ENVIRONMENT PROTECTION, CHEMICAL AND BIOTECHNOLOGY

UDC 616-073.75(045)
DOI: 10.18372/2306-1472.81.14601

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SYSTEM OF ARTIFICIAL VENTILATION OF LUNGS FOR USE IN EXTREMAL CONDITIONS "MOLFARKA-CORONA NAU"

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Abstract

The possibility of rapid adjustment of mass production of systems for lungs artificial ventilation of the type "Molfarka-Corona" is shown, which possesses minimal sufficient functional capabilities for using in patients with COVID-19 and gives a chance to survive in the most difficult situation of the pandemic.

Keywords: lungs artificial ventilation; ventilator; design; mass production

1. Formulation of the problem

Modern systems of lungs artificial ventilation (LAV) are complex computerized complexes that meet the most demanding medical requirements for providing patients with the least risk of consequences [1]. However, the availability of such systems in specialized medical centers in countries, even with advanced health care systems, is limited by their very high cost and the inability to quickly establish their mass production in epidemics and pandemics. Countries with disrupted or underdeveloped health care systems have a particular problem when, under normal conditions, the number of ventilator systems they have is limited. In the current conditions of the spread of COVID-19, such problems with provision of artificial ventilation systems are clearly demonstrated also by developed countries such as Italy and Spain, where the number of LAV systems during the epidemic is simply not enough for patients, that causes fatal cases. One of the solutions to the problem of the inability to provide fast all the patients with modern automated and computerized mechanical ventilation systems is the rapid and large-scale production of simple mechanical ventilation systems, which will give them a chance to save their lives despite some possible consequences.

2. Analysis of research and publications

Artificial lung ventilation systems with completely no automation and equipped with a manual drive were used during World War I to aid chlorine or yperite poisoning. The modification of such systems for 1950s was intended for the military in the case of radiation damage to the lungs and patients with polio and was called "Ambu bag". But in its standard form, the Ambu bag is not intended for a long-term work. For this reason the system of lungs artificial ventilation "Molfarka-Corona" was developed for long-term work and providing the possibility of rapid adjustment of its mass production at factories even previously unsuitable for medical equipment manufacturing.

The purpose of manufacture of the "Molfarka-Corona" ventilation system is to show the possibility of rapid mass production of a ventilator possessing minimal sufficient functional properties, which will give a chance to patients with COVID-19 in the most difficult situation of the pandemic.

3. Article text

Systems of lungs artificial ventilation of the series "Molfarka-Corona" (Fig. 1) are specially designed to supply and remove decontaminated by biologically-active composites air under a given pressure and of a required volume in the lungs of a patient with coronavirus disease, and are designed for rapid deployment of mass production at non-specialized factories. The systems are not certified and are a "last chance" system for use in critical extremal pandemic conditions.

a) «Molfarka-Corona NAU -159-A»

b) «Molfarka-Corona NAU -159- BISS»

Fig. 1. Systems of artificial ventilation of the lungs of the series "Molfarka-Corona"

«Molfarka-Corona» artificial ventilation systems are “last-chance” systems for use in critical extremal conditions in the absence or lack of complex scarce stationary LAV systems. The developed modification of the ventilation system is not automated, it must be actuated manually. The lack of automation allows to reduce the time of its manufacture.

Fig. 2. shows the system of artificial ventilation of the lungs "Molfarka-Corona NAU-159-A". A pump with a handle may be seen in the foreground. In tubes an ionizer or oxygen generator is allocated. Only mechanical and hydraulic basic controls are used and placed in the demonstrated in the figure white elongated casing. In fact, the device is a modified Ambu bag, elaborated for a long term operation, and which includes an ozone or oxygen generator. The system has the ability to be equipped with foot pumps and bellows. Electric pumps are at first glance better, but require additional valves and are unreliable, susceptible to overheating. The device is intentionally made so simple as possible, so that mass production could be organized quickly at factories or sites with easiest equipment.

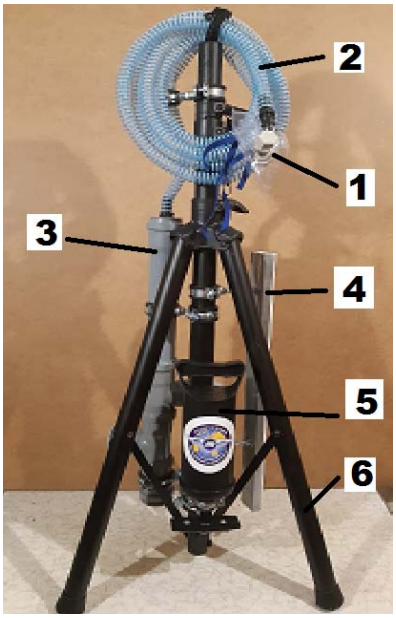

Fig. 2. The system of lungs artificial ventilation "Molfarka-Corona NAU-159-A" and main components of the device: 1 - mask (preferably with a valve); 2 - supply hose; 3 - oxygen generator or concentrator (in the first models can be simplified and replaced by a filter); 4 - minimal safety and control system; 5 - the pump; 6 - the form factor stand.

