Detachable coil embolization for aneurysms and arteriovenous malformations in the pelvis: technical points, equipment and procedural details

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Learning objectives

1. To summarize the major preferences of embolization techniques using **controlled-release detachable coils** for internal iliac artery (IIA), iliac artery aneurysms (IIAAs) and pelvic arteriovenous malformations (AVMs).

2. To introduce the "**anchoring technique**" using a new complex-shaped Guglielmi detachable coil (**GDC 360°**) to prevent distal migration of coils in the pelvic high-flow AVMs or IIAAs, which is an uncommon technique for intracranial lesions.

Background

Most internal IIAAs are asymptomatic and occur in the context of aortoiliac aneurysm. Isolated IIAAs are rare. The natural course of an IIAA consists of progressive expansion with eventual rupture. Additionally, aneurysm may compression of adjacent structures like iliac veins. And, it is often necessary to embolize IIA before stent-grafting of abdominal aortic aneurysm for the prevention of type II endoleak. Pelvic AVMs are rare congenital lesions and present a difficult diagnostic and therapeutic challenge.

Therapeutic embolization with coils has been performed successfully for more than 35 years since the original description of the Gianturco-Wallace stainless steel coil [1], and a variety of metallic coils can be available now. Most of the coils are deployed by pushing them with a wire or a special wire pusher (**pushable coils**). Other coils have some mechanism with controlled deployment that allows re-position before final release of the coil (**detachable coils**). **The main advantage of detachable coils** is that in case of initial misplacement, they can be retrieved. Detachable coils allow very precise deployment and embolization of different-sized vessels especially in the complicated cases. **Disadvantages** include that the setup takes more time and they are significantly more expensive.

In 1995, the **Food and Drug Administration** (FDA) approved the **Guglielmi detachable coil** (**GDC**, Stryker) [2] for treatment of high-risk or inoperable brain aneurysms in the United States, and the GDC has certainly revolutionized the field of neurointervention. This was the first coil system to allow for easy repositioning and controlled detachment and was also very effective and safe in the obliteration of aneurysms [3]. A variety of techniques and devices have been developed to aid in improving the final result of endovascular coil embolization including the balloon-remodeling technique, stent-assisted coiling and the application of complex coils, with variable results.
The Most Commonly Used Detachable Coils

<table>
<thead>
<tr>
<th>Type</th>
<th>Product name</th>
<th>Manufacturer</th>
<th>Diameter [mm]</th>
<th>Length [mm]</th>
<th>Advantage</th>
<th>Disadvantage</th>
<th>cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Detachable</td>
<td>IDC™</td>
<td>Boston Scientific</td>
<td>2-30</td>
<td>20-200</td>
<td>Nonfibered, platinum coil, 2D-sh amended coil, less expensive.</td>
<td>Many complications during deployment, such as early detach, unraveling, and so on.</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>DETACH-11/18</td>
<td>Cook</td>
<td>2-15</td>
<td>20-300</td>
<td>Nonfibered, platinum coil, many size variations, 2D,3D-shaped coil, less expensive.</td>
<td>Many complications during deployment, such as early detach, unraveling, and so on.</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>Interlock™ Fibered IDC™ Occlusion System</td>
<td>Boston Scientific</td>
<td>2/6-14</td>
<td>23-300</td>
<td>Highly visible due to platinum-tungsten alloy, Easy deployment. Very long coils allow compact packaging with one coil.</td>
<td>May accidentally deploy inside a 0.027-inch or larger lumen catheter. Lock may accidentally engage and retrieve the deployed coils if pushed inside the deployed coils.</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>AZUR™ Peripheral Hydrocoil*</td>
<td>Terumo</td>
<td>2-20</td>
<td>20-200</td>
<td>Hybrid hydrogel-platinum 2D coil and an expandable hydrogel polymer.</td>
<td>Few cases reported in visceral lesions.</td>
<td>++++</td>
</tr>
<tr>
<td>Electrical detachable</td>
<td>GDC™ Detachable Coils</td>
<td>Stryker</td>
<td>2-24</td>
<td>10-400</td>
<td>Nonfibered, extremely soft, platinum coil.</td>
<td>Require more operator experience, elaborate setup for delivery.</td>
<td>++++</td>
</tr>
<tr>
<td></td>
<td>CERECYTE™</td>
<td>Micrus</td>
<td>1.5-20</td>
<td>10-500</td>
<td>Nonfibered, platinum coil, a lot of size/length variations, 2D/3D complex-shaped coil, easy/repeated-repositioning, bioactive coating available.</td>
<td>Same disadvantage in GDC.</td>
<td>++++</td>
</tr>
<tr>
<td>Hydraulic pressure</td>
<td>MICROPLEX™</td>
<td>Micro Vention</td>
<td>2-20</td>
<td>10-600</td>
<td>Complex- or helical-shaped coils, random loop geometry technology, very soft, easy deployment.</td>
<td>Potential for coil motion during release.</td>
<td>++++</td>
</tr>
<tr>
<td>detachable</td>
<td>TRUFLOR DCS ORBIT+</td>
<td>Codman</td>
<td>2-20</td>
<td>15-300</td>
<td>Complex- or helical-shaped coils, random loop geometry technology, very soft, easy deployment.</td>
<td>Potential for coil motion during release.</td>
<td>++++</td>
</tr>
</tbody>
</table>

