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PICTORIAL ESSAY

# Endovascular Treatment for Upper Body Central Venous Obstruction

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**Abstract:**
Endovascular treatment, such as catheter-directed thrombolysis, thrombectomy, balloon angioplasty, and metallic stent placement, is performed for symptomatic upper body central venous obstruction caused by both malignant and benign etiologies. In particular, metallic stent placement should be performed in emergent situations for malignant superior vena cava syndrome presenting with cerebral or laryngeal edema. In malignant cases, the obstruction is usually traversed via the femoral vein. When it fails, an additional trial via the brachial or internal jugular vein is performed, and if necessary, through-and-through access is established. In benign chronic obstructions that cannot be crossed by conventional techniques, sharp recanalization techniques are salvage options. The procedures are relatively safe; however, major complications such as acute pulmonary edema, cardiac tamponade, pulmonary embolism, and stent migration should be warned.

**Keywords:**
upper body central venous obstruction, superior vena cava syndrome, endovascular treatment, metallic stent

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## Introduction

Upper body central venous obstruction (UBCVO) develops due to several etiologies. Complete or partial obstruction of the superior vena cava (SVC) typically causes SVC syndrome, such as face, neck, and upper-extremity swelling, dyspnea, dizziness, and syncope due to blockage of venous return. Obstruction of the subclavian or brachiocephalic vein also causes the upper-extremity swelling. Approximately 60% of UBCVOs are caused by malignant tumors, mainly lung cancer (accounting for 75-80%), followed by mediastinal lymph nodes, whether from lymphoma or metastasis [1, 2]. Moreover, UBCVO develops in patients with hemodialysis, fibrosing mediastinitis, and prior thoracic radiation therapy, and the increasing utilization of intravascular devices, such as pacer wires or indwelling catheters, has led to a growing incidence of benign UBCVO up to 40% [1].

Endovascular treatment is widely performed for symptomatic UBCVO caused by both malignant and benign etiologies, and this paper presents several representative UBCVO cases treated with endovascular treatment.

## Indications of Endovascular Treatment

Endovascular treatment, such as catheter-directed thrombolysis, thrombectomy, balloon angioplasty, and metallic stent placement, is performed for symptomatic UBCVO caused by malignant tumors (**Fig. 1-6**, Video 1), acute thrombus contraindicated or refractory to systemic anticoagulation therapy (**Fig. 7**), and benign chronic obstruction (**Fig. 8-10**, Video 2) [1-10]. Among them, metallic stent placement is indicated for malignant SVC syndrome because it can lead to a more rapid relief of symptoms compared with chemotherapy and radiation therapy (RT). In particular, the symptom of cerebral or laryngeal edema warrants emergent stenting. If the patient cannot lie on their back due to respiratory distress, the procedure should be performed in a semi-recumbent position (**Fig. 1**) [5] or under general anesthesia [1, 6]. Metallic stent placement is also indicated for subclavian or brachiocephalic vein obstruction by chemotherapy- and/or RT-resistant malignancies and for benign hard obstruction, especially in patients with hemodialysis or fibrosing mediastinitis, when rapid blood flow cannot be achieved by balloon angioplasty (**Fig. 9** and **10**) [1, 7, 8].

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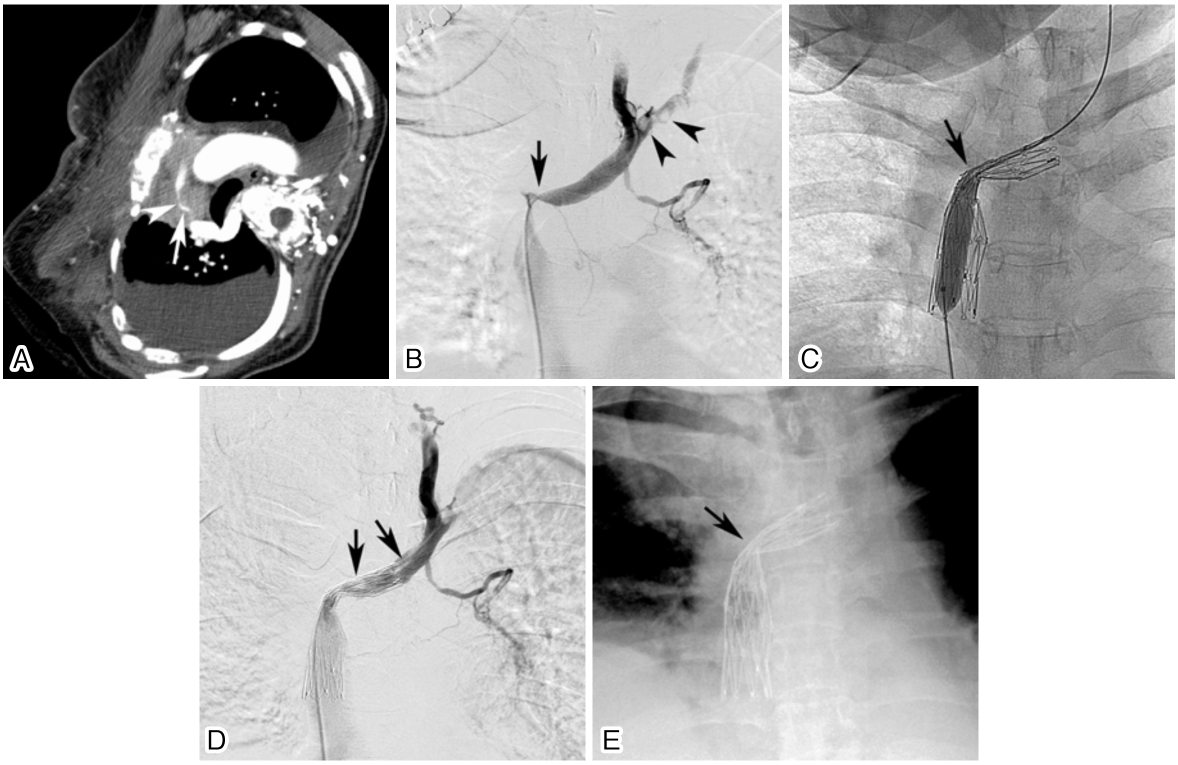


**Figure 1.** Emergent metallic stent placement in the stenosed left brachiocephalic vein due to metastatic mediastinal lymphnodes from breast cancer in a semi-recumbent position.
A. The patient was referred to the emergency room due to face, neck, and upper-extremity edema and severe dyspnea. Contrast-enhanced CT performed in the right lateral decubitus position due to respiratory distress showed severe stenosis of the left brachiocephalic vein (arrowhead) and superior vena cava (SVC) (arrow) by mediastinal lymph node metastases. The right brachiocephalic vein was also occluded (not shown). B. Emergent endovascular treatment was performed in a semi-recumbent position. A guidewire could not traverse the occluded right brachiocephalic vein; therefore, a catheter was advanced into the left brachiocephalic vein. A venogram showed occlusion of the right brachiocephalic vein and severe stricture of the left brachiocephalic vein (arrow). Thrombi were also seen in the left subclavian vein (arrowheads). C. The stricture of the left brachiocephalic vein was dilated with an 8-mm-diameter balloon catheter (not shown). A tapered 12/20 × 80-mm spiral Z-stent was then placed from the left brachiocephalic vein to SVC; however, it was kinked at the confluence of the left brachiocephalic vein. Postdilation of the stent was attempted using a 10-mm-diameter balloon catheter; however, it could not be advanced through the kinked stent portion (arrow), and only the proximal portion of the stent could be dilated. D. The final venogram showed that the stricture was slightly dilated and the thrombi (arrows) had migrated to the left brachiocephalic vein. E. Face edema and respiratory distress were improved after stent placement, although the stent was still kinked on chest X-ray obtained 14 days after the procedure (arrow).

