

Case Report

Reconstruction of the Superior Vena Cava Following Invasive Thymoma Resection by Monitoring Cerebral Oxygenation

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Invasive thymoma often invades adjacent organs, such as the pleura, lungs, pericardium, and great vessels; the superior vena cava and brachiocephalic vein are particularly susceptible. A 31-year-old woman was admitted after chemotherapy for invasive thymoma involving the superior vena cava and left brachiocephalic vein. During the operation, regional cerebral oxygenation was measured using the INVOS™5100C monitor to avoid adverse effects due to long-time total clamping of the superior vena cava because left brachiocephalic vein could not be reconstructed due to total occlusion of the distal lumen. We could decide if the SVC was safely clamped with this INVOS™5100C monitor. Then complete resection of the tumors was successfully performed, and a single artificial graft was used for reconstruction of the superior vena cava. Postoperative clinical course was uneventful, and she was discharged on the 18th postoperative day.

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Introduction

Mediastinal tumors tend to invade the great vessels, nerves, lungs, and pericardium. Superior vena cava (SVC) or brachiocephalic veins are often reconstructed to achieve total tumor resection. In that situation, we have worried that how long the SVC could be clamped and how we could avoid the brain damage in the decrease of venous return. The INVOS™ 5100C monitor has been used for monitoring regional oxygenation in cardiac surgery.¹ But there have been no reports about the usefulness of monitoring the cerebral oxygenation during the total clamping of SVC. Herein, we report a case of successful reconstruction of SVC following invasive thymoma resection by monitoring cerebral oxygenation.

Case Report

A 31-year-old woman with dyspnea and back pain visited a regional hospital. She was found to have a huge mass on chest X-ray (Fig. 1) and a mediastinal mass invading the superior vena cava (SVC) and the left brachiocephalic vein (BCV) on enhanced chest CT. Five tumors were seen in the right thorax (two were above the diaphragm and near the paravertebral lesion, and one was on the surface of the lower lobe), which were considered disseminated tumors. Transcutaneous needle biopsy was done, and type B3 thymoma was suspected. Based on these findings, she was diagnosed with Masaoka Stage IVa disease. Thus, she was given 9 cycles of chemotherapy, that is, the CODE regimen, including cisplatin 25 mg/m², vincristine 1 mg/m²,

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Figure 1. Chest X-ray shows a huge mediastinal mass in the thorax and elevation of the right diaphragm.

adriamycin 40 mg/m², and etoposide 80 mg/m². However, despite aggressive chemotherapy, the tumor size remained stable disease status (Fig. 2). Moreover, dilatations of many collateral veins were seen due to the obstruction of left BCV (Fig. 3). Therefore, she was referred to our department for further examination and evaluation of surgical treatment. She was still young and in good medical condition after repeated chemotherapy, so it was decided to perform surgery with detailed informed consent.



Figure 2. Contrast-enhanced chest CT shows the tumors obstructing the superior vena cava (arrow). Despite nine cycles of chemotherapy, the tumor remains stable disease status.

Under general anesthesia, the median sternotomy was made. The tumor occupied the upper mediastinum and was invading the right upper lobe, the middle lobe, the SVC, the left BCV, and the azygous vein. First, the left BCV was dissected due to involvement of the tumor. Since the tumor dissection was very difficult, an additional right thoracotomy at the 4th intercostal space was made to produce an inverted L-shaped thoracotomy.

