Practical Handbook of **Advanced Interventional Cardiology**

TIPS AND TRICKS

THIRD EDITION

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Foreword to the Second Edition

Interventional cardiovascular medicine has evolved from an extremely crude method of opening femoral arteries initiated by Dotter, to a field that has now been recognized as having a sufficient fund of knowledge to require boards sanctioned by the American Board of Internal Medicine. From Andreas Gruentzig's development of the noncompliant balloon method, we have seen an explosion of bioengineering technology. The discipline of interventional cardiovascular medicine has perhaps initiated more registries and clinical trials than any other discipline in medicine. Indeed, the whole emphasis on evidence-based medicine has evolved during the era of interventional cardiology. Many basic science breakthroughs have been stimulated by the advances produced in interventional cardiology, as well as the problems and complications created by the new technologies.

However, no matter how advanced the science becomes, the success of solving a patient's problem with interventional techniques usually depends on the operator's technical ability. This ability springs from the wealth of experience the operator has acquired to deal with routine situations as well as complex and almost unique problems that may present themselves. Because of the large number of interventional cardiologists and the rapidly expanding number of procedures that can be performed, it is difficult for many cardiologists to experience all of the situations that can be helpful in building this database.

Dr Thach N. Nguyen has prepared a remarkable book, rich with tips and tricks for performing interventional cardiovascular medicine procedures. He has enlisted numerous experts on various aspects of interventional cardiovascular medicine to describe their areas of expertise. Rather than let them recite the evidence from registries and trials that are available elsewhere, he forces the contributors to provide the practical tips that they have learned. It is almost as though Dr Nguyen is trying to simulate the type of scenarios that exist in the catheterization laboratories with new cardiology fellows or less experienced operators. It is the type of advice that he has often given to cardiologists in developing countries who are bringing interventional techniques to help cope with the rapidly expanding new threat in these countries, vascular disease. Since new techniques are constantly appearing, all operators, experienced or not, can benefit from these tips. Whereas every operator will not agree with every approach to a problem or a complication, it is always instructive to understand many potential approaches. In this regard, the book does a masterful job of collecting not only the authors' experiences, but those of many others collected from the published literature, from numerous postgraduate courses, and from one-on-one demonstrations throughout the world.

This book should be a valuable resource to trainees in formal programs that have now evolved in the United States and other countries, as well as the many preceptorships that are the major means of training in other countries. In addition, operators of all levels of experience will find many useful pearls of wisdom. Dr Nguyen and his colleagues are to be congratulated for compiling this most practical guide.

Spencer B. King III, MD
Atlanta, Georgia

Preface

ADVANCED INTERVENTIONAL CARDIOLOGY ART AND SCIENCE

In 2007, more than 25 years after its humble beginning, interventional cardiology is a mature and major player in the management of complex cardiovascular problems. Thanks to modern micro-technology and nano-engineering, with miniaturized equipment, the techniques of interventional cardiology have also made giant leaps forward to become ever-more effective and user-friendly. These techniques can be formulated as a sequence of rigorously controlled maneuvers which can be taught to fellows or staff, or programmed into robots. To understand and explain the physical, chemical, biologic, and engineering mechanism of any of these techniques or maneuvers is a science. To perform a procedure cost- and time-effectively in a humane manner is an art. In any interventional laboratory, a lesion could be dilated with one guide, wire, balloon or stent by a senior operator or by x (> 1) numbers of devices by a beginner. This is the result of mixing science and art.

Which is the Best Option to Apply to this Real-Life Situation? During a procedure, each operator (*or any commander on the battlefield*) has the luxury (*and the responsibility*) to select, to change, delete or modify direction, position of a device (*a tank*), a drug (*a battalion*), a strategy (*conventional, guerilla or urban house-to-house combat*); or to be forced to use one when the others are not available. These options are listed plentifully and discussed ad nauseam everywhere in the print or electronic media. However, the main question always remains: which one is the best option to apply to this real-world situation (*jungle or urban*), with the equipment (*arms and troop*) available in this particular cardiac interventional laboratory (*or in Iraq*)? In this third edition of this handbook, the authors try to answer this question and give practical suggestions derived from their own daily labor in the cardiac interventional laboratories.

