July 30, 2021

Edwards Lifesciences, LLC
Lisa Gilman
Distinguished Regulatory Affairs Program Manager
One Edwards Way
Irvine, California 92614

Re: K203224
Trade/Device Name: Acumen™ Hypotension Prediction Index
Regulation Number: 21 CFR 870.2210
Regulation Name: Adjunctive predictive cardiovascular indicator
Regulatory Class: Class II
Product Code: QAQ
Dated: October 30, 2020
Received: November 2, 2020

Dear Lisa Gilman:

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

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

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)*
K203224

Device Name
Acumen Hypotension Prediction Index

Indications for Use *(Describe)*

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 or non-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.

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."

SECTION 5 – 510(k) SUMMARY

Acumen™ Hypotension Prediction Index	
Sponsor	Edwards Lifesciences LLC One Edwards Way Irvine, CA 92614
Establishment Registration Number	2015691
Contact Person	Lisa Gilman Distinguished Regulatory Affairs Program Manager One Edwards Way Irvine, CA 92614 Telephone: (949) 250-1478 Fax: (949) 809-2996
Date Prepared	June 16, 2021
Trade Name	Acumen™ Hypotension Prediction Index
Common Name	Adjunctive Predictive Cardiovascular Indicator
Classification Name	Adjunctive Predictive Cardiovascular Indicator
Regulation Class / Product Code	21 CFR 870.2210/Class II/QAQ
Predicate Device(s)	Acumen Hypotension Prediction Index (HemoSphere Advanced Monitoring Platform, K201446 (Primary Predicate) Acumen Hypotension Prediction Index, DEN160044 (Reference Predicate)

Device Description	The Acumen Hypotension Prediction Index feature consists of software running on the Edwards Lifesciences HemoSphere Advanced Monitoring Platform paired with the Acumen IQ extravascular blood pressure transducer (K152980) and a peripheral arterial catheter. The monitoring system includes the Acumen Hypotension Prediction Index (HPI), and graphical user interface features displaying hemodynamic parameters relevant to assessing the root cause of a potential hypotensive event.* The Acumen Hypotension Prediction Index is an index related to the likelihood of a patient experiencing hemodynamic instability defined as a hypotensive event* within 15 minutes, where zero (0) indicates low likelihood and one hundred (100) indicates a hypotensive event is occurring. The Acumen Hypotension Prediction Index parameter (HPI), should not be used exclusively to treat patients. A review of the patient's hemodynamics is recommended prior to initiating treatment. *A hypotensive event is defined as mean arterial pressure (MAP) < 65 mmHg for one minute in duration
Indications for Use/Intended Use	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 or non-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.
Comparison to Predicate Device	The Acumen Hypotension Prediction Index feature as implemented on the HemoSphere Advanced Monitoring Platform (K201446, October 1, 2020) is identical to itself as there are no changes to the Acumen™ Hypotension Prediction Index feature indications for use, algorithm, nor the hardware and software of the HemoSphere Advanced Monitoring Platform. The Acumen Hypotension Prediction Index (HPI parameter) algorithm as implemented on the HemoSphere Advanced Monitoring Platform (K201446, October 1, 2020) is identical to Acumen Hypotension Prediction Index (HPI parameter) algorithm granted in DEN160044. **Modifications** • The modifications are to the labeling of the HemoSphere Advanced Monitoring Platform to provide additional data demonstrating the utility of the Acumen™ Hypotension Prediction Index Feature Software in the detection of hemodynamic instability and the treatment of intraoperative hypotension (IOH) during non-cardiac surgery.

