

FDA Executive Summary

Prepared for the
September 11, 2013 meeting of the
Circulatory System Devices Panel

**Classification of the External Cardiac
Compressor (including CPR Aid Devices)
[21 CFR 870.5200]**

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Overview

On September 11, 2013, the Food and Drug Administration (FDA) will convene the Circulatory System Devices Advisory Committee to discuss the classification of external cardiac compressors (21 CFR 870.5200) for use on victims of cardiac arrest to augment manual cardiopulmonary resuscitation (CPR) and/or encourage effective and consistent application of manual CPR.

External cardiac compressors (ECCs), also known as chest compressors, assist in the act of CPR. The devices in this classification are divided into two types: (1) Devices that provide automatic chest compressions at a fixed compression rate and depth (automated external cardiac compressors), which are placed directly on the patient's chest and are powered manually, pneumatically, or electrically and (2) devices that aid the emergency medical professional in delivering manual compressions at a compression depth and rate that are consistent with current guidelines (CPR Aids). These devices are placed beneath the hands of the emergency medical professional or in the vicinity of the cardiac arrest victim and provide audio and/or visual feedback to assist emergency personnel in following the recommended steps for CPR and maintaining the recommended rate and depth of compressions for the duration of CPR.

The external cardiac compressor (ECC) devices are one of the remaining pre-amendment Class III medical devices currently cleared for marketing through the premarket notification [510(k)] pathway. FDA proposed a revised definition/identification for ECC devices, as well as reclassification from Class III to Class II (Special Controls) for these devices (see 78 FR 1162, January 8, 2013). FDA also proposed that CPR aid devices that provide feedback consistent with the current AHA guidelines would also be exempt from the requirement for submission of a 510(k). After consideration of the comments received on the proposed order, FDA is presenting at this panel meeting additional suggested changes to the identification language, including dividing the cardiac compressors and CPR aid devices into separate regulations, along with refinement of the classification and special controls for these devices.

The panel will be asked to provide input on the risks to health and benefits of external cardiac compressors including the devices designed to compress the chest, as well as the CPR aid devices that encourage and/or provide feedback to the rescuer regarding the application of effective and consistent CPR to the cardiac arrest victim. The panel will also be asked to discuss the FDA's proposed premarket regulatory classification strategy for external cardiac compressors including (also see Figure 3 below):

- 1) Dividing the current devices into two separate classification regulations, so that the external cardiac compressor (ECC) and cardiopulmonary resuscitation (CPR) aid devices will have distinct regulations with distinct identifications/definitions:
 - a. 870.5200 External Cardiac Compressor
 - b. 870.5210 Cardiopulmonary Resuscitation (CPR) Aid
- 2) Recommending a classification of Class II (Special Controls) for 870.5200 External Cardiac Compressor
- 3) Recommending a split classification for 870.5210 CPR aid devices:

- a. Class I (exempt from 510(k) and subject only to general controls) for CPR aid devices that do not offer feedback on CPR quality, e.g., metronomes, hand placement devices.
- b. Class II for CPR aid devices that offer real-time feedback regarding the quality of CPR being administered;
 - i. Exempt from 510(k) for mechanically or electro-mechanically designed devices that offer prompts and feedback (e.g., rate, compression/pressure); and
 - ii. 510(k) required for devices that are software driven; i.e. advanced technology (e.g., CPR guidance, coaching for rate, depth, breathing, different algorithms for different rescuer or patient scenarios, etc.).

The recommended re-classification from Class III to Class II and Class I is based upon the existing valid scientific evidence and the benefit/risk profile and the ability of the proposed level of control to mitigate the identified risks to health. If the panel agrees with the classification strategy recommendation being proposed, then the panel will also be asked to discuss the adequacy of the special controls proposed by FDA to mitigate the risks to health for the devices proposed for Class II and further comment on whether general controls alone are sufficient for the CPR aid device(s) without feedback.

