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CASE STUDY

EFFICACY OF ENDOVASCULAR MANAGEMENT APPROACH OF RUPTURED ABDOMINAL AORTIC ANEURYSM

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ABSTRACT

The abdominal aortic aneurysm can present a serious complication, which is rupture, which is associated with a high mortality rate. As a result, the early surgery of ruptured abdominal aortic aneurysm can provide greater survival for these patients. However, there are two methods to do this fix. This article makes a bibliographical revision, in order to compare the procedures used in this emergency surgery (open and endovascular surgery technique), with the purpose of defining which approach offers greater benefit.

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INTRODUCTION

Abdominal aortic aneurysm (AAA) is a vascular condition that causes permanent dilation of the abdominal aorta, which can lead to death due to aortic rupture. Aortic vascular smooth muscle cell inflammation, apoptosis, angiogenesis, oxidative stress and vascular remodeling are implicated in pathogenesis AAA (Li *et al.*, 2016). AAA is usually defined as the permanent dilation of the aortic abdominal wall beyond the maximum diameter of ≥ 30 mm (Sakalihasan *et al.*, 2005; Moxon *et al.*, 2010). AAA progressive dilatation can lead to rupture of the aorta, which causes bleeding and commonly death. AAA most commonly affect men aged over 65 years (Gillum, 1995), and clinical practice lacks effective treatment other than surgical approaches to repair AAAs (Kniemeyer *et al.*, 2000). Patients who have small AAA (< 55mm), which are at low risk of rupture, are generally monitored through surveillance imaging. Patients with large (≥ 55mm), rapidly growing (> 10mm/year) or symptomatic AAA usually undergo repair by open surgical techniques or endovascular stents. However, postoperative morbidity and mortality are still common (Moxon *et al.*, 2010; The UK small aneurysm trial participants, 1998). The break is a fatal complication of abdominal aortic aneurysm (AAA). An aneurysm is said to be broken when the bleeding is present on the outside wall of the aneurysm. The elective correction of the aneurysm is associated with low rates of morbidity and mortality in appropriately selected patients. However, despite intensive care

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advances and techniques for repair, mortality after correction of ruptured abdominal aortic aneurysm (AAA) remains high (Dillavou *et al*., 2006). The surgical results are better using the correction of aneurysm by endovascular technique (EVAR), however, the placement of aortic endoprosthesis in emergencies presents many challenges. A growing number of institutions have initiated protocols for endovascular repair of ruptured AAA with promising results in small series, but not all institutions are equipped to treat all ruptured AAA using minimally invasive technology. In addition, the transfer of patients with ruptured AAA can be associated with an increased mortality (17 to 19%) compared with those who undergo repair in the institution in which they feature (Mell *et al*., 2014; Brattheim *et al*., 2012).

MATERIALS AND METHODS

The present study is a review of the literature in the databases PubMed, Scopus and Web of Science, using the descriptors "cardiovascular diseases", "abdominal aortic aneurysms", "ruptured aortic aneurysm", "angioplasty", "endoluminal repair", "cardiovascular surgical procedures". We included English, Spanish and Portuguese language articles, published between 2006 and 2016, which portrayed the treatment of the ruptured aneurysm of abdominal aorta.

RESULTS

Anatomy

The aorta is the largest artery in the human body and when surpasses the diaphragm muscle receives the name of Abdominal Aorta, where it emits several branches, forking more distally in the common iliac arteries (Moore, 2007).

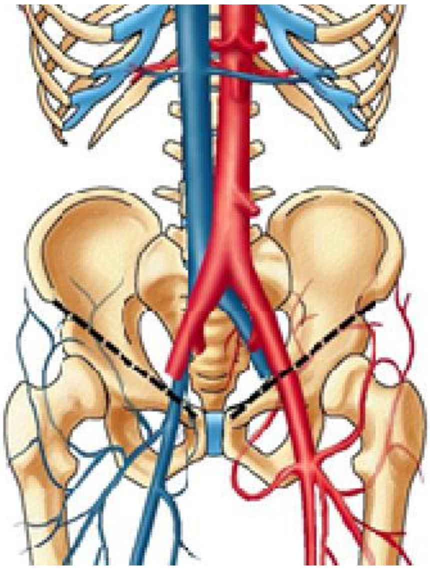

Figure 1. Abdominal aorta if bisecting the common iliac arteries (Moore, 2007)

