Successful Double-Catheter Coil Embolization of an Iatrogenic Subclavian Artery to Internal Jugular Vein Fistula After Minimally Invasive Cardiac Surgery

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Title

Successful double-catheter coil embolization of an iatrogenic subclavian artery-internal jugular vein fistula after minimally invasive cardiac surgery

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Author contributions

All authors contributed to the study conception and design. Material preparation and data collection were performed by K. Matsuo and A. Fujita. The first draft of the manuscript was written by K. Matsuo and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscripts.

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The authors have no personal, financial, or institutional interest in any of the drugs, materials, and devices described in this article.

Conflict of interest

The authors declare that they have no competing interests.

Ethical statement

Written informed consent was obtained from a patient identifiable information or images within the manuscript. All patient information was anonymized and deidentified prior to the analysis.

Abstract

It is essential to establish cardiopulmonary bypass by percutaneous insertion of a large-bore catheter via both the femoral vein and internal jugular vein (IJV) for minimally invasive cardiac surgery (MICS). Complications associated with IJV catheterization during MICS have been reported in the literature; however, vascular injury of the subclavian artery (SCA) is rare. We herein present a rare case in which an iatrogenic arteriovenous fistula (AVF) between the right SCA and IJV after MICS was successfully treated by endovascular coil embolization. A 61-year-old man who had undergone mitral valve repair by MICS 10 months before presentation was referred because of pulsatile cervical bruit and tinnitus. Radiographic examination revealed a pseudoaneurysm associated with an AVF located between the right common carotid artery and vertebral artery. The AVF was completely occluded with detachable coils using a double-catheter technique to avoid coil migration into the IJV. This technique has been used to treat high-flow or complex AVFs, including pulmonary and renal AVFs. As shown in the present case, it is also useful to treat an iatrogenic AVF between the SCA and IJV.

Key words

Arteriovenous fistula, Internal jugular vein, Minimally invasive cardiac surgery, Pseudoaneurysm, Subclavian artery

Introduction

Minimally invasive cardiac surgery (MICS) has evolved during the last decade partly because of the reduced length of hospitalization, improvements in patients' satisfaction with the cosmetic results, and achievement of outcomes comparable to those of traditional cardiac surgery.[1,2] During MICS, it is essential to establish cardiopulmonary bypass (CPB) by percutaneous insertion of a large cannula because of the restricted operative field. Superior vena cava (SVC) drainage can be achieved by percutaneous insertion of a large-bore cannula via the right internal jugular vein (IJV). Although peripheral cannulation should be carefully performed using ultrasound guidance, vascular-related complications tend to occur more frequently in MICS than in cardiac surgery performed by median sternotomy.[3,4] Reported complications after the use of CPB include local hematoma, vascular injury, catheter-related thrombosis, and pulmonary complications of variable severity. The incidence of vascular complications in MICS has been reported to between 0.68% to 4.3% by different groups.[5-7] Although IJV catheterization is widely performed and recognized as a safe procedure, unexpected vascular injuries can occur and may have serious consequences.[8] The most common arterial injury associated with IJV cannulation is carotid artery injury; the subclavian artery (SCA) is injured less frequently than the carotid artery. Thus, the optimal management strategy remains unclear.[9]

We herein present a rare case of an iatrogenic arteriovenous fistula (AVF) between the SCA and IJV due to a right SCA pseudoaneurysm following IJV cannulation for CPB in mitral valve repair performed by MICS. The fistulous segment and the pseudoaneurysm were successfully treated by endovascular coil embolization using a double-catheter technique. We discuss the usefulness of this technique particularly when a high-flow AVF increases the risk of coil migration into the venous side.