Below is FDA's proposed regulatory classification strategy:

870.5200 External Cardiac Compressor

- (1) *Identification:* An external cardiac compressor is an externally-applied prescription device that is electrically, pneumatically, or manually powered and is used to compress the chest periodically in the region of the heart to provide blood flow during cardiac arrest. External cardiac compressor devices are used as an adjunct to manual cardiopulmonary resuscitation (CPR) during patient transport, extended CPR when fatigue may prohibit the delivery of effective/consistent compressions to the victim, or when insufficient EMS personnel are available to provide effective CPR.
- (2) *Classification:* Class II (special controls)

870.5210 Cardiopulmonary Resuscitation Aid Devices

CPR Aid without Feedback

- (1) *Identification:* A Cardiopulmonary Resuscitation (CPR) Aid without feedback is a device that performs a simple function such as proper hand placement and/or simple prompting for rate and/or timing of compressions/breathing for the professionally trained rescuer, but offers no feedback related to the quality of the CPR being provided. These devices are intended for use by persons professionally trained in CPR, to assure proper use and the delivery of optimal CPR to the victim.

(2) *Classification:* Class I (general controls).

CPR Aid with Feedback

(1) *Identification:* A CPR Aid device with feedback is a device that provides real-time feedback to the rescuer regarding the quality of CPR being delivered to the victim, and provides either audio and/or visual information to encourage the rescuer to continue the consistent application of effective manual CPR in accordance with current accepted CPR guidelines (e.g., to include, but not be limited to, parameters such as compression rate, compression depth, ventilation, recoil, instruction for one or multiple rescuers, etc.). These devices may also perform a coaching function to aid rescuers in the sequence of steps necessary to perform effective CPR on a victim.

(a) *Classification:* Class II (special controls). The device is exempt from the premarket notification procedures in subpart E of part 807 of this chapter if it does not contain software (e.g., is mechanical or electro-mechanical).

As discussed in the Introduction & Regulatory Reference Sheet provided, the panel will need to consider the risks to health of ECC and CPR aid devices as a class and determine whether the information available, which is subsequently discussed, fits the following criteria:

- (i) The information represents valid scientific evidence (according to 21 CFR 860.7) that is adequate to demonstrate a reasonable assurance of product safety and effectiveness; and
- (ii) Special controls can be established to mitigate the identified risks to health.

The Panel is tasked with discussing whether the risks to health for all the ECC and CPR aid devices currently included within this classification regulation have been appropriately identified. Further, the panel will be asked to discuss available scientific evidence for the currently-marketed technologies and indications.

As defined in 21 CFR 860.7(d)(1), there is reasonable assurance that a device is safe when it can be determined, based upon valid scientific evidence, that the probable benefits to health from use of the device for its intended uses and conditions of use, when accompanied by adequate directions and warnings against unsafe use, outweigh any probable risks. As defined in 21 CFR 860.7(e)(1), there is a reasonable assurance that a device is effective when it can be determined, based upon valid scientific evidence, that in a significant portion of the target population, the use of the device for its intended uses and conditions of use, when accompanied by adequate directions for use and warnings against unsafe use, will provide clinically significant results.

If a recommendation of Class III is made, each device would be expected to provide an independent dataset to demonstrate a reasonable assurance of safety and effectiveness prior to marketing the device. The collection of such data translates into establishing an initial knowledge basis of safety and effectiveness information on which to rely. Class

III devices, regulated through the PMA program, can be considered for reclassification at a later date once a valid scientific body of evidence has been collected to establish safety and effectiveness and special controls can be developed to mitigate risks.

If a recommendation of Class II is made, then it should be noted that it is the current body of evidence considered today as part of this panel meeting that will be leveraged to support future substantially equivalent determinations through the 510(k) program or legal marketing of devices that are exempt from 510(k). Special controls would be required to provide continual assurance through mitigating known risks that any new devices coming to market through the 510(k) program are “as safe and effective” as existing legally marketed devices (Refer to Section 513(i)(1)(A) of the FD&C Act). Further, if a recommendation of Class II, exempt from 510(k) is made^a, then it should be noted that a manufacturer’s compliance with the special controls will be documented in the design history file, but will not be reviewed by FDA prior to marketing of the device.

If a recommendation of Class I is made, then it should be noted that it is the current body of evidence considered today as part of this panel meeting that will be leveraged to support future marketing of these devices without a 510(k), and that general controls only (inclusive of design controls for software technology as required per 820.30(a)(2)(i)) will be sufficient to provide continual assurance that any new devices coming to the market will be “as safe and effective” as existing legally marketed devices.

