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CASE REPORTS

Oxygen delivery failure due to improper installation of carbon dioxide absorbent canister: a case report

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Abstract The CLIC system in the Dräger Apollo anesthesia workstation allows a successful pre-use machine checkout without the presence of a carbon dioxide absorbent canister. It also allows the canister to be changed without interrupting controlled ventilation. However, this canister can be easily installed improperly with the CLIC adapter. We report a case in which a patient could not be ventilated by mask after the induction of general anesthesia, resulting in oxygen desaturation before successful ventilation was achieved with a bag valve mask. This case illustrates the importance of a leak test after components of the breathing circuit are changed.

Introduction

The CLIC adapter (Drägersorb CLIC system; Dräger, Inc, Telford, Pennsylvania) on the Apollo anesthesia workstation (Dräger, Inc) allows the disposable soda lime carbon dioxide (CO_2) absorbent canister (Drägersorb 800+ CLIC disposable absorber; Dräger, Inc) to be changed without interrupting controlled ventilation. The CLIC adapter is fitted with a spring-loaded rubber valve.[1] A release button on the CLIC adapter is pressed to detach the CO_2 absorbent canister, activating a valve mechanism that bypasses the absorber and thus maintains a seal in the internal breathing circuit to allow controlled ventilation while changing the canister. For anesthesia workstations without this feature, replacing the CO_2 absorbent canister during a procedure interrupts the patient's controlled ventilation and the administration of volatile anesthetics. However, the design has a flaw that becomes apparent when the CO_2 absorbent canister can be secured without being seated correctly, failing to seal the breathing circuit. Another problem is that the CLIC system allows a successful pre-use machine checkout without the presence of the absorbent canister. Anesthesiologists should be aware of potential problems with the CLIC system to troubleshoot a machine circuit leak. As described in the present case report, the use of a functioning bag valve mask (BVM)

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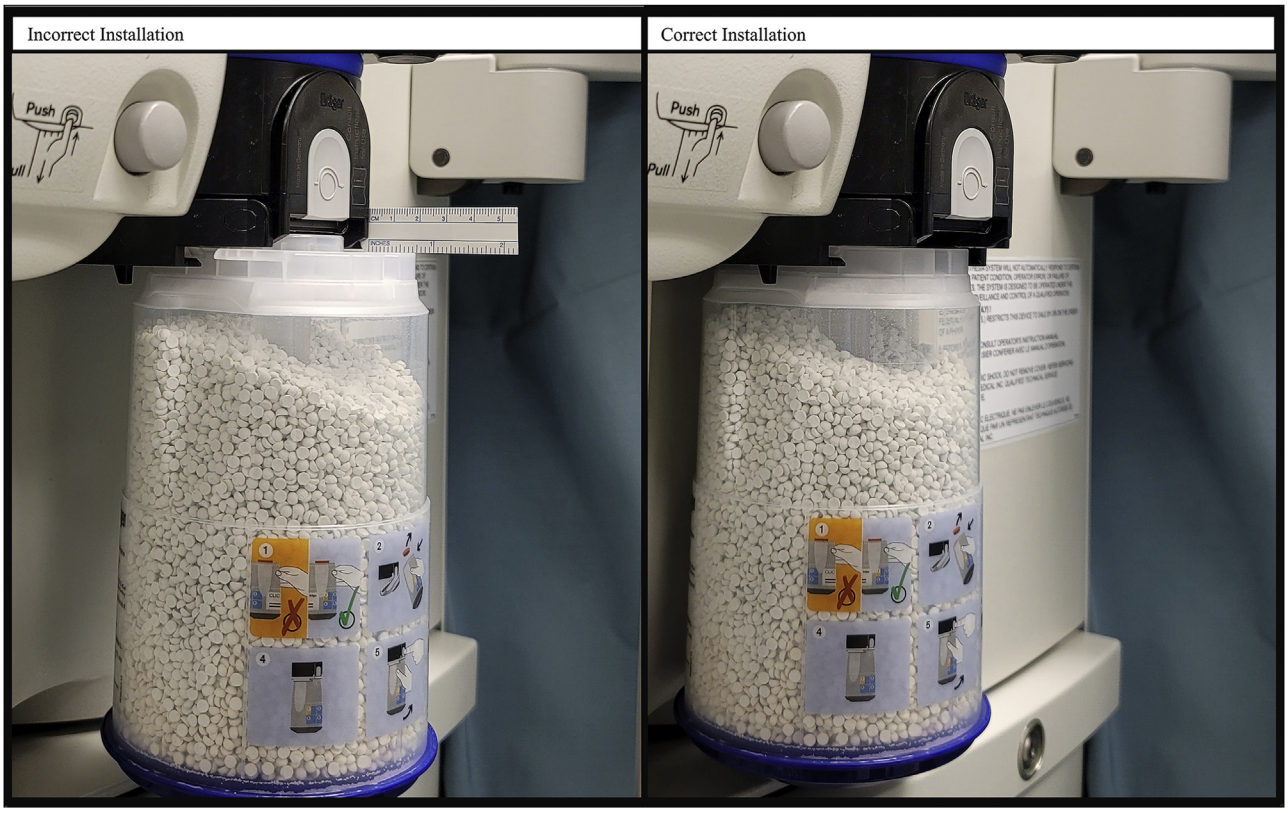

