Korean J Thorac Cardiovasc Surg 2015;48:1-6 □ Review □
ISSN: 2233-601X (Print) ISSN: 2093-6516 (Online) http://dx.doi.org/10.5090/kjtcs.2015.48.1.1

General Considerations of Ruptured Abdominal Aortic Aneurysm: Ruptured Abdominal Aortic Aneurysm

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Although development of surgical technique and critical care, ruptured abdominal aortic aneurysm still carries a high mortality. In order to obtain good results, various efforts have been attempted. This paper reviews initial management of ruptured abdominal aortic aneurysm and discuss the key point open surgical repair and endovascular aneurysm repair.

Key words: 1. Aorta
2. Aneurysm, abdominal
3. Aneurysm
4. Rupture

INTRODUCTION

Due to developments in surgical technique and critical care, the mortality rate of elective abdominal aortic aneurysm repair has been greatly improved. However, Cooley and DeBakey's early presentation of surgical treatments for ruptured abdominal aortic aneurysms (rAAA) noted a 50% survival rate [1], which has proven difficult to improve over six decades of subsequent effort [2-4].

Endovascular aneurysm repair (EVAR) has the advantage of having relatively low perioperative mortality and morbidity compared to open surgical repair (OSR) [5-7], and consequently, patients increasingly undergo EVAR for rAAA [8]. Nevertheless, OSR still plays an important role in the treatment of rAAA due to the anatomical and institutional limitations of EVAR. In this article, we review strategies for the initial management of rAAA in order to reduce perioperative mortality and morbidity and discuss key features of OSR and EVAR.

INITIAL MANAGEMENT

Preoperative hemodynamic stability is directly associated with the patient's mortality [9-11], and preoperative shock is the most serious risk factor affecting survival after rAAA. For this reason, it is important to stabilize the patient's blood pressure. However, aggressive fluid resuscitation before achieving control of the proximal aorta can lead to further hemorrhaging, which may result in an increased risk of mortality [11]. Thus, the primary goal in the initial management of patients with rAAA is achieving hemodynamic stability to allow perfusion of the vital organs. This is the concept underlying permissive hypotension [12]. This usually involves maintaining a systolic blood pressure of 70 to 80 mmHg, and avoiding aggressive resuscitation to pressures higher than 100 mmHg [13]. Dick et al. [14] report that aggressive volume resuscitation of patients with rAAA before proximal aortic control resulted in an increased perioperative risk of death in-

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Received: July 1, 2014, Revised: July 7, 2014, Accepted: July 7, 2014, Published online: February 5, 2015
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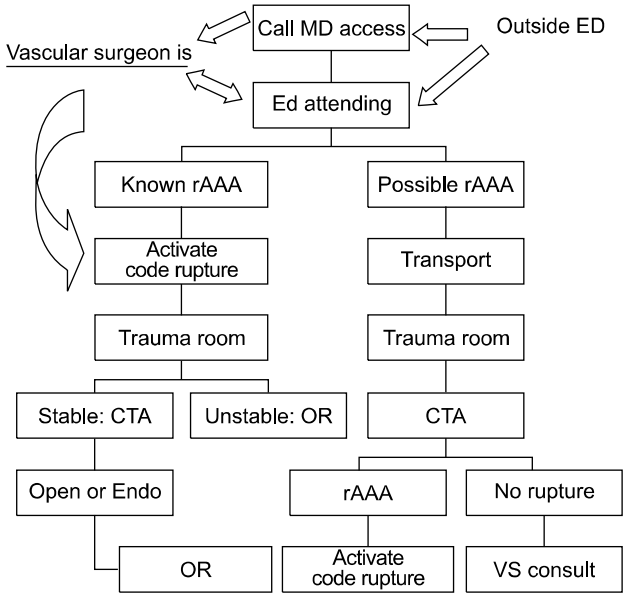

Fig. 1. Fast-track algorithm for the care of patients with ruptured abdominal aorta aneurysm (rAAA) presenting to UMass Memorial or an outside ED. MD, medicinae doctor; ED, emergency department; CTA, computed tomographic angiography; OR, operating room.

dependent of systolic blood pressure. Therefore, volume resuscitation should be delayed until surgical control of bleeding is achieved.

