CASE REPORTS

Anesthesiology
78:1175–1177, 1993

Contamination of Anesthetic Vaporizer Contents

Maurice Lippmann, M.D., Wayne Foran, M.D.,† Richard Ginsburg, M.D.,† Joan Lewis, M.D.‡*

COMPLICATIONS related to anesthesia often are attributable to human error relating to improper use of anesthesia drugs and equipment.[1,2] The following case report describes a potentially serious incident, the occurrence of which relates to the storage, handling, and administration of volatile anesthetic agents.

Case Report

A 47-yr-old man with mitral valve regurgitation presented for elective mitral valve replacement. The only underlying medical problem was a history of well controlled hypertension.

Preoperatively, the patient received 2 mg midazolam and 6 mg intramuscular morphine sulfate. During the preparation for an opioid-based induction, the patient breathed oxygen at 8 L/min by mask *via* the semiclosed circle anesthesia circuit of a Dräger Narkomed 2A anesthesia machine (Lübeck, Germany) fitted with Vapor 19.1 vaporizers (Telford, PA).

While invasive monitoring catheters were being inserted during local anesthesia, the attending physician noted that the isoflurane vaporizer was empty because it had been left in the "on" position, with oxygen flowing. The vaporizer was placed in the "off" position and the refill cap opened. An open (seal previously removed) but apparently full bottle of isoflurane§ was taken from the top drawer of the anesthesia machine and used to fill the anesthesia vaporizer to near full. While the vaporizer refill cap was being closed, an acrid odor began to fill the room, noticeable to both attending and resident physicians. The odor was strong enough to warrant comment by the anesthesia and operating room personnel and to seek the source of the odor, initially assumed to be outside the operating room. Further investigation revealed, however, that the odor emanated from the residual agent in the filling port of the anesthesia vaporizer. Examination of the now near-empty bottle of "isoflurane" revealed that it produced the same pungent odor.

The contents of the vaporizer were drained into a fresh empty bottle and, along with the remaining sample in the original "isoflurane" bottle, was returned to Anaquest (Liberty Cornen, NJ) for analysis. The vaporizer was removed from the machine and sent to the manufacturer for inspection before being replaced on the anesthesia machine.

Chemical Analysis

Three sample bottles were returned to Anaquest and identified as 1: remainder in the open isoflurane bottle and not put in vaporizer; 2: drained from vaporizer; and 3: unused and completely sealed bottle from the same production lot (no. T145J103). Table 1 depicts the results of the analysis performed by Anaquest using gas chromatography and mass spectroscopy methods.

Results

Analysis of the samples revealed that bottle 3 was pure Forane® (Anaquest). Bottles 1 and 2 contained isoflurane, methyl methacrylate, toluidine, phenol, and phenyl salicylate. Other chemicals were present in trace quantities. Quantitation of individually analyzed components was not performed. A sample from the same production lot at Anaquest, retained for Manufacturer's Quality Control, was similarly tested and proved to be pure isoflurane. Comparison of the chemical analyses of the contaminants from the vaporizer to that of the contents of the liquid-containing ampule from the Surgical Simplex® P Radiopaque Bone Cement (Rutherford, NJ) used in our institution demonstrated marked similarity. The ampule contained 19.5 ml methylmethacrylate (97.4% v/v), 0.5 ml n,n-dimethyl-para-toluidine (2.6% v/v), and 75 ± 15 ppm hydroquinone. The possibility exists that this liquid was the contaminant in the isoflurane bottle obtained from the anesthesia machine drawer.

Discussion

After this analysis, a thorough investigation was conducted at the manufacturing facility to ascertain whether chemicals found in the analysis were present there, thereby contaminating the production or packaging process. Of the chemicals detected, other than

* Professor of Anesthesiology.

† Assistant Professor of Anesthesiology.

‡ Resident, Department of Anesthesiology.

Received from the Department of Anesthesiology, Harbor-UCLA Medical Center, Torrance, California. Accepted for publication February 15, 1993.