Performance Data	**Clinical Performance** A Prospective, Single-Arm, Open-Label, Multicenter Study of the Hypotension Prevention and Treatment in Patients Receiving Arterial Pressure Monitoring with Acumen Hypotension Prediction Index Feature (HPI Study) was undertaken to further understand the impact that the Acumen Hypotension Prediction Index (HPI) feature may have in the detection of hemodynamic instability and the treatment of intraoperative hypotension in non-cardiac surgery. The comparison group was a retrospective historical control group with patient-level data from a non-profit academic consortium group, the Multicenter Perioperative Outcomes Group (MPOG), that collects perioperative data from hospitals across United States. The primary objective of the HPI Study was to determine whether the use of the Acumen HPI Feature to guide intraoperative hemodynamic management in non-cardiac surgery reduces the duration of intraoperative hypotension (defined as MAP < 65 mmHg for at least 1 minute) as compared with a historic retrospective control group. The HPI Study was a single-arm, prospective, unblinded study conducted in 485 eligible Subjects (460 pivotal with an additional 25 roll-in cases) at the same 11 study sites in the United States that contributed to the historical control group. The HPI arm to determine if using the Acumen HPI Feature to predict hypotension within 15 minutes of an actual event could reduce the mean duration of IOH by at least 25%.[1] The incidence of IOH in the MPOG group was 88% (n=19,445/22,109) and the dates of treatment were between January 1, 2017 and December 31, 2017. The secondary effectiveness endpoint was the determination of total area under the curve of the time and MAP for all time periods for which MAP < 65 mmHg in each Subject. This endpoint is correlated with the duration and a descriptive analysis of this endpoint was presented with the mean, standard deviation (SD), median, minimum and maximum.

[1] Shah NJ, Mentz G, Kheterpal S. The incidence of intraoperative hypotension in moderate to high risk patients undergoing non-cardiac surgery: A retrospective multicenter observational analysis. J Clin Anest. 2020: 66; 109961.

The primary safety endpoint was the percentage of serious adverse events to include perioperative events, postoperative complications, and device-related serious adverse events. The secondary objective for this study (secondary safety endpoint) was to determine if the guidance provided by the Acumen HPI Feature reduced a composite measure of complications as indicated below:

- Post-operative episodes of non-fatal cardiac arrest;
- In-hospital death;
- Stroke;
- Acute Kidney Injury (AKI) within 30 days of the procedure;
- Myocardial Injury in non-cardiac surgery (MINS) within 30 days of the procedure.

Patient Demographics

Description		HPI (Intent-to-Treat)	HPI (Full Analysis Set)	MPOG (Full Analysis Set)
# of patients (N)		460	406*	22,109
Gender (%)	Male	51.7 (n=238)	52.96 (n=215)	57.8 (n=12,770)
	Female	48.3 (n=222)	47.04 (n=191)	42.2 (n=9330)
Age (year)	Mean ± SD	63.0 ± 13.0	62.8 ± 13.0	63.3 ± 13.8
	Median	65 (19 – 94)	65 (19 - 89)	65 (18 – 90)
BMI	Median (25th and 75th percentile)	28.09 (24.37, 32.81)	28.09 (24.41, 32.86)	28.1 (24.2, 32.9)
ASA Score (%)	II**	0.2 (n=1)	0.25 (n=1)	0.0 (n=0)
	III	91.5 (n=421)	92.12 (n=374)	80.83 (n=17,870)
	IV	8.0 (n=37)	7.64 (n=31)	19.17 (n=4,239)
	Not specified	0.2 (n=1)	0.0 (n=0)	0.0 (n=0)
Surgery duration (minutes)	Mean ± SD	338.1 ± 145.38 (n = 458)	363.6 ± 134.04	355.2 ± 145.8
	Median (25TH and 75th percentile)	315.5 (235 - 416) (n = 458)	336 (262 - 430)	317 (245, 427)

*The Full Analysis Set (FAS) represent those subjects from the Intent-to-Treat (ITT) population that had a surgery duration of ≥3 hours.

** ASA II subject was identified as a protocol deviation, though not excluded from ITT and FAS populations as this subject met the defined criteria (surgery > 3 hours and hemodynamic monitoring data). This subject was included in the efficacy and safety analyses, although by inclusion/exclusion criteria should not have been enrolled in the study.

Procedure Type (HPI)

