

throughout the world indicates that our objectives in describing it have been achieved: to fill a gap left by previous systems for assessing level of consciousness. We have never recommended using the Glasgow Scale *alone*, either as a means of monitoring coma, or to assess the severity of brain damage or predict outcome.

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### Cylinder Caution: Open Slowly to Minimize Recompression Heat

*To the Editor:*—Feeley *et al.*<sup>1</sup> reported that medical compressed gas cylinders are potential hazards to patients and medical personnel. They recorded 120 (1.2 per cent) potentially hazardous irregularities out of a total of 14,500 cylinders delivered to Beth Israel Hospital over a four-year period (actually 0.83 per cent). While all of the irregularities described are potential hazards, it seems that the hazard with the highest potential for injury or damage is not discussed. The hazard I speak of is "opening a cylinder valve too fast," and in particular an oxygen cylinder fully charged to 2,200 psi.

For the last 18 years, I have been involved in the design of aircraft oxygen breathing equipment and inhalation anesthesia equipment. Since this equipment is used in conjunction with medical gas cylinders, I have become familiar with the hazards associated with compressed gas cylinders. My observations indicate to me that personnel involved in the everyday handling of medical gas cylinders in conjunction with other medical apparatus do not receive adequate instructions regarding the safe handling and use of these cylinders. Even those that do receive adequate training tend to become complacent about safe handling procedures, apparently because thousands of cylinders are handled every day without incident. Even trained and experienced personnel do not gain respect for the potential hazard

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### Prevention of Ventilator Accident

*To the Editor:*—There are several points to be made about Dr. Waterman's report of accidental ventilator-induced hyperventilation.<sup>1</sup> First, while wall oxygen is supplied at 50 psi, there is a pop-off valve in the venti-

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of opening an oxygen cylinder valve too quickly unless they have been involved in or observed the results of a disastrous fire that occurred because the cylinder valve was not opened *SLOWLY*.

Instructional material such as CGA Pamphlet P-1<sup>2</sup> and labels on cylinders instruct the user to open the cylinder valve slowly. However, the reason for doing this is not stated, and therefore this instruction tends to be forgotten or disregarded. The potential for future accidents would be decreased considerably if instructions and instructors would change the statement from "open cylinder valve slowly" to "open cylinder valve slowly to minimize recompression heat."

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lator to prevent large quantities of oxygen at this high pressure from being delivered to a patient. A pressure of 50 psi is equivalent to more than 3,500 cm H<sub>2</sub>O,<sup>2</sup> certainly in excess of the pressure limit of the ventila-

tor, which is 50 torr for the Ohio anesthesia ventilator.<sup>3</sup> Second, if the inspired concentration of oxygen ( $F_{I_{O_2}}$ ) is routinely measured, one may detect small leaks in the bellows before they reach the magnitude described. On several occasions I have noticed a small (about 5 per cent) increase in  $F_{I_{O_2}}$ , as measured by an in-line oxygen analyzer, when switching from a rebreathing bag to a ventilator such as the Ohio. Using the rebreathing bag, the  $F_{I_{O_2}}$  predicted from the flowmeters on the anesthesia machine corresponded to the  $F_{I_{O_2}}$  given by the oxygen analyzer. On switching to the ventilator, the flowmeters and the oxygen analyzer no longer agreed. On each occasion, examining the ventilator bellows revealed small holes in the bellows, with the increased  $F_{I_{O_2}}$  resulting from contamination with the driving gas (oxygen). In the case described,  $F_{I_{O_2}}$

should have been about .75, calculated as:

$$\frac{(650 \text{ ml}) (.33) + 1,050 \text{ ml}}{1,700 \text{ ml}}$$

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*To the Editor:*—Waterman *et al.*<sup>1</sup> recently reported the case of an anesthetized patient connected to a faulty ventilator that delivered a tidal volume of 1,700 ml rather than the preset volume of 650 ml (10 ml/kg). The error was suspected after the blood pressure decreased from 140/70 to 80/30 torr, central venous pressure increased from 10 to 20 torr, and arterial blood-gas analysis showed  $P_{CO_2}$  17 torr and pH 7.60. The authors confirmed the error by measuring the gas volume at the expiratory port with a Wright respirometer. They recommended close inspection of ventilators before use and routine use of a Wright respirometer to measure tidal volumes. We take issue with this conclusion, and ask why the anesthesia personnel apparently could not or did not rely on clinical inspection of the patient to recognize at once that the patient was receiving a tidal volume almost three times greater than that intended. When the initial training of residents is carefully supervised and accompanied by tidal volume and arterial blood-gas measurements, they usually learn within three to six months to maintain a given tidal volume within 200–300 ml of that desired and a  $P_{CO_2}$  between 30 and 45 torr. This skill is largely learned by observation of chest and abdominal motion and correlation of the visual events with the aforementioned measurements. There is no reason to doubt the ability of these particular anesthesiologists. It seems probable that they deferred acting on observation out of faith in the ventilator and the formula used to establish minute ventilation.

When a ventilator is used, even experienced anesthesiologists often subjugate their judgment to some arbitrary formula designed primarily to give novices

a starting point. This technique is intrinsically dangerous since it focuses attention on the ventilator settings rather than the ventilation of the patient's lungs. We suggest that when a patient is initially placed on a ventilator, anesthesia personnel should rely primarily on observation of chest motion to adjust the ventilator. When ventilation appears adequate but the ventilator settings then appear unreasonable, or when adequate ventilation cannot be obtained, manual ventilation should be resumed while the machine is being rechecked. Although the use of a Wright respirometer is helpful, we have seen numerous potentially lethal malfunctions that will not be detected by this method or by the pressure and volume alarms incorporated in more sophisticated ventilators. We do not mean to suggest that clinical observation is infallible; only that it will improve with practice and that it is more likely to avoid extremes of error than a blindly applied formula.

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