

## A Dramatic Transport Respirator Failure

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### Introduction

Failure of the anaesthesia workstation is largely described in the anaesthesia literature but there is few descriptions of such hazards with transport ventilators [1-4]. This clinical case reports a transport ventilator severe failure leading to death and whose diagnosis was delayed because anesthesiologist attention was distracted to solve other priorities. This type of failure highlights also organization and apparatus maintenance dysfunction and the importance of human defect of attention as the root causes of severe adverse events.

### Clinical Case

Our hospital responsible Institutional Review Board gave permission to publish this report. In this clinical case, an 80-years old man was scheduled for coronary artery bypass graft under extracorporeal circulation (ECC). After uneventful surgical bypass graft, and ECC weaning, the patient exhibited stable hemodynamic without any need of inotropes. After chest closure, the patient was transferred into his bed with continuous cardiovascular monitoring. Thereafter, the anaesthesia ventilator was replaced by the transport ventilator (Oxylog 2000, Dräger), with similar ventilatory parameters settings (tidal volume 480 ml, frequency 15 c.p.m., PEEP 8 cm H<sub>2</sub>O, maximal pressure 40 cm H<sub>2</sub>O).

Following the transfer of the patient into his bed, the arterial pressure curve flattened despite normal EKG. Carotid pulse disappearance confirmed electromechanical dissociation; external cardiac massage was undertaken immediately with simultaneous epinephrine 1mg intravenous injection. The patient was transferred back again on to the operating table and his lung connected with the anaesthesia ventilator. Extracorporeal circulation was re-established. The duration of no flow reached 18 minutes. A transient bilateral pupillary dilation occurred and rapidly reversed. Surgery excluded hemorrhage or graft dysfunction. Extracorporeal circulation was maintained over 30 min then the patient was weaned under low dose intravenous epinephrine. The patient was transferred again into his bed but progressively step by step to check hemodynamic tolerance at each step. The portable ventilator with the same settings as the anesthesia machine was connected again to the patient. Hardly after 3 respiratory cycles, peak inspiratory pressure increased and end expiratory pressures heightened to 20 cm H<sub>2</sub>O despite a pep level set at 5 cm H<sub>2</sub>O without triggering any alarm. Arterial pressure at the same time fell dramatically.

The failing ventilator was immediately disconnected and replaced by a new one then sent to quarantine. Epinephrine infusion was increased, the patient put in trendelenburg position to improve venous return and cardiac massage undertaken again until complete restoration of correct hemodynamic status. Unfortunately, a post-anoxia encephalopathy developed thereafter and the patient remained in a semi vegetative state.

The ventilator was isolated from clinical use to analyze precisely the cause of the failure. Immediately after, the anesthesiologist in charge of the patient observed that the expiratory valve of the Oxylog 2000 was blocked forbidding gas escape. Thereafter, the failure was reproduced

in front of a panel of clinical medical and nurse experts; with the biomedical engineer. The inspiratory valve was twisted and induced the observed increase in pep values.

This anaesthesia accident was also analyzed during medical staff. The apparent defect was valve dysfunction undetected before equipment use. Staff concluded to human error and lack of organization. The root causes were as follow: defect of equipment maintenance resulting from reusable valve and circuit, valve dysfunction resulting from error in valve assembly after sterilization, absence of verification procedure before use, defect of failure detection by audible alarms, lack of prompt medical diagnosis because of diverted attention to other aims (funnel effect). Following this analysis and discussion with the constructor, a maintenance protocol and weekly verification of the apparatus was set, with a trace ability form. The Oxylog 2000 has only maximal pressure alarm during insufflation and disconnection alarm (minimum inspiratory pressure alarm) but none for expiration pressures. Because this apparatus is used by other services, the information was spread in the whole hospital. Statement of the failure and its causes were sent to the hospital manager, the equipment watch national committee AFSSAPS (Agence Française de Sécurité Sanitaire des Produits de Santé) and to the constructor. Dräger Medical (GmbH, 23542 Lübeck) sent back a mail to its customers to complete the notice of use of Oxylog 2000 and to remind safety instructions.

### Discussion

This clinical case shows a rare but dramatic failure of anaesthesia equipment and highlights the complex reasons favoring its occurrence.

Cardiac arrest management was in accordance with American Heart Association (AHA) guidelines [5]: early external cardiac massage (absence of no flow) associated with epinephrine iterative bolus (1 mg per 3 to 5 minutes). A peripheral ECC was quickly performed to get a good perfusion (low flow 18 minutes) before surgical recovery. However this was not in accordance with the European Association for Cardiothoracic Surgery guidelines (EACTS) [6]. EACTS recommends surgical recovery first but this guidelines deal with Intensive Care Unit patients, where technical and human resources are not quickly available to start ECC and emergency re sternotomy is not easy. Our case was different: cardiac arrest occurred in operative room and all of the devices needed for emergency ECC and sternotomy were available and ready to use. In addition, American Heart Association guidelines

