Controlled-release detachable coil embolization of wide-necked renal artery bifurcation/trifurcation aneurysms and renal high-flow arteriovenous fistulas

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<th>Poster No.:</th>
<th>C-2053</th>
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<tr>
<td>Congress:</td>
<td>ECR 2011</td>
</tr>
<tr>
<td>Type:</td>
<td>Educational Exhibit</td>
</tr>
<tr>
<td>Keywords:</td>
<td>Interventional vascular, Kidney, Catheter arteriography, CT-Angiography, Embolisation, Balloon occlusion, Stents, Aneurysms, Arteriovenous malformations</td>
</tr>
<tr>
<td>DOI:</td>
<td>10.1594/ecr2011/C-2053</td>
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Learning objectives

1. To summarize the technical preferences of embolization for renal artery aneurysms (RAAs) and renal arteriovenous fistulas (AVFs) using controlled-release detachable microcoils, which help to avoid serious complications.

2. To describe detachable coil embolization using a balloon/stent-assisted "remodeling technique" for wide-necked RAAs located at the bifurcation/trifurcation of the renal artery.

3. To introduce the "anchoring technique" using complex-shaped Guglielmi detachable coils (GDC 360°) to prevent distal migration of coils in the renal high-flow AVF, which is an uncommon technique for intracranial lesions.

Background

RAA are the third most common visceral artery aneurysms but uncommon, occurring in 0.09% of the population. Most RAAs are asymptomatic, but RAA rupture has been associated with a high death rate, especially during pregnancy. Ippolito et al. described that RAA rupture was to result in a mortality of about 80% [1], so that the most feared complication of RAA is rupture. Renal arteriovenous malformations (AVMs) and fistulas (AVFs) include various abnormal connections between the intrarenal arterial and venous systems. Renal high-flow AVF can show symptoms of gross hematuria, renal dysfunction, hypertension, and cardiac failure.

Indications for RAA /renal AVM /renal AVF treatment are in details as follows: [2, 3, 4].

#an expanding or symptomatic aneurysm

#aneurysmal size > 1.5 cm

#renal infarction

#intractable hypertension

#in the context of anticipated pregnancy

Treatment of RAAs is determined by the anatomic location of the aneurysm [5, 6]. Surgical approaches for treatment of RAAs are technically challenging, requiring retroperitoneal
dissection for exposure, and carry a morbidity rate of up to 28%, making endovascular approaches a viable alternative [2, 3]. In particular, the aneurysms located at the bifurcation/trifurcation of the renal artery are difficult to exclude from circulation surgically without sacrificing at least a part of the kidney. Although coil embolization may be complicated by thromboembolism, intra-operative aneurysm rupture, coil migration, bacteremia and vasospasm. Coil migration is displacement of the coil into the parent artery lumen after detachment. Closure of high-flow AVF with coil embolization can be technically challenging and fraught with complication as a result of the possibility of coil migration into venous circulation and subsequent embolization to distant sites such as the heart and lungs.

Therapeutic embolization with coils has been performed successfully for more than 35 years since the original description of the Gianturco-Wallace stainless steel coil [7], 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 most commonly used detachable coils are shown in table 1 on page .

<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>
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<tbody>
<tr>
<td>Mechanical Detachable</td>
<td>IDC™</td>
<td>Boston Scientific</td>
<td>2-30</td>
<td>20-200</td>
<td>Nonferred, platinum coil, 2D-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>DETACH-11/18</td>
<td>Cook</td>
<td>2-15</td>
<td>20-300</td>
<td>Nonferred, platinum coil, many size variations, 2D-U-shaped coils, less expensive.</td>
<td>Many complications during deployment, such as early detach, unraveling, and so on.</td>
<td>++</td>
</tr>
<tr>
<td>Interlock™ Fibered IDC™</td>
<td>Oclusion System</td>
<td>Boston Scientific</td>
<td>2/5-14</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>Electrical detachable</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></td>
<td>GDC™ Detachable Coils</td>
<td>Stryker</td>
<td>2-24</td>
<td>10-400</td>
<td>Nonferred, extremely soft, platinum coil.</td>
<td>Require more operator experience, elaborate setup for delivery.</td>
<td>++++</td>
</tr>
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<td></td>
<td>CERECYTE™</td>
<td>Micrus</td>
<td>1.5-20</td>
<td>10-500</td>
<td>Nonferred, platinum coil, a lot of size/length variations, 2D/3D/complex-shaped coils, easy/ repeated-repositioning, bioactive coating available.</td>
<td>Same disadvantage in GDC.</td>
<td>++++</td>
</tr>
<tr>
<td></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></td>
<td>TRUFL 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>
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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) [8] 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. 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.

<Major advantages of GDC for renal artery lesions>

# Electrical detachable method can adjust the position of the coil safely and certainly before release; those have high utility values for severe case demanded delicate technique.

