

## Non-programmed clamping of superior vena cava. The anesthesiologist's Achilles' heel

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**Abstract** : This case presentation focuses on the hemodynamic alterations due to acute clamping of superior vena cava (SVC) during a right pneumonectomy for lung cancer and on the alternatives for drug administration. In a 71-yr-old female patient without clinical manifestations of SVC syndrome, this large vein was clamped for 22 minutes for patch placement after sudden and unpredictable hemorrhage. The patient became acutely cyanotic and edematous in the face and upper extremities, arterial blood pressure dropped and the venous pressure in the right internal jugular vein was elevated. Drugs for managing the patient were given endobronchially and via an established right atrium line. Postoperatively, no neurologic deficit was noted. This case demonstrates the difficulties for managing patients without superior vena cava syndrome in which acute, non-programmed intraoperative SVC clamping is performed, as this is followed by systemic and brain hemodynamic deteriorations that may lead to bad outcome.

**Keywords** : Superior Vena Cava ; Lung Cancer ; Anesthesia.

### INTRODUCTION

In the adult population, surgery involving superior vena cava (SVC) is mainly for lung cancer, invasive thymomas, retrosternal extension of thyroid, other mediastinal masses and vascular lesions (3, 4, 6, 7, 9, 17). Thoracic injuries and complications caused by mediastinoscopy or other diagnostic and therapeutic procedures may also lead to such an operation. Patients scheduled for operations involving SVC can be divided according to the presence or not of manifestations of SVC syndrome. Findings as dilated veins in the upper half of the body, edema of the head, neck and upper extremities, profound veins in the chest wall and cyanosis denote a gradually reduced flow in SVC and activation of collateral vein networks. In case of absence of these symptoms, the normal collateral venous circulation, connecting the upper and the lower compartments of venous return, is unable to

serve the flow load when SVC is clamped acutely. In this situation, three major problems have to be faced : the sudden reduction of venous return and the consequent decrease of both cardiac output and systemic pressure, the decreased cerebral perfusion pressure and flow and, finally, the inability to access the "free" circulation if, as usual, peripheral or/and central venous catheters are already introduced in veins draining to the SVC. Under these circumstances, clamping of SVC is hardly tolerated and extracorporeal circulation may be necessary to avoid bad operative outcome (16, 17).

### CASE REPORT

A 71-yr-old female patient (62 kg, 153 cm), A.S.A. class III with a 7-year history of controlled hypertension was scheduled for upper/median bilobectomy for lung cancer. The patient reported some limitation of ordinary activity in the previous two months. Compared to predicted, maximum

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breathing capacity and FEV<sub>1</sub> were 72% and 68% respectively and FEV<sub>25-75</sub> was 1.65 L. Preoperative evaluation revealed normal blood gas values. Diazepam (10mg) was given orally one hour before transportation to the operating room. There, the patient was connected to the monitor (*Solar 8000, Marquette Medical Systems, Milwaukee, USA*) and a BIS sensor (*BIS/XP, Aspect Medical systems, USA*) was placed showing a value of 98. Peripheral venous and radial artery catheters were inserted in the left arm. An epidural catheter was introduced and advanced for 2-3 cm through L<sub>1</sub>-L<sub>2</sub> interspace. Induction was achieved with the administration of 100 mg of fentanyl, 2 mg of midazolam and 14 mg of etomidate and muscle relaxation with 8 mg of pancuronium. A left-sided 35 F double lumen tube (DLT) was inserted and the classical maneuvers for testing its position and the integrity of lung separation were followed by fiberoptical bronchoscopy (*3.5mm, ENF/P3 Olympus, Japan*). Mechanical ventilation was instituted and administration of sevoflurane started, targeting to a BIS value of  $\approx$  40. After nasogastric and urinary catheter placement, a triple-lumen catheter was inserted *via* the right internal jugular vein and a continuous infusion of remifentanyl ( $\approx$  0.3 $\mu$ g/kg/min) was connected. The patient was positioned exposing the right hemithorax for the operation. She tolerated well the one-lung ventilation receiving FiO<sub>2</sub> = 1. The operation proved to be technically difficult as the tumor invaded the hilum and the surgeons decided to proceed to intrapericardial pneumonectomy. After two hours, the monitored parameters of the patient remained satisfactory with the transfusion of one unit of packed red cells. During lysis of adhesions between tumor and SVC, below azygos junction, a partial clamp on the SVC slipped with sudden serious hemorrhage. Only then, with the decision for total clamping already taken, the anesthesiologists were informed with the expression "give us five minutes". The clamps were placed after the administration of 10000iu of heparin, with arterial pressure abruptly dropping from 110/68 to 45/35 mmHg, heart rhythm becoming for seconds bradycardic and then slightly increased (65 to 70 beats/min), loss of CVP trace in the monitor and EtCO<sub>2</sub> dropping from 29 to 12 mmHg. In seconds it was realized that, although flow from the infusion lines was not interrupted, the administration of drugs and volume was not reaching target organs and infusion was cut off. The table was tilted to 10° "head down" position and the arterial pressure was raised to 56/39 mmHg. The patient became gradually cyanotic with an identifiable pulse oximetry

