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Progressive Suppleness Pursil Catheter: A New Tool for Superselective Angiography and Embolization

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Over the past few years, major advances in the development of new microcatheter systems have greatly improved the safety and efficacy of therapeutic endovascular techniques [1–4]. The ideal embolization catheter should have the following characteristics: simplicity of use, ability to negotiate tortuous curves with a minimum of manipulations and without trauma to the artery or induction of spasm, outer diameter small enough that the physical presence of the catheter in the vessel is not occlusive, and inner diameter large enough to permit a choice of embolic agents of various types and sizes. We present our experience with the Progressive Suppleness Pursil Catheter,* which helps fulfill these criteria.

Materials and Methods

The thermoplastic catheter material used to construct the Pursil catheter is as flexible as Silastic tubing, and has a smooth surface and low friction coefficient with the coaxial introducer catheter. When the catheter is heated, a curve can be made and/or the tip can be enlarged to a bulblike configuration to make the catheter even more flow-sensitive [1, 2]. The Progressive Suppleness Pursil 3F/1.8F Catheter (Fig. 1A) consists of a metal, braided, polyurethane, 105-cm, 3-French proximal portion to which is bonded a 15-cm, 2.5-French Pursil catheter; the last 10-cm segment consists of 1.8-French pursil material (polyurethane-Silastic compound). A gold ring is positioned in the tip of the catheter to increase the visibility at fluoroscopy. A 110° curve is present in the last 8 mm of the catheter. The pursil catheter material itself is impregnated with bismuth oxide and mildly radiopaque. Because of the floppiness of the last 25 cm of the catheter, a 0.010-inch (0.025-cm) stiffening mandrel must be positioned inside it for coaxial introduction through a 5-French or 6-French guiding catheter. The mandrel is then removed before the microcatheter emerges from the tip of the guiding catheter. Care should be taken to push the catheter slowly because the soft portion may buckle itself in larger caliber vessels when it is pushed too rapidly. A variant of the tip of the 1.8-French catheter (Fig. 1B) is available for use with detachable, inner-valve balloons,[†] in which a 3-mm, 1-French Teflon tubing protrudes from the end of the 1.8-French catheter. The detachable, inner-valve latex balloon is mounted on the 1-French "peg" and detached by continuous gentle traction. Round and oval balloons with inflated volumes between 0.20 and 3.0 ml are available for use with this system. Larger variants of the catheter (3-French,

4.5-French) (Figs. 1C and 1D) are available for injection of particles (<250 μ m, <500 μ m, respectively), and they require either 5-French or 7-French introducer catheters. These variants do not have a distal gold ring.

Results

With the 3-French/1.8-French microcatheter, tortuous vessels can be catheterized and good quality superselective angiograms can be obtained (Fig. 2). Bench experiments showed that attempting wire manipulation can result in separation of the Pursil catheter from the proximal 3-French shaft because of friction between wire and catheter; therefore, this maneuver should be attempted only with extreme caution or should not be attempted at all. Two or three separate injections per catheter may be performed providing the following steps are followed: a homogeneous mixture of tantalum powder (1 g) and iophendylate (0.3–1 ml, depending on the polymerization time desired) should be obtained by gentle swirling before addition of 1 ml of isobutyl 2-cyanoacrylate (bucrylate) (IBCA); a 25-gauge needle should be used to aspirate the supernatant portion of the IBCA-iophendylate-tantalum mixture in order to prevent loading of clumps (which can block the microcatheter) into the embolization syringe (1-ml Luer lock); with the microcatheter loaded with 5% dextrose in water solution (D₅W), no more than 0.3-ml IBCA-iophendylate-tantalum mixture should be initially loaded via a three-way stopcock; then the mixture should be pushed through using either a 1- or 3-ml syringe containing D₅W; after removing the stopcock and syringes, at least 5 ml of D₅W should be flushed through the catheter. Despite these precautions, deposition of small amounts of tantalum powder on the inner wall will cause progressive narrowing of the catheter lumen; this increases the force required for injection and can eventually result in occlusion or even rupture of the catheter near its junction with the 3-French segment. Hence, the total number of IBCA injections should not exceed three per catheter if the described steps for IBCA preparation are followed (if they are not followed, only one injection of IBCA should be performed per catheter).

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Fig. 1.—A, 3F/1.8F Progressive Suppleness Catheter for embolization of fluid embolic agents.

B, 3F/1.8F Progressive Suppleness Catheter modification with 1-French Teflon tip for use with internal-valve, detachable-balloon system.

C, 3F Progressive Suppleness Catheter for embolization of particles <250 μ m.

