September 11, 2024

Diagnoly
% Nima Akhlaghi
Associate Director, Digital Health Regulatory Affairs
MCRA, LLC
505 Park Avenue, 14th Floor
New York, NY 10022

Re: K241380
Trade/Device Name: FETOLY-HEART
Regulation Number: 21 CFR 892.1550
Regulation Name: Ultrasonic Pulsed Doppler Imaging System
Regulatory Class: Class II
Product Code: IYN, IYO, QIH
Dated: August 9, 2024
Received: August 9, 2024

Dear Nima Akhlaghi:

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 (the 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 available 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.

FDA's substantial equivalence determination also included the review and clearance of your Predetermined Change Control Plan (PCCP). Under section 515C(b)(1) of the Act, a new premarket notification is not required for a change to a device cleared under section 510(k) of the Act, if such change is consistent with an

established PCCP granted pursuant to section 515C(b)(2) of the Act. Under 21 CFR 807.81(a)(3), a new premarket notification is required if there is a major change or modification in the intended use of a device, or if there is a change or modification in a device that could significantly affect the safety or effectiveness of the device, e.g., a significant change or modification in design, material, chemical composition, energy source, or manufacturing process. Accordingly, if deviations from the established PCCP result in a major change or modification in the intended use of the device, or result in a change or modification in the device that could significantly affect the safety or effectiveness of the device, then a new premarket notification would be required consistent with section 515C(b)(1) of the Act and 21 CFR 807.81(a)(3). Failure to submit such a premarket submission would constitute adulteration and misbranding under sections 501(f)(1)(B) and 502(o) of the Act, respectively.

Additional information about changes that may require a new premarket notification are provided in the FDA guidance documents entitled "Deciding When to Submit a 510(k) for a Change to an Existing Device" (https://www.fda.gov/media/99812/download) and "Deciding When to Submit a 510(k) for a Software Change to an Existing Device" (https://www.fda.gov/media/99785/download).

Your device is also subject to, among other requirements, the Quality System (QS) regulation (21 CFR Part 820), which includes, but is not limited to, 21 CFR 820.30, Design controls; 21 CFR 820.90, Nonconforming product; and 21 CFR 820.100, Corrective and preventive action. Please note that regardless of whether a change requires premarket review, the QS regulation requires device manufacturers to review and approve changes to device design and production (21 CFR 820.30 and 21 CFR 820.70) and document changes and approvals in the device master record (21 CFR 820.181).

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 Part 803) for devices or postmarketing safety reporting (21 CFR Part 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 Part 4, Subpart A) for combination products; and, if applicable, the electronic product radiation control provisions (Sections 531-542 of the Act); 21 CFR Parts 1000-1050.

All medical devices, including Class I and unclassified devices and combination product device constituent parts are required to be in compliance with the final Unique Device Identification System rule ("UDI Rule"). The UDI Rule requires, among other things, that a device bear a unique device identifier (UDI) on its label and package (21 CFR 801.20(a)) unless an exception or alternative applies (21 CFR 801.20(b)) and that the dates on the device label be formatted in accordance with 21 CFR 801.18. The UDI Rule (21 CFR 830.300(a) and 830.320(b)) also requires that certain information be submitted to the Global Unique Device Identification Database (GUDID) (21 CFR Part 830 Subpart E). For additional information on these requirements, please see the UDI System webpage at https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance/unique-device-identification-system-udi-system.

Also, please note the regulation entitled, "Misbranding by reference to premarket notification" (21 CFR 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,

Yanna S. Kang -S

Yanna Kang, Ph.D.
Assistant Director
Mammography and Ultrasound Team
DHT8C: Division of Radiological
Imaging and Radiation Therapy Devices
OHT8: Office of Radiological Health
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: 07/31/2026
See *PRA Statement below.*

Submission Number *(if known)*

K241380

Device Name

FETOLY-HEART

Indications for Use *(Describe)*

Fetoly-Heart is intended to analyze fetal ultrasound image sequences using machine learning techniques to automatically detect heart views and quality criteria within the views.
The device is intended for use as a concurrent reading aid during the acquisition and interpretation of fetal ultrasound images.

Fetoly-Heart is indicated for use during routine fetal heart examination of 2nd and 3rd trimester pregnancy (gestational age: from 17 to 40 weeks).

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

[X] 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."

In accordance with 21 CFR 807.92 the 510(k) summary for FETOLY-HEART is provided below.