Figure 1 Installation of the carbon dioxide absorbent canister.

allowed timely ventilation and oxygenation of the patient, minimizing harm.

This case report focuses solely on the designs of the anesthesia workstation, not on patient demographics. The Case Reports (CARE) guidelines were used in writing the article. Patient information has been deidentified in accordance with the institutional review board policy and the Health Insurance Portability and Accountability Act (HIPAA). The patient completed an institutional HIPAA authorization form to give written authorization to use existing protected health information.

Case report

A 70-year-old man was brought to the operating room for repair of a right inguinal hernia. After induction of general anesthesia and placement of a laryngeal mask airway, manual ventilation with a reservoir bag in the anesthesia machine breathing circuit was not possible because of a lack of positive pressure. Oxygen (O_2) desaturation occurred (from 100% to 62%) before a BVM connected to the auxiliary O_2 source was used for ventilation. When the patient was successfully oxygenated and ventilated, the machine was inspected. On inspection, controlled mechanical ventilation with the ventilator provided positive pressure ventilation, but manual ventilation with the reservoir bag did not. It was then discovered that the CO_2 absorbent canister was not completely inserted. The canister was secured with the CLIC adapter system but was not fully seated in the absorbent canister bracket (Fig. 1), creating a large leak where the top of the canister pressed on the spring-loaded rubber valve. An air leak could be felt near the canister. When the problem was identified, the canister was unclamped with a push of the CLIC adapter button, completely inserted into the bracket, and then secured by reengaging the adapter with a click. Correct installation of the CO_2 absorbent canister stopped the air leak (Fig. 1), and the case continued uneventfully. On further investigation, the pre-use automated machine checkout had been successfully completed without a CO_2 absorbent canister in place. The CO_2 absorbent canister was installed after checkout, and no additional leak test was performed after canister installation. At the end of the procedure, the laryngeal mask airway was removed, and the patient was awake and alert without any signs of complications approximately 20 minutes after arriving in the recovery room.

Discussion

With the CLIC adapter, the Dräger Apollo anesthesia machine allows the disposable CO_2 absorbent canister to be changed without interrupting the patients' controlled ventilation.[1] It also allows the automated checkout to be passed without a CO_2 absorbent canister in place.[2] This anesthesia workstation lacks a mechanism to ensure that the replaceable CO_2 absorbent canister is fully inserted into the canister bracket before engaging the *U*-shaped CLIC adapter clamp. When the canister is secured with the *U*-shaped clamp but not fully inserted into the absorbent canister bracket, the top of the canister presses on the spring-loaded rubber valve

