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Air Entrainment during Cardiopulmonary Bypass Surgery

To the Editor:—Accidental needlestick exposure remains a significant source of potential risk for the spread of blood-borne disease. While abandoning the practice of "recapping" used needles would decrease the risks involved, an injection system that totally avoids the direct use of needles when dealing with patients seems desirable. Quest Medical, Inc. (product code 9222) and Burron Medical, Inc. (product code ET-06V) have introduced extension sets incorporating multiple injection sites having normally "closed" backcheck valves. (fig. 1, B and C, respectively.) In addition, Quest Medical provides an extension set (product code 9113) the valves of which require little if any pressure to open and have been frequently used with infusion pumps that might otherwise alarm when required to generate enough force to open normally closed valves (approximately 1.5 psi for product 9222) (fig. 1, A)

This report describes two patients undergoing cardiopulmonary bypass (CPB) for myocardial revascularization in whom air entrainment occurred through an injection port of such an extension set. In each patient, the right internal jugular vein was cannulated with an 8.5-Fr introducer to permit placement of a pulmonary artery catheter. In each patient, double venous return cannulae were used. Infusion of intravenous fluids was discontinued during CPB. During the procedure on the first patient, air entrainment was noted in the superior vena caval venous return tubing, which was unresponsive to usual methods of correcting for entrainment—*e.g.*, manipulating the tubing and filling the pericardium with saline. While assuring ourselves that the introducer catheter itself did not become disconnected, we observed air in the sideport and Quest Medical extension set, originating at the site of an uncapped injection port. This was promptly capped off with no further air entrainment and no adverse patient consequence. Proper use of such extension sets was reviewed within the department and the manufacturer notified of our experience.

The second occurrence took place 1 week later. A Burron Medical extension set was used on the introducer sideport, and when not in use, the injection ports were promptly covered with the caps provided with the set. Air entrainment was again noted in the superior vena caval return tubing, to a degree greater than noted in the previous patient, and nearly enough to cause an "air lock" in the venous return tubing. Further inspection revealed that the caps over the injection ports had failed to provide an occlusive seal and had allowed the entrainment of air. Prompt recognition and intervention prevented any patient sequelae. A representative of Burron Medical was made aware of the potential risk given the above circumstances.

Although the use of a single venous return cannula has become standard for most adult applications at our institution, the use of separate vena caval return cannulae is necessitated from time to time, *e.g.*, for mitral valve replacement and for retrograde, coronary sinus cardioplegia. The use of two venous cannulas may enhance gravitational venous drainage as well. The scenario of very low or negative central venous pressure infusion rate associated with cardiopulmonary bypass and low intravenous fluid combined to produce a set of circumstances favoring the entrainment of air at an otherwise competent injection port. The purpose of this report is to underscore the need for occlusive caps when these injection ports are not in use, particularly when circumstances such as these would favor air entry. The caps currently provided by Burron for their device failed to produce a tight seal and must be replaced with appropriate caps if the product is to be used for this application.

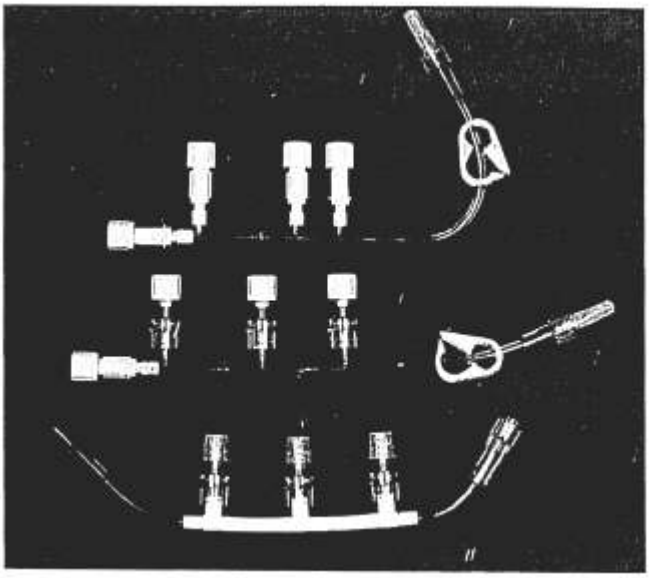

FIG. 1. Extension sets that may allow air entrainment when not properly configured. *A:* Quest Medical extension set with backcheck valves, code 9113. *B:* Quest Medical extension set with backcheck valves, code 9222. *C:* Burron Medical extension set, code ET-06V.