1 510(k) owner

Owner	Diagnoly 60 Avenue Rockefeller 69008 Lyon, France +33(0)4.78.76.85.75
Primary contact person	Ivan Voznyuk Chief Executive Officer Diagnoly Phone: +33(0)6.95.87.04.55 Email: ivan@diagnoly.com
Secondary contact person	Nima Akhlaghi Associate Director, Digital Health Regulatory Affairs MCRA, LLC Phone: 202.742.3889 Email: nakhlaghi@mcra.com
Date prepared	2024-08-30

2 Device

Trade Name	FETOLY-HEART
Classification name	Accessory to Ultrasonic Pulsed Doppler Imaging System, 21 CFR 892.1550 Accessory to Ultrasonic Pulsed Echo Imaging System, 21 CFR 892.1560 Medical image management and processing system, 21 CFR 892.2050
Class	II
Product code	IYN (Primary) IYO, QIH (secondary)

3 Predicate device identification

The predicate device used for FETOLY-HEART is the cardiac-related component of Sonio Detect (K240406).

Additionally, a reference device was chosen for FETOLY-HEART based on its substantially equivalent technical characteristics of automatic extraction of views from a sequence of images. This reference

device corresponds to the SonoLystLive view suggestion feature within the Voluson Expert Series 22/20/18 (K220358).

4 Device description

FETOLY-HEART is a software that aims at helping sonographers, obstetricians, radiologists, maternal-fetal medicine specialists, and pediatric cardiologists (designated as healthcare professionals i.e. HCPs) to perform fetal ultrasound examinations of the fetal heart in real-time. FETOLY-HEART can be used by HCPs during fetal ultrasound examinations in the second and third trimesters (gestational age window: from 17 to 40 weeks). The software is intended to assist HCPs in the completeness assessment of the fetal heart ultrasound examination in accordance with national and international guidelines.

To utilize FETOLY-HEART, the software needs to be installed on a hardware device which is connected to an Ultrasound Machine through an HDMI connection. The software receives ultrasound images captured by the connected Ultrasound Machine in real-time. The software's frozen deep learning algorithm, which was trained by supervised learning, analyzes images of this ultrasound image stream to detect heart views and quality criteria within those views. The software provides the following user-accessible information:

- **Examination completeness**: the software displays in real-time which heart views and quality criteria are verified by the software during the examination. ***It is the main and principal output of the FETOLY-HEART device.*** The verified heart views and quality criteria are accessible by clinicians at any moment of the ultrasound examination, in real-time.
- **Completeness illustration:** the software selects an image subset that illustrates the verified views and quality criteria. These images can be reviewed by clinicians to verify the views and criteria's presence. This is a secondary output of the FETOLY-HEART device. Optionally, clinicians can display detected quality criteria localization on selected images.

4.1 Definition of a complete examination

Heart views	Quality criteria within the views	
 **(A) ABD Abdomen view (n = 8)**	(A1) Sp	Spine
	(A2) lRb	Left rib
	(A3) rRb	Right rib
	(A4) Ao	Descending aorta
	(A5) VC	Inferior vena cava
	(A6) St	Stomach
	(A7) Uv	Umbilical vein
	(A8) Ap	Thorax apex
	(B1) Sp	Spine

 **(B) 4CH** **Four chamber view** **(n = 19)**	(B2) lRb	Left rib
	(B3) rRb	Right rib
	(B4) Ao	Descending aorta
	(B5) lPV	Left pulmonary vein
	(B6) rPV	Right pulmonary vein
	(B7) LA	Left atrium
	(B8) RA	Right atrium
	(B9) FOP	Foramen Ovale flap (Vieussens valve)
	(B10) FO	Open Foramen Ovale
	(B11) MV	Mitral valve
	(B12) TV	Tricuspid valve
	(B13) bCr	Connection between crux and atrial septum (vestibular septum)
	(B14) Cr	Atrioventricular valve offset in crux
	(B15) tCr	Connection between interventricular septum and crux
	(B16) IVS	Interventricular septum
	(B17) LV	Left ventricle
	(B18) RV	Right ventricle
	(B19) Str	Sternum
 **(C) LVOT** **Left Ventricular Outflow Tract view** **(n = 6**)	(C1) LA	Left atrium
	(C2) aAo	Proximal ascending aorta
	(C3) SV	Semilunar valves
	(C4) LV	Left ventricle
	(C5) IVS	Interventricular septum
	(C6) RV	Right ventricle
 **(D) RVOT** **Right Ventricular Outflow Tract view** **(n = 10**)	(D1) dAo	Descending aorta
	(D2) Tr	Trachea / bronchi
	(D3) lPA	Left pulmonary artery
	(D4) Du	Ductus arteriosus
	(D5) rPA	Right pulmonary artery
	(D6) Or	Origin of pulmonary arteries
	(D7) S	Septum between pulmonary artery trunk and ascending aorta
	(D8) aAo	Ascending aorta
	(D9) SVC	Superior vena cava
	(D10) PA	Pulmonary trunk
 **(E) 3VX** **Three vessels view** **(n = 9)**	(E1) Sp	Spine
	(E2) Tr	Trachea
	(E3) ES	Side space on the left of ductus / pulmonary artery
	(E4) PA	Main pulmonary artery
	(E5) Du	Ductus (Ductal arch)
	(E6) aAo	Ascending aorta
	(E7) aAr	Aortic arch
	(E8) SVC	Superior vena cava
	(E9) Th	Thymus / sternum

Table 1. List of 52 quality criteria defining the quality of the 5 views recommended by the International Society of Ultrasound in Obstetrics and Gynecology for the foetal heart screening of 2nd and 3rd trimesters of pregnancy. Abbreviations from this table are corresponding to the abbreviations used within the software.