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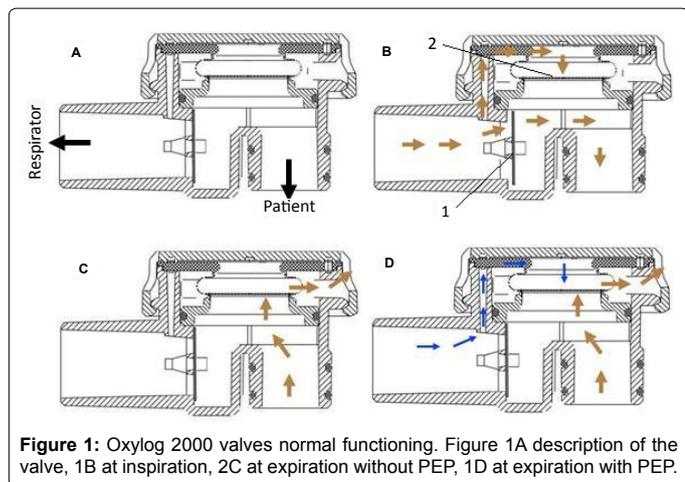


Figure 1: Oxylog 2000 valves normal functioning. Figure 1A description of the valve, 1B at inspiration, 2C at expiration without PEP, 1D at expiration with PEP.

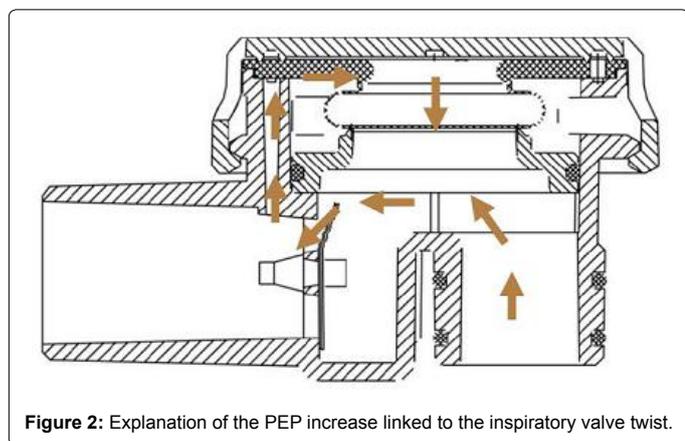


Figure 2: Explanation of the PEP increase linked to the inspiratory valve twist.

[5] recognize this technique in the immediate postoperative period because most cardiac arrests etiologies in this situation can be cured and because no- and low-flow duration is usually of brief duration preventing the occurrence of multi-organ failure.

A gas tamponade secondary to a dynamic hyperinflation caused by an expiratory valve failure was the cause of cardiac arrest. Oxylog 2000 valves normal opening and closure are explained in Figure 1. At inspiration (Figure 1B), normally the pressure gradient between ventilator's pneumatic circuit and patient's airways allows the opening of inspiratory valve [1] and closure of the expiratory valve [2]. At normal expiration (Figure 1C), the pressure difference is reversed so that the inspiratory valve is closed and the expiratory valve allows gas outflow. The ventilator can create a positive expiratory pressure (PEP) by generating a continuous flow opposed to expiratory valve opening (Figure 1D). In this case report (Figure 2), the inspiratory valve was twisted and couldn't close at expiration leading to a continuous gas inflow directly from ventilator to patient through the unclosed inspiratory valve. Thus a higher PEP than that prescribed was generated, increasing at each insufflation. This phenomenon repeated at each insufflation caused progressively the dramatic increase in alveolar pressure up to gas tamponade and cardiac arrest. Patient circuit had been sent for maintenance and the valve incorrectly positioned after washing. Mail from manufacturer issued to users after this accident as well as the Oxylog 2000 operating instructions contain clear warnings about this valve deformation or improper positioning : « do not remove the disc rubber enclosure, do not damage or twist it, otherwise interfere

with the operation of the valve and put the patient in danger.» Valve failure can be detected during the mandatory auto-test: « checking the status market », asked by Oxylog 2000 after each valve or respirator maintenance and at least once every six month. This test was not made in this case.

Recently, a similar case report also leading to excessive and undesirable PEP increase was described in an anesthetic work station. The failure set inside the machine [7]. Few transport's ventilator failures have been described in the literature. Most of the mare battery failures [8] or deformation of the Oxylog 2000 breathing hose near the proximal joint [9]. In these cases, only capnography drop triggered alarm, without any oxygenation concerns for the patient. The failure described here has been reported in another context [10]. Ventilator failures are mainly reported in the operating room (86%), more rarely in the post-operative recovery room (8%) or in intensive care unit (6%). It can also occur during intra hospital transport of critically ill patient [11]. In 1998, more than two-thirds of respirator failures were related to equipment improper use and only one third to true equipment failure [2]. Ventilator failures were severe and led in 76% of cases to permanent damage or death. A posteriori analyzes of each case led to enhanced security by equipment improvement in one hand and, in the other hand, to standardization and traceability of equipment checking. These simple means can decrease significantly adverse events related to respirators [1]. After this severe adverse event, transport ventilators are now verified weekly and after each use with a check list and with a traceability procedure. The mandatory testing of the valve is part of check list. Human error remains the main source of respiratory failure. Thus in Fasting et al series, among the 21 severe adverse events related to the anesthetic work station, 18 were related to non-compliance to instructions for equipment use [4].

This transport ventilator complication occurred in a particular context, at a time when it was not expected. The attention needed to care patients during transport should not be released. Check lists can avoid most of severe adverse events. Such one needs complete investigation to identify its root causes, to propose corrective actions in order to prevent subsequent recurrence.

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