

Potentially Lethal Failure of the Vapor Exclusion System

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A properly functioning anesthesia machine is fundamental to safe anesthesia care. Routine periodic maintenance§ and preoperative checklists have been established to minimize the occurrence of anesthetic mishaps.^{1,2} Failure of the vapor exclusion system has not been among the many mechanical malfunctions previously reported. The vapor exclusion system, also known as the interlock device,³ is attached to the control dials of temperature compensated vaporizers in series on the machine back bar and is designed to prevent more than one vaporizer being turned on at a time. The purpose of this system is to mechanically prevent the simultaneous administration of more than one inhalation agent. The following case report describes a failure of the vapor-exclusion system on a North American Drager Narkomed™ Model 2A anesthesia machine.

REPORT OF A CASE

A 37-yr-old, 64 kg, ASA Physical Status I woman was scheduled for revision of a left cochlear implant. The patient has sensorineural hearing loss but was proficient at lip reading. Preoperative blood pressure was 94/60 with a heart rate of 60 without premedication.

Monitors were applied in the operating room and 100% oxygen was administered by face mask for 3 min before intravenous induction with thiamylal and succinylcholine. The trachea was easily intubated, anesthesia was maintained with 1% enflurane in oxygen, and ventilation was controlled without additional neuromuscular relaxants. Auscultation established the presence of bilateral equal breath sounds. After incision, 20 min following induction, and with the patient breathing 0.5% enflurane, the blood pressure was 80/50 and the heart rate was 55. Five minutes later the blood pressure was 70/50 with heart rate of 50. Oxygen saturation was 98% and end-tidal CO₂ was 36 mmHg. Following a rapid infusion of 200 ml of fluid, blood pressure was still

only 60/45 and the heart rate 50. Enflurane was discontinued, the rapid intravenous infusion was continued, ventilation with 100% oxygen was begun, and 10 mg of ephedrine was administered intravenously without improvement in the vital signs.

Approximately 1 min later the halothane vaporizer was noted to be set at 3%. It was immediately turned off and the blood pressure quickly rose to 100/60 with a heart rate of 70. The operation was completed uneventfully with enflurane 1% and 70% nitrous oxide in oxygen. The patient did not suffer any adverse consequences from her hypotensive episode.

DISCUSSION

Most patients would object to the strong odor of halogenated agents during preoxygenation. This patient did not complain or exhibit any overt sign of displeasure during a 3-min period before induction when she was breathing oxygen with 3% halothane. Perhaps being mute, with the added difficulty of communication in the operating room, contributed to her tolerating the smell of halothane during this preinduction period. Anosmia could also explain her stoicism, but cursory preoperative examination by the surgeon had noted an intact cranial nerve I.

Human error is the most common cause of anesthetic mishap.⁴ It is the duty of every anesthesiologist to check the availability and proper function of the supplies and equipment to be used before every anesthetic.¶ Failure to do so, whether it be due to the pressure for rapid turnover between cases or the confidence engendered by having used the equipment personally on the previous case, places the patient's life at unnecessary risk. This potentially lethal incident could have been prevented by a more thorough systematic check of the anesthesia machine between cases. Routine frequent intraoperative scanning of the anesthesia machine by the anesthesiologist even then failed to detect that the halothane vaporizer was turned on until 26 min into the case.

Equipment failure, although less frequent, has previously been identified as the second most common cause of a preventable anesthetic critical incident. This anesthesia machine was fitted with a vapor exclusion system that is designed to prevent the occurrence of this type of

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§ North American Drager Narkomed™ 2A Technical Service Manual, June 1985.

¶ APSF Newsletter, Anesthesia apparatus checkout recommendations, September 1986, from FDA, August 1986.

