February 21, 2020

Fresenius Medical Care Renal Therapies Group, LLC
Denise Oppermann
Senior Director, Regulatory Affairs
920 Winter Street
Waltham, Massachusetts 02451

Re: K191407
Trade/Device Name: Novalung System
Regulation Number: 21 CFR 870.4100
Regulation Name: Extracorporeal circuit and accessories for long-term respiratory/cardiopulmonary failure
Regulatory Class: Class II
Product Code: QJZ
Dated: January 17, 2020
Received: January 21, 2020

Dear Denise Oppermann:

We have reviewed your Section 510(k) premarket notification of intent to market the device referenced above and have determined the device is substantially equivalent (for the indications for use stated in the enclosure) to legally marketed predicate devices marketed in interstate commerce prior to May 28, 1976, the enactment date of the Medical Device Amendments, or to devices that have been reclassified in accordance with the provisions of the Federal Food, Drug, and Cosmetic Act (Act) that do not require approval of a premarket approval application (PMA). You may, therefore, market the device, subject to the general controls provisions of the Act. Although this letter refers to your product as a device, please be aware that some cleared products may instead be combination products. The 510(k) Premarket Notification Database located at https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm identifies combination product submissions. The general controls provisions of the Act include requirements for annual registration, listing of devices, good manufacturing practice, labeling, and prohibitions against misbranding and adulteration. Please note: CDRH does not evaluate information related to contract liability warranties. We remind you, however, that device labeling must be truthful and not misleading.

If your device is classified (see above) into either class II (Special Controls) or class III (PMA), it may be subject to additional controls. Existing major regulations affecting your device can be found in the Code of Federal Regulations, Title 21, Parts 800 to 898. In addition, FDA may publish further announcements concerning your device in the Federal Register.

Please be advised that FDA's issuance of a substantial equivalence determination does not mean that FDA has made a determination that your device complies with other requirements of the Act or any Federal statutes and regulations administered by other Federal agencies. You must comply with all the Act's

requirements, including, but not limited to: registration and listing (21 CFR Part 807); labeling (21 CFR Part 801); medical device reporting (reporting of medical device-related adverse events) (21 CFR 803) for devices or postmarketing safety reporting (21 CFR 4, Subpart B) for combination products (see https://www.fda.gov/combination-products/guidance-regulatory-information/postmarketing-safety-reporting-combination-products); good manufacturing practice requirements as set forth in the quality systems (QS) regulation (21 CFR Part 820) for devices or current good manufacturing practices (21 CFR 4, Subpart A) for combination products; and, if applicable, the electronic product radiation control provisions (Sections 531-542 of the Act); 21 CFR 1000-1050.

Also, please note the regulation entitled, "Misbranding by reference to premarket notification" (21 CFR Part 807.97). For questions regarding the reporting of adverse events under the MDR regulation (21 CFR Part 803), please go to https://www.fda.gov/medical-devices/medical-device-safety/medical-device-reporting-mdr-how-report-medical-device-problems.

For comprehensive regulatory information about medical devices and radiation-emitting products, including information about labeling regulations, please see Device Advice (https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance) and CDRH Learn (https://www.fda.gov/training-and-continuing-education/cdrh-learn). Additionally, you may contact the Division of Industry and Consumer Education (DICE) to ask a question about a specific regulatory topic. See the DICE website (https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance/contact-us-division-industry-and-consumer-education-dice) for more information or contact DICE by email (DICE@fda.hhs.gov) or phone (1-800-638-2041 or 301-796-7100).

Sincerely,

Fernando Aguel
Assistant Director
Division of Circulatory Support,
Structural and Vascular Devices
Office of Cardiovascular Devices
Office of Product Evaluation and Quality
Center for Devices and Radiological Health

Enclosure

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Food and Drug Administration

Indications for Use

Form Approved: OMB No. 0910-0120
Expiration Date: 06/30/2020
See PRA Statement below.

