Determination of system sizes

Intra-arterial (IA) chemotherapy is usually performed with a double coaxial catheter system using a 5F, 4F, or 3F parent catheter and a microcatheter. In principle, a triple coaxial catheter system with an inner catheter is not used. The most common combination is a 5F guiding catheter (GC) and a 1.6 – 2.3F microcatheter. The reasons for using a GC as a parent catheter are 1) continuous intra-catheter rinsing with heparinized saline, 2) the availability of contrast enhancement while using a microcatheter, and 3) the need for a backup when performing superselective catheter placement to the most distal segment of a feeding artery, or arterial redistribution technique using a coil. Therefore, if there is no need for them, the parent catheter can be downsized. In principle, we use 5F catheter for the first time in all cases, and switch to a 3F diagnostic catheter for the second and later treatments for cases that do not involve low origin arteries including the facial artery, or that can be treated in a short procedure when a single branch is feeding.

Table 1. Characteristics of Each System

	GC	Diagnostic Catheter	Sheathless Catheter	Diagnostic Catheter	Diagnostic (Seiha®)
	5F	4F	3F		
Backup	Good	Moderately poor	Good	Very poor	Fairly good
Cost	Comparatively high	Low	Comparatively high	Low	Low
Rinse with Heparinized Saline	Good	Moderately poor	Good	Poor	Poor
Rotating Parent Catheter	Possible	Possible	Slightly difficult	Possible	Possible
Bilateral Neck Lesions	Suitable	Suitable	Not Suitable	Suitable	Suitable
Guidewire	No limitations	0.038”	No limitations	0.032”	0.032”
Microcatheter	No limitations	Mostly no limitations	No limitations	Specialized one for 3F	Specialized one for 3F
Rest Time	6-7 hours	4-5 hours	3 hours	3 hours	3 hours

Originally, the replacement of 5F guiding catheters with diagnostic catheters in intra-arterial (IA) chemotherapy was largely intended to reduce the cost of medical devices. However, with the start of the JCOG 1212 clinical trials, the number of IA infusion increased from original four to a

maximum of seven, which raised concerns about complications associated with femoral artery puncture and a lower complication rate due to increased patient burden. Therefore, increasing the completion rate by reducing the complications with femoral puncture and the postoperative rest time became one of the important goals of the size reduction.

There are mainly two methods to reduce the size of a parent catheter. One is using a diagnostic catheter, and the other is using a sheathless guiding catheter.

Size Reduction Using Diagnostic Catheters

Use a 4F or 3F diagnostic catheter instead of a guiding catheter. In particular, a 3F diagnostic catheter reduces not only the cost but also a patient's mental and physical burden in that the patient can be ambulatory within 3 hours after surgery (1 hour of compression and 2 hours of bed rest). This contributes to the completion of a long treatment with up to 7 cycles by increasing the motivation of the patient to continue the treatment. However, there are various technical limitations due to the specifications of the diagnostic catheter itself and of the microcatheter that passes through inside it. The following are the issues that may occur when using a diagnostic catheter.

Issues with Sheath Insertion

The sheath introducer for 3F has a thin puncture needle of 20G or 22G. Compared to the 17-18G needle usually used in 5F and 6F, backflow of the arterial blood is weaker, and it is possible that it may be misinterpreted as a failed puncture at first. Furthermore, the 0.032" guidewire that can be used with an 18G puncture needle does not pass through the sheath. This means that it is not possible to divert a 0.032-in., 150-cm Radifocus Terumo guidewire (Terumo, Tokyo, Japan) for use with the parent catheter when the guidewire provided in the sheath kit has poor guiding performance. The wires provided in the kits are very thin and have poor fluoroscopic visibility. Note that when the tip is not J-shaped, the friction outside the artery or in the dissection cavity is quite small.

Manufacturer Differences in Sheath Introducer

The sheath introducers also differ slightly in outer diameter depending on the manufacturer. If the French size is the same, Medikit Catheter Introducer (Medikit, Tokyo, Japan) is generally the thickest, followed by their Slim Type and Radiforcus Introducer IIH (Terumo, Tokyo, Japan), and XEMEX Introducer Sheath (ZEON Medical Inc., Tokyo, Japan) is the thinnest.