Address reprint requests to Dr. Lippmann: Department of Anesthesiology, Harbor-UCLA Medical Center, 1000 West Carson Street, Box 10, Torrance, California 90509.

Key words: Anesthetics: volatile. Contamination. Vaporizers.

§ Forane®, Anaquest, Liberty Cornen, New Jersey.

Table 1. Analysis of Samples Performed by Anaquest

Samples*
1 Lot no. T147J103 (remainder in open isoflurane bottle, not put in vaporizer)
2 Lot no. T145J103 (drained from vaporizer)
3 Lot no. T145J103 (unused bottle, sealed isoflurane bottle)
Compounds
Isoflurane†
3-Hydroxy-3methyl-3-butanone†
Butylacrylate
N-N-dimethyl-*p*-toluidine†
$HO(O)CCH(CH_3)CH_2CH_2C(CO_2H)=C(CH_3)_2$(?)
Methylisobutyrate
Methylmethacrylate
N-methyltoluidine
Phenylsalicylate
Phenol†

* The samples were qualitatively analyzed by gas spectrometry and mass spectrometry. Quantification of contaminants was not performed. Sample 3 was pure isoflurane. Samples 1 and 2 contained foreign material listed as compounds.

† Compound could be vaporized *via* a vaporizer.

isoflurane, only phenol is present at the manufacturing facility, and it is used only in laboratory procedures. Neither phenol nor the remaining chemicals are used in production or packaging operations. Investigation within the anesthesia department and operating room suite, including all ancillary personnel, revealed no evidence to explain how or why a foreign contaminant was introduced to the isoflurane bottle.

It is a common practice in this and other institutions to freely distribute bottles of volatile anesthetics to the operating rooms so that the agent is readily available if a vaporizer needs to be refilled intraoperatively. With free access to bottles of volatile anesthetics, however, the potential for tampering is present, especially when previously opened, partially used bottles are left in the drawers. Even sealed bottles of Forane® and Ethrane® (Anaquest) are subject to tampering, as the caps can be removed with minimal or even no damage to the plastic safety seal. Halothane (Halocarbon, North Augusta, SC), with a metal screw cap that breaks away from a metal corrugated lock ring, provides a more effective tamper-proof seal. Desflurane has been introduced with a crimped top on the bottle and a special filling device to allow only desflurane filling into their special vaporizers.

The Dräger Vapor 19.n vaporizers are available in several models. Our institution uses the Vapor 19.1 with an open filling spout. All Vapor 19.n models are also available with a safety filling device, designed to prevent misfilling of vaporizers with the wrong agent.‖ This system uses a filling cap with an indexed tubing extension that fits directly into the vaporizer filling port. The presence of such a safety filling device would have prevented the evaporation and detection of spilled volatile compounds. Since this provided the only means of contaminant detection in this case, our outcome from this incident could have been significantly worse. This demonstrates that no system is foolproof and that this type of event argues against the use of indexed filling systems. However, indexed filling systems are used widely, and the risk-benefit ratio of these systems is well documented.[3]

This event prompted our department to institute changes in its policy regarding handling of bottles of volatile anesthetic agents. We no longer allow bottles of volatile agents, open or sealed, to remain in the anesthesia machine drawers and operating rooms. Instead, we maintain a central supply stock in the anesthesia operating room pharmacy. Vaporizers are to be filled in the morning during the complete machine check before the day's operating schedule begins. Partially used bottles are to be returned to the central supply immediately after use. All empty bottles are to be discarded and not to be left in the drawer of the anesthesia machine or used as a repository for other nonanesthetic liquids, which could lead to the events described here.

A satellite operating room pharmacy with a pharmacist present would provide even better control. In the absence of the ideal situation, the importance of anesthesia personnel checking for sealed bottles (with a plastic seal that encompasses the cap and bottle neck) that are full prior to use is stressed. If the seal is missing, or if the seal is in place but the bottle is not full, it is possible that evaporation or tampering may have occurred. These bottles should be returned to the main pharmacy.