Case report

A 61-year-old man presented for evaluation of progressive exertional dyspnea of several months' duration and was referred to our cardiovascular surgery department because of severe mitral regurgitation. Mitral valve repair was performed by MICS through a right mini-thoracotomy with percutaneous CPB. During the MICS procedure, CPB was planned with venous drainage through the femoral vein using a 25-French cannula and right IJV using a 17-French cannula and with arterial return through the right femoral artery using a 20-French cannula. Ultrasound-guided right IJV puncture was performed by an 18-gauge needle, and the outflow from the needle appeared to be venous. During insertion of a 17-French HLS cannula (Getinge Group, Gothenburg, Sweden) over the guidewire, undue resistance was felt at the depth at which the cannula was expected to reach the SVC, and blood could not be aspirated. We found this cannula was non-functional and stabilized in place while the surgery was carried out using just the femoral venous access. The patient was hemodynamically stable, and the surgical procedure was completed as planned; mitral plasty was performed with resection of P2 and a 30-mm annuloplasty band (CG Future; Medtronic, Minneapolis, MN, USA). Upon weaning from CPB, the venous tear was sutured with the assistance of a jugular compression maneuver for control of venous bleeding. The patient was successfully separated from the CPB system; however, he required intubation for 1 week because of a neck hematoma. A postoperative day 2 contrast-enhancement computed tomography (CT) scan revealed a right AVF between the SCA and IJV. After confirming shrinkage of the hematoma on postoperative day 5 cervical CT scan, the patient was extubated and showed no neurological deficits. The decision not to address the lesion was made based on the findings of reduced size of neck hematoma. When the patient was discharged one month after surgery, we recommended conservative treatment after discussion with the vascular surgery team because the patient had no signs of heart failure or disturbances of intracranial venous circulation. A focal bruit was auscultated on the right side at the time of discharge.

He was again referred to our neurosurgical department with worsening of pulsatile cervical bruit and tinnitus 10 months after the mitral valve repair by MICS. On admission, the patient's neurological examination findings were normal; however, he complained of persistent right-sided pulsatile tinnitus and could not hang a bag on his shoulder because of a sensation of heaviness of his right upper extremity. Neck auscultation revealed prominent bruit radiating up the right side of the neck to the angle of the jaw without signs of jugular venous distention. Magnetic resonance angiography suggested an AVF between the right SCA and right IJV (Fig. 1A). A pseudoaneurysm (Fig. 1A, white arrow) was present in the caudal aspect of the right SCA between the right common carotid artery and vertebral artery. The engorged right IJV (Fig. 1A, arrowheads) suggested arterial flow reflux toward the brain. Three-dimensional CT angiography images clearly showed a 12- × 9-mm pseudoaneurysm with a 3-mm neck of the right SCA connected to the right IJV (Fig. 1B, C). The dorsal oblique view of three-dimensional CT angiography showed that the dilated right IJV was associated with multiple enlarged cervical veins (Fig. 1D). A diagnostic right SCA injection showed that the AVF was associated with retrograde flow into the right IJV (Fig. 2A). A late venous-phase injection of the right internal carotid artery showed no opacification of the right IJV suggesting disturbance of the intracranial venous circulation. Based on these findings, we planned to perform endovascular obliteration of the AVF with preservation of the right SCA.

The endovascular procedure was performed under local anesthesia through the right femoral artery approach. A 7-French ultralong guiding sheath (Shuttle Sheath; Cook Medical, Bloomington, IN, USA) was placed in the right SCA supported by a 300-cm, 0.035-in guidewire (Radifocus; Terumo, Tokyo, Japan) as a buddy wire using a right anteroposterior oblique view for a working angle (Fig. 2B). This working angle clearly showed the angioarchitecture between the pseudoaneurysm (Fig. 2B, arrow) and the IJV (Fig. 2B, arrowheads). We initially experienced difficulty forming a cage or anchoring the vessel wall at the shunting site because of the high-flow shunt. Several released coil loops of a 10-mm × 40-cm Target XXL coil (Stryker Neurovascular, Fremont, CA, USA) readily migrated into the IJV, and accurate coil placement at the fistula site was impossible. Therefore, we decided to use the double-catheter technique. To perform the double-catheter technique, two microcatheters (Excelsior 1018; Stryker Neurovascular, Fremont, CA, USA) were advanced into the shunting point immediately outside the pseudoaneurysm (Fig. 2C, arrowheads). This allowed the controlled advancement and adjustment of the two coils until they interlocked together and remained within the shunting site. Simultaneous delivery of two 10-mm × 40-cm Target XXL coils by the two catheters assured accurate placement of the two coils with a stable coil configuration (Fig. 2D). After release of the two coils, a total of 13 coils were placed in both the shunt and the pseudoaneurysm. A working view (Fig. 2E) and anteroposterior view (Fig. 2F) of the right SCA injection showed complete obliteration of the fistula and pseudoaneurysm with preservation of the right SCA.