Fig.: Table 1: The Most Commonly Used Detachable Coils

References: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN

Imaging findings OR Procedure details

A variety of techniques and devices have been developed to aid in improving the final result of coil embolization including the balloon/stent-assisted "remodeling technique" and application of complex-shaped detachable coils.

In this presentation, the complex-shaped detachable coil (GDC-18 360°) or fibered-IDC (Interlocking detachable coil: Interlock™) was selected as the first "anchoring" coil in a high-flow parent artery, followed by more dense packing with additional coils.

1. Coil packing embolization (Schema 1 on page 19)

#Basic embolization technique for coil packing is composed of "framing" and "filling".
# GDC-18 360° (GDC18 coil) frames effectively for the irregular and larger aneurysm.

# The microcatheter tip location is important for coil packing because it is not uncommon for the coil to push back the catheter into the parent vessel, resulting in nontargeted embolization.

# Insert one loop of GDC in to the aneurysm such that the tip of the coil points away from the dome. This prevents the catheter tip from getting wedged against the aneurysm dome when the balloon is inflated and limits of the risk of aneurysm perforation during coil insertion.

# Select the diameter of coil nearly equal to the maximum diameter of aneurysm for "framing" into the aneurysm.

# In the case of the aneurysm of proximal IIA, there is a risk of the coil migration to the external iliac artery and more distal. Particularly in the wide-neck aneurysm, the risk of migration is increased.

# For a very large aneurysm, it is non-efficiency in costs to coil packing intra-aneurysm. In that case, isolation technique is preferable.

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**Coil packing embolization**

- **Object:** Coil packing for simple aneurysms
- **Tips:** Ensure the catheter position is stable and select the appropriate coil size/shape.
- **Advantage:** Preservation of the blood flow of parent artery and distal organs.
- **Demerits:** Coil migration and occlusion of parent artery.
Fig.: Schema 1; Coil packing embolization

References: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN

2. Stent-assisted "remodeling technique" (Schema 2 on page 20)

# This technique is worth considering when the width of the aneurysm neck is approaching 70-80% of the maximum width of the aneurysm or a compliant balloon is insufficient to bridge the aneurysm neck as wide and short neck IIAA.

# In those cases described as above, there is a method to use a stent graft for parent artery. However, it is type II endoleak risk and higher stenosis risk of a parent artery than stenting.