Definition

Aneurysm means irreversible dilatation limited a vessel or heart wall (Stedman's medical dictionary, 1995). Thus, the aneurysm is a localized dilatation of a blood vessel by more than 50% of its normal diameter (Johnston *et al*., 1991). If also accepts that a vessel is when the cross-section aneurysmal (latero side or anteroposterior) have twice the normal diameter (Svensson and Crawford, 1997). The average growth rate for the small AAA (≤ 5 cm) is 2.6 to 3 mm per year, which increases with the diameter of the aneurysm. AAA expansion studies, as well as factors associated with the expansion, have been limited by the size of the sample or by the limited number of observations in series (Brady *et al*., 2004).

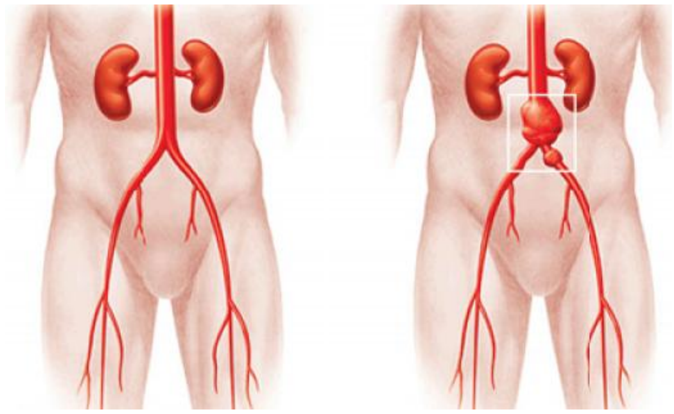

Figure 2. Representing the left abdominal aortic artery without amendment, and the right image with the presence of an aneurysm of the final portion of the abdominal aorta and common iliac artery left (Moore, 2007)

Diagnosis

Most aortic aneurysms are detected so incidental, when the image is made for other purposes or through routine exams. 90% of these aneurysms are below the threshold of intervention at the time of his diagnosis (Timothy Baxter *et al*., 2008). The main challenges in this clinical pathology, include the lack of biomarkers for early diagnosis, as well as effective clinical therapies that can prevent the progression of the disease in its early stage ((Timothy Baxter *et al*., 2008). Currently, significant technological advancements regarding abdominal imaging AAA size and growth have made recordings more accurate and reproducible than ever. According to evidence reported in the literature which has also been implemented in current guidelines, ultrasound may be used as the primary imaging modality for aneurysm screening and follow up and the policy of ultrasonographic surveillance is advised for small asymptomatic AAAs (Kontopodis *et al*., 2016). In order to accurately capture aneurysm size and determine need but also method (*i. e*., open surgery or EVAR) for AAA repair, CT imaging is appropriate additional to US, if an AAA is approaching the size requiring intervention, or if rapid growth is suspected (Kontopodis *et al*., 2016).

