May 28, 2021

Edwards Lifesciences LLC
Varad Raghuwanshi
Sr. Specialist, Regulatory Affairs
One Edwards Way
Irvine, California 92614

Re: K203687
Trade/Device Name: HemoSphere Advanced Monitoring Platform
Regulation Number: 21 CFR 870.1425
Regulation Name: Programmable Diagnostic Computer
Regulatory Class: Class II
Product Code: DQK, DQE, QAQ, MUD, DXN, DSB
Dated: April 23, 2021
Received: April 26, 2021

Dear Varad Raghuwanshi:

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,

for

LT Stephen Browning
Assistant Director
Division of Cardiac
Electrophysiology, Diagnostics
and Monitoring Devices
Office of Cardiovascular Devices
Office of Product Evaluation and Quality
Center for Devices and Radiological Health

Enclosure

Indications for Use

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

510(k) Number *(if known)*
K203687

Device Name
HemoSphere Advanced Monitoring Platform

Indications for Use *(Describe)*

HemoSphere Advanced Monitor with HemoSphere Swan-Ganz Module:

The HemoSphere Advanced Monitor when used with the HemoSphere Swan-Ganz Module and Edwards Swan-Ganz Catheters is indicated for use in adult and pediatric critical care patients requiring monitoring of cardiac output [continuous (CO) and intermittent (iCO)] and derived hemodynamic parameters. It may also be used for monitoring hemodynamic parameters in conjunction with a perioperative goal directed therapy protocol in a hospital environment. Refer to the Edwards Swan-Ganz catheter indications for use statement for information on target patient population specific to the catheter being used.

Refer to the Intended Use statement below for a complete list of measured and derived parameters available for each patient population.

HemoSphere Advanced Monitor with HemoSphere Oximetry Cable:

The HemoSphere Advanced Monitor when used with the HemoSphere Oximetry Cable and Edwards oximetry catheters is indicated for use in adult and pediatric critical care patients requiring monitoring of venous oxygen saturation (SvO2 and ScvO2) and derived hemodynamic parameters in a hospital environment. Refer to the Edwards oximetry catheter indications for use statement for information on target patient population specific to the catheter being used.

Refer to the Intended Use statement for a complete list of measured and derived parameters available for each patient population.

HemoSphere Advanced Monitor with HemoSphere Pressure Cable:

The HemoSphere Advanced Monitor when used with the HemoSphere Pressure Cable is indicated for use in critical care patients in which the balance between cardiac function, fluid status, vascular resistance and pressure needs continuous assessment. It may be used for monitoring hemodynamic parameters in conjunction with a perioperative goal directed therapy protocol in a hospital environment. Refer to the Edwards FloTrac, Acumen IQ and TruWave DPT sensor indications for use statement for information on target patient population specific to the sensor being used.

The Edwards Lifesciences Acumen Hypotension Prediction Index feature provides the clinician with physiological insight into a patient's likelihood of future hypotensive events (defined as mean arterial pressure < 65 mmHg for at least one minute in duration) and the associated hemodynamics. The Acumen HPI feature is intended for use in surgical patients receiving advanced hemodynamic monitoring. The Acumen HPI feature is considered to be additional quantitative information regarding the patient's physiological condition for reference only and no therapeutic decisions should be made based solely on the Hypotension Prediction Index (HPI) parameter.

Refer to the Intended Use statement for a complete list of measured and derived parameters available for each patient population.

HemoSphere Advanced Monitor with HemoSphere Tissue Oximetry Module:

The noninvasive FORE-SIGHT ELITE tissue oximeter module is intended for use as an adjunct monitor of absolute regional hemoglobin oxygen saturation of blood under the Sensors in individuals at risk for reduced-flow or no-flow ischemic states. The FORE-SIGHT ELITE tissue oximeter module is intended to allow for the display of StO2 on the HemoSphere advanced monitor.

• When used with large sensorsis indicated for use on adults and transitional adolescents ≥40 kg.
• When used with Medium Sensors, the FORE-SIGHT ELITE tissue oximeter module is indicated for use on pediatric subjects ≥3 kg.
• When used with Small Sensors, the FORE-SIGHT ELITE tissue oximeter module is indicated for cerebral use on pediatric subjects <8 kg and non-cerebral use on pediatric subjects <5kg.