510(k) Number *(if known)*
K191407

Device Name
Novalung System

Indications for Use *(Describe)*
The Novalung System is indicated for long-term (> 6 hours) respiratory/cardiopulmonary support that provides assisted extracorporeal circulation and physiologic gas exchange (oxygenation and CO2 removal) of the patient's blood in adults with acute respiratory failure or acute cardiopulmonary failure, where other available treatment options have failed, and continued clinical deterioration is expected or the risk of death is imminent. These may include:

- Failure to wean from cardiopulmonary bypass following cardiac surgery in adult patients
- ECMO-assisted cardiopulmonary resuscitation in adults

Type of Use *(Select one or both, as applicable)*

☒ Prescription Use (Part 21 CFR 801 Subpart D) ☐ Over-The-Counter Use (21 CFR 801 Subpart C)

CONTINUE ON A SEPARATE PAGE IF NEEDED.

This section applies only to requirements of the Paperwork Reduction Act of 1995.

DO NOT SEND YOUR COMPLETED FORM TO THE PRA STAFF EMAIL ADDRESS BELOW.

The burden time for this collection of information is estimated to average 79 hours per response, including the time to review instructions, search existing data sources, gather and maintain the data needed and complete and review the collection of information. Send comments regarding this burden estimate or any other aspect of this information collection, including suggestions for reducing this burden, to:

Department of Health and Human Services
Food and Drug Administration
Office of Chief Information Officer
Paperwork Reduction Act (PRA) Staff
PRAStaff@fda.hhs.gov

"An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB number."

5. 510(K) SUMMARY

This 510(k) Summary is in accordance with the requirements of the Safe Medical Device Act (SMDA) of 1990. The content of this 510(k) summary is provided in conformance with 21 CFR § 807.92.

5.1. Submitter's Information

Name:	Fresenius Medical Care Renal Therapies Group, LLC
Address:	920 Winter Street Waltham, MA 02451-1457
Phone:	(781) 996-9103
Fax:	(781) 699-9635
Contact Person:	Denise Oppermann, Senior Director Regulatory Affairs – Devices
Preparation Date:	23 May 2019

5.2. Device Name

Trade Name:	Novalung System
Common Name:	Oxygenator, Blood Pump, Tubing, Extracorporeal Circuit Accessories, Console, Console Accessories, Long Term Support Greater Than 6 Hours
Regulation Name :	Extracorporeal circuit and accessories for long-term respiratory/cardiopulmonary failure
Regulatory Class:	Class II (special controls) per 21 CFR § 870.4100
Product Code:	QJZ
Classification Panel:	Cardiovascular

5.3. Legally Marketed Predicate Device

FDA's final order for Extracorporeal Circuit and Accessories for Long-Term Respiratory/Cardiopulmonary Failure (81 FR 7451, February 12, 2016) was used as the predicate.

The following reference predicate devices were used to demonstrate substantial equivalence:

- Rotaflow Centrifugal Pump System (K991864)
- BPX-80 Bio-Pump Centrifugal Blood Pump (K973011)
- Medos Hilite 7000 LT Oxygenator (K133261)
- Novalung® Surgical Lung Assist (sLA) Membrane Lung™ (K072362)

5.4. Device Description

The Novalung System is a blood oxygenation and carbon dioxide removal system designed to provide extracorporeal cardiac and/or pulmonary support. The following therapies are available with the Novalung System:

- Extracorporeal CO_2 removal ($ECCO_2R$)
- Extracorporeal membrane oxygenation (ECMO)

The Novalung System consists of the Novalung console and XLung kit. The Novalung console is composed of the following components:

- Control panel
- Power supply
- Sensor box
- Pump drive

The Novalung console powers and monitors the operation of the blood pump head in the extracorporeal circuit. The control panel has a touchscreen display on which all data, parameters, and values are displayed. Parameters can be selected and adjusted by pressing the touchscreen as well as by using the control panel function keys and the center knob. The control panel is attached to the power supply, which provides power to the console. The console also provides two (2) battery packs that supply power to the console if there is a power failure.

The sensor box allows data to be transferred to the console and displayed on the control panel. It has connectors for pressure sensors that connect to the XLung kit tubing set and a flow sensor.