## Endovascular Treatment

### *Traversing CVO*

Traversing malignant UBCVO is usually performed via the femoral vein (**Fig. 1-6**, Video 1). An angiographic catheter is advanced into the right internal jugular or subclavian vein because the route is relatively straight; however, the left internal jugular or subclavian vein is selected in patients with complete obstruction of the right brachiocephalic vein (**Fig. 1** and **2**) or dominant swelling of the left arm. In benign UBCVO, crossing is also attempted via the affected brachial route (**Fig. 8-10**). If traversing the stricture by a conventional hydrophilic guidewire is unsuccessful, a microcatheter-guidewire system facilitates crossing there (**Fig. 3**, **8-10**). When secure access is achieved, the guidewire is exchanged for a 0.035-in. stiff-type guidewire. Additional puncture for approaching the opposite side of the stricture is also helpful to traverse it (**Fig. 2**, **3**, **6-10**). Once a guidewire can cross the stricture via one approach route, it is withdrawn from the sheath placed in the other approach route and through-and-through (pull-through) access is established (**Fig. 2**, **3**, **7** and **10**) [5, 6]. This technique can increase the trackability of devices through the tight stricture and prevent stent migration into the right atrium (**Fig. 10**); however, it is not always necessary.

### *Sharp recanalization technique*

Chronic obstruction, particularly in hemodialysis patients, sometimes cannot be crossed by conventional techniques. Sharp recanalization using sharp instruments, such as needles (**Fig. 8**), stiff ends of guidewires, guidewires for

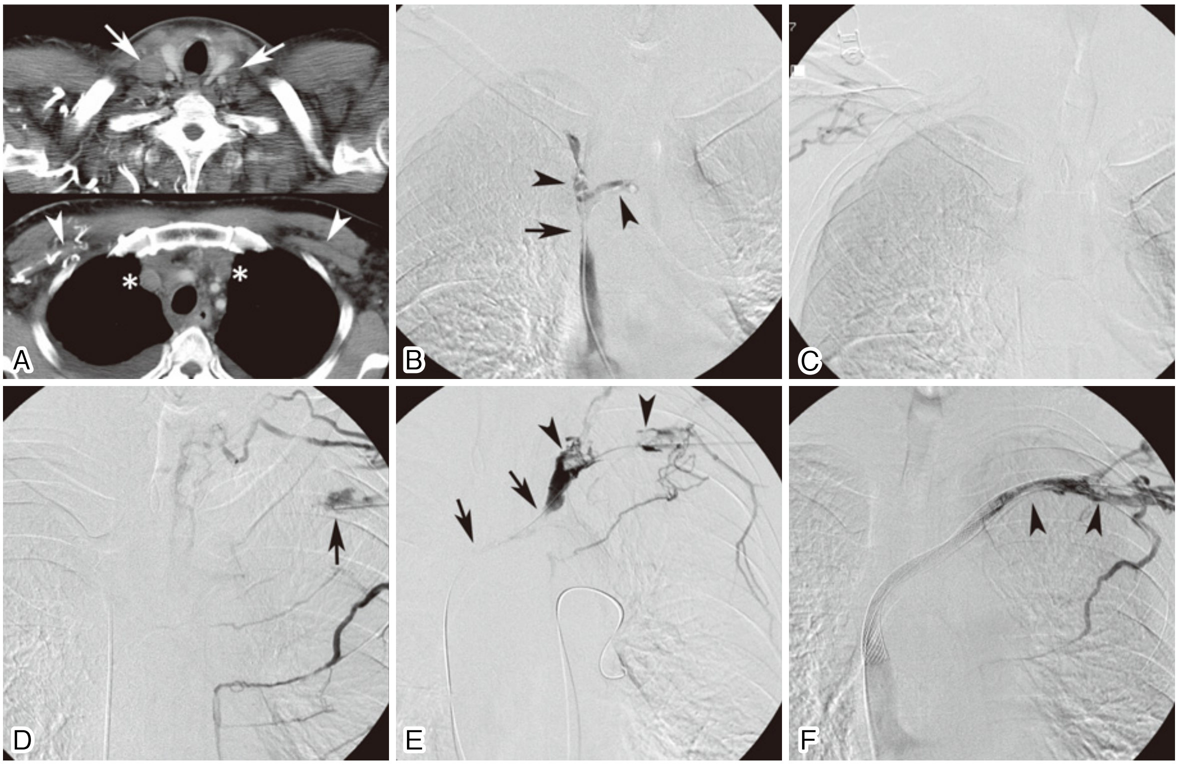


**Figure 2.** Endovascular treatment for superior vena cava (SVC) syndrome due to lung cancer and massive thrombi. A. The patient presented with face, neck, and upper-extremity edema. Contrast-enhanced CT showed massive thrombi in the bilateral subclavian (arrowheads), internal jugular (arrows), and brachiocephalic veins (asterisks) and bilateral pleural effusion. SVC was also obstructed by mediastinal lymph node metastases (not shown). B. A catheter was advanced into SVC via the right femoral vein, and a venogram showed severe stricture of SVC (arrow) and thrombi in the bilateral brachiocephalic veins (arrowheads). C. A venogram via the right median cubital vein showed that the right axillary vein was not opacified. D. Contrast-enhanced CT showed that the left axillary vein was partially opened (not shown). Therefore, the left median cubital vein was punctured and another catheter was advanced into the left subclavian vein, and a venogram showed complete occlusion of the left subclavian vein. The arrow indicates a catheter tip in the left subclavian vein. E. The occluded segment (arrows) was then crossed by a conventional technique via the left brachial route. The arrowheads indicate massive thrombi. The guidewire was withdrawn from the sheath in the right femoral vein, and through-and-through access could be established (not shown). After thrombolysis using 480,000 U of urokinase and thromboaspiration using a 6-F thromboaspiration catheter, two Wallstents (14 × 90 and 12 × 90 mm, respectively) were placed from SVC to the left subclavian vein via the right femoral route. The stents were then dilated using a 10-mm-diameter balloon catheter (not shown). F. The final venogram showed rapid blood flow through the stent, although residual thrombi (arrowheads) were seen in the stent lumen.

chronic total occlusive lesions (**Fig. 9**, Video 2), and radiofrequency guidewires that can vaporize a channel through the occluded segment using pulsed radiofrequency energy, is a salvage option [5-6, 8]. When it is performed, placing a target, such as a catheter, balloon catheter, or snare, on the opposite side of the obstruction is key to guide the correct direction of the recanalization (**Fig. 8** and **9**). In addition, three-dimensional rotational angiography and CT/cone-beam CT are helpful to navigate the needle direction (**Fig. 8**) [5-6, 8].

### *Catheter-directed thrombolysis and thrombectomy*

In cases with underlying massive thrombi in occluded veins, thrombolysis using a pulse-spray catheter and mechanical thrombectomy using a thromboaspiration catheter or large guiding catheter/sheath are performed (**Fig. 2**, **4-8**) [1, 3]. However, urokinase is currently not available in Japan and tissue-plasminogen activator is also off-label; therefore, thromboaspiration is mainly performed. In particular, free-floating thrombi above the stricture should be aspirated as much as possible before revascularization to prevent pulmonary embolism (PE). A heparin bolus is also considered [2], and 2,000-5,000 U of heparin are intravenously administered before catheter-directed interventions [9].

