FIG. 1. Recurrent sinus node exit block on a continuous ECG recording following vecuronium bromide administration.

dium, and cimetidine. Lorezapam 3 mg iv had been given 2 h before the first dose of vecuronium; no other sedative was used during this time period.

To recognize this potential complication of vecuronium bromide may be important in patients with abnormal sinus node function, sick sinus syndrome, and those patients receiving medications known to affect cardiac automaticity and conduction.

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Should Multiorifaced Central Venous Catheters be Heparin Bonded?

To the Editor:—Multiorificed catheters placed at the junction of the superior vena cava with the right atrium have been demonstrated both in a Silastic® atrial model[1] and an experimental animal model[2] to improve the recovery of air following venous embolism (VAE). Two different manufacturers' models of these catheters are in use at our institution (Bunegin-Albin Air Aspiration Set, CVAE-580, Cook Inc., Bloomington, IN; Antecubital Catheterization Kit, AK-04250, Arrow, Reading, PA). Occasionally, the catheter is removed when the patient arrives in the recovery room. When this has been done, it has been noted that, in many instances, the catheter appears to be clotted despite apparent adequate intraoperative function as reflected by a good central venous pressure (CVP) waveform. Since this was first noted, we have made a practice of injecting fluid through the catheter at the time of removal to determine its patency. Of the 20 catheters so far examined, we have found that, in 14 (70%), fluid escaped from only the most proximal orifice, the other orifices being obstructed by clot (fig. 1). Four of the 20 catheters (20%) were completely patent and, in 2 (10%), the proximal two or three orifices were patent.

The duration of the cases involved ranged from 4–8 h. In most cases, the catheter was used to monitor CVP for the majority of the case, so that only a slow transducer flush (3 ml/h) of heparinized saline with an occasional rapid flush was infused through the catheter. However, in four cases, the CVP catheter was also used for slow fluid infusion. Of these four catheters, only one was completely patent. Eighteen of the 20 catheters had

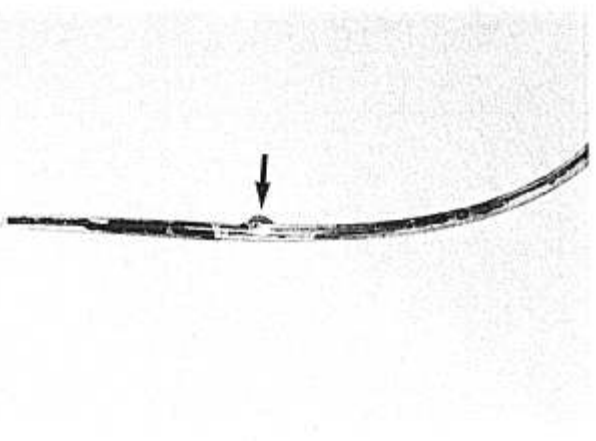

FIG. 1. Fluid injected into the proximal opening of the multi-orificed catheter escapes only from the proximal orifice (arrow); the other orifices are occluded.

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.

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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 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.

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