FDA is proposing to modify the regulatory identification/definition for external cardiac compressors (870.5200) from:

21 CFR 870.5200 External Cardiac Compressor

Identification. An external cardiac compressor is an external device that is electrically, pneumatically, or manually powered and is used to compress the chest periodically in the region of the heart to provide blood flow during cardiac arrest.

To:

21 CFR 870.5200 External Cardiac Compressor

Identification. An external cardiac compressor is an external device that is electrically, pneumatically, or manually powered and is used to compress the chest periodically in the region of the heart to provide blood flow during cardiac arrest. External cardiac compressor devices are used as an adjunct to manual

^a The medical device would be exempt from 510(k) notification unless it trips one of the limitations noted in §870.9 Limitations of exemptions from section 510(k) of the Federal Food, Drug, and Cosmetic Act. For these devices, the limitations of exemption included (21 CFR 870.9(a)): “The device is intended for a use different from the intended use of a legally marketed device in that generic type of device; e.g., the device is intended for a different medical purpose, or the device is intended for lay use where the former intended use was by health care professionals only”; or (b) The modified device operates using a different fundamental scientific technology than a legally marketed device in that generic type of device...”

cardiopulmonary resuscitation (CPR) during patient transport, extended CPR when fatigue may prohibit the delivery of effective/consistent compressions to the victim, or when insufficient EMS personnel are available to provide effective CPR.

for the following reasons:

- The revised identification for the ECC regulation to be down-classified to Class II is supported by the understanding that compressions in accordance with the AHA guidelines are effective, and that the ECC devices, as the proposed identification defines, are intended to replace compressions for situations where the alternative is no effective compression.
- The evidence available for the use of ECC devices *in place of* manual CPR remains unclear with respect to the effectiveness of the use of these devices when *substituted* for manual CPR.^{6, 9-11} As such, devices that seek labeling where the device will be used in place of manual CPR are outside the scope of this reclassification proposal, will be a new intended use, and will require the submission of a premarket application (PMA) or a *de novo*.

FDA is proposing a new regulation for CPR Aid devices [21 CFR 870.5210], which are currently being reviewed and cleared under the same classification regulation as ECC devices [21 CFR 870.5200]. The new regulation will provide distinct identifications between the Class I and Class II [special controls, both exempt and requiring a 510(k)] CPR Aid devices based on device design/technology:

21 CFR 870.5210 Cardiopulmonary Resuscitation (CPR) Aid Device

CPR Aid without Feedback (Class I)

Identification: A CPR Aid without feedback is a device that performs a simple function such as proper hand placement and/or simple prompting for rate and/or timing of compressions/breathing for the professionally trained rescuer, but offers no feedback related to the quality of the CPR being provided. These devices are intended for use by persons professionally trained in cardiopulmonary resuscitation, to assure proper use and the delivery of optimal CPR to the victim.

CPR Aid with Feedback (Class II, special controls)

Identification: A CPR Aid device with feedback is a device that provides real-time feedback to the rescuer regarding the quality of CPR being delivered to the victim, and provides either audio and/or visual information to encourage the rescuer to continue the consistent application of effective manual CPR in accordance with current accepted CPR guidelines (e.g., to include, but not be limited to, parameters such as compression rate, compression depth, ventilation, recoil, instruction for one or multiple rescuers, etc.). These devices may also

perform a guiding function to aid rescuers in all the steps necessary to perform CPR on a victim.

The further distinction within the Class II devices is based on the complexity of the technology utilized, with software technology requiring a 510(k). It should also be noted that different fundamental scientific technology that exceeds the limitations of exemption for the Class II exempt devices that do not contain software would also require the submission of a 510(k).

In summary, given the situation where there is an adequate knowledge base and *general controls*^b are sufficient to assure a safe and effective device on the market;

FDA recommends Class I (CPR Aid device without feedback).

When there is an adequate knowledge base and *special controls*^c, in combination with general controls, can be established to adequately mitigate the risks to health,

FDA recommends Class II (i.e., ECC device use as an adjunct to manual CPR, and CPR aid devices with feedback).