### *SVC filter placement*

Although there are no guidelines for SVC filter placement for upper-extremity deep vein thrombosis (DVT), it is considered in patients who are contraindicated for systemic anticoagulation therapy and/or who have a high risk of PE. However, SVC filter placement is challenging due to the short length of SVC and greater risk of life-threatening complications, such as perforation of SVC or thoracic aorta, cardiac tamponade, and pneumothorax [3]. The risk of PE

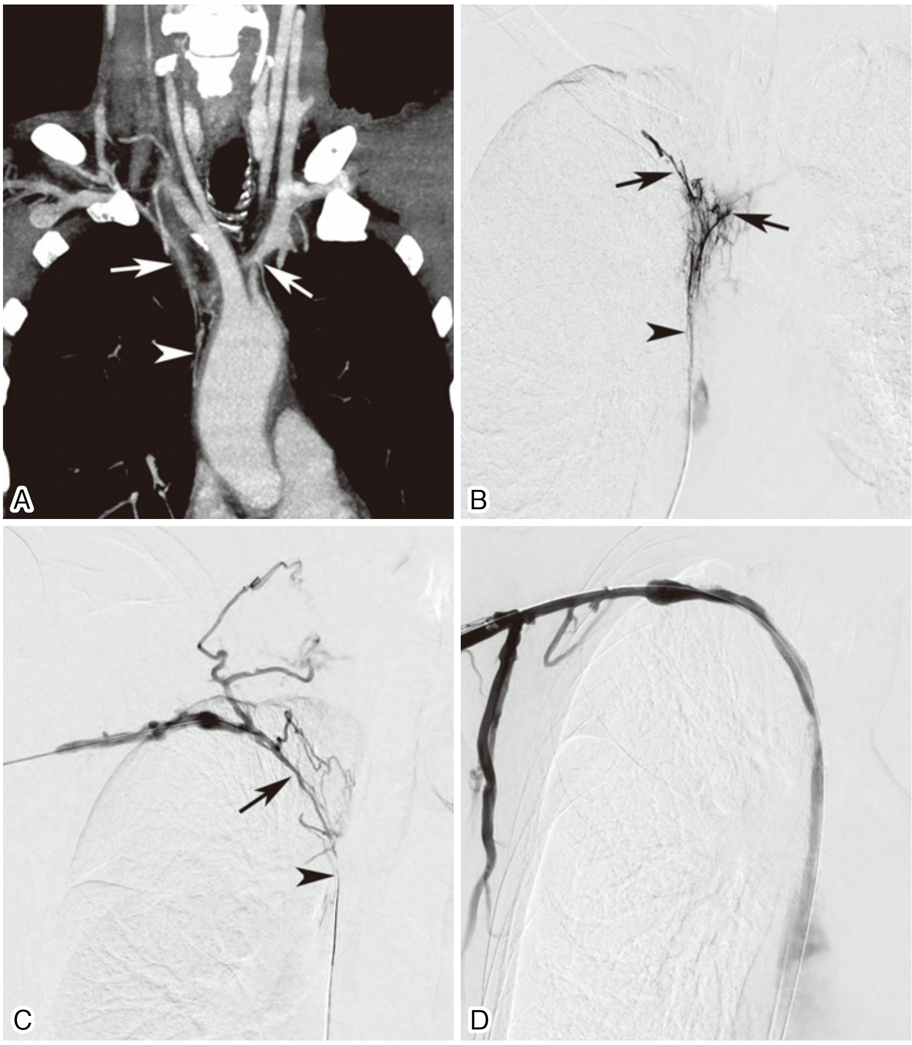


**Figure 3.** Deployment of SMART stents for superior vena cava (SVC) syndrome due to lung cancer.

A. The patient presented with face, neck, and right arm edema, and a coronal view of reconstructed contrast-enhanced CT showed severe strictures of SVC (arrowhead) and bilateral brachiocephalic veins (arrows), like fibrosing mediastinitis without definite mass formation. This patient had been treated with chemotherapy and had no histories of radiation therapy. B. First, a microcatheter was advanced into the stenosed SVC through a catheter placed in SVC via the right femoral vein, and a venogram showed severe strictures of the bilateral brachiocephalic veins (arrows) and SVC (arrowhead) and proliferation of small vessels around them. Traversing the occluded segment was attempted, but it was unsuccessful. C. The right median cubital vein was then punctured under sonography, and another catheter was advanced into the right subclavian vein. A venogram also showed occlusion of the right brachiocephalic vein (arrow) and collaterals. The arrowhead indicates the microcatheter advanced via the right femoral vein. Traversing the occluded segment was successful through this route using a microcatheter-guidewire system, and the stricture was dilated using a 4-mm-diameter balloon catheter. Another microwire was then advanced into the right brachiocephalic vein via the right femoral route, and it was snared through the right median cubital vein and through-and-through access was established. Three SMART stents (14 × 60, 12 × 60, and 10 × 60 mm, respectively) were deployed from SVC to the right brachiocephalic vein via the right brachial route and were dilated using an 8-mm-diameter balloon catheter (not shown). D. The final venogram showed rapid blood flow across the stents.

from upper-extremity DVT is five times lower than that from lower-extremity DVT [3]; therefore, the indication of the SVC filter should be discussed according to achieving a good balance between the risk of PE and complications in each patient. A temporary filter can be safely placed in SVC to prevent PE during catheter-directed thrombolysis/thrombectomy and crushing the thrombus by a balloon catheter (**Fig. 7**).