Refer to the Intended Use statement for a complete list of measured and derived parameters available for each patient population.

HemoSphere Advanced Monitor with HemoSphere ClearSight Module:

The HemoSphere advanced monitor when used with the HemoSphere ClearSight module, pressure controller and a compatible Edwards finger cuff are indicated for patients over 18 years of age in which the balance between cardiac function, fluid status and vascular resistance needs continuous assessment. It may be used for monitoring hemodynamic parameters in conjunction with a perioperative goal directed therapy protocol in a hospital environment. In addition, the noninvasive system is indicated for use in patients with co-morbidities for which hemodynamic optimization is desired and invasive measurements are difficult. The HemoSphere advanced monitor and compatible Edwards finger cuffs noninvasively measures blood pressure and associated hemodynamic parameters.

The Edwards Lifesciences Acumen Hypotension Prediction Index feature provides the clinician with physiological insight into a patient's likelihood of future hypotensive events (defined as mean arterial pressure < 65 mmHg for at least one minute in duration) and the associated hemodynamics. The Acumen HPI feature is intended for use in surgical patients receiving advanced hemodynamic monitoring. The Acumen HPI feature is considered to be additional quantitative information regarding the patient's physiological condition for reference only and no therapeutic decisions should be made based solely on the Hypotension Prediction Index (HPI) parameter.

Refer to the ClearSight finger cuff and Acumen IQ finger cuff indications for use statements for information on target patient population specific to the finger cuff being used.

Refer to the Intended Use statement for a complete list of measured and derived parameters available for each patient population.

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.

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510(k) Summary – HemoSphere Advanced Monitoring Platform

I. Submitter:

Sponsor: Edwards Lifesciences LLC
One Edwards Way
Irvine, CA 92614

Establishment Registration Number: 2015691

Contact Person: Varad Raghuwanshi
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Date Prepared: May 26, 2021

II. Device Information:

Platform Name (Name of the Device) HemoSphere Advanced Monitoring Platform

Trade Name:
HemoSphere Advanced Monitor
HemoSphere Swan-Ganz Module
HemoSphere Oximetry Cable
HemoSphere Pressure Cable
Acumen Hypotension Prediction Index (HPI) feature for Minimally Invasive and Non-Invasive technology
HemoSphere Tissue Oximetry Module
HemoSphere ClearSight Module

Common Name: Cardiac Output/Oximetry/Ejection Fraction Computer

Classification Name:

Programmable Diagnostic Computer	21 CFR 870.1425
Fiberoptic Oximeter Catheter	21 CFR 870.1230
Adjunctive Predictive Cardiovascular Indicator	21 CFR 870.2210
Oximeter	21 CFR 870.2700
Noninvasive blood pressure measurement system	21 CFR 870.1130
Impedance plethysmograph	21 CFR 870.2770

Product Code and Regulatory Class:	DQK, Class II DQE, Class II QAQ, Class II MUD, Class II DXN, Class II DSB, Class II

III. Predicate Device

Primary Predicate Device:	HemoSphere Advanced Monitoring Platform manufactured by Edwards Lifesciences, K201446 cleared October 1, 2020.
Additional Predicate Devices:	HemoSphere Advanced Monitoring Platform by Edwards Lifesciences, K180881 cleared November 16, 2018, utilized for the Acumen Hypotension Prediction Index software feature. Acumen Hypotension Prediction Index feature by Edwards Lifesciences DEN160044, granted March 16, 2018 utilized for the Acumen Hypotension Prediction Index software feature.