International and national guidelines[1] recommend 5 foetal cardiac views for routine ultrasound examination of 2nd and 3rd trimesters: (A) Abdomen view, (B) Four chamber view, (C) Left Ventricular Outflow Tract view, (D) Right Ventricular Outflow Tract view, (E) Three vessels view. The quality of these 5 heart views depends on the presence of 52 anatomical quality criteria within the views (**Table 1**). Thus, an examination can be defined as complete when all 5 heart views and their quality criteria are obtained by the HCP.

4.2 Functionality 1: completeness overview

The software assesses the completeness of the foetal ultrasound examination. It verifies whether all the information corresponding to the recommended guidelines for the foetal heart examination has been acquired. This information corresponds to the presence of 5 main foetal cardiac views and 52 quality criteria, detailed in the above section, allowing for compliance in cardiac screening.

4.3 Functionality 2: completeness illustration

This functionality was developed to enhance the security of the completeness evaluation which is done by the first module. It enables clinicians to verify the examination completeness overview, i.e. verified views and quality criteria by the software through the gallery page of the software interface. Operating continuously, it evaluates each image processed by the first module in real-time, retaining an image set as visual evidence of the verified heart views and quality criteria up to that moment.

FETOLY-HEART does not aim to select the 'best' or of 'high' diagnostic quality according to a given qualitative scale. Rather, FETOLY-HEART aims to select images illustrating the examination quantitative completeness in terms of verified views and quality criteria.

5 Indications for use

FETOLY-HEART is intended to analyse fetal ultrasound images and clips using machine learning techniques to automatically detect heart views and quality criteria within the views. The device is intended for use as a concurrent reading aid during the acquisition and interpretation of fetal ultrasound images.

FETOLY-HEART is indicated for use during routine fetal heart examination of 2nd and 3rd trimester pregnancy (gestational age: from 17 to 40 weeks).

[1] Carvalho JS, Axt-Fliedner R, Chaoui R, Copel JA, Cuneo BF, Goff D, Gordin Kopylov L, Hecher K, Lee W, Moon-Grady AJ, Mousa HA, Munoz H, Paladini D, Prefumo F, Quarello E, Rychik J, Tutschek B, Wiechec M, Yagel S. ISUOG Practice Guidelines (updated): fetal cardiac screening. Ultrasound Obstet Gynecol 2023; 61: 788–803.

6 Summary of the technological characteristics of FETOLY-HEART compared to the predicate device

Aspect	Predicate device: Sonio Detect (Cardiac Features) K240406	Reference device: Voluson Expert 18/20/22 (Cardiac-related SonolystLive Feature) K220358	Proposed device: FETOLY-HEART	Comparison between Proposed and Predicate device
General				
Manufacturer name	Sonio	GE Healthcare	Diagnoly	NA
Device name	Cardiac-related features in Sonio Detect	Cardiac-related SonolystLive in the Voluson Expert 18/20/22	FETOLY-HEART	NA
Product code(s)	IYN (Primary) IYO, QIH (secondary)	IYN (Primary) IYO, ITX (Secondary)	IYN (Primary) IYO, QIH (secondary)	**Substantially equivalent** Primary codes are the same for all devices
Regulation number	- Accessory to Ultrasonic Pulsed Doppler Imaging System, 21 CFR 892.1550 - Accessory to Ultrasonic Pulsed Echo Imaging System, 21 CFR 892.1560	- Ultrasonic Pulsed Doppler Imaging System, 21 CFR 892.1550 - Ultrasonic Pulsed Echo Imaging System, 21 CFR 892.1560 - Diagnostic Ultrasound Transducer, 21 CFR 892.1570, 90-ITX	- Accessory to Ultrasonic Pulsed Doppler Imaging System, 21 CFR 892.1550 - Accessory to Ultrasonic Pulsed Echo Imaging System, 21 CFR 892.1560 - Medical image management and processing system, 21 CFR 892.2050	**Substantially equivalent** All devices are class II devices subject to 510(k) regulatory pathway.
Brief description	The predicate device is a software that aims at helping sonographers, OB/GYNs, MFMs and Fetal surgeons (all three designated as healthcare professionals i.e. HCP) to perform their routine fetal heart ultrasound	The reference device is a software that aims at helping sonographers, OB/GYNs, MFMs and Fetal surgeons (all three designated as healthcare professionals i.e. HCP) to perform their routine fetal heart ultrasound	FETOLY-HEART is a software that aims at helping sonographers, OB/GYNs, MFMs and Fetal surgeons (all three designated as healthcare professionals i.e. HCPs) to perform their routine fetal heart ultrasound	**Substantially equivalent** The subject device and the predicate devices have the same objective.

