ARDS patients during a pandemic. They often do not provide PEEP, have no spontaneous assist mode and are not approved for critical care use. Inefficient use of compressed air and electricity also make them ill-suited for low-resource environments and developing nations.

[0006] Low-cost resuscitators are currently available for under two hundred dollars ($200). These devices are designed as a last resort in acute situations and require constant direct supervision. They are generally not used to support an ARDS patient for any clinically relevant length of time.

[0007] When considered on a global scale, the disparity in pandemic resources between wealthy and impoverished nations is alarming. With the majority of the world's vaccine supply already purchased by wealthy nations, coverage in developing nations may be inadequate. Many countries already face an extreme shortage of ventilators, even in the absence of a pandemic. For example, in the United States, there are approximately 205,000 ventilators for a population of 300 million. In India, where the population exceeds 1.1 billion, there are only 35,000 intensive care ventilators available. What is needed to address this disparity is an extremely low-cost ventilator, specifically tailored to meet the needs of acute respiratory distress patients in low-resource, rural and emergency environments.

SUMMARY OF THE INVENTION

[0008] The present invention is directed generally to ventilators and systems and methods of ventilation for humans and other animals. For example, the ventilators described herein may be built with minimal resources, e.g., allowing for inexpensive mass production.

[0009] In accordance with an exemplary embodiment, a ventilation system / ventilator is provided that includes a source of pressurized gas; a patient / storage vessel; a first pressure sensor coupled to the patient vessel for detecting the pressure of ventilation gas within the patient vessel; and a valve assembly, e.g., including one or more valves, communicating with the gas source via a source line, the patient vessel, and an inhalation line for delivering ventilation gas to a patient. A controller may be coupled to the valve assembly for selectively directing the valve assembly between a storage configuration where ventilation gas is delivered from the gas source into the storage vessel, and a delivery configuration where ventilation gas is delivered from the storage vessel to a patient via the inhalation line. The controller may also be coupled to the first pressure sensor for detecting a first pressure within the storage vessel when the valve assembly is directed to the delivery configuration, and detecting subsequent pressure thereafter while ventilation gas is delivered from the storage vessel to

the patient via the inhalation line, the controller determining the volume of ventilation gas delivered to the patient based at least in part on the difference between the first pressure and the subsequent pressure. The gas source may comprise: a compressor; and a pre-fill vessel, wherein the one or more valves are coupled to the compressor and the pre-fill vessel such that, in the delivery configuration, the compressor communicates with the pre-fill vessel for delivering pressurized gas into the pre-fill vessel, and wherein, in the storage configuration, the storage vessel communicates with the compressor and the pre-fill vessel for receiving pressurized gas from both the compressor and the pre-fill vessel.

[0010] In accordance with another embodiment, a ventilator is provided that includes a source of pressurized gas; a pre-fill vessel; a patient vessel; a valve assembly (including one or more valves) communicating with the gas source via a source line, the pre-fill and patient vessels, and an inhalation line for delivering ventilation gas to a patient; and a controller coupled to the valve assembly for selectively directing the valve assembly between a delivery configuration where ventilation gas is delivered from the patient vessel to a patient via the inhalation line and pressurized gas is delivered from the gas source to the pre-fill vessel, and a storage configuration where pressurized gas is delivered from the gas source and the pre-fill vessel into the storage vessel to store pressurized gas in the storage vessel.

[0011] In accordance with yet another embodiment, a method for ventilating a patient is provided that includes placing the patient's airway in fluid communication with an inhalation line of a ventilator, the ventilator including a storage vessel therein and a source of pressurized gas. Ventilation gas is delivered from the gas source into the storage vessel during a storage phase, and ventilation gas is delivered from the storage vessel to the patient via the inhalation line during a delivery phase. During the delivery phase, the change in pressure in the storage vessel may be measured, e.g., to determine a volume of pressurized gas being delivered to the patient from the storage vessel. The ventilator may be operated based at least in part on the change in pressure in the storage vessel independent of the duration of the inhalation phase and/or based at least in part on the change in pressure in the storage vessel without measuring a flow rate of ventilation gas delivered to the patient.

[0012] In accordance with still another embodiment, a method for ventilating a patient is provided that includes performing the following steps one or more times sequentially: a) delivering ventilation gas from a storage vessel within a ventilator to the patient via an inhalation line with the storage vessel isolated from a gas source of the ventilator; b)

measuring the change in pressure in the storage vessel while ventilation gas is delivered to the patient from the storage vessel; c) determining the volume of ventilation gas delivered to the patient based at least in part on the change in pressure; d) discontinuing delivery of ventilation gas from the storage vessel to the patient; and e) delivering ventilation gas from the gas source into the storage vessel to refill the storage vessel with pressurized gas.