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Affordable Ventilator: Design and Fabrication For COVID-19

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ABSTRACT: Human lungs use reverse pressure generated by the contraction of diaphragm to suck air from atmosphere for breathing. A similar mechanism is used by a ventilator to inflate the lungs by using a pump. The ventilator designed here can deliver in the range of 10 – 30 breaths per minute. It can also monitor the patient's blood oxygen level. This ventilator is affordable and can help in the time of pandemic.

KEYWORDS: Oximeter, Lung Pressure, Affordable Ventilator, Cost Effective, COVID-19

I. INTRODUCTION

The WHO (World Health Organization) declared the coronavirus disease a global pandemic on March 11, 2020. Coronavirus disease (COVID-19), caused by a novel coronavirus (SARS-CoV-2), is dangerous because it threatens to overwhelm our medical infrastructure at the regional level, causing spikes in mortality rates. Within the medical infrastructure, there are critical technologies that are generally available, but simply do not exist in a high quantity to handle the excessive volume of patients associated with pandemics. Thus, people die unnecessarily throughout the world because of a combination of COVID-19 infections and the lack of access to some of these technologies. Ventilator is an example of such technology that is critical but has short supply during the pandemic. Mechanical ventilators are essential for treating both influenza and COVID-19 patients in severe acute respiratory failure. Past studies have shown that intensive care units (ICUs) will not have sufficient resources to treat all patients requiring ventilator support during a massive pandemic, and ethically challenging triage would need to be used to decrease mortality over first-come first-served basis for ventilator allocation among patients. Even then if they decide to buy the conventional ventilator the cost is high, it will be affected by the person who got infected. So, to overcome this situation an affordable ventilator will solve the problem. A mechanical ventilator with affordable cost should match the outcome of the normal ventilator as this will create the solution to the problem. It should have the control option to specify the pumping of the oxygen into the lungs as required for the patient's needs. The breath length and the breath per minute must be controlled regarding the patient.

II. RELATED WORK

The present ventilators are expensive and too complex for anyone to operate or repair. So, a mechanical ventilator at an affordable cost should match the standard of the normal ventilator, and it should have the control options to specify the pumping of the oxygen into the lungs as required for the patient's needs. To treat the person affected by the coronavirus the ventilator must have some basic factors like Breath per minute, Breath length, Blood oxygen sensing, lung pressure sensing. These factors are monitored constantly by the patient to provide a better oxygen supply using a ventilator. The ventilator should have less manual control as it will be easy to operate by a normal person. It should be compact in size as it can be used and carried anywhere for emergency purposes.

Required Parameters

As this is the life support system it is mandatory to pump the oxygen according to the patient health condition by taking the consideration of 4 most important parameters to be monitored and controlled to pump the required amount of oxygen to the patient.

- Pressure sensing
- Blood oxygen monitor
- Breath per minute

- Breath length

Pressure Sensing:

Human lungs are reverse pressure generated by the contraction motion of the diaphragm to suck in air for breathing. A contradictory motion is used by a ventilator to inflate the lungs by pumping type motion. As the human lungs are having a conditional diaphragm it is mandatory to check the volume of the air pumped and the pressure of the air to assure the safety of the oxygen supply to the lungs. It is the most important parameter to be considered for the pumping of the air using a mechanical ventilator.

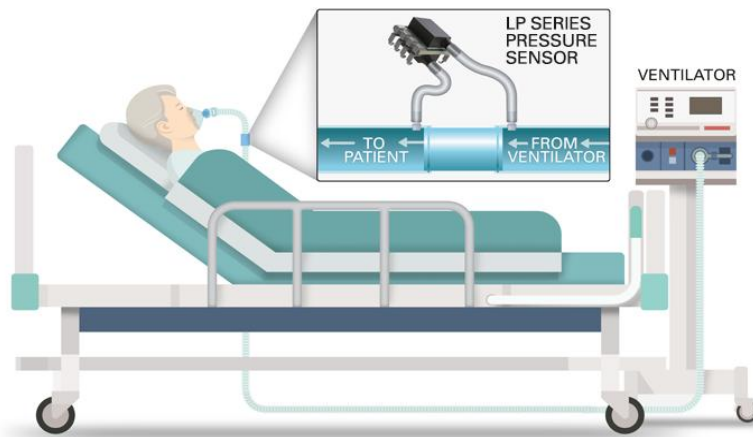


Fig.1: Pressure sensing

Blood Oxygen Monitor:

