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(Accepted for publication December 21, 2007.)

Anesthesiology 2008; 108:763–4

Backup Failure of an Adjuvant Battery in an Evita 4® Ventilator

To the Editor:—Electrical power failure in the hospital presents a severe challenge to intensive care unit patients.[1] We recently experienced electrical backup failure in an Evita 4® ventilator (Dräger Medizintechnik, Lübeck, Germany), which was caused by the internal erosion of a connecting cable of an adjunct battery Dryfit A512® (Sonnenschein, Budingen, Germany) to the ventilator.

Because of renovation of the power supply system in our hospital, the temporary interruption of electrical supply in the intensive care unit was scheduled. According to an advance notice from the hospital management division, the electrical supply would be stopped for only several minutes before the emergency electrical generator would start up to supply electricity. At the time of power interruption, three patients were ventilator dependent. The ventilators used in our intensive care unit are checked annually, and adjunct batteries are replaced by engineers from the manufacturers. At the time of power stoppage, two ventilators continued to function, but an Evita 4® ventilator shut down instantly without any alarm. An attending nurse noticed the incident and ventilated the patient manually using a resuscitation bag. Electricity was reestablished quickly, and the ventilator restarted immediately. The patient had no identifiable injury as a result of the shutdown.

The AC and DC power modules of the ventilator were 8 yr old. The ventilator functioned steadily with an external power supply. Because the Evita 4® is normally configured to function for 10 min with backup from a fully charged battery in case of a power cut, the battery assembly was suspected to be responsible for the problem. The ventilator was sent to the manufacturers for close inspection to identify the source of the power backup failure. Dräger Germany found that the cable connector to an adjunct battery was eroded by leaked battery solution. Inside the moist electronic unit, the minor erosion had degraded the connecting cable over time and increased the electrical resistance, leading to the malconduction to the ventilator system and power failure even though the adjunct battery was properly charged (figs. 1–3). Close examination of the manufacturer's database for batteries of approximately 10,000 serial numbers showed that the erosion occurred rarely. The current case was formally registered in the manufacturer's incident list. The manufacturer replaced the emergency power unit of the ventilator with a Panasonic lead–acid battery (Mastushita Battery Industrial, Osaka, Japan). Dräger Japan explained that all Evita 4® ventilators used in Japan would be inspected eventually, and batteries would be replaced, because there was a risk of leakage with the current battery unit.

The internal component of life-supporting devices including ventilators is a "black box" to medical users. We have no precise information about battery life. Depending on the rate of deterioration over time, the life of a battery is usually within 3–5 yr. Regular checkup and periodical replace-

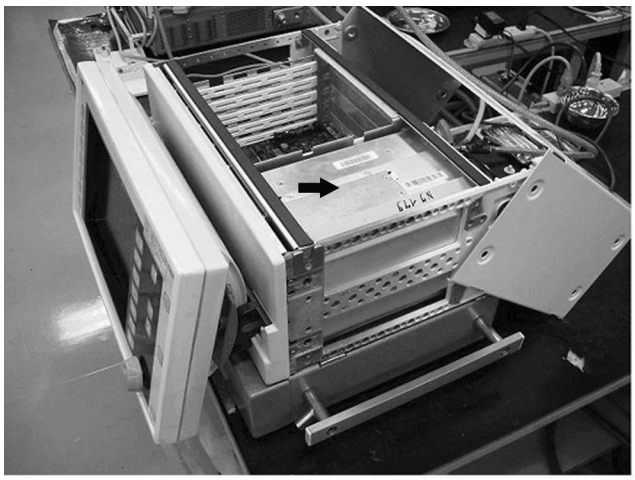

Fig. 1. The AC and DC power modules (*arrow*) are set in the electrical power unit of an Evita 4® ventilator (Dräger Medizintechnik, Lübeck, Germany).

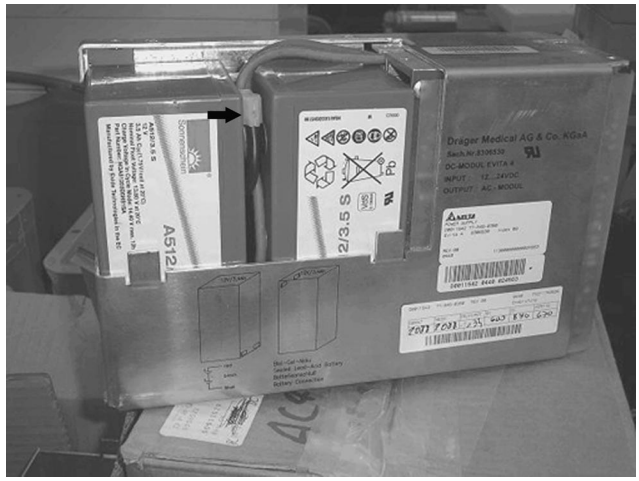

Fig. 2. A pair of the same type of batteries as the failed battery is placed in the adjuvant battery assembly of the DC power module. The *arrow* indicates the cable connector to a battery.

