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Case Report
The Use of Passive and Invasive CO2 Elimination via interventional Lung Assist System iLA [Novalung®] on a Small Intensive Care Unit of a Hospital for Basic and Regular Care

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Abstract
Background: High volume intensive care units with high expertise on respiratory distress syndromes are familiar with extracorporeal CO2 elimination procedures in regard to their maintenance. In contrast, small intensive care units offer a lack of this experience. So, a novel approach (passive, invasive, without any further specification) plugs this lack of experience. Case Report: A 60 years old male patient in poor health conditions was presented to our small intensive care unit due to shortness of breath in regard to bilateral pneumonia in septic shock. Sedated and intubated, we monitored blood gas analyses and observed pCO2 problems, raising to 150mmHg with stable pO2 85mmHg. We used interventional arteriovenous lung assist system iLA (Novalung®, Heilbronn, Germany) and improved respiratory conditions by reduction of pCO2 to normal levels constantly for 10 days. Using iLA (Novalung®) on our small ICU we healed passively and invasive the patient for discharging on day 15. Conclusion: This case report clearly demonstrates the unspectacular use of the highly effectual passive and invasive CO2 elimination system iLA, Novalung® (Heilbronn, Germany) even on a small intensive care unit of a hospital for basic and regular care in Germany.

Keywords: CO2 retention, passive and invasive CO2 elimination, interventional Lung Assist system: iLA (Novalung®, Heilbronn, Germany), septic pneumonia

Introduction
Extracorporeal gas exchange by extracorporeal membrane oxygenation (AVCO2R) has been established clinically in patients with acute lung failure [1]. The interventional lung-assist (iLA) Membrane Ventilator device (Novalung®) is a sophisticated representative of a new generation of pumpless extracorporeal lung-assist devices that are driven by the patient’s cardiac output and therefore, do not require extracorporeal pump assistance. The system is characterized by a new membrane gas exchange system with optimized blood flow that is integrated in an arteriovenous bypass established by vascular cannulation. This particular pumpless extracorporeal lung-assist device was applied in 1800 patients for artificial lung assistance with easy use and low cost [2]. AVCO2R is commercially available through Novalung® (Heilbronn, Germany) and marketed as the interventional lung assist (iLA) membrane ventilator. The membrane lung, frequently called the ‘Novalung’, utilizes a low resistance design allowing blood flow using the patient’s own arteriovenous pressure gradient. Cannulas are placed percutaneously in the femoral artery and vein [1,3]. A similar system has been developed in the United States using the Affinity NT (Medtronic, Minneapolis, MN) [4]. Pumpless systems require an arteriovenous pressure gradient ≥60 mmHg, which is unsuitable for hemodynamically unstable patients [5]. Further, cannulation of a major artery can result in distal ischemia, although measuring the artery diameter with ultrasound and selecting a cannula that occupies no more than 70% of the lumen reduces this risk [1,3]. AVCO2R has been successfully used to facilitate LPV in patients with ARDS, severe asthma and as a bridge to lung transplantation [6-8]. High volume intensive care units with high expertise on respiratory distress syndromes are familiar with extracorporeal CO2 elimination procedures in regard to their maintenance [1-13]. In contrast, small intensive care units offer a lack of this experience [5]. So, a novel approach (passive, invasive, without any specification) plugs this lack of experience [1].

Case Report
A 60 years old male patient in poor health conditions (180cm length, 55kg weight) suffering severe septic bilateral pneumonia reported and confirmed on chest x-ray slides (Figure 1) was supported to the small intensive care unit (ICU: 4 beds – personally adjusted for breathing) of a hospital with in total 196 beds, distributed to the departments for internal medi-
medicine [cardiology, gastro-enterology and hematology/oncology], orthopedics, neurology, obstetrics-gynecology and anesthesiology and critical care medicine, neurology, orthopedics and trauma surgery, gynecology for basic and regular care in South Germany due to shortness of breath in the emergency room. As co-morbidities, we had to handle with schizophrenia, multiple sclerosis, epilepsy, chronic obstructive lung disease due to extreme consume of nicotine.

