apart from the cylinder mixing valve, the only modifications necessary would be relabeling and recalibrating the nitrous oxide flow meter, and these costs should be relatively low.

I accept that anesthetists would have to "recalibrate" themselves to some extent in terms of gas flows, but a simple graph, as shown in figure 1, would allow instant calculation of delivered percentages as with air/oxygen mixtures. Thus, at a convenient 8 l/min total flow (solid line), if no added oxygen were given, the nitrous oxide/oxygen mixture alone would be delivered, i.e., 20% oxygen. If one liter of oxygen through the oxygen flow meter were added to seven liters of the nitrous oxide/oxygen mixture (thereby maintaining the eight-liter total flow), the total oxygen concentration would be made up of 20% of seven liters (1.4 l) and the added one liter, giving 2.4 l out of the eight liters total flow, i.e., 30%. Thus, by "exchanging" one liter of the nitrous oxide/oxygen mixture for one liter of pure oxygen, the oxygen concentration of the delivered 8 l/min is increased by 10%. Other "flow-lines" (dotted lines) can be used accordingly. In practice, most anesthetists tend to use the same total flow for any given anaesthetic breathing system, so that we would all soon become "preprogrammed."

Such a step, radical though it would be, would permanently protect patients, anesthetists, and hospital authorities from the disastrous effects of the delivery of accidental hypoxic mixtures. Of course, there might be an increase in awareness during anesthesia from the delivery of unduly oxygen-rich mixtures, but surely, this is the lesser of two evils!

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Postlaryngospasm Pulmonary Edema in Adults

To the Editor—The recent report by Lee and Downes states that pulmonary edema following laryngospasm has not been reported in adults.1 I have had the misfortune, however, to be associated with two such cases.

The first was a 48-year-old man undergoing laryngoscopy and bronchoscopy for intermittent upper airway obstruction occurring during sleep or when he was in the supine position while awake. His only other medical problem was hypertension controlled with inderal and hydrochlorothiazide. The patient was induced using enflurane with spontaneous ventilation in a semisitting position. After induction, he was intubated without problem. Anesthesia was maintained with enflurane, nitrous oxide, and oxygen. The endoscopy revealed no pathology other than an irritated upper airway.

On emergence, the patient opened his eyes, became agitated, pulled out his endotracheal tube, and then developed apparent laryngospasm with complete upper airway obstruction. His airway could not be maintained with bag and mask ventilation, and cyanosis rapidly developed. Succinylcholine, 100 mg, was administered, iv resulting in cessation of laryngospasm. The patient was intubated and ventilation was controlled. Within 30 s, copious, frothy pink fluid poured from the endotracheal tube. A chest x-ray showed diffuse pulmonary edema without cardiomegaly. Arterial blood gases on 100% FiO2 showed PaO2 116 mmHg, PpCO2 41 mmHg, and pH 7.37. The patient received lasix and morphine, was placed on mechanical ventilation with 5 cm H2O PEEP, and was transferred to the ICU. The next morning the pulmonary edema had cleared and he was extubated successfully without sequelae.

The second patient was a healthy 21-year-old man who underwent an uncomplicated general anesthetic for septrhinoplasty. At the end, he was extubated and then went into laryngospasm with complete upper airway obstruction. The airway could not be managed with bag and mask ventilation. Succinylcholine, 60 mg, relaxed the laryngospasm, and once spontaneous ventilation resumed, the patient was transferred to the recovery room. In the recovery room, the patient had a persistent cough and dyspnea. A chest x-ray showed bilateral middle lobe infiltrates without cardiomegaly. The patient was given lasix with resolution of dyspnea. Three hours later, the chest x-ray was clear.

These cases show that postlaryngospasm pulmonary edema is not confined solely to children. It can occur in adults with normal or marginally abnormal upper airways. It should be considered as part of the differential diagnosis in all recovery room patients who are coughing or complaining of dyspnea who have had an episode of laryngospasm.
Negative Inotropic Effects of Midazolam

To the Editor—Midazolam is a new water-soluble 1–4 benzodiazepine used for induction of anesthesia. Laboratory investigations in the dog demonstrate a dose-related decrease in left ventricular dP/dt after the administration of midazolam.1,2 Indirect evidence (increase in pulmonary artery diastolic pressure with decreased cardiac index) from the dog also suggests a transient negative inotropic effect when midazolam (10 mg/kg) is given.3 As there are no studies comparing the relative negative inotropic effect of midazolam with that of diazepam on the isolated heart, we have completed a series of experiments examining the effects of these two benzodiazepines on left ventricular (LV) myocardial contractility.

The inotropic effect of midazolam and diazepam was determined in a modified Langendorff retrograde perfusion system recently described in detail.4 Incremental increases were made in the concentration of benzodiazepines in the perfusate. These concentrations were 14, 16, 18, and 20 µg/ml of midazolam and 15, 20, 25, and 30 µg/ml diazepam. Duration of perfusion at each drug concentration was 14 min, and the LV dP/dt max measurements were made at peak effect (usually within 5 min). The ED50 myocardial depression was 15.1 ± 2.6 µg/ml with midazolam and 22.7 ± 3.2 µg/ml for diazepam. Midazolam is a 1.4-fold more potent negative inotropic drug than diazepam in this preparation. The slopes of the dose effect curve are significantly (P = <0.01) different (fig. 1); relatively small changes in midazolam concentration exert greater decrements in contractility than seen with diazepam, since the midazolam curve is steeper than that of diazepam. Of note is that at small degrees (20%) of myocardial depression differences between midazolam and diazepam were less pronounced than at high (80%) degrees of depression.

The clinical relevance of these relative negative inotropic data are not clear, since we found that when a small group (n = 5) of patients who had normally elevated pulmonary artery occluded pressure (PAO > 18 mmHg) and low CI (<2.0 l/min1·m−2), were anesthetized with midazolam (0.2 mg/kg iv), their PAO and CI returned to normal.5 The presumed reason for the improvement in these variables was the vasodilating effect of midazolam: any negative inotropic effects were more than adequately counterbalanced by the decrease in afterload. Midazolam tends to decrease SVR more than diazepam6 and produces greater venodilation.7 We believe that there are subtle but important differences in cardiovascular effects of midazolam and diazepam. In view of the relatively greater negative inotropic effects and potential for vasodilation, midazolam probably should be given with caution to hypovolemic patients and those with significant left ventricular impairment.

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REFERENCES
1. Jones DJ, Stehling LC, Zauder HL: Cardiovascular responses to diazepam and midazolam in the dog. ANESTHESIOLOGY 51:430–434, 1979