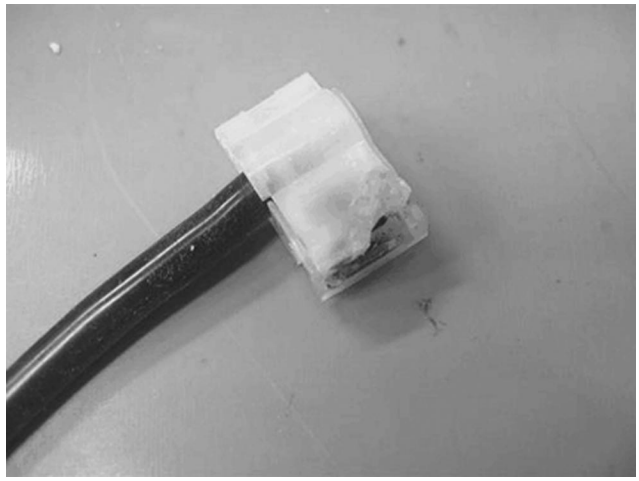

Fig. 3. The eroded cable connector that caused the malconduction trouble.

Support was provided solely from institutional and/or departmental sources.

ment of the battery assembly by trained technicians are mandatory. Moreover, we have to be aware that without reliable power supply, life-supporting machines such as ventilators would be lethal.[2]

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(Accepted for publication October 2, 2007.)

Anesthesiology 2008; 108:764–5

Green Plasma—Revisited

To the Editor:—It has recently come to our attention that the etiology and suitability of fresh frozen plasma with a marked green color are not well understood by a significant number of anesthesia providers. We reviewed the issue of "green plasma" after a unit with a striking green color (fig. 1) appeared in our operating room. Because of the contrast with the typical yellow appearance of plasma, the anesthesiologist refused to accept the unit. Although the blood bank assured him that the unit was safe, the anesthesiologist decided to take the more conservative approach and returned the unit to the blood bank for disposal.

We shared the picture below with more than 30 members of our departments and other departments, including anesthesiologists, nurse anesthetists, internists, intensivists, and surgeons. With one exception, no clinician identified the green color of the plasma as a possible normal variant for the color of fresh frozen plasma, and all suggested infection or bacterial contamination as the most likely reason for the green color. The vast majority concurred with the anesthesiologist's decision to refuse the unit.

We could find no reports on green plasma in the past 40 yr in either the surgical or the anesthesia literature, which perhaps explains the lack of knowledge on the part of today's clinicians. However, we found several articles dating back to the 1960s.[1–3] At that time, green plasma was appearing in blood banks in fairly significant numbers (as many as 1% of all plasma units in large blood bank centers in England). Discoloration of plasma units by gram-negative cryophilic contaminants such as the *Pseudomonas* species was still a concern at that time but was increasingly less likely in the antibiotic age and did not explain the relatively sudden increase in the number of green units. An additional etiology was therefore sought.

The yellow color of plasma is due to the presence of the yellow pigments bilirubin, carotenoids, hemoglobin, and iron transferrin. A previous report had noted the green appearance of sera obtained from donors with rheumatoid arthritis and had identified a corresponding decrease in the yellow pigments of these sera, especially in patients with disease duration of more than 10 yr.[4] However, Tovey and Lathe[1] reported hundreds of units of strikingly green plasma subsequently identified to be from a second cohort of donors (young married women) who did not have rheumatoid arthritis and whose sera had normal levels of yellow pigments. They were unsuccessful in extracting a green pigment from the green plasma; however, they found an unexpected blue precipitate. This pigment was subsequently identified as ceruloplasmin. Ceruloplasmin is a normal plasma glycoprotein, α_2 globulin, that functions as a carrier for copper and also acts as an acute phase reactant.[5] The level of ceruloplasmin can be elevated with elevated copper levels, in rheumatoid arthritis, and in high-estrogen states such as pregnancy and oral contraceptive use.[6,7] Tovey and Lathe were able to confirm elevated ceruloplasmin levels in the green plasma units in their study.[1] A subsequent study by Wolf *et al.*[2] also found high normal or elevated ceruloplasmin levels in 15 donors, all of whom were taking oral contraceptives and all of whom had extremely green plasma. The authors suggested oral contraceptives, which were just then gaining wide clinical use, as the most likely cause of the increase in the number of green plasma units. They also noted that more modern techniques of blood collection (use of large-bore needles *etc.*) had resulted in less hemolysis at the time of donation, and consequently there were no longer large amounts of yellow pigments from free hemoglobin in the sera.

Fig. 1. The green plasma unit on the *right*, shown with a typical yellow unit.

The unit of green plasma that reached our operating room was cleared as a normal color variant by both regional and hospital blood bank staff using a visual inspection standard published by the American Red Cross and last updated in 2006. This can be viewed online.* As part of our *post hoc* review, we sought the ceruloplasmin level of this unit of plasma; however, the refused unit had already been discarded. Blood bank records showed that the donor was a 27-yr-old female graduate student in excellent health, absent all medical conditions and medications, except for a 5-yr history of oral contraceptive use.

Currently, approximately 0.3% of the inventory of fresh frozen plasma in our region is greenish in color. The American Association of Blood Banks is pursuing strategies to reduce the number of blood donors known to be at risk for leukocyte alloimmunization (pregnant females) as part of their plan to reduce the number of transfusion-related acute lung injury. Whether this strategy will make green plasma of only historical interest is doubtful. Blood banks will not be able to exclude pregnant women or women on birth control pills altogether as plasma donors because they simply will not be able to meet the needs of the country. Anesthesia providers should be aware of variations in physical properties of blood products and

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* Available at: www.redcross.org/visualinspectionguide. Accessed December 7, 2007.