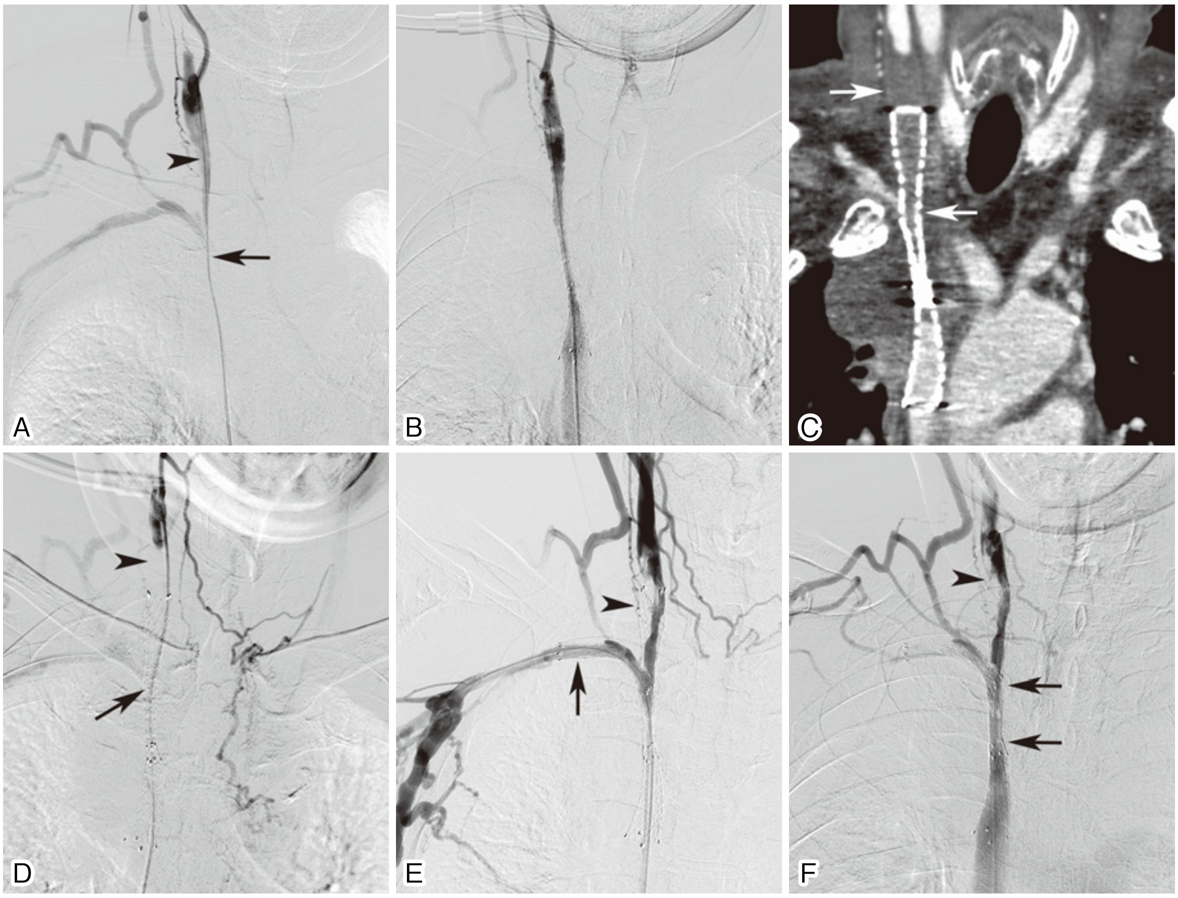

**Figure 4.** Usefulness of a Palmatz stent for hard stricture of the superior vena cava (SVC) due to lung cancer.
A. The patient presented with face, neck, upper-extremity, and laryngeal edema. A venogram showed occlusion of the right brachiocephalic vein (arrow) and thrombi in the right internal jugular vein (arrowhead). First, thrombolysis was performed using 240,000 U of urokinase. The stricture was then dilated using a 5-mm-diameter balloon catheter, and the residual thrombi were aspirated using a 10-F long sheath (not shown). B. Thereafter, two Luminexx stents (12 × 60 and 12 × 40 mm, respectively) were placed from the right internal jugular vein to SVC, and a venogram showed that the stents were insufficiently expanded but relatively good blood flow across the stents was achieved. Therefore, the procedure was ended with the expectation of subsequent self-expansion of the stents. C. However, the symptoms of SVC syndrome were not improved, and a coronal view of contrast-enhanced CT performed 4 days after stent placement showed stent occlusion by thrombi (arrows). D. Additional endovascular treatment was performed 7 days after the initial procedure. At that time, the stents were slightly expanded by self-expanding force; however, the lumen was occluded by massive thrombi (arrowhead). The right subclavian vein was also stenosed (arrow). E. After thrombolysis using 240,000 U of urokinase and thrombectomy using a 6-F thromboaspiration catheter, the insufficiently expanded stents were dilated by a 10-mm-diameter balloon catheter at 10 atm (not shown). A 10 × 40-mm Luminexx stent was then placed in the right subclavian vein (arrow). A subsequent venogram showed that thrombi in the right internal jugular vein (arrowhead) were reduced in size and the right subclavian vein was recanalized, but SVC was still occluded. Therefore, an 8 × 30-mm Palmatz stent was deployed in the insufficiently expanded stent lumen and was dilated by a 10-mm-diameter balloon catheter at 12 atm (not shown). F. The final venogram showed good blood flow across the stents, although residual thrombi were also seen in the right internal jugular vein (arrowhead). The arrows indicate the Palmatz stent. No symptoms of SVC syndrome recurred for 115 days after the second procedure until the patient's death.

### *Balloon angioplasty*

Current treatment practice for UBCVO in hemodialysis patients favors initial treatment with balloon angioplasty (**Fig. 9**), because the primary and secondary patency rates are similar for stenting and angioplasty after 2 years [7]. Balloon angioplasty is also performed before metallic stent placement. However, it should only be performed for cases with a tight stricture that prevents from advancing a delivery system safely, due to risks of vessel rupture and PE [2]. To avoid SVC rupture, the use of a balloon <16 mm in diameter (approximately ≤10 mm in diameter) is recommended, and balloon inflation should also be done slowly from a low atm [2].

### *Metallic stent placement*

A stent oversized by 10 to 20% of the normal reference vessel is recommended to prevent migration and should


**Figure 5.** Metallic stent placement for superior vena cava (SVC) syndrome due to mediastinal lymph node metastases from duodenal cancer in a patient with an indwelling central venous catheter.
A. The patient presented with face, neck, upper-extremity, and laryngeal edema. A venogram via the right median cubital vein showed occlusion of SVC (arrow) and thrombi in the bilateral brachiocephalic veins (arrowheads). The asterisk indicates an indwelling catheter in SVC. B. First, 240,000 U of urokinase were infused using a pulse-spray catheter, and a subsequent venogram showed that most thrombi were resolved. The arrowheads indicate metallic markers on the pulse-spray catheter. A 12 × 60-mm Wallstent was then deployed; however, it did not expand sufficiently. Therefore, the stent was dilated with a 10-mm-diameter balloon catheter (not shown). C. The final venogram showed sufficient expansion of the stent and rapid blood flow across it, although residual thrombi (arrows) were also seen. The indwelling catheter in SVC could be used without any problem after stent placement.

cover at least 10 mm above and below the stricture [2]. However, the use of a stent >16 mm in diameter has risks of SVC rupture and acute pulmonary edema [10]. In Japan, two types of a spiral Z-stent (Spiral relief stent, Cosmotec, Tokyo, Japan) have been approved for malignant UBCVO: a straight stent of 16 mm in diameter and 60 mm long (**Fig. 6**) and a tapered stent of 12/20 mm in diameter and 80 mm long that is mainly placed from the brachiocephalic vein to SVC (**Fig. 1**, Video 1). Biliary or self-made spiral Z-stents had also been used (**Fig. 6**). The spiral Z-stent is more flexible than an original Z-stent; however, it requires a large delivery sheath and is sometimes kinked when deployed from the left brachiocephalic vein to SVC (**Fig. 1**). Therefore, more flexible and lower-profile stents, such as SMART stents (Cordis, Bridgewater, NJ, USA) (**Fig. 3**), Luminexx stents (Bard Peripheral Vascular, Tempe, AZ, USA) (**Fig. 4**), or Wallstents (Boston Scientific, Marlborough, MA, USA) (**Fig. 2**, **5**, **8** and **10**), are suitable for tight, angulated, or moving segments, although they have not been approved for venous strictures. The maximum diameter of SMART and Luminexx stents is 14 mm, but a Wallstent >10 mm in diameter is no longer on the market. Wallstents also shorten by 20%-50% during deployment [5]. These stents can be deployed via the jugular or brachial route (**Fig. 3**, **5** and **10**), and the stiff-type guidewire should be anchored in the inferior vena cava to prevent stent migration into the right atrium when doing so [6].

A spiral Z-stent is deployed through a 14-F sheath; therefore, predilation of the stricture is necessary in most cases to advance the delivery sheath safely. After advancement of a stent to the target position by a pusher catheter, it can be deployed by withdrawal of the delivery sheath while keeping the pusher catheter. Postdilation is performed when the stent is insufficiently expanded or no rapid blood flow across the stent is obtained (**Fig. 1**-**5**, **10**, Video 1). However, a balloon catheter sometimes cannot be passed through a kinked stent (**Fig. 1**). The endpoint of the procedure is an increase of the vessel diameter >50% with resolution of preprocedural collaterals, and returning to a physiologic SVC pressure of 2-8 mmHg or gradient pressure across the stenosis <3-5 mmHg can also be used to confirm the technical success [6].

