# INTERVENTIONAL MANAGEMENT OF AORTIC ANEURYSMS

**C. Mohan*, K. M. Rai**, O.P. Mathew****, I. K. Indrajit***, M. Patel***, A Chaturvedi*****
*Professor of Radiology,****Commandant & Director & Senior Consultant (Cardiology), **Professor of Vascular Surgery, ***Associate Professor of Radiology
*Department of Radiodiagnosis, Army Hospital (Research and Referral) Delhi Cantt, New Delhi 110010, India*

***Abstract:*** *Traditional surgical management of aortic aneurysm is associated with high risk f rupture and complications such as distal embolization, aorto-caval fistula, bowel erosion and compression of adjacent structures. Since the introduction of endovascular aneurysmal repair (EVAR) for treatment of aortic aneurysms by J Parodi in 1991, this minimally invasive technique has gained considerable popularity. EVAR has many distinct advantages over surgical techniques. Complete exclusion of the aneurysm sac is the goal of stent-graft placement and the definition of early clinical success. EVAR uses a stent-graft which is an intraluminal device that consists of a supporting framework (currently made of metal such as stainless steel or nitinol) and a synthetic graft material. Pre procedural imaging of potential abdominal aortic aneurysm stent-graft candidates consists of both, contrast enhanced CT and catheter angiography. The technique of EVAR includes introduction of angiography catheter in aorta to obtain an angiogram to assess the final suitability and anatomical landmarks. Care should be taken to position this stent-graft below the renal arteries in case of abdominal aortic aneurysms (AAA). The contralateral limb can be introduced via the opposite femoral artery and docked with the main device. The device is ballooned thereafter to ensure adequate fixation. Post procedure angiograms are performed to confirm the suitable positioning and to detect any endoleak. Endoleaks are classified by its cause and time of occurrence. Although many early endoleaks disappear within 6 months, reappearance of leaks and delayed appearance of new leaks can occur at any time. The follow-up of patients with stent-grafts requires evaluation of aortic aneurysm sac size, perfusion, stent-graft patency, changes in diameter of the vessels at the sites of endograft attachment, changes in stent-graft morphology, and detection of new aneurysms.*
**Key Words :** Aneurysms Endovascular aneurysm repair: Endoleak

## INTRODUCTION

Management of aortic aneurysms remain a challenging problem for surgeon. It is asscociated with high risk of rupture, and complications such as distal embolization, aorto-caval fistula, bowel erosion and compression of adjacent structures. Mortality from rupture is high in aortic aneurysms more than 5 cm in diameter. Conventional treatment consists of replacing the diseased aneurysmatic segment with a tube or bifurcation graft. This major surgical undertaking is associated with 5-10% mortality and 10-20% complication rate even in the best centers in the world.

Juan Parodi of Argentina is generally credited with the first endovascular aneurysm repair (EVAR) in 1991. He used a metallic stent covered with synthetic graft to exclude the aneurysm. This was introduced through a small cut down in the femoral artery in the groin. This was a quantum advance both conceptually and practically. The mortality and morbidity associated with conventional aneurysm repair was drastically reduced. The technology was refined in the ensuing years, and there are at least 5 commercial devices available for EVAR of abdominal aortic aneurysms (AAA), and two for thoracic aortic aneurysms (TAA). This paper outlines the technique of minimally invasive EVAR technique of aortic aneurysm repair.

## DEFINITION AND COURSE

The definition of an abdominal aortic aneurysm is focal enlargement of the abdominal aorta, usually involving the infrarenal portion of the vessel, to more than 50% larger in diameter than the normal aorta or to greater than 3 cm in its largest true transverse dimension[1]. As a rule, even large abdominal aortic aneurysms are asymptomatic until rupture occurs. Prophylactic repair is therefore recommended for aneurysms exceeding -5 cm in diameter[3,4].

## STENT GRAFT

A stent-graft is an intraluminal device that consists of a supporting framework (currently made of metal such as stainless steel or nitinol) and a synthetic graft material. Stent-grafts can be either self-expanding or balloon-expandable, depending on the type of metal in the stent. The stent may be located inside, outside, or within the graft material, and it may be along the entire length of the graft or restricted to the ends. To deliver the stent-graft through a small vascular access, the device is compacted onto a catheter or compressed into a sheath. With the use of imaging guidance, the device is advanced into an appropriate location in the aorta from a remote access site and deployed.