Blood needs a specific amount of oxygen for the circulation all over the body to maintain the standard of purifying the blood and to pump the required percent of oxygen as needed to the patient health condition .so the composition of O2 in the blood must be constantly watched for the patient to provide appeal amount of oxygen, mechanical ventilation must have the blood oxygen sensing to provide better ventilation using a ventilator.

| SPO2 LEVEL | INDICATION | HEALTH CARE INTERVENTION |
|-------------------------------|---------------------------|--|
| Normal in healthy individuals | More than or equal to 95% | No significant intervention needed. |
| Normal in people with COPD | 88% to 92% | Continue with respiratory assessment and monitoring. |
| Hypoxic | 85% to 94% | Assess for underlying respiratory diseases and initiate oxygen therapy, especially in COPD patients. |
| Severely Hypoxic | Less than 85% | Administer supplemental oxygen immediately. |

Fig.2: Spo2 Level Indication

Breath length:

One cycle of the ventilation using the ventilator is known as breath length, as the breath length is also depending on the health condition of the patient and his age because the composition of the age and health status of the patient will judge the breath length. In difficult situations like accidents and any other serious condition of the patient, the breath length varies.

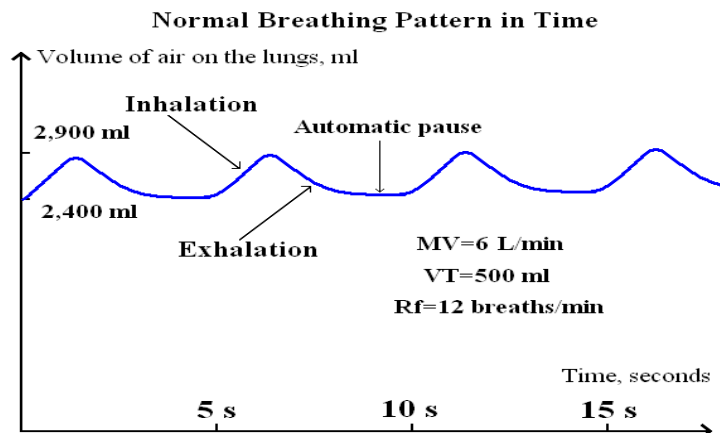


Fig. 3: Breathing Pattern

Breath per minute

The breath taken by the individual in one minute is referred to as breath per minute as the ordinary breath per minute of the adult is 12 - 20 bpm this will rely upon the state of the patient wellbeing and status of recovery. Generally, the specialist will choose the BPM of the ventilator as per the patient condition and recuperation status. yet in this project, the manual choice is utilized where the breath per minute value will be given by the age of the individual. so, it is a prime aspect to be considered and must be eventually monitored during the medication as the breath has to change in accordance with the state of the patient. In strange circumstances of the patient, respiratory issues like asthma, utilization of narcotics, and other lung infections

Condition for rapid breathing

The normal respiratory rate changes with age which is given below for specific age:

- Newborn 30-40 breaths per mins
- Less than 1 year: 30-40 breaths per mins
- 1-3 years: 23-35 breaths per mins
- 3-6 years: 20-30 breaths per mins
- 6-12 years 18-26 breaths per mins
- 12-17 years: 12-20 breaths per mins
- Adults over 18: 12-20 breaths per mins

III. WORKING

The ventilator designed here work on modes like programmed and manual, as it tends to be controlled physically as per the directions given by the specialist/doctor, by varying the BPM and BL or it very well may be utilized in programmed mode (Using ventilation algorithm) which does not need any support from the specialist, by observing the blood oxygen concentration and the pressing factor detecting of the patients breathing circumstance.

