Vascular Endoscopy for Intravascular Surgery
—An Experimental Study—

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Abstract

A combination of endoscope and high-pressure saline irrigation system was tested in the occlusion of experimental aneurysms, and angioplasty and fibrinolysis of vascular occlusive lesions in canine femoral arteries. Endoscopy provided detailed information about the aneurysmal orifice and lumen and aided balloon placement and detachment. Endoscopy visualized the dynamic changes accompanying thrombolysis and the fine intimal injury due to angioplasty invisible on angiography. Vascular endoscopy is valuable for pre-, intra-, and postoperative evaluation of intravascular interventions.

Key words: vascular endoscope, experimental aneurysm, balloon embolization, fibrinolysis, angioplasty

Introduction

Intravascular surgery usually uses radiofluoroscopic guidance and angiographic evaluation. However, radiological methods only define lesions by morphological changes in the vessel lumen, while vascular endoscopy can observe intravascular lesions directly.

Recent technical advances in fiberoptics have allowed the development of a high-quality, flexible endoscope with a diameter less than 1 mm. This endoscope can be inserted into coronary arteries, the extracranial cerebrovascular system, and other peripheral vessels safely and with minimal trauma. However, removing blood from the visual field has been a major problem.

We have devised a technique using a combination of a double-lumen balloon occlusion catheter and a high-pressure saline irrigation system to achieve an unobstructed visual field. We describe the experimental use of a vascular endoscope for balloon occlusion of aneurysms, and intravascular treatment of arterial occlusive diseases.

Materials and Methods

This study used an AS-001 vascular fiberoptic endoscope (Fukuda-Denshi, Tokyo) with 0.75 mm diameter and 205 cm length. The depth of the field of vision was 2–15 mm and the maximum field width 55 degrees. The endoscope was connected to an FCA-8000 video processor system (Fukuda-Denshi), and the image displayed on a color monitor.
Fig. 2  A: Angiogram, showing a well-shaped, saccular aneurysm (left). Endoscopy, demonstrating the orifice (asterisk) and common carotid artery (right). Note the sutures of the anastomosis at the orifice edge and folds with adherent clots.  B: Endoscopy, showing the inner surface of the aneurysm (right). Folds with anastomosis undetected angiographically (left) are clearly observed with the endoscope close to the lumen.  C: Endoscopy, showing the detachable balloon within the aneurysm (right). Note the protruding balloon tail and the thin clots covering the balloon surface. The protruding tail can be observed by angiography, but the thin clots are invisible (left).  D, E: Angiogram, showing complete aneurysmal embolization by the balloon, which protrudes slightly into the lumen (D, left). Endoscopy, demonstrating the endothelialized balloon surface (D, right). The balloon appears to protrude more than by angiography. Note the smooth transition of the surface to the arterial lumen. These findings are confirmed by the specimen (E).

A 6-French, double-lumen balloon occlusion catheter was introduced into the femoral or carotid artery by the Seldinger technique, and the endoscope was advanced to the tip of the guide catheter. Blood was eliminated by balloon inflation and continuous high-pressure saline irrigation (Fig. 1).

An 8 mm diameter carotid artery aneurysm was created in 40 mongrel dogs (weight, 12-13 kg) by anastomosing a pouch of jugular vein to the lateral wall of the common carotid artery. Angiography confirmed the presence of the aneurysm. Endoscopy then visualized the orifice and internal lumen of the aneurysm. The aneurysm was occluded with a detachable balloon (Dow-Corning, Kanagawa). Angiography and endoscopy were used to evaluate the balloon placement and study the endothelialization process of the occluded aneurysmal orifice.

Experimental arterial thrombosis and thrombolysis were induced by abrasion of the intima of 12 canine femoral arteries by 30 inflations of a balloon-
tipped catheter. The proximal and distal ends of the injured segment were then occluded with clips for 2 hours. Endoscopy demonstrated the formation of intraluminal clots. Tissue plasminogen activator (t-PA) (50,000 U) (Toyobo, Ohtsu) was injected intraarterially within 30 minutes. Endoscopy visualized the thrombolytic process with heparinized saline irrigation. When thrombolysis was complete, angiography was performed.

Experimental vasospasm was induced by direct vessel compression in eight canine femoral arteries. Endoscopy was used to control angioplasty with a non-detachable, silastic balloon catheter (Dow-Corning) inflated to 4-5 torr five times every 15 seconds. The results were evaluated by endoscopy and angiography.