Degradation of Backup Performance

Needless to say, the backup performance of diagnostic catheters is inferior to that of guiding catheters. When a microcatheter is inserted close to the tumor, or when a coil is used for the arterial redistribution technique, a diagnostic catheter is not able to support the reaction, and the catheter tip may deviate from the external carotid artery to the common carotid artery and finally to the aortic arch. Especially with the 3F diagnostic catheter, it is almost impossible to approach the most distal part of the facial artery (the end of the angular artery). A diagnostic catheter is also

not suitable for the approach to the superior thyroid artery, which normally requires the catheter to be placed in the low position (common carotid artery), since the catheter tends to drop. This problem is particularly apparent in the latter half of the procedure when the catheter softens with body temperature, so the order in which microcatheters are placed in the artery should also be carefully considered. For example, the facial artery with a low starting position and strong tortuosity requires strong backup support, and should be approached early in the treatment when 3F is used as a parent catheter. On the other hand, since the internal maxillary artery is the terminal branch of the external carotid artery and runs relatively straight, even if the procedure is delayed, the microcatheter can be advanced by raising the 3F catheter back to the distal part of the external carotid artery after it was lowered to the proximal part of the artery due to a kickback force.

The 3-Fr catheter (Seiha®, MEDIKIT, Tokyo, Japan) was developed for cardiovascular applications and has stronger backup performance than the standard 3F catheters. The JB-2 is being supplied on demand in the head and neck region, and a multi-purpose version will be manufactured starting in the summer of 2017. It will be the first choice when using the 3F system. It should not be confused with their Seiya® peripheral diagnostic catheter (which has a weak backup performance).

Limitations of Guidewires

Guidewires that can be used with 3F diagnostic catheters are up to 0.032". therefore, if there is a strong atherosclerotic change in the carotid arteries, it is not possible to increase the size of the wire to 0.035" or 0.038". However, the 3F system is not likely to be used from the first time of this treatment. If it is confirmed that the patient has a strong atherosclerotic change, it is advisable to give up size reduction or to use a sheathless guiding catheter as described later. Note that the 3F diagnostic catheter has a narrow gap even when used with a 0.032" guidewire, and air is easily drawn in if the wire is removed quickly.

Limitations of Microcatheters

Microcatheters compatible with 3F diagnostic catheters are made thinner from the handle to the middle than those that are not compatible with 3F (2.4F at the handle). The wall at the handle side is thinner than those of general microcatheters that are not compatible with 3F, resulting in inferior pushability, torque transmission and backup performance when coils are used. Therefore, 3F-compatible microcatheters have some difficulty reaching distally in arteries with strong tortuosity. In addition, the thinness of the wall of the microcatheter makes it prone to "neck break" when the entire length of the catheter is used, as will be described later. Nonetheless, the performance of contrast enhancement and guidewire trackability have been improved, and the performance is becoming almost equivalent to that of the non-3F-compatible products.

Decreased Ability of Contrast Enhancement

With the microcatheter in the diagnostic catheter, the gap between the two is so narrow that it is not possible to perform imaging through the diagnostic catheter. Therefore, for example, if the patient moves during the “road mapping”, the microcatheter must be removed and the imaging reperformed, or the procedure may be switched to a blind procedure. This will not be a major problem in the second or later IA infusions where the vascular anatomy is already identified, or in

cases where preoperational 3D-CTA has been sufficiently performed. In addition, recent improvements in the performance of contrast syringes have made it possible to obtain relatively good contrast images even from small-diameter microcatheters. It is not impossible to substitute a roadmap from the parent catheter with one from the microcatheter (although the image quality will be reduced).

Difficulties in Continuous Rinsing with Heparinized Saline

In IA infusion, the gap between the parent catheter and the microcatheter should be continuously rinsed with heparinized saline to prevent cerebral thromboembolism. However, when a diagnostic catheter is used as the parent catheter, the gap between the lumen of the diagnostic catheter and the microcatheter may be too narrow to allow adequate rinse. Currently, only the combination of a 4F or larger diagnostic catheter and a 1.6F microcatheter is proved to reliably perform continuous internal lumen rinsing with heparinized saline. The 3F diagnostic catheter can virtually never perform heparin rinsing. Therefore, the 3F system should be avoided, or combination with systemic heparinization should be considered for approaches to the lower origin of the facial artery or the superior thyroid artery where the parent catheter may descend to the common carotid artery.