The patient's tinnitus and cervical bruit completely disappeared immediately after the procedure, and his postoperative course was uneventful. The sensation of heaviness of his shoulder and upper extremity also disappeared within 1 week, and he was able to carry baggage as before. The 6-month follow-up magnetic resonance angiography examination showed no evidence of recurrence.

Discussion

The performance of MICS through a small thoracotomy has been increasing because of the rapid recovery time and the cosmetic advantages.[1] A recent German study showed that 43.2% of isolated mitral valve surgeries were performed by MICS,[10] and accumulation of additional experiences has led to MICS becoming an established option for mitral valve repair. Nishi et al.[11] evaluated the current status of mitral valve repair by MICS using a nationwide surgical database and found that 15.6% of mitral valve repairs were performed by MICS in 2012 and that the 30-day mortality rate was 0.3%. Although the reported rate of MICS-related complications remains very low, MICS can be a potentially hazardous procedure because of the small operative field. An important difference between MICS and conventional cardiac surgery is the safety and secure establishment of CPB during MICS using a relatively large-bore cannula percutaneously placed in a peripheral vessel. A 15- to 21-French cannula may be inserted percutaneously via the right IJV; however, this cannula is considerably larger than the multilumen 7- to 9-French catheter inserted into the IJV for hemodynamic monitoring and administration of fluid and vasoactive medications.[1] The incidence of catheter-related complication in MICS is reported as 0.68% to 4.3%[5-7]; however, these vascular injuries can lead to devastating complications if a large-bore cannula is inadvertently inserted too deeply. To avoid vascular complications during MICS, routine use of transesophageal echocardiography is recommended to monitor the tip of the cannula placed in the SVC.[12] In our institution, routine fluoroscopic guidance is not used, but the surgical setting of routine fluoroscopy or hybrid room are recommended options in a situation where undue resistance is felt during advancement of the cannula deep into the SVC.[3] Researchers have speculated that although the initially punctured guidewire is in the correct intravascular space in the right IJV, the stiff dilator cannula can be advanced over the guidewire and puncture the posterior wall of the vein, thereby causing injury.[13]

A few studies have focused on the rate of iatrogenic supra-aortic vascular injury associated with catheter cannulation in the IJV.[9,14-16] According to these reports, the incidence of inadvertent arterial trauma with a small needle and a large cannula was 0% to 11%, 0.1% to 0.8%, respectively. These injuries included hematoma formation due to vascular perforation (potentially resulting in airway obstruction), pseudoaneurysms, and AVFs. According to these reports, surgical exploration and direct closure of the artery under general anesthesia is safe with low rates of morbidity and mortality, whereas immediate catheter removal with external blind manual compression results in high rates of major complications. The decision regarding the need for such a procedure should be made during surgery. A pseudoaneurysm or AVF can also develop after arterial laceration secondary to iatrogenic puncture, and surgical repair may require additional thoracotomy during MICS. An AVF between the SCA and IJV may be asymptomatic and incidentally found during auscultation; however, it may also present with heart failure, arterial steal, radiculopathy, or upper extremity symptoms.[17,18] Although the natural course of iatrogenic AVFs remains unclear, such fistulas should be treated immediately after MICS. Endovascular management using coil embolization or stent grafting has recently been reported as a less invasive alternative option and has shown acceptable outcomes.[9,18] The first-line treatment for these lesions may shift to endovascular therapy with a covered stent, however, the long-term durability is unclear because of the occurrence of early and delayed stent stenosis or occlusion.[19]