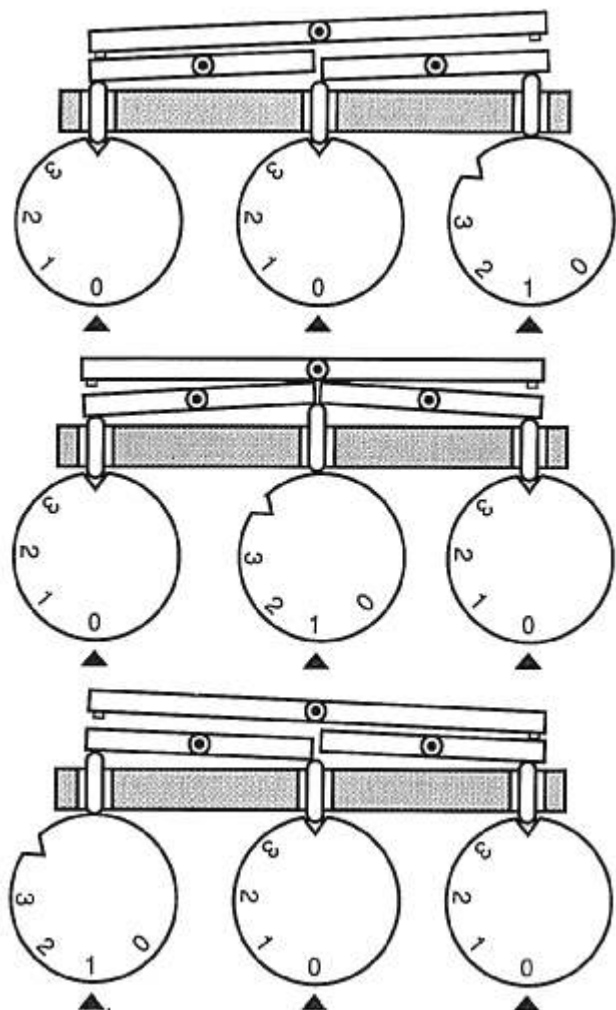


FIG. 1. Schematic diagram of the vapor exclusion system. Reproduced from Narkomed™ 2A technical service manual, June, 1985, with permission courtesy of North American Drager. When a vaporizer is turned on, the interlock bars are mechanically pivoted to positions preventing the remaining vaporizers being used.

accident due to the simultaneous use of more than one vaporizer (fig. 1). Failure of this system allowed the anesthesiologist to turn on the enflurane vaporizer when the halothane vaporizer was already on. The anesthesia machine was removed from service. Inspection revealed that four Allen screws located on the bar of the vapor exclusion device were loose (fig. 2). Using somewhat greater-than-usual force, as though the control dial was stiff, it was possible to turn on more than one vaporizer. Tightening these Allen screws with the adjustment of two additional jam nuts restored the device to proper function.

Periodic maintenance of all anesthesia machines in our department is performed every 3 months by the depart-

ment of biomedical engineering. Routine maintenance records dating from 8 weeks prior to this incident specifically indicate that the vapor exclusion system on this machine was functioning properly. All Narkomed™ anesthesia machines in our department were subsequently inspected, and three other 2 and 2A machines were found to have the same problem. There was no evidence of wear in the vapor exclusion devices concerned the problem being limited to loosening of the retaining screws and nuts only. The maintenance records on these other machines, dated between 9 and 12 weeks prior to inspection, also indicated proper functioning of the vapor exclusion devices. The technicians concerned with maintenance were trained by the manufacturer, but the manufacturer's present maintenance instructions recommend that the vapor exclusion device's function be checked by ensuring that only one vaporizer can be turned on at a time, rather than requiring a physical check that all Allen screws and jam nuts are tight. There had been no episodes of this type of failure in departmental machines before and inquiries of the Drager representative did not produce any reports of other failures of this sort.

This report re-emphasizes the prime importance of the preanesthetic machine check. The vapor exclusion system is intended to prevent this type of incident should the anesthesiologist fail to perform a preoperative inspection of the vaporizers. Numerous investigators have attempted to determine the incidence and causes of anesthetic mishaps due to equipment failure.⁵⁻⁸ All stress the importance of the preanesthetic machine check. Some have further suggested that the anesthesiologist should routinely sniff the new breathing circuit after flushing with O₂ before use to detect the presence of unintended inhalation agents.