Size Reduction Using Sheathless Guiding Catheters

Generally, the outer diameter of the sheath introducer is the thickness of the corresponding catheter plus 2F. In recent years, sheath walls have been made thinner, and the actual measurement is about the thickness of the corresponding catheter plus 1.6F. The sheathless system eliminates this difference in the outer diameter, so that the same size catheter is expected to be able to make the puncture thinner by 1.6-2F (Table 2). As shown in the profile, the sheathless 4F Fubuki guide catheter (Asahi Intecc, Aichi, Japan) equivalent to 6F guiding has a nominal 4F sheath, while it is actually about 4.5F. The 3F guiding catheter (Parent Plus 30, Medikit, Tokyo, Japan) equivalent to 5F guiding has a 3F sheath in the catalog, while it is actually around 3.5F. The following is the order of size reduction:

(Thin) 3F Diagnosis ＜ 3.5F Sheathless ＜ 4F Diagnosis ＜ 4.5F Sheathless ＜ 5F GC (Thick)

Indications of Sheathless Guiding Catheters

Although a sheathless catheter offers strong contrast enhancement and backup performance equivalent to GC with a small puncture size, frequent insertion and removal is undesirable from the perspective of local anesthesia and hygiene. Therefore, it is indicated for cases in which the catheter is not to be moved after placement in a specific site in the external carotid artery (i.e., not suitable for cases requiring contralateral IA infusion). It is also not indicated for cases including the ascending pharyngeal artery and occipital artery, where the parent catheter must be rotated and oriented as needed. In addition, the dilator must be replaced during insertion, which is a four-handed procedure in principle. Although it is possible for a single surgeon to place the device once used to it, if pressure on the puncture site is not applied properly during replacement, a subcutaneous hematoma may occur. Note that the intention to reduce the size to reduce the burden on the puncture site may possibly backfire.

Parent Plus 30

At present, the only sheathless guiding catheters that are equivalent to 5F GC (equivalent to 3.5F sheath) are Works and Parent Plus 30 manufactured by Medikit. The former has cardiovascular indications and a slightly larger multi-purpose tip flexure. The latter is indicated for the peripheral extremities and has a small tip flexure. The former has a thin needle, since it is designed for the radial artery approach, requiring a 0.025" guidewire for catheter exchange, while the latter allows the use of a 0.032" guidewire. Therefore, Parent Plus 30 is suitable for IA infusion. Both have been developed based on the manufacturer's Slim Guide, a guiding catheter, which has excellent lumen width and flow velocity, but slightly lower backup performance than the Launcher Guide Catheter (Medtronic, Minneapolis, MN, USA).

Table 2. Profiles of Major Sheath, Sheathless GC and GC

	Item	Effective Length	Internal Diameter	Outer Diameter
3F Sheath	Sheath introducer		0.049” 3.7F	0.060” 4.6F
4F Sheath	Sheath introducer		0.060” 4.6F	0.071” 5.6F
5F Sheath	Sheath introducer		0.073” 5.6F	0.086” 6.5F
3F Parent Plus	Sheathless GC	100cm	0.059” 4.5F	0.067” 5.1F
4F FUBUKI-S	Sheathless GC	80-100cm	0.071” 5.4F	0.082” 6.2F
5F Launcher	GC (guiding catheter)	100cm	0.058” 4.4F	

Guiding Catheters

Generally, 5F, 90 cm long, angled type is used. A Y-connector is attached at the end, and the internal catheter is continuously rinsed with heparinized saline.

Tip Shapes of Guiding Catheters

The tip shape of the guiding catheter should be selected according to the atherosclerotic changes of the aortic arch. There is a trade-off between the ease of raising the catheter from the common carotid artery to the external carotid artery and the maneuverability of the catheter after it reaches the external carotid artery.

JB-2

A catheter with a large curve, such as JB-2, has superior ability to receive the downward reaction to the guidewire advancement in the aortic arch and can be easily guided into the neck artery. However, once the catheter is placed in the external carotid artery, the strong curve becomes a disadvantage, causing vasospasm due to continuous stimulation by pulsation through the tip of the catheter, or unintentional insertion of the catheter into a side branch.

Malti-Purpose Types

Catheters with relatively small curves, including multipurpose, vertebral, or JB-1, have excellent maneuverability and safety in the external carotid artery, but there can be difficulties in the initial stage of raising the catheter from the aortic arch into the carotid artery. The tip shape should be determined while keeping in mind that most patients with head and neck cancers are middle-aged or older and may have atherosclerotic changes to some degree.

Triple-Coaxial System

The safe and reliable approach to the carotid artery is a triple-coaxial system with a 120-cm diagnostic catheter. In case this system must be used, since JB-2 can be used as a diagnostic catheter, the tip shape of the guiding catheter can be a multi-purpose type that prioritizes maneuverability after raising the catheter into the carotid artery.

Stiffness of Guiding Catheters

Catheter stiffness may also be a factor when selecting a catheter. Catheter stiffness is associated with risk of vasospasm and backup performance. There is also a trade-off between the two, and it is advisable to use different products depending on the case. For example, Launcher has good support and excellent pushability and torque transmission, but their stiffness often causes vasospasm. The Slim Guide is less likely to cause spasm and has excellent contrast enhancement, although it may be too soft in cases with strong atherosclerotic changes, making it difficult to guide into the carotid artery. While ENVOY has an intermediate stiffness between the two, it has a narrower lumen and poorer contrast enhancement performance.