# Wide variation of the size, flexibility, and shape.

# 3D or complex-shaped (GDC3D/GDC360°): Radial force is higher than 2D coils.

<Features of GDC360°> (Fig 1 on page______)

# Complex-shaped, bare platinum coil mounted on a double strand of polypropylene suture.

# The first 1.5 loops have a 2D configuration and are 25% smaller than the stated coil diameter.

# The GDC360° can also form a complex basket in irregularly shaped and/or wide-necked aneurysms or in a high-flow parent artery into which the subsequent coils can be deposited.

# Stretch-resistant (SR) mechanism is installed to prevent unraveling (GDC10).

# Complex-shaped coils have been designed to provide greater conformability to the aneurysm and reduce the incidence of coil compaction over time.
The GDC360° is available for an "anchor" because of its strong radial force.

Fig.: Fig 1. Guglielmi electrical detachable coil (GDC): complex-shaped GDC-18 360°

References: Permission from Stryker

Imaging findings OR Procedure details

1. Balloon-assisted "remodeling technique" for wide necked RAAs

"Remodeling technique" is balloon-assisted coil embolization for wide neck cerebral aneurysms, first documented by Jacques Moret.

We introduce the possibility of application of this technique to wide-necked RAAs located at the bifurcation/trifurcation/quadrafurcation of the renal artery.

To achieve homogenous packing density of wide-necked, complex-shaped aneurysms that otherwise would not be amenable to primary coiling without any coil protrusion into the parent artery.

Select a compliant balloon/microballoon along with the ability to adapt its shape to the anatomy of the arterial bifurcation/trifurcation/quadrafurcation by bulging into the aneurysm neck or the branches coming off the sac.

Coil embolization with GDC360° (stronger radial force) may improve stability of coiled renal aneurysms when compared to other helical coils.

Case 1: Wide-necked renal artery bifurcation aneurysm
A 62-year-old woman was pointed out multiple renal artery aneurysms by an ultrasound abdominal screening. Left renal artery angiogram revealed a 16 mm left main renal artery (RA) bifurcation aneurysm and an 8 mm additional distal aneurysm of ventral branch of left main RA (Fig 2A on page ). During the coil embolization of those aneurysms, a remodeling balloon (5.0-Fr. compliant balloon catheter (Selecon MP: 9 mm, Terumo Clinical Supply)) was placed along the aneurysm neck. The main RA aneurysm was embolized with framing coils (GDC18-360°: 14 mm/30 cm × 2, 13 mm/30 cm, 12 mm/30 cm and 10 mm/30 cm), followed by the filling coils (IDC: 8 mm/20 cm and IDC: 7 mm/20 cm × 2) (Fig 2B on page ). The aneurysm of ventral branch was embolized with framing coil (GDC18-360°: 6 mm/20 cm), followed by the filling coils (Orbit: 3 mm/4 cm and 3 mm/6 cm × 2).

Fig.: Fig 2A: Balloon-assisted "remodeling" technique for wide-necked renal bifurcation aneurysm

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

Fig.: Fig 2B: Balloon-assisted "remodeling" technique for wide-necked renal bifurcation aneurysm

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

Case 2: Renal artery trifurcation aneurysm with fibromuscular dysplasia (FMD)
A 53-year-old woman was pointed out left RAA by an ultrasound abdominal screening. Left RA angiogram revealed a 22 mm-left main RA trifurcation aneurysm associated with a radiographic appearance of "string of beads", which characterizes fibromuscular dysplasia (FMD) (Fig 3A on page ). A 3.0-Fr. microballoon catheter (Attendant [balloon diameter: 4.5 mm; length: 15 mm], Terumo Clinical Supply) was placed along the aneurysm neck to protect the three branch arteries during the embolization procedure. The aneurysm was embolized with framing coils (GDC18-360°: 20 mm/33 cm × 2, 18 mm/40 cm × 2, 14 mm/30 cm × 2 and 10 mm/30 cm × 2), followed by the filling coils (IDC: 9 mm/20 cm × 2, 8 mm/20 cm × 2, 7 mm/20 cm × 2, 6 mm/20 cm × 2 and 6 mm/10 cm × 2) (Fig 3B on page ).

**Fig.:** Fig 3A: Balloon-assisted "remodeling" technique for wide-necked renal trifurcation aneurysm with fibromuscular dysplasia (FMD)

**References:** T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN
Case 3: Wide-necked renal artery quadrafurcation aneurysm

A 65-year-old man was pointed out right renal artery aneurysm by a screening abdominal echo study. Right RA angiogram revealed a 15 mm right main RA quadrafurcation aneurysm (Fig 4A on page ). A 4.0-Fr. balloon catheter (Sterling ES [balloon diameter: 2.5 mm; length: 20 mm,]; Boston Scientific) was placed along the aneurysm neck to protect the four branch arteries during the embolization procedure. The aneurysm was embolized with framing coil (GDC18-360°: 9 mm/20 cm, 8 mm/20 cm and 6 mm/15 cm), followed by the filling coils (GDC10-360°: 6 mm/11 cm × 2; GDC10 soft 2D SR: 6 mm/10 cm, 5 mm/10 cm × 2, 4 mm/8 cm and 3 mm/8 cm) (Fig 4B on page ).