D, 4.5F Progressive Suppleness Catheter for embolization of particles <500 μ m.

M = mandrel.

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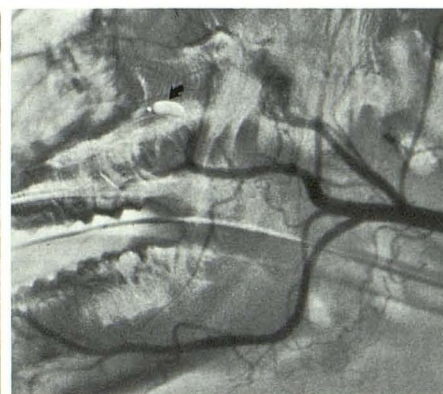
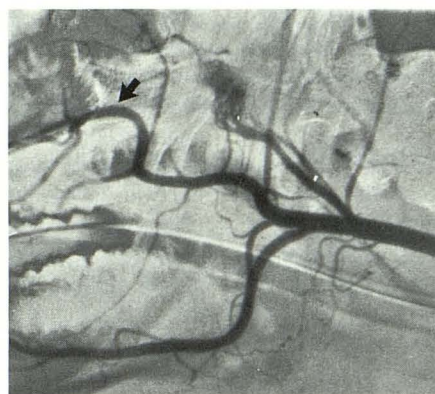
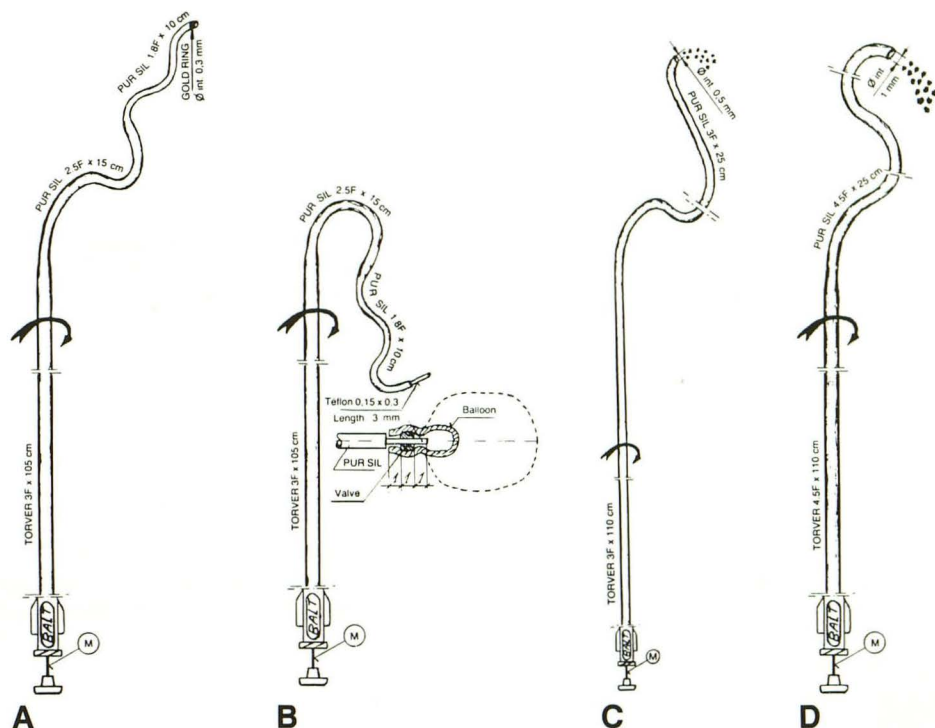


Fig. 2.—Superselective angiogram (lateral projection) of left superior cerebellar artery (distal to brainstem perforators) feeding a vermian arteriovenous malformation. 3F/1.8F Progressive Suppleness Pursil Catheter was used.

Fig. 3.—Common carotid angiogram (lateral projection) in pig before (A) and after (B) balloon embolization (curved arrow) of distal internal maxillary artery (straight arrow).

Table 1 summarizes the authors' experience with the different types of Progressive Suppleness Pursil Catheters in humans and animals with IBCA, polyvinyl alcohol foam, or detachable latex balloons as embolic agents. The 1.8-French variant for fluid embolic material embolization was used in 16 patients with brain arteriovenous malformations to embolize 34 feeders. In one patient, a transient spasm of the distal left vertebral and basilar arteries precipitated severe nystagmus and vertigo, which disappeared within 5 min of catheter removal. We postulate the jet effect of the catheter tip may have irritated the vessel wall and caused the spasm. In the remaining 15 patients, catheterization and embolization were uneventful. Detachable balloons were easily navigated and

detached in various distal sites of the pig external carotid artery (Fig. 3); we have not yet had the opportunity to use this system in humans, but good results have been reported in other centers (personal communication, Jacques Moret and Mario Hébert).