Length of Guiding Catheters

Catheter length will now be discussed more specifically. For products usually used, the effective length is 90 cm or 85 cm for a length of 90 cm. Catheters with an effective length of 85 cm often fail to reach the external carotid artery in patients with severe atherosclerotic changes. Even for products with an effective length of 90 cm, soft catheters (e.g., Slim Guide) are easily affected by meandering of the thoracoabdominal aorta and are often short in length (effective length should be considered to be minus 5 cm from stiffer guiding catheters). In cases where the catheter length is insufficient, the tip is often located at the bifurcation of the internal and external carotid arteries. Therefore, unintentional manipulation (outside the fluoroscopic range) can cause the tip to rotate or deviate toward the internal carotid artery, which may pose a considerable risk if there is wall irregularity or plaque at the site. As mentioned earlier, it is ideal to select a 100 cm-long catheter

in advance by evaluating atherosclerotic changes in advance. If the catheter length is unexpectedly insufficient and the catheter tip must be placed in a dangerous location where there is wall irregularity, it is safer to pull the catheter down to the middle of the common carotid artery and use a longer microcatheter with systemic heparinization.

Guidewires

Since the external carotid artery system is prone to vasospasm caused by guidewire stimulation, a 0.032" diameter is preferred over the 0.035" diameter that is often used in general angiography. This rarely causes problems with tracking of the parent catheter. In rare cases, the catheter may not go up to the external carotid artery at all with the above-mentioned system in patients with very strong atherosclerotic changes in the carotid artery. In this case, the guidewire should be changed from 0.035" to 0.038". If it is still difficult, switch to a triple-coaxial system using a 125 cm diagnostic catheter (JB-2). If the diagnostic catheter is raised but the guiding catheter does not follow, the diagnostic catheter can be raised first and then catheter exchange can be performed with a 260-cm guidewire.

Microcatheters

Catheter Diameter

The smaller the diameter of the microcatheter, the smaller the branches in which IA infusion can be done. On the other hand, the thinner diameter reduces contrast and increases kickback during drug infusion. In addition, the use of coils may become impossible, forcing the use of thinner, less maneuverable microguidewires.

This means that when determining the tip diameter of the microcatheter, it is desirable to select one that is reasonably large, within the range allowed by the diameter of the vessel in which placement will be done (more precisely, the depth to which it is to be placed). To do this, it is necessary to predict in advance which artery will receive the infusion, and it is required to assess the feeding artery based on the area of tumor extension using CT and MRI images taken in advance. For example, in the case of a maxillary sinus cancer or a tongue cancer with a typical extension pattern, it would be better to select 2.0F or larger since it is expected to be infused from the main trunk of the lingual artery or the large internal maxillary artery, while in the case of a base of tongue cancer that extends beyond the lingual tonsillar groove, it may be necessary to select 1.8F or smaller since it may target a thin tonsillar branch. If it is the first treatment, the prospect of performing a coil-based blood flow alteration procedure will be added to the decision-making process.

Microcatheters with diameters of about 2.3-2.5F can be easily selected for the main arteries (such as the internal maxillary, facial, lingual, and superior thyroid arteries). Microcatheters of 2.0-

2.1F can be placed in secondary branches from these. When the thinnest branch (dorsal lingual or tonsillar branch) is selected, a 1.6-1.8 F microcatheter is often required.

Catheter Length

Microcatheters used in Japan include those with effective lengths of around 110 cm, 130 cm, and 150 cm, of which 110 cm are not long enough to be used. In most cases, 130 cm or 135 cm is sufficient for IA infusion. Products with an effective length of 125 cm (e.g., Veloute) have a slight advantage in contrast and followability, but may not be long enough for selective placement in the four terminal branches of the most distally located internal maxillary artery or in the angular artery. There is also a high risk of “neck breakage” as described below.

An exceptional case in which 130 cm is not long enough is when the tip of the guiding catheter can only reach the lower carotid artery due to strong sclerotic changes in the main arteries such as the aorta and common carotid artery. If the third segment of the internal maxillary artery or further or the angular artery must be selected in this situation, 150 cm may be needed. 150cm is also better when a triple-coaxial system is used.

In other cases, there are situations where blood flow modification with coils is planned for initial treatment, but the safe range of the artery in which the coil will be implanted is limited, forcing the use of a detachable coil. In this case, a 2-marker product will be selected for the microcatheter, so the catheter length is automatically 150 cm.