A self-expandable metallic stent gradually expands within a few days after placement. However, a stent placed in a hard obstruction is likely to expand insufficiently. When the symptoms are not improved, additional placement of a balloon-expanding stent in the insufficiently expanded stent, such as a Palmaz stent (Cardinal Health, Dublin, OH, USA) that has a high radial force [6], can maintain the stent lumen (**Fig. 4**). A covered stent has the advantage of the prevention of tumor ingrowth, although it has associated risks of migration and occlusion of branch vessels [1, 5, 6]. Moreover, it can reduce the recurrence rate of symptoms more than an uncovered stent in patients with fibrosing mediastinitis (29 vs. 60%, respectively) [6]. However, the use of both balloon-expanding and covered stents for venous strictures is off-label.

Stent placement in the unilateral brachiocephalic vein is sufficient to relieve the symptoms even in patients with bilateral brachiocephalic vein obstruction. In addition, bilateral stenting leads to higher rates of re-stenosis and complications [2, 6]. However, additional stent placement in the contralateral brachiocephalic vein is required when arm swelling on the non-stented side is continued or worsens after the procedure (**Fig. 6**).

In cases of pacemaker-induced SVC obstruction, pacer wires were previously considered to be removed before stent placement and be replaced after stent placement. However, stents can be safely placed over pacer wires without removal

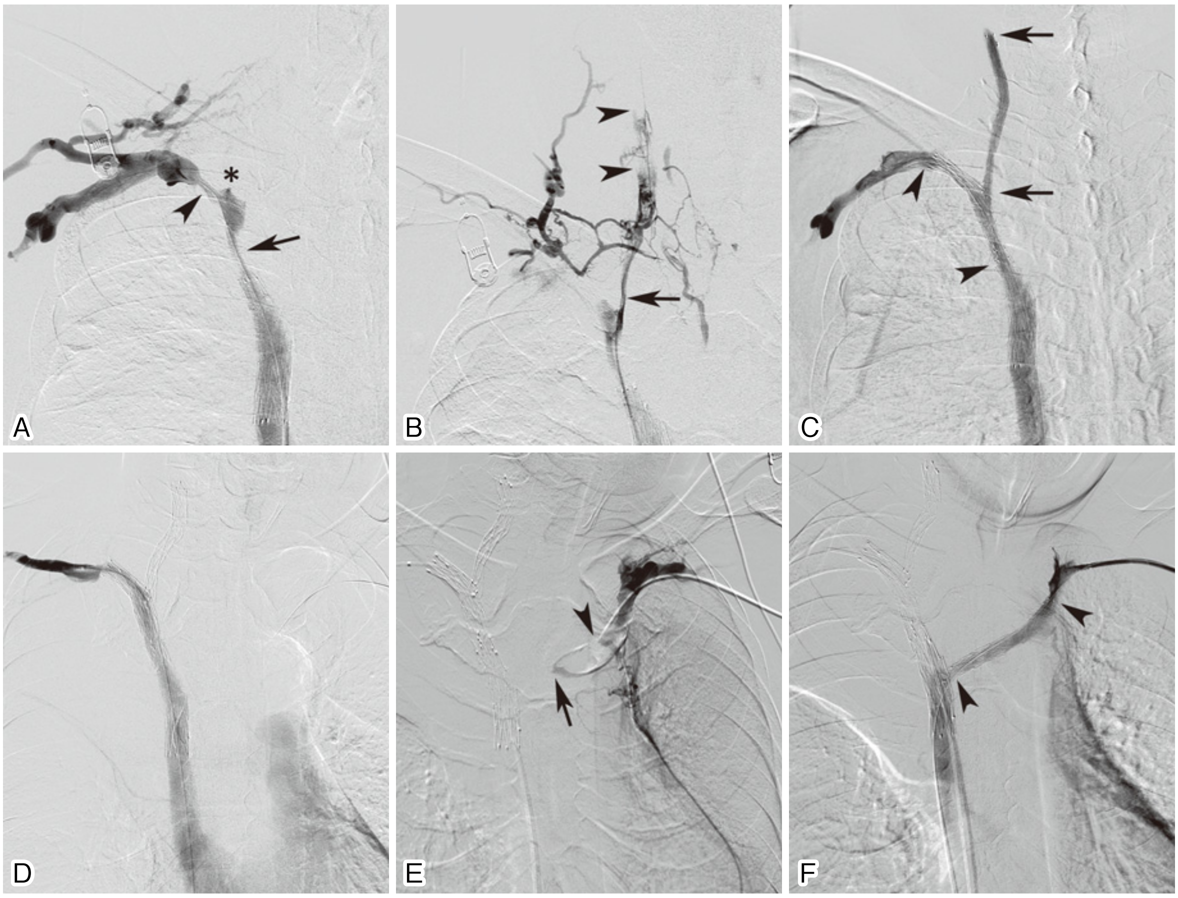


**Figure 6.** Repeated endovascular treatment for superior vena cava (SVC) syndrome due to lung cancer.
A. The patient had undergone placement of a 16 × 60-mm straight spiral Z-stent in the stricture of SVC due to face, neck, upper-extremity, and laryngeal edema. However, the symptoms of SVC syndrome recurred 44 days later. Additional endovascular treatment was performed, and a venogram showed strictures of the right brachiocephalic vein above the stent (arrow) and the right subclavian vein (arrowhead). The right internal jugular vein (asterisk) was also occluded. B. The catheter was navigated into the right internal jugular vein, and a venogram showed the stricture of the right internal jugular vein (arrow) and massive thrombi (arrowheads). After thrombolysis using 240,000 U of urokinase and thrombectomy using a 6-F thromboaspiration catheter, a 10 × 75-mm biliary spiral Z-stent was placed in the right internal jugular vein, and a 14 × 60-mm self-made spiral Z-stent was placed from the right subclavian vein to right brachiocephalic vein through a 10-F sheath (not shown). C. The final venogram showed good blood flow across the stents. The arrows indicate the biliary spiral Z-stent and arrowheads indicate the self-made spiral Z-stent. D. However, swelling of the left arm developed 41 days after the second procedure, and third endovascular treatment was performed. First, a venogram performed through a catheter via the right femoral vein confirmed that the previously placed stents were patent. E. Another catheter was then advanced into the left brachiocephalic vein via the left median cubital vein, and a venogram showed occlusion of the left brachiocephalic vein (arrow) and massive thrombi (arrowhead). After thrombolysis using 240,000 U of urokinase and thrombectomy using a 6-F thromboaspiration catheter, a 10 × 75-mm biliary spiral Z-stent was placed in the left brachiocephalic vein through an 8-F sheath (not shown). F. The final venogram showed rapid blood flow across the stent. The arrowheads indicate the biliary spiral Z-stent played in the left brachiocephalic vein.

because pacer wires have electrical insulation and are likely covered by vessel endothelium [2]. In cases with an indwelling central venous port system, metallic stent placement can be performed without removal of the central venous catheter (**Fig. 5**).

## Postprocedural Management

The necessity of anticoagulation after stent placement is controversial [3, 9], and it can be skipped in patients with potential risks associated with anticoagulation. Antiplatelet therapy alone (aspirin/clopidogrel) is usually performed in patients with fibrosing mediastinitis [1]. Subsequent repeat interventions are necessary according to the cause of recurrence when the symptoms recur (**Fig. 4** and **6**).