Fig.: Fig 3B: Balloon-assisted "remodeling" technique for wide-necked renal trifurcation aneurysm with fibromuscular dysplasia (FMD) using detachable coils
References: T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN
2. Stent-assisted "remodeling technique" for wide-necked RAAs (Fig 5 on page _____)

#Stent-assisted "remodeling technique" for wide-necked RAA 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.
# This is the most effective technique to prevent coil protrusion into the parent artery. Parent arteries should be relatively horizontal and straight.

# On the other hand, thromboembolic complications might increase than balloon-assisted technique, and distal flow might be compromised.

# Stent-assisted "remodeling technique" is an effective option to embolize the complicated RAAs; however, considering the long-term thrombogenic complications, we strongly recommend "balloon-assisted technique" more than "stent-assisted technique.

![Fig: Stent-assisted "remodeling technique" for wide-necked aneurysm](image)

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

3. "**Anchoring technique**" using GDC360° for high-flow renal AVM or AVF (Fig 6 on page)

#A feature technique of GDC360° 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 and nidus, followed by more dense packing with softer coils.

# 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).
Case 4: Large high-flow renal AVM

A 39-year-old female complaining of mild dyspnea on effort was pointed out renal mass by an abdominal echo study. Contrast-enhanced CT demonstrated a giant renal AVM with aneurismal feeding vessels. Right RA angiogram demonstrated rapidly filling giant niduses between the right RA and the right renal vein. AVM drains into inferior vena cava, thus the angiogram showed intensive venous drainage (Fig 7A on page ).

A 5.0-Fr. compliant balloon catheter (Selecon MP: 9 mm) was advanced into the right renal artery for the flow control, then a microcatheter was placed at the most distal lesion of the niduses. A complex-shaped GDC18-360° was selected as the first anchoring coil for embolization because of its strong radial force. GDC360° (GDC18-360°: 24 mm/40 cm × 2, 22 mm/40 cm, 18 mm/40 cm and 16 mm/40 cm) were placed in the nidus as anchoring coils under the flow control using a balloon catheter (Fig 7B on page ). And then, the nidus was filled with 11 detachable coils (GDC18-2D 14 mm/30 cm × 2, IDC 12 mm/20 cm × 3, 10 mm/20 cm × 3 and 9 mm/20 cm × 3) for the complete embolization. Next, the neighboring nidus was embolized with anchoring and filling coils (GDC18-360°: 24 mm/40 cm × 2, 22 mm/40 cm and 20 mm/33 cm). After embolization of these niduses, intensive venous drainage to IVC was remained.

At the end, the most proximal nidus was clearly visualized under balloon occlusion after the embolization of niduses described above. This nidus was embolized with anchoring coils (GDC18-360°: 18 mm/40 cm and 16 mm/40 cm), followed by the filling coils (GDC18 2D: 14 mm/30 cm; IDC: 12 mm/20 cm × 2, 10 mm/20 cm × 2, 9 mm/20 cm × 2; GDC18-360°: 13 mm/30 cm, 12 mm/30 cm; IDC 8 mm/20 cm × 5, 8 mm/10 cm × 2, 6
mm/20 cm × 3 and IDC soft 5 mm/12 cm). After embolization of this nidus, neither AVM nor intensive venous drainage was demonstrated.

**Fig.**: Fig 7A: "Anchoring technique" using GDC360° as the first coil for high-flow renal AVM

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

**Fig.**: Fig 7B: GDC-18 360° as the first "anchoring" coil for large high-flow renal AVM under flow-control

**References:** T. Hasebe; Radiology, Toho University Sakura Medical Center, Sakura, Chiba, JAPAN
Case 5: Arteriovenous fisula (AVF) after biopsy of the transplanted kidney (Fig 8 on page____)

A 33-year-old female complained of thrill on grafted kidney. Right RA angiogram demonstrated high-flow AVF between a dilated renal artery branch and a renal vein. A 5.0-Fr. balloon catheter (Selecon MP: 9 mm) was advanced into the right RA. An IDC coil (3 mm/6 cm) was placed as the first "anchoring" coil in a high-flow parent artery under flow control, followed by more dense packing with additional coils (IDC: 2 mm/4cm and 2 mm/2 cm; Tornado microcoil: 2 mm/10 cm and 2 mm/3 cm). Renal AVF and intensive venous drainage to IVC were completely disappeared.

At the time of procedure of this case (2009), GDC has not been allowed to use in the abdominal lesion in Japan. Mechanical detachable coils (IDC) were found to be very useful for the embolization of AVF; however, to select GDC360°as the first anchoring coil might be more suitable and safe for such a case to embolize high-flow renal AVF.

Fig.: Fig 8. Detachable coils embolization for arteriovenous fisula (AVF) after biopsy of the transplanted kidney ("anchoring" technique)

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

Conclusion

Our preliminary experience indicates that the detachable coil embolization is technically feasible and effective for the exclusion of challenging RAAs without the sacrifice of any branch arteries or renal AVFs without coil migration.
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References