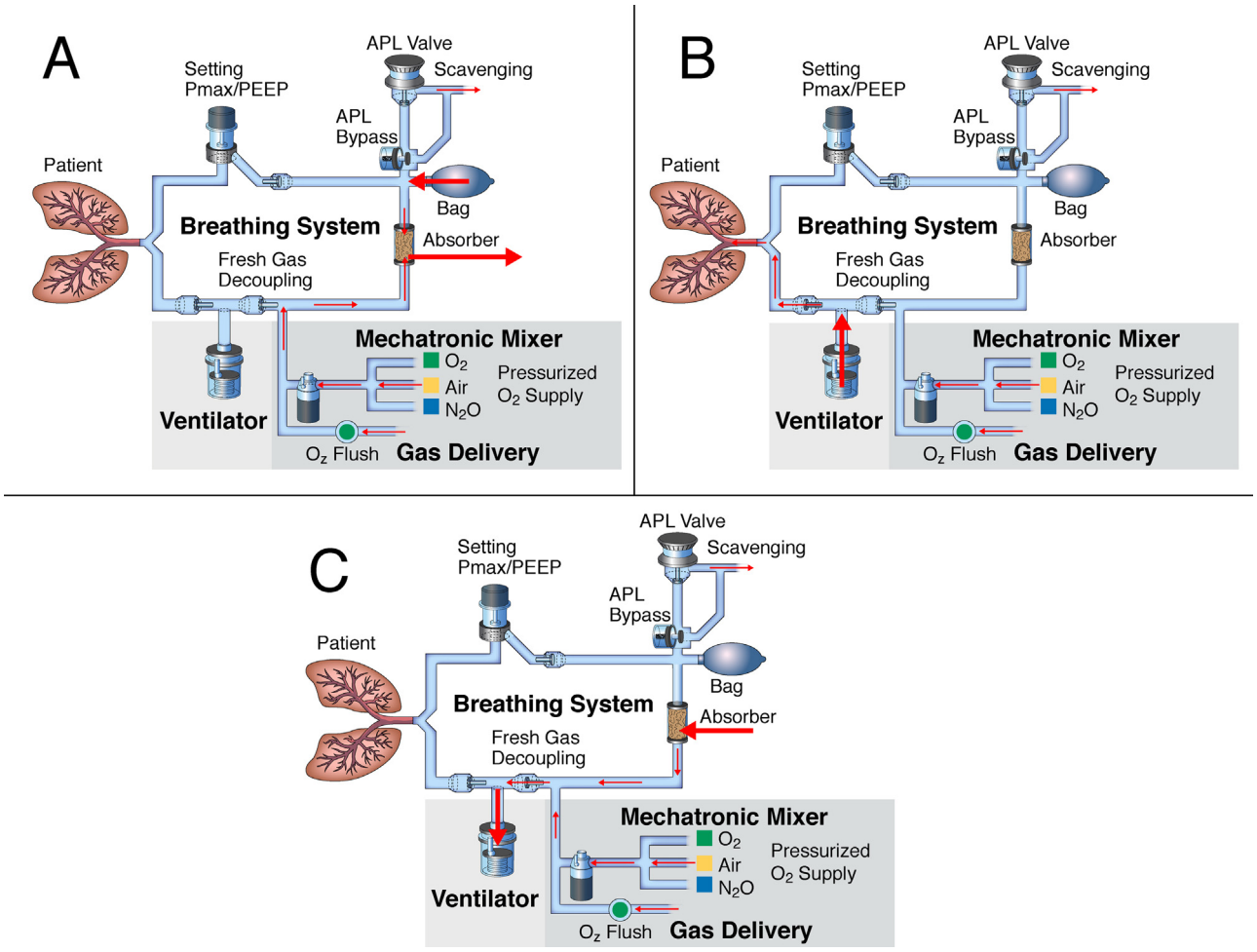

Figure 2 Gas flow diagrams. A, Manual ventilation mode. B, In controlled ventilation during the inspiratory phase, the fresh gas decoupling valve closes and allows positive pressure ventilation to the lungs. C, In controlled ventilation during the expiratory phase, room air is drawn into the breathing circuit. Red arrow indicates the gas flow. APL indicates adjustable pressure-limiting; N_2O, nitrous oxide; O_2, oxygen; PEEP, positive end-expiratory pressure; Pmax, maximum expiratory pressure.

and causes a large gas leak where the machine connects to the CO_2 absorbent canister. The result is minimal preoxygenation to the patient when the machine is in spontaneous ventilation mode, and manual positive pressure ventilation is not possible (Fig. 2A).

The location of the fresh gas decoupling valve in the Dräger Apollo design allows positive pressure ventilation to be provided if the machine is switched to controlled ventilation. The fresh gas decoupling valve excludes machine leaks between the ventilator and the exhalation valve, preventing retrograde gas flow through the CO_2 absorbent canister (Figs. 2B and 2C). However, concentrations of O_2 and inhalational agents will vary depending on the degree of gas leak. The leak may also cause volatile anesthetics to be in the working environment without being properly scavenged. Without a functioning CO_2 absorbent, the patient's end tidal CO_2 partial pressure may increase.