In the "Strategic Mapping" boxes, the operator (*as commander*) draws in his or her mind a global schema of procedural sequences he or she would execute in order to achieve success (*victory*). This strategic map also includes preventive or corrective measures in case of crisis situations such as complications or suboptimal performance of any tactics or strategy.

In the "Tactical Move" boxes, the authors break up the whole strategy into detailed procedural sequences with limited local goals (i.e., tactics). At the beginning, it is how to select an appropriate device, e.g. guides (best choice among many), so it can achieve its goal at a

first attempt. Then, if a device does not function as expected, there are many simple maneuvers (best maneuvers chosen from many) to correct or reverse the situation. In any case, the operators try to exhaust the full potential of any device first without prematurely and wastefully discarding it. However, at the same time, while there are many parallel competing tactics or strategies, which one is objectively best in which situation? This is the role of critical thinking, because a subjective change of tactics could save the whole procedure and lead either to success or to our worst nightmare. In this section, each maneuver is graded according to time spent, cost of extra equipment and the level of risk of complication. For every extra 10 minutes, it is one more hour on the clock. One dollar sign means that $100.00 US extra are spent. One drop of blood is the symbol for moderate complication; for two drops, there is high risk.

In the "Caveat" boxes, we warn the readers of any treacherous images, deceiving roadside sign posts or wrong moves that harbinger impending disaster. This information combines past personal failures, near death experience of the patient (*or of the operators*) and successful (*almost miraculous*) resolution of the critical events. Altogether they constitute a collective memory of how to avoid failure and how to achieve success: this is called experience. If the hard earned lessons of that collective memory are applied in real life, the rate of procedural success would be higher and the incidence of complications would be lower. The rate of complications depends on the operator's skill, the technology available, and patient selection. Rigorous preventive measures learned from that collective memory (i.e., experience) preempt the appearance of complications (*one of the best ways to avoid EVERY complication is to perform NO procedures*). With the use of current low-profile balloons and high torqueable wires, most patients with "simple" stenoses will have good results, even in the hands of relatively inexperienced operators. However, in patients with complex anatomy or when simple cases become complicated, experienced operators are likely to have superior outcomes. This is what experience is for [1].

To the readers who are all friends and colleagues: The authors and editors, who are all your friends and colleagues, labor every day in the cardiac interventional laboratories, like yourself. We write from our limited subjective experiences and our hearts, during many sleepless nights. This handbook contains practical advice aimed at you the readers, and at us, the authors ourselves. We practice what we preach. They are not from an ivory tower: they are practiced by those with experience and beginners, by the young and old, by men and women, by serious operators and by the urban week-end warriors, so there are no questions of class, age, sex, or race division here. In this book, we try to highlight these practical suggestions with all of the dramatic colorings or ups and downs – reminiscent of an Italian opera – which happen daily in every interventional laboratory

across the globe. However, we hope the outcome of these procedures is always happy and beautiful as the end of any Chinese martial arts movie.

The bottom line is that we practice interventional cardiology in a responsible manner: cost- and time-effective without causing more harm (*prima non nocere*). All of us are equal in this quest of striving for the best procedural and clinical success. This is the only goal of this handbook.

REFERENCE

1. Ellis S. Elective coronary angioplasty: Techniques and complications. In Topol EJ, editor. Textbook of Interventional Cardiology. 3rd edition. Lippincott-Raven Publishers. pp. 147–62, 1998.

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Chapter 1
Vascular Access

Thach N. Nguyen, Hoang Pham, Ta Tien Phuoc

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- ***Preclosure of the venous access with the perclose
- **Caveat:** Suspecting intra-arterial deployment of collagen plug

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*Basic; **Advanced; ***Rare, exotic, or investigational.