## Complications

The reported major complication rate is 3.7%, including 0.7% of fatal complications, mostly due to cardiac tampon-

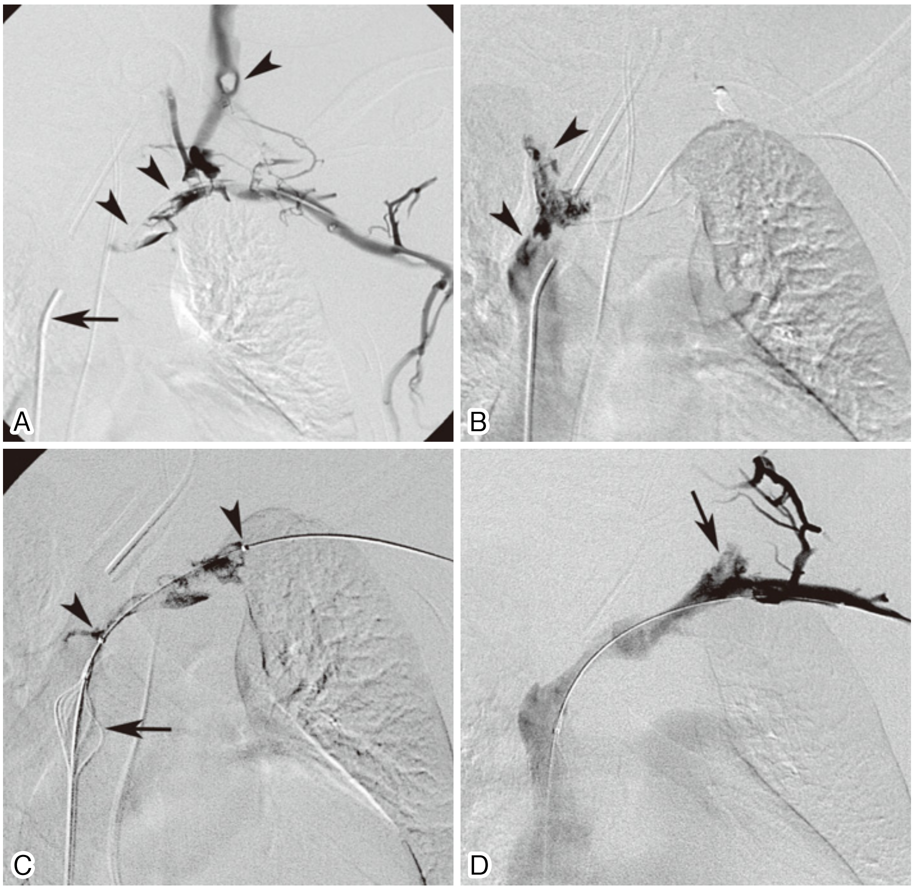


**Figure 7.** Temporary filter placement during endovascular treatment for superior vena cava (SVC) syndrome due to acute thrombosis in a patient with encephalitis.
A. The patient presented with face, neck, and upper-extremity edema, and CT showed occlusion of the bilateral subclavian, internal jugular, and brachiocephalic veins due to massive thrombi (not shown). First, a catheter (arrow) was advanced into SVC via the right femoral vein, and complete occlusion of SVC was confirmed (not shown). Another catheter was then advanced into the left subclavian vein via the left median cubital vein, and a venogram showed thrombi in the left brachiocephalic and internal jugular veins (arrowheads). B. The occluded segment was traversed via the left brachial route, and a venogram showed thrombi in the right brachiocephalic vein and SVC (arrowheads). A guidewire from the left brachial route was withdrawn through a sheath in the right femoral vein and through-and-through access was established (not shown). C. A temporary filter (arrow) was placed in SVC via the right femoral vein, and thrombolysis was performed using 120,000 U of urokinase through a pulse-spray catheter advanced into the left brachiocephalic vein via the left brachial route.The arrowheads indicate metallic markers of the pulse-spray catheter. The pulse-spray catheter was then advanced into the left internal jugular vein, and thrombolysis using 120,000 U of urokinase was also performed. Thereafter, non-resolved thrombi in the left brachiocephalic and internal jugular veins were aspirated using a 6-F thromboaspiration catheter. Finally, the residual thrombi in the left brachiocephalic vein were crushed by a 10-mm-diameter balloon catheter (not shown). D. The final venogram showed the disappearance of most thrombi and good flow of the left brachiocephalic vein, although residual thrombi were seen in the left internal jugular vein (arrow). Thereafter, the temporary filter was removed, and thrombi trapped by the filter were also confirmed (not shown).

ade, PE, and respiratory insufficiency [9]. The use of a large balloon catheter/metallic stent >16 mm in diameter is a risk factor for SVC rupture that leads to hemopericardium and cardiac tamponade [1-3, 10]. Perforation of SVC by the guidewire also leads to cardiac tamponade, when it occurs in the lower half of SVC, the pericardium-covered portion [5]. Sealing of the injured portion by balloon inflation (balloon tamponade) or covered stent placement should be performed to avoid fatal cardiac tamponade [1, 5]. A pericardial drainage catheter should also be placed when sonography confirms the presence of hemopericardium. Acute right heart strain develops due to increased venous return and more