# The stent is deployed across the aneurysm neck, and placing a microcatheter through the stent coils the aneurysm.

# To increase stent stability, parent arteries should be relatively horizontal and straight.

![Stent-assisted “remodeling technique”](image)

- **Object:** Wide-necked, complex-shaped artery bifurcation aneurysms.
- **Tips:** Select an appropriate diameter of stent size.
- **Advantage:** The most effective technique to prevent coil protrusion into the parent artery.
- **Demerits:** Thromboembolic complications might increase and distal flow might be compromised.

Fig.: Schema 2; Stent-assisted "remodeling technique"
Stent-assisted coil embolization for right internal iliac artery aneurysm (IIA)

Case 1:

A 77-year-old male complaining of intermittent claudication due to right common iliac artery stenosis and external iliac artery stenosis with right internal iliac aneurysm (Fig. 1A on page ).

Fig.: Fig. 1A) Right common iliac artery and external iliac artery stenosis with right internal iliac artery aneurysm.

References: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN
A balloon-expandable stent (Express LD, Boston Scientific; 8 mm in diameter and 57 mm in length) was deployed for the treatment of a stenosis of right common/external iliac artery. 4-Fr. cobra type catheter selects right IIA from stent strut. The microcatheter was pushed forward to aneurysm. Embolized by GDC-18 360° (24/40cm, 22/40cm, 22mm/40cm, 18mm/40cm, 16mm/40cm, 16mm/40cm, 16mm/40cm, 18mm/40cm, 18mm/30cm, 18mm/30cm, 16mm/30cm, 18mm/30cm, 18mm/30cm, 16mm/30cm, 18mm/30cm, 16mm/30cm, 18mm/30cm, 18mm/30cm, 16mm/30cm, 18mm/30cm, 18mm/30cm) and GDC-18 2D (9mm/4cm) (Fig. 1B on page 21). After stent-assisted embolization, the stenosis of right common/external artery disappeared immediate after stenting and the huge IIAA was completely sacrificed without any complication. A 1.5-year follow-up CT study demonstrated that there was no aneurysm recanalization.

3. "Anchoring Technique" Using GDC360° and/or Fibered-IDC (Interlock™) (Scherma 3 on page 21)

# A feature technique of GDC is "anchoring technique", which is not so common in the intracranial area.
# GDC360° for the first coil as an "anchor" in a high-flow parent artery, followed by more dense packing with softer coils or fibered detachable coils (Fibered-IDC: Interlock™).

# Strong radial force of complex-shaped GDC360° can achieve the "anchoring" effect in a short segment of the parent vessel. To prevent coil compaction is important to avoid vessel recanalization.

# Select the larger coil diameter as an anchor (1.5 times or more the diameter of targeted vessel). Fibered-IDC (Interlock™; helical shape and long fibered coils variation) can enhance the anchoring performance in a short segment of parent vessel by high thrombogenicity.

# Isolation technique of an aneurysm using fibered IDC by embolizing both the inflow and the outflow arteries of the artery is effective; however, when a more accurate anchor performance is requested in a complicated case, choosing GDC360° as the first coil is recommended.

Fig.: Schema 3; "Anchoring Technique"

References: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN
**Isolation/anchoring techniques for isolated IAA**

**Case 2:**

An 83-year-old male with high blood pressure complaining of the swelling of the right limb for recent two months. CT images demonstrate the 40mm-aneurysm in right IAA with a short neck length (36mm in length), which compress the iliac vein and cause the strong edema (Fig. 2A on page ).

**Fig.:** Fig. 2A) Aneurysm in right IAA with a short neck length.

**References:** T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN
Case 2

Fig.: Fig. 2B) 1. The distal outflow arteries were embolized with microcoils. 2. Proximal inflow artery with a short neck was embolized with GDC18-360° using an "anchoring technique" under balloon flow-control.

References: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN

The distal outflow arteries were embolized with non-detachable microcoils. Proximal inflow artery with a short neck was embolized in the short segment with GDC18-360° (12 mm/30 cm, 9 mm/20 cm and 8 mm/20 cm) using an "anchoring technique" under balloon flow-control, followed by the filling coils (12 microcoils and IDC: 7 mm/10 cm) (Fig. 2B on page ). Isolation of the aneurysm improved the swelling of lower limb after coiling. No coil compaction and recanalization at 1 year-follow-up CT.