$ < 100.00 $US extra; **$$** > 100.00 $US extra

⧖ < 10 minutes extra; ⧖⧖ > 10 minutes extra

♦ low risk of complications; ♦♦ high risk of complications

FEMORAL APPROACH

Locate the femoral artery and inguinal ligament that runs from the anterior superior iliac spine to the pubic tubercle. The true position of the inguinal ligament is 1–2 cm below that line [1]. Ninety-seven percent of patients have the femoral artery lying on the medial third of the femoral head. Only 3% have the artery totally medial to the femoral head [2].

Preparations in Obese Patients: The femoral pulse at the inguinal crease is not a reliable landmark for the common femoral artery (CFA), particularly in the obese or elderly patients whose crease tends to be much lower than the inguinal ligament. The protruding abdomen and panniculus should be retracted, and taped to the chest with 3- to 4-inch tapes that are in turn secured to the sides of the catheterization table. Keep the tissue layer above the artery as thin and taut as possible, so the needle will not be deflected from the projected angle and selected pathway.

TECHNICAL TIPS

***Directing the Needle:** Once the needle tip is near the artery, it tends to pulsate except in those patients with severe local scarring (following many prior remote femoral artery cannulations, total hip replacement, or in severely calcified arteries etc.). If the hub inclines to the right, the needle should be withdrawn by 1 or 2 cm and the tip redirected to the right before advancing forward. If the hub inclines to the

left side, the tip is redirected to the left before pushing in. If the needle pulsates on the vertical axis, it just needs to be inserted deeper [2].

***If the Wire Cannot be Inserted:** Most often, this is because the needle hit the contralateral wall. Just move the needle by a slight pull or rotate it a little, the wire may be able to be inserted. If there is a problem, it is better to withdraw the needle and re-puncture the artery rather than dissect the artery with a slippery wire [3]. After the sheath has been inserted where there is strong arterial back flow and the wire is not able to negotiate the tortuous iliac artery, then pull the sheath a little (to disengage it from under a plaque if that is what has happened) and a gentle injection of contrast may help to delineate the anatomy and determine the reason why the wire could not be advanced. If there is no strong back flow, then the sheath is not in the arterial lumen. In a very tortuous iliac artery, a diagnostic Judkins Right (JR) catheter can be inserted with caution and advanced in order to help steer the wire tip. Injection through the JR would also help to find out why there is a problem advancing the wire.

***Sequential Order for Arterial and Venous Puncture:** The order of arterial and venous access is often a matter of personal preference. We prefer to puncture the vein first and insert a wire inside the vein to secure the access. Then, less than a few seconds later, after puncturing the artery, we would insert the sheath into the artery and the vein. Because there is only a wire in the vein, there is minimal distortion of the arterial puncture site, which may be caused by the placement of the venous sheath. Less than 1 minute without a sheath will not produce a hematoma at the venous site. If inadvertently the artery is punctured first, we would cannulate the artery, then puncture the vein under fluoroscopy, with the needle medial and parallel to the arterial sheath.

****Kinked Wire:** It is not unusual that the wire will pass into the lumen easily but attempts to advance any dilator over the wire will result in kinking of the wire at the point of entry. Instead of exchanging the wire, if the wire is not too crooked, the first best maneuver is to advance the wire further, so the dilator can be advanced to dilate the entry site on a straight and stiff segment of the wire. If the wire is too soft, then the second best maneuver is to exchange the softer wire with a stiffer wire over the needle at the straight portion or over a smallest size 4F dilator [4].

****Puncture of Pulseless Femoral Artery:** As usual, the artery should be punctured over the middle of the medial third of the femoral head. Localize the skin puncture site by fluoroscopy just below the inferior border of the femoral head in order to prevent high punctures (above the inferior epigastric artery) that may lead to uncontrollable bleeding. However, these proportions are valid only in the anterior-posterior (AP), neutral position. Internal or external rotation of the femur can considerably change the relationship of the femoral artery

to the femoral head [5]. Another way to puncture the femoral artery is to use Doppler guidance with the SmartNeedle (Escalon Medical, New Berlin, WI), which is an arteriotomy needle that incorporates a continuous Doppler probe, and enable the identification of arterial or venous vessels by means of continuous auditory feedback. This technique is very helpful in puncturing an artery with very weak pulse or a pulseless artery, especially when the standard anatomy is disturbed by a large hematoma, or thick scar after surgery for artificial femoral head replacement [6].