Please note that the Panel is tasked today with discussing the appropriate regulatory classification of external cardiac compressors and CPR aid devices that have been currently cleared within the classification regulation 21 CFR 870.5200. FDA contends that there is sufficient safety and effectiveness information to recommend re-classifying ECC devices as an adjunct to manual CPR to Class II with appropriate special controls, and CPR Aid devices into Class I (general controls) and Class II (special controls).

^b A device is Class I if general controls are sufficient to provide reasonable assurance of the safety and effectiveness of the device. Examples of general controls are: registration and listing, medical device reporting, labeling and good manufacturing practices (GMPs).

^c A Class II device is a device for which general controls by themselves are insufficient to provide reasonable assurance of the safety and effectiveness of the device, and for which there is sufficient information to establish special controls to provide such assurance. Examples of special controls are: performance standards, postmarket surveillance, patient registries, special labeling requirements, and development and dissemination of guidelines. Special controls may also include specific types of performance testing (e.g., biocompatibility, sterility, electromagnetic compatibility, pre-clinical testing) or labeling, which FDA may outline in the regulation or a special controls guideline.

Device Description

External Cardiac Compressor

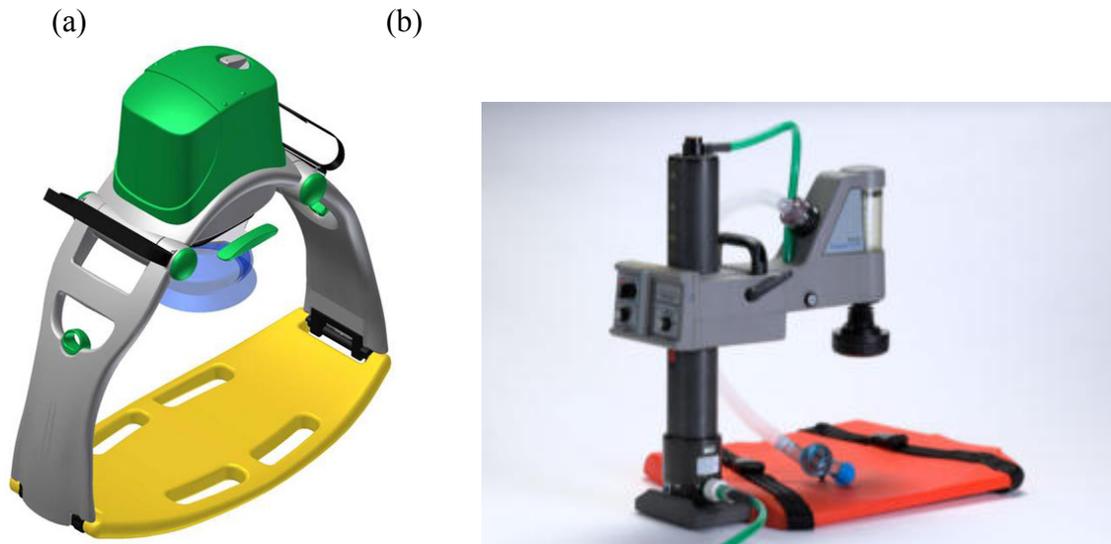
External cardiac compressor (ECC) devices physically compress a cardiac arrest victim's chest (similar to manual chest compressions), and are intended to be used as an adjunct to manual CPR and intended for use by professionally trained EMS rescuers.

Piston Mechanism

Piston type devices compress the patient's chest, in accordance with the currently accepted CPR guidelines with respect to rate and depth, via a padded piston. The devices are usually pneumatically (using compressed air or oxygen) or electrically powered. Examples of piston-type ECC devices are shown in Image 1 below.