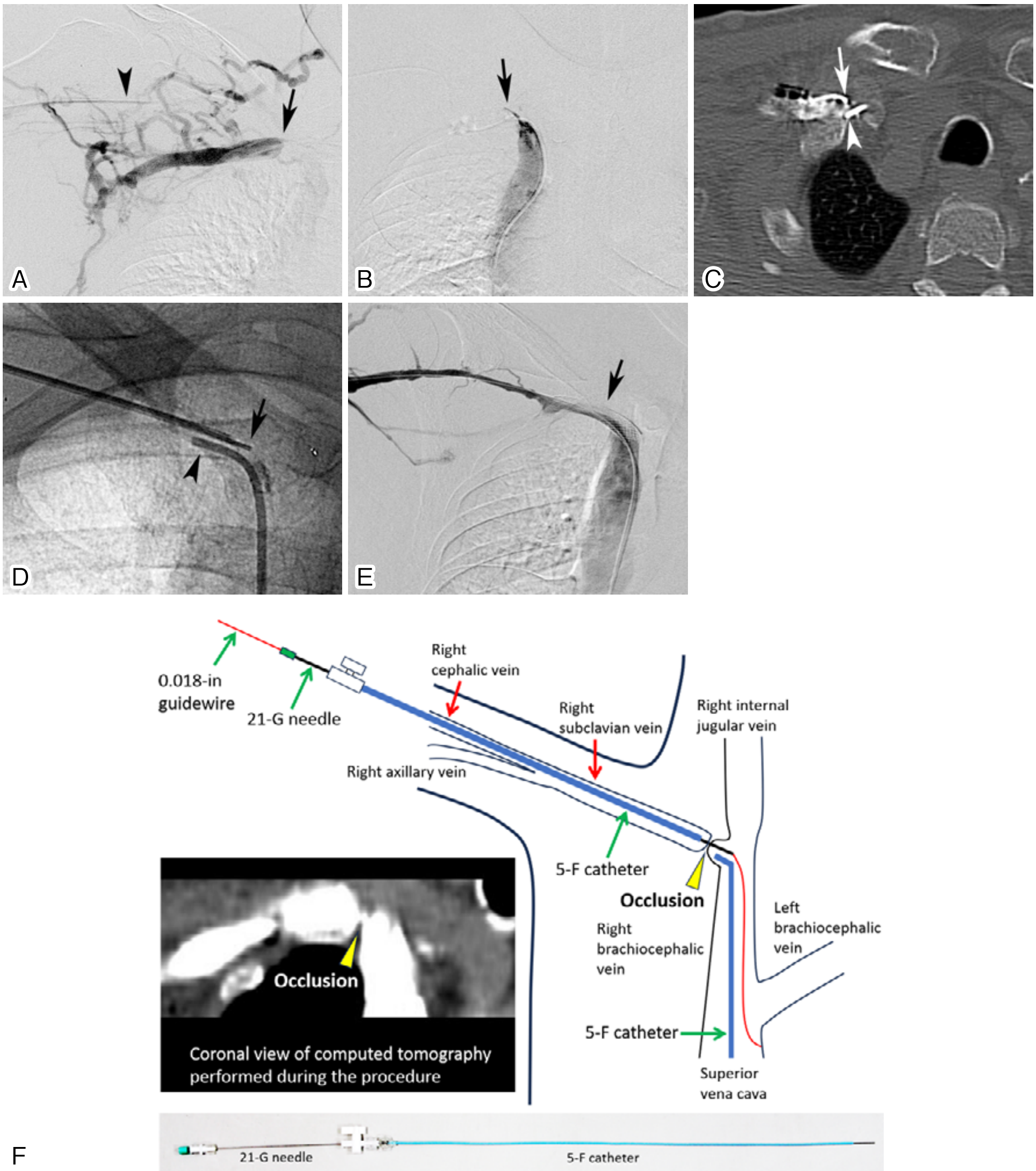


**Figure 8.** Sharp recanalization using a 21-G needle for an occluded right subclavian vein in a hemodialysis patient.
A. The patient presented with marked right arm swelling. The right cephalic vein was punctured under sonography and a catheter was advanced into the right subclavian vein, and a venogram showed complete occlusion of the right subclavian vein (arrow). The arrowhead indicates the catheter. First, thrombolysis using 240,000 U of urokinase was performed. Traversing the occlusion by both conventional catheter-guidewire and microcatheter-guidewire combinations was then attempted, but it failed (not shown). B. Another catheter was then advanced into the right brachiocephalic vein via the right femoral vein, and complete occlusion of the right subclavian vein (arrow) was confirmed. Traversing the occluded segment was also attempted by the same fashions, but it failed. C. CT performed during the procedure showed that both catheters closely faced each other. The arrow indicates the catheter advanced via the right cephalic vein and the arrowhead indicates the catheter advanced via the right femoral vein. D. Puncture of the obstruction with the stiff ends of 0.016- and 0.035-in. guidewires was attempted via both routes, but this failed because the obstruction was hard (not shown). Therefore, the right arm was moved to the side to straighten the cephalic vein, and a 75-cm-long 21-G percutaneous transhepatic cholangiography needle (Hakko, Chikuma, Japan) (arrow) was advanced into a 5-F straight catheter placed in the right subclavian vein via the right brachial route, and the obstruction was punctured. The arrow indicates the 21-G needle and the arrowhead indicates a catheter advanced via the right femoral vein. Thereafter, a 0.018-in. guidewire was advanced into the superior vena cava through the needle, and the 5-F catheter crossed the occluded segment over the guidewire. Balloon angioplasty was performed using 5- and 8-mm-diameter balloon catheters. The absence of extravasations of contrast material was confirmed on subsequent venograms; however, sufficient blood flow could not be obtained (not shown). E. Finally, a 12 × 30-mm Wallstent (arrow) was placed covering the recanalized segment, and rapid blood flow across the stent could be achieved. F. Schematic drawing of the sharp recanalization procedure and a photograph of a 5-F catheter and 21-G needle. Figure 8D reprinted from Ref. [8] with permission.

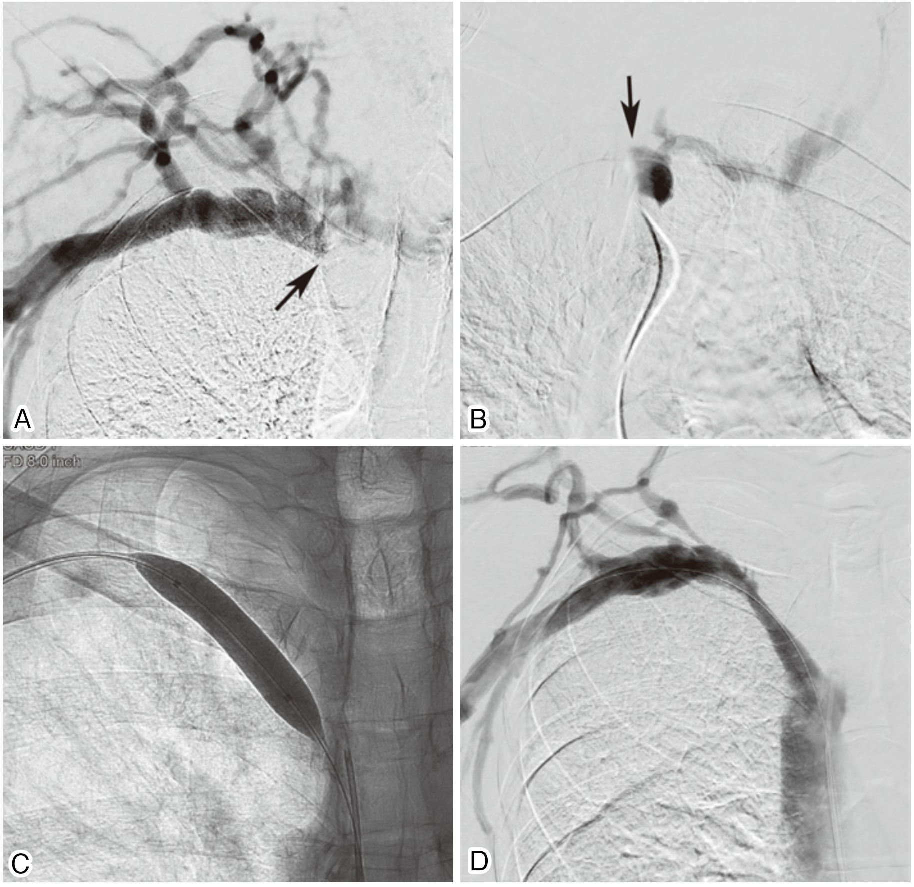


**Figure 9.** Recanalization using a guidewire for chronic total occlusive lesions for the right brachiocephalic vein occlusion in a hemodialysis patient.
A. The patient presented with marked right arm swelling due to occlusion of the right brachiocephalic vein (arrow). First, a catheter was advanced into the right brachiocephalic vein via the right median cubital vein. Thereafter, traversing the occlusion via the right brachial route was attempted using both conventional catheter-guidewire and microcatheter-guidewire combinations, but it failed. B. Another catheter was then advanced into the right brachiocephalic vein via the right femoral vein, and a right oblique venogram also showed complete occlusion of the right brachiocephalic vein (arrow). Traversing the occlusion via the right femoral route was also unsuccessful, even using the stiff end of the microwire. Retrial via the right brachial route was performed using a 0.018-in. guidewire for chronic total occlusive lesions (Vasallo GT 18 G12, Cordis), and the guidewire could easily cross the occlusion (Video 2). Thereafter, the microcatheter was navigated in the superior vena cava (SVC), and the catheter was advanced into SVC over the microcatheter (not shown). C. After balloon angioplasty using a 5-mm-diameter balloon catheter (not shown), the occluded segment was dilated using a 10-mm-diameter balloon catheter. D. The final venogram showed good blood flow of the right brachiocephalic vein.

likely in a patient with concurrent pulmonary artery obstruction. In such a patient, pulmonary artery stenting is a potential option [2]. Administration of diuretics should also be started before stent placement in patients with cardiac dysfunction [2].