	examinations in real-time.	examinations in real-time.	examinations in real-time.	
Indications for use	The predicate device is intended to analyze fetal ultrasound images and clips using machine learning techniques to automatically detect heart views, detect anatomical structures within the views and verify quality criteria of the views. The device is intended for use as a concurrent reading aid during the acquisition and interpretation of fetal ultrasound images.	The device is a general purpose ultrasound system intended for use by qualified and trained healthcare professionals.	FETOLY-HEART is intended to analyse fetal ultrasound images and clips using machine learning techniques to automatically detect heart views and quality criteria within the views. The device is intended for use as a concurrent reading aid during the acquisition and interpretation of fetal ultrasound images. FETOLY-HEART is indicated for use during routine fetal heart examination of 2nd and 3rd trimester pregnancy (gestational age: from 17 to 40 weeks).	**Substantially equivalent** Indications for Use are the same between predicate and subject devices.
Targeted population	Pregnant women during the 2nd and 3rd trimester of pregnancy	Pregnant women during the 2nd trimester of pregnancy	Pregnant women during the 2nd and 3rd trimester of pregnancy	**Substantially equivalent** Subject device has the same intended patient population than the predicate devices.
Clinical outcome	- Images labeled with correct fetal heart view	- Images labeled with correct fetal heart view	- Images labeled with correct fetal heart view for patient cases	**Substantially equivalent** Performance testing has successfully validated the clinical outcomes
	- Quality criteria identified as “Verified” when detected and “Not verified” when not detected	- Quality criteria identified as “Found” when detected and “Not found” when not detected	- Quality criteria identified as “Verified” when detected and “Not	**Substantially equivalent** In the subject device, quality criteria bounding box localization can be

			verified" when not detected - Images labeled with the localization of quality criteria	optionally displayed on post-acquisition images to enhance explainability of the AI model. Performance testing has been performed and does not introduce new questions of safety and effectiveness.
Intended user	Qualified healthcare professional specialized in prenatal ultrasound imaging	Qualified healthcare professional specialized in prenatal ultrasound imaging	Qualified healthcare professional specialized in prenatal ultrasound imaging	**Substantially equivalent** Subject device has the same intended users as the predicate devices.
Clinical applications	Fetal/Obstetrics	Fetal/Obstetrics	Fetal/Obstetrics	**Substantially equivalent** Clinical application is the same for subject and predicate devices.
Inclusion of a PCCP	N/A	N/A	Included	**Different** The PCCP in the subject device includes proposed modifications related to modifying model training hyperparameters, additional retraining with new training and validation datasets collected, and addition/removal of heart quality criteria.
Functionality 1: completeness overview				
Automatically detect views	Detection of 4ch, 3vx, LVOT, RVOT and Abd views (complete implementation of ISUOG recommendations)	Detection of 4ch, 3vx, LVOT, RVOT and Abd views (complete implementation of ISUOG recommendations)	Detection of 4ch, 3vx, LVOT, RVOT and Abd views (complete implementation of ISUOG recommendations)	**Substantially equivalent** The subject device includes the detection of the same views than the predicate device.

Automatically detect quality criteria	Detection of 28 heart quality criteria. The quality also incorporates the zoom level of the view.	Detection of NA heart quality criteria.	Detection of *52* heart quality criteria (see Table 1). The quality also incorporates the zoom level of the view.	**Substantially equivalent** The subject device includes the detection of new quality criteria when compared to the predicate device. This quantitative enhancement has been tested and does not raise any new question of safety and effectiveness.
Functionality 2: completeness illustration				
Automatically selects views	NA	Automatic suggestion of views from a sequence of images.	Automatic extraction of views from a sequence of images.	**Substantially equivalent** This image selection functionality is a feature absent in the predicate device but present in the reference device. Software testing has been performed to validate its use and does not introduce new questions of safety and effectiveness.
Technical characteristics				
Data input	Accepts images and image sequences from ultrasound machines	Accepts images and image sequences from ultrasound machines	Accepts images and image sequences from ultrasound machines	**Substantially equivalent** The input data is the same for the subject device and the predicate and reference devices.
Algorithm Methodology	Artificial Intelligence: Utilizes computer vision algorithms to analyze ultrasound images and provides visualization of detected landmarks and views	Artificial Intelligence: Utilizes computer vision algorithms to analyze ultrasound images and provides visualization of detected landmarks and views	Artificial Intelligence: Utilizes computer vision algorithms to analyze ultrasound images and provides visualization of detected landmarks and views	**Substantially equivalent** The subject device and the primary predicate device use both artificial intelligence.