Embolization of pelvic AVM: "Anchoring" techniques for drainage vein

Congenital pelvic AVMs are rare and their clinical behavior is quite variable. Internal iliac arteriovenous malformations (AVM) are difficult to treat. Permanent occlusive agents including isobutyl cyanoacrylate, particles of polyvinyl alcohol foam, and coils are used to embolize the multiple feeding vessels and the nidus of the AVM.
The present case of pelvic high-flow AVM was embolized with a mixture of N-butyl-2-cyanoacrylate (NBCA) and iodized oil after the embolization of the main drainage vein with detachable coils.

**Case 3:**

A 63-year-old female. It was pointed out abnormal structure in the pelvis by an ultrasound study. The right internal iliac AVM was diagnosed with a CT-scan study. This case of congenital pelvic AVM was lack of significant symptoms; however, a part of nidus was located in immediate proximity to rectal wall (Fig. 3A on page ).

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**Fig.:** Fig. 3A) The right internal iliac AVM was located in immediate proximity to rectal wall.

**References:** T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN
**Fig.**: Fig. 3B) High-flow fistula between the multiple feeding artery and right common iliac vein.

**References:** T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN

An angiography confirmed a high-flow fistula between the multiple feeding artery (superior rectal artery, median sacral artery, lateral sacral artery, internal pudendal artery) and right common iliac vein (Fig. 3B on page ). In the first session of the interventional procedure, NBCA with lipiodol (1:5) was used to embolize the nidus of AVM under the flow control using a balloon catheter; however, complete embolization of AVM could not be accomplished.

After 6 months later, a follow-up CT study demonstrated the nidus of AVM still remained. The second session of the interventional procedure was planned.
**Case 3**

**Fig.**: Fig. 3C) Embolized with fibered IDCs and IDCs using a side-branch anchoring technique under balloon flow-control.

**References**: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN
Fig.: Fig. 3D) Pre-2nd Intervention: Feeding arteries still remained 6 months after 1st intervention. Post-2nd Intervention: Feeding arteries and nidus of pelvic AVM were completely embolized with NBCA-lipiodol (1:10) after the embolization of drainage vein using detachable coils.

References: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN
Fig.: Fig. 3E) CT image of post 1st embolization and 2nd embolization.

References: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN

The drainage veins were embolized with fibered IDCs (14mm/30cm × 3, 14mm/20cm × 3, 12mm/30cm × 3, 12mm/20cm × 3, 10mm/30 × 3, 10mm/20cm × 3 and 8mm/20cm × 3) and IDCs (16mm/20cm × 2 and 14mm/20cm × 2) using a side-branch anchoring technique under balloon flow-control (Fig. 3C on page ). Thereafter, feeding arteries were embolized with NBCA-lipiodol (1:10) to multiple feeders (superior rectal artery, median sacral artery, lateral sacral artery and internal pudendal artery). Finally, the nidus and feeding arteries of pelvic AVM were completely sacrificed (Fig. 3D on page ). A 1-year follow-up CT study demonstrated that there was no AVM recurrence (Fig. 3E on page ).

Pre-EVAR (endovascular aneurysm repair) Embolization of IIA

Prophylactic embolization to prevent type II endoleak pre-endovascular aneurysm repair (EVAR) is much more common than embolization for isolated internal iliac artery aneurysm (IIAA).
Indications: Need to occlude IIA and IIAA in association with aortoiliac aneurysm pre-EVAR.

Endovascular repair of abdominal aortic aneurysms involving the iliac artery, which is seen in about 20% of patients, requires extension of the stent-graft limb into the external iliac artery. Occlusion of the IIA is used to prevent a potential type II endoleak via retrograde flow in the IIA after covering the IIA origin with a stent-graft limb[4]. In AAA cases of comorbid bilateral common iliac artery aneurysms, lateral IIA embolization and contralateral internal-external iliac artery (IIA-EIA) bypass performed and stentgraft is extended to bilateral EIA to prevent buttock claudication and ischemic colitis[5]. Specific complication is buttock claudication, erectile dysfunction and bladder ischemia. Complications are most common if the entire internal iliac circulation is embolized if embolization involves the branches of the IIA.