Treatment

The treatment of ruptured AAA is urgency, due to its high mortality from hemorrhage and hypovolemic shock. In case of an emergency, and with the objective of offering a greater survival rate to patients, is discussed in the scientific field which procedure to be chosen for the correction of a ruptured AAA (Chang *et al*., 1990). The elective AAA repair is a prophylactic procedure designed to avoid rupture of the aneurysm. Like any therapeutic effort, its success should be measured by the safety of the procedure itself and its long-term effectiveness in preventing breakage (Bollinger and Ruttimann, 2002). The diameter of the aneurysm shows as the most important criterion to consider the disruption as a viable condition. As a result, is the main factor in the decision to recommend repair or just submit the patient to periodic clinical surveillance (Brown and Powell, 1999; Glimaker *et al*., 1991; Scott *et al*., 1998). Several randomized trials have identified the 5cm size limit for the indication of surgical approach open (Kenneth Ouriel, 2009). However, if there was any procedure with morbidity and survival uniforms, all aneurysms would be treated, regardless of their size (Kenneth Ouriel, 2009). Open surgical repair of ruptured AAA is similar to elective AAA repair with technical modifications that reflect the urgency of the patient's clinical presentation and pathophysiology of break (Dillavou, 2015). The incision open surgical correction of the AAA can be performed through the midline abdominal or retroperitoneal left by (Chang *et al*., 1990). For the AAA roto infrarenal, a midline approach is preferred because the right iliac artery exposure becomes better, which is important if an iliac aneurysm is present or there are signs of thromboembolism. In patients who are known to have an ruptured aneurysm justarrenal, a retroperitoneal approach can provide a better exhibition (Chang *et al*., 1990). EVAR and surgical repair of ruptured AAAs have equivalent in-hospital mortality, demonstrated by randomized controlled trials. However, large-scale, nationwide observational studies, and meta-analyses do have shown EVAR to in-hospital mortality and morbidity conference improved in patients with favorable aneurysm morphology stable enough to undergo imaging. Therefore, the current best evidence supports the use of an ' EVAR-first ' policy, while future studies may reveal further subtle outcome differences between EVAR and open repair, which may be magnified by reconfiguration of acute vascular services (Antoniou *et al*., 2015). Endovascular abdominal aortic aneurysm repair (EVAR) has over time become the preferred approach to treating aortic abdominal aneurysms (AAA) when anatomically suitable. One reason for this is that the minimally invasive approach utilizes EVAR that has been associated with reduced perioperative mortality, morbidity, and length of hospital stay (Lederle *et al*., 2012; Stather *et al*., 2013). However, these initial benefits appear to be reduced over time. For example, recent studies have demonstrated increases in reintervention rates post-EVAR and the convergence of mortality rates after 4 years (Greenhalgh *et al*., 2010; De Bruin *et al*., 2010; Becquemin *et al*., 2011; Dangas *et al*., 2012). One explanation for this convergence may be an increase in late aneurysm rupture (Greenhalgh *et al*., 2010; Becquemin *et al*., 2011; Dangas *et al*., 2012). Several anatomical factors must be considered to perform endovascular AAA correction in elective circumstances as well as the AAA roto. Up to 50% of patients with ruptured AAA has no proper Anatomy for correction by endovascular (Ten Bosch *et al*., 2010). In the patient with AAA roto hemodynamically unstable or you have a hostile abdomen (abdominal operations in advance), some of the criteria for endovascular graft placement elective can be put in the background. Endoprosthesis placement can serve as a temporary measure, until the patient is hemodynamically stable, postponing the need for open surgery (Ten Bosch *et al*., 2010; Starnes *et al*., 2010; Veith *et al*., 2009; IMPROVE Trial Investigators, 2014).

Endovascular surgery or open surgery?

