and intubation was facilitated with 0.15 mg/kg of pancuronium bromide. Ventilation with 100% oxygen was controlled to maintain normocapnea. Figure 1 shows that, in spite of an increase in norepinephrine following sternotomy, there was no change in serum potassium. Current evidence may have predicted an increase in serum potassium, especially in the presence of β-blockade. Measurement of extracellular serum potassium, however, is an insensitive index of continuous transmembrane ionic flux. Therefore, in spite of our findings, we suggest that intraoperative extrarenal potassium regulation can be influenced by adrenergic mechanisms and that this is a potential cause of cardiovascular morbidity.

It is well established that catecholamine levels often are increased intraoperatively.[4] Changing sympathoadrenal activity, modified by the presence of receptor blockade, may occur because of mismatching between the depth of anesthesia and the degree of surgical stress or during the administration of vasoactive adrenergic agents. Arrhythmogenesis may ensue as a result of subsequent potassium effects on phase iv depolarization of cardiac pacemaker and conduction cells.

In summary, the intraoperative relationship between sympathoadrenal activity and extrarenal potassium regulation merits further investigation.

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REFERENCES

1. McCammon RL, Stoelting RK: Exaggerated increase in serum potassium following succinylcholine in dogs with beta blockade. ANESTHESIOLOGY 61:723–725, 1984
2. Williams ME, Rosa RM, Silva P, Brown RS, Epstein FH: Impairment of extrarenal potassium disposal by α-adrenergic stimulation. N Engl J Med 311:145–149, 1984
3. Rosa RM, Silva P, Young JB, Landsberg L, Brown RS, Rowe JW, Epstein FH: Adrenergic modulation of extrarenal potassium disposal. N Engl J Med 302:431–434, 1980
4. Halter JB, Pflug AE, Porte D: Mechanism of plasma catecholamine increases during surgical stress in man. J Clin Endocrinol Metab 45:936–944, 1977

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Anesthesia Ventilators Should Have Adjustable High-pressure Alarms

To the Editor:—We wish to call attention to a serious shortcoming of the Drager Model AV-M® anesthesia ventilator with the integral Model DPM-S pressure alarm (North American Drager, P.O. Box 121, Telford, Pennsylvania 18969). We discovered this while investigating a critical incident in which the high-pressure alarm did not sound when an endotracheal tube became occluded by kinking.

In experiments on a properly functioning ventilator and a lung simulator, we found that there are certain typical settings of the ventilator at which even total occlusion of the endotracheal tube will not activate the alarm, nor will there be any noticeable change in the rhythmic sounds from the ventilator to alert the anesthesiologist to the problem. This occurs because, for a given inspiratory flow setting on the machine, the delivered flow rate will vary with the respiratory system impedance. Thus, when outflow is obstructed, the bellows may not completely empty, and the airway pressure may not increase to the alarm threshold of 63.5 cmH_2O $\pm$ 10%. Because the machine is time-cycled, the inflation time remains fixed, and the ventilator's sound does not change.

There are too many parameters involved to permit us to state exactly the settings under which the alarm can fail. However, the following factors, in various combinations, tend to favor alarm failure: high respiratory rate, low inspiratory/expiratory ratio, low tidal volume, high tubing compliance, low inspiratory flow rate, and low rate of fresh gas inflow from the anesthesia machine.

The alarm would not fail to trip if the pressure limit could be adjusted to a value slightly greater than the peak inflation pressure of any given patient. Adjustable high-pressure alarms are now commonly build into intensive care ventilators. Nevertheless, only two of the 11 stand-alone ventilation alarms in a comparative review* had this capability, and the Drager Model DPM-S was the best-rated model because of its other features.

* Health Devices 10:204–220, 1981.

The manufacturer is aware of this shortcoming† and plans to incorporate an adjustable high pressure alarm in its forthcoming Narcomed 3™anesthesia machine but not in its separate anesthesia ventilators. Until fail-safe ventilator alarms become available, patient safety continues to depend upon a vigilant anesthesiologist and an esophageal stethoscope.

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† Horsfield T: Personal communication, North American Drager.

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In reply:—The letter by Dr. Bashein, and Dr. MacEvoy raises the following three questions: 1) Is a high-pressure alarm an adequate device to reveal an occluded breathing system? 2) Under what conditions should alarm sensing points be made adjustable? 3) Should the maximum ventilation pressure in the anesthesia breathing system be adjustable?

1) A safety device that becomes active in only a certain percentage of the critical incidents but does not respond to all of the critical incidents will introduce a false sense of security and may be more dangerous than not having a safety device at all. In some instances, an occluded patient breathing system may be accompanied by the occurrence of an excessive high pressure in some sections of the system (if the occlusion occurs during artificial ventilation, and ventilator settings, equipment compliance, and preset tidal volume permit the generating of an excessive high pressure); however, the occurrence is not always accompanied by an excessive high pressure (for example, when the patient breathes spontaneously or when the above-referenced parameters are such that they do not produce an excessive high pressure during artificial ventilation). In light of the above, it can be stated that an excessive high pressure does not necessarily accompany the occurrence of an occluded system. Therefore, high-pressure alarms cannot be recommended for use as monitors to determine the occurrence of an occluded system. This has been pointed out on pages 30, 36, 52, 53, 54, and 55 in the Safety Guidelines published and distributed by North American Drager. It is stated on page 36, ". . . a pressure monitor is not designed to warn of occlusions or misconnections in the breathing system and should not be relied upon for that purpose." Due to the fact that an occluded system interrupts gas flow and, in most cases, separates the patient from the machine, the only monitoring devices that will reveal the occlusion of a system are monitors that measure respiratory flow in the system or changes of CO_2 concentrations at the patient's airways. The problem addressed above has been thoroughly discussed in North American Drager's Safety Guidelines for Anesthesia Systems, which has been distributed to all users of North American Drager anesthesia machines.

2) An anesthesia system, as it is used in the operating room today, including the various monitors, incorporates up to and, in many cases, in excess of 50 possible, different alarm messages. At the present time, the proliferation of alarm signals in the operating room represents one of the most immediate problems manufacturers of anesthesia machines and suppliers of monitors have to address. The amount of equipment set-up time required at the beginning of a procedure would be prohibitive if all of the alarms were adjustable. It is known that a hazard can be introduced in many instances by using adjustable alarm levels rather than fixed alarm points (adjustable pressure setting for disconnect alarms). It is a challenging task for a manufacturer to decide which of the alarms shall be adjustable and which of the alarms shall be preset. However, it should be known that no manufacturer takes this task lightly. Consultations are made with physicians and users of the equipment, and the final decision to make an alarm adjustable or not adjustable may be disputed.

3) The maximum ventilation pressure in the system may be adjustable in some ventilators. This is the result either of a customer's request for adjustability of the maximum ventilation pressure or the result of the design of the flow adjustment device in the ventilator. Whatever the reasons may be, a limitation of the ventilation pressure in the system is a desirable safety feature that should not be disputed for the benefit of making a high-pressure alarm the tool to reveal an occluded breathing system when the high-pressure alarm was not designed nor advertised for that purpose.

Conclusion: It is important to remember that medical devices should only be used for the purpose for which they are designed. Such purpose is described in the instruction material accompanying the device. This in-