Image 1 (Source: Google Images)

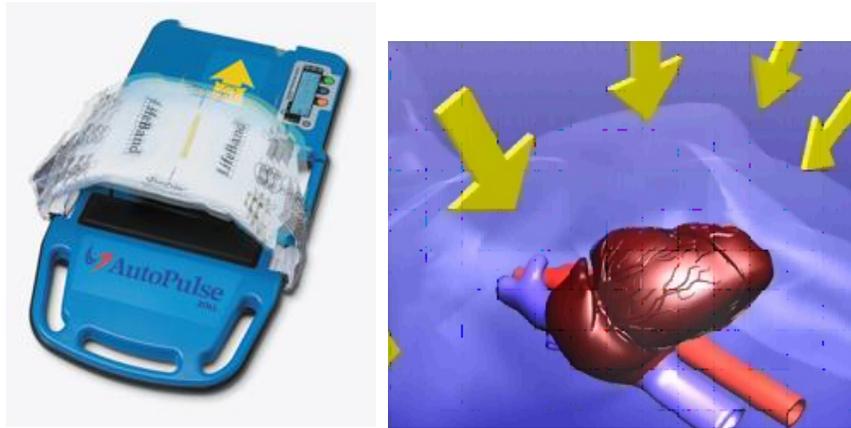
Piston type ECC devices: (a) Lucas, and (b) Thumper.



Band Mechanism

Band type devices perform compressions on the victim's chest via a broader compression band as seen below. The device consists of a reusable platform (backboard), a chest compression assembly, and a power system (e.g., rechargeable batteries). The mechanical drive mechanism, control system, software and electronics necessary to generate and control the force required to perform mechanical chest compressions are all included within the device to make it portable. The device shown below has a chest compression assembly that is single-use and consists of a cover plate and two bands integrated with a compression pad and Velcro fastener. It is attached to the Platform before each use, automatically adjusted to the patient, and provides compressions to the patient's chest in the region of the heart.

Image 2 (Source: Google Images)
Band type ECC device: Autopulse.



Cardiopulmonary Resuscitation (CPR) Aid Devices

CPR Aid devices do not physically compress a patient's chest, but provide guiding prompts, CPR prompts, and/or feedback regarding the quality of the CPR being delivered by the rescuer to encourage appropriate application of CPR and/or consistent and optimal delivery of CPR for the duration of the therapy. There have been both CPR Aid devices with and without feedback mechanisms cleared through the 510(k) process. Examples include:

CPR Aid Device without Feedback

Examples of devices in this category include metronome devices and devices which simply locate proper hand placement on the patient's chest.

An example of this technology is the Rhythm of Life:

Rhythm of Life

The Rhythm is Life is simply a metronome, and does not include feedback regarding chest compression depth or force. Additionally, no prompts regarding calling 911, checking breathing, or other CPR-steps are provided with the device.

The metronome contains the guidelines for all age groups: infant (0-1y), child (1-7y), and adult (8 and over) – and single or double rescuer situations. The device requires the user to input the age group, the number of rescuers, whether CPR, rescue breathing or compressions only will be performed, and whether a mask or advanced airway is being used. The device then outputs the proper resuscitation rates and ratios for that specific patient.

Image 4 (Source: Google Images)
CPR Aid Device with Feedback – PocketCPR



Indications for Use

Examples of the indications for use statements that have been cleared for the **external cardiac compressors** include:

LUCAS 2 Chest Compression System

“The LUCAS 2 Chest Compression System is to be used for performing external cardiac compressions on adult patients who have acute circulatory arrest defined as the absence of spontaneous breathing and pulse, and loss of consciousness. The LUCAS 2 must only be used in cases where chest compressions are likely to help the patient.”

Zoll Circulation AutoPulse

“The AutoPulse Model 100 automatic Mechanical Chest Compressor is intended to be used as an adjunct to manual CPR, on adult patients only, in cases of clinical death as defined by lack of spontaneous breathing and pulse.”

Michigan Instruments Thumper

“The Thumper Model 1008 is intended to perform CPR on adult patients in cases of clinical death as defined by a lack of spontaneous breathing and pulse.”

Examples of indications for use statements that have been cleared for **CPR Aid devices** include:

Rhythm of Life

“The Rhythm of Life is a visual and audio timing device assisting individuals trained in CPR to provide effective resuscitation by conforming to the guidelines promoted by the American Heart Association in the field, clinical, and hospital settings...”

PocketCPR

“To assist users in the performance of effective CPR on victims 8 years or older.”

Regulatory History and Classification for 21 CFR 870.5200

A brief summary of the regulatory history for external cardiac compressor (ECC) devices is provided within this section.

