TITLE: PEEP FOR TREATMENT OF VENOUS AIR EMBOLISM

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Introduction. Positive end expiratory pressure (PEEP) has been advocated for the acute treatment of air embolism because it is known to increase venous pressure and might thus decrease air entrainment if venous pressure could become positive at incision level. However, an acute increase in right atrial pressure could be dangerous if it tended to drive embolized air bubbles across a probe-patent foramen ovale (present in 25% of the adult population)[1] and into the systemic circulation. This would be more likely to occur if left atrial pressure did not increase as much as right atrial pressure during PEEP therapy. This study was designed to examine the impact of acute PEEP treatment on interatrial pressure gradient, hemodynamics and venous pressure at incision level during neurosurgical procedures performed in the seated position.

Methods. The subjects of the study were eleven informed, consenting adult patients (ASA Class I or II) undergoing elective cervical laminectomy in the seated position. The protocol was approved by the Human Investigation Committee. Anesthesia was induced with thiopental (4 mg/kg) and maintained with 70% N_2O in O_2 and morphine, 0.3-0.5 mg/kg IV. Pancuronium 0.1 mg/kg was given to facilitate intubation and ventilation was controlled to maintain $PaCO_2$ between 30 and 35 mmHg. Using pressure waveform control, radial arterial, and thermistor-tipped Swan-Ganz catheters were placed percutaneously and cardiovascular pressures were referenced to right atrial level. Heart rate, mean arterial pressure, right atrial pressure, pulmonary capillary wedge pressure, and cardiac output (thermodilution technique in triplicate) were recorded (Brush Model 440 recorder) at the following times: 1) During steady state general anesthesia with constant surgical stimulation immediately before applying 10 cm H_2O PEEP to the anesthesia circuit (ZEEP) and 2) 5 minutes after 10 cm H_2O PEEP was added to the anesthesia circuit. During each of these periods the negative venous pressure at the level of the incision also was estimated by elevating the right atrial pressure transducer to the height of the incision. Hemodynamic variables measured during PEEP were compared to those obtained during ZEEP using Student's t-test for paired data. $P<.05$ was regarded significant.

Results. 10 cm H_2O PEEP applied in the seated position during surgery caused significant reductions in mean arterial pressure (99.4 mmHg ± 9.6 SE vs 85.6 mmHg ± 3.4 SE, $p<.05$) and cardiac output (5.4 l/min ± 0.7 SE vs 4.6 l/min ± 0.5 SE, $p<.05$) without causing a change in heart rate. Right atrial pressure and venous pressure at incision level both increased significantly with PEEP, although the latter still remained negative in value (Fig. 1) PCWP did not increase significantly with PEEP and mean inter-atrial pressure gradient (RAP-PCWP) changed from negative to positive. Two of the 11 patients had RAP > PCWP before PEEP whereas 7 of the 11 patients had RAP > PCWP during PEEP.

Discussion. These data indicate that acute institution of 10 cm H_2O PEEP during neurosurgical procedures in the seated position is not effective in increasing venous pressure high enough to stop air embolism. Furthermore, PEEP significantly impairs cardiovascular performance at a time when it might already be markedly limited by air embolism. Finally, because PEEP increases RAP more than left atrial pressure (as reflected by PCWP), air bubbles in the venous circulation may be driven across a probe-patent foramen ovale and into the systemic circulation, where coronary or cerebral air embolism could occur. Based on these data we recommend that PEEP not be instituted as a therapeutic maneuver for acute treatment of venous air embolism.

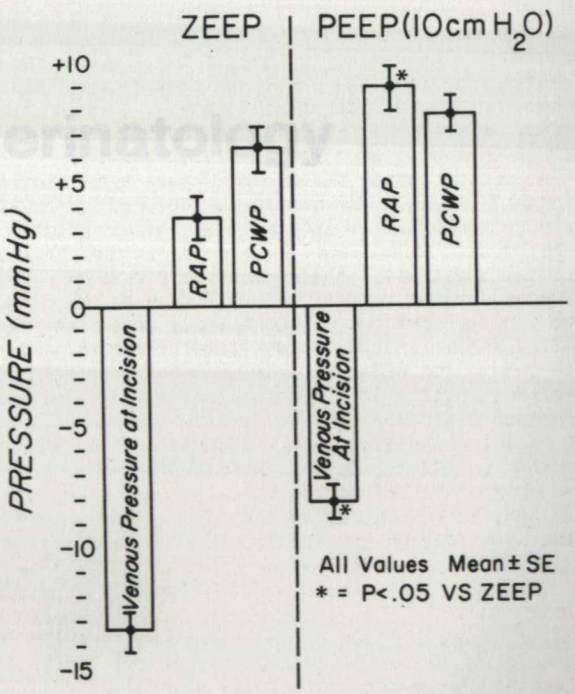

Figure 1. Changes in right atrial (RAP), pulmonary capillary wedge (PCWP) and venous pressure at the level of incision before and after application of 10 cm H_2O PEEP.

References.

1. Edwards JE: Interatrial communication, Pathology of the Heart. Edited by Gould, SE. Illinois, Charles C. Thomas, 1960, pp 260-261.