## ENDOVASCULAR REPAIR

The ultimate goal of endovascular repair of abdominal aortic aneurysm with a stent-graft is the same as for surgical repair ie. depressurization of the aneurysm sac to prevent rupture. In the ideal situation, the stent-graft excludes all blood flow from the aneurysm sac allowing its thrombosis. First step is, determination of the appropriate graft size and configuration for an individual patient. Accurate pre procedural imaging and measurements are therefore paramount. Second, the

**Correspondence : Dr. C. Mohan**, M.D.Professor & Senior Adviser Department of Radiodiagnosis, Army Hospital (Research and Referral) Delhi Cantt, New Delhi 110010, India **e-mail** : colcm30@yahoo.com

approximation between the stent-graft and the vessel wall should be good. The ends of the device must push against the inner walls of the vessel with sufficient force to prevent blood from flowing around the device into the abdominal aortic aneurysm. Third, patent branch vessels arising from the aneurysm sac cannot be inspected and occluded directly. Fourth, the skill sets for most of the elements of the procedure, including online interpretation of fluoroscopic images and complex catheter manipulations, are extensions of traditional interventional radiology rather than surgical practice. Lastly, complete exclusion of the aneurysm sac does not occur in all stent-graft procedures, as it does with open surgical repair[5].

## GUIDELINES AND TECHNIQUE

Standard guidelines for EVAR are (a) aneurysm diameter of more than 5 cm, (b) suitable portion of proximal aorta (infrarenal segment of at least 1.5 cm for AAA; aneurysm distal to left subclavian artery for TAA)(case 1), (c) a suitable distal landing zone, (d) aneurysm neck angulation of less than 60 degrees, (e) absence of tapering of the aneurysm neck, (f) limited life expectancy or severe co-morbidities precluding open aneurysm repair.

Technique of EVAR. All procedures should be preferably performed in the Operation Theater (OT), under strict aseptic conditions. After draping and pre-op antibiotics, both femoral arteries should be exposed in the groin via vertical incisions. Brachial artery access can be used. The brachial artery catheterization for intraprocedu ral endovascular diagnosis and intervention aids positioning of the proximal end of the stent device, accurate delineation of the renal artery ostia and avoids an additional angiographic catheter in the access and deployment zone. However, the disadvantages being (a) brachial artery pseudo-aneurysms. (b) Subclavian artery thrombosis and embolization. (c) Cubital fossa haematomas, ecchymosis and puncture-site bleeding. (d) Cerebral events: carotid and vertebral embolization.

Angiography catheter is introduced in aorta and an angiogram taken to assess the final suitability and anatomical landmarks. The aortic Stent graft (Talent, AneuRx, or Excluder) can be negotiated over a stiff (Backup Meier/Amplatz) wire to the desired level and released. Care should be taken to position this stent-graft below the renal arteries in case of AAAs. The contralateral limb can be introduced via the opposite femoral artery and docked with the main device. The device is then ballooned thereafter to ensure adequate fixation. Post procedure angiograms are required to be done to confirm the suitable positioning and to detect any endoleak. Few patients may require coil embolization of one of the internal iliac arteries in addition to the primary procedure. The device sheath and catheters can then be removed and the femoral arteriotomy closed with 6/0 prolene. Groin wounds can then be closed in conventional manner. Patients are monitored in the ICU overnight and discharged to home after 48 hours. Groin sutures are better removed on the 10$^{th}$ day.

Patients can be followed up by careful clinical examination (specifically looking for the pulsatility of the abdominal mass), Color Doppler studies, and CT angiograms at 3 or 6 months, at one year, and once a year thereafter.

## IDEAL CANDIDATES

Several factors determine whether a patient is a suitable candidate for endovascular repair of abdominal aortic aneurysm: patient demographics, the type of aneurysm, and the type of device. The type of abdominal aortic aneurysm most appropriate for stent-graft repair is open to interpretation. In general, simple unruptured atherosclerotic abdominal aortic aneurysms(case 2) that would otherwise qualify for surgical repair (>4.5 cm in diameter) can be considered for stent-graft repair, although a precise size criterion may vary with sex[8]. Finlayson et al suggested that patients with inflammatory abdominal aortic aneurysm respond well to endovascular repair [9].

The dominant limiting factor in patient selection is the stent-graft itself [10]. Each device has specific and relatively restrictive requirements with regard to the diameter, length, and angulation of the proximal and distal attachment sites and to the ability of the iliofemoral arteries to accommodate the stent-graft delivery systems (case 3). Patients who do not fit the device cannot be treated.

The size of the stent-grafts should be 10-20% greater than the outer diameter of the normal vessel at the proposed attachment sites to maximize the chance of an effective seal. In addition, this allows potential enlargement of the attachment site over time[4,11].

Pre procedural imaging of potential abdominal aortic aneurysm stent-graft candidates consists of both CT and catheter angiography. Unenhanced abdominal—pelvic helical CT to assess vascular calcification is followed by thin-section (2-3 mm) helical CT angiography from the celiac artery to at least the iliac artery bifurcations, but preferably to the groins. Diameter measurements (outer wall-to-outer wall) are obtained from the contrast-enhanced axial sections by either measuring the narrowest dimension, when the vessel appears to be imaged on a bias, or using workstations to create true axial sections. The vessel lumen, particularly at the anticipated attachment sites, is inspected for thrombus, calcification, and atherosclerotic disease. Angiography using a graduated pigtail catheter that has markers over a 20 to 25cm distance is preferred for length measurements. Anteroposterior and lateral views of the aorta, oblique views of the proximal aortic neck, if necessary, and anteroposterior and bilateral oblique views of the pelvis are obtained.

## TEAM WORK

Successful endovascular repair of abdominal aortic aneurysm is a multidisciplinary effort, with contributions from several specialties. The degree of participation from each discipline will vary from one institution to another. The following

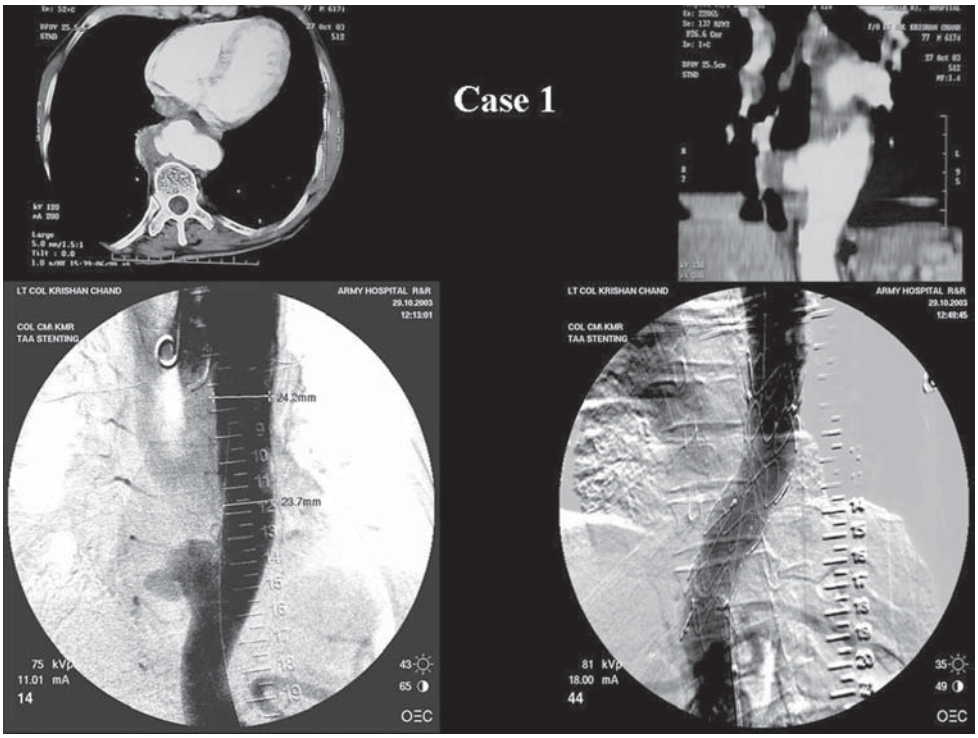


*Figure 1 : Case 1(Clockwise)* ***1(a)&(b)*** *Contrast enhanced CT scan shows a saccular aneurysm involving lower thoracic aorta.* ***1(c)*** *Digital Subtraction angiography outlines an irregular saccular aneurysm.* ***1(d)*** *DSA after successful exclusion of the aneurysm by inserted stent graft*

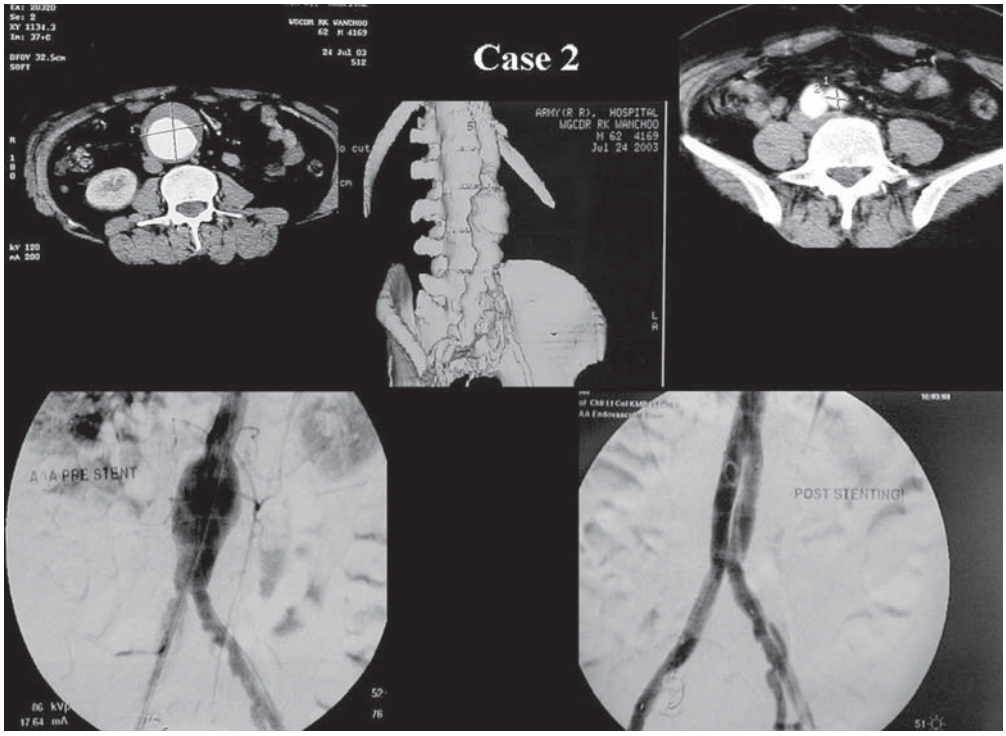


*Figure 2 : Case 2 (Clockwise)* ***2(a,b,c)*** *Contrast enhanced CT scan shows an athersclerotic aneurysm involving infra renal abdominal aorta involving the aortic bifurcation and proximal right common iliac artery.* ***2(d)*** *Digital Subtraction angiography outlines an infrarenal aneurysm.* ***2(e)*** *DSA after successful exclusion of the aneurysm by bifurcated stent graft and a tubular extension*

