LETTER TO THE EDITOR

# Transport Circuit during COVID-19 Crisis: A Simple Modification of the Bain's Circuit for Safety of Healthcare Workers

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Dear Editor,

The present COVID-19 pandemic has brought many new challenges to the healthcare system. One such challenge is the transport of patients on ventilator support within the hospital and to other facilities with utmost safety. Modified Mapleson D (Bain) and Mapleson F (Jackson-Rees) circuits are safe and widely used for intra-hospital transport of patients on controlled ventilation at our institute. However, there is a significant risk of infection to the healthcare workers (HCWs) due to exposure to the respiratory aerosol. To overcome this hazard, we have designed a simple modification of the conventional Bain circuit for short transport of patients on controlled ventilation without compromising the safety of the patient and enhancing the protection of the HCW at the same time.

The conventional Bain circuit (modified Mapleson D type)[1,2] is a coaxial circuit with a small inner tube (inspiratory limb) and a wider outer tube (expiratory limb). One end of this circuit is attached to the endotracheal tube (ETT) and the other end has the reservoir bag with an adjustable pressure limiting (APL) valve near the operator. Similarly, the Mapleson F circuit (modification of the Mapleson E by Jackson Rees[3]) is used for the transport of pediatric patients (<20 kg).[4] The patient end of the circuit is connected to ETT and the operator's end has a reservoir bag with an APL valve at the end. These circuits being semi-closed systems (opened to the environment through APL valves) may disseminate aerosol from the patient's respiratory system into the surrounding environment, thus increasing the vulnerability of the operator to get exposed to infection especially in COVID-19 suspect or confirmed cases.

Hence, we felt a palpable need to modify the circuit for the safety of the operator. The pressing concern was to shift the source of the aerosol, i.e., the exhaust or APL valve away from the operator end. So, we transferred the APL valve to the patient end keeping the fresh gas flow (FGF) inlet at the patient end through the inner tube. The resultant modification thus converted the existing coaxial Mapleson D to a coaxial Mapleson B circuit (Fig. 1).

We tested our new circuit for two possible limitations, i.e., rebreathing and the requirement of high gas flows. A portable end-tidal $CO_2$ connector (Continuum Life Care, India) was attached to the patient end of the circuit to monitor end-tidal $CO_2$ ($EtCO_2$) and fractional inspired $CO_2$ ($FiCO_2$) level, and an FGF of 10 L/minute was used for ventilating the patient. After adequate administration of muscle relaxants, a baseline arterial blood gas (ABG) analysis was obtained to observe the $PaCO_2$ levels. The patient was ventilated with adequate tidal volume at a fixed rate of 16 breaths/minute for 15 minutes and the $PaCO_2$ level was again obtained by ABG. During this exercise, the patient remained hemodynamically stable. The whole procedure was repeated on the same patient using the conventional Bain circuit using 10 L/minute FGF and the results of the two circuits were compared. It was found that after 15 minutes of controlled ventilation, the rise in $PaCO_2$ was 3.5 and 7.3 mm Hg with the Bain circuit and the new circuit, respectively (Fig. 2) while the rise in fractional inspired $CO_2$ level ($FiCO_2$) was 4 and 7 mm Hg, respectively. Both the circuits were tested with FGF of 10 L/minute, which is the standard flow used routinely. Hence with a transport oxygen cylinder of 660 L, we can use the circuit for at least 1 hour at a flow of 10 L/minute.[4] Our new circuit is around 1.8 m in length and this gives a safe distance for the operator to stay away from the APL valve (a distance of >1 m is recommended to prevent the spread of COVID-19 infection). Similar to the Bain circuit, the new circuit is lightweight, with minimum dead space and resistance, with no evidence of a rise in airway pressures or barotrauma, and