***Puncture in Cyanotic Patients:** In children with cyanotic heart disease, especially those weighing less than 15 kg and with severe polycythemia, the blood flow from a femoral puncture can resemble a venous sample: a gentle flow of dark blood. This color is due to arterial desaturation and hyperviscosity secondary to polycythemia. If there is doubt, confirm the arterial puncture by attaching the needle to a pressure transducer or by making a small contrast injection into the arterial lumen [7].

TROUBLE-SHOOTING TRICKS

***Insertion of Intra-Aortic Balloon Pump (IABP) Through Diseased Iliac Artery:** When an IABP needs to be inserted and an iliac lesion is found, the lesion should be dilated first. Insert the balloon pump, then perform stenting of the lesion later after the IABP is removed. When a balloon pump is to be inserted through a previously stented iliac artery, do it under fluoroscopy to be sure the balloon does not get stuck on the stent struts. To remove the IABP deflated balloon, insert a large femoral sheath and withdraw the winged balloon into the sheath so the folds of the winged balloon are not caught by struts at the stent edges. Chronic endothelialization of the stent struts should diminish this problem.

***Two Catheters Inserted With One Puncture Technique:** Used in situations such as angioplasty for chronic total occlusion (CTO) when there is a need for contralateral injection. Another puncture higher or lower than the puncture site of the first site of vascular access, or in the contralateral artery, is suggested. However, if there is no need for another puncture, then change the sheath to an 8F introducer. There two 4-Fr diagnostic catheters can be inserted and attached to separate injection manifolds for diagnostic purposes [8].

Puncture of Femoral Bypass Graft: The problems involving puncture of an old vascular graft in the femoral area include: uncontrollable bleeding and hematoma formation because of the nonvascular nature of the punctured graft; disruption of the anastomotic suture line with subsequent false aneurysm formation; infection of the graft site; and catheter damage, kinking, and separation due to scar tissue in the inguinal area and firmness of the healed graft material [4].

Inadvertent entry to the native arterial system may lead to the dead-end stump in the common femoral or iliac artery.

TECHNIQUE Bypass Graft Puncture: Because the exact location of the suture line is not known, to avoid puncture of the anastomotic site, it is best to puncture the proximal end of the inguinal incision site or as close to the inguinal ligament as possible. To avoid kinking of the catheter at the puncture site, it is better to introduce the needle at an angle of approximately 30–45° to the estimated long axis of the graft [4]. Sometimes, because of severe scarring, the entry site has to be prepped by sequential dilation with small to progressively larger dilators **up to 1Fr** size larger than the sheath selected for the procedure.

TROUBLE SHOOTING TRICKS

***Parallel Technique:** If the native artery is punctured and the wire could not be advanced because the artery ends up with a dead-end pouch, then leave the small 4F sheath inside as a landmark. Palpate again the femoral artery and try to feel the two pulsations there: the first one is the native artery with the sheath and the second stronger and harder one is the bypass graft. Then puncture the second pulsatile artery while avoiding the one with the sheath in it. This can be done under fluoroscope guidance to avoid any area near the first sheath.

ANTEGRADE PUNCTURE

The antegrade femoral puncture can be greatly simplified and is more successful if the tissue thickness between the skin surface and the artery is as thin as possible. This may be made possible by placing a pillow under the buttocks. The hyperextension of the hip joint by this maneuver stretches the skin taut over the puncture site and decreases tremendously the tissue thickness. In obese patients, fatty panniculus may have to be retracted away from the puncture site manually and taped in position before the puncture is attempted [5].

