

Title: Treatment of Air Embolism with a Special Pulmonary Artery Catheter Introducer Sheath in Sitting Dogs

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Introduction. The treatment of venous air embolism by aspiration of central venous catheters is well established. However, some anesthesiologists prefer to use a pulmonary artery catheter to monitor patients undergoing a sitting craniotomy. While offering certain advantages, pulmonary artery catheters may be of limited use in the treatment of venous air embolism because the small diameter of the proximal port is poorly suited for efficient air aspiration. We have designed a special pulmonary artery catheter introducer sheath which can be positioned electrocardiographically to provide an efficient and effective means of air aspiration, while permitting the simultaneous use of a pulmonary artery catheter for pressure monitoring. The flow characteristics of this sheath, with and without side holes, were tested in vitro by measuring the capacity to aspirate water. The introducer sheath was then compared to a pulmonary artery catheter for the treatment of a 4 mg/kg venous air embolism in sitting, anesthetized dogs.

Methods. Special pulmonary artery catheter introducer sheaths were fabricated by Cook Inc. They are 25 cm in length, 9 French size, with "side arms" for aspiration or infusion. The last 5 cm of the sheath is perforated with 6, 1.0 mm diameter holes. Identical sheaths without the side holes were fabricated also. Flow characteristics of the sheaths were examined in vitro, with a 7.5 French pulmonary artery catheter placed through the lumen, in comparison to a Sorenson CVP catheter, the Bunegin-Albin Air Aspiration CVP catheter, and the proximal port of the pulmonary artery catheter. Each catheter was connected to a 60 ml syringe clamped to a bench. The tip of the catheter was placed in water and a 10 pound weight was suspended from the plunger of the syringe. The time required to fill the syringe with 50 ml of water was determined. In vivo studies were performed in 24 mongrel dogs (5 dogs per group), assigned randomly to receive a pulmonary artery catheter inserted through a special introducer sheath with side holes (Group 1), a pulmonary artery catheter inserted through a special introducer sheath without side holes (Group 2), a pulmonary artery catheter without the introducer (Group 3), or no catheter (controls, Group 4). The dogs were anesthetized with isoflurane, intubated and ventilated. The introducer sheaths (Groups 1 and 2) or pulmonary artery catheters (Group 3) were placed in the right internal jugular vein, and advanced with electrocardiographic guidance to the position previously reported to allow the most efficient retrieval of air emboli. While the dogs were in a sitting position a 4 ml/kg bolus of air was injected over 25 seconds into the left internal jugular vein. At the first recognizable fall in end tidal CO_2 , the introducer sheath (Groups 1 and 2) or pulmonary artery catheter (Group 3) was aspirated with 60 ml syringes until no more air could be recovered. In Group 3 (no introducer) the distal port and the proximal port of the pulmonary artery catheter were aspirated simultaneously. In Groups 1 and 2 the side port of the special introducer sheaths was aspirated, but the ports

of the pulmonary artery catheters were not.

Results. The rank order of flow rate in the in vitro comparison was: introducer sheath with side holes > Bunegin-Albin CVP > introducer sheath without side holes >> Sorenson CVP >> pulmonary artery catheter ($p=0.0001$). The pulmonary artery catheter was six times slower than the sheath with side holes. There were no significant differences between the 4 groups of dogs for the dose of air, PaO_2 , $PaCO_2$, pH, hemoglobin, MAP, CVP, PCWP, heart rate or temperature. The mean proportion of injected air recovered by the pulmonary artery catheter, 16%, was far less than the mean proportion retrieved by the introducer sheaths with and without side holes, 57% and 80% respectively ($p=0.01$ side holes, $p=0.002$ no side holes). The difference in air retrieval between the two introducer sheaths was not significant ($p=0.23$). Of the air aspirated from the pulmonary artery catheter, 16% was from the distal port and 84% was from the proximal port. No control dogs survived air embolism, while 3 of 6 dogs survived in Group 1 (sheath with side holes), 2 of 6 in Group 2 (sheath without side holes) and 1 of 6 in Group 3 (pulmonary artery catheter without sheath). The volume of air aspirated from the dogs which survived (68% of injected air) was about twice as great as from dogs which died (33% of injected air, $p=0.0007$, Fig 1).

Discussion. This study shows that either version of the special introducer sheath, positioned electrocardiographically, is an efficient and effective catheter for aspiration of venous air emboli in sitting dogs. A pulmonary artery catheter may be used simultaneously for pressure and cardiac output monitoring without the need to rely on the narrow proximal port for air aspiration. Special introducer sheaths with side holes are now being developed for use in neurosurgical patients.

References.

1. Bunegin L, Albin MS, Helseel PE, Hoffman A, Hung T: Positioning the right atrial catheter: a model for reappraisal. *Anesthesiology* 55:343-348, 1981