The treatment of a patient with rAAA requires a cooperative relationship between multidisciplinary specialties to ensure a timely diagnosis, appropriate preoperative and perioperative support, efficient aneurysm repair, and excellent postoperative care. Thus, specific protocols for patients with rAAA are useful, such as the fast-track algorithm for the care of patients with rAAA used in the UMass Memorial Healthcare System (Fig. 1) [15] or the standardized protocol for the use of EVAR to treat rAAA by the Vascular Group in Albany, New York, USA (Fig. 2) [16].

OPEN SURGICAL MANAGEMENT

Coordination between the surgeon, anesthesiologist, and scrub nurse is important for the successful operation. There are two ways to approach the abdominal aorta: the transperitoneal approach through a median laparotomy and the retroperitoneal approach. The transperitoneal approach is generally preferred because it enables the surgeon to examine the intra-abdominal organs and perform quick supraceliac clamping [17-19]. On the other hand, some investigators advocate the retroperitoneal approach, as it is associated with less intraoperative hypotension and lower mortality than the transperitoneal approach [20,21]. The most important factor in choosing the incision path is the familiarity of the surgeon with each method.

The most important step in surgery on a patient with rAAA is the rapid, safe, and effective control of the proximal aorta with a consequent reduction of blood loss. After aortic clamping takes place, the anesthesia team should replace blood loss more aggressively. Several options exist for establishing control of the aorta. Supraceliac control has the advantage of allowing the quick and safe control of the aorta in a bloodless field. However, it has the disadvantage of inflicting an ischemic injury on a visceral organ, which can lead to further visceral injuries through hemorrhagic shock, which in turn may ultimately contribute to the development of multisystem organ failure [18,22]. In addition, supraceliac control can increase the cardiac afterload and promote myocardial ischemia [23]. Another method for aortic control is balloon occlusion. Proximal control of the aorta can be carried out by placing a balloon in the proximal aorta without supraceliac exposure. An occlusion balloon can be inserted directly through the aorta or with fluoroscopic guidance through femoral or brachial artery [15].

Although it is controversial, heparin should be administered as soon as aortic clamp control is established [24]. Due to the risk of coagulation disorders, dissections should be minimized to reduce injury to blood vessels and other structures. The patient should be kept warm because hypothermia can lead to surgical bleeding and adverse cardiac events [15]. Use of red blood cell saver during surgery has been proven to reduce blood-product use in rAAA surgery [25].

ENDOVASCULAR MANAGEMENT

The first successful endovascular repair of a rAAA was performed in 1994 by Marin et al. [26]. Since EVAR has some theoretical advantages over OSR, it has been increasingly used to treat rAAA. It is less invasive, avoids damage to periaortic and abdominal structures, reduces bleeding from