Platform	Operates in a cloud-based environment functioning independently from the ultrasound equipment.	Operates as a local software embedded in the ultrasound equipment.	Operates as a local software functioning independently from the ultrasound equipment.	**Substantially equivalent** The edge-based approach reduces exposure to potential cloud-related vulnerabilities and latency issues. Therefore, this difference does not raise any safety or effectiveness concerns.
Ultrasound Machine compatibility	Compatible with ultrasound system from GE Medical, Samsung, Canon and Philips	NA	Compatible with ultrasound system from GE Medical, Samsung and Canon	**Substantially equivalent** This compatibility has been tested and validated as part of device generalizability in the performance testing study.
User interaction	The user can interact with the software to override the software's outputs. The user has the ability to review and edit/override the matching at any time during or at the end of the exam.	NA	The user can interact with the software to override the software's outputs. The user has the ability to review and edit/override the matching at any time during or at the end of the exam.	**Substantially equivalent** User interactions are the same between primary predicate and subject devices.

7 Non-clinical performance data

7.1 FETOLY-HEART testing strategy

The following V&V testing were included into the development of the system:

- Software verification testing per IEC 62304 standard
- Tablet compatibility testing
- Cybersecurity verification testing
- Software AI model validation

FETOLY-HEART uses a machine learning (ML) algorithm for detection of heart views and quality criteria within these views in ultrasound images. Modifications to FETOLY-HEART will be made in accordance with the guiding principles on predetermined change control plans (PCCP) for machine learning-enabled medical devices. This PCCP provides a description of the device's planned modifications, and those modifications will be triggered and implemented in a controlled manner that ensures the continued safety and efficacy on the performance testing dataset, mitigating risks associated with changes to the ML model to not adversely impact the device's performance, safety, or effectiveness associated with its indications for use, and an impact assessment of the planned modifications.

In accordance with the PCCP, all algorithm modifications will be adequately trained, tuned, and locked prior to release of the software with the modified ML model. The PCCP does not include the implementation of adaptive algorithms that will continuously learn in the field. Implemented modifications to the FETOLY-HEART algorithm will be communicated to users via the software update notifications and through updated labelling. The modifications outlined in the PCCP are summarized in the table below. The PCCP in the subject device with the proposed modifications related to modifying model training hyperparameters, additional retraining with new training and validation datasets collected, and addition/removal of heart quality criteria do not raise different questions of safety and effectiveness from the predicate device (see table below).

Summary of changes to FETOLY-HEART per the PCCP:

Modification	Rationale	Testing Methods	Impact Assessment
Modification of training and/or validation datasets	Increase or recovery (in case of data drift) of FETOLY-HEART's performance.	Re-training of the FETOLY-HEART model with new data to optimize its performance followed by internal testing and a comparison of the initial model to the modified model using performance metrics on the test dataset.	Increased performance metrics of the modified model for view or quality criteria detection. Benefits: Increase or recovery of performance; generalization for diverse cases. Risks: Performance decrease (overfitting, unintended bias). Risk mitigation: The modified model will be tested for superiority on the performance study test dataset which will contain new unseen data.
Modification of model training hyperparameters	Improvement and optimization of FETOLY-HEART's performance	Re-training of the FETOLY-HEART model with new parameters to optimize its performance followed by internal testing and a comparison of the initial model to the modified model using performance	Increased performance metrics of the modified model for view or quality criteria detection. Benefits: Increased performance; generalization for diverse cases. Risks: Performance decrease (overfitting, unintended bias).

		metrics on the test dataset.	Risk mitigation: The modified model will be tested for superiority on the performance study test dataset which will contain new unseen data.
Heart quality criteria addition/removal	Maintain alignment with quality criteria recommended for fetal heart screening in state-of-the-art international guidelines.	New quality criteria will be controlled using the same acceptance criteria as defined by secondary endpoints.	Enhanced compliance with standard international guidelines. Benefits: Keeping the device relevant by aligning with the updated list of heart quality criteria. Risks: Performance decrease and user confusion. Risk mitigation: Proper performance testing with no decrease in test performance. This change only pertains to quality criteria belonging to one of the 5 heart views already included in FETOLY-HEART.

7.2 FETOLY-HEART performance study

Diagnoly conducted a standalone performance testing on a dataset of 2,288 fetal ultrasound images across 480 patient cases, including full examination still images, cardiac clip frames and full examination video frames from 7 clinical sites in the United States and France. These sites and cases are representative of the intended use population. This testing dataset originated from distinct clinical sites from which the data used during model development (training/validation) was sourced, ensuring testing independence.

