Case Report

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

Takuro Miyazaki, Naoya Yamasaki, Tomoshi Tsuchiya, Keitaro Matsumoto, Koichi Tomoshige, Tsutomu Tagawa and Takeshi Nagayasu

Division of Surgical Oncology, Nagasaki University Graduate School of Biomedical Sciences, 1-7-1 Sakamoto, Nagasaki 852-8501, Japan
Tel: +81-95-819-7304; Fax: +81-95-819-7306

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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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.

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, 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 units 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-
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.

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 ($rSO_2$).

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. 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. Dartelle and colleague 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 less 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. However, there have been few reports in the general thoracic surgery field.

Measurement of $rSO_2$ is based on the different absorption characteristics of oxygenated and deoxygenated hemoglobin: oxygenated hemoglobin (HbO$_2$) 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 HbO$_2$ does not. Due to the variability of baseline $rSO_2$ 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 $rSO_2$ is < 50%, then reduction by 15% below baseline is the critical threshold for ischemia detection. 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 $rSO_2$ 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 $rSO_2$ 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. Knirsch 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**

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**References**