In observational studies, the endovascular repair of ruptured AAA is associated with lower rates of mortality, in comparison with the open repair (EVAR: 16-31%; Conventional surgery/open: 34-44%), which may be due to the reduction of bleeding and ischemia (Starnes *et al*., 2010; Veith *et al*., 2009; IMPROVE Trial Investigators, 2014; Thomas *et al*., 2014; Speicher *et al*., 2014; McPhee *et al*., 2009; Chagpar *et al*., 2010; Lesperance *et al*., 2008; Mureebe *et al*., 2008; Davenport *et al*., 2010; Ali *et al*., 2015; Mehta *et al*., 2013). The main criticism of these studies is hemodynamically stable patients with ruptured AAA are routinely selected for EVAR, and hemodynamically unstable patients tend to be treated through open repair (Dubois *et al*., 2015). Some studies have suggested that such bias from patient selection influences the comparison between the procedures, and that the mortality rate for EVAR and open repair for ruptured AAA are really similar (Takagi *et al*., 2008). Foster *et al*. compared studies in patients hemodynamically stable who performed a CT scan to confirm the diagnosis of ruptured AAA. According to the scientific literature, there is criticism of the selection of patients, in which the majority of the tests do not take a specific protocol compliance for groups treated with open surgery or EVAR, limiting the external validity of these studies (Foster *et al*., 2010). However, the largest study, a multicentric cohort in 49 different institutions and 13 countries showed a fall in mortality until 30 days after surgery (mean 19.7% and 36.3% EVAR surgery open; $p < 0.0001$) (Visser *et al*., 2007). Other randomized clinical trials comparing open repair versus EVAR in patients with ruptured AAA were published in recent years (IMPROVE Trial Investigators, 2014; Hinchliffe *et al*., 2006; Reimerink *et al*., 2013). The first was a small study, pilot, in which the authors reported a high mortality rate of 53% for both groups, which led to widespread criticism of the design of the study by the scientific community (Hinchliffe *et al*., 2006) A dutch research has been major, distributing 132 patients randomly between the two types of treatment, and no difference in mortality was found in the postoperative period (30 days) among those who have received versus open repair (EVAR 21% x 25%) (Reimerink *et al*., 2013). It has been suggested that the anatomical suitability for EVAR related to a long-necked aneurysm, can confer a survival advantage, even in patients treated by conventional surgery (IMPROVE Trial Investigators, 2014). Immediate treatment of the patients with rupture, a multicenter study (IMPROVE) held in the United Kingdom and in Canada, sought to determine the optimal management of AAA means roto using a drawing of "reality" (IMPROVE Trial Investigators, 2014). The study randomly distributed 613 patients for which there was a suspected ruptured AAA based on history or clinical examination, but before the final image to open correction surgery or EVAR. Patients assigned to a particular group were designated treatment; due to the death before repair or establishment of an alternative diagnosis, the researchers chose to change the type of treatment or patients have not undergone any therapeutic procedure (IMPROVE Trial Investigators, 2014). No difference in postoperative mortality was observed among selected groups. In a pre-specified subgroup analysis, the perioperative mortality was significantly lower for women assigned to the EVAR in comparison with women designated for open repair (37 x 57%), but this difference was not observed among men. Patients referred for EVAR, received hospital earlier compared to those undergoing conventional surgery (94 x 77%) (IMPROVE Trial Investigators, 2014). The mortality in patients who underwent EVAR, was 25%, compared to 38% of those who underwent open fix (IMPROVE Trial Investigators, 2014). IMPROVE study shows that patients with suspected, but no evidence of ruptured AAA, the open surgical or endovascular are equally valid (Antoniou *et al*., 2013).

Table 1. Mortality Differences - Open surgery x EVAR

Mortality		
Study	Open repair	Endovascular repair (EVAR)
GENERAL (Li *et al*., 2016; Brattheim *et al*., 2012; Brady *et al*., 2004; Timothy Baxter *et al*., 2008; Kontopodis *et al*., 2016; Chang *et al*., 1990; Bollinger and Ruttimann, 2002; Brown and Powell, 1999; Glimaker *et al*., 1991; Scott *et al*., 1998; Kenneth Ouriel, 2009; Dillavou, 2015; Antoniou *et al*., 2015)	34-44%	16-31%
Pilot study (Greenhalgh *et al*., 2010)	53%	53%
Dutch (De Bruin *et al*., 2010)	25%	21%
IMPROVE (Moore, 2007; Timothy Baxter *et al*., 2008; Becquemin *et al*., 2011; Dangas *et al*., 2012; Ten Bosch *et al*., 2010)	Women: 57%	Women: 37%
IMPROVE (Chagpar *et al*., 2010)	38%	25%

Although the mortality rates associated with the correction of the ruptured AAA with open surgery versus endovascular correction can be contested, perioperative morbidity rates have been consistently and significantly lower for EVAR, in comparison with the open repair in randomized trials of elective AAA (Antoniou *et al*., 2013; von Meijenfeldt *et al*., 2014; Lederle *et al*., 2009; Becquemin *et al*., 2011). Extrapolating from these findings, it appears that EVAR would be highly desirable in patients with ruptured AAA who have poor prognosis factors for the open repair. The apparent advantage of EVAR probably relates to its minimally invasive nature, which minimizes the physiological stress and decreases the risk of cardiovascular disease, and pulmonary subsequent renal (Collin and Murie, 2001). Table 1 brings the studies with the proportional differences between mortality rates after each type of procedure performed.

