

Plumbing

Updated 1 April 2020

This page described the means by which a patient should be connected to a manual resuscitator-based ventilator. Some considerations include:

This document describes critical design requirements of the patient breathing circuit. This details a key dead space issue, which if not addressed, will result in a patient breathing in expelled CO₂ and deoxygenation fast with immediate adverse result. For a detailed primer on Breathing Circuits read [Mapleson's Breathing Systems](#).

Normally, self-inflating manual resuscitators are directly connected to the patient's endotracheal tube adapter. Manual resuscitators have a "patient valve" that directs oxygen / air gas mixture into the patient and shunts the exhaled gas out to the environment. (See [Wikipedia](#) as a good primer on self-resuscitating manual resuscitators.) Integrated into the end bag valve mask (BVM) are a number of critical features:

- Oxygen connection and reservoir
- Pop-off valve for safety (location not important)
- One-way valve that guides air to the patient
- Exhalation valve (this stays closed while there is any pressure on the bag)
- PEEP valve that is installed post the exhalation valve and maintains backpressure
- Sensing port for manometer connection (we use this for our pressure sensor connection)

Caution: Manual resuscitator bags are in no way FDA approved for use as long-term ventilation solutions.

This page described the means by which a patient should be connected to a manual resuscitator-based ventilator. Some considerations include:

- The ventilator must be placed as close to the patient as possible.
- Bag should be secured to ventilator to prevent an awake patient from pulling on it or otherwise disengaging the bag from the mechanism. This is a fault condition that should be detected by pressure sensing.
- Care must be taken to prevent rebreathing of CO₂ due to long hoses. A fundamental challenge is the location of the one way and expiratory valves, which are typically directly integrated into the bag.

REGISTER
LOGIN

Search

NEWS

[Plumbing & Dead Space](#)

[Updated Study Results & Non-invasive Ventilation](#)

[Study Results](#)

[Updated Electrical & Operations](#)

[FDA Ventilator Guidance](#)

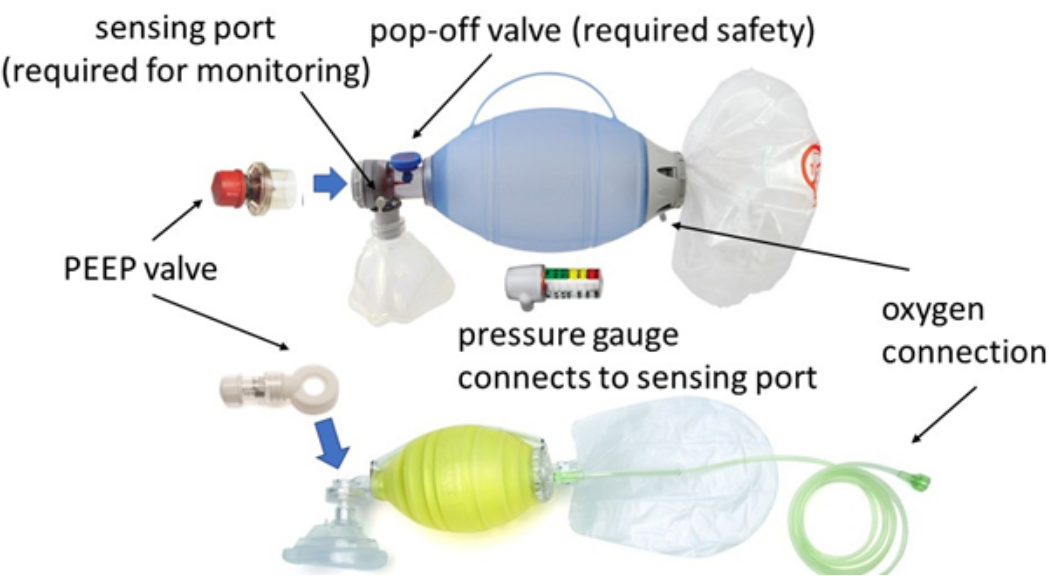
RECENT COMMENTS

- [Tippanna Shetgar](#) on [Mechanical](#)
- [Alan Lichtenstein](#) on [Plumbing](#)
- [Walter Goodidge](#) on [Mechanical](#)
- [Robert M. Ellsworth](#) on [Plumbing](#)
- [Jim DeLillo](#) on [Plumbing](#)

TERMS AND CONDITIONS

[Read the terms of use for this website](#)

Manual Resuscitator Bag Features



When a manual resuscitator is placed into an MIT E-Vent, or similar design, the system cannot be placed right up against the patient's head. In addition, patients need to be turned intermittently for routine care and patients can thrash and move in their beds. Even when patients are paralyzed, the paralytic may wear off at times and we must consider how to keep the patient safe from inadvertent breathing circuit disconnection or extubation. Therefore, a safe method to extend the "reach" and flexibility of the manual resuscitator to a patient lying on a hospital bed is needed. If a simple tube is used to do so, it creates a critical safety concern of "dead space."