JOHN F. QUINN, M.D.
Assistant Professor
Department of Surgery/Division of Anesthesiology
University of South Carolina, School of Medicine
Richland Memorial Hospital
Five Richland Medical Park
Columbia, South Carolina 29203

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In Reply:—As Quinn states, when not in use, the valves must be capped with a dead-end cap, as noted on the directions. Quinn states, "The injection ports were promptly covered with the caps provided with the set." However, the "caps provided with the set" are vented touch-contamination protectors—not dead-end caps. Vented caps are placed on the valves during packaging as touch-contamination protectors and allow ethylene oxide gas through the set during sterilization.

The product to which Quinn refers is not a standard catalog item.

However, to avoid situations such as this in the future, we have changed the product insert for all new products manufactured and will provide dead-end caps with the set. The product labeling will indicate to "replace caps on valves when not in use."

EILEEN BROBST-LANE

Group Product Director, I.V. Products
Burron Medical Inc.
824 Twelfth Avenue
Bethleham, Pennsylvania 18018

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Should Calcium Be Administered Prior to Separation from Cardiopulmonary Bypass?

MICHAEL P. HOSKING, M.D.
Director of Cardiovascular Anesthesia
Brooke Army Medical Center
Fort Sam Houston, Texas 78234-6200

To the Editor:—Robertie *et al.*[1] provide an excellent study on the changes in calcium homeostasis observed during cardiopulmonary bypass. However, the data do not support their conclusion that administration of calcium during attempts at separation from bypass is unnecessary and potentially harmful. The authors point out that a change of 0.07 mM of ionized calcium (Ca_I) will elicit a maximal parathyroid hormone response. Prior to separation from bypass, the authors observed a decrease in Ca_I of over double this value when compared with the prebypass value but report this as a return to "near-normal." It seems that such a difference has significant physiologic implications. The reference cited relating deleterious effects of Ca_I in the setting of ischemia also implicates oxygen free radical formation as a major component in reperfusion injury.[2] In fact, reperfusion injury responds favorably to agents such as catecholamines that increase intracellular calcium.

A point often overlooked is that the bulk of calcium influx and free radical formation occurs within the first few minutes after reperfusion and is complete within 10 min.[2-4] Administration of calcium prior to separation from bypass occurs long after removal of the aortic clamp and is unlikely to contribute in any significant way to reperfusion injury. Correction of Ca_I after bypass has been demonstrated to significantly improve left ventricular compliance and enhance myocardial performance.[5] The inhibitory effect of calcium on epinephrine cited by the authors was observed in normocalcemic patients rendered hypercalcemic and was recorded 24 h after surgery.[6] It seems logical to achieve normocalcemia prior to separation from bypass before administering catecholamines whose mechanism of action involves enhanced intracellular transport of calcium. A pump works most efficiently when properly primed.

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In Reply:—We thank Hosking for his comments about our study.[1] We did not intend to give readers the impression that we totally oppose administration of calcium salts upon emergence from cardiopulmonary bypass. Rather, we believe that the *routine* administration of calcium salts is unwarranted. In a hemodynamically unstable and severely hypocalcemic patient (ionized calcium concentration < 0.8 mM), we would administer calcium salts (guided by frequent measurements of the ionized calcium concentration in blood) to restore normocalcemia. Likewise, calcium salt administration is appropriate therapy for severe hyperkalemia.

In our study, we observed a return of ionized calcium concentrations to near-normal values prior to separation from bypass. The precipitous decline in parathormone concentrations that we measured simultaneously confirms that these ionized calcium concentrations are near normal. Nonetheless, we do not know the *optimal* ionized calcium concentration for critically ill patients. For example, animals given endotoxin have improved survival with hypocalcemia compared to either normocalcemia or hypercalcemia.[2]

We believe that hypercalcemia is dangerous and should be avoided. In addition to the concerns that we cited in our paper (lack of efficacy of calcium at stimulating cardiac output,[3-5] inhibition by calcium of the actions of both epinephrine[4] and dobutamine,[6] and the importance of calcium ions in reperfusion injury,[7] a recent study[8] has identified *therapeutic* hypercalcemia (from overzealous calcium salt administration to cardiac surgery patients) as a risk factor for the development of perioperative pancreatitis. In addition, increased intracellular calcium ion concentration is associated with delayed after-depolarizations, a frequent mechanism of postischemic arrhythmias.[9] In fact, hypocalcemia has been used in the past as a treatment for these arrhythmias.[10]

Cardiac ischemia is not terminated when the clamp is released, as is implied by Hosking. Smith *et al.* have documented a higher incidence of cardiac ischemia after separation from bypass than before bypass.[11]