Although attempts have been made to quantify the risk of mortality with AAA roto, no variable or sorting proved reliable to predict such outcome (Tambyraja *et al*., 2008). An assessment in the medium and long term, Han *et al.*, in their meta-analysis compared seven (Acosta *et al*., 2007; Ockert *et al*., 2007; Alsac *et al*., 2005; Anain *et al*., 2007; Visser *et al*., Peppelenbosch *et al*., 2006; Castelli *et al*., 2005) studies with range of 3.6 to 56.2 months about mortality. The authors observe that, when it comes to a longer period of time and given any cause of death, there is no reduction in mortality between the EVAR and open surgery. However, this meta-analysis reveals benefits of EVAR for less blood transfusions (1328mL/EVAR and 2809mL/open surgery), less surgical time, reduced need for care in the intensive care unit (average reduction of 2.34 days) and reduced mortality (25.7% and 39.6%/EVAR/open surgery), in this case, the 30 first days post-op (Han *et al.,* 2013). The complications of surgery to repair ruptured AAA are similar to those of the elective procedure, but there is a higher incidence of complications such as myocardial infarction, respiratory failure and acute kidney injury compared to the elective AAA repair (Mehta *et al*., 2006). Prolonged surgical time, increased blood loss, largest fluid replacement and intraoperative hypotension are predictive of postoperative intestinal ischemia, which has a mortality rate of nearly 60% in patients undergoing open repair of ruptured AAA (Cho *et al*., 2008). In a small review, 22% of the patients had some degree of colonic ischemia after repair of ruptured AAA (Tøttrup *et al*., 2013). The conversion of EVAR for open repair is unusual in elective AAA repair and, as yet, undefined with the AAA roto. Conversion of EVAR for open repair is generally associated with higher rates of mortality in comparison with the open repair. There are no studies on this aspect in relation to AAA roto. In a study of elective early conversion EVAR for open surgery was associated with a mortality rate of 12.4% (Moulakakis *et al*., 2010), which contrasts with the mortality of approximately 3% for the initial AAA repair (Dillavou *et al*., 2006). Currently, the 5,5cm criterion is a well-respected threshold to set the indication for elective AAA repair, which is widely used to determine therapeutic management of these patients. Nevertheless, and despite the fact that currently SVS recommendations require 3D reconstruction in order to record maximum diameter in a plane perpendicular to the centerline of flow, diameters measured in this way have not previously been used in the landmark studies and therefore may not be absolutely and correctly correlated with current treatment indications (Kontopodis *et al*., 2016). The addition of ILT status into the estimation of possible rupture risk seems applicable and needs further investigation. Moreover, rapid advancements in medical imaging and post-processing and computational analysis have given access to several parameters that may influence AAA rupture risk. Hopefully, the pinpoint comparison of wall stress and strength throughout the aneurysmal surface will soon become possible and widely available which then will make the 5.5-cm diameter criterion obsolete or outdated (Kontopodis *et al*., 2016; Johnston, 1994; Gupta *et al*., 2014; Karkos *et al*., 2014).

Mortality

Despite improvements in pre-hospital care, anesthesia, and cardiovascular intensive care, postoperative mortality after correction of ruptured AAA remains about 40 to 50% (Chagpar *et al*., 2010). Factors that worsen survival during the open surgical repair of the aorta ruptured AAA supraceliac include procedure more than 30 minutes, blood volume administered greater than 3500mL, intraoperative diuresis less than 200 mL, thrombosis of other vascular beds and intraoperative hypotension (Johnston *et al*., 1994). The EVAR has the potential to minimize these variables and complications can improve survival after rupture of AAA, but this has not been definitely established. In a review, the open surgery was an independent risk of postoperative death (30 days) compared with endovascular treatment for hemodynamically unstable patients and patients hemodynamically stable (Gupta *et al*., 2014), as shown in Table 2.