The patient got immediately intubated, ventilated and physiologically dependent to the respiratory breathing system (Evita, Infinity V500, Draeger®, Lübeck, Germany). Related to the ventilation, we were forced to decrease the observed CO2 retention and we monitored blood gas analyses with pCO2 rising to 150mmHg under all additive ventilatory support (bronchoscopy, kinetic mobilisation, lung-targeted use of antibiotics, lung-preventive ventilation support, respectively) with pO2 maximum stable to 85mmHg. On top, pH levels decreased to lowest 6.99. Additional, the septic shock was attacked using nor-epinephrine and hydrocortisone, preventive support was applied as well: pantoprazole or i.e. support of enteral nutritive factors up to 1.75 liter a day (correspondence to 1750kcal a day). The daily medications in reflection to his co-morbidities were applied as well orally.

We decided additionally to use a passive, invasive interventional Lung Assist system to eliminate CO2 (9): iLA (Novalung®, Heilbronn, Germany) [Figure 2] in regard to the lack of physicians in afternoon-/night worktime on the ICU board maintaining an active extra corporal lung assist, i.e. CARDIOHELP, Marquet® or LIFEBRIDGE 2.0, Zoll® (10). We assumed 15 French (15F) artery support to the iLA femoral left, set the iLA system (Novalung®) between his legs and re-insufflated the blood venously (15F) to the right femoral vein passively (Figure 2). Flow of oxygen was initially adapted to 10 liters per minute and nor-epinephrine was used to support blood flow to 1.2 liters per minute in the iLA system and to abolish the CO2 monitored through external device (Figure 3) with a “device related receptor” fixed on the venous blood flow system (Figure 4). The iLA Novalung® system was developed as passive as well as invasive artery-venous Shunt system for diffusion and displacement of CO2 to O2 in the patient own blood flow [11]. Therefore, the circulatory cardiac conditions have to be improved, monitored intensively and supported (nor-epinephrine). Inside of the iLA, the membrane ventilation occurs, and displaces CO2 to O2 in the blood flow maintained through the own patient’s circulation. In general, the use of these CO2 elimination systems were maintained on ICU’s with fast turnover and effective experiences.
branous filters of the iLA system (Figure 5 - upper diagram) – without any further medical support and without having physicians continuously monitored the iLA system throughout the afternoon-/ night worktime. Oxygen levels stayed stable throughout the whole use of the device (Figure 5 - lower diagram). Additionally, initial decreased pH levels to lowest 6.99 were maintained to increase to normal levels over the complete use of iLA on ICU and marked stable (see figure 6). The patient was sedated in a RASS-State -3-4 (Richmond Agitation and Sedation Scale) with Sevoflurane via the AnaConDa-S®-System.

On iLA-day 10 (in total day 12 on the ICU) we retracted successfully the system by primarily removing the venous tubing (15F) manually and secondly the arteriosus system (15F) using Femostop, St. Jude Medical® for at least 12h. Finally, we found unremarkable conditions on both groins and warm pulsed feed. Lastly, the patient recovered quick and got discharged from hospital on day 15 in total for rehabilitation in reflection to medical purposes.

**Summary and Conclusions**

This case report clearly demonstrates (i) the unspectacular use of the highly effectual passive and invasive CO2 elimination system iLA from Novalung® (Heilbronn, Germany) even on a small intensive care unit of a hospital for basic and regular care in Germany [12]. (ii) The effectual elimination of CO2 in patients suffering septic pneumonia will support faster recovery, will lower breathing mechanics [13] for the patients under specific intensive care unit conditions and ventilatory support even when no further problem for oxygenation occurs [10]. Therefore, (iii) pH levels and pCO2 levels were improved as fast as possible. Without specific vascular surgeons (iv) we handled and managed the device successfully. During afternoon and night-shift, (v) no additional physician was necessary to maintain the CO2 elimination system.
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Figure 6. pH measurements in blood gas analyses (BGA). Shown here are the various BGA’s of pH levels in relation to the use of the iLA system for 10 days. The use of the passive and invasive iLA system (Novalung®, Heilbronn, Germany) improved quickly the reduced pH levels from 6.99 to normal and kept these normal levels during the ICU stay as demonstrated in the shown diagram.

Conflicts of Interest: Nothing to Disclose

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