Regional cerebral oxygenation (rSO₂) was measured using the INVOS™ 5100C monitor (Somanetics Corporation, Troy, MI) every 30 minutes. From the start of this operation, two sensors were placed on both sides of the patient's forehead,

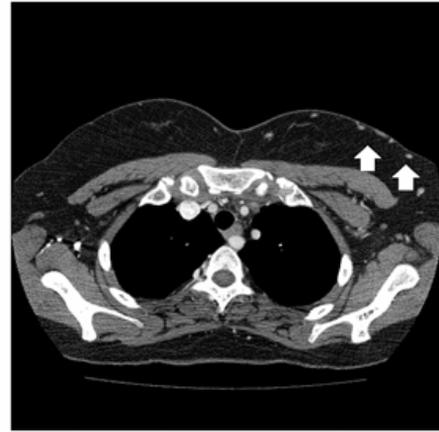


Figure 3. Contrast-enhanced chest CT shows that many collateral veins were seen due to the occlusion of the left brachiocephalic vein (arrows).

directly above the eyebrows. Before clamping of the right BCV, the right-sided rSO₂ value was 65%. When the right BCV was clamped, the corresponding rSO₂ value decreased to 48%. We decided that we could clamp the SVC and that we did not have to bypass the left BCV to the right appendage prior to SVC reconstruction. The patient received 5000 unites of intravenous heparin sodium, and the SVC was safely reconstructed by end-to-end anastomosis using a 12mm, ringed, polytetrafluoroethylene (PTFE) graft with continuous 5-0 monofilament sutures (Fig. 4). Total SVC clamping time was 77 minutes. Finally, all tumors, including the upper lobe and middle lobe and the five disseminated tumors, were resected. Bilateral rSO₂ values recovered promptly after re-

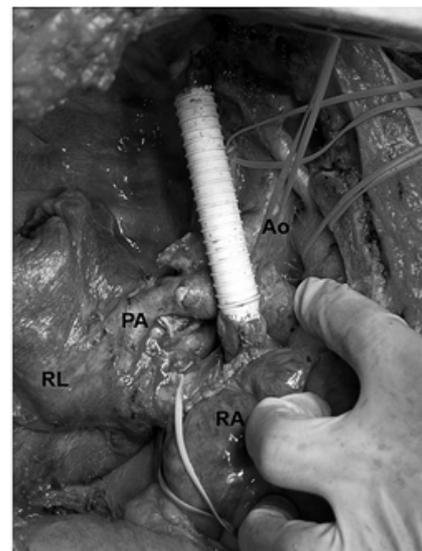


Figure 4. The superior vena cava is successfully reconstructed using a 12mm, ringed, polytetrafluoroethylene graft. (Ao = aorta, PA = pulmonary artery, RA = right atrium, RL = right lower lobe)

construction (Fig. 5). The operation time was 663 minutes, and the total amount of bleeding was 1760 ml. Pathological findings showed that the tumor was invasive type B2 thymoma and tumor free in the margin of SVC, left BCV. Her postoperative course was uneventful, and the enhanced chest CT showed good patency of the SVC graft with anti-coagulation therapy. The patient was discharged on the 18th postoperative day. After 12 months, the tumor recurrence was seen near the pericardium. We could resected the tumor, but it resulted in incomplete resection. Radiotherapy was given to the residual tumor for local control.

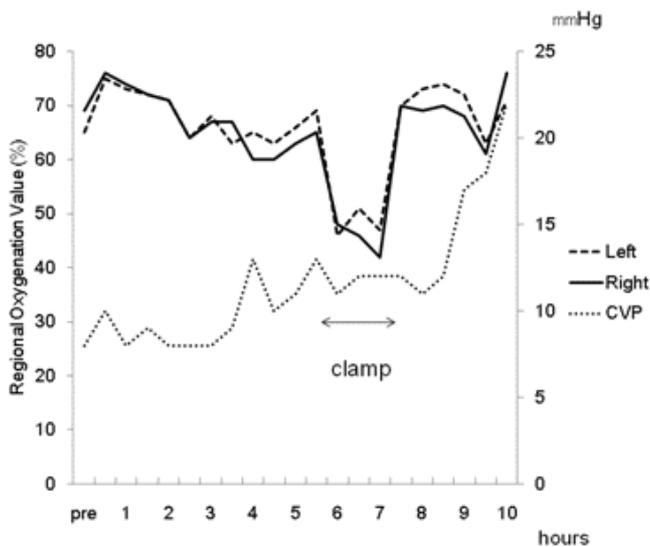


Figure 5. Every 30 minutes, regional cerebral oxygenation was measured using the INVOS™ 5100C during the operation. Decline of the regional oxygenation value was seen during clamping of the superior vena cava. However, the values recover quickly (pre = pre-surgery, Left = left side of the head, Right = right side of the head, CVP = central venous pressure).