IV. Device Description

Device Description:	HemoSphere Advanced Monitoring Platform consists of the HemoSphere Advanced Monitor that provides a means to interact with and visualize hemodynamic and volumetric data on a screen and five (5) optional external modules: the HemoSphere Swan-Ganz Module (K163381 Cleared, April 14, 2017), the HemoSphere Oximetry Cable (K163381 Cleared, April 14, 2017), HemoSphere Pressure Cable (K180881 Cleared, November 16, 2018), HemoSphere Tissue Oximetry Module (K190205 August 29, 2019), and the HemoSphere ClearSight Module (K201446 Cleared October 1, 2020). The HemoSphere Advanced Monitor with HemoSphere ClearSight module is a non-invasive monitoring platform intended to continuously and noninvasively measure blood pressure and associated hemodynamic parameters. The HemoSphere Advanced Monitoring Platform when used with ClearSight Module uses the same technology as the predicate device. The volume clamp method of Peňáz is the measurement method, and the pressure waveform reconstruction is based on the generalized transfer function and level of correction of Gizdulich.

The platform also includes the Acumen Hypotension Prediction Index (HPI) feature for the ClearSight (non-invasive) technology. Currently, the HemoSphere Pressure Cable enables the HPI feature when connected to an Acumen IQ sensor. This feature has been updated to also enable the HPI feature when connected to the Acumen IQ finger cuff (ClearSight finger cuff).

The modified ClearSight System receives the pressure signal from the finger cuff and reconstructs it to a radial arterial pressure representation of the signal. This radial reconstructed signal is then used to calculate the previously available key hemodynamic parameters; PR, MAP, SYS, DIA, PPV and SVV. Additionally, the radial reconstructed signal is also used to calculate the parameters associated with the Hypotension Prediction Index feature (HPI, Ea_{dyn}, and dP/dt).

The cardiac output (CO) and other measurements derived from cardiac output, such as stroke volume (SV), cardiac output index (CI), stroke volume index (SVI) remain unchanged and will continue to use previously cleared ClearSight algorithm to reconstruct the finger pressure waveform into a brachial arterial pressure waveform.

The associated accessories include:

Model Number	Associated Accessories
PC2	Pressure controller
EVHRS	Heart Reference Sensor
CSCS	ClearSight Finger Cuff Small
CSCM	ClearSight Finger Cuff Medium
CSCL	ClearSight Finger Cuff Large
CSC2S	ClearSight Finger Cuff Small
CSC2M	ClearSight Finger Cuff Medium
CSC2L	ClearSight Finger Cuff Large
AIQCS	Acumen IQ Finger Cuff Small
AIQCM	Acumen IQ Finger Cuff Medium
AIQCL	Acumen IQ Finger Cuff Large
HEMBAT10	HemoSphere Battery Pack
HEMRLSTD1000	HemoSphere Roll Stand

V. Indications for Use:

Note: *The Indication for Use statements are identical for all the previously cleared technologies (K201446 Cleared October 1, 2020) with the exception of the addition of the indication for Acumen Hypotension Predication Index (HPI) for the non-invasive (ClearSight) technology.*

HemoSphere Advanced Monitor with HemoSphere Swan-Ganz Module

The HemoSphere Advanced Monitor when used with the HemoSphere Swan-Ganz Module and Edwards Swan-Ganz Catheters is indicated for use in adult and pediatric critical care patients requiring monitoring of cardiac output [continuous (CO) and intermittent (iCO)] and derived hemodynamic parameters. It may also be used for monitoring hemodynamic parameters in conjunction with a perioperative goal directed therapy protocol in a hospital environment. Refer to the Edwards Swan-Ganz catheter indications for use statement for information on target patient population specific to the catheter being used.

Refer to the Intended Use statement below for a complete list of measured and derived parameters available for each patient population.

HemoSphere Advanced Monitor with HemoSphere Oximetry Cable

The HemoSphere Advanced Monitor when used with the HemoSphere Oximetry Cable and Edwards oximetry catheters is indicated for use in adult and pediatric critical care patients requiring monitoring of venous oxygen saturation (SvO2 and ScvO2) and derived hemodynamic parameters in a hospital environment. Refer to the Edwards oximetry catheter indications for use statement for information on target patient population specific to the catheter being used.

Refer to the Intended Use statement for a complete list of measured and derived parameters available for each patient population.

HemoSphere Advanced Monitor with HemoSphere Pressure Cable

The HemoSphere Advanced Monitor when used with the HemoSphere Pressure Cable is indicated for use in critical care patients in which the balance between cardiac function, fluid status, vascular resistance and

pressure needs continuous assessment. It may be used for monitoring hemodynamic parameters in conjunction with a perioperative goal directed therapy protocol in a hospital environment. Refer to the Edwards FloTrac, Acumen IQ and TruWave DPT sensor indications for use statement for information on target patient population specific to the sensor being used.