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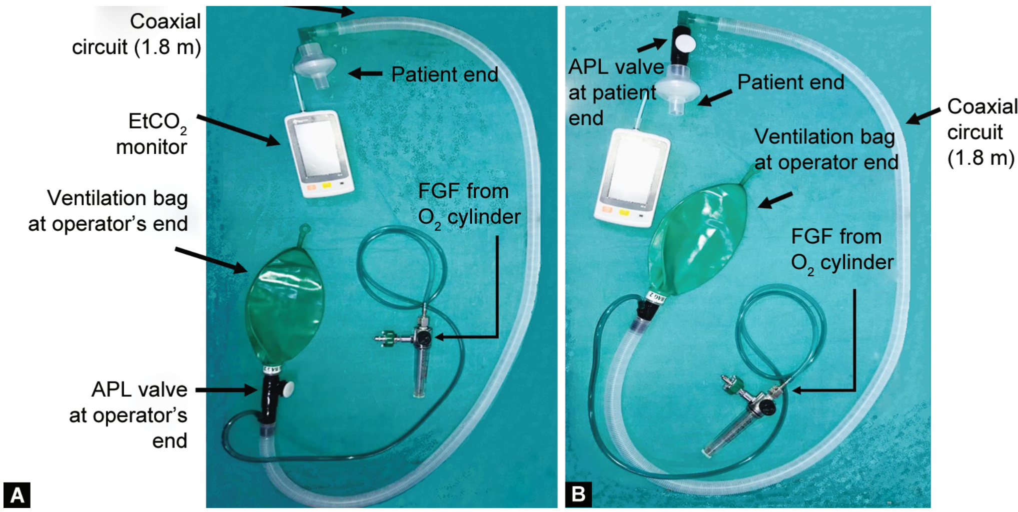
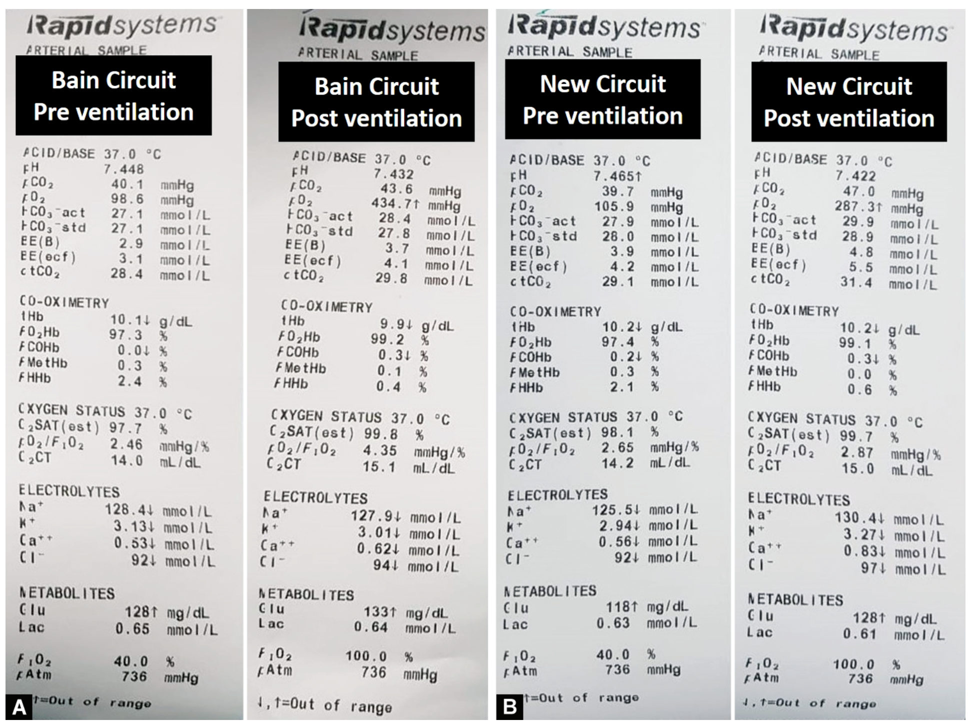