Table 2. Factors that raise mortality

Postoperative intestinal ischemia;
Extended surgery time (> 30 min);
Increased blood loss;
Increased fluid Administration (> 3500mL);
Intraoperative hypotension;
Early conversion of EVAR to open;
Intraoperative < 200 mL urine output;
Thrombosis of other vascular beds;
Open surgery.

The complications inherent to the EVAR should not be cast aside. Among them, the abdominal compartment syndrome

(ACS), which in the postoperative period open repair of ruptured AAA is a documented cause of multiple organ dysfunction, contributes significantly to the increased mortality of these patients. Some authors claim that the numbers of ACS in endovascular therapy would be even higher, because there is no possibility to drain the retroperitoneal hematoma formed by the AAA. A systematic review and meta-analysis done by Karkos *et al*. involving 39 studies reported the incidence of ACS after repair of ruptured AAA endovascular approximately 8%, but that could reach 20% if elevate the sensitivity of the diagnosis and postoperative monitoring. This data corroborates with the fact that most long-term studies find no difference in mortality between the two roads, even with the possible benefits have spoken of EVAR (Karkos *et al*., 2014). Among other factors, the delay in definitive treatment is one of the main causes of poor prognosis involved to establish the endovascular therapy as first choice. Some studies show that among patients treated 40 to 50% of the deaths occurred in the first 2h of arrival at hospital (Boyle *et al*., 2005). Whereas the average time spent for perform the scan is 20 minutes, the need of this examination for applying the technique would delay treatment and would increase the chances that a patient present hemodynamic instability. Slater *et al*. showed that 50% of patients undergoing CT scan study were inadequate for EVAR (Slater *et al*., 2008; Livesay and Talledo, 2013). The cost benefit of the institution of EVAR as first choice is also relevant. There needs to be a vascular team availability of readiness and organized, besides the preparation for immediate conversion into open surgery if necessary. In addition to equipment such as CT with quick succession, high-resolution video, image by fluoroscopy and intravascular ultrasound. The stock of endovascular products should be well stocked, with a range of different sizes to meet the various anatomical standards (Livesay and Talledo, 2013). Reimerink *et al*. still found that the main factor involved in the survival of patients with ruptured AAA is a systematic execution of care, regardless of the surgical route chosen. In the long term (5 years) survival after repair of ruptured AAA is 53 to 64%, in contrast to survival rates after elective repair, ranging 74-69% (Johnston, 1994). Factors associated with lower long-term survival include advanced age, renal dysfunction, respiratory failure and myocardial infarction (Johnston, 1994).

Conclusion

There are three important features of AAA that lend themselves to medical treatment: cheap and accurate methods for detecting, long period of surveillance before the intervention and the life expectancy of the population affected. As a result, through the awareness of the population and the availability of an efficient screening, you can raise the detection of aneurysm in next decade (Timothy Baxter *et al*., 2008). The current standard treatment for small AAA's "watchful waiting". Because of this, the provision of a relatively benign and effective medical therapy for these patients, can bring improvements in quality of life, through the identification of a potentially fatal condition, whose immediate treatment is not yet established (Timothy Baxter *et al*., 2008). Significant differences in the mortality rates of open surgery compared to the endovascular treatment of ruptured aneurysm, have not been demonstrated definitively. There is still some suggestive evidence that during the postoperative period (30 days), the results of the endovascular approach (EVAR) ruptured AAA can be better than open repair of AAA (Ten Bosch *et al*., 2010; Starnes *et al*., 2010; IMPROVE Trial Investigators, 2014; IMPROVE Trial, 2009; Ricotta *et al*., 2010; Coppi *et al*., 2009; Mohan and Hamblin, 2014). As a result, in cases where there are multiple risk factors and a poor prognosis with regard to the open technique, as well as a proper anatomy for the endovascular procedure, we suggest an attempt to EVAR, since the hospital service has experienced staff and appropriate equipment available.

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