Diagnosis and techniques to improve the clinical success of the transarterial embolization of type II endoleaks after endovascular aneurysm repair

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Learning Objectives & Background

(Learning Objectives)
The learning objectives of this presentation are to understand the possible causes of failure of a transarterial embolization (TAE), as well as diagnostic and technical improvements for a successful TAE of type II endoleaks (T2ELs) after endovascular aneurysm repair (EVAR).

(Back ground)
The varied technical success of the TAE of T2ELs is due primarily to the anatomical characteristics of the collaterals of aortic side branches, and special skills are required for successful TAE when collaterals are small, tortuous, and multiple.

The low clinical success rate of TAE is also problematic. This low rate comes about because T2ELs sometimes newly develop and remained after successful TAE. Repeating reinterventions is an only solution for such newly developed T2ELs, however, remained T2ELs can be decrease with more accurate diagnosis of T2EL and improved embolization techniques.

Countermeasures to achieve successful TAE are discussed in accordance with accurate preoperative diagnosis, catheter systems, embolization techniques, and evaluation during TAE.
1. Correct diagnosis of T2ELs using non-contrast enhanced MRI

a. Detection of occult T2ELs

CTA has been the gold standard for the diagnosis of T2ELs, but dynamic MRI is superior for the detection of ELs. These modalities depend on hemodynamics, and sometimes miss the occult T2ELs unless super-delayed images are obtained. Non-contrast enhanced MRI can be used to determine the properties of a thrombus and can detect the EL cavities where coagulation is incomplete, irrespective of blood flow.

A T2EL is detectable in the lower sac (yellow arrows) on CTA, but non-contrast enhanced MRI revealed another low-signal area suggesting an EL cavity in the upper sac (red arrows). A T2EL from 2nd lumbar artery (LA) was confirmed on angiogram (black arrow).
Clinical Findings/Procedure Details

1. Correct diagnosis of T2ELs using MRI

   b. Detection of other types of EL on non-contrast enhanced MRI

   Non-contrast MRI can diagnose some specific types of endoleak, including multiple atypical T2ELs, type IIIb ELs due to multiple suture holes, or possibly IV ELs.

   (T2EL from multiple vaso vasorum: multiple atypical T2ELs)  
   (Type IIIb EL due to multiple suture holes)

   A diffuse abnormal signal area just below the aneurysmal wall is a characteristic finding of multiple atypical T2ELs.

   An abnormal signal area around the graft is another typical finding of type IIIb EL due to multiple suture holes, and possibly type IV EL.
2. Techniques/devices for successful microcatheter advancement & glue injection

   a. Double coaxial system and 0.008- and/or 0.010-inch micro guidewire.

   A double coaxial system, consisting of a 2.8 F hi-flow microcatheter, and a 1.5 F or 1.6 F microcatheter, is the best catheter system for TAE. The hi-flow microcatheter provides sufficient back-up, and the small-bore microcatheter allows easy advancement into small and tortuous vessels with the use of a 0.008- and/or 0.010-inch guidewires. ≤ 0.014-inch non-fibered coils can also be used.

   b. Knuckle wire technique using a 0.008-inch guidewire

   The guidewire can advance into small and tortuous vessels by this technique with no special skill.

       (How to do it)

   1. Bend the wire at the 1-mm tip using a inserter.
   2. Simply push the wire till it knuckles, and then push it further. The knuckled wire will advance toward the larger and more straightforward collateral.
   3. Advance the 1.5- or 1.6F microcatheter when the knuckled wire no longer advances, so that the wire can be further advanced by pushing it again.
   4. Use an angle-shaped 0.010-inch guidewire, and cannulate the targeted collateral if the knuckled wire advanced to an unexpected collateral.
Clinical Findings/Procedure Details

(Double coaxial system and knuckle wire technique using a 0.008-inch guidewire)

The knuckled wire was retrieved since it advanced into another branch.

The wire was successfully advanced into the main collateral.

The wire was then simply pushed and pushed.

The wire was successfully advanced into the main collateral.

A 1.6F microcatheter was advanced when the wire no longer advanced.

Pushing the wire and advancing the catheter were repeated.

Since the catheter had entered an unexpected branch, it was retrieved and a 0.010-inch guidewire was utilized to cannulate the main collateral.

The wire finally successfully advanced into the 4th lumbar artery.