trace and SpO<sub>2</sub> value of 100. One thousand  $\mu$ g of adrenaline were diluted in a 10 ml syringe and were given through the endobronchial lumen of the DLT, raising the arterial pressure to 78/54 mmHg and the heart rate to 105 beats/min. Five minutes with the SVC occluded, the patient was cyanotic, tremendously edematous, with bulged eyeballs, uncovered by the swelling eyelids. The table was re-tilted to slight "head up" position and a second dose of 500  $\mu$ g of adrenaline was given to the patient as before. Systolic blood pressure remained above 70 mmHg, EtCO<sub>2</sub> was around 15 mmHg, SpO<sub>2</sub> was 100 and venous pressure, measured via the proximal lumen of the 3L-catheter, was 38/32 mmHg with an almost systemic pressure waveform. The alarm of the remifentanyl infusion pump was activated as the distal lumen of the 3L-catheter was clamped. Throughout this period, BIS remained stable with a value near 40. The surgeons were asked to establish a right atrium line. A 14 G venous catheter was introduced and was fixed with a purse-string stitch to the atrium wall. One thousand mg of thiopental was administered intraatrially and BIS value dropped to 2. A minor decrease in arterial pressure was noted (68/48 mmHg) while venous pressure decreased significantly to 19/18 mmHg. Five minutes later and after the intraatrial administration of 100  $\mu$ g of adrenaline, the arterial and venous pressure were 74/52 and 26/23 respectively. Time necessary for SVC patch placement was 22 minutes. Before restoration of flow, the color and size of the lips, tongue, ears and the rest of the upper body of the patient were altered in such a degree to make her unrecognizable. Restoration of flow was immediately followed by better hemodynamics, elevation of BIS values to near 20 and a gradual improvement of the patient's look. The completion of the surgical procedure was followed by the epidural administration of 5 mg of morphine and the change to a single lumen endotracheal tube, which proved to be uneventful, although the laryngoscopic view revealed an edematous upper airway. The patient was transported to the I.C.U. where six hours later she was extubated without any neurologic deficit.

#### DISCUSSION

Total clamping of SVC acutely reduces venous return with further, beat-by-beat, reduction to an amount equal to the percentage of stroke volume that goes to the upper compartment. Stroke volume is progressively decreased. Equilibrium is reached when venous pressure gradient between the

upper and lower compartments leads to activation of "sleeping" venous networks and increased collateral flow. Blood volume is pooled in the upper compartment and the systemic flow and pressure are decreased. The percentage of stroke volume directed to the upper compartment is equal to the flow by the collateral veins towards the lower compartment. In sub-acute occlusion, a kind of equilibrium may be achieved followed by a severe clinical picture (13). In acute occlusion due to clamping, as in our case, severe brain damage or hemodynamic deterioration possibly happen before reaching equilibrium. Intraoperatively, every attempt to restore venous return by fluid administration to the lower compartment (i.e. establishing a femoral infusion) is leading to a new equilibrium with higher venous pressure in the upper compartment. This situation has detrimental effects to the brain as cerebral perfusion pressure is decreased to time. In a controlled experimental animal setting with extracorporeal circulation after ascending aortic and bicaval cannulations, complete occlusion of SVC was followed by significant decreases in cerebral blood flow and cerebral oxygen delivery, significant elevation of SVC pressure and acidosis (14).