The XLung kit contains a disposable tubing set and accessories (gas line, priming line, stopcocks, luer caps, Christmas tree connector, tubing clamps, cable ties). The tubing set is pre-connected to a hollow fiber membrane oxygenator (XLung oxygenator) and blood pump head (Deltastream DP3 3/8”), which forms an extracorporeal circuit. All blood-contacting surfaces of the tubing set, except for the blood pump head, are coated with x.ellence coating.

The XLung kit tubing has 3 integrated pressure sensors (IPS) that connect to the sensor box. The flow sensor detects air bubbles in the extracorporeal circuit and measures blood flow. The XLung kit provides treatment for a blood flow range of 1–7 L/min and has a total extracorporeal priming volume of 605 mL ± 10%.

The blood pump head is pre-connected to the XLung kit tubing set, which is provided sterile. Blood flow in the XLung kit tubing set is driven by the pump drive when it is connected to the blood pump head.

The following accessories are available with the Novalung System:

- Bracket and rail connector
- Flow sensor

- Pressure sensor connecting cables
- System cart
- Compact holder spike and bracket
- Pump drive holders
- Infusion holder

5.4.1. Environment of Use

The Novalung System is used in the hospital environment (e.g., intensive care units, cardiac catheterization laboratories, emergency rooms) to provide extracorporeal cardiac and/or pulmonary support.

5.5. Indications for Use

The Novalung System is indicated for long-term (>6 hours) respiratory/cardiopulmonary support that provides assisted extracorporeal circulation and physiologic gas exchange (oxygenation and CO2 removal) of the patient's blood in adults with acute respiratory failure or acute cardiopulmonary failure, where other available treatment options have failed, and continued clinical deterioration is expected or the risk of death is imminent. These may include:

- Failure to wean from cardiopulmonary bypass following cardiac surgery in adult patients
- ECMO-assisted cardiopulmonary resuscitation in adults

5.6. Comparison of Technological Characteristics with the Predicate Device

Substantial equivalence of the Novalung System was demonstrated by meeting the special controls in FDA's final order (81 FR 7451, February 12, 2016) and through bench testing using reference predicate devices.

5.6.1. Predicate – Special Controls

The Novalung System meets all special controls required by 21 CFR § 870.4100 as described below:

- Geometry and design parameters are consistent with the device's intended use in extracorporeal life support procedures. The Novalung console is designed to be compatible with the XLung kit and its accessories.
- The XLung kit and its accessories have been demonstrated to be biocompatible as a prolonged use device in accordance with ISO 10993-1:2009 and with FDA guidance document *Use of International Standard ISO 10993-1, "Biological evaluation of medical devices – Part 1: Evaluation and testing within a risk management process"* (16 June 2016)

- Testing demonstrated the that the sterility, integrity, durability, and reliability of the XLung kit were maintained over the intended shelf-life
- Substantial equivalence of the Novalung System performance characteristics was demonstrated through bench testing, mechanical integrity testing, electrical safety and electromagnetic compatibility testing, and software testing
- An animal study demonstrated the Novalung System's performance over a 9-day duration of use
- The labeling includes a detailed summary of the non-clinical and *in vivo* evaluations pertinent to the device's use in extracorporeal membrane oxygenation and physiologic gas exchange. Adequate instructions are included with respect to anticoagulation, circuit setup, maintenance during a procedure, and performance characteristics relevant to compatibility among different devices and accessories in the circuit. A 9-day duration of use is specified.

5.6.2. Reference Predicate Devices

The components of the Novalung System (Novalung console and the XLung kit) are substantially equivalent with respect to the following technological characteristics of the reference predicate devices.

- Principle of operation
- Design characteristics
- Sterilization method
- Patient fluid-contacting materials: polymethylpentene, polyethyleterephthalate, polycarbonate, polyurethane
- Coating materials

5.7. Performance Data

The following performance tests were conducted on the Novalung System to support the determination of substantial equivalence:

- Software verification and validation testing
- Functional design verification testing
- Electrical safety and electromagnetic compatibility (EMC) testing
- Interoperability evaluation
- Simulated shipping and distribution
- Package integrity validation
- 9-day leaching testing
- 18-day simulated use testing

- 18-day integrity testing (Blood pathway integrity and heat exchanger fluid/water pathway integrity)
- Gas pathway integrity
- Heat exchanger performance
- Blood volume capacity
- Pull test
- Blood cell damage
- Gas transfer and pressure drop performance
- Coating quantification

All testing met predetermined acceptance criteria.