Case 4:

A 74-year-old male with high blood pressure and angina pectoris post coronary stenting. It was pointed out AAA comorbid right CIA aneurysm with the CT scan (Fig. 4A on page ).
Case 4

Fig.: Fig. 4A) AAA comorbid right CIA aneurysm.

References: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN
Fig.: Fig. 4B) Embolized by GDC18-360° as "anchoring" coils and additional detachable coils (Fibered-IDCs).

References: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN

A cobra type catheter (4.0-Fr.) selects right CIA inserted from left femoral artery (cross over). The microcatheter (Renegade 2 marker type, Boston Scientific) was pushed forward to ostial right IIA. Embolized by GDC18-360° (14mm/30cm and 12mm/30cm) as "anchoring" coils, followed by additional detachable coils (Fibered-IDC: 10mm/30cm × 2, 8mm/20cm × 2, 6mm/20cm and 4mm/15cm). After coil embolization, anterograde flow of right IIA was disappeared and confirmed delay-enhancement of right IAA branches from opposite side (Fig. 4B on page ).
Case 4

Post Intervention

**Fig.**: Fig. 4C) Post embolization of right IIA and stentgrafting (Excluder 23×12×16mm).

**References:** T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN

Bilateral inguinal skin incision

Bilateral CFA exposure

Main body: Excluder 23×12×16mm (**Fig. 4C** on page )

Contra lateral leg: 20×9.5mm

Touch up using Reliant balloon

**Images for this section:**
Coil packing embolization

- **Object**: Coil packing for simple aneurysms
- **Tips**: Ensure the catheter position is stable and select the appropriate coil size/shape.
- **Advantage**: Preservation of the blood flow of parent artery and distal organs.
- **Demerits**: Coil migration and occlusion of parent artery.

**Fig. 1**: Schema 1; Coil packing embolization
**Stent-assisted “remodeling technique”**

- **Object:** Wide-necked, complex-shaped artery bifurcation aneurysms.
- **Tips:** Select an appropriate diameter of stent size.
- **Advantage:** The most effective technique to prevent coil protrusion into the parent artery.
- **Demerits:** Thromboembolic complications might increase and distal flow might be compromised.

**Fig. 2:** Schema 2; Stent-assisted "remodeling technique"
“Anchoring Technique” Using GDC360° and/or Fibered-IDC (Interlock™)

- **Object:** A High-flow parent artery.
- **Tips:** Select larger size of GDC360° /Fibered IDC (Interlock) as the first anchoring coil under flow-control using a balloon catheter.
- **Advantage:** Coiling a parent vessel safely in a short segment for a complicated case.
- **Demerits:** Coil migration.

**Fig. 3:** Schema 3; "Anchoring Technique"
Conclusion

- Our experience indicates that detachable coil embolization combined with "remodeling" techniques is a safe and effective way to treat IAAs and pelvic AVMs. Choosing an appropriate therapeutic option is essential for achieving excellent long-term results and reducing potential complications.
- Complex-shaped coils are designed to better conform to irregularly shaped and/or wide-necked aneurysms. In addition, complex-shaped coils may augment packing attenuation, a factor that is believed to decrease aneurysm recanalization by minimizing coil compaction. Complex-shaped coils have been designed to provide greater conformability to the aneurysm and reduce the incidence of coil compaction over time.
- The fact that the GDC360° has a nonspherical shape may improve homogenous filling of irregularly shaped aneurysms. GDC360° has excellent ability as an anchoring coil, followed by fibered-detachable coils (Fibered-IDC) under balloon-assisted flow control in the pelvic complicated embolization cases.
- Disadvantages include that the setup takes more time and they are significantly more expensive; however, safety issue in

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