The Edwards Lifesciences Acumen Hypotension Prediction Index feature provides the clinician with physiological insight into a patient's likelihood of future hypotensive events (defined as mean arterial pressure < 65 mmHg for at least one minute in duration) and the associated hemodynamics. The Acumen HPI feature is intended for use in surgical patients receiving advanced hemodynamic monitoring. The Acumen HPI feature is considered to be additional quantitative information regarding the patient's physiological condition for reference only and no therapeutic decisions should be made based solely on the Hypotension Prediction Index (HPI) parameter.

Refer to the Intended Use statement for a complete list of measured and derived parameters available for each patient population.

HemoSphere Advanced Monitor with HemoSphere Tissue Oximetry Module

The non-invasive FORE-SIGHT ELITE tissue oximeter module is intended for use as an adjunct monitor of absolute regional hemoglobin oxygen saturation of blood under the Sensors in individuals at risk for reduced-flow or no-flow ischemic states. The FORE-SIGHT ELITE tissue oximeter module is intended to allow for the display of StO_2 on the HemoSphere advanced monitor.

- When used with large sensors, is indicated for use on adults and transitional adolescents ≥40 kg.
- When used with Medium Sensors, the FORE-SIGHT ELITE tissue oximeter module is indicated for use on pediatric subjects ≥3 kg.
- When used with Small Sensors, the FORE-SIGHT ELITE tissue oximeter module is indicated for cerebral use on pediatric subjects <8 kg and non-cerebral use on pediatric subjects <5kg.

Refer to the Intended Use statement for a complete list of measured and derived parameters available for each patient population.

HemoSphere Advanced Monitor with HemoSphere ClearSight Module

Note: *There is no change to the ClearSight indication from what was cleared in K201446 October 1, 2020 with the exception of the addition of Acumen Hypotension Index (HPI) indication for non-invasive technology. The Acumen HPI indication for non-invasive technology is identical to the predicate K180881 (Cleared November 16, 2018).*

The HemoSphere Advanced Monitor when used with the HemoSphere ClearSight module, pressure controller and a compatible Edwards finger cuff are indicated for patients over 18 years of age in which the balance between cardiac function, fluid status and vascular resistance needs continuous assessment. It may be used for monitoring hemodynamic parameters in conjunction with a perioperative goal directed therapy protocol in a hospital environment. In addition, the non-invasive system is indicated for use in patients with co-morbidities for which hemodynamic optimization is desired and invasive measurements are difficult. The HemoSphere advanced monitor and compatible Edwards finger cuffs non-invasively measures blood pressure and associated hemodynamic parameters.

The Edwards Lifesciences Acumen Hypotension Prediction Index feature provides the clinician with physiological insight into a patient's likelihood of future hypotensive events (defined as mean arterial pressure < 65 mmHg for at least one minute in duration) and the associated hemodynamics. The Acumen HPI feature is intended for use in surgical patients receiving advanced hemodynamic monitoring. The Acumen HPI feature is considered to be additional quantitative information regarding the patient's physiological condition for reference only and no therapeutic decisions should be made based solely on the Hypotension Prediction Index (HPI) parameter.

Refer to the ClearSight and Acumen IQ finger cuff indications for use statements for information on target patient population specific to the finger cuff being used.

Intended Use: The HemoSphere Advanced Monitoring Platform is intended to be used by qualified personnel or trained clinicians in a critical care environment in a hospital setting.

The HemoSphere advanced monitoring platform is intended for use with compatible Edwards Swan-Ganz and oximetry catheters, FloTrac sensors, Acumen IQ sensors, TruWave DPTs, ForeSight Elite sensors, and ClearSight/Acumen IQ finger cuffs.

A comprehensive list of parameters available while monitoring with the HemoSphere advanced monitor and a connected HemoSphere Swan-Ganz module are listed below in table 1-1. Only iCO, iCI, iSVR, and iSVRI are available to the pediatric patient population.