In our case, decisions were taken under pressure and in very short time. Trendelenbourg's position was decided as it increases venous return. However, when SVC is clamped, this position could further decrease cerebral perfusion pressure. It was decided to test the net result of this maneuver by the gain in mean arterial pressure against the grossly estimated change in level distance of the head. It was considered ineffective and the table was re-tilted to slight "head up" position. The setting was not allowing placement of a new venous access to the "free" circulation for, at least, vasoactive drug administration. The intra-bronchial administration was the only alternative as surgeons were too busy to administer hemodynamic drugs to the already exposed right atrium. The establishment of a right atrium line, when and if it is allowed, may also be proved effective. Flattening EEG with thiopental seemed a good choice for increasing brain tolerance to the impaired perfusion. Thiopental reduces cerebral metabolic requirements. Nevertheless, it may cause supplementary hypotension as it depresses myocardial function and decreases venous return. In our case, the decision to treat the patient with cardio-vasoactive drugs was already taken and the adequate response to the previously given adrenaline was kept as a somehow back-up in case of further hemodynamic deterioration due to thiopental administration. It was considered that thiopental's

effect would be beneficial for brain integrity as its cardiovascular action could be prevented or reversed with cardio-vasoactive drugs. This high dose would probably cause a significant drop in BIS value and would erase its diagnostic value for brain ischemia (12). At that time, decision was towards brain viability instead of monitoring. Nevertheless, transient ischemia cannot be excluded by BIS readings.

In surgeries involving SVC, with or most often without the presence of SVC syndrome, the perioperative team has to decide whether to support or not the patient with extracorporeal circulation, with or without oxygenator (CPB). These modalities provide a safety net in the event of injury to vascular structures during tumor resection. Sometimes, this need may arise intraoperatively under urgent conditions (17). In a series of fourteen consecutive patients, the use of CPB during the resection of locally advanced thoracic malignancies was classified as planned or emergency (8 vs 6), as in the later the use of CPB was required during surgery due to injury of SCV, IVC or pulmonary artery (1). The use of extracorporeal circulation is also proposed for surgical correction of other causes of SVC syndrome (2, 4, 11) and for patients presenting significant obstruction of the lower airway, irrespectively of the existence of SVC syndrome (5). Venovenous or femoral artery and vein cannulation under local anesthesia, before anesthetic induction, in readiness for upper compartment's venous decompression or CPB is proposed (5, 10). Right axillary artery-inferior vena cava cardiopulmonary bypass can be established intraoperatively, before the main surgical intervention (11). Alternatively, to avoid full heparinization, a temporary by-pass between the left or right innominate vein and right auricula (2, 18), or an axillofemoral (15, 16), or axillosaphenous (8) venovenous by-pass can be established, by using artificial vessels, before clamping of the SVC. Simplicity, non-dependency on special equipment as heart-lung machine, reduced costs, avoidance of full heparinization and lesser inflammatory response are among the advantages of the types of above-mentioned venovenous by-pass. However, cardiopulmonary by-pass would be of important value intraoperatively in case of problematic oxygenation or significant bleeding and it would allow the application of hypothermia. Finally, although findings from monitoring of brain tissue oxygenation in humans (near-infrared spectroscopy/NIRS) are not available for these procedures, the use of this modality is expected to be of most help.

