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*In Reply:*—Dr. Rupp has made a number of pertinent comments regarding our Letter to the Editor of January, 1987.<sup>1</sup>

We would like to emphasize that, under conditions of a truly emergent cesarean section, where time may be the critical factor for maternal and, particularly, fetal survival, we certainly do not advocate delaying this procedure by spending the 5 or 10 min necessary to insert a central venous catheter solely to be able to aspirate should air embolus occur.

We identify the patients at greatest risk for venous air embolism (VAE) as those with pre-existing hypovolemia due to bleeding, severe dehydration, shock, or pre-eclampsia. Clinical management of these patients is made optimal if central venous pressure is used as a guide for fluid therapy, and this can be accomplished with the same multiorificed catheter used for air aspiration.

The time for insertion and the morbidity associated with a central venous catheter are certainly critical factors. In our hands, the placement of a multiorificed air aspiration-CVP catheter *via* a vein in the antecubital fossa has a greater than 90% success rate, since a Seldinger type "J" wire is first inserted into the SVC and the catheter threaded over it.<sup>2</sup> We have seen a rare arrhythmia (catheter in RV) and no mortality in many thousands of catheter applications with insertion times ranging from 5-15 min.

Dr. Rupp indicated that the value of central venous catheters as a treatment modality for VAE therapy is "controversial," and that the emphasis should be placed on the "detection and rapid maneuvers to the entrainment of air." Recent experimental work of Colley and Artur<sup>3</sup> indicates that significant survival in dogs occurs during a constant intravenous infusion of air when air is aspirated *via* a multiorificed catheter placed in the SVC near the RA, as compared to aspiration from a single-orificed catheter or when no catheter is employed. Albin *et al.*<sup>4</sup> reported 13 cases of VAE, in which five were in the lateral, seven in the supine, and one in the

prone position, with gradients ranging from 5-18 cm, where the amount of air aspirated ranged from 2.0-200 ml. All 13 cases developed clinical symptoms immediately after air bubble detection (Doppler). Thus, it appears that one can aspirate significant volumes of air<sup>4</sup> with the patient in the supine, lateral, and prone position, even using a single-orificed catheter with the tip in the right atrium just past the junction of the SVC.

To further evaluate the optimal catheter position in a patient undergoing cesarean section, we remounted the silastic model<sup>5</sup> Dr. Rupp referred to in a position to mimic a supine patient with 15° left lateral table tilt. We observed that air arriving at the heart formed a bubble in the non-dependent dome of the right atrium above the level of the tricuspid valve orifice. We believe that a balloon-tipped multiorifice catheter may be an ideal combination to allow for easy aspiration of embolized air, as was described for the sitting position.<sup>6</sup> The dynamics of VAE for patients in the supine position using the right atrial model will be the subject of a future communication.

We feel that the central line aspiration immediately after Doppler activation has great validity as a therapeutic measure. A closer look at Michenfelder's<sup>7</sup> editorial cited by Dr. Rupp indicates that, "In the event of abrupt aspiration of large volumes of air, such as can occur with inadvertent opening of a major dural sinus, the catheter may be life saving. . . . Secondly, there is a nagging concern that some of the embolized air may cross to the systemic circulation with possibly disastrous cardiac or cerebral consequences." Michenfelder ends his editorial with the statement, "The catheter is no longer a primary diagnostic tool and now rarely plays an important role in therapy. But on those few occasions that it does become important the "bother" of a reasonable effort to place the catheter seems well worth it." As was noted in the recent paper by Younker *et al.*,<sup>8</sup> massive VAE can occur *via* lacerations of the turgid uterine sinuses, through which large volumes of air can be entrained.

The report by Malinow *et al.*<sup>9</sup> that 31 of 66 women developed ultrasonic precordial Doppler changed during cesarean sections under regional anesthesia, and that 14 of the 31 Doppler positive patients developed chest pain and dyspnea within 1–6 min after Doppler sound changes, indicates the need to develop more prospective studies to give us a better idea as to the incidence of VAE not only during and after cesarean section, indicating the influence of methods of anesthesia, but also during and after vaginal deliveries. In the most recent description of maternal deaths in the USA,<sup>10</sup> 25 cases (about 1%) were found to be due to VAE, although there were no details given of the circumstances of these deaths. This is almost the same number of deaths seen from aspiration of gastric contents associated with anesthesia, and, since much effort is expended in attempts to reduce this mortality, we feel that the same level of care is indicated to prevent, diagnose, and treat VAE.

We totally agree with Dr. Rupp that the precordial Doppler should be used routinely in all cesarean sections, since it is non-invasive, sensitive, reliable, and gives an early warning of a potentially dangerous phenomenon.

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### More on Dyes and Pulse Oximeters

*To the Editor:*—A recent publication by Kessler *et al.* entitled “Spurious Pulse Oximeter Desaturation with Methylene Blue Injection,” may contain “spurious” conclusions.<sup>1</sup> We studied the effects of three commonly used intravenous dyes on the Nellcor N-100 pulse oximeter readings.<sup>2</sup> Our results also demonstrated that methylene blue had a striking but transient effect on SaO<sub>2</sub> readings. However, we take issue with the mechanisms proposed by Kessler *et al.* to explain the transient nature of this phenomenon. Kessler *et al.* state that the effect was transient because of the “dilution of the dye and its rapid renal clearance.”<sup>1</sup> It is known that methylene blue is not rapidly cleared (when administered in a dose similar to that used by Kessler *et al.*), and will

falsely depress *in vitro* oximetry reading for up to 48 h.<sup>3,4\*</sup> *In vitro* oximetry uses a similar technology to calculate hemoglobin saturation, as do pulse oximeters.

We suggest that the transient effect of methylene blue (or any intravenous dye) is due to the manner in which the pulse oximeter calculates arterial (Pulsatile) saturation. The pulse oximeter has an algorithm which calculates arterial hemoglobin saturation by the subtraction of the light absorption of the non-pulsatile (veno-capillary) blood from the light absorption of the pulsatile (arterial) blood.<sup>5</sup> When the concentration of methylene blue (or any dye for that matter) is equal in these two compartments, there will be no effect on the pulse oximetry reading. This is how the pulse oximeter