The left iliolumbar artery (ILA) communicating with the left 4th LA.
Clinical Findings/Procedure Details

2. Techniques for successful microcatheter advancement & glue injection

c. Embolization of small collaterals and/or peripheral LAs

(Grading of the communication between ILAs and LAs)

<table>
<thead>
<tr>
<th>Type of anastomoses</th>
<th>G1 (n=7)</th>
<th>G2 (n=7)</th>
<th>G3 (n=24)</th>
<th>G4 (n=7)</th>
<th>G5 (n=12)</th>
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<tbody>
<tr>
<td>Successful advancement</td>
<td>7/7</td>
<td>7/8</td>
<td>10/24</td>
<td>2/7</td>
<td>0/12</td>
</tr>
<tr>
<td>Success rate</td>
<td>100%</td>
<td>87.5%</td>
<td>41.7%</td>
<td>28.6%</td>
<td>0%</td>
</tr>
</tbody>
</table>

G1: Large single communication with the 4th LA.
G2: Single communication with the 4th LA, but with severe bending or a narrow segment.
G3: Multiple communications or communication with fenestration with the 4th LA.
G4: Direct communication with the 3rd LA,
G5: Multiple communication with the 3rd LA through the 2nd or 4th LA.

In our previous study, it was more difficult to achieve advancement of the microcatheter in collaterals with multiple communication than in those with a single communication (G3 vs. G1&G2, G5 vs. G4). Managing T2ELs associated with multiple collaterals is a key to successful TAE.
2. Techniques for successful microcatheter advancement & glue injection

c. Embolization of small collaterals and/or peripheral lumbar arteries

Glue injection will be successful even with a proximal injection after embolizing all collaterals (downgrading). This helps to avoid reflux of the glue via other collaterals and insufficient glue injection.

A 1\textsuperscript{st} LA angiogram reveals four collaterals communicating with the 2\textsuperscript{nd} LA.

The proximal 2\textsuperscript{nd} LA was not depicted on the No.4 collateral angiogram, and the same result was obtained on the No.3 collateral angiogram after embolizing the No.4 collateral.

The glue was injected from the No.2 collateral. The EL cavity was filled with glue via the 3\textsuperscript{rd} LA (arrow). Reflux of glue to the 1\textsuperscript{st} LA would occur without embolization of the distal collaterals.
3. Points to be noted during TAE to avoid missing T2ELs

a. Use of CT during a lumbar arteriogram to detect tiny ELs

Typical T2ELs are usually depicted with selective angiography, however tiny endoleaks are sometimes obscured by the staining of the vertebral body or a motion artifact of intestinal peristalsis. CT during a lumbar arteriogram should be considered when an EL is indistinct on angiography.

A left 1st lumbar angiogram could not depict the EL, but CT during a 1st lumbar arteriogram revealed a faint T2EL at the level of the 3rd LA (red arrows).
Clinical Findings/Procedure Details

3. Points to be noted during TAE to avoid missing T2ELs

b. Steal phenomenon

Even selective angiography sometimes fails to depict a T2EL angiographically. This may occur due to a steal phenomenon, that is, the injected contrast flows not into the central branch but into peripheral branches, which are usually outflow vessels. Embolization of the peripheral branches will allow the EL cavity to be detected.

The EL cavity, contralateral 4\(^{th}\) LA, and middle sacral artery became visible after the communication between the 4\(^{th}\) and the 3\(^{rd}\) LA was embolized (red arrow).

Super selective angiography of a branch of the internal thoracic artery failed to depict a T2EL in a TEVAR patient. EL cavities were seen after embolizing the bronchial artery (arrows).
Clinical Findings/Procedure Details

3. Points to be noted during TAE to avoid missing T2ELs
   
   c. Throughout angiographical evaluation for multiple atypical T2ELs

   An atypical T2EL is an EL that is supplied from the vaso vasorum. Since it develops from evenly occluded side branches over time, all feeding artery angiograms and glue injections are necessary to avoid remaining T2ELs, including those in the ILA, SICA, 1st LA, and inferior mesenteric artery (IMA) when MRI reveals a suspicious finding of possible multiple atypical T2ELs.

   Multiple T2ELs (arrows) were confirmed by angiograms of all possible feeding arteries, including the right. 1st LA, right. ILA, and left. ICA.
Conclusions

Appropriate pre- and perioperative evaluations, improved embolization techniques, the use of special devices including the double coaxial system, and an understanding of the specific T2EL (multiple atypical T2ELs) will contribute to the improvement of technical and clinical success of TAE.