**Figs 1A and B:** (A) Bain's circuit (coaxial Mapleson D); (B) New modified circuit (coaxial Mapleson B)



Rapidsystems — ARTERIAL SAMPLE

| | | Bain Circuit Pre ventilation | Bain Circuit Post ventilation | New Circuit Pre ventilation | New Circuit Post ventilation |
|---|---|---|---|---|---|
| **ACID/BASE 37.0 °C** | | | | | |
| pH | | 7.448 | 7.432 | 7.465↑ | 7.422 |
| $pCO_2$ | mmHg | 40.1 | 43.6 | 39.7 | 47.0 |
| $pO_2$ | mmHg | 98.6 | 434.7↑ | 105.9 | 287.3↑ |
| $HCO_3^-$act | mmol/L | 27.1 | 28.4 | 27.9 | 29.9 |
| $HCO_3^-$std | mmol/L | 27.1 | 27.8 | 28.0 | 28.9 |
| BE(B) | mmol/L | 2.9 | 3.7 | 3.9 | 4.8 |
| BE(ecf) | mmol/L | 3.1 | 4.1 | 4.2 | 5.5 |
| $ctCO_2$ | mmol/L | 28.4 | 29.8 | 29.1 | 31.4 |
| **CO-OXIMETRY** | | | | | |
| tHb | g/dL | 10.1↓ | 9.9↓ | 10.2↓ | 10.2↓ |
| $FO_2Hb$ | % | 97.3 | 99.2 | 97.4 | 99.1 |
| FCOHb | % | 0.0↓ | 0.3↓ | 0.2↓ | 0.3↓ |
| FMetHb | % | 0.3 | 0.1 | 0.3 | 0.0 |
| FHHb | % | 2.4 | 0.4 | 2.1 | 0.6 |
| **OXYGEN STATUS 37.0 °C** | | | | | |
| $O_2SAT$(est) | % | 97.7 | 99.8 | 98.1 | 99.7 |
| $pO_2/F_IO_2$ | mmHg/% | 2.46 | 4.35 | 2.65 | 2.87 |
| $O_2CT$ | mL/dL | 14.0 | 15.1 | 14.2 | 15.0 |
| **ELECTROLYTES** | | | | | |
| $Na^+$ | mmol/L | 128.4↓ | 127.9↓ | 125.5↓ | 130.4↓ |
| $K^+$ | mmol/L | 3.13↓ | 3.01↓ | 2.94↓ | 3.27↓ |
| $Ca^{++}$ | mmol/L | 0.53↓ | 0.62↓ | 0.56↓ | 0.83↓ |
| $Cl^-$ | mmol/L | 92↓ | 94↓ | 92↓ | 97↓ |
| **METABOLITES** | | | | | |
| Glu | mg/dL | 128↑ | 133↑ | 118↑ | 128↑ |
| Lac | mmol/L | 0.65 | 0.64 | 0.63 | 0.61 |
| $F_IO_2$ | % | 40.0 | 100.0 | 40.0 | 100.0 |
| pAtm | mmHg | 736 | 736 | 736 | 736 |

↓, ↑=Out of range

**Figs 2A and B:** (A) Arterial blood gas (ABG) values pre- and post-ventilation for 15 minutes with Bain's circuit; (B) ABG values pre- and post-ventilation for 15 minutes with the new modified circuit

can be safely used for short transport (15–20 minutes) of the patient with controlled ventilation.

In this COVID-19 era, it is the need of the hour to have robust objectives to save the HCWs and at the same time, not to compromise the safety of the patient. This simple modification of conventional Bain's circuit enables the operator to maintain a safe distance from the APL valve and thus adds to the safety of HCWs. Other measures such as the use of HMEF filter (viral filtration capacity of 99.99%)[5] at the patient end of the circuit must be used to decrease the spread of infection. We also suggest the use of a portable $EtCO_2$ monitor for a continuous and close watch on $EtCO_2$ and $FiCO_2$ during the transport of a patient. These measures will not only reduce the spread of infection but will also enhance the safety of patients while transportation during the time of the present pandemic.

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