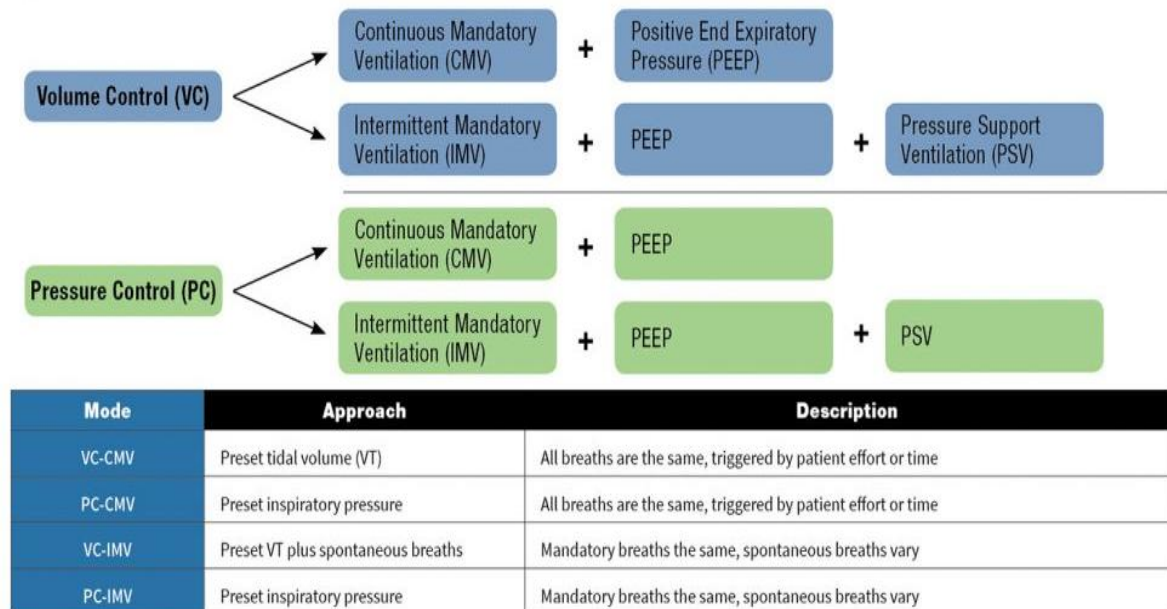


Fig. 4: Modes of Ventilation

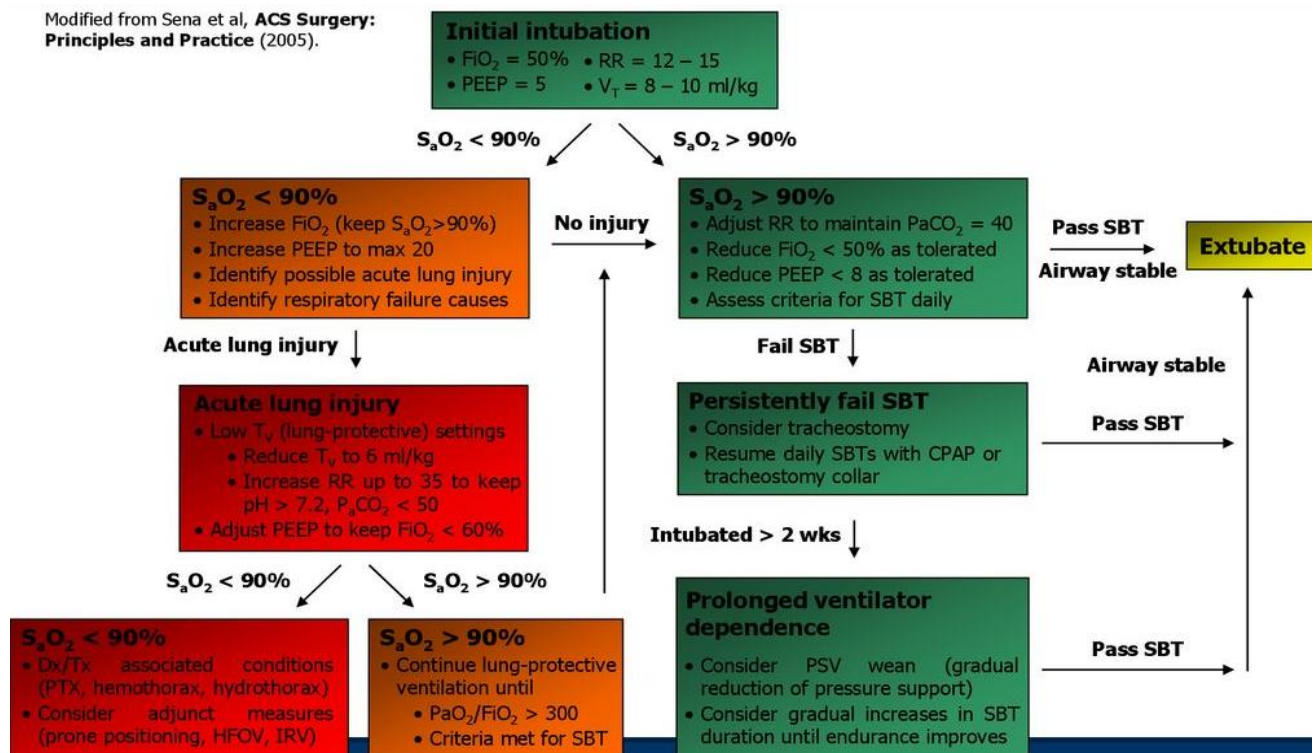


Fig. 5: Ventilation Algorithm

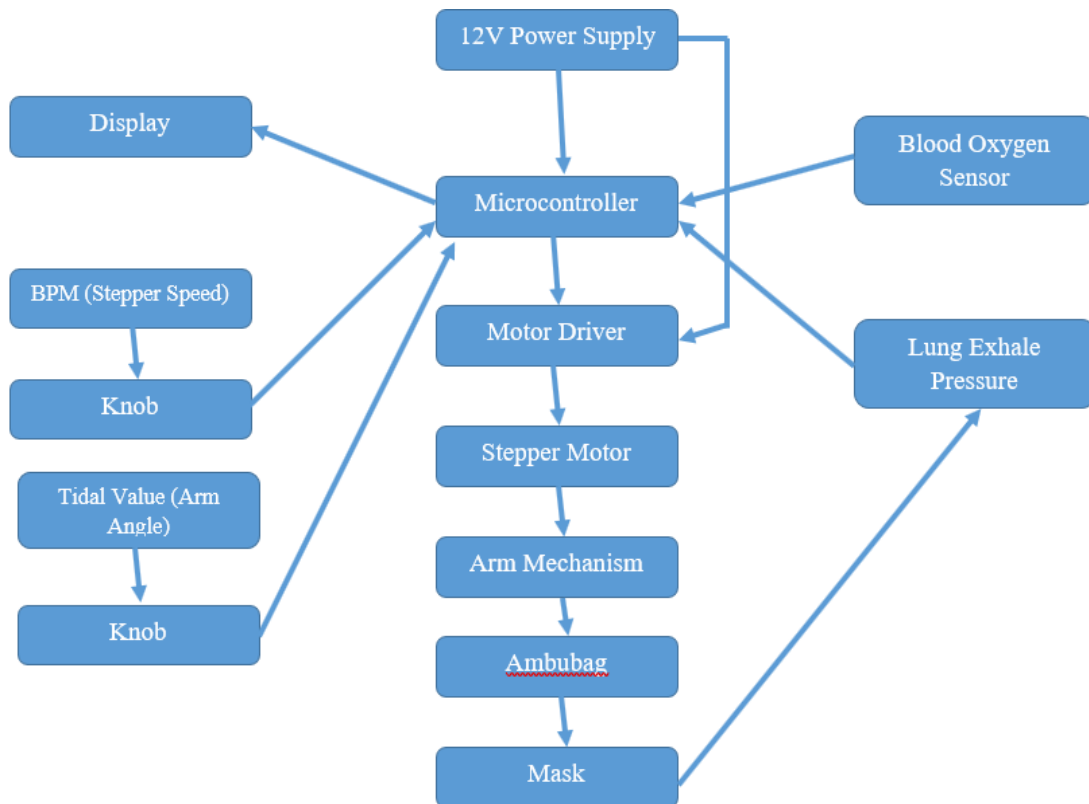


Fig. 6: Flowchart of the system

IV. DESIGNING

The mechanical ventilator is designed in three dimensions to visualize the manufacturing outcome and the final design of the model prior to manufacturing the ventilator, as this helps in a change in the measurement as well as material composition as well. The most essential part is not replaced but arranged in an organized manner which will help in making the compact model of the mechanical ventilator.

The essential parts like:

Arm Mechanism: Instead of the normal conventional mechanism, this arm mechanism will provide an accurate and efficient outcome. In this design, the arms are created using the 3D printing as the design is more adequate and simpler to use for manufacturing. This mechanism is controlled by the measure of the breath per minute, the breath length, and the amount of oxygen that has been supplied during the medication.



Fig. 7: Arm Mechanism

Side Plates: These side plates help in holding the resuscitator bag for the compression mechanism. In these plates, there are grooves to reduce the tension when the compression mechanism is working.