Percutaneous endovascular coil embolization may be feasible for vascular access to an AVF between the SCA and IJV. Angiographically, an iatrogenic AVF of the SCA is often revealed as a single direct fistulous connection between the SCA and an adjacent vein, occasionally with a coexisting pseudoaneurysm. The goal of treatment of this type of AVF is complete obliteration of the direct communication between the arterial and venous components. Transarterial coil embolization at the shunting site with preservation of the parent artery is a feasible treatment; however, distal coil migration is a well-known complication, especially in high-flow or complex fistulas.

We used a double-microcatheter technique from a single arterial access for ensure good control of flow during the stable anchoring of coils in the fistulous segment. We initially attempted to insert a platinum coil, but it was impossible to place the coil through a single catheter into the shunting point without migration of the coil into the venous segment. Next, two microcatheters were inserted into the fistulous segment and two coils were inserted alternatively from each catheter, resulting in stable placement of the coils. This technique was first reported in the treatment of wide-necked intracranial aneurysms to create a stable coil frame within the aneurysm by using two coils to brace each other.[20] Since then, the double-microcatheter technique has been used successfully to treat difficult vascular lesions including high-flow or complex pulmonary, renal AVFs, and visceral artery aneurysms.[21] Additionally, the second microcatheter can be changed to the balloon catheter for the aim of flow control of the feeding artery, it could be an alternative technique to prevent the distal migration of embolic materials.[22] We also discussed the use of a covered stent in our case; however, the pseudoaneurysm was located in a short segment of only 3 cm between the right common carotid artery and vertebral artery. This segment had a relatively straight course with a sufficient diameter for insertion of a covered stent, but insertion of even the shortest covered stent without obstructing the orifices of major branches was difficult.

Despite the limitation of being a single case with a 6-month follow up, our double-catheter coiling of both the shunting point and the pseudoaneurysm can be simple and effective method for an iatrogenic AVF between the SCA and IJV. When a large laceration resulting in a hemodynamically unstable condition, however, endovascular management with the placement of a covered endograft or direct surgical repair should be considered as an alternative option. Previous study reported that the treatment indications of these AVF were to relieve symptoms and prevent congestive heart failure, although some questions remain about the benefit of asymptomatic lesion.[9] In our case, closure of the iatrogenic AVF was delayed until 10 months after surgery, however, such lesions should be treated immediately after surgery. More clinical studies or case series are needed to further understand the indications and limitations of endovascular treatment of an iatrogenic vascular injury after large-bore catheterization via the right IJV.

Conclusions

We have presented a rare case of iatrogenic SCA injury with a resultant AVF between the SCA and IJV by a large cannula inserted via the right IJV during mitral valve repair by MICS. A pseudoaneurysm of the SCA was successfully treated by double-catheter endovascular coiling, which provided obvious advantages in terms of avoiding venous migration of the initially placed coils. The incidence of this complication has substantially decreased with the development of minimally invasive cannulation techniques; however, surgeons should still be aware of the risk of vascular complications associated with peripheral percutaneous venous cannulation for CPB.