Parameter	Description	Sub-System Module Used	Patient Population	Hospital Environment
CO	continuous cardiac output	HemoSphere Swan-Ganz Module	Adult only	Operating Room, Intensive Care Unit, Emergency Room
sCO	STAT cardiac output			
CI	continuous cardiac index			
sCI	STAT cardiac index			
EDV	right ventricular end diastolic volume			
sEDV	STAT right ventricular end diastolic volume			
EDVI	right ventricular end diastolic volume index			
sEDVI	STAT right ventricular end diastolic volume index			
HR_{avg}	averaged heart rate			
LVSWI	left ventricular stroke work index			
PVR	pulmonary vascular resistance			
PVRI	pulmonary vascular resistance index			
RVEF	right ventricular ejection fraction			
sRVEF	STAT right ventricular ejection fraction			
RVSWI	right ventricular stroke work index			
SV	stroke volume			
SVI	stroke volume index			
SVR	systemic vascular resistance			
SVRI	systemic vascular resistance index			
iCO	intermittent cardiac output		Adult and Pediatric	
iCI	intermittent cardiac index			
iSVR	intermittent systemic vascular resistance			
iSVRI	intermittent systemic vascular resistance index			

A comprehensive list of parameters available for adult and pediatric patient populations while monitoring with the HemoSphere Advanced Monitor and a connected HemoSphere oximetry cable are as listed below:

Parameter	Description	Sub-System Module Used	Patient Population	Hospital Environment
SvO2	Mixed Venous Oxygen Saturation	HemoSphere Oximetry Cable	Adult and Pediatric	Operating Room, Intensive Care Unit, Emergency Room
ScvO2	Central Venous Oxygen Saturation			

A comprehensive list of parameters available for adult and pediatric patient populations while monitoring with the HemoSphere advanced monitor and both a connected HemoSphere Swan-Ganz module and oximetry cable are listed below:

Parameter	Description	Sub-System Module Used	Patient Population	Hospital Environment
DO2	Oxygen Delivery	HemoSphere Swan-Ganz Module and HemoSphere Oximetry Cable	Adult and Pediatric	Operating Room, Intensive Care Unit, Emergency Room
DO2I	Oxygen Delivery Indexed			
VO2	Oxygen Consumption			
VO2e	Estimated Oxygen Consumption when ScvO2 is being monitored			
VO2I	Oxygen Consumption Index			
VO2Ie	Estimated Oxygen Consumption Index when ScvO2 is being monitored			

A comprehensive list of parameters available for adult patient populations while monitoring with the HemoSphere Advanced Monitor and a connected HemoSphere pressure cable are as listed below:

Parameter	Description	Sub-System Module Used	Patient Population	Hospital Environment
CO/ CI	Continuous Cardiac Output[1]/ Continuous Cardiac Index[1]	HemoSphere Pressure Cable	Adult only	Operating Room, Intensive Care Unit, Emergency Room
CVP	Central Venous Pressure			
DIA_{ART}	Systemic arterial diastolic blood pressure			
DIA_{PAP}	pulmonary artery diastolic blood pressure			
dP/dt	Systolic slope[2]			
Ea_{dyn}	Dynamic Arterial Elastance[2]			
MAP	Mean Arterial Pressure			
MPAP	Mean Pulmonary Arterial Pressure			
PPV	pulse pressure variation[1]			
PR_{ART}	Pulse rate			
SV/ SVI	Stroke Volume[1]/ Stroke Volume Index[1]			
SVR/ SVRI	Systemic Vascular Resistance[1]/ Systemic Vascular Resistance[1] Index			
SVV	Stroke Volume Variation[1]			
SYS	Systolic Blood Pressure			
HPI	Acumen Hypotension Prediction Index			

[1]FloTrac parameters are available when using a FloTrac/Acumen IQ sensor and if the FloTrac feature is enabled.
[2]HPI parameters are available when using an Acumen IQ sensor and if the HPI feature is activated.

