Title: Management of air embolism during Cardiopulmonary Bypass

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Introduction: Air embolism during cardio pulmonary bypass remains a major concern even though there have been several advances in the technology involved. Consequently neurological and neuro-psycho-cognitive complications and the ways to prevent them remain high in the priority of all those who take care of these patients undergoing cardiac surgery with cardiopulmonary bypass. The risk of such complications is quoted anywhere between 0-40%1. The risk of significant air embolism is estimated at around 1 in 250002, though the risk of micro embolism is likely to be much higher. This combined with the possibility of pre-existing cerebro-vascular disease, hypoxia, hypoperfusion and associated metabolic derangements ensure the need for utmost care in the management of such patients.

The Case: Preoperative assessment. A 23 year old male was admitted for resection of a recurrent sub-aortic membrane. He had undergone a resection of a sub-aortic membrane at the age of 10 years. Past medical history includes bilateral cleft lip and palate repair. He has a solitary kidney as a result of a prior nephrectomy for a non functioning kidney. Examination revealed a 97kg relatively healthy male. Cardiovascular examination showed a grade 2 systolic murmur in the aortic area. Rest of the examination was normal. Intra operative course. Anesthesia was induced without problems, two 16g iv catheters, an arterial line and a central line in the right IJV were placed without any difficulty. An infusion of Dexmedetomidine and sufentanil were also commenced. A redo sternotomy was performed and the pericardium carefully dissected. Purse string sutures were placed in the distal ascending aorta and right atrial appendage. Intravenous heparin was given and the heart was cannulated in the standard fashion. Cardiopulmonary bypass was instituted and the patient cooled to 35°C. A left ventricular vent was placed through the right superior pulmonary vein. Carbon dioxide was infused in the field. A cardioplegia catheter was place in the mid ascending aorta. Immediately upon placing the cardioplegia catheter air bubbles were seen coming up the catheter. An alert was raised immediately. The patient was placed in a trendelenberg position, the cardioplegia catheter was converted into a root vent. All components of the bypass circuit were inspected thoroughly. The patient was cooled rapidly. The heart started fibrillating and had to be cardioverted. At 28 degrees the aorta was clamped and the heart arrested. A NIRS monitor was placed on the patient. Sodium Thiopental was given to the patient. We also treated him with steroids. We then opted to perfuse the brain in a retrograde fashion to try and flush out the emboli. To achieve this we proceeded with circulatory arrest at 28 degrees for three minutes. The brain was selectively perfused in a retrograde manner at 400 ml per minute for this period. The aorta was opened and visually inspected for obvious air bubbles. The inspection was negative. The procedure was then completed without any further complications. Post operative course. A decision was made to keep him intubated, sedated and moderately hypothermic at 35 degrees for neuro protection. Barbiturates were re-dosed in the ICU. A MRI scan (stroke protocol) was obtained in the immediate postoperative period and was negative for obvious defects. A cisatracurium drip along with remifentanyl was used for sedation. Strict control of his glycemic status was maintained. Adequate perfusion was also maintained with the use of ionotropes. Vasodilation was achieved with the use of milrinone. Neurological examination in the postoperative period showed pupils equal and reacting to light. Whilst still sedated he responded to painful stimuli and was able to move all his extremities. After weaning from the sedation he had a non focal neurological examination. He was extubated the next morning but remained delirious and combative. Over the next 24-48 hours he appeared to have fully recovered with no cognitive, sensory or motor derangement. He was discharged home on the fifth postoperative day with a followup in the surgical clinic to reassess his neurological status. At his clinic visit he did not have any deficits whatsoever.

Discussion: Air embolism during cardiopulmonary bypass remains a major concern in spite of advances in technology. Some of the more common reasons for macro air embolism include depletion of the reservoir, reversal of the vent line, defects in the tubing, use of high pressure suction in the pulmonary artery, unexpected heartbeat and pressurized cardiotomy reservoirs. Microscopic air embolism on the other hand is much more difficult to identify and to treat. Treatment of obvious massive air embolism requires a multimodal approach and involves in the first instance prevention of further emboli. The use of various monitoring techniques to assess adequacy of cerebral perfusion such as the Near Infra Red Spectroscopy is a useful adjunct. However the Neuro-protection remains the corner stone in the treatment of this potentially lethal complication. Cooling the patient is perhaps the most important measure in achieving this3. Ensuring adequate perfusion is essential as is maintaining a high oxygen content in the blood. One of the accepted ways of treating this complication is to proceed as quickly as possible to circulatory arrest and then to perfuse the brain in a retrograde manner via a cannula in the SVC2. The dilemma here is to decide at which point should the circulatory arrest take place and at what temperature. Warm ischemia can be equally disastrous. The other issue is determining the duration of retrograde perfusion and the flow rates. Considering the amount of air involved we chose to perfuse at 400ml/min for three minutes at 28 degrees. The use of hyperbaric oxygen has been successfully described in the treatment of this condition4. The use of steroids and barbiturates in this situation is not well established5. Tight control of the glycemic status can help prevent further insult to the brain. The best way to treat this dreaded complication is to prevent it. Meticulous preparation, checklists and an obsessive nature is the key to avoiding air embolism.

References: