, hyperuricemia,5, colitis? 6, chronic obstructive pulmonary disease grade I | The abdominal aortic aneurysm, did not mention breaking up |
| Name of surgery | Endovascular exclusion of abdominal aorta with covered stent and balloon angioplasty of common iliac artery were performed | Endovascular exclusion of abdominal aorta with covered stent, iliac artery stent placement, transcatheter internal iliac artery embolization, and abdominal aortography were performed |
| Methods of anesthesia | General anesthesia was induced by intubation and maintained during local anesthesia. The procedure was the same as the first patient. | |
| Outcome | Discharged after cure | Discharged after cure |

**Figure 3:** The anesthetic procedures used for the 2nd and 3rd patients

## Discussion

It would be reasonable and necessary to consider a combination method of anesthesia for surgery of endovascular abdominal aortic aneurysm repair, due to the approach benefits to increase analgesic effect of LA mode and prevent patient body from moving and vasospasm occlusion caused by patient stress during LA procedure. Besides, it can reduce the adverse reactions of GA drugs on cardiovascular and cerebrovascular systems therefore maintaining intraoperative hemodynamic stability.

The local anesthetic mode is considered to be a better modality of anesthesia [18] compared to GA approach, as it may reduce the risk of cardiac events [19]. After propensity matching, patients under locoregional anesthesia had a lower risk of 30-day postoperative myocardial infarction and pulmonary complications after EVAR surgery [20]. As per-recommendation 67 of the Eu-

ropean Society of Vascular Surgery 2019 guidelines, "local anesthesia should be considered as the anesthetic modality of choice for endovascular repair of ruptured abdominal aortic aneurysm whenever tolerated by the patient" [21]. According to the two-hit hypothesis [22], the first hit occurs when aneurysms rupture, priming the system, and the second hit is caused by hypotension or surgery with the potential to activate an inflammatory cascade that can lead to multisystem organ failure (MSOF). As has been shown to have negative effects on hemodynamics and temperature control, GA appears to cause a second hit. Therefore, LA may reduce the occurrence of the hit in hemodynamically stable patients but shows no obvious benefits in those with early second hit caused by rupture related hypotension. In other words, they are already in the process of MSOF, and LA cannot provide significantly more benefits rather than GA. Consistent with the hypothesis, no significant difference was found in patients with unstable hemodynamics. The findings in all the secondary outcomes showed no significant differences between LA and GA, so there was no sufficient evidence to validate the different prognosis of the two anesthetic options.To get more comprehensive evidence of anesthetic options, studies afterwards should focus on patients with hemodynamic instability and the incidence of postoperative ICU admission and other more severe complications not described in this article.

However, LA also has some disadvantages that may negate some of 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 [23-26]. General anesthesia overcomes most of the MAC-related disadvantage, but it is associated with hypotension, which in turn, may negatively impact on organs' perfusion and patient prognosis [27].

Based on our own experience, the combination method developed in the report is a valuable approach for EVAR of RAAA patients who has multiple basic diseases and should receive complicated surgical procedures.

All patients in the report have heart, lungs and a variety of basic diseases. The first patient was suspected of aneurysm rupture after admission, hemorrhagic shock, blood pressure decreased to 53/41mmHg, and on the verge of life. We chose to use rapid induction of GA with norepinephrine and other vasopressor drugs to ensure sedative and analgesic effects. The use of LA during the operation minimized the amount of GA drugs, therefore it reduced the side-effect of GA drugs on hemodynamics. By using this anesthetic method, the patient can perfectly cooperate with the surgeon in the state of sleep, maintain hemodynamic stability, prevent from body moving due to mono-approach of LA and from low blood pressure caused by GA drugs. The second patient took the same type of anesthesia based on his health situation. For the third one, we had to take the same method as well because of complex surgical procedure. The complex operation took a long time for performance of puncture operation and placement of catheters at multiple venipuncture sites, called Multi-point Windowing, this caused discomfort, painful and body moving of the patient, eventually. All of above negative factors made less effectiveness of analgesics if only using mono approach of local anesthetic, thus it was necessary to add drugs (e.g. in combination with midazolam MAC) for maintenance of anesthesia. Take all together, the rapid induction of general anesthesia and intubation made the patient fall asleep quickly and in the relaxed state. This benefited to conduct effective drugs to dilate blood vessels and to perform puncture operation at the beginning of EVAR surgery. Intraoperative use of lidocaine in combination with midazolam MAC helped to successfully complete the long time operation as 5-6 hours.

## Conclusion

We reported a valuable type of anesthesia for endovascular abdominal aortic aneurysm repair surgery in three RAAA patients, they have multiple underlying diseases including cardiovascular or lung disease, and have to receive complex surgical procedure and long operation time.

The benefits of using the method include: 1) increasing sedation analgesia effect of LA mode and preventing patient body from

moving and vasospasm occlusion caused by patient stress during LA procedure; 2) reducing the adverse reactions of GA drugs on cardiovascular and cerebrovascular systems therefore maintaining intraoperative hemodynamic stability.

Clearly, as the combination anesthesia for EVAR is the most contemporary and evolving clinical problem, there should be several limitations in our case report, such as the small sample size and potential biases e.g. the inclusion and exclusion criteria for the patient selection. This can to some degree be improved by getting an understanding of the merits and limitations of the method.

It is concluded that our method provides a new and valuable anesthetic consideration for emergency endovascular repair surgery, especially for the patients having multiple basic diseases and pre-surgery anxiety, and receiving complex surgical procedure.

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