Procedure Type	% (n/N)
Spine Surgery	18.5 (85 / 460)
Hepatectomy	13.7 (63 / 460)
Whipple	10.0 (46 / 460)
Major, vascular	8.5 (39 / 460)
Other	8.5 (39 / 460)
Nephrectomy	5.7 (26 / 460)
Other Genitourinary Surgery	5.4 (25 / 460)
Cystectomy	5.0 (23 / 460)
Pancreatectomy	5.0 (23 / 460)
Renal Transplant	4.3 (20 / 460)
Head & Neck Surgery	3.9 (18 / 460)
Complex Combined Oncologic Surgery (including 2 or more distinct organs)	3.0 (14 / 460)
Exploratory Laparotomy	3.0 (14 / 460)
Colectomy	2.8 (13 / 460)
Adrenalectomy	2.6 (12 / 460)
Gastrectomy	2.0 (9 / 460)
Other Gastrointestinal Surgery	2.0 (9 / 460)
Hip Revision	1.7 (8 / 460)
Prostatectomy	1.7 (8 / 460)
HIPEC	1.3 (6 / 460)
Hysterectomy with Debulking	1.3 (6 / 460)
Cholecystectomy	0.9 (4 / 460)
Reoperative Orthopedic Surgery	0.9 (4 / 460)
Splenectomy	0.9 (4 / 460)
Bariatric Surgery	0.4 (2 / 460)
Liver Transplant	0.4 (2 / 460)
Sigmoidectomy	0.4 (2 / 460)
Not Specified	0.2 (1 / 460)

MPOG group surgery types were determined by CPT grouping. The MPOG group included head; neck; thorax extra- and intra-thoracic; spine and spinal cord; abdomen upper or lower; urology; gynecologic; male reproductive system; pelvis; hip/leg/foot; shoulder/arm/hand; radiologic; obstetrics; and, other procedure.

Study Results

Effectiveness

The HPI Study was designed to evaluate the ability of the Acumen HPI Feature, as a decision support tool, to reduce the duration of IOH by at least 25% in surgical patients that require advanced hemodynamic monitoring. An episode of intraoperative hypotension (IOH) was defined as a mean arterial pressure (MAP) below 65 for three (3) or more consecutive 20 second events for each subject, across all sites.

The primary effectiveness endpoint is a weighted average of site means and standard deviations combined in the same proportion of subjects that were included in the MPOG cohort. This weighted average and its properly computed standard deviation was compared to the estimates obtained from the subjects of the MPOG cohort.

The HPI Study met its primary effectiveness endpoint. The HPI Pivotal Subjects of the full analysis set experienced a mean IOH duration of 11.97 ± 13.92 minutes compared with the MPOG historical control mean IOH of 28.20 ± 42.60 minutes. The table below demonstrates that this result was a reduction of 57.6% compared to the MPOG historical control ($p<0.0001$). When considering instances where there were zero episodes of IOH experienced during surgery, there was a 65% reduction of IOH ($p<0.0001$).

Mean IOH Duration – Primary Effectiveness Endpoint

Statistics	HPI (Subject=406)	MPOG (Subject=22,109)	p value
Sample size (n)	293	19,446	-
Total IOH Minutes	3,508	548,465	-
IOH Mean (mins)	11.97	28.20	<0.0001*
IOH STD	13.92	42.60	-

Note: IOH Estimated with Stand Method; STD Estimated with Pooled Method (Pivotal Subject with IOH Episode in Test Arm). Standard Method - IOH episode is defined with at least three consecutive observations having MAP<65. FAS pivotal Subjects, with at least 3-hour surgery time.
*One-sided unequal variances t-test was used in analysis. Nominal alpha for the test is 0.025.

The results of the secondary effectiveness endpoint, determination of total area under the curve (AUC) of the time, and MAP for all time periods for which MAP < 65 mmHg in each Subject, are included in the table below**.**

Intraoperative Hypotension AUC – ITT, Pivotal Subjects (AUC displayed as Min*mmHg)

Study Category	Subject	AUC Mean	AUC SD	AUC Median	AUC Range	AUC Q3-Q1
All pivotal Subjects	457	46.38	82.75	16.67	833.00	54.00
All pivotal Subjects with at least one episode	328	64.63	91.46	32.33	832.00	68.00
All pivotal Subjects with ≥3 hours surgery duration	406	47.07	85.30	16.83	833.00	51.00
All pivotal Subjects with ≥ 3 hours surgery duration and at least one IOH episode	293	65.23	94.36	32.00	832.00	62.67
All pivotal Subjects with <3 hours surgery duration	51	40.89	58.94	12.33	291.00	71.33
All pivotal Subjects with <3 hours surgery duration and at least one IOH episode	35	59.58	62.94	37.00	290.00	73.33

Note: Standard Method - IOH episode is defined with at least three consecutive observations having MAP<65. ITT pivotal subjects, with valid surgery time.

Safety

The Acumen HPI Feature was shown to be safe when used in surgical patients that require advanced hemodynamic monitoring.

