

been inserted *via* an antecubital vein (60 cm), but the same finding was present in the two short catheters (24 cm) inserted *via* a more central route. In one case, a significant amount of air (30 ml) was withdrawn during an episode of VAE early in the case, although all but the proximal orifice were found to be occluded postoperatively.

Using a constant infusion pump, we have found that it is not possible to uniformly perfuse all of the orifices, even with infusion rates as high as 1000 ml/h. These findings have been of concern to us, because it appears that a slow, continuous flush is inadequate to ensure continued patency of the multiorificed catheters as they are presently designed and used. This seems likely to defeat the purpose for which these catheters are designed.

It has been demonstrated that treatment of certain types of catheters by chemical methods can be used to reduce thrombus formation. Bonding heparin to the polymer plastics used in pulmonary artery catheters reduces the incidence of the thrombogenesis resulting from these catheters.³ We wonder if a similar process could be used for multiorificed CVP catheters.

Anesthesiology
68:179, 1988

In Reply:—We certainly appreciate the observations and comments of Drs. Donegan and Rupp concerning their experience with clot formation in multiorificed catheters. Their observations encompassed both the Cook CVAE-580 and the Arrow AK-04250 catheter sets. Our experience is limited to the Cook Bunegin-Albin Air Aspiration Set, which is available in both a heparin-coated (CVAE-580-BH) and the uncoated (CVAE-580) versions. We have been routinely using the heparin-coated catheter, and have found little or no clot formation following removal after 6–8 h *in situ*. These catheters were used for both CVP monitoring and/or fluid infusion at a minimal rate of 0.5 ml/min with occasional heparinized saline bolus flush.

In four animal experiments using the 60-cm heparin-coated Cook catheter, some clot formation was noted in the distal orifices, but these clots were easily flushed off after removal of the catheter following 6 h *in situ*.

If the catheters appear to have functioned adequately during the intraoperative course, as indicated by Drs. Donegan and Rupp, it is possible that orifice-clotting may have possibly occurred during patient transfer from the operating room to recovery room or intensive care unit if the infusion through the catheters was significantly reduced or terminated during that time.

In terms of orifice perfusion-patency, Poiseuille's

JUDITH H. DONEGAN, M.D., PH.D.
Professor of Anesthesia and Neurosurgery
University of California
San Francisco, California 94143

STEPHEN RUPP, M.D.
Staff Anesthesiologist
Virginia Mason Clinic
1100 Ninth Avenue
Seattle, Washington 98111

REFERENCES

1. Bunegin L, Albin MS, Helsel PE, Hoffman A, Hung T-K: Positioning the right atrial catheter: A model for reappraisal. *ANESTHESIOLOGY* 55:343–348, 1981
2. Artru AA, Colley PS: Bunegin-Albin CVP catheter improves resuscitation from lethal venous air embolism in dogs (abstract). *Anesth Analg* 65:S7, 1986
3. Hoar PF, Wilson RM, Mangano DT, Avery GJ, Szarnicki RJ, Hill JD: Heparin bonding reduces thrombogenicity of pulmonary-artery catheters. *N Engl J Med* 305:993–995, 1981

(Accepted for publication October 1, 1987.)

Law relating to the flow of liquid through a tube indicates that the most proximal orifice will have the greatest outflow, the more distal ones exhibiting proportionately smaller outflows. As such, it would be impossible, regardless of the catheter flow, to perfuse each orifice equally. Our laboratory evaluation of the Bunegin-Albin multiorificed catheter indicates that a minimal flow of 0.3 ml/min is necessary for perfusion of all the orifices.

It is felt that the problems concerning orifice clotting with the multiorificed catheter can, for the most part, be obviated by using the heparin-coated catheter; by occasional bolus flushes with heparinized saline when it is in the CVP mode; and by vigilantly ensuring that catheter perfusion occurs when it is in the infusion mode.

LEONID BUNEGIN, B.S.
Assistant Professor of Anesthesiology

MAURICE S. ALBIN, M.D., M.Sc (ANE.)
Professor of Anesthesiology and Neurological Surgery
Department of Anesthesiology
University of Texas Health Science Center
7703 Floyd Curl Drive
San Antonio, Texas 78284

(Accepted for publication October 1, 1987.)