The results of the standalone performance testing demonstrate that FETOLY-HEART automatically detects fetal heart ultrasound views with a sensitivity ≥ 85% (acceptance criterion) and specificity ≥ 85% (acceptance criterion), detects quality criteria within heart views with a sensitivity ≥ 90% (acceptance criterion) and a specificity ≥ 90% (acceptance criterion), and localizes bounding boxes of quality criteria with a mean intersection over union (IoU) of ≥ 50% (acceptance criterion). Sensitivity and specificity were evaluated individually for each view, and the performance goal to exceed 85% as the lower bound of the corresponding 95% Confidence Interval (CI) was met. The CI was estimated using bootstrap resampling at the subject level based on 1,000 samples, with traditional bootstrap CI confidence limits derived as the 2.5th and 97.5th percentiles of the distribution of bootstrap estimates. The results are summarized in the tables below:

Fetal heart view	**Sensitivity**			**Specificity**		
	N(positive)	**Point estimate**	**Bootstrap CI (95%)**	**N(negative)**	**Point estimate**	**Bootstrap CI (95%)**
Abdomen view	428	0.976	(0.960,0.990)	1860	0.998	(0.996,1.000)

Four chamber view	391	0.987	(0.974,0.997)	1897	1.00	(1.000,1.000)
Left ventricular outflow tract view	360	0.983	(0.969,0.994)	1928	0.999	(0.998,1.000)
Right ventricular outflow tract view	313	0.987	(0.974,0.996)	1975	0.998	(0.996,1.000)
Three vessels view	316	0.981	(0.965,0.993)	1972	0.998	(0.997,1.000)
Other view	480	0.985	(0.972,0.995)	1808	0.983	(0.977,0.989)

Quality criterion	**Sensitivity**			**Specificity**			**mIoU**	
	N	**Point estimate**	**Bootstrap CI (95%)**	**N**	**Point estimate**	**Bootstrap CI (95%)**	**Point estimate**	**Bootstrap CI (95%)**
Abdomen view								
Spine	417	0.966	(0.949,0.981)	1871	0.995	(0.992,0.998)	0.739	(0.728,0.750)
Left rib	401	0.903	(0.873,0.933)	1887	0.997	(0.995,0.999)	0.651	(0.631,0.673)
Right rib	388	0.910	(0.882,0.940)	1900	0.997	(0.994,0.999)	0.624	(0.602,0.643)
Descending aorta	417	0.947	(0.925,0.969)	1871	0.998	(0.996,0.999)	0.528	(0.515,0.542)
Inferior vena cava	363	0.915	(0.884,0.941)	1925	0.992	(0.988,0.996)	0.512	(0.496,0.528)
Stomach	414	0.976	(0.961,0.988)	1874	0.995	(0.992,0.998)	0.734	(0.720,0.746)
Umbilical vein	345	0.962	(0.942,0.980)	1943	0.991	(0.987,0.994)	0.676	(0.660,0.693)
Thorax apex	397	0.919	(0.893,0.944)	1891	0.993	(0.989,0.997)	0.571	(0.549,0.592)
Four chamber view								
Spine	339	0.965	(0.944,0.982)	1949	0.999	(0.997,1.000)	0.768	(0.754,0.779)
Left rib	308	0.945	(0.917,0.970)	1980	0.996	(0.993,0.999)	0.744	(0.726,0.764)
Right rib	309	0.958	(0.934,0.980)	1979	0.996	(0.993,0.998)	0.749	(0.730,0.768)
Descending aorta	361	0.981	(0.965,0.994)	1927	0.996	(0.994,0.999)	0.646	(0.632,0.659)
Left pulmonary vein	127	0.921	(0.871,0.965)	2161	0.998	(0.995,1.000)	0.628	(0.601,0.653)
Right pulmonary vein	198	0.904	(0.860,0.943)	2090	0.996	(0.993,0.999)	0.601	(0.578,0.623)
Left atrium	387	0.990	(0.979,0.997)	1901	0.998	(0.996,1.000)	0.759	(0.747,0.771)
Right atrium	391	0.987	(0.975,0.997)	1897	1.00	(1.000,1.000)	0.774	(0.763,0.786)
Foramen ovale flap	113	0.929	(0.883,0.971)	2175	1.00	(0.999,1.000)	0.530	(0.505,0.561)
Open Foramen Ovale	348	0.951	(0.928,0.972)	1940	0.996	(0.993,0.999)	0.616	(0.598,0.634)
Mitral valve	207	0.908	(0.866,0.948)	2081	0.998	(0.995,1.000)	0.676	(0.654,0.695)
Tricuspid valve	243	0.959	(0.931,0.983)	2045	0.995	(0.992,0.998)	0.718	(0.701,0.735)
Connection between crux and atrial septum	299	0.943	(0.915,0.969)	1989	0.990	(0.986,0.994)	0.587	(0.567,0.603)
Atrioventricular valve offset in crux	115	0.939	(0.897,0.980)	2173	0.992	(0.988,0.995)	0.648	(0.623,0.673)
Connection between interventricular septum and crux	177	0.910	(0.868,0.951)	2111	0.996	(0.993,0.999)	0.565	(0.544,0.585)