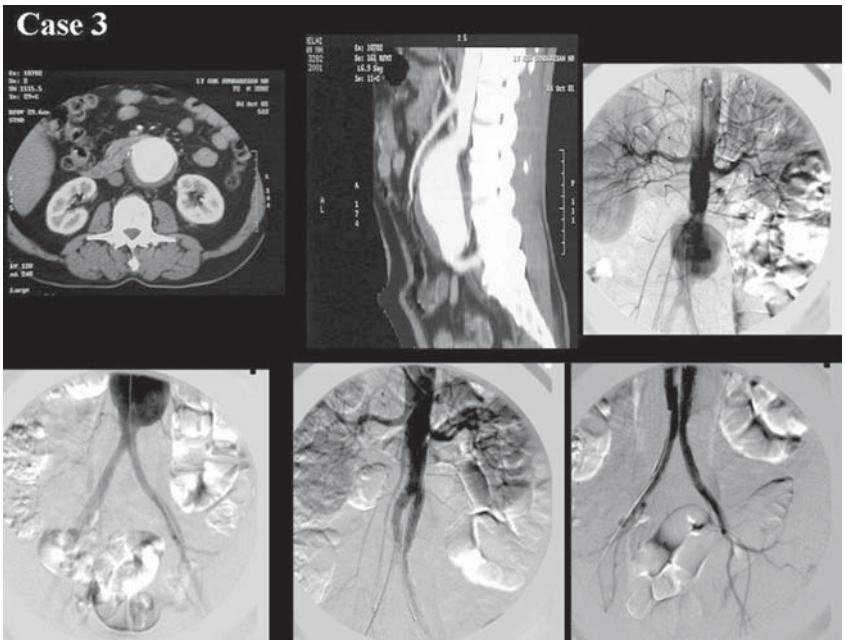


*Figure 3 Case 3(Clockwise)* 3(a,b) *Contrast enhanced CT scan shows a large atherosclerotic aneurysm involving infra renal abdominal aorta involving the aortic bifurcation and tortuous right common iliac artery.* ***3(c,d)*** *Digital Subtraction angiography outlines an infrarenal aneurysm.* ***3(e,f)*** *DSA after successful exclusion of the aneurysm by bifurcated stent graft and a tubular extension*

procedural components are essential: excellent imaging with a 12inch or greater (>30cm) image intensifier, digital subtraction angiography, and the capability to perform aortography (preferably with a power injector) in multiple obliquities; a procedure room that can support open aortic surgery; access to the full range of interventional radiology tools; and a dedicated team who is familiar with the operation of the imaging equipment and the stent-graft delivery system.

## ADVANTAGES

Endovascular repair has a number of advantages over open surgical techniques. The stent graft procedure is less stressful to the patient and results in less blood loss and therefore fewer blood transfusions. If general anesthesia is used, the time to extubation is markedly reduced, stays in the intensive care unit are shorter, and ambulation without assistance occurs earlier. In most cases, patients quickly return to a regular diet, and hospital stay is reduced by two thirds, to about 3.4 days[4,12,13]. The 30-day mortality rate in large stent-graft series ranges from 0.7% in low-risk populations to 15.7% in high-risk patients[14]. Death during a stent-graft procedure is rare. Acute intraprocedural rupture of abdominal aortic aneurysm during stent-graft placement with successful outcome has been reported[15]. Multiorgan system failure, myocardial infarction, bowel infarction, stroke, pulmonary embolism, and peripheral arterial embolism have all been described after stent-graft procedures, but most early complications are minor and consist of injuries to access arteries or issues related to groin incisions[16,17].

## AIMS OF ENDOVASCULAR REPAIR

Complete exclusion of the aneurysm sac is the goal of stent-graft placement and the definition of early clinical success [18]. Persistent opacification of the aneurysm sac after insertion of a stent-graft is termed an "endoleak" and is classified by cause and time of occurrence[19]. Most early endoleaks are currently types II and IV, because type I leaks can be minimized by careful patient selection and preprocedural measurements[20] Although many early endoleaks disappear within 6 months, reappearance of leaks and delayed appearance of new leaks can occur at any time[21].

## COMPLICATIONS

Death during the stent graft procedure is rare, but complications do occur. Delayed rupture of abdominal aortic aneurysm has been a concern. The ultimate goal of stent graft placement is complete exclusion of the aneurysm sac. One criterion for success is the absence of "endoleaks," which are indicated by persistent opacification of the aneurysm sac after insertion of the stent graft. Type I and III endoleaks are risk factors for subsequent rupture although the significance of type II endoleak remains uncertain. However, there is currently little long-term follow-up information about the clinical significance of this type of problem. Therefore, it is unclear whether further intervention is warranted. In addition, more than 50% of endoleaks diagnosed at the time of initial placement of a stent graft resolve spontaneously and need no further intervention[18,20]. Delayed rupture of abdominal aortic aneurysm after endovascular repair is rare but does occur. The presence of a persistent endoleak is clearly a major contributing factor

to delayed rupture.
In addition to aneurysm enlargement or rupture, other late complications of stent-grafts include limb thrombosis, infection, disconnection of modular components, and distortion and fracture of the stent-graft during aneurysm shrinkage[21,22].