- There were no Subjects with events adjudicated to have any relationship to the Acumen HPI Feature.
- There were no ADEs or SADEs adjudicated as related to the Acumen HPI Feature.
- There were no unanticipated ADEs (0%) related to the HPI Feature.
- There were no deaths that occurred whether related/unrelated to HPI Feature.

The secondary safety endpoint was a composite of 30-day post-operative AEs in the completed cases (CC) population. The table below shows the components of the 30-Day post-operative composite endpoint for the Completed Cases (CC) population. The results demonstrate that the composite event rate was 4.75% (composite events =19 [95% CI: 2.88, 7.32], with one subject experiencing more than one of the individual composite elements).

HPI Study - 30 Days Post-Operative Composite Endpoint Components -CC Analysis Population (Pivotal Subjects, n=400)

Analysis Endpoint	AE Event		POD Post-surgery Days		
	Events n(%)	95% CI	Mean	Median	Range
Postoperative Non-Fatal Cardiac Arrest	1 (0.25)	0.01, 1.38	2.00	2.00	2, 2
In-Hospital Death	0 (0.00)	0.00, 0.92	N/A	N/A	N/A
Stroke	0 (0.00)	0.00, 0.92	N/A	N/A	N/A
Acute Kidney Injury - Overall	16 (4.00)	2.30, 6.41	5.94	1.00	0, 27
Acute Kidney Injury - Stage 1	11 (2.75)	1.38, 4.87	6.82	1.00	0, 27
Acute Kidney Injury - Stage 2	3 (0.75)	0.15, 2.18	6.33	7.00	2, 10
Acute Kidney Injury - Stage 3	2 (0.50)	0.06, 1.79	0.50	0.50	0, 1
Myocardial Injury (MINS)	3 (0.75)	0.15, 2.18	1.67	1.00	0, 4

CC=Complete (Evaluable) Group, CI=confidence interval, Post-surgery Days (POD)=AESTDT-SGDT

Analysis of in the intent-to-treat population (n=460) yielded 3 (.066%) instances of myocardial injury (MINS) and 17 (3.7%) incidents of acute kidney injury (AKI).

Study Summary

These results demonstrate a reduction in mean IOH, that was consistent across most sites; most sites had a > 25% reduction in its mean duration of IOH, with all sites but one exceeding 35%; ranging from a23% to 72% mean IOH reduction. The findings of the study showed a reduction of the duration of IOH to 11.97 mins (SD 13.92), representing a 57.6% reduction ($p<0.0001$). This reduction is clinically relevant, as IOH lasting at least 1-minute has been associated with perioperative complications and morbidity such as AKI, MINS and stroke[1].

The results demonstrate that Acumen HPI Feature was shown to be safe when used in surgical patients that require advanced hemodynamic monitoring, with no device-related adverse events. Additionally, the composite event rate 4.75% (composite events =19 [95% CI: 2.88, 7.32] is low when considering that the subjects were ASA Physical Status 3 and 4 undergoing non-cardiac surgery.

Conclusion

The results of this study provide valid scientific evidence that the Acumen HPI feature is safe and provided a clinically significant reduction in mean IOH. Acumen HPI is effective in detecting hemodynamic instability and reducing the amount ofintraoperative hypotension when used in surgical patients who require intraoperative hemodynamic monitoring during non-cardiac surgery.

Conclusion	Acumen Hypotension Prediction Index Feature as implemented on the HemoSphere Advanced Monitoring Platform (K201446, October 1, 2020) is equivalent to itself as there are no changes to the Acumen Hypotension Prediction Index feature indications for use, algorithm, nor the hardware and software of the HemoSphere Advanced Monitoring Platform. Additionally, the Acumen Hypotension Prediction Index (HPI parameter) algorithm as implemented on the HemoSphere Advanced Monitoring Platform (K201446, October 1, 2020) is identical to Acumen Hypotension Prediction Index (HPI parameter) algorithm (DEN160044, March 16, 2020). The clinical performance data further demonstrate the utility of the Acumen Hypotension Prediction Index Feature Software in the detection of hemodynamic instability and in the treatment of intraoperative hypotension (IOH) during non-cardiac surgery. The Acumen Hypotension Prediction Index is substantially equivalent to the Acumen Hypotension Prediction Index (HemoSphere Advanced Monitoring Platform), K201446.