## References

1. Byrne J. G., Leacche M., Agnihotri A. K., Paul S., Bueno R., Mathisen D. J., Sugarbaker D. J. *The use of cardiopulmonary bypass during resection of locally advanced thoracic malignancies : a 10-year two-center experience.* CHEST, **125**, 1581-1586, 2004.
2. Chuang H. I., Wong K. L., Lai K. B., Wong K. S., Wei T. T., Chern F. C. *Anesthetic considerations in complete obstruction of major veins of upper trunk — report of two cases.* MA ZUI XUE ZA ZHI., **27**, 385-388, 1989.
3. Dave S. T., Kamath S. K., Shetty A. N., Naik L. D. *Anaesthesia management for subtotal thyroidectomy in a case of multinodular goitre with retrosternal extension and superior vena caval syndrome.* J. POSTGRAD. MED., **47**, 219, 2001.
4. Furuya A., Matsukawa T., Kumazama T. *Anesthetic management of a patient with thymoma presenting superior vena cava syndrome.* MASUL, **45**, 107-110, 1996.
5. Goh M. H., Liu X. Y., Goh Y. S. *Anterior mediastinal masses : an anaesthetic challenge.* ANAESTHESIA, **54**, 670-674, 1999.
6. Gombar S., Mitra S., Thapa D., Gombar K. K., Pathak R. *Anesthetic considerations in steroid-induced mediastinal lipomatosis.* ANESTH. ANALG., **98**, 862-864, 2004
7. Gozdzkiuk K., Czekajska-Chehab E., Wrona A., Tomaszewski A., Drop A. *Saccular aneurysm of the superior vena cava detected by computed tomography and successfully treated with surgery.* ANN. THORAC. SURG., **78**, e94-95, 2004.
8. Gutowicz M. A., Quinones-Baldrich W. J., Lieber C. P., Pecora D. V. *Operative treatment of refractory superior vena cava syndrome.* AM. SURG., **50**, 399-401, 1984.
9. Ko P. J., Liu Y. H., Hsieh H. C., Lin P. J. *Reconstruction using a pericardial tube and ringed Gore-Tex graft for malignant superior vena cava syndrome : report of two cases.* CHANG GUNG MED. J., **27**, 222-227, 2004.
10. Mao Z., Cheng B., Xia J., Gao S., Huang J., Kang G. *Surgical treatment for giant solid tumors of the mediastinum : a study of 26 cases.* INT. SURG., **88**, 164-168, 2003.
11. Mayo Moldes M., Tur Alonso A., Serrano Martinez F., Mira Quiros M. D., Moreno Gazquez A., Villalain Perez C., Alepuz Ferrer R., Montero Benzo R. *Anesthesia for a patient with superior vena cava syndrome.* REV. ESP. ANESTESIOLOG. REANIM., **51**, 100-103, 2004.
12. Okawa H., Hirota K., Sakai I., Tsubo T., Ishihara H., Matuki A. *Early detection of hypoxia with BIS monitoring during percutaneous cardiopulmonary support.* MASUL, **50**, 429-432, 2001.
13. Rizwan Hamer, Senyo Tagboto. *Superior vena caval obstruction following central venous cannulation.* NEPHROL. DIAL. TRANSPLANT., **19**, 258, 2004.
14. Sakamoto T., Duebener L. F., Laussen P. C., Jonas R. A. *Cerebral ischemia caused by obstructed superior vena cava cannula is detected by near-infrared spectroscopy.* J CARDIOTHORAC. VASC. ANESTH., **18**, 293-303, 2004.
15. Shimokawa S., Yamashita T., Kinjyo T., Iwamura H., Watanabe S., Moriyama Y., Taira A. *Extracorporeal venous bypass : a beneficial device in operation for superior vena caval syndrome.* ANN. THORAC. SURG., **62**, 1863-1864, 1996.
16. Shimokawa S., Yamashita T., Kinjyo T., Watanabe S., Yamaoka A., Moriyama Y., Toyohira H., Taira A. *Temporary extracorporeal axillofemoral venous bypass—a beneficial device in operation for superior vena caval syndrome due to intrathoracic malignancies.* NIPPON KYOBU GEKA GAKKAI ZASSHI., **45**, 1827-1832, 1997.
17. Spaggiari L., Magdeleinat P., Kondo H., Thomas P., Leon M. E., Rollet G., Regnard J. F., Tsuchiya R., Pastorino U. *Results of superior vena cava resection for lung cancer. Analysis of prognostic factors.* LUNG CANCER., **44**, 339-346, 2004.
18. Sugiuchi N., Yagi K., Suzuki T., Okano Y., Kikuchi S., Aoki T. *Anesthetic management for reconstruction of the superior vena cava by monitoring of peripheral venous pressure in a patient with a mediastinum tumor.* MASUL, **49**, 655-658, 2000.