

Endoleaks: Current concepts and treatments - A Narrative Review

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Abstract

Endoleaks are the most common complications following endovascular aneurysm repair. Depending upon their origin, there are five types of endoleaks, types I-V, which can also be classified as direct and indirect endoleaks. Direct endoleaks (type I and III) have higher risk of aneurysm rupture due to rapid sac expansion, and require immediate correction. Indirect endoleaks (type II, IV and V) have a relatively benign course compared to direct endoleaks. Most of them resolve with time and very few need interventions upon sac enlargement. Type V endotension is a special situation where there is sac enlargement despite no demonstrable endoleak. Proper planning and appropriate selection of stent-graft can prevent most of these endoleaks. With improvement in stent-graft technology, the incidence of endoleaks has been reduced. The current narrative review was planned to describe the pathophysiology, risk factors and treatment options for each type of endoleak.

Keywords: Endovascular, Endoleak, Embolisation.

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Introduction

Endovascular aortic aneurysm repair (EVAR) has become the preferred treatment modality for treating aortic aneurysms. Endoleaks are the most common complication following EVAR, and are regarded as treatment failure. They are traditionally divided into five types based on their origin (Table). Type I, or implantation, endoleaks occur at the stent-graft landing sites. These are due to inadequate apposition of stent-graft with arterial wall. Type II, or backflow, endoleaks are due to retrograde filling of the aneurysm cavity from one of the branch vessels. Type III, or junction, endoleaks are due to extravasation of blood at stent-graft component junction points or due to graft fabric tear. Type IV, or porosity, endoleaks are due to porosity of the stent-graft. Type V is a special situation where there is sac enlargement despite no demonstrable endoleak. The limitation of this classification is that it does not shed light on any urgency of treatment. A more practical way to

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Table: Classification of endoleaks.

Type of Endoleak	Description
Type I	Failure to achieve adequate seal Ia- Proximal Landing site Ib- Distal landing site Ic- Common Iliac artery
Type II	Backflow of blood from aortic collaterals into the aneurysm sac Early — Occurring within 30 days of Endovascular aortic aneurysm repair (EVAR) Late — Occurring after 1 year of EVAR Persistent- Present for more than 6 months after EVAR
Type III	Endoleak secondary to structural failure of endograft IIIa — Component separation IIIb — Stent fabric disturbance
Type IV	Related to graft fabric porosity
Type V (Endotension)	Continued high intra-sac pressure following EVAR without evidence of aneurysmal sac perfusion

classify endoleaks is to divide them into 'direct' and 'indirect' endoleaks. Direct endoleaks types I and III transmit direct systemic pressure into the aneurysmal cavity. Due to this direct pressure, there is always risk of rapid aneurysm enlargement and rupture. Therefore, they need immediate repair. Indirect endoleaks increase sac pressure by an indirect way either through small branches or through the graft wall. The sac can increase in size, but at a slower rate than direct endoleaks. They have a relatively benign course as most resolve with time and very few require interventions (Figure-1).

Best way to detect endoleaks

Completion angiogram can detect early types I and III endoleaks. Delayed images can show type II endoleaks. Contrast-enhanced computed tomography (CT) is the gold standard for the detection of endoleaks on subsequent visits. A complete CT study requires a triple-phase CT angiography (CTA), also called an angiogram. Arterial phase images show types I and III endoleaks, images delayed by 2-3 minutes show type II endoleaks, and non-contrast-enhanced images show mural calcium, which might otherwise be misidentified as contrast-enhanced blood, or endoleak.

Duplex ultrasound can also detect an endoleak. It is economical, free of radiation and contrast. Besides detecting the endoleak, it can also provide information on different types of flow and directions in these endoleaks.¹