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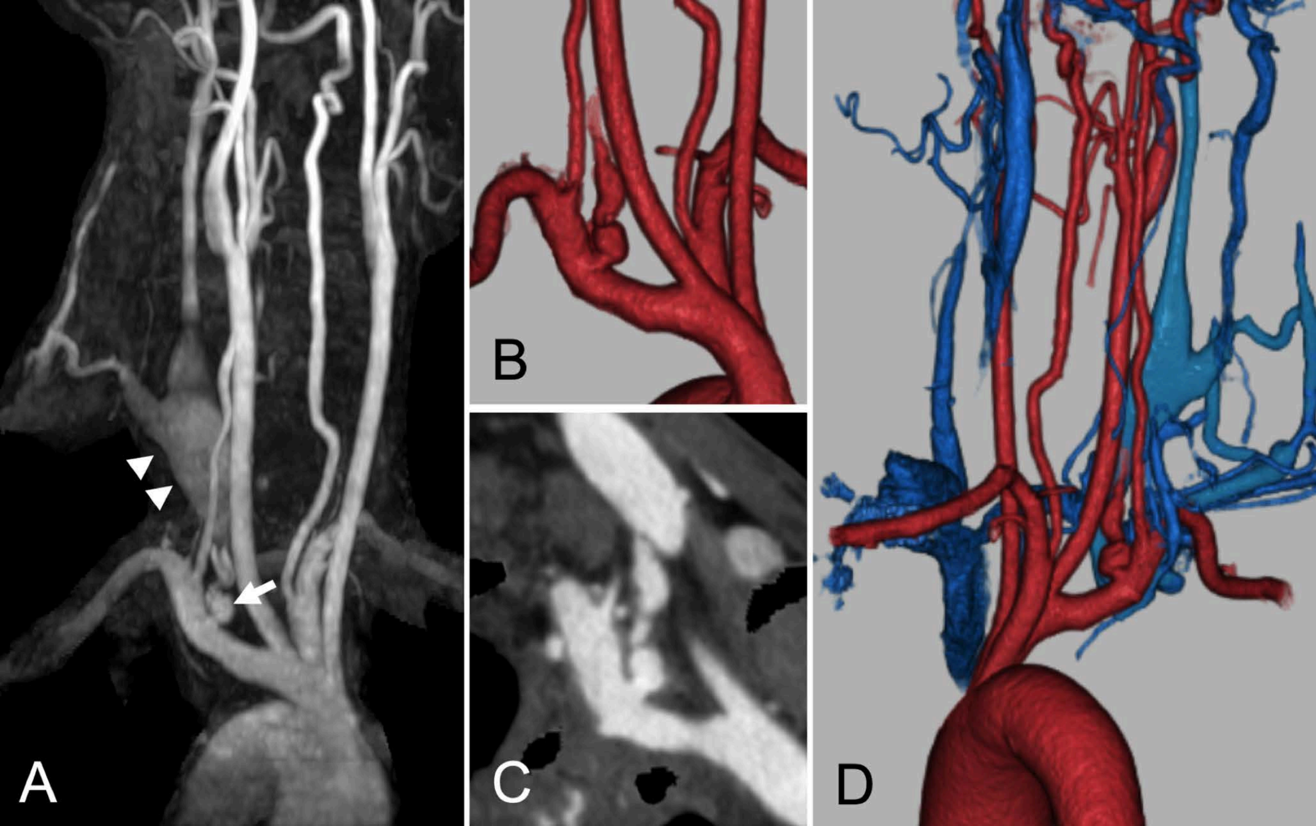
Figure captions

Fig. 1. (A) Right oblique view of magnetic resonance angiography shows an arteriovenous fistula (AVF) between the right subclavian artery (SCA) and the right internal jugular vein (IJV). Note the pseudoaneurysm (white arrow) of the right SCA and the dilated right IJV (arrowheads). **(B)** Volume rendering and **(C)** multiplanar reconstruction imaging of three-dimensional computed tomography angiography show the AVF originating from a pseudoaneurysm of the right SCA connected to the right IJV. The pseudoaneurysm is located between the origin of the right common carotid artery and the vertebral artery. **(D)** Dorsal oblique view of three-dimensional computed tomography angiography shows the dilated right IJV associated with multiple enlarged cervical veins suggesting venous congestion.