Although in this case the odor from the volatile compound in the bottle was pungent so as to necessitate investigation of its source and subsequently prevent a patient-related mishap, it is apparent that such a mishap could have been avoided with strict attention to existing machine checkout protocols and the institution of the guidelines outlined here regarding judicious handling of volatile agent bottles.

‖ Drägerwerk AG: Dräger-Vapor® 19.n Anesthetic Vaporizer Instructions for Use, 16th ed. Lübeck: Drägerwerk, 1991.

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Anesthesiology
78:1177–1181, 1993

Deliberate Hypoventilation in a Patient with Air Trapping during Lung Transplantation

Joseph J. Quinlan M.D., Charles W. Buffington, M.D.†*

TRANSPLANTATION of one or both lungs is an evolving surgical treatment for pulmonary insufficiency caused by a variety of lung diseases. One critical decision during lung transplantation is whether to use cardiopulmonary bypass (CPB). Although circulatory support may be useful, especially during pneumonectomy, CPB during lung transplantation often is associated with both early graft dysfunction and coagulopathy. In the absence of severe pulmonary hypertension, unilateral lung transplantation often can be carried out without CPB, as can bilateral lung replacement using the "bilateral sequential" lung transplant technique.[1] Still, some patients undergoing single or double lung transplantation will develop cardiac or respiratory instability during the procedure that is serious enough to require CPB. Such instability may be caused by acute right ventricular failure when the pulmonary artery (PA) is clamped or by inadequate ventilation or oxygenation, especially during pneumonectomy. An additional reason for cardiorespiratory instability during this procedure is hyperinflation of the lungs (air trapping), which leads to decreased venous return, decreased cardiac output, and systemic hypotension.[2] We report a case in which a patient undergoing bilateral sequential lung transplantation developed hemodynamic instability as a result of air trapping. We used deliberate hypoventilation to increase venous return. Although this deliberate hypoventilation was accompanied by severe respiratory acidemia, the patient's oxygenation remained adequate. Deliberate hypoventilation was well tolerated and allowed the transplant to proceed without CPB.

Case Report

The patient was a 28-year-old, 54-kg woman with end-stage lung disease secondary to cystic fibrosis and repeated lung infections. Preoperative medications included prednisone, warfarin, famotidine, and albuterol *via* an inhaler. Pulmonary function tests indicated the presence of severe obstructive lung disease: forced vital capacity (FVC) 1.51 L, forced vital capacity in 1 s (FEV_1) 0.79 L (26% of predicted), FEV_1/FVC 52%, diffusing capacity for carbon monoxide 15.20 (77% of predicted). Sequential bilateral lung transplantation *via* a "clamshell" thoracosternotomy was planned.

Immediately before the procedure, the patient was dyspneic and receiving oxygen while sitting upright. Frequent paroxysms of coughing produced copious, tenacious brown sputum. Auscultation of the chest disclosed distant breath sounds and rhonchi. Laboratory examination was notable for a serum bicarbonate level of 42 mEq/L, a hemoglobin level of 10.8 g/dl, a prothrombin time of 14 s, and a normal electrocardiogram.

Two 16-G intravenous catheters and a 20-G femoral arterial catheter were inserted before the induction of anesthesia. The blood pressure was 140/70 mmHg, and the electrocardiogram showed sinus tachycardia at a rate of 120 bpm. Blood gas analysis during spontaneous ventilation with supplemental oxygen at 6 L/min by nasal cannulae

* Assistant Professor.

† Professor.

Received from the Department of Anesthesiology and Critical Care Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania. Accepted for publication February 15, 1993.

Address correspondence to Dr. Quinlan: Department of Anesthesiology, C-213 Presbyterian University Hospital, O'Hara at Desoto Street, Pittsburgh, Pennsylvania 15213-2582.

Key words: Acid-base equilibrium. Carbon dioxide: hypercapnia. Complications: air trapping. Lung: ventilation. Transplantation: lung.