In addition to the disposable CLIC absorber, the Apollo workstation allows the optional use of a reusable CO_2 absorbent canister (Drägersorb CLIC Free) without the *U*-shaped CLIC adapter. We are not aware of published reports on safety issues with the CLIC Free design.[2] The CLIC Free design lacks the CLIC adapter, so the anesthesia workstation would not pass the pre-use machine leak check without a properly seated CO_2 absorbent canister because of the gas leak at the CO_2 absorbent canister site. With the *U*-shaped CLIC adapter present, as in our case, the anesthesia machine checkout will pass with the CO_2 absorbent canister either absent or properly placed.[2] The canister can be easily changed after the machine checkout is completed and passed. It is acceptable to change the CO_2 absorbent canister during the case, but proper placement of the canister must be ensured.

The Apollo workstation manual recommends a leak test after replacing the absorbent canister. However, the CLIC system is designed to allow absorbent canister replacement during use, and an automatic leak test is not possible when the workstation is being used. The location of the CO_2 absorbent canister on the Apollo workstation may make visual identification of an improperly installed absorber canister difficult because it is low in the machine and is obscured by the workstation table. A manual pressure check of the breathing circuit must be performed immediately before the induction of anesthesia to ensure proper machine function-

ing and to avoid relying solely on the automated pre-use machine leak test.

Besides Apollo, other Dräger workstations that are compatible with the CLIC adapter, such as the Fabius Tiro, all have the similar design concern. Anesthesia machine manufacturers may want to review CO_2 absorbent bypass designs to verify their safety and to identify other possible operating issues. In fact, when the incident was reported to the manufacturer, the Dräger representative mentioned that the company's newer Perseus anesthesia workstation has an optional radio frequency identification sensor for the CO_2 absorbent canister to ensure that a canister is present and properly seated in the workstation.

When the risk with the CO_2 absorbent canister was identified, our anesthesiologists, nurse anesthetists, and anesthesia technicians were given education and reminders on proper installation of the canister. This case is a reminder of the importance of performing the additional manual pressure leak check of the machine immediately before the beginning of each procedure. It consists of setting the machine to spontaneous-manual ventilation mode, setting all gas at minimum flow, occluding the Y-piece of the breathing circuit, closing the adjustable pressure-limiting valve, and inflating the breathing bag with O_2 from the O_2 flush valve. A sustained pressure of 30 cm H_2O for more than 10 seconds confirms the integrity of the system.[3] A BVM must always be available and functioning in the operating room.[4]

Conclusions

Although modern anesthesia workstations conduct automated pre-use checks for machine and breathing circuit leaks, the anesthesiologist is responsible for ensuring proper machine function before each procedure. Anesthesiologists should be aware that the presence of the fresh gas decoupling valve on the machine side of the ventilator enables positive pressure ventilation during controlled ventilation despite the presence of a leak because it closes as the piston ventilator generates positive pressure. During manual ventilation, a leak in the CO_2 absorbent canister will prevent positive pressure ventilation because gas flow follows the path of least resistance and escapes through the leak rather than creating positive pressure to inflate the lungs. Although the design flaw may be limited to only the Dräger Apollo anesthesia machine, this case report provides important lessons for a proper machine check and the need for a functioning BVM in the operating room. The breathing circuit should undergo a manual pressure check immediately before induction of anesthesia to ensure proper machine functioning. The presence of a functioning BVM in operating rooms is essential because it can allow timely ventilation and oxygenation of the patient if the machine malfunctions.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Drager. Just ''CLIC'' it!; 2015. Available at: https://www.draeger.com/Products/Content/lsa_draegersorb_clic_casestudy_9051467_en.pdf. Accessed 2019 Apr 22.
2. Drager. Advanced Anesthesia Solutions: Drager Apollo Anesthesia Workstation; 2017. Available at: https://www.draeger.com/products/content/apollo-br-9050390-us.pdf. Accessed 2019 Apr 22.
3. Ianchulev SA, Comunale ME. To do or not to do a preinduction check-up of the anesthesia machine. Anesth Analg. 2005;101:774–6.
4. American Society of Anesthesiologists, Available at: https://www.asahq.org/standards-and-guidelines/2008-asa-recommendations-for-pre-anesthesia-checkout. Published 2019. Accessed Apr 22, 2019 ASA Recommendations for Pre Anesthesia Checkout; 2008.