Discussion

Successful reconstruction of the superior vena cava for invasive thymoma was performed because we could decide if the SVC was safely clamped under monitoring of regional cerebral oxygenation (rSO₂).

The superior vena cava (SVC) is susceptible to invasion from tumors arising from the anterior mediastinal component, such as thymomas, thymic carcinomas, and so on.

Several successful cases of reconstruction of such a great vessel using ringed polytetrafluoroethylene (PTFE) grafts with long-term survival have been reported.^{2,4} However, surgeons have been concerned about the need for bypass grafts and reconstruction of these veins because of the

potential adverse effects of venous clamping, which sometimes causes severe complications. Darteville and colleague⁵ reported that abrupt venous clamping could induce decreased right ventricular pre-load, decreased cardiac output, and systemic hypotension. They also reported increased venous pressure leading to an increase in the risk of thrombosis of the cerebral veins.

In the clinical setting, SVC clamping time was usually 60 minutes or less⁶ in the presence of venous collaterals. Thus, it has been recommended that we should establish the left BCV graft before reconstruction of the SVC to avoid hemodynamic compromise. However, in the present case, the left BCV could not be reconstructed at all due to occlusion of the distal lumen. Thus, there was a significant concern about reconstructing the SVC because venous pressure in the jugular vein might increase and harm the brain.

Optimizing cerebral oxygenation is of paramount importance in certain intra-operative situations. Central venous pressure monitoring has generally been used, but some complications after SVC reconstruction do occur. The INVOS™ 5100C monitor has been used for monitoring regional oxygenation in neurosurgery, cardiac surgery, and vascular surgery.⁷ However, there have been few reports in the general thoracic surgery field.

Measurement of rSO₂ is based on the different absorption characteristics of oxygenated and deoxygenated hemoglobin: oxygenated hemoglobin (HbO₂) absorbs less red light (600-750 nm) and more infrared light (850-1000 nm) than deoxygenated hemoglobin. As a result, deoxygenated hemoglobin has an absorption peak at 740 nm while HbO₂ does not.⁸ Due to the variability of baseline rSO₂ among patients, a baseline should be determined for each patient before induction of general anesthesia, and detection of cerebral ischemia is based on deviations from baseline, rather than on absolute INVOS™ values. If baseline rSO₂ is < 50%, then reduction by 15% below baseline is the critical threshold for ischemia detection.⁷ But the procedure for patients in this report were intended for cardiac surgery and carotid endarterectomy, not for the vein. If collateral veins were less developed or if more clamping time were needed, brain venous return would decrease, and the rSO₂ values would decline more than in the present case. In that severe situation, we would use the ANTHRON® bypass tube (Toray industries, Tokyo) between right subclavian or jugular vein and right appendage. As a result, it was possible to reconstruct the SVC with careful monitoring of the critical rSO₂ values.

Though this is just case report we cannot define the total clamping time, with this objective cerebral oxygenation

monitoring system and collateral veins, clamping the SVC for more than 60 minutes became possible. Knirsch⁹ et al reported that regional cerebral oxygenation by near-infrared spectroscopy does not correlate with central venous oxygen saturation during interventional catheterization in children. So we should accumulate clinical cases to clarify the usefulness of INVOS system.

Conclusion

We believe that the INVOS™ 5100C monitor could be one of the useful and objective devices during the total clamping of SVC. It also encourages surgeons to achieve radical tumor excision with reconstruction of the great vessels.

Disclosures and Freedom of Investigation

The authors have no personal conflict of interest and no outside support for this research.

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