Interventricular septum	216	0.917	(0.877,0.949)	2072	0.996	(0.993,0.999)	0.71	(0.689,0.728)
Left ventricle	389	0.987	(0.975,0.997)	1899	1.00	(1.000,1.000)	0.748	(0.734,0.761)
Right ventricle	387	0.990	(0.979,0.997)	1901	0.999	(0.997,1.000)	0.758	(0.746,0.770)
Sternum	322	0.972	(0.952,0.988)	1966	0.991	(0.986,0.995)	0.681	(0.661,0.700)
Left ventricular outflow tract view								
Left atrium	356	0.98	(0.966,0.992)	1932	0.997	(0.995,0.999)	0.656	(0.633,0.676)
Proximal ascending aorta	360	0.983	(0.969,0.994)	1928	0.999	(0.998,1.000)	0.716	(0.702,0.730)
Semilunar valves	165	0.909	(0.866,0.950)	2123	0.998	(0.995,1.000)	0.527	(0.503,0.552)
Left ventricle	358	0.978	(0.961,0.992)	1930	0.999	(0.998,1.000)	0.745	(0.732,0.758)
Interventricular septum	199	0.925	(0.888,0.959)	2089	0.995	(0.992,0.998)	0.663	(0.638,0.690)
Right ventricle	358	0.980	(0.964,0.992)	1930	0.999	(0.997,1.000)	0.698	(0.675,0.719)
Right ventricular outflow tract view								
Descending aorta	294	0.949	(0.924,0.971)	1994	0.997	(0.994,0.999)	0.617	(0.595,0.638)
Trachea / bronchi	180	0.922	(0.882,0.960)	2108	0.990	(0.985,0.994)	0.520	(0.491,0.548)
Left pulmonary artery	125	0.960	(0.921,0.992)	2163	0.995	(0.992,0.998)	0.615	(0.582,0.646)
Ductus arteriosus	177	0.944	(0.907,0.974)	2111	0.997	(0.995,0.999)	0.631	(0.606,0.656)
Right pulmonary artery	302	0.980	(0.965,0.994)	1986	0.994	(0.991,0.997)	0.654	(0.633,0.675)
Origin of pulmonary arteries	258	0.922	(0.889,0.953)	2030	0.997	(0.994,0.999)	0.589	(0.568,0.610)
Septum between pulmonary artery trunk and ascending aorta	218	0.945	(0.911,0.973)	2070	0.993	(0.989,0.996)	0.692	(0.672,0.710)
Ascending aorta	312	0.974	(0.957,0.990)	1976	0.998	(0.996,1.000)	0.633	(0.613,0.650)
Superior vena cava	218	0.940	(0.910,0.971)	2070	0.994	(0.991,0.998)	0.577	(0.549,0.603)
Pulmonary trunk	312	0.971	(0.952,0.990)	1976	0.999	(0.998,1.000)	0.760	(0.744,0.775)
Three vessels views								
Spine	276	0.953	(0.929,0.975)	2012	0.998	(0.996,1.000)	0.792	(0.779,0.805)
Trachea	206	0.932	(0.899,0.964)	2082	0.997	(0.994,0.999)	0.539	(0.517,0.562)
Side space on the left of ductus	270	0.933	(0.901,0.961)	2018	0.991	(0.987,0.995)	0.784	(0.767,0.800)
Main pulmonary artery	169	0.947	(0.910,0.976)	2119	0.999	(0.998,1.000)	0.733	(0.708,0.755)
Ductus	141	0.972	(0.944,0.993)	2147	0.998	(0.996,1.000)	0.749	(0.724,0.771)
Ascending aorta	181	0.978	(0.954,0.995)	2107	0.999	(0.997,1.000)	0.621	(0.599,0.643)
Aortic arch	133	0.97	(0.942,0.993)	2155	0.997	(0.995,0.999)	0.724	(0.699,0.747)
Superior vena cava	303	0.964	(0.942,0.983)	1985	0.996	(0.994,0.999)	0.528	(0.508,0.547)
Thymus/sternum	212	0.915	(0.876,0.953)	2076	0.998	(0.995,1.000)	0.716	(0.693,0.737)