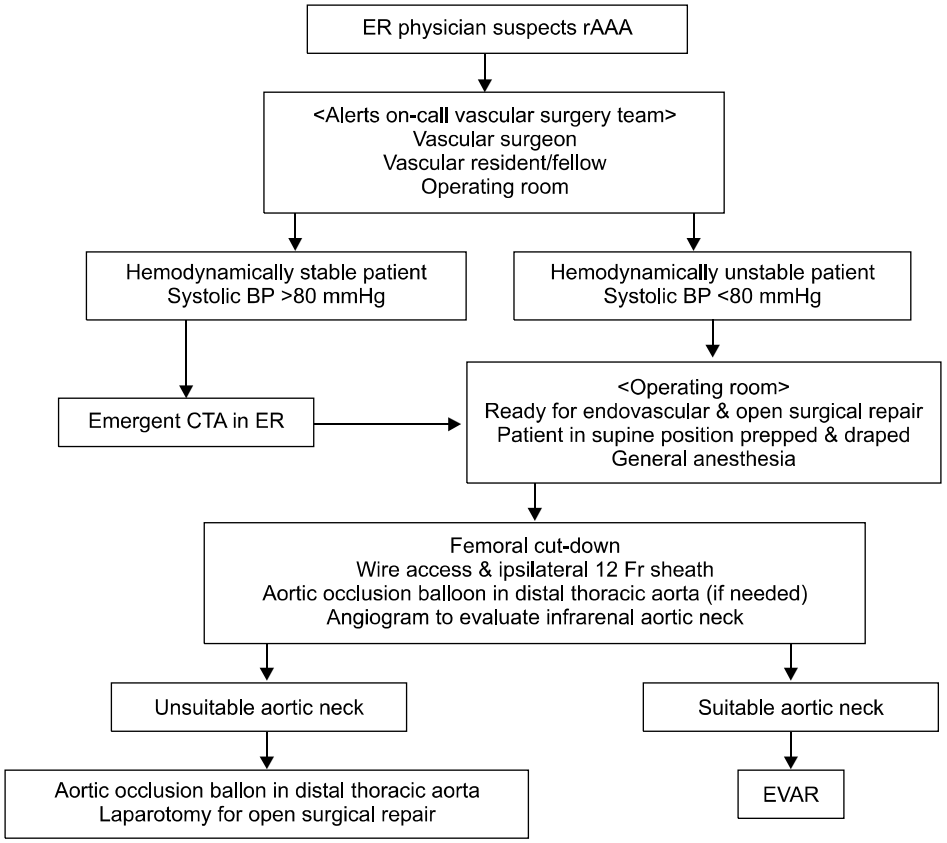

Fig. 2. The vascular group standardized protocol for EVAR of ruptured abdominal aortic aneurysms (rAAA). ER, emergency room; BP, blood pressure; CTA, computed tomography angiography; EVAR, endovascular aneurysm repair.

surgical dissection, minimizes hypothermia, and lessens the requirement for deep anesthesia [27]. Because of these potential advantages combined with reports of lower procedural mortality, EVAR has been regarded as superior to OSR for the treatment of rAAA [28-32].

When performing EVAR on a patient with rAAA, the surgeon needs to consider different factors than when performing elective EVAR, namely: the use of an aortic occlusion balloon, possible conversion to an aortouniiliac implant, and the possible occurrence of abdominal compartment syndrome (ACS).

An aortic occlusion balloon is generally used only when severe hemodynamic instability occurs. There are two ways to approach the proximal aorta in such cases: the femoral approach and the brachial approach. Mehta et al. [33] have been preferred to use the femoral approach because of the following advantages. First, it allows the anesthesia team to have access to both upper extremities for arterial and venous access. Second, the patients who require aortic occlusion balloons are often hypotensive and, in these patients, percutaneous brachial access can be difficult and more time consuming than femoral cutdown. Finally, currently available aortic occlusion balloons require at least a 12 Fr sheath, which requires a brachial artery cutdown and repair, and stiff wires and catheters across the aortic arch without earlier imaging under emergency circumstances might lead to other arterial injuries and/or embolization causing stroke.

It is necessary to pay close attention to ensure that the aortic occlusion balloon is not trapped between the stent graft and the aortic neck while deploying the main body of the stent graft. If a hemodynamically unstable situation persists, the aortic occlusion balloon can be repositioned into the aortic neck from the side ipsilateral to the main body of the stent graft and reinflated at the infrarenal aorta within the main body of the stent graft [16].

If a bifurcated stent graft is used, bleeding is possible until distal fixation is carried out after cannulation of the contralateral gate. Thus, an aortouniiliac implant and femoro-femoral bypass can be considered in the situation of hemodynami-

cally unstable patients or when it is difficult to access the contralateral iliac artery due to stenosis, occlusion, or tortuosity [34].

ACS is the major cause of morbidity and mortality after EVAR performed to treat rAAA [24]. Several factors contribute to the occurrence of ACS after EVAR in patients with rAAA. Retroperitoneal hematomas are lesions that occupy a significant amount of space in the abdomen and are a significant factor contributing to intra-abdominal hypertension. Persistent bleeding from the lumbar and inferior mesenteric arteries into the ruptured aneurysm sac in the situation of severe coagulopathy might also contribute to the development of ACS [35]. Moreover, the state of shock involved in rAAA is associated with alterations in microvascular permeability that can lead to visceral and soft tissue edema. Monitoring of bladder pressure is helpful for the early detection of ACS [29,32]. Laparotomy and open abdomen treatment are needed to relieve the hypotension, high pulmonary compliance, and oliguria that occur in serious cases of ACS [24].