A comprehensive list of parameters available for adult patient populations while monitoring with the HemoSphere Advanced Monitor and a connected HemoSphere pressure cable and a connected HemoSphere oximetry cable are as listed below:

Parameter	Description	Sub-System Module Used	Patient Population	Hospital Environment
DO_2	Oxygen Delivery	HemoSphere Swan-Ganz Module and HemoSphere Oximetry Cable	Adult only	Operating Room, Intensive Care Unit, Emergency Room
DO_2I	Oxygen Delivery Indexed			
VO_2	Oxygen Consumption			
VO_2e	Estimated Oxygen Consumption when $ScvO_2$ is being monitored			
VO_2I	Oxygen Consumption Index			
VO_2Ie	Estimated Oxygen Consumption Index when $ScvO_2$ is being monitored			

A comprehensive list of parameters available while monitoring with the HemoSphere advanced monitor and both a connected HemoSphere Swan-Ganz Module and a connected HemoSphere pressure cable are as listed below.

Parameter	Description	Sub-System Module Used	Patient Population	Hospital Environment
CO_{20s}	20-second cardiac output	HemoSphere Swan-Ganz module and HemoSphere pressure cable	Adult only	Operating room, intensive care unit, emergency room
CI_{20s}	20-second cardiac index			
SV_{20s}	20-second stroke volume			
SVI_{20s}	20-second stroke volume index			

Tissue oxygen saturation, StO_2, can be monitored with the HemoSphere Advanced Monitor, a connected HemoSphere Tissue Oximetry Module, and the FORE-SIGHT ELITE Tissue Oximeter Module. Refer to the FORE-SIGHT ELITE HemoSphere Advanced Monitoring Platform Operators Manual for specific information on the intended use environment and patient population.

Parameter	Description	Sub-System Module Used	Patient Population	Hospital Environment
StO_2	Tissue oxygen saturation	HemoSphere Tissue Oximetry Module and Fore-Sight Elite Module	Adult and Pediatric	Operating Room, Intensive Care Unit, Emergency Room

A comprehensive list of parameters available while monitoring with the HemoSphere advanced monitor and a connected HemoSphere ClearSight module are listed below

Parameter	Description	Sub-System Module Used	Patient Population	Hospital Environment
CO/CI	Continuous Cardiac Output/ Continuous Cardiac Index	HemoSphere ClearSight Module	Adult only	Operating Room, Intensive Care Unit, Emergency Room
DIA	Noninvasive arterial diastolic blood pressure			
MAP	Noninvasive Mean Arterial Pressure			
PPV	pulse pressure variation			
PR	Noninvasive Pulse rate			
SV/ SVI	Stroke Volume/ Stroke Volume Index			
SVR/ SVRI	Systemic Vascular Resistance Systemic Vascular Resistance Index			
SVV	Stroke Volume Variation			
SYS	Systolic Blood Pressure			
dP/dt	Maximal slope of the arterial pressure upstroke[1]			
Ea_{dyn}	Dynamic Arterial Elastance[1]			
HPI	Acumen Hypotension Prediction Index[1]			Operating Room only

[1]HPI parameters are available when using an Acumen IQ cuff and if the HPI feature is activated.
Note: CO/CI and SV/SVI are measured using a reconstructed brachial arterial waveform. All other monitored parameters use a reconstructed radial arterial waveform. SVR/SVRI are derived from CO/CI and MAP along with an entered or monitored CVP value.

A comprehensive list of parameters available for adult patient populations while monitoring with the HemoSphere advanced monitor and both a connected HemoSphere ClearSight module and oximetry cable are listed below

Parameter	Description	Sub-System Module Used	Patient Population	Hospital Environment
DO_2	Oxygen Delivery	HemoSphere ClearSight Module and HemoSphere Oximetry Cable	Adult only	Operating Room, Intensive Care Unit
DO_2I	Oxygen Delivery Indexed			
VO_2	Oxygen Consumption			
VO_2e	Estimated Oxygen Consumption when $ScvO_2$ is being monitored			
VO_2I	Oxygen Consumption Index			
VO_2Ie	Estimated Oxygen Consumption Index when $ScvO_2$ is being monitored			

VI. Comparison of Technological Characteristics with the Predicate Devices:

The existing HemoSphere Advanced Monitoring Platform which is the primary predicate for this submission consists of:

- HemoSphere Advanced Monitor
- HemoSphere Swan-Ganz Module
- HemoSphere Oximetry Cable
- HemoSphere Pressure Cable
- Acumen Hypotension Prediction Index (use with Minimally invasive technology only)
- HemoSphere Tissue Oximetry Module
- HemoSphere ClearSight Module

The subject and predicate devices are based on the following same technological elements:

- Platform: The subject device uses the same platform as the predicate (K201446 cleared October 1, 2020).