Even if there is no shortage of length, it is not advisable to use the catheter until its effective length is exhausted. The reason is that the latest small-diameter products (1.6-1.8F) have a very thin wall thickness in order to achieve both thinness and flow rate, and when the catheter is inserted all the way to the root (because the Y connector protrudes diagonally upward from the groin), the hub part often hangs down by its own weight, causing the shaft of the catheter to kink (so-called “neck breakage”). To avoid this situation, a 150 cm product should be prepared in advance if the length of the microcatheter is expected to be insufficient.

If you start a procedure with a 130-135 cm microcatheter and find that it is not long enough, do not rush to get a 150 cm product, but try replacing the Y-connector with a hemostatic valve first. It can extend the effective length by 4 cm for about 1/40th the price of a microcatheter. However, the hemostatic valve is somewhat complicated to handle because the heparinized saline route connected to the side tube must be rotated together when the guiding catheter is rotated.

Manipulation in the Head and Neck, and Required Characteristics of Microcatheters

As mentioned earlier, the external carotid artery system is prone to vasospasm. Therefore, when selecting a target branch with a micro guidewire, the so-called “kuru-kuru method,” which uses probability theory by repeatedly spinning the wire, is not recommended, and the wire should be advanced with as few insertions and removals as possible. To do this, it is necessary to know the three-dimensional shape of the origin and to keep the tip of the microcatheter close to the target branch and oriented toward the origin of the branch. In other words, the tip of the microcatheter should be pre-shaped or manually bent (about 90° is desirable). It is not recommended to perform the procedure with a straight shape.

In addition, some target vessels (e.g., transverse facial artery, ascending pharyngeal artery, ascending palatine artery) may spasm even if the wire is advanced protectively, and in such cases, the wire should be placed into the branch by catheter advancement without exiting the tip (non-guidewire technique). Such a situation is not rare in IA chemotherapy. If all procedures can be performed over-the-wire technique, a microcatheter with excellent follow-up capability (e.g., Veloute) is recommended. However, Veloute has extremely thin walls to ensure flow velocity as well as followability, so it often kinks when torque is applied without a microguidewire in it. If a catheter advance is required, the Carnelian PIXIE ER/LP, which has superior pushability and torque transfer capability rather than followability, or the ProgreatΛ17, which has both followability and pushability/kink resistance, would be preferable.

Tip Shaping of Microcatheters

Steam or hot air guns are used to shape a catheter tip. When using steam, insert the included stylet from the tip of the catheter and bend it to twice the angle you want it to be, wipe off any water droplets well, and expose it to steam for 20 seconds. If using a hot air gun, insert the stylet in the same way, bending it as much as the angle at which you want it to be, and expose it to hot air at 150°C for about 40 seconds. We use a hot air gun manufactured by BOSCH. Tip shaping can be performed immediately when it becomes necessary, and has the advantage of slower return to shape due to body heat compared to when using steam. However, some catheters get a hardened tip or have an elliptical deformation of the cross section, which makes it difficult to pass through the Y connector. In this case, steam is used.

Combination with a Microguidewire

Note that for 1.8F microcatheters, microguidewires of 0.016“ diameter can be used, while for 1.7F (except Veloute and ProgreatΛ17), only guidewires of 0.014” or smaller can be used. There are also combinations with adjusted compatibility outside the catalog specifications, such as 1.5F Veloute Ultra and Meister S14.

In the combination of a 1.8F microcatheter or larger, especially 2.0F, and a 0.014-inch-diameter microguidewire, beware of poor catheter tracking (so-called Ridge effect) due to the large difference in diameter between the two.

Using Coils for Arterial Embolization

Standard embolic coils (fibered platinum coils) can be used up to 1.9F microcatheters. While 1.8F products are generally usable, they may be out of the manufacturer's warranty and may become easily stuck after repeatedly passing coils through. We avoid the combination of 1.8F products and Vortex in our hospital. Below 1.7F, mechanical or electrical breakaway coils (virtually the only ED coil available with a single marker) or C-Stopper 0.014” Filling Coil may be used. Although the C-Stopper coil is a bare platinum coil and therefore has less immediate embolic force, it is a good option in cases where you may hesitate to use the detachable coils. The 1.5F Veloute Ultra has a tip inner diameter of 0.015“, and according to specifications, a 0.014” coil will pass through it, but not a coil pusher (most coils have a 0.017“ to 0.018” tip; even the thinnest C-Stopper is 0.015"). If a coil embolization is absolutely necessary, you should choose a detachable coil, even if it is more expensive, instead of taking the risk of injecting water forcefully from a

syringe, using the water pressure to push a short coil forward in the catheter, or using the end of a microguidewire.