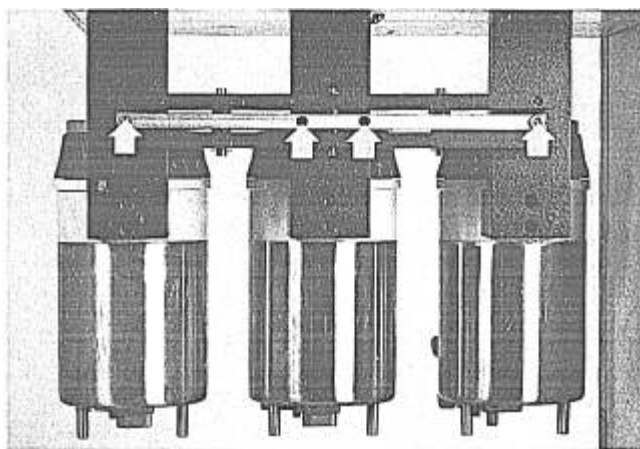


FIG. 2. Arrows indicate the location of the Allen screws and jam nuts on the vapor exclusion device.

Although not routinely used at our institution, mass spectrometers and infrared gas analyzers are available that can measure inspired and expired anesthetic agents concentrations. A recent case report describes the detection of mixed anesthetic agents by mass spectrometry during anesthesia.⁹

Pending definitive recommendations from the manufacturer, our department now requires that the function of the vapor exclusion system of all Narkomed machines be checked every month, including a physical check of the tightness of the Allen screws and jam nuts.

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Esmolol for Perioperative Management of Thyrotoxic Goiter

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Although optimal perioperative management of patients with thyrotoxicosis should include rendering the patient euthyroid prior to surgery, this may not always be possible. In such circumstances, beta-adrenergic blockade with an agent such as propranolol has become standard therapy.¹⁻³ This case report describes the use of the ultra-short acting beta-blocking drug, esmolol, for perioperative management of a patient who required surgical excision of a large toxic goiter that was refractory to both propranolol and high-dose antithyroid medications.

CASE REPORT

A 19-yr-old, 57-kg woman who smoked ½ pack of cigarettes per day presented with a 1-yr history of hyperthyroidism and progressive thyroid enlargement requiring surgical excision due to impending airway compromise. She had been treated with methimazole, 15 mg tid,

and propranolol, 80 mg tid, with unsatisfactory control of her hyperthyroidism. After 2 weeks of pretreatment with strong potassium iodide solution (Lugol's), surgery was attempted at an outside hospital. It was reported that during attempted awake tracheal intubation she developed a tachyarrhythmia, with a ventricular rate over 220/min, necessitating cancellation of surgery.

After transfer to our hospital initial thyroid function tests (TFTs) were: serum T4 = 238 ng/ml (normal = 45-120) and serum T3-RAI = 13.8 ng/ml (normal = 0.8-2.0). Methimazole and propranolol were increased to 40 mg and 80 mg, q 6 h, respectively. During the second week of hospitalization, saturated solution potassium iodide (SSKI) was begun, three drops every 6 h. On the day prior to surgery, the serum T4 was 95 ng/ml. Although the T3-RAI had decreased considerably, the values plateaued at twice normal, in the 3.8-4.0 range, and the methimazole was increased to 40 mg q 3 h.

Since the patient apparently could not be made euthyroid with medical therapy alone, it was decided to proceed with surgery, despite obvious symptoms of thyrotoxicosis.

Preanesthetic physical exam revealed BP = 135/65, and HR = 84-88, despite propranolol therapy. There was ophthalmopathy and proptosis; it was reported that the patient's eyes did not close when she slept. She had a large, tender goiter involving both sides of the neck up to the mandible, making swallowing difficult and painful (fig. 1). She complained of fatigue, generalized weakness, perspiration, nervousness, emotional lability, shortness of breath, and dyspnea on exertion. She was hoarse and could not lie flat in bed without a feeling of suffocation. When lying upright at a 60° angle she displayed a normal respiratory rate, 16-18/min, and a normal pattern of breathing.

Preoperative EKG revealed normal sinus rhythm, left ventricular hypertrophy, and strain. An echocardiogram was normal. A computerized tomographic scan of the neck revealed moderate tracheal narrowing and a chest roentgenogram demonstrated a 4-cm segment of cervical trachea narrowed to a diameter of 1 cm, compared with a

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Key words: Complications: thyrotoxicosis. Hormones: pretreatment; thyroid. Surgery: thyroidectomy. Sympathetic nervous system, beta adrenergic antagonists: esmolol.