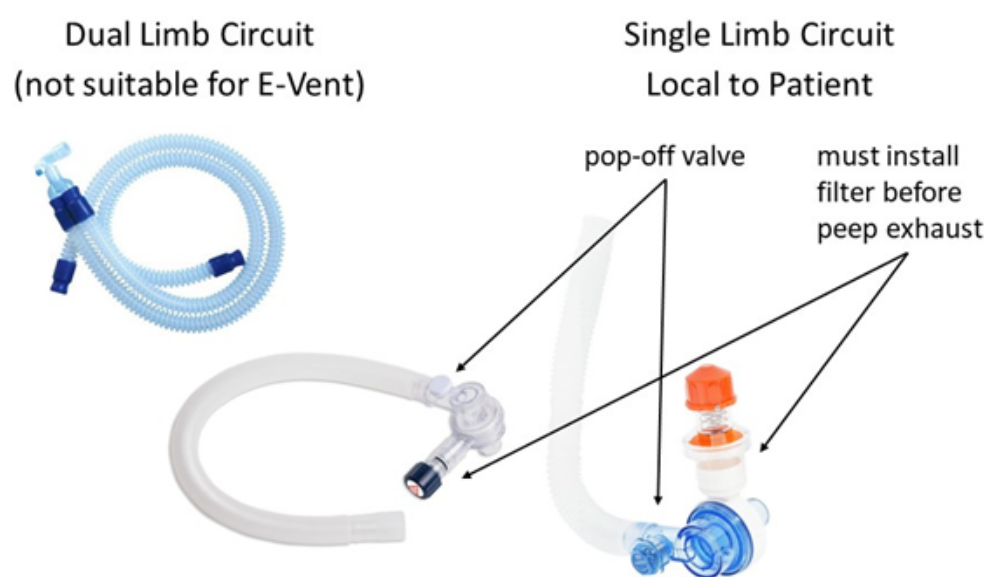
Note: In a 1 m long tube of nominal 2 cm diameter, there is an unacceptable 314 mL dead space that the patient will breath in and out and not be oxygenated.

Dead space simply means volume in the respiratory circuit that does not participate in gas exchange in the lungs. Our natural anatomy has dead space as well. Considering gas exchange occurs at the alveoli in our lungs, every anatomical structure above it can be considered "dead space": nasal/oral passages, pharynx, larynx, trachea, and primary/secondary/tertiary bronchi. Extending the tubing through which bidirectional flow of inhaled / exhaled gas mixture occurs only increases dead space and the patient, see [Wikipedia](#).

A way to move the patient valve of the manual resuscitator closer to the patient is critical in solving this issue. Standard ventilator circuits have two limbs, one for inspiration and one for expiration, so that gases can be recaptured by the ventilator. Single limb ventilator circuits with a patient valve located distally already exist on the market, but are not necessarily optimized for use with a manual resuscitator.

Note: Solving this problem requires creativity – No manual resuscitator manufacturer makes an approved solution and no manufacturer makes all the parts that will assemble together correctly.