OPEN SURGICAL REPAIR COMPARED TO ENDOVASCULAR ANEURYSM REPAIR

Three randomized controlled trials have compared OSR and EVAR in the treatment of patients with rAAA. Hinchliffe et al. [36] observed 32 patients with rAAA, finding a 30-day mortality rate of 53% in the EVAR group and 53% in the OSR group. Moderate or severe operative complications occurred in 77% of the patients in the EVAR group and in 80% of the patients in the OSR group. The median total hospital stay in the EVAR group was 10 days, compared to 12 days in the OSR group. Reimerink et al. [37] randomized 116 patients with rAAA to treatment with either OSR or EVAR. The combined rate of death and severe complications at 30 days post-surgery was 42% in the EVAR group versus 47% in the OSR group. The 30-day mortality was 21% among the patients assigned to EVAR compared to 25% among the patients assigned to OSR in this study. In the IMPROVE (Immediate Management of the Patient with Rupture: Open Versus Endovascular repair) trial [38], 613 patients were prospectively recruited. The 30-day mortality rate was 35.4% (112/316) in the EVAR group and 37.4% (111/297) in the OSR group. The 30-day mortality rate among patients with confirmed ruptures was 36.4% (100/275) in the EVAR group and 40.6% (106/261) in the OSR group. Although these trials had some limitations due to the relatively small number of patients who were recruited, no significant differences were found between EVAR and OSR regarding either the mortality rate or the complication rate.

Van Beek et al. [39] performed a meta-analysis of 3,769 studies assessing short-term survival rates in patients with rAAA. They concluded that EVAR and OSR have comparable outcomes in patients with rAAA, which supports using EVAR in suitable patients while reserving OSR as an alternative strategy.

CONCLUSION

Most patients with rAAA die before they can be operated upon [40]. Furthermore, surgery for rAAA has a high mortality rate. After decades of marginal improvements in OSR survival rates, a paradigm shift has occurred. Endovascular techniques, advances in perioperative management, and centralization of services have improved outcomes, with substantial reductions in mortality in some regions [41-43].

One study has reported a mean of 8.5 quality-adjusted life years for hospital survivors of rAAA surgery [38]. No difference was observed in the quality of life of rAAA patients who had major postoperative complications compared to those who did not. Therefore, patients who survive rAAA repair have an acceptable quality of life, which suggests that a continued aggressive approach to repair is indicated [44].

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENTS

This work was supported by clinical research grant from Pusan National University Hospital 2014.