Small Diameter Catheters and Micro Snares

Some microcatheters around 1.8F will not pass through a micro snare (e.g., Bishop, Cross I Legato) even if a coil or coil pusher can be used. A micro snare will pass through a lumen of 0.021“ at the tip according to catalog specs; in practice, it will pass through a lumen of 0.020”. If your facility can use detachable coils on a regular basis, there is no need to be concerned, but if your facility exclusively uses pusherable coils for blood flow alteration procedures, it is a good idea to have a micro snare available just in case. In rare cases, embolization of the shallow temporal artery or middle meningeal artery can cause coil deviation.

Contrast Capability

As for the contrast capability of microcatheters, there is no problem for products up to 2.0F. The 1.8F and 1.7F products may cause unsatisfactory injection pressure with the disposable syringes normally included in angiography kits (the syringes break if sufficient contrast intensity is attempted). Contrast can be adequately achieved by using a syringe intended for the use of contrast enhancement, which will be discussed later. 1.6F products are often inadequate for imaging from areas with high flow velocity, such as the lingual artery and proximal facial artery, even when using a syringe dedicated for contrast enhancement (The exception is 1.5F Veloute Ultra, which has a flow rate of 2.0 to 2.5 mL/sec and has sufficient practical contrast capability for head and neck IA infusion). Even at 1.8F, 150-cm microcatheters and microcatheters with non-tapered lumens designed for coil delivery have clearly inferior contrast performance.

Distal End Movable Microcatheter

The Leonis Mova® so-called “steering” microcatheter manufactured by SB Kawasumi is the world's first microcatheter with a movable tip. It was developed based on Toray Medical's Estream® and is quite similar in characteristics. Three types of tips (2.0F, 2.4F, and 2.9F) with lengths of 125 cm or 150 cm are fitted for the head and neck region, and the tips are edge-removed (slightly tapered). The 2.4F type performs well enough to be used for infusion from primary feeding arteries, but is not suitable when selecting small branches, such as the infraorbital, accessory meningeal, and ascending palatine arteries. It is also less flexible and is more likely to cause vasospasm if it is advanced distally when selecting the transverse facial artery or facial artery. The 2.0F type is practical enough in terms of tip diameter, but its straight (non-tapered) lumen makes contrast performance extremely poor, requiring the use of an automatic injector for DSA. The 2.9F type demonstrates its full performance in a triple-coaxial technique combined with an even thinner microcatheter.

This device has a higher reimbursement price than regular microcatheters (75,900 yen), making it difficult to use frequently. However, it is highly effective when used at critical points in the 7-unit IA infusion. For example, during the initial IA infusion, the surgeon may not have a clear understanding of the three-dimensional positional relationship of each branch and its starting angle, and the optimal tip shape of the microcatheter is not yet known, making it difficult to select a branch, and prolonging the initial treatment. The steering microcatheter almost completely solves the problem of microguidewires not reaching the target branch due to the tip shape of the microcatheter, especially the insufficient curve diameter. It also has many advantages by enabling

switching to the loop technique at any time and avoiding kickback by actively rotating during coil embolization.

Balloon Catheter with a Side Hole

Patients sometimes have very narrow feeding arteries that make superselective microcatheter placement difficult. In such cases, coil embolization (blood flow alteration) of the distal portion of the mother artery is the usual procedure, but permanent embolization may not be desirable if the mother artery is an important blood supply to healthy tissues. The balloon catheter with a side hole is a device that attempts to solve the above problem by occluding the mother artery with a temporary balloon and releasing the anticancer drug through a separate lumen in front of it. Micro Sight® (Fuji Systems), approved in 2011, was the forerunner in Japan, but its 3.3F tip was too thick for use in the head and neck region, and its contrast performance was inadequate. In addition, problems such as the tip at the end of the flow stopper which controls the flow path in the lumen falling off have prevented widespread use of the device.

Logos Switch® (Piolax) is a new balloon catheter with a side hole that does not have a flow stopper, but uses the balloon itself to change the flow path to achieve an ideal tip diameter of 1.8F. Although the lack of compatibility with automatic injectors and the fact that the head and neck region is not indicated remain problems, it is expected to work well in IA infusion in several areas, including cancer of the anterior wall of the oropharyngeal (root of the tongue).