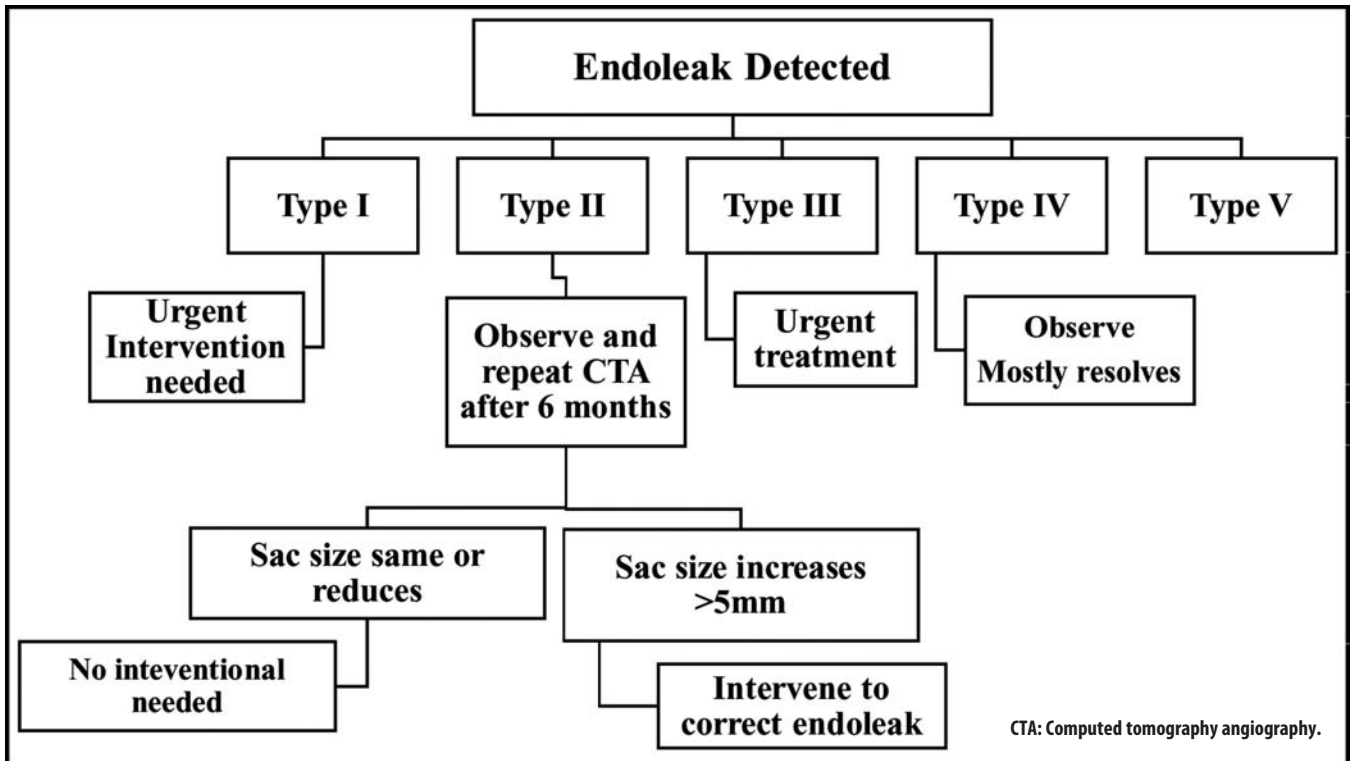


Figure-1: Flow-chart showing timing and approach to different types of endoleaks.

Its limitations are that it is operator-dependent.

Type I implantation endoleaks

Type I endoleaks are due to poor apposition of stent-graft to the arterial wall and occur either at proximal (type Ia) or distal (type Ib) sites. They normally occur when an unfavourable anatomy, such as hostile aortic neck or ectatic iliac artery, is being treated. The persistent flow between the graft and arterial wall increases pressure within the aneurysm. Most type I endoleaks occur 'early'. Due to graft migration or late neck dilation, some patients can develop 'late' type 1 endoleaks.

Early type 1 endoleaks

Short, angulated, heavily calcified infrarenal neck, and neck with thrombus are the risk factors for early type Ia endoleaks. Currently permitted infrarenal stent-grafts mandate minimum neck length of 10-15mm to achieve an adequate seal. Depending on the accuracy of stent-graft placement, a significant length of infrarenal coverage can be lost and this may jeopardise the endograft seal.