TECHNIQUE Antegrade Puncture: The first step is to localize the CFA and its bifurcation under fluoroscopy. The CFA usually overlies the medial third of the femoral head and the bifurcation occurs below the lower border of the femoral head [3]. Once the landmark is located, to make the puncture, the needle may be directed toward the superior aspect of the femoral head, under fluoroscopy. The purpose of this maneuver is to prevent the inadvertent puncture of either or both the superficial femoral or the profunda femoral arteries. It is important to puncture the femoral artery as high above the bifurcation as possible so that there will be enough space between the puncture site and the bifurcation for catheter exchanges and manipulation of catheters into the SFA.

Using fluoroscopy, the site of the intended arterial puncture is identified (upper or middle third of the femoral head). The femoral pulse

is palpated against the femoral head. Local anesthetic is infiltrated 2–3 cm cranial to the intended site of puncture. A 18 gauge needle is advanced at 45–60° directed caudally, aiming at the intended site of arterial puncture. Once pulsatile flow is obtained, a soft tip wire is inserted toward the SFA. The wire should follow a straight caudal course in to the SFA. Lateral deviation indicated entry into the profunda femoral artery (PFA). The wire can be withdrawn and the needle tip deflected laterally to redirect the wire into the SFA.

TECHNICAL TIPS

****Manipulation of Wire:** If the wire was inserted into the PFA, it can be withdrawn and redirected by angling the tip of the needle medially toward the SFA. The other option is to have a wire with a curved tip and manipulate it so the tip points toward the SFA. The needle may be exchanged for a short dilator with a gently curved tip, which can be directed toward the SFA. This dilator can be withdrawn slowly from the PFA while injecting the contrast agent. Once the orifice of the SFA is seen under fluoroscopy, it can be selectively catheterized or it can be used to direct a wire into the SFA [5].

****Puncture of CFA with High Bifurcation:** In patients with high bifurcation, one single puncture can result in entries of both the SFA and PFA. When this occurs, the first spurt of blood may indicate that the PFA is punctured. Do not remove the needle completely. Instead, withdraw it slowly and watch for a second spurt of blood. At this point, the contrast injection may show that the needle is in the SFA. In the rare cases of high bifurcation, it may not be possible to puncture the CFA that is excessively high in the pelvic area [5]. When the bifurcation is located more proximally, puncture of the CFA is more challenging, especially in the obese. In these cases, it may be acceptable to selectively puncture and cannulate the SFA, if this appears without significant atherosclerotic disease and of adequate size [9].

****Puncture with Abduction and External Rotation of the Thigh:** Another option to cannulate the SFA is with the thigh in abduction and external rotation. The goal of this maneuver is to facilitate a more mediolateral puncture site in the CFA. In the usual antegrade puncture, the needle is seen to point more toward the PFA that is lateral to the SFA. In the abduction and external rotation position, the needle points more toward the SFA, and the PFA is seen medial to the SFA. This relationship is important when observing the course of the wire during its intended selective entry into the SFA. If the patient is punctured in this position, after the procedure, the local compression of the artery should be in the abduction and external rotation of the thigh because the puncture site is more mediolateral than usual [5].

BRACHIAL APPROACH

Even though the radial artery is the most common location used in the upper extremity, the brachial artery is still the access site of choice for procedures requiring a large sheath: subclavian artery stenting, renal stenting, or aortic aneurysm exclusion. The radial access is discussed in the following chapter.

TRANSLUMBAR APPROACH

In patients with total occlusion of arteries to lower and upper extremities, percutaneous coronary interventions (PCI) can still be performed through the translumbar approach [10]. This problem occurs rarely, only once in 6000–9000 cases. However, if the lumbar approach is the only access available in those rare circumstances in which conventional sites are not available, then it is worth offering the option to the patient [11].