Microguidewire

Micro guidewires with a 0.016-0.014” diameter and 90° angle tip are most used. Depending on the branching angle of the target vessel, a double-angle type may be used. A formable tip is also acceptable. When using 1.8F or larger microcatheters (and 1.7F Veloute/ Progreat λ17), microguidewires of 0.016“ (Meister) or 0.014” (Meister S14, Chikai Black, Chikai Black Soft) is selected. When using 1.6F microcatheters, the only micro guidewire option is 0.014” (Meister S14, Chikai Black).

Micro Guidewire Tip Shaping

The tip of the microguidewire should be bent to a 90° angle as close as possible to the tip using a shaping needle. The major branches of the external carotid artery, especially the internal maxillary and facial arteries, tend to have many side branches emanating from the outside curve. When a straight guide wire is advanced, the tip of the wire hugs the outside curve, causing it to enter the side branches one after another. Bending the wire tip solves this problem and prevents vasospasm.

Also, in situations where a small target branch originates from a large mother vessel, a small bend at the end of the microguidewire will not be enough to select the branch, and the physician may try to reshape the wire to increase the bend. However, this would make it difficult to advance the wire to the distal portion of the branch (due to increased vascular resistance caused by the large bend), even if the target branch could be successfully selected. In the head and neck region, a large curve is often temporarily formed by aligning the direction of the microcatheter tip bend with that of the microguidewire tip bend to select a branch without reshaping the wire.

Ridge Effect

Microcatheters with a tip diameter of 1.8F or greater are compatible with 0.016” diameter microguidewires. When this catheter is paired with a 0.014-inch-diameter wire, a ridge occurs at the tip of the catheter due to the difference in diameter between the wire and the catheter. Then, when selecting a target branch, the catheter may get caught on a ridge where the branch originates from the mother vessel and not follow the catheter any further, even though the wire can be advanced to the distal portion of the branch (ridge effect). 0.014-inch-diameter wires are often used since 0.016-inch-diameter wires can often be a cause of vasospasm in the head and neck region. Depending on the choice of catheter, there may be combinations that can cause a ridge effect. If this situation occurs during the initial IA infusion, it is a good idea to consider resizing the device.

CHIKAI Black 14 Soft Tip

With a diameter of 0.014”, this product is the first choice among the CHIKAI series of microguidewires for the head and neck region. Tip shaping is possible and the gap with the microcatheter is small, which is effective when following a catheter from a large-diameter mother vessel to a small branch that originates at a steep angle. The tip of the soft tip model is soft and does not easily cause vasospasm even when advanced with a J shape (so-called “knuckle” technique). However, the middle part is conversely made stiffer and may cause vasospasm proximally when advanced to the peripheral end of strongly tortuous vessels such as the facial artery. Torque responsiveness is relatively good; CHIKAI was considered to have a poor sliding property, but this problem has been improved with the polymer coating applied to CHIKAI Black and Meister.

CHIKAI X 014

Also 0.014” in diameter, this model has been improved with a focus on both flexibility and torque response. Fine tip shaping is possible, and the torque responsiveness is very good. As for torque, surgeons accustomed to conventional models may find it rather peaky. It is sometimes used as a reliever when encountering a branch that is very difficult to select, but its maneuverability has more than a few quirks, so regular use requires familiarity.

Meister S14

This 0.014” diameter microguidewire is less maneuverable than the above CHIKAI Black 14 soft tip. However, only when 1.5F Veloute Ultra is selected as the microcatheter, it is very compatible with this wire and fully brings out the full performance of the catheter. It is recommended that they be used as a set.

Meister

This is a 0.016” diameter microguidewire. It is an excellent product with outstanding operability, selectivity, breakthrough force, and followability. However, the 0.016-inch diameter may cause vasospasm in vessels in the head and neck region despite the most conservative manipulation possible, making it a hesitant first choice. It is best used in situations where the microcatheter will not follow the 0.014” diameter wire by any means, where it seems to be insufficient, or in situations where the aforementioned ridge effect becomes a problem.

Contrast Syringes

Although the performance of microcatheters has improved over the years, it is still not easy to achieve adequate contrast manually from catheters with diameters smaller than 2.0F. When using the disposable syringes (2.5 mL) included in regular angiography kits, it is not uncommon for the pusher (plunger) to break off when a certain amount of injection pressure is applied. The 3-mL syringe (Medallion), which is specially designed for contrast, costs a little more per unit, but provides surprisingly good contrast even from a thin catheter. It is recommended that they be used during IA infusion.

There are also several microcatheter products that include a contrast-only syringe. Some of these accessories have the same contrast performance as the Medallion. Note that some products have a very slippery gasket on the tip of the pusher, and if left connected to a microcatheter, arterial pressure can cause blood to flow backwards.