Fig. 2. (A) Anteroposterior view of a right subclavian artery (SCA) angiogram shows the arteriovenous fistula (AVF) associated with the dilated right internal jugular vein (IJV) and enlarged cervical veins. **(B)** Working view (right anterior oblique projection) of the right SCA angiogram shows the orifice of the pseudoaneurysm (white arrow). Note the dilated right IJV (white arrows) opacifying in the early arterial phase. **(C)** Unsubtracted anterior oblique view image shows the tips of the microcatheters located in the AVF through a 7-French ultralong sheath supported by a 0.35-inch guidewire. **(D)** Another unsubtracted image shows tight interlocking of the two coils in the shunt using the double-catheter technique. **(E)** Anterior oblique and **(F)** anteroposterior views of a right SCA angiogram obtained at the end of the procedure show complete obliteration of the AVF with preservation of the SCA.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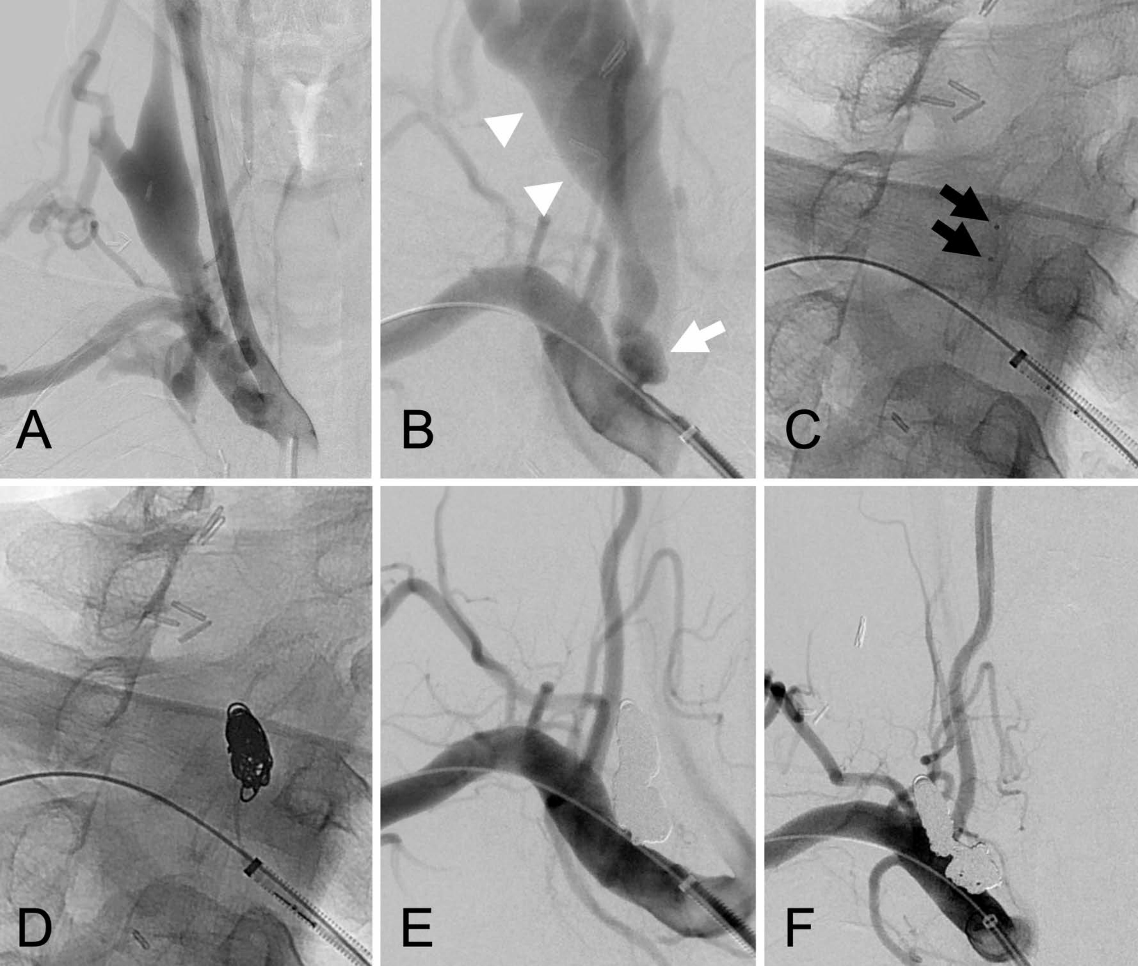
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