Stent migration also occurs, and a Wallstent migrates more frequently than other stents (**Fig. 10**) [5]. To prevent stent migration, it is important to deploy the stent while ensuring that the stenosis is located at the middle of the stent [5]. Through-and-through access prevents further migration of the stent, allowing repositioning of the migrated stent by pushing with a balloon catheter or fixing it by additional stent placement (**Fig. 10**) [2, 6]. Stent fracture also develops due to antagonistic movement during cardiac contraction, diaphragmatic movement, and tumor ingrowth [5].

## Conclusion

Endovascular treatment is relatively safe and effective for symptomatic UBCVO caused by both malignant and benign etiologies. Therefore, interventional radiologists should be familiar with this procedure.

**Conflict of Interest:** None

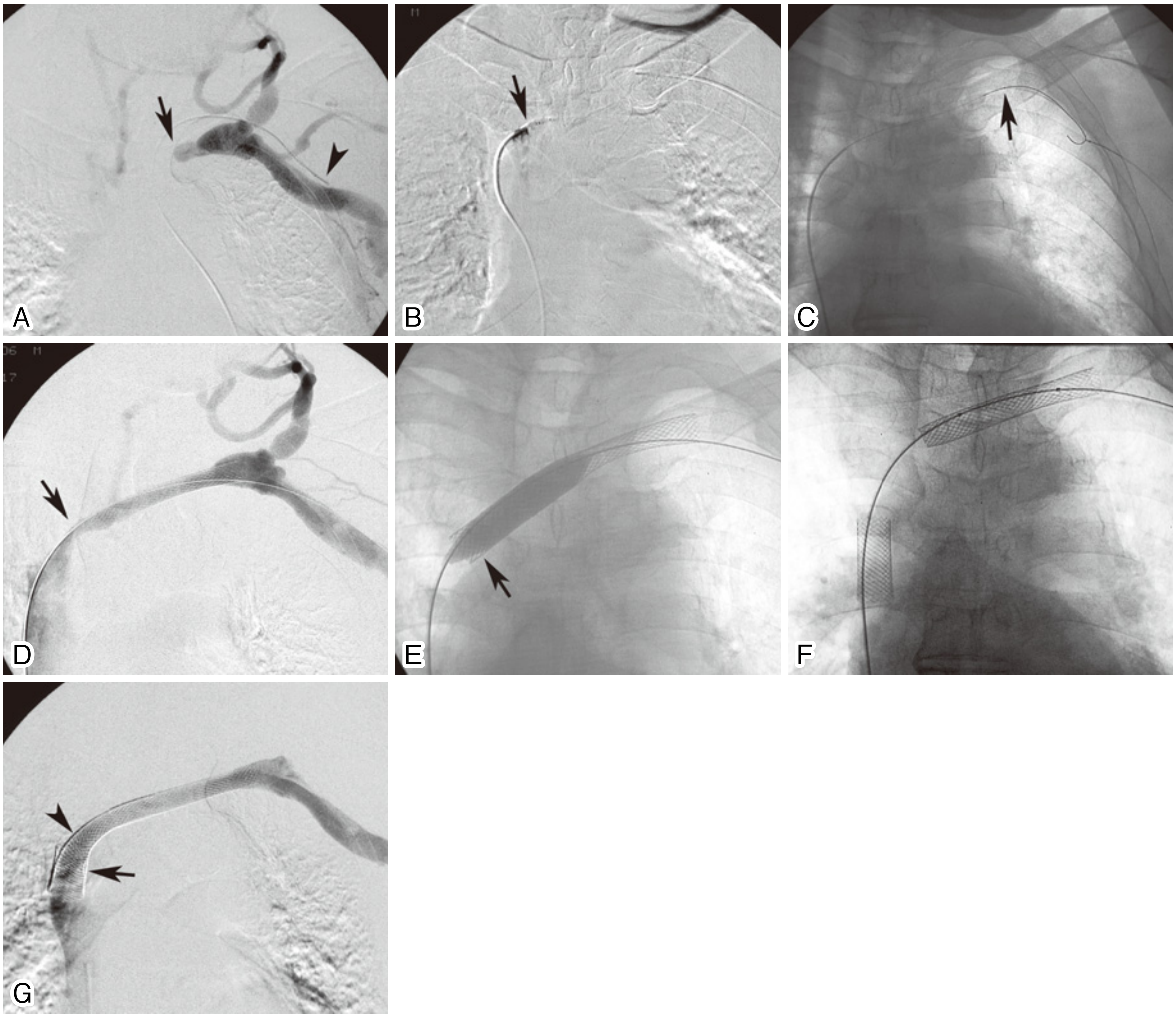


**Figure 10.** Stent migration placed in the occluded left brachiocephalic vein in a hemodialysis patient.
A. An arteriogram of the left subclavian artery was performed to evaluate the function of the arteriovenous fistula for hemodialysis because the left brachial artery could not be palpable due to marked left arm swelling, and complete occlusion of the left subclavian vein (arrow) was demonstrated. The arrowhead indicates a catheter in the left subclavian artery. Endovascular treatment was performed 2 days later. First, the left median cubital vein was punctured under sonography, and a catheter was advanced into the left subclavian vein. Traversing the occlusion was attempted, but it failed (not shown). B. Another catheter was then advanced into the superior vena cava (SVC) via the right femoral vein, and occlusion of the left brachiocephalic vein (arrow) was also confirmed. C. Traversing the occluded segment via the right femoral vein by a conventional technique failed, but it was successful using a microcatheter-guidewire system. The guidewire was grasped by a snare in the left axillary vein advanced via the left brachial route and through-and-through access was established. The arrow indicates a microcatheter tip. D. The occluded segment was dilated using an 8-mm-diameter balloon catheter, and a venogram showed partial recanalization of the occluded segment; however, sufficient blood flow could not be obtained (not shown). Therefore, a 12 × 80-mm Wallstent was placed; however, the stent did not cover the proximal portion of the stricture (arrow). E. Therefore, an additional 14 × 40-mm Wallstent (arrow) was placed there, and the stents were dilated using a 10-mm-diameter balloon catheter advanced via the right femoral vein. F. During postdilation of the stents, the balloon catheter slipped proximally due to high venous flow, and the proximal Wallstent migrated into SVC. G. Therefore, the migrated stent was pushed above by a 20-mm-diameter occlusion balloon catheter advanced via the right femoral vein (not shown), and a 16 × 60-mm Wallstent was advanced into the migrated stent via the left brachial route. The stent was then partially deployed and pulled back to the left brachiocephalic vein to fix the migrated stent, and the entire stent was placed. The final venogram showed rapid blood flow across the stents. The arrow indicates the migrated stent that was repositioned by the balloon catheter, and the arrowhead indicates the finally deployed stent.

**Author Contribution:** S.M. was mainly involved in the drafting of the manuscript and created the figures. S.M., M.Y., R.I., A.Y., and T.F. were involved in the interventional procedures. N.S. was involved in image analysis. All authors reviewed the manuscript.

**IRB:** This was a pictorial essay with no change in patient care, and institutional review board approval is not required at our institution for this type of article. Written informed consent was obtained from each patient before the procedure. All manuscript preparation processes complied with the Declaration of Helsinki.

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