## FOLLOW UP

The follow-up of patients with stent-grafts requires evaluation of abdominal aortic aneurysm sac size and perfusion, stent-graft patency, changes in diameter of the vessels at the sites of endograft attachment, changes in stent-graft morphology, and detection of new aneurysms. The imaging requirements are quite different from those after surgical repair of abdominal aortic aneurysm, in which imaging is limited in scope and frequency. The single most useful imaging test that allows rapid assessment of patients with stent-grafts is contrast-enhanced helical CT[23].

## FUTURE-TRENDS

Although endovascular repair of infrarenal abdominal aortic aneurysms is proving to be helpful in carefully selected patients, there is still much we do not know about stent graft repair of abdominal aortic aneurysms. What are the long-term consequences of persistent endoleaks? What improvements can be made to allow more patients to qualify for stent graft placement? Is this means of repair cost-effective? These are just a few of the questions that have not been answered completely.
Stent graft repair of abdominal aortic aneurysms reduces use of hospital resources during and immediately after the procedure. However, the cost is 10 to 20 times higher than that for surgical repair. Imaging studies for follow-up also are costly. Despite these concerns, patient interest and enthusiasm are likely to continue to drive this technology.

## CONCLUSION

Endovascular repair of abdominal aortic aneurysm is a new evolving procedure that is undergoing rapid clinical implementation. As is often the case with new technologies, there is more that we do not know than we do. It is entirely possible that this procedure will undergo major modification as long-term outcomes become known. Even at this early stage, it is evident that a good stent-graft by itself is not enough to make this procedure successful. Persistent perfusion of the aneurysm sac from retrograde flow in branch vessels is a major long-term concern. An additional intervention may be required, such as sac ablation with a thrombogenic substance, to ensure complete depressurization of the aneurysm. Perhaps combined endovascular deployment of the stent-graft with retroperitoneal endoscopic ligation of branch vessels will be required[24].
Patients whose aneurysms begin just below the renal arteries are difficult or impossible to accommodate with current stent-grafts. Experience with the placement of uncovered metal extensions of the stent-graft over the renal artery ostia to obtain a secure proximal seal has been favorable, with no increased incidence of renal dysfunction when compared with infrarenal designs. The development of stent-grafts with side-arms to accommodate critical aortic branches will further increase the applicability of this technology[25].