- Non-Invasive technology: The subject and predicate (K201446 cleared October 1, 2020) are non-invasive blood pressure measurement systems and use the same method of measurement.

- Graphical User Interface: The subject and predicate (K201446 cleared October 1, 2020) have the same Graphical User Interface (GUI)

- Predictive Algorithm: The subject and predicate (initially cleared in DEN160044 and later cleared in K180881 for HemoSphere Advanced monitoring Platform) have the same core predictive algorithm for Acumen Hypotension Predication Index.

- Accessories/Components: The subject and the predicate (K201446 cleared October 1, 2020) device both use previously cleared Pressure controller, Heart Reference Sensor and ClearSight Cuffs for measurement of non-invasive parameters.

The following technological differences exist between the subject and predicate devices:

- ClearSight Algorithm update: The currently cleared ClearSight algorithm (K201446) has been modified such that the non-invasive pressure signal acquired from the finger cuff is reconstructed using the subject modified algorithm to a radial arterial pressure representation of the signal instead of a brachial arterial representation as cleared in K201446 on October 1, 2020.

  This radial reconstructed signal is used to calculate the previously available key hemodynamic parameters; PR, MAP, SYS, DIA, PPV and SVV. Additionally, the radial reconstructed signal is also used to calculate the parameters associated with the Hypotension Prediction Index feature (HPI, Eadyn, and dP/dt).

  The cardiac output (CO) and other measurements derived from cardiac output, such as stroke volume (SV), cardiac output index (CI), stroke volume index (SVI) remain unchanged and will continue to use previously cleared ClearSight algorithm to reconstruct the finger pressure waveform into a brachial arterial pressure waveform

The purpose of this 510(k) submission is to introduce the following modifications to the HemoSphere Advanced Monitoring Platform (K201446 on October 1, 2020):

- **Modifications to existing features/algorithm of the HemoSphere Advanced Monitoring Platform (previously cleared in K201446 on October 1, 2020):**

  - Algorithm Modification: Update to the existing ClearSight™ Algorithm

    The existing ClearSight algorithm receives the pressure signal from the finger cuff and reconstructs it to a *brachial* arterial pressure representation of the signal. This reconstructed signal is then used to calculate Cardiac Output along with the other derived parameters for Cardiac Output (CO), Pulse Rate (PR), Mean Arterial Blood Pressure (MAP), Systolic Blood Pressure (SYS), Diastolic Blood Pressure (DIA) Blood Pressure, Pulse Pressure Variation (PPV) and Stroke Volume Variation (SVV) and to derive additional hemodynamic parameters (CI, SV, SVI, SVR and SVRI) from the calculated parameters.

The modified ClearSight algorithm receives the pressure signal from the finger cuff and reconstructs it to a *radial* arterial pressure representation of the signal. This radial reconstructed signal is then used to calculate the currently available key hemodynamic parameters PR, MAP, SYS, DIA, PPV and SVV. Additionally, the radial reconstructed signal is also used to calculate the parameters associated with the Hypotension Prediction Index (HPI) feature (HPI, Ea_{dyn}, and dP/dt) as further detailed below.

The cardiac output (CO) and other measurements derived from cardiac output, such as stroke volume (SV), cardiac output index (CI), stroke volume index (SVI) remain unchanged and will continue to use previously cleared ClearSight algorithm to reconstruct the finger pressure waveform into a brachial arterial pressure waveform.