REFERENCES

1. Cooley DA, Debakey ME. *Ruptured aneurysms of abdominal aorta; excision and homograft replacement.* Postgrad Med 1954;16:334-42.
2. Bown MJ, Sutton AJ, Bell PR, Sayers RD. *A meta-analysis of 50 years of ruptured abdominal aortic aneurysm repair.* Br J Surg 2002;89:714-30.
3. Hoornweg LL, Storm-Versloot MN, Ubbink DT, Koelemay MJ, Legemate DA, Balm R. *Meta analysis on mortality of ruptured abdominal aortic aneurysms.* Eur J Vasc Endovasc Surg 2008;35:558-70.
4. Dillavou ED, Muluk SC, Makaroun MS. *A decade of change in abdominal aortic aneurysm repair in the United States: have we improved outcomes equally between men and women?* J Vasc Surg 2006;43:230-8.
5. Greenhalgh RM, Brown LC, Kwong GP, Powell JT, Thompson SG; EVAR trial participants. *Comparison of endovascular aneurysm repair with open repair in patients with abdominal aortic aneurysm (EVAR trial 1), 30-day operative mortality results: randomised controlled trial.* Lancet 2004;364:843-8.
6. Prinssen M, Verhoeven EL, Buth J, et al. *A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms.* N Engl J Med 2004;351:1607-18.
7. Lederle FA, Freischlag JA, Kyriakides TC, et al. *Outcomes following endovascular vs open repair of abdominal aortic aneurysm: a randomized trial.* JAMA 2009;302:1535-42.
8. Lesperance K, Andersen C, Singh N, Starnes B, Martin MJ. *Expanding use of emergency endovascular repair for ruptured abdominal aortic aneurysms: disparities in outcomes from a nationwide perspective.* J Vasc Surg 2008;47:1165-70.
9. Samy AK, Murray G, MacBain G. *Glasgow aneurysm score.* Cardiovasc Surg 1994;2:41-4.
10. Visser JJ, Williams M, Kievit J, Bosch JL; 4-A Study Group. *Prediction of 30-day mortality after endovascular repair or open surgery in patients with ruptured abdominal aortic aneurysms.* J Vasc Surg 2009;49:1093-9.
11. Hardman DT, Fisher CM, Patel MI, et al. *Ruptured abdominal aortic aneurysms: who should be offered surgery?* J Vasc Surg 1996;23:123-9.
12. Bickell WH, Wall MJ Jr, Pepe PE, et al. *Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries.* N Engl J Med 1994;331:1105-9.
13. Holt P, J.E, Thmpson M, M. *Abdominal aortic aneurysm, evaluation and decision making.* Rutherford RB Vascular surgery 8th ed. Philadelphia: Elsevier Saunders 2014;2: 1999-2023.
14. Dick F, Erdoes G, Opfermann P, Eberle B, Schmidli J, von Allmen RS. *Delayed volume resuscitation during initial management of ruptured abdominal aortic aneurysm.* J Vasc Surg 2013;57:943-50.
15. Eslami MH, Messina LM. *Ruptured AAA: open surgical management.* Semin Vasc Surg 2010;23:200-5.
16. Mehta M. *Endovascular aneurysm repair for ruptured abdominal aortic aneurysm: the Albany Vascular Group approach.* J Vasc Surg 2010;52:1706-12.
17. Crawford ES. *Ruptured abdominal aortic aneurysm.* J Vasc Surg 1991;13:348-50.
18. Bown MJ, Nicholson ML, Bell PR, Sayers RD. *The systemic inflammatory response syndrome, organ failure, and mortality after abdominal aortic aneurysm repair.* J Vasc Surg 2003;37:600-6.
19. Nguyen AT, de Virgilio C. *Transperitoneal approach should be considered for suspected ruptured abdominal aortic aneurysms.* Ann Vasc Surg 2007;21:129-32.
20. Darling C 3rd, Shah DM, Chang BB, Paty PS, Leather RP. *Current status of the use of retroperitoneal approach for reconstructions of the aorta and its branches.* Ann Surg 1996;224:501-6.
21. Chang BB, Paty PK, Shah DM, Leather RP. *Selective use of retroperitoneal aortic exposure in the emergency treatment of ruptured and symptomatic abdominal aortic aneurysms.* Am J Surg 1988;156:108-10.
22. Lindsay TF, Walker PM, Romaschin A. *Acute pulmonary injury in a model of ruptured abdominal aortic aneurysm.* J Vasc Surg 1995;22:1-8.
23. Wahr JA, Gallagher KP, Tait AR, Hantler CB, Knight PR. *Hemodynamic alterations and regional myocardial blood flow during supraceliac aortic occlusion in dogs with a critical coronary stenosis.* J Cardiothorac Vasc Anesth 1991;5:3-9.
24. Veith FJ, Cayne NS, Berland TL, Mayer D, Lachat M. *Open surgical and endovascular management of ruptured abdominal aortic aneurysm. In: Moore WS, editor. Vascular and endovascular surgery: a comprehensive review.* 8th ed. Philadelphia: Elsevier/Saunders; 2013. p. 685-90.
25. Shantikumar S, Patel S, Handa A. *The role of cell salvage autotransfusion in abdominal aortic aneurysm surgery.* Eur J Vasc Endovasc Surg 2011;42:577-84.
26. Marin ML, Veith FJ, Cynamon J, et al. *Initial experience with transluminally placed endovascular grafts for the treatment of complex vascular lesions.* Ann Surg 1995;222:449-65.
27. Veith FJ, Powell JT, Hinchliffe RJ. *Is a randomized trial necessary to determine whether endovascular repair is the preferred management strategy in patients with ruptured abdominal aortic aneurysms?* J Vasc Surg 2010;52:1087-93.
28. Lachat ML, Pfammatter T, Witzke HJ, et al. *Endovascular repair with bifurcated stent-grafts under local anaesthesia to improve outcome of ruptured aortoiliac aneurysms.* Eur J Vasc Endovasc Surg 2002;23:528-36.
29. Hechelhammer L, Lachat ML, Wildermuth S, Bettex D, Mayer D, Pfammatter T. *Midterm outcome of endovascular repair of ruptured abdominal aortic aneurysms.* J Vasc Surg