The performance validation dataset included the following clinical subgroups: maternal age, gestational age, territory, BMI, scanner manufacturer, heart abnormality. It also comprised races and ethnicities and various clinical sites, ensuring representation across the intended use population. Image digital quality (bad, average, good) and image type (still image from entire examination, cardiac clip frame, full examination frame) were identified as potential confounders and controlled for. Performance metrics were analyzed for each subgroup and confounder to validate the model's robustness and generalizability. The subgroups distribution is summarized in the table below:

Subgroup		Number of cases (total=480)	Number of images (total=2,288)
Center	Center 1	99 (20.6%)	505 (22.1%)
	Center 2	63 (13.1%)	248 (10.8%)
	Center 3	84 (17.5%)	378 (16.5%)
	Center 4	55 (11.5%)	264 (11.5%)
	Center 5	54 (11.2%)	275 (12.0%)
	Center 6	55 (11.5%)	265 (11.6%)
	Center 7	70 (14.6%)	353 (15.4%)
Territory	US	234 (48.8%)	1157 (50.6%)
	EU	246 (51.2%)	1131 (49.4%)
Gestational age	2nd trimester	233 (48.5%)	1189 (52.0%)
	3rd trimester	243 (50.6%)	1075 (47.0%)
	Unknown	4 (0.8%)	24 (1.0%)
Maternal age	< 20 years	27 (5.6%)	128 (5.6%)
	[20-29] years	214 (44.6%)	1020 (44.6%)
	[30-39] years	194 (40.4%)	901 (39.4%)
	≥40 years	26 (5.4%)	127 (5.6%)
	Unknown	19 (4.0%)	112 (4.9%)
BMI	<18.5 kg/m2	20 (4.2%)	99 (4.3%)
	[18.5;24.9] kg/m2	137 (28.5%)	661 (28.9%)
	[25;29.9] kg/m2	108 (22.5%)	491 (21.5%)
	≥30 kg/m2	157 (32.7%)	712 (31.1%)
	Unknown	58 (12.1%)	325 (14.2%)
Scanner manufacturer	General Electric	163 (34.0%)	781 (34.1%)
	Samsung	297 (61.9%)	1405 (61.4%)
	Canon	20 (4.2%)	102 (4.5%)
Fetus cardiac normality	Abnormal	32 (6.7%)	179 (7.8%)
	Normal	448 (93.3%)	2109 (92.2%)
Image digital quality	Bad	-	708 (30.9%)
	Average	-	815 (35.6%)
	Good	-	765 (33.4%)
Image type	Full exam video frame	-	145 (6.3%)

	Cardiac clip frame	-	771 (33.7%)
	Full exam still image	-	1372 (60.0%)
Race and ethnicity	**Asian and Pacific Islander**	23 (4.8%)	107 (4.7%)
	Black	125 (26.0%)	607 (26.5%)
	Hispanic	43 (9.0%)	209 (9.1%)
	White	277 (57.7%)	1295 (56.6%)
	Unknown	12 (2.5%)	70 (3.1%)

Patient cases were retrospectively collected in reverse chronological order until at least 20 patient files per subgroup and an overall of 275 patient files were reached. To limit correlation of the images used for evaluation, one image maximum per view per patient case was selected by categorizing 12,934 images from the patient cases into heart views and randomly picking one image maximum per view, resulting in a total of 2,288 images.

A 2+1 ground truth procedure was used to obtain the reference standard of the dataset. Six annotators (3 sonographers and 3 OB/GYN doctors) were paired and assigned uniformly distributed batches of images. The attribution was randomized so that each pair treated images belonging to various subgroups. Each image was annotated by a pair of annotators as belonging to one of 6 views. Images with annotator agreement were considered ground truth. Images in which the pair of annotators disagreed were reviewed by an adjudicator, who made the final decision.

For quality criteria classification and localization, each image was annotated by a pair of annotators who drew bounding boxes on present criteria. If their boxes had at least 50% overlap, their coordinates were averaged to form the ground truth. If the overlap was lower or there was a disagreement on the criterion presence, an adjudicator reviewed the boxes. The final decision regarding the presence was based on majority consensus among the adjudicator and annotators. The final decision for the criteria localization was based on the adjudicator's decision to either keep one of the annotator's boxes or draw a new one.

The results of verification and performance testing demonstrate the safe and effective use of FETOLY-HEART.

8 Clinical performance data

Not applicable.

9 Conclusion from non-clinical tests

FETOLY-HEART intended users, clinical outcome and clinical applications are similar to those of the predicate device Sonio Detect. The technological characteristics differences identified and discussed in Section VI are covered by a reference device, the SonoLystLive view suggestion feature within the Voluson Expert Series 22/20/18 (K220358), and do not raise different questions of safety and effectiveness of the device.

Furthermore, results of successful verification and validation activities and additional performance testing do not raise any new issue regarding the safety and effectiveness of the device. FETOLY-HEART is therefore substantially equivalent to its predicate device Sonio Detect (K240406).