- Acumen Hypotension Prediction Index (HPI) feature for Non-invasive technology:

Currently, the HemoSphere Pressure Cable enables the Acumen Hypotension Prediction Index (HPI) feature when connected to an Acumen IQ sensor (K180881 Cleared, November 16, 2018). This feature has been modified to now recognize the Acumen IQ finger cuff for non-invasive (ClearSight) technology when using HPI. HPI cannot be used without either an Acumen IQ sensor (minimally invasive technology) or Acumen IQ finger cuff (non-invasive technology). No modifications to the core predictive HPI algorithm have been made from the granted version in DEN160044 (granted March 16, 2018). The HPI algorithm processes the non-invasive radial arterial pressure waveform identically to the previously cleared minimally invasive radial arterial pressure waveform.

Performance Data:

❖ **Modifications to the labelling of the HemoSphere Advanced Monitoring Platform (K201446, cleared October 1, 2020):**

- Indication expansion and additions to accommodate the expanded functionality for non-invasive HPI and modified ClearSight algorithm:

The HemoSphere Advanced Monitoring Platform Operator's Manual is being updated to include the expanded indications for use for non-invasive (ClearSight) HPI for surgical patients. Additions are also being made to support the usage and

expanded functionality of the non-invasive Acumen HPI when using the non-invasive ClearSight technology.

The following verification and validation activities were performed in support of a substantial equivalence determination for the modifications being made as part of this submission.

Usability Study

Usability study was conducted per FDA's guidance document "*Applying Human Factors and Usability Engineering to Medical Devices*" to investigate primary operating functions and critical tasks of the system for any usability issues regarding the HemoSphere Advanced Monitoring Platform that may lead to patient or user harm. A total of 30 participants were included. There were two user groups; a minimum of 15 participants from each user group was included in testing.

The usability study demonstrated that the intended users can perform primary operating functions and critical tasks of the system without any usability issues that may lead to patient or user harm.

System Verification (Non-Clinical Performance):

Completion of all verification and validation activities demonstrated that the subject devices meet their predetermined design and performance specifications. Verification activities performed confirmed that the differences in the design and materials used did not adversely affect the safety and effectiveness of the subject device.

Measured and derived parameters were tested using a bench simulation. Additionally, individual modules were tested at a system level to verify the safety of these modules. They were also integrated as a system and verified for their safety and effectiveness. All tests passed.

Electrical Safety and Electromagnetic Compatibility (EMC)

Electrical safety and EMC testing were conducted on the subject HemoSphere Advanced Monitoring Platform, consisting of the HemoSphere Monitor, the ClearSight Module, Pressure Controller, Heart Reference and finger cuff. The system complies with the IEC 60601-1, IEC 60601-1-2, IEC 60601-1-6, IEC 60601-1-8, IEC 62304, IEC 62366-1, IEC 60601-2-34, IEC 60601-2-57, IEC 60601-2-49 and IEC 80601-2-49. All tests passed.

Wireless Coexistence Testing

Bench and simulated environment testing were performed on the entire HemoSphere Advanced Monitoring Platform, including all sub-system modules and interfacing analog inputs and outputs. All tests passed.

Software Verification

Software verification was performed per FDA's Guidance for Industry and FDA Staff, "Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices". Software on each of the individual modules was tested at a sub-system level to ensure the safety of the device. All tests passed.

Algorithm Verification (Clinical Performance Data):

Algorithm performance was tested using clinical data. The results establish that the usage of the HPI algorithm with non-invasive technology did not adversely affect the safety and effectiveness of the subject device.

Clinical Performance

Prospective analyses of retrospective clinical data from multiple independent datasets, comprised of data from patients over the age of 18 years undergoing surgical procedures with both minimally invasive and non-invasive monitoring, were analyzed to verify the safety and performance of the subject device.

Conclusions

The clinical data demonstrate that the safety and effectiveness profile of the subject device is substantially equivalent to the predicate device.
The technological characteristics of the subject and predicate devices are similar, and the differences do not raise any concerns of safety and effectiveness of the subject device. The nonclinical and clinical tests demonstrate that the HemoSphere Advanced Monitoring Platform has successfully passed functional and performance testing, including software verification and validation, algorithm, clinical validation and bench studies. The testing performed demonstrates that the HemoSphere Advanced Monitoring Platform with the subject modifications and expanded indications for use of the HemoSphere ClearSight Module is substantially equivalent to the legally marketed predicates.