Contrast Agent

The viscosity of the contrast agent affects the injection rate, and the osmotic pressure affects the thermal sensation and immediate adverse reaction. To avoid involuntary movement of facial and masticatory muscles due to heat sensation during imaging and to obtain images without motion artifacts, select products with the lowest possible osmolarity (and even better if the viscosity is low).

The ionic dimer formulation (Hexabrix), which had a high affinity for the head and neck region due to its low heat sensitivity and low risk of thromboembolism, was discontinued in 2017, leaving two options for contrast agents: nonionic monomers and nonionic dimer formulations. It is advisable to use contrast agents that each facility is familiar with when dealing with adverse events, while combining systemic heparinization and premedication with corticosteroids, depending on the case.

While there is no respiratory movement or peristalsis of organs in the head and neck region, involuntary swallowing movements due to the thermal sensation of the contrast agent, as mentioned above, are a serious obstacle to imaging. This, allergy risk, and thrombogenicity are three factors that must be weighed when selecting a formulation.

Nonionic Monomers (e.g., Iopamilon)

Nonionic monomer preparations have a relatively low risk of iodine allergy. On the other hand, its lack of anticoagulant properties slightly increases the risk of thromboembolism. This risk can be reduced by mixing 1,000 units of heparin per 100 mL of contrast agent. In addition, contrast of the tongue and pharyngeal region may not produce satisfactory images because the patient's body movements may not be controlled due to the strong thermal sensation.

Nonionic Dimer (Visipaque)

Nonionic dimer products are not actively used because delayed allergy was once a major problem, but a product currently on the market (Visipaque 270) is reported to have the same infrequency of adverse events as ionic dimers. The low thermal sensation during IA infusion is outstanding, and this contrast agent should be the first choice at any facility that employs it.

Equipment

Angiography

IA chemotherapy in the head and neck is a procedure that can be performed with a single-plane angiography. However, since branches of the external carotid artery system often require observation from multiple directions, a biplane system is even more desirable. Facilities such as cancer centers (since they may not have cardiology or neurosurgery departments) are likely to have only a single-plane system. In this case, it is important to ensure proper working angles through oblique positioning. Since the C-arm angle will be moved frequently depending on the target vessel, it is advisable to be familiar with the memory function.

It is highly desirable that IA-CT/CTA can be imaged. Angio-CT which has a CT system attached to it has excellent contrast resolution and is useful for IA-CT. On the other hand, cone-beam CT, in which a flat-panel detector is rotated for imaging, has superior spatial resolution and is considered useful in IA-CT angiography. However, there is no definitive difference between the two at the clinical level, and imaging with either one is acceptable.

Auto-injector

An automatic injector is used for IA-CT/CTA imaging and injection of anticancer drug (cisplatin). This can be done with an automatic injector normally used for angiography. The range of adjustment of the injection rate should be in increments of 0.05 mL/sec. Even 0.1 mL/second increments are acceptable, but somewhat less accurate. In angiography, contrast agent is often injected manually without using an automatic injector. This is because an optimal amount of contrast agent can be delivered to the periphery while avoiding backflow into the mother artery or internal carotid artery. One auto-injector can accomplish this by switching between contrast and anticancer drugs, but if two injectors are available, the procedure will be smoother. However, even in this case, the concentration of contrast agent used for IA-CT and IA-CTA is different (3x dilution for the former and undiluted for the latter), so refilling is eventually necessary.

Two-Cylinder Automatic Injector

A two-cylinder auto-injector and mixing tube can be used to inject any concentration of contrast agent without refilling, but in the two-cylinder system, the sum of the minimum injection rate of each cylinder is the minimum overall injection rate. Therefore, it may not be possible to perform arterial infusion at a very low rate of 0.1 mL/sec or 0.2 mL/sec as required in the head and neck region. When used, the performance specifications should be confirmed in advance.

Automatic Injector for Anticancer Drug Injection

IA infusion of anticancer drugs by automatic injectors is widely used throughout Japan regardless of the target organ, but at present the only injector approved for anticancer drug use in Japan is Seaman's “Zone Master® SR Fusion”.

Additional Information

The angio set, pressure bag, Y-connector, three-way stopcock, and pressure-resistant extension tube used at each facility are acceptable. For facilities that do not regularly use pressure bags, a PVC-free infusion set for pumps is recommended (with clear tubes and good bubble release). Infusion sets for cisplatin suction should be checked for with the hospital materials department for drug compatibility of the tubing material. Continuous perfusion with heparinized saline should only be performed on guiding catheters, not microcatheters.