Mask 1 of the system of artificial ventilation of the lungs "Molfarka-Corona" is shown in Fig. 3. It may be produced of silicone, rubber or plastic. Gray hexagons are the inhalation safety valves. In the black transition coupling to the hose there is an expiratory blocking valve so that the exhaled air does not enter the inlet hose. The problem of artificial ventilation of the lungs with the use of masks is the removal of the inhalation pressure of the mask from the patient's face, which causes large leaks. This requires holding the mask on the face of

the patient with the hands of the operator, since no mounting systems are actually effective, however, it confirms the concept of manual control of the mechanical ventilation system by the operator who is still involved.

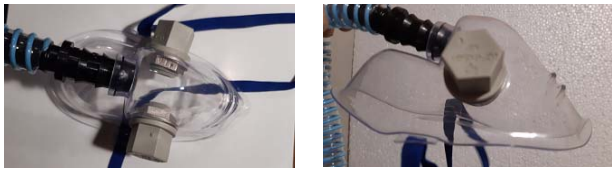

Fig. 3. Mask of the lungs artificial ventilation system "Molfarka-Corona"

Exhalation blocking valve, which serves for that exhaled air does not enter the supply hose 2, and the supply hose 2 of a diameter of 18-20 mm, are shown in Fig.4. The exhalation blocking valve is located inside the black adapter sleeve and is of a ball design. The supply hose should be soft and flexible, but not to be susceptible of being compressed or crushed. Flexible spiral reinforcement (blue strip) prevents the supply hose from contracting and breaking. For the aim of avoiding failure of the supply hose under tension, it is additionally connected to the stand with a clamp of double collar.

Fig. 4. Exhalation blocking valve and supply hose

The generator or oxygen concentrator 3 (on the first models it can be maximally simplified or replaced by a filter) is located in a gray tube and is connected to the mask and pump inlet hose using fittings, as it is shown in Fig. 5. On the tube there is an additional fitting valve (resembling and structurally similar to the nipple of an automobile wheel chamber), which is designed to connect to an oxygen cylinder or an oxygen line of the hospital room, and the outlet of the safety valve tube, if installed on this model. The unit is fastened to the form factor stand with two clips of double collars.

According to the authors, the presence of an autonomous generator or oxygen concentrator in the LAV system design is desirable, since they predict a shortage under the conditions of epidemics and pandemics of medical oxygen in cylinders and an absence of centralized oxygen supply systems in non-stationary mobile hospitals.

Fig. 5. Design features of an oxygen generator or concentrator

The minimal safety and control system 4, which is located in a white elongated casing, elementary control devices are completely mechanical and hydraulic (may be absent in some models), is shown in Fig. 6. The casing is fastened to the form factor stand with two clamps of double collars.

Fig. 6. Safety and control system

A piston type hand pump 5 with a cylinder volume of 900 cm3 is shown in Fig. 7. A feature of the piston pump of this model is a movable cylinder with a fixed piston. The pump handle is located on the movable cylinder. The pump is attached to the form factor stand with two clamps of double collars. Changing the distance between the clamps is limited to a one-time portion of the air supplied to the lungs. On a rack there are marks of a dosage of air. Adjustment with a Phillips screwdriver defines loosening of the clamps of double collars. The valves of the pump are of the petal type and produced of a rubberized fabric.

Fig. 7. The piston pump of the LAV system of the «Molfarka-Corona NAU 159 A» type

The form factor stand 7 is made of thin-walled metal pipes. Form factor stand tripod is folding. Opening of the tripod of the form factor stand is regulated by the clutch. In the upper part there is an additional telescopic extension that is incrementally fixed with a pin on the ribbon. At the ends of the pipes, tripods are equipped with plastic (or rubber) anti-slip stub legs. The edge of the upper extension pipe is covered with a plastic plug. An example of the design of elements and assemblies may be seen in the photographs shown in Fig. 8. All elements are attached to the stand form factor by unified clamps of double collars. Such the design makes it possible to quickly change and reorganize individual structural elements during modifications without changing other elements of the system. The system is modular and thus adapted to further replacement of mechanical units with automated components.

Fig. 8. An example of design of components and units of the stand form factor

The lungs artificial ventilation system of the "Molfarka-Corona NAU 159 A" type was tested on volunteers and showed full functional performance and reliability.

The moral and ethical aspects of the medical use of the lungs artificial ventilation system of the type “Molfarka-Corona NAU 159 A” were not considered in this work.

4. Conclusions

The possibility of creating and rapid setting up of mass production of a fully functional artificial system of lungs ventilation of the type "Molfarka-Corona NAU", which possesses the minimal sufficient functional properties, was experimentally confirmed, that gives an additional chance to patients with COVID-19 in the most difficult situation of a pandemic.

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Система штучної вентиляції легенів для використання в екстремальних умовах «Мольфарка-Корона НАУ»

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Показана можливість швидкого налагодження масового виробництва систем штучної вентиляції легень типу «Мольфарка-Корона» з мінімально потрібними функціональними властивостями, що надасть шанс хворим на COVID-19 у найскладнішій ситуації пандемії.

Ключові слова: штучна вентиляція легенів; пристрій ШВЛ; конструкція; масове виробництво

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Система искусственной вентиляции легких для использования в экстремальных условиях «Мольфарка-Корона НАУ»

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Показана возможность быстрого налаживания массового производства систем искусственной вентиляции легких типа «Мольфарка-Корона» с минимально необходимыми функциональными свойствами, что позволит дать шанс больным COVID-19 в сложной ситуации пандемии.

Ключевые слова: искусственная вентиляция легких; прибор ИВЛ; конструкция; массовое производство

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