## REFERENCES


1. Hodges TC, Cronenwett J. Abdominal aortic and iliac artery aneurysms: clinical presentation, natural history, and indications for intervention. In: Perler BA, Becker GJ, eds. Vascular intervention: a clinical approach. New York: Thieme, 1998:339 - 350
2. Dardik A, Burleyson G, Bowman H, et al. Surgical repair of ruptured abdominal aortic aneurysms in the state of Maryland: factors influencing outcome among 527 recent cases. J Vasc Surg 1998;28:413 -421.
3. Hallett JJ, Bower T, Cherry K, Gloviczki P, Joyce J, Pairolero P. Selection and preparation of high-risk patients for repair of abdominal aortic aneurysms. Mayo Clin Proc 1994;69:763 -768.
4. John A. Kaufman, Stuart C. Geller, David C. Brewster, Chieh-Min Fan, Richard P. Cambria, Glenn M. LaMuraglia Endovascular Repair of Abdominal Aortic Aneurysms Current Status and Future Directions AJR 2000; 175:289-302
5. Gorich J, Rilinger N, Sokiranski R, et al. Leakages after endovascular repair of aortic aneurysms: classification based on findings at CT, angiography, and radiography. Radiology 1999;213:767 -772.
6. Dotter C. Transluminally-placed coilspring endarterial tube grafts: long-term patency in a canine politeal artery. Invest Radiol 1969;4:329 -332.
7. Parodi J, Palmaz J, Barone H. Transfemoral intraluminal graft implantation for abdominal aortic aneurysms. Ann Vasc Surg 1991;5:491 -499.
8. Finlayson S. Should endovascular surgery lower the threshold for repair of abdominal aortic aneurysms? J Vasc Surg 1999;29:973 -985.
9. Boyle J, Thompson M, Nasim A, Sayers R, Holmes M, Bell P. Endovascular repair of an inflammatory aortic aneurysm. Eur J Vasc Endovasc Surg 1997;13:328 -329.
10. Armon M, Yusuf S, Latief K, et al. Anatomical suitability of abdominal aortic aneurysms for endovascular repair. Br J Surg 1997;84:178 -180.
11. Sonesson B, Malina M, Ivancev K, Lindh M, Lindblad B, Brunkwall J. Dilatation of the infrarenal aneurysm neck after endovascular exclusion of abdominal aortic aneurysm. J Endovasc Surg 1998;5:195 -200.
12. Zarins C, White R, Schwarten D, et al. AneuRx stent graft versus open surgical repair of abdominal aortic aneurysms: multicenter prospective clinical trial. J Vasc Surg 1999;29:292 -305.
13. Buth J, Laheij R. Early complications and endoleaks after endovascular abdominal aortic aneurysm repair: report of a multicenter study. J Vasc Surg 2000;31:134 -146.
14. May J, Schulze K. Successful completion of endoluminal repair of an abdominal aortic aneurysm after intraoperative iatrogenic rupture of the aneurysm. J Vasc Surg 1999;30:901 -906.
15. Brewster DC, Cronenwett JL, Hallett JW, Jr., Johnston KW, Krupski WC, Matsumura JS et al. Guidelines for the treatment of abdominal aortic aneurysms. Report of a subcommittee of the Joint Council of the American Association for Vascular Surgery and Society for Vascular Surgery. Journal of Vascular Surgery 2003;37(5):1106-1117.
16. Thompson M, Sayers R, Nasim A, Boyle J, Fishwick G, Bell P. Aortomonoiliac endovascular grafting: difficult solutions to difficult aneurysms. J Endovasc Surg 1997;4:174 -181.
17. Ahn S, Rutherford R, Johnston K, et al. Reporting standards for infrarenal endovascular abdominal aortic aneurysm repair. J Vasc Surg 1997;25:405 -410.
18. White G, May J, Waugh R, Chaufour X, Yu W. Type III and type IV endoleak: toward a complete definition of blood flow in the sac after endoluminal abdominal aortic aneurysm repair. J Endovasc Surg 1998;5:305 -309.
19. Becquemin J, Lapie V, Favre J, Rousseau H. Mid-term results of a second generation bifurcated endovascular graft for abdominal aortic aneurysm repair: the French Vanguard trial. J Vasc Surg 1999;30:209 -218.
20. Jacobowitz G, Rosen R, Riles T. The significance and management of the leaking endograft. Semin Vasc Surg 1999;12:199 -206.
21. Maleux G, Rousseau H, Otal P, Colombier D, Glock Y, Joffre F. Modular component separation and reperfusion of abdominal aortic aneurysm sac after endovascular repair of the abdominal aortic aneurysm: a case report. J Vasc Surg 1998;28:349 -352.
22. Harris P, Brennan J, Martin J, et al. Longitudinal aneurysm shrinkage following endovascular aortic aneurysm repair: a source of intermediate and late complications. J Endovasc Surg 1999;6:11 -16.
23. Rozenblit A, Marin M, Veith F, Cynamon J, Wahl S, Bakal C. Endovascular repair of abdominal aortic aneurysm: value of postoperative follow-up with helical CT. AJR 1995;165:1473 -1479.
24. Cerveira J, Cohen J. Laparoscopically assisted abdominal aortic aneurysm repair. Surg Clin North Am 1999;79:541 -550.
    Duda S, Raygrotzki S, Wiskirchen J, et al. Abdominal aortic aneurysms: treatment with juxtarenal placement of covered stent-grafts. Radiology 1998;206:195 -198.