The Novalung console performance characteristics were demonstrated through bench testing, mechanical integrity testing, electrical safety and electromagnetic compatibility testing, and software testing.

Testing demonstrated that the integrity, durability, and reliability of the XLung kit was maintained over the intended shelf-life.

5.7.1. Biocompatibility Testing

Testing was conducted to support the biological safety of the XLung kit.

- Cytotoxicity, ISO elution method
- Sensitization, guinea pig maximization
- Intracutaneous irritation
- Acute systemic toxicity
- Systemic toxicity, short-term (2-week) repeated exposure
- Material-mediated pyrogenicity
- Genotoxicity, bacterial mutagenicity assay
- Genotoxicity, *in vitro* mouse lymphoma gene mutation assay
- ASTM hemolysis – Extract
- ASTM hemolysis – Direct
- Platelet and leukocyte counts
- Complement activation - SC5b-9
- Partial Thromboplastin Time (PTT) – Direct
- Exhaustive extraction evaluation

- Extractables – Simulated use

A toxicological risk assessment was also performed.

5.7.2. Human Factors Validation Testing

The Novalung System was validated in accordance with FDA guidance document *Applying Human Factors and Usability Engineering to Medical Devices* (03 February 2016).

5.7.3. Animal Studies

An 18-day animal study was conducted to evaluate the safety and performance of the Novalung System for extracorporeal membrane oxygenation (ECMO) when used for longer than 6 hours (up to 9 days). The 18-day study was conducted on a total of 15 sheep. Five (5) out of the 15 sheep were used specifically to evaluate the Novalung System (Novalung console and XLung kit).

5.7.4. Clinical Studies

A retrospective analysis of clinical data was conducted to support the clinical efficacy and safety profile of the Novalung System. Clinical data from the Regensburg ECMO Registry were retrospectively analyzed for product efficacy and safety during long-term use (30-day observation period) for respiratory (ECMO) and cardiopulmonary (ECLS) support.

The analysis included 148 patients (100 veno-venous (VV) ECMO patients and 48 veno-arterial (VA) ECMO patients) treated with the Novalung System for a cumulative treatment duration of 1,382 days. Forty-nine (49) patients received ECMO treatment for longer than 9 days (18.1 ± 11.1 days)—41 VV ECMO patients (18.2 ± 11 days) and 8 VA ECMO patients (18 ± 12.2 days).

The maximum treatment duration for VV ECMO treatment was 65 days. The maximum treatment duration for VA ECMO treatment was 47 days. The average circuit life was 7.85 days in the entire population, and 8.03 days when considering device-related exchanges only.

Data from the start to the termination of ECMO treatment (the “observational period”) was evaluated. The death of a patient while on ECMO treatment was considered termination of treatment.

The following data was evaluated:

- Demographic, procedure, and outcome data
- Performance profile
- Safety profile

Data evaluated for this analysis was compared to data obtained from the Extracorporeal Life Support Organization (ELSO), which maintains a registry of ECLS cases and provides annual data on patient survival and center-based performance. The mortality and survival rates reported in this analysis are comparable to clinical data obtained from the ELSO Registry.

The system performed well in providing both veno-venous and veno-arterial support. Outcome and rate of technical complications is comparable to ELSO registry data. No treatment was discontinued due to device malfunction. The clinical data justify the long-term use of the Novalung System for respiratory and/or cardiopulmonary support.

5.8. Conclusion

The Novalung System meets the special controls in FDA's final order (81 FR 7451, February 12, 2016) and is substantially equivalent to the reference predicate devices. The information and data in this Traditional 510(k) demonstrate that the Novalung system is substantially equivalent to the predicate and reference predicate devices for long-term (> 6 hours) respiratory/cardiopulmonary support that provides assisted extracorporeal circulation and physiologic gas exchange (oxygenation and CO_2 removal) of the patient's blood in patients with acute respiratory failure or acute cardiopulmonary failure, where other available treatment options have failed and continued clinical deterioration is expected or the risk of death is imminent.