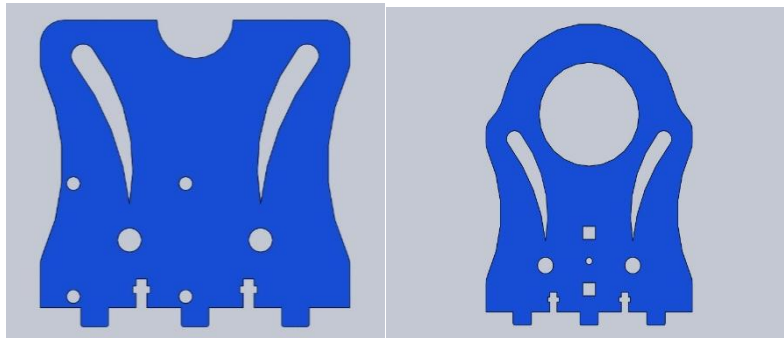


Fig.8: Side Plates

Casing: Fibre plastic casing is used, as this is a medical equipment it should not expose to the outer exposure. The casing is transparent which helps in detecting the error or any anomaly in the system easily.

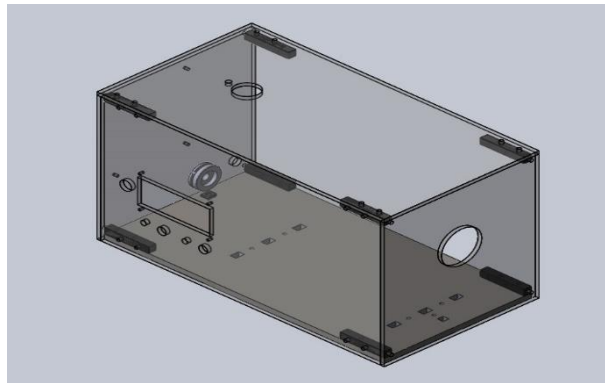


Fig. 9: Casing

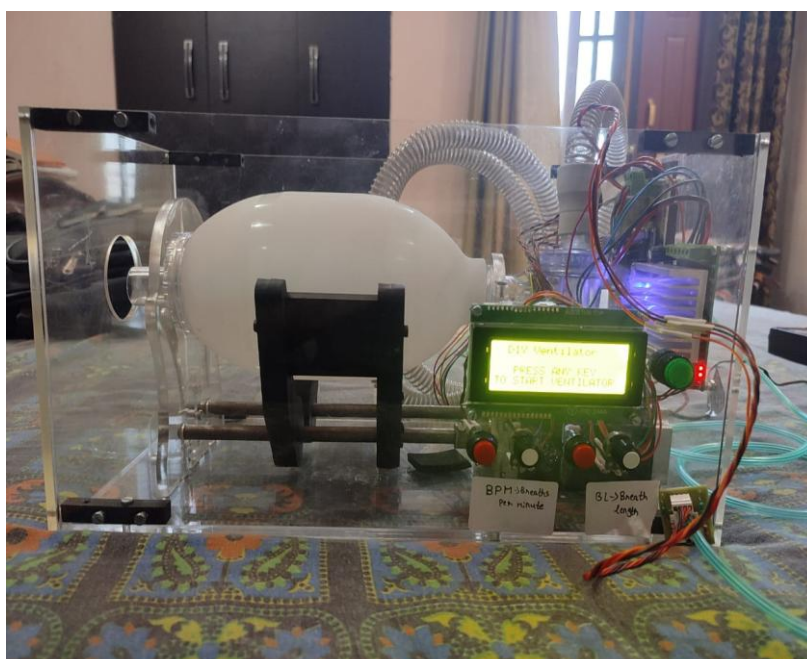


Fig.10: Completed Model

V. BENEFITS

There are numerous amounts of benefits to this ventilator. Some of which I am going to list below:

Cost-Effective: The cost of a ventilator as compared to others is very cost-effective as it uses very cheap and generic components other than using complex and costly parts. The entire setup is made using good quality plastic and the enclosure is made of glass. Both are widely available in the market. The manufactured parts are also selected keeping in mind that they should be easily and widely available and they are cheap in price.

Ease of Manufacturing: The availability of all the parts specified for this cheap ventilator makes it easy to assemble or manufacture without the need for any expensive or complex manufacturing machine or skilled technician.

Low Complexity: The main idea of this ventilator was to solve the problems of the number of ventilators in the time of covid pandemic as they were millions of diagnoses, but only a few could avail ventilators due to two main reasons, they were not available and if available they were very expensive and could not be afforded by the public. And as it was very complex and expensive, it could not be manufactured in huge numbers that were needed during the covid pandemic. The main aim was to make it very simple to easily manufacture and replicated and without the need for complex manufacturing machines or very skilled technicians.