Late type I endoleaks

Most cases of late type I endoleaks are those in which stent-graft had been placed outside of instructions for use (IFU) criteria.² The presence of hostile neck anatomy

affects long-term outcome.³ Wide and angulated necks and dilated iliac landing zones have a higher risk of producing late type I endoleaks.⁴ It is essential to position the stent-graft in healthy landing zones at both proximal and distal ends to achieve a good long-term outcome. It may mean outspreading the repair across the visceral arterial segment and/or prolonging the repair beyond the iliac bifurcation, if needed.

Type I endoleak management

There are some adjuncts that can be used to treat type I endoleaks (Figure-2).

a. Intraoperative angioplasty

The first step to treat a proximal type I endoleak is a balloon angioplasty with a semi-compliant balloon, like Coda (Cook) or Reliant (Medtronic), which passes over a stiff wire, such as Lunderqvist (Cook) or Amplants (Cordis). Percutaneous transluminal angioplasty (PTA) will sometimes align the graft better in an angled neck and/or decrease graft infolding and gutters that may arise with graft oversizing. If it is unable to correct type I endoleak, the aortic cuff can be considered to seal this.

b. Cuff placement

The practice for an endograft cuff employment is almost

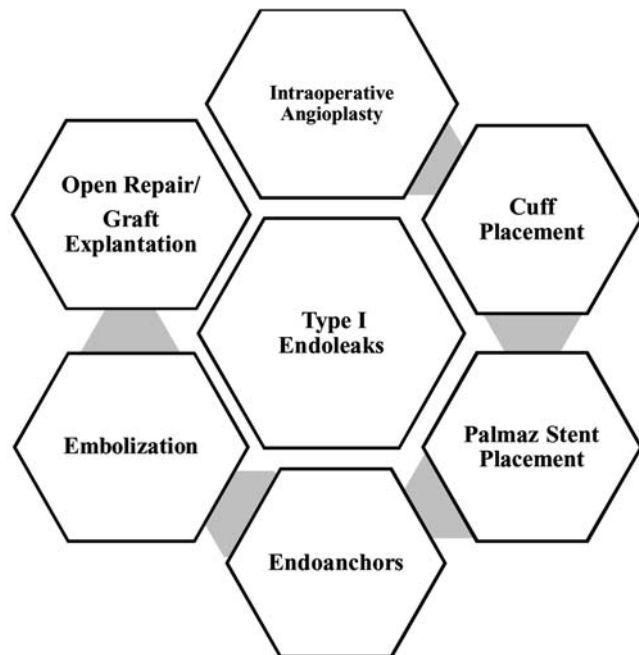


Figure-2: Flow-chart showing different options for treating type 1 endoleaks.

similar to the initial endograft placement. Initial type Ia endoleak treatment is predicted on the position of the endograft to the lowest renal artery. If the distance is <3mm, the seal zone should undergo angioplasty with a compliant moulding balloon. If the distance is >5mm, the initial placement of an aortic cuff is followed by compliant balloon angioplasty.

If type I endoleak is due to insufficient neck length or utilisation of such a neck, proximal cuff extension might not be an appropriate option. The problem can be better solved by Palmaz stent placement.

c. Palmaz stent placement

Various techniques have been described for Palmaz stent placement. One of them is described here:

The first step involves placing a 16F 45cm sheath from the groin with its tip positioned above the renal arteries. The giant Palmaz stent (40-14) is then crimped onto a Coda balloon. By gently dilating the stent with a 14-16F dilator, it is easier to fit it onto the balloon. The mounted stent is passed through sheath while being careful when pushing it through the valve so it does not slip off the balloon. The stent is positioned partially across the renal arteries. Since the nominal size of the stent is 14mm, it will foreshorten significantly when taken up to the size of an endograft. Exactly how much it will shorten is sometimes difficult to determine precisely. The 16F sheath is retracted so that it may cover about 1/3 of the distal end of the stent. The

balloon is then inflated steadily at a slow pace. Inflating or deflating the balloon is done until the stent is fully deployed. A slight cranial pressure is also deployed to mitigate the 'wind sock' effect. When the proximal end of the stent is deployed against the endograft, an assistant is asked to retract the 16F sheath to fully uncover the stent. The balloon can be deflated and repositioned to allow for further moulding of the stent that is sometime necessary.