Discussion

Superselective catheterization is important in the proper evaluation, planning, and treatment of vascular system diseases. In the cervicocephalic territory, the use of conventional catheters is hampered by the presence of many tight curves, preventing distal catheter placement, and by the exquisite

TABLE 1: Authors' Experience with Progressive Suppleness Pursil Catheter

Catheter Type	Number of Subjects	Number of Feeders Catheterized	Pathology	Embolitic Agents
1.8 French	16	34	Brain arteriovenous malformation	IBCA
1.8 French with balloon	5 (swine)	5	Normal external carotid artery	Latex balloon
3.0 and 4.5 French	4	5	Epistaxis; juvenile angiofibroma	PVA (250–590 μ m)

Note.—IBCA = isobutyl 2-cyanoacrylate (bucrylate); PVA = polyvinyl alcohol foam.

sensitivity of the external carotid artery system to catheter-wire manipulation, resulting in vasospasm.

In order to overcome this problem, calibrated-leak balloon, 2-French, Silastic catheter systems were developed [5], but they were cumbersome to use because the catheter material was so floppy it had to be injected using an embolization chamber. Rupture of a vessel by the balloon was a significant risk, which has been well described in the literature [5, 6]. Only liquid embolic agents could be injected through the small hole of the calibrated-leak balloon [3].

In 1986, Rufenacht and Merland [1, 2] reported their experience with embolization using thermoplastic catheter material. The flexibility characteristics were similar to those of Silastic tubing, but with much less friction, so that these catheters would slide easily through coaxial systems. The catheter tip could be flared and different curves could be given to the distal end using heat, thus creating a catheter with both flow and geometry-dependent characteristics, without the risks of balloon or wire manipulation.

The Tracker-18 catheter[†] [4] allows safe and efficient superselective catheterization of most cervicocephalic vessels; however, when the territory is tortuous, considerable wire-catheter manipulations are required. These maneuvers stretch and can potentially damage or perforate a vessel; if this occurs in fragile and eloquent arteries (such as the communicating arteries and the vertebrobasilar system), serious complications may result. Finally, it is not always possible to reach as distally as planned for a safe embolization with the Tracker catheter. On the other hand, one major advantage of the Tracker catheter-wire combination is its remarkable torquability.

The 3F/1.8F Progressive Suppleness Pursil Catheter makes catheterization of these vessels safe and technically simple. Because this catheter is flow-directed and the stiffer proximal portion makes pushing easy, no guidewire manipulations are needed; hence, there is no stretching and no risk of perforation. Many consecutive turns can be managed successfully because of the remarkable floppiness of the pursil material (Fig. 2). The presence of a gold ring in the tip makes its position easy to monitor on the fluoroscopic screen. Because of the small size of the catheter, small vessels can be catheterized without causing trauma and without compromising blood flow.

One drawback is the size of the inner lumen of the distal part of the 1.8-French catheter, which precludes embolization

of particulate agents; only a fluid embolic material can be injected. Up to two or three separate injections of IBCA may be performed per catheter if special attention is given to the preparation of the IBCA-iophendylate-tantalum powder mixture as described in this report. Otherwise, only one injection per catheter should be performed; this is important because catheter blockage and rupture will lead to spillage of embolic material outside the target area.

A second minor drawback is that wire manipulations are not possible (and potentially unsafe if attempted), so that the catheter is entirely flow-dependent; directional change is only possible through (1) the jet effect provided by injection of contrast material or saline or (2) change of the tip shape with steam. In our 16 brain arteriovenous malformations, superselective catheterization of 34 feeders was achieved easily, atraumatically, and rapidly, usually after prolonged or unfruitful attempts with the Tracker wire combination. The Progressive Suppleness Pursil 1.8F Catheter was especially useful in catheterizing anterior cerebral, distal (postopercular) middle cerebral, and superior cerebellar arteries. Because of the extreme suppleness of the pursil material, the detachable balloon variant worked well in the swine for navigation and detachment of balloons through various tortuous areas. Larger variants of the Pursil catheter (3-French, 4.5-French) are useful for embolization of particles, but some loss of flexibility naturally occurs owing to the larger size.

In conclusion, the Progressive Suppleness Pursil Catheter (in particular the 3-French/1.8-French type) is a useful addition to the tools used in endovascular therapy.

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