Open-Source Design: All the parts used and whether obtained from online platforms or parts specially manufactured for this project are clearly specified along with the project. This project will remain open source so that the design can be utilized by anyone interested in modifying or adding value to this project. This will enable many people to utilize and carry on what was started with this project.

Blood Oxygen Sensor: A blood oxygen sensor or pulse oximeter was found to be extremely helpful and accurate in diagnosing the COVID 19 virus and other lung diseases. So, the blood oxygen sensor used in this ventilator can easily detect the coronavirus and confirm it. It can also tell the patient if the levels have started to drop or can be used as an indicator of recovery if the reading comes back to normal. Blood oxygen is measured in percentage where 100 is the max value, normal value ranges from 94 to 100 in normal age, if it is much below than 94 or is in the 80s. These readings are alarming and proper aid and medicine should be given accordingly.

VI. LIMITATIONS

- The power needs to be provided continuously because of the great voltage necessity.
- This ventilator is restricted to one individual.
- Blood oximeter has a little delay in the detection of Spo2 level of blood.
- The pipe connecting the pressing factor sensor and the mask must be consistently kept up clean to maintain the standard of pressure sensing factor detecting.

VII. COMPARISON WITH PRESENT TECHNOLOGY

Conventional ventilators which are used in hospitals presently have some drawbacks, such as high maintenance, complex to operate, expensive which was focused to remove these aspects in the present design of the mechanical ventilator.

- This ventilator is in Affordable cost when compared to the normal conventional ventilator, with the cost of the conventional ventilator around 50k to 60k,4 ventilators can be mad which helps to assist more at the same time.
- Convectional ventilators are complex to operate, so a ventilator with less complexity is designed by arranging the components in the specific portion and regular components available in the market.
- As the design is less complex it is easy to mass manufacturing when compared to the conventional ventilators
- As it has less manual control this ventilator can easily operate by normal person, which does not require any skill to use.
- Easy to use in emergencies as it is compact in size, it can be easy to carry anywhere.



VIII. CONCLUSION

This project is mostly inspired by the situations happened all over the world in the time of pandemic where the lack ventilators became the hectic situation in hospitals to treat affected people. So, the present work is an attempt to make an affordable Ventilator which will be useful in the emergency situations and easy to carry and durable Ventilator. This project can fulfil the requirement of the situations in emergency.

Aspect like—

- Less components
- Durability
- Affordable cost
- Minimum maintenance
- Compact in size.

This ventilator is more than capable of performing the basic operation and can be used as the complete kit in case of any lung disease or COVID 19 as it contains a blood oxygen sensor. The mission to design a simple, affordable and fully functional ventilator with commonly available material was achieved to a great extent.

REFERENCES

- [1] www.sciencedirect.com
- [2] Research on Physico Chemical Properties of Diethyl Ether Linseed Oil Blends for by Grski -2020
- [3] <https://www.cablesandsensors.com/pages/what-is-pulse-oximetry-the-definitive-guide-for-monitoring-oxygen-saturation-levels>
- [4] www.fgdc.gov
- [5] <https://slideplayer.com/slide/16406997/>
- [6] microbiology notes .com
- [7] digitalcommons.library.tmc.edu
- [8] healthy. Kaiserpermanente.org
- [9] <https://meritsensor.com/pressure-measurement-for-ventilators-and-respirators>
- [10] Kohbodi GNA, Rajasurya V, Noor A. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): Aug 11, 2020. Ventilator-associated Pneumonia. [PubMed]
- [11] Branson RD. Automation of Mechanical Ventilation. Crit Care Clin. 2018 Jul;34(3):383-394. [PubMed]
- [12] O'Gara B, Talmor D. Perioperative lung protective ventilation. BMJ. 2018 Sep 10;362:k3030. [PMC free article] [PubMed]
- [13] Luo J, Wang MY, Liang BM, Yu H, Jiang FM, Wang T, Shi CL, Li PJ, Liu D, Wu XL, Liang ZA. Initial synchronized intermittent mandatory ventilation versus assist/control ventilation in treatment of moderate acute respiratory distress syndrome: a prospective randomized controlled trial. J Thorac Dis. 2015 Dec;7(12):2262-73. [PMC free article] [PubMed]



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