Results

Endoscopy achieved excellent exposure of the visual field and optical quality in all 40 cases. The shape of the aneurysmal orifice and the detail of the vascular lumen (thrombus, scar, and even anastomosis sutures) were visible. The roughness of the intraneurysmal lumen, undetected angiographically, was also seen (Fig. 2A, B). The video processor captured balloon placement and detachment, allowing timing to be better controlled. Unexpectedly, in 32 cases the tail of the detached balloon protruded into the arterial lumen, causing stenosis. Endoscopy demonstrated this stenosis more accurately than two-dimensional angiography. The occluding balloon was partially covered by thrombus within several hours of occlusion (Fig. 2C). Endothelialization was complete and the orifice smooth in the six cases observed for 2 months (Fig. 2D, E).

Experimental thromboses blocked the arterial lumen just after clip release. Loose clots in the main artery were flushed with heparinized saline, leaving gelatinous thrombi obstructing the branches. Fresh thrombi appeared as irregular-shaped, berry-like red masses at the orifice of the obstructed branch. Thin, adherent clots were also seen on the injured endothelium. Before saline flushing, thrombus fragments obstructed the visual field. After a clear view was obtained, t-PA infusion was started. Clots gradually shrank until less than half the initial size when they peeled from the vessel wall and flowed distally. Post-procedure angiography confirmed complete thrombolysis (Fig. 3). Three of 12 cases achieved thrombolysis by only heparinized saline flushing. Two of 12 cases did not achieve complete thrombolysis even after t-PA infusion.

Endoscopy confirmed angioplasty dilation of the intraluminal space. However, the degree of dilation was difficult to evaluate. In all eight cases, clots adhered to the expanded lumen due to intimal injury.
produced by balloon inflation (Fig. 4).

**Discussion**

Information about the shape and size of the aneurysmal orifice and the features of the intraneurysmal wall is valuable in selecting the most suitable occlusion balloon and anticipating technical difficulties in placement. The risk of embolic complications due to intraneurysmal thrombi can also be estimated. However, our method could not visualize the proximal aspect of the aneurysms, even with a modified catheter with an angled tip. Therefore, further improvements in the endoscope thickness and flexibility are necessary.

Direct visualization of balloon detachment increases the precision of a maneuver which now depends on the operator’s “feel.” Endoscopy also shows the arterial stenosis caused by the balloon and any intimal injury with thrombus formation resulting from catheter manipulation. Additional procedures may be indicated, such as replacement with a non-detachable balloon catheter or postoperative medical treatment. Endoscopy of arterial stenosis varies with the viewing angle, so should be correlated with angiography in determining clinical management.

Angiography in occlusive diseases demonstrates stenosis only as a defect in the contrast medium. Endoscopy provides information about the shape and size of a stenotic lumen or intimal lesion, and the cause of stenosis. Endoscopy can accurately localize and differentiate embolus or thrombus from atherosclerotic or hypertrophic stenosis, and help determine appropriate therapy for an atherosclerotic lesion. An occlusion caused by embolism or thrombosis requires fibrinolytic therapy, while atheromatous plaque requires angioplasty or endarterectomy. Plaque associated with ulcer formation requires standard vascular reconstruction as intravascular treatment may be dangerous. The recent development of laser spectroscopy will allow the analysis of atheromatous plaques endoscopically.

Observation of the thrombolytic process is valuable in determining when fibrinolysis is complete. However, endoscopy is not as informative as angiography about angioplastic dilation because the luminal diameter cannot be measured exactly. Endoscopy gives a poor perspective and the apparent diameter may vary depending upon the distance to the measuring point. A severely curved vessel or a tandem lesion prevents a clear view or evaluation of the stenotic diameter. However, endoscopy can identify intimal injury following angioplasty, indicating anticoagulant therapy. Distal embolism must be avoided in the carotid or vertebrobasilar artery systems. In particular, the persistent white fibrin core after fibrinolytic therapy for t-PA resistant thrombus may reobstruct the artery. A method of total debris removal after laser angioplasty or rotary endarterectomy must be developed.

Our combination of endoscope and high-pressure irrigation system proved successful in the treatment of experimental lesions and improving visualization of arterial artifacts. Further improvements such as thinner and more flexible endoscopes will increase the applicability of this technique.

**References**


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