Comparable results have been noted between the patients undergoing bare metal stent versus those having extension cuff repair.⁵

d. EndoAnchors

The results of Phase I multicentre trial (STAPLE 1) of the Aptus endovascular repair system showed the usefulness of EndoAnchors in EVAR to aid proximal fixation and sealing.⁶ A study also showed effectiveness of EndoAnchors as an adjunct in the treatment of infrarenal abdominal aortic aneurysm (AAA) with short neck, and pararenal AAA.⁷ It demonstrated sealing of type Ia endoleaks in that case series. When selecting EndoAnchors, cost implications of these have to be considered. The cost of EndoAnchors can be as high as the actual EVAR stent-graft.

e. Embolisation

Embolisation in the perigraft space can seal the endoleak in 'selected' cases. This option has been shown to be effective by using various combinations of coils and embolics.⁸⁻¹⁰ The commonly used agents are N-butyl cyano acrylate (NBCA) (Trufill, Cordis, Miami, FL) and Onyx (Plymouth, MN).

f. Other options

If endovascular manoeuvres fail to improve the seal, conventional open surgical repair, banding the neck with soft nylon umbilical tape or a segment of Dacron graft material, fenestrated endovascular aortic aneurysm repair (FEVAR) or leaving the endoleak untreated are some of the options.

Treatment of type Ib endoleak

Ectatic common iliac arteries up to 2cm in diameter are suitable landing zones for the iliac limb of an aortic endograft. However, common iliac arteries >2cm generally necessitate extension of the endograft to the external iliac artery. When extending to the external iliac artery, one should be particularly mindful of oversizing, which can predispose to limb thrombosis or a type Ib endoleak. There is frequently significant iliac tortuosity in these cases, which makes accurate length measurements difficult. When in doubt, a longer limb length should be

chosen for external iliac extension. The internal iliac artery should be embolised prior to extending the limb into the external iliac artery.

Type II endoleaks

Type II endoleaks are due to retrograde filling of the aneurysmal sac from either lumbar, inferior mesenteric, middle sacral, or aberrant renal arteries. These are the most common types of endoleaks with surveillance CT scans showing in 10-20% cases. When managing a patient with type II endoleaks, questions that come to mind are: what is the natural course of these endoleaks?; Which patients are more at risk of developing type II endoleaks?; What can be the strategies to reduce incidences of these endoleaks?; Which of the patients with type II endoleaks need intervention?; What is the best method to deal with 'persistent type II endoleak?

a. Natural course of type 2 endoleaks

Compared to direct endoleaks, type II endoleaks are relatively benign.¹¹ As many as 80% of type 2 endoleaks resolve spontaneously within 6 months of the stent-graft implantation.¹² Those that persist are unlikely to cause aneurysm pressurisation, dilatation or rupture.¹³ There is about 1% of aneurysm rupture reported at 2 years in such cases.¹⁴

b. Risk factors for type II endoleaks

Patients with patent inferior mesenteric artery (IMA) and lumbar arteries (LA) on the pre-operative CTA are more at risk of developing type 2 endoleaks than patients with occluded IMA and LA. Out of the patent arteries, patients with IMA >3mm and lumbar arteries >2mm are more at risk of developing type 2 endoleaks.¹⁵

It is also important to look for the type of aneurysm. Patients with aorto-iliac type aneurysms are more at risk of developing this endoleak than patients with saccular type aneurysms.

c. Prevention of type II endoleaks

Patients with IMA >3mm and LA >2mm can benefit from prophylactic embolisation which has been shown to be effective in reducing the incidence of endoleaks.¹⁶

d. Indication for intervention for type II endoleaks

Most type II endoleaks resolve with time. Persistence of endoleak itself is not an indication for intervention. Indication is warranted in patients where there is aneurysmal sac enlargement >5 mm.^{17,18}

e. Treatment of type 2 endoleaks

Embolisation and occlusion of the feeding arteries is the aim whilst treating patients with type II endoleaks. Embolisation can be done by either transarterial or translumbar route. The sac can be thrombosed by

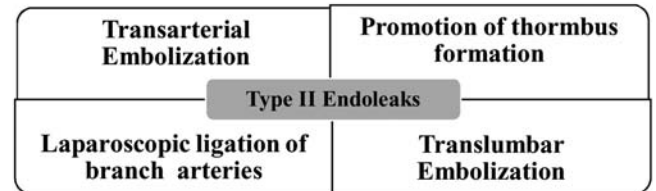


Figure-3: Flow-chart showing options for treating type 2 endoleaks.

injecting various chemicals (Figure-3).