TECHNIQUE Translumbar Puncture: The patient is placed in the prone position. Utilizing the left flank approach, an appropriate puncture site is selected, which is approximately four fingerbreadths lateral to the midline and two fingerbreadths below the left 12th rib margin. Verification that this position is below the posterior sulcus of the lung is made by fluoroscopy. After local anesthesia, a small skin incision is made with a blade and enlarged by the hemostat. The tip of the translumbar access needle (TLA) and the outer Teflon sheath (Cook, Bloomington, IN) are placed in the skin incision and directed toward the T12 vertebral body. Three successive attempts are made, with each increasing the vertical degree of the pass in order to "step off" the vertebral body. When the needle tip abuts the aorta, pulsation can be felt against the fingertip. The TLA needle is then given a short thrust until the initial resistance is not felt. The tip of needle is watched closely and should never cross the midline of the body. The inner stylet of the TLA needle is removed, and blood is seen at the hub. A floppy J wire is inserted and an introducer sheath is inserted in the usual fashion. Coronary angiogram and angioplasty are performed by the standard technique. After documentation of active clotting time (ACT) less than 150 sec, the sheath is removed without complication while the patient is in the prone position. Given the prone position of the patient, the fluoro scopic images appear in reverse, compared to standard images. This problem can be corrected by using the sweep reversal mode on the video monitor [10].

TRANSEPTAL APPROACH

Femoral and radial access is universally used for interventional procedures. However, in some patients with pulseless disease (Takayasu's arteritis), there are no arterial pulses in four extremities, then the PCI has to be done through the femoral vein approach. Tips and tricks for puncturing the septum are discussed and illustrated extensively in Chapter 24.

CAVEAT

Maintaining a Long Loop in the Ventricle: At all times, care must be taken to maintain a loop of catheter or wire in the left ventricular apex. Shortening of this loop to the straight path between the mitral and aortic valves could result in trauma to the anterior mitral leaflet causing acute mitral regurgitation [12]. There are few problems cannulating the left main (LM); however, it is difficult to cannulate the right coronary artery (RCA) because the catheters keep dropping into the ventricle when manipulated [13].

TRANSTHORACIC LEFT VENTRICULAR PUNCTURE

TECHNIQUE Transthoracic Apical Puncture: In order to perform left ventricular puncture, the left ventricular apex is identified by palpation or echocardiography. The skin and the intercostal space area below the apex is infiltrated with 1% xylocaine. Transthoracic puncture is performed, entering the chest wall in the intercostal space below the site of maximal impulse using a 5.5Fr $\times$ 20.5 cm One-Stem fluid drainage assembly (Electro-Catheter, Rahway, NJ). This assembly is composed of a trocar, a needle, and a pigtail catheter. The assembly is introduced percutaneously through the chest wall and directed posterior aiming to the right shoulder. Upon contact with the left ventricle, the assembly is advanced rapidly in a single motion aiming from the apex to the mitral plane. The needle and trocar are removed, leaving the pigtail catheter in the left ventricular cavity. The incidence of major complications of direct left ventricular puncture includes ventricular fibrillation (0.2%), tamponade (1.4%), pneumo- or hemothorax (2.7%), stroke or transient ischemic attack (0.3%), vasovagal reaction (1.0%), unsuccessful puncture (0.9%), and death (0.5%). In patients with multiple previous cardiac operations, this complication rate may be even lower as the pericardium becomes thickened and adhesive, making tamponade less likely to occur [14].

CLOSURE DEVICES

Closure device can be used after any procedure such PCI, valvuloplasty, IABP or due to inadvertent arterial puncture such as after cannulation of a subclavian artery instead of a jugular vein. The choice between collagen plugs and suture closure is largely a matter of personal preference and experience. The time needed to deploy the various devices is unique to each system. When physicians' time to utilize the device and staff time for adjunctive compression or puncture site management are considered together, sealing devices do not provide an advantage over manual pressure in decreasing complications [15]. Thorough training of operators in how to use any device is warranted to reduce vascular access complications. When deploying an AngioSeal device (St Jude

Medical Devices, Minneapolis MN), an iliac angiogram needs to show the artery diameter is at least 4 mm and there is no bifurcation within 2 cm of the arterial entry site.

Preclosure of Large Arterial Access: In cases where a large sized sheath is needed (e.g. for aortic valvuloplasty), preplacement of untied sutures using the Perclose percutaneous suture delivery system (Abbotts Vascular, Redwood City CA) prior to placement of a large intended sheath can be done. A 5Fr to 6Fr sheath may be used for arterial angiography to identify appropriate anatomy for suture delivery, and then a suture device is used to place untied sutures. At the end of the procedure, the existing "purse string" is then closed around the arteriotomy [16].

