Angioplasty iliac & SFA

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History of angioplasty
The historical relationship between interventional radiology and angioplasty is long and deep. Since Swedish radiologist Dr. Sven Ivar Seldinger (1921-1998), invented a way of percutaneous angiography that is now known as Seldinger's method in 1953\(^1\), the angiogram spread rapidly worldwide. The first interventional radiology was conducted by Charles Theodore Dotter (1920-1985) in 1964\(^2\), where the stenosis of the superficial femoral artery was dilated by large dilators. After then, the metallic scaffold was developed by Dotter\(^3\) or Julio Palmaz (1945-\(^4\)). Therefore, the beginning of the interventional radiology is angioplasty and its related techniques and devices has been invented by radiologists.

Why the IRists should not give up doing angioplasty
While many physicians including vascular surgeons, cardiologists, and radiologists have been doing angioplasty, the number of radiologists involving angioplasty is decreasing worldwide. The cause of this phenomenon varies depending on the regulations or situations in each institution. Radiologist should not give up doing angioplasty not only because it is a root of IR but because it includes specific and basic skills such as using balloons and stents.

Classifications of the symptom and the lesion
Clinical severity classification (Fig.1)
The Fontaine or Rutherford classifications are often used to categorize clinical symptoms of peripheral arterial disease. The physicians must be familiar with these clinical gradings. The indication and efficacy of the treatments should be discussed based on this clinical presentation.

Classifications of the lesion (Fig.2,3)
The TASC II classification has been used to characterize lesions\(^5\). Iliac and SFA lesions have often been discussed using this classification in many series. For TASC C & D, surgical treatment including bypass surgery has been recommended. However, recommendation of recent guidelines has shifted toward an endovascular-first strategy using recent devices and technologies if the lesion length is less than
25 cm (e.g. ESC 2017)\(^6\).

**<Basic matter>**

**Pre-, peri-, and post-procedural medication**

Preprocedural antiplatelet therapy is recommended to prevent acute occlusions or intraprocedural complications. Dual antiplatelet therapy (Aspirin 100mg and Clopidgrel 75mg) should be started at least 1 week before procedures. In the Asian population, there are significant number of people (around 20% in Japan) who are resistant to Clopidgrel therapy due to poor metabolism of CYP2C19. P2Y12 or Aspirin Reactive Units have to be evaluated by using VerifyNow® to assess antiplatelet therapy. Additional doses of the drug or switching to Cilostazol 200mg have to be considered in cases of poor metabolism.

During the procedure, systemic heparization is mandatory with monitoring ACT time of around 200-250 seconds. Postprocedural dual antiplatelet therapy is recommended for at least 1 month. Recent stents like drug eluting stents or stent-grafts demand postoperative dual antiplatelet therapy for over 6 months.

**Access route and introducer system**

The physicians have to decide the access route for approaching to the lesion(s), including crossover access, retrograde access, or brachial access. Before applying brachial access, existence of plaque in brachiocephalic or subclavian arteries and aorta has to be evaluated using contrast-enhanced CT to avoid stroke or other embolic sequelae. Application of a 6F sheath introducer system is recommended, because most stents can be delivered through it. The advancement of a long sheath close to the target vessel is recommended, because it facilitates crossover or brachial accesses.

**Guide wires**

The guide wires used in the procedure is one of the most important factors for successful recanalization. Physicians can choose 0.035 inch conventional guide wires, and 0.018 or 0.014 micro guide wires those are available for angioplasty. Its selectin depends on the physician's preference.

**Ballooning**

Pre-dilatation ballooning is often necessary in severe stenotic or occlusive lesions before delivering stents. Small balloons measuring 4 or 5 mm in diameter are sufficient to deliver the stent. Dilatation using oversized balloons potentially increase the risk of complications like arterial injury, dissection, and thromboembolic events during the procedure.

If the lesion is going to be treated without stents (Plain Old Balloon Angioplasty,
"POBA"), optimal sizing of the balloon is crucial. The diameter of the balloon should be identical or slightly larger than the inner diameter of the reference artery. Gradual inflation of the balloon is recommended to prevent long segment dissection. Long inflation for around 3-4 minutes is also considerable in POBA.

Stent selection and placement
The stent must cover all the lesions consisted of atheromatous plaque with healthy proximal and distal landing zones. The size of the balloon-expandable stent should be identical or slightly smaller than the diameter of the reference artery, while the size of the self-expandable stent should be slightly larger than it. For precise positioning of the stent on the lesion where greater radial force is needed, balloon expandable stents are useful. Self-expandable stents are useful for longer and/or tortuous lesions. Covered stents must be prepared for arterial rupture as one of the severe complication, especially in iliac lesions.

Post-dilatation balloon
A post-dilatation balloon is essential in self-expandable stents. The diameter of the balloon should be same as the reference vessel diameter. The balloon dilatation should be limited inside of the stent to prevent vessel injury or balloon rupture.

Procedural imaging
Digital subtraction angiography (DSA)
DSA is the gold standard during the procedure. A roadmap is also helpful. For longer occlusive lesions, biplane angiography is also helpful to navigate the wire and the catheter.