1. Transarterial embolisation

Embolisation of the branches may be performed through a super-selective catheterisation or a translumbar approach. Transarterial embolisation is more likely to succeed when the endoleak cavity is fed through a patent inferior mesenteric artery. It is usually possible to pass a microcatheter through the middle colic branch of the superior mesenteric artery, around the colonic arcade, and through the left colic artery to the inferior mesenteric artery. The reported success rate is 71.4%.¹⁹

2. Translumbar embolisation

If transarterial access fails or is not possible, translumbar access is the alternative.²⁰ Selective catheterisation is performed with coaxial microcatheter systems through which mechanical, liquid, or combined embolic agents can be delivered.^{7,21,22} The average success rate after translumbar embolisation is 81% (range: 67-100%).²³ The target of embolisation should be the nidus and the feeder branches of the endoleak.

3. Promotion of thrombus formation

Aneurysm is lined by thrombus. Promotion of thrombus formation inside the aneurysmal sac is considered another possible method of preventing type 2 endoleak. A study reported coil embolisation, gelform and fibrin glue as useful adjuncts in promoting aneurysmal sac thrombosis.²⁴

f. Treatment for persistent type II endoleaks

If the endoleak persists and the sac continues to grow after 'technically' successful embolisations, or when embolisation is impossible, more invasive approach is required.

Laparoscopic ligation of the feeding lumbar, IMA and other side branches are options.²⁵ Laparotomy and suturing of the side branch ostia within the aneurysmal sac or conversion to open can be offered in extreme cases.

Type III endoleaks

Type III endoleaks are either due to disconnection of stent-graft components or due to fabric tear. These endoleaks are typically treated by the placement of additional stent-graft.

Component overlap between stent-graft limbs as well as between main stent-graft components can readily be seen on plain X-ray films of the abdomen. Often, at times, radio-opaque markers on the device or the skeletal components themselves serve as good landmarks for comparison. Changes in overall stent-graft configuration, like increased limb or body angulations, often give a direct hint that the prosthesis is moving, thus increasing the risk of disconnection and endoleaks.

CT can also be used, but it is more difficult to detect small configurational changes and minor graft dislocation. To do this, reconstructions that highlight only the stent-graft metal components must be used. With modern three-dimensional (3D) workstations, this can be achieved partially or fully automatically. The radiation dose is manifold higher with CT and this should be taken into consideration. CTA is of course very useful for identifying and analysing the endoleak itself.

Both in the peri- and post-operative periods, type III endoleaks are mostly treated by the placement of new stent-graft components in the so-called "relining". This is often quite straightforward as long as total separation has not occurred. In very challenging tortuous anatomy, it is sometime difficult to place additional main components. In such a setting, balloon expandable stent can be used to reinforce junctions if complete dislocation has not occurred.

Type IV endoleaks

Type IV endoleak is due to porosity of stent-graft fabric without any signs of tear or erosion. This usually happens when the graft material is highly porous. Mostly it resolves by itself. This endoleak is typically observed without any intervention. With improved quality of graft fabric, the incidence of these endoleaks has markedly decreased.

Type V endotension endoleaks

Endotension is when there is no demonstrable endoleak, but there is sac expansion. Its exact aetiology is not known. The treatment is exclusion of any endoleak and close surveillance. In case of expanding aneurysm, the

open conversion and explantation is advised which is a major undertaking. The other is a hybrid approach using both endovascular and laparoscopic options. It may include laparoscopic clipping of all lumbar arteries, placement of a Dacron cuff to seal the neck laparoscopically, use of EndoAnchors to help fixate the stent-graft, and introducing a thrombotic agent into the aneurysmal sac to occlude the cavity.

Conclusion

Endoleaks are the most common complications following EVAR. Proper planning and appropriate selection of stent-graft can prevent most of these endoleaks. With improvement in stent-graft technology, the incidence of endoleaks has been reduced.

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