Preclosure of Large Venous Access: The technique of "preclosure" involves preloading a 6Fr Perclose suture closure device into the femoral vein after access with a 6Fr or 8Fr dilator, prior to insertion of a 14Fr venous introducer sheath used for antegrade aortic valvuloplasty. Intravenous placement of the Perclose device within the venous system is then verified by either back-bleeding from the marker port, or contrast injection through the marker port. Then the needles are pulled and the sutures clipped, and after the sutures are deployed, a wire is placed into the femoral vein through the Perclose device, and an exchange is made over the wire for a 14Fr sheath while the sutures are laid alongside of the puncture and covered with betadine-soaked gauze. Upon completion of the valvuloplasty procedure, a wire is passed through the 14Fr sheath to secure the vessel in case the suture closure fails. Heparin is not reversed. The sheath is then removed through the existing sutures, and the sutures are tied around the wire. If hemostasis is successfully achieved with the suture, the wire is gently removed, and the knot pushed further to complete the closure.

TECHNICAL TIPS

***Preclosure of the Venous Access with the Perclose:** Since veins are comparatively thin-walled, the amount of tension applied when pulling back the Perclose device is necessarily LESS than for arterial closure. It is possible to securely contact the vessel wall with the foot of the device while applying steady pressure, with LESS force than needed for arterial closure. Back-bleeding through the marker port occurs in the vast majority of cases. Due to the lower pressure in the venous system, this is of course less prominent than in arterial closure. Usually, a slow dribbling of blood from the marker port can be noted. There is a delay in the appearance of back-bleeding due also to the low venous pressure, and this may be accentuated by having the patient take in a deep breath or by employing the Valsalva maneuver [17].

CAVEAT

Suspecting Intra-Arterial Deployment of Collagen Plug: During deployment of an AngioSeal device, intra-arterial deployment of the collagen plug can be due to inadequate tension on the suture, vigorous tamping, too deep insertion of device into the artery then the anchor is caught in the posterior wall, etc. Suspicion of a problem is aroused when there is a long travel distance of the tamper tube or continued bleeding [18].

CASE REPORT Management of Intra-Arterial Deployment of Collagen Plug: In a case reported by Stein *et al.*, a possible intra-arterial deployment of the collagen plug was suspected. At that time, while inserting deeper the tamper tube, it was observed that it could be inserted much deeper than usual. The patient continued to bleed, so a tension spring was placed as usual. At that time, the author used a Hemostat to secure the end of the suture, and a FemoStop compression device (Femostop, Radi Medical Systems AB, Sweden) was applied above the AngioSeal to stop bleeding. Then the author waited for 4 hours, so the anchor that is composed of an absorbable polymer material, becomes softened and so pliable. A Hemostat was placed on the suture at the level of skin. If the suture were to break during traction, the hemostat would prevent the anchor and the collagen plus from embolizing. Then steady traction was applied to the suture, perpendicular to the femoral artery. The pressure should not be excessive. After 20 minutes, the plug was removed. The FemoStop was reapplied and hemostasis was achieved [18]. The management is summarized in Table 1-1.

Table 1-1 What To Do if Collagen is Inserted Intra-arterially [18]

1	Prevent the problem: always maintain tension on the suture and avoid tamping with excessive force
2	Recognize the problem: absence of resistance during tamping and inadequate hemostasis are clues
3	Duplex ultrasound can document intra-arterial collagen
4	Apply tension string in the usual fashion; secure suture with hemostat at the skin level to add security
5	**Do not cut suture:** embolization of the anchor and plug may occur
6	If there are signs of embolism and thrombosis, obtain vascular surgery consultation
7	Wait at least 4 hours to allow softening of the anchor
8	Steady vertical traction on suture with approximately 10 lbs of force
9	If removal of the device is achieved, maintain manual compression to achieve hemostasis
10	Femo-Stop device should be ready for rapid deployment after device is removed
11	Remove the collagen plug by atherectomy device (not needed)