Sample Breathing Circuits



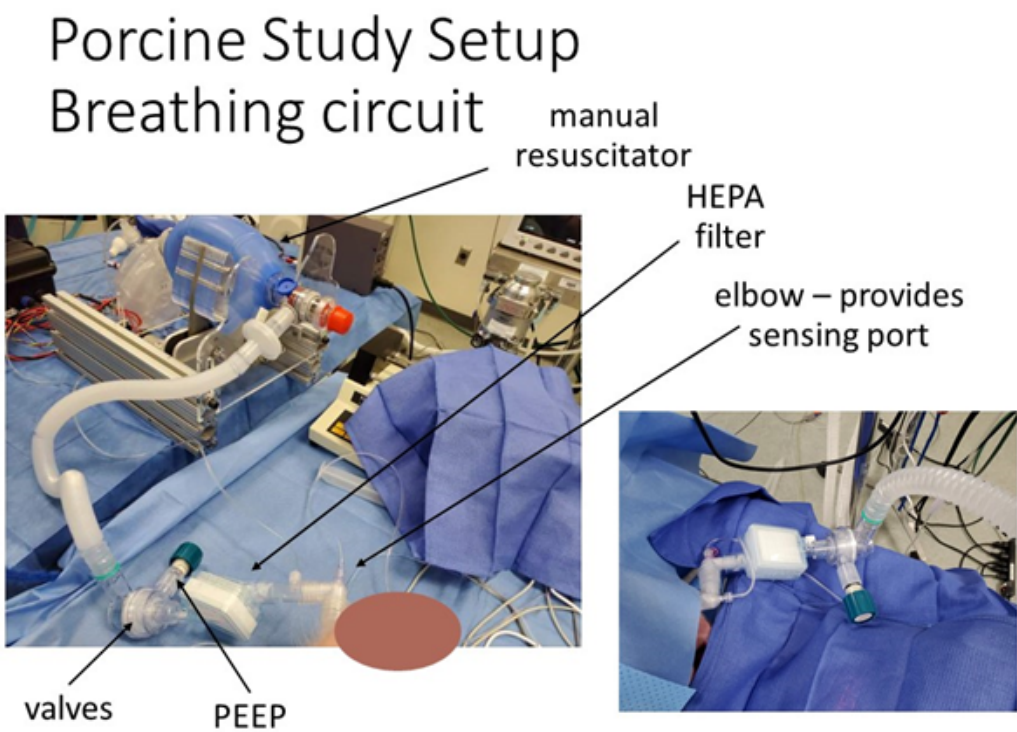
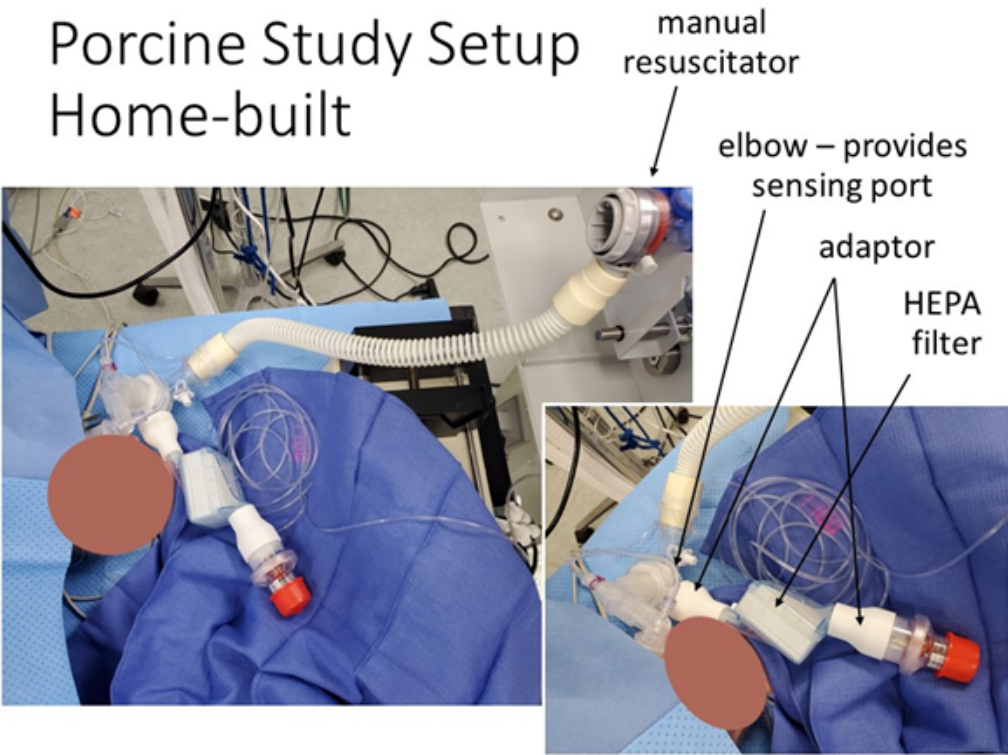
Industry Notes

In reviewing products available on the market, we have some notes:


- No bag makers supply extension hoses with the appropriate fittings.
- Bags designed for reuse, i.e. autoclavable, are the only bags that can potentially survive under repeated use. We do not have any information about lifespan.
- Ambu brand bags do not have detachable heads, but they do incorporate pop-off and easily attached PEEP valves in their designs. They can only be used if extended with a separate head and extension tube.
- Laerdal bags do have detachable heads, however in the adult sizes these heads do NOT come with pop-off valves; these are available in the Pediatric model. The pediatric model head will probably fit the adult bag.
- When a long tube is used, without a dual limb circuit and one way valving to address the dead space issue, this may affect the volume delivered to the patient; it may be necessary to increase the inspired volume.
- Addition of the HEPA filter will cause a pressure drop and may affect PEEP settings.
- Tightness of all connections is important.

Caution: In the worst-case scenario, placing the head as close as possible to the patient will reduce the dead space, but it is not an optimal or safe solution, especially for patients with reduced inspiratory volume.

Two version of single limb circuits are shown below. The first made use of readily available components and two printed adaptors to make them fit together, with the HEPA filter placed between the exhalation port and the PEEP. The second used a single limb breathing circuit, with most of the necessary features integrated, and a HEPA filter added inline between the porcine and the breathing circuit. This is a better position as it filters air heading both in and out of the patient, including any air that escapes from the pop-off valve. It may also help to moisten air inbound to the patient.



19 Replies to “Plumbing”



Yueh Lee

2 April 2020 at 01:12

Reply

Bingo – thanks for posting this, it is absolutely critical and unfortunately not recognized by most teams who are getting into this for the first time.



Anuruddha Tennakoon

2 April 2020 at 02:22

Reply

HME Filter?