Intravascular ultrasound (IVUS)
As the IVUS provides high-resolution cross-sectional image of the vessel, it is useful in assessing the nature of the lesion, vessel lumen diameter, extent of the dissection, the tract of the wire in occlusive lesions, and the shape of implanted stent.

Ultrasound (US)
Percutaneous ultrasound is also useful in evaluating the puncture site and wire crossing in long occlusive lesions of the SFA with continuous monitoring of the motion of the guide wire tip. Conversely, it is not helpful for aortoiliac or distal SFA, or strongly calcified lesions.

Iliac artery
Because of the promising clinical results, primary stent placement is recommended for
aortoiliac lesions (10 year patency rate of 83% in TASC II A, B and 71% in TASC II C&D lesion)\(^7\). Long occlusive lesions or severe stenotic lesions with abundant plaque raise the risk of distal thromboembolic complication. A covered stent has to be prepared in the procedure for long, torturous, and calcified occlusive lesions, because vessel rupture induced by PTA potentially results in lethal retroperitoneal hemorrhage. Aortoiliac lesions extending to superficial femoral artery should be treated with a combination of endarterectomy and stenting. However, stenting in the common femoral artery should be avoided because of possible stent-fracture in the follow up period. Moreover, common femoral stenting may impede re-intervention.

**Superficial femoral artery (SFA)**
Although SFA lesions tend to be long and occlusive, PTA provides acceptable technical success rates. However, the long-term patency of bare metal stents is not acceptable especially in TASC C&D lesions\(^8\). POBA may be considerable for this kind of lesions. As the vessel strongly bends during daily activity of the patient, stent placement at the proximal or distal SFA can cause stent fracture during long-term follow-up. Flexible stent\(^9\) or drug eluting stent\(^10\) have been invented to improve long-term patency, although the patency rate after bare metal stent placement is still inferior to that of surgical bypass.

**CTO occlusion**
There are various reported techniques to cross long occlusive lesions. For instance, IVUS or ultrasound guided approach is helpful to cross lesions. Bidirectional approach is also useful; however, puncture of the distal artery is necessary in the PTA of SFA.

**Covered stent (game changer in long SFA lesion)**
Recent developments of heparin bonding ePTFE covered stent has changed the game in long SFA treatments. This covered stent dramatically improved the patency in long occlusive lesions of up to 25cm in length\(^11\). The reported midterm results are close to that of surgical bypass\(^12\). Furthermore, it is useful for fixing the rupture of the target vessel during the procedure, and it increases the safety of the PTA procedure.

**Other and future devices**
Re-entry devices, CTO crossing devices, calcium debulking devices, and atherectomy devices are adoptable in this field to improve the results of endovascular therapy.

**Conclusion**
Adequate preparation, application of the techniques or devices in PTA by skilled interventional radiologists with precise evaluation of the lesion are needed to achieve
good results with safety of the procedure.

References
23. Angioplasty iliac & SFA (Norio Hongo, MD, PhD)

Fontaine and Rutherford classification system of peripheral arterial disease

<table>
<thead>
<tr>
<th>Stage</th>
<th>Clinical symptom</th>
<th>Grade</th>
<th>Category</th>
<th>Clinical symptom</th>
<th>Objective criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Asymptomatic</td>
<td>0</td>
<td>0</td>
<td>Asymptomatic</td>
<td></td>
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<tr>
<td>IIa</td>
<td>Mild Claudication</td>
<td>1</td>
<td>I</td>
<td>Mild claudication</td>
<td>Completes treadmill exercise; AP after exercise &gt; 50 mm Hg but at least 20 mm Hg lower than resting value</td>
</tr>
<tr>
<td>IIb</td>
<td>Moderate to severe claudication</td>
<td>2</td>
<td>I</td>
<td>Moderate claudation</td>
<td></td>
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<tr>
<td>III</td>
<td>Ischemic rest pain</td>
<td>3</td>
<td>II</td>
<td>Severe claudation</td>
<td>Cannot complete standard treadmill exercise, and AP after exercise &lt; 50 mm Hg</td>
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<tr>
<td>IV</td>
<td>Ulceration or gangrene</td>
<td>4</td>
<td>III</td>
<td>Ischemic rest pain</td>
<td>Resting AP &lt; 40 mm Hg, flat or barely palpable ankle or metatarsal PVR: TP &lt; 10 mm Hg</td>
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<td>5</td>
<td>II</td>
<td>Minor tissue loss</td>
<td>Resting AP &lt; 60 mm Hg, ankle or metatarsal PVR flat or barely palpable; TP &lt; 40 mm Hg</td>
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<tr>
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<td></td>
<td>6</td>
<td>III</td>
<td>Major tissue loss</td>
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AP: ankle pressure; PVR, pulse volume recording; TM, transmetatarsal; TP, toe pressure.

Fig.1 Fontaine and Rutherford classification system of peripheral arterial disease

Fig2 Trans-Atlantic Inter-Society Consensus (TASC) Document classification of aortoiliac lesions
Fig. 3 Trans-Atlantic Inter-Society Consensus (TASC) Document classification of femoral popliteal lesions