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## Air Entrainment Through a Multiport Injection System

*To the Editor:*—The FDA recommends that anesthesiologists avoid recapping of needles after their use to prevent needle stick injuries.\* For anesthesiologists, who administer multiple drugs for complex cases, this poses a considerable difficulty. Consequently several devices have recently been introduced that allow the injection of multiple drugs via a manifold system of one-way valves interposed in the intravenous tubing. We have recently discovered that such a system may allow significant air entrainment.

Report of a case: A 64-yr-old male was scheduled for coronary artery bypass grafting. Prior to induction of anesthesia, a 14-gauge catheter was inserted in a vein in the left forearm, a 20-gauge catheter was inserted into the left radial artery, and a pulmonary artery catheter was inserted via the right internal jugular vein. A Multiport Anesthesia Injection Set with Check Valves (item 9113, Quest Medical Inc., Carrollton, Texas) was interposed in the side port of the sheath introducer. Anesthesia was induced with fentanyl (100  $\mu$ g/kg) and maintained with fentanyl/oxygen. All drugs were administered via the Multiport Anesthesia Injection Set. Just prior to initiation of cardiopulmonary bypass, the anesthetist administered additional fentanyl and muscle relaxants and removed the syringes from their individual check valves. Upon initiation of bypass, the perfusionist immediately noted that large amounts of air were returning via the venous cannulae. The anesthetist noted that air bubbles were moving down the side port of the sheath introducer into the internal jugular vein. Since it appeared that the air bubbles were originating from the check valve areas of the Multiport Anesthesia Injection Set, the anesthetist capped each port with a solid plastic Luer-Lock cap. This immediately stopped the air from being entrained. The Multiport Anesthesia Injection Set was removed and the case continued uneventfully.

In order to rule out the possibility that the valves in this case were "stuck" in the open position, we measured the negative pressure necessary to open the one-way valves in this system and in two other check valve systems currently available in our department. A simple water manometer was attached to each system in turn. The pressure required to open the one-way valves to allow air entrainment and to overcome the valve to cause a leak was measured. Tested were the device described above, which consists of a hard plastic manifold with three side ports, the Quest™ model 9107 trifurcated extension set which has two side ports with check valves, and the Cutter Chexet™ anesthesia set which has one check valve on the main intravenous tubing and a spring-loaded check valve on a single side port. Each set is sold with plastic caps attached to the side ports.

Results for the two models manufactured by Quest were similar:

when used directly from the package, a negative pressure of 28–35 cm H<sub>2</sub>O resulted in entrainment of air. With the caps then tightened as much as possible, a negative pressure greater than 100 cm H<sub>2</sub>O was required to overcome the valve and entrain air. With the caps removed, however, as is the case whenever drug injections are made, negative pressures of as little as 2–4 cm H<sub>2</sub>O were sufficient to overcome the valve. Altering the orientation of the valves made little difference. Also noted was that, of eight sets of valves tested, two leaked with back pressures of only 15–20 cm H<sub>2</sub>O (i.e., considerably less than that achieved by injections at an adjacent valve). The remaining valves remained closed to pressures over 100 cm H<sub>2</sub>O. We also demonstrated that there was an apparent Venturi effect that resulted in entrainment of air through the one-way valves when fluid was infused into the iv port of the set.

The spring loaded check valve in the side port of the Cutter Chexet™ withstood negative pressures greater than 60 cm H<sub>2</sub>O, and did not leak with back pressures of greater than 100 cm H<sub>2</sub>O. The check valve without a spring entrained air at 3–5 cm H<sub>2</sub>O.

These studies demonstrate that currently available multiport injection systems entail significant risk of air entrainment unless they are continuously capped or clamped. Most worrisome was that the Venturi effect of rapidly infusing fluid past the side ports was sufficient to entrain air. The Cutter spring-loaded valve successfully resisted entrainment when properly connected, but since only one side of the Y contains a spring-loaded valve, it entails the same risk as the Quest sets if the intravenous and side port connections are reversed.

Anesthesiologists must carefully examine multiport injection systems in use in their hospitals, and take measures to prevent air entrainment. Manufacturers are urged to provide spring-loaded check valve systems on each arm of multiport systems, or to clearly delineate which ports allow air entrainment.

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