2005;41:752-7.
30. Coppi G, Silingardi R, Gennai S, Saitta G, Ciardullo AV. *A single-center experience in open and endovascular treatment of hemodynamically unstable and stable patients with ruptured abdominal aortic aneurysms.* J Vasc Surg 2006;44:1140-7.
31. Moore R, Nutley M, Cina CS, Motamedi M, Faris P, Abuznadah W. *Improved survival after introduction of an emergency endovascular therapy protocol for ruptured abdominal aortic aneurysms.* J Vasc Surg 2007;45:443-50.
32. Mayer D, Pfammatter T, Rancic Z, et al. *10 years of emergency endovascular aneurysm repair for ruptured abdominal aortoiliac aneurysms: lessons learned.* Ann Surg 2009;249: 510-5.
33. Mehta M, Taggert J, Darling RC,3rd, et al. *Establishing a protocol for endovascular treatment of ruptured abdominal aortic aneurysms: Outcomes of a prospective analysis.* J Vasc Surg 2006;44:1-8.
34. Katsikas VC, Dalainas I, Martinakis VG, Xiromeritis K. *The role of aortouniiliac devices in the treatment of aneurysmal disease.* Eur Rev Med Pharmacol Sci 2012;16:1061-71.
35. Mehta M, Darling RC,3rd, Roddy SP, et al. *Factors associated with abdominal compartment syndrome complicating endovascular repair of ruptured abdominal aortic aneurysms.* J Vasc Surg 2005;42:1047-51.
36. Hinchliffe RJ, Bruijstens L, MacSweeney ST, Braithwaite BD. *A randomized trial of endovascular and open surgery for ruptured abdominal aortic aneurysm: results of a pilot study and lessons learned for future studies.* Eur J Vasc Endovasc Surg 2006;32:506-13.
37. Reimerink JJ, Hoornweg LL, Vahl AC, et al. *Endovascular repair versus open repair of ruptured abdominal aortic aneurysms: a multicenter randomized controlled trial.* Ann Surg 2013;258:248-56.
38. IMPROVE Trial Investigators, Powell JT, Sweeting MJ, et al. *Endovascular or open repair strategy for ruptured abdominal aortic aneurysm: 30 day outcomes from IMPROVE randomised trial.* BMJ 2014;348:f7661.
39. Van Beek SC, Conijn AP, Koelemay MJ, Balm R. *Editor's choice: endovascular aneurysm repair versus open repair for patients with a ruptured abdominal aortic aneurysm: a systematic review and meta-analysis of short-term survival.* Eur J Vasc Endovasc Surg 2014;47:593-602.
40. Turk KA. *The post-mortem incidence of abdominal aortic aneurysm.* Proc R Soc Med 1965;58(11 Part 1):869-70.
41. Nedeau AE, Pomposelli FB, Hamdan AD, et al. *Endovascular vs open repair for ruptured abdominal aortic aneurysm.* J Vasc Surg 2012;56:15-20.
42. Mehta M, Byrne J. *Abdominal aortic aneurysm ruptured.* In: Rutherford RB, editor. *Vascular surgery.* 8th ed. Philadepphia: Elsevier Saunders; 2014. p. 2062-82.
43. Mehta M, Byrne J, Darling RC 3rd, et al. *Endovascular repair of ruptured infrarenal abdominal aortic aneurysm is associated with lower 30-day mortality and better 5-year survival rates than open surgical repair.* J Vasc Surg 2013;57:368-75.
44. Hill AB, Palerme LP, Brandys T, Lewis R, Steinmetz OK. *Health-related quality of life in survivors of open ruptured abdominal aortic aneurysm repair: a matched, controlled cohort study.* J Vasc Surg 2007;46:223-9.