ECC devices were on the market prior to 1976 and as such are preamendment devices. These devices provide active chest compressions on a victim’s chest, in accordance with currently recognized CPR guidelines, and are intended to be used as an adjunct to the manual CPR therapy delivered by the emergency medical professional.^d Forty (40) 510(k)s have been cleared for the US market in this category to date.

CPR Aid devices were introduced in the 1980s and do not physically compress the victim’s chest. These devices are intended to assist the rescuer in providing consistent and effective/optimal CPR, and can include instruction, rate and/or breathing prompts, and real-time feedback through the duration of CPR and in accordance with current accepted CPR guidelines. These CPR Aid devices have also been cleared under the external cardiac compressor regulation (870.5200), thus are currently regulated as a Class III medical device. As of July 17, 2013, twenty-three (23) 510(k)s for CPR Aid devices have been cleared for the US market.

1979 Proposed Rule and 1980 Final Rule

On March 9, 1979, FDA published a proposed rule outlining the recommendations of the Cardiovascular Device Classification Panel and a proposed classification for ECC devices as Class III requiring premarketing approval (44 FR 13424). The proposed rule provided the following in the “Summary of reasons for recommendation:”

^d 44 Federal Register Notice, Friday March 9, 1979; pgs 13424-13425

- “The Panel recommends that external cardiac compressors be classified into class III because this device is life-supporting and is potentially hazardous to life or health even when properly used.”
- “This device is attached directly to the body and is used in a clinical environment where excessive leakage current can be a serious hazard.”
- “Performance characteristics, including accuracy, reproducibility and any limitations on the device’s compression rate and applied force should be maintained at a generally accepted satisfactory level and should be made known to the user through special labeling.”
- “The Panel believes that general controls alone would not provide sufficient control over the performance characteristics of this device. The Panel also believes that a performance standard would not provide reasonable assurance of the safety and effectiveness of the device, and that there is not sufficient information to establish a standard to provide such assurance.”

The Panel also indicated in the original 1979 Order (page 13425) that “...the device is not designed to replace manual CPR. The literature seems to recommend it for certain situations such as long-term applications and patient transport.”

The risks identified by the Panel were as follows:

- *Tissue damage, bone breakage, or inadequate blood flow:* Damage to the heart, other organs or tissues, or inadequate blood flow can result from poor mechanical design, improper surface area of the plunger, improper vertical excursion of the plunger, improper force applied by the plunger or improper energy transmission by the device.
- *Cardiac arrhythmias or electrical shock:* Excessive electrical leakage current can disturb the normal electrophysiology of the heart, leading to the onset of cardiac arrhythmias.

No written comments were received regarding the proposed regulation to classify external cardiac compressors into Class III. As a result, the final rule was published on February 5, 1980 (45 FR 7959). The following codified language was published in Part 870 of the Code of Federal Regulations:

870.5200 External Cardiac Compressor

- (a) *Identification.* An external cardiac compressor is an external device that is electrically, pneumatically, or manually powered and is used to compress the chest periodically in the region of the heart to provide blood flow during cardiac arrest.
- (b) *Classification.* **Class III (premarket approval)**

No effective date was established for the submission of premarket applications.

2009 515(i) order (call for information) for Remaining Class III Pre-amendments Devices

On April 9, 2009 [74 FR 16214], FDA issued an order requiring the manufacturers of the remaining Class III pre-amendments devices (including 870.5200 External Cardiac Compressors) "...for which regulations requiring submission of premarket approval applications (PMAs) have not been issued..." to submit a summary of "...information known or otherwise available to them respecting such devices, including adverse safety or effectiveness information concerning the devices...in order to determine...whether the classification of the device should be revised to require the submission of a PMA or a notice of a completion of a Product Development Protocol (PDP), or whether the device should be reclassified into Class I or II." This information was requested to be submitted by August 7, 2009.

Industry Response

FDA received responses from four (4) manufacturers of external cardiac compressors and/or CPR aids:

- Michigan Instruments, Inc. – Thumper
- Zoll Circulation – Autopulse
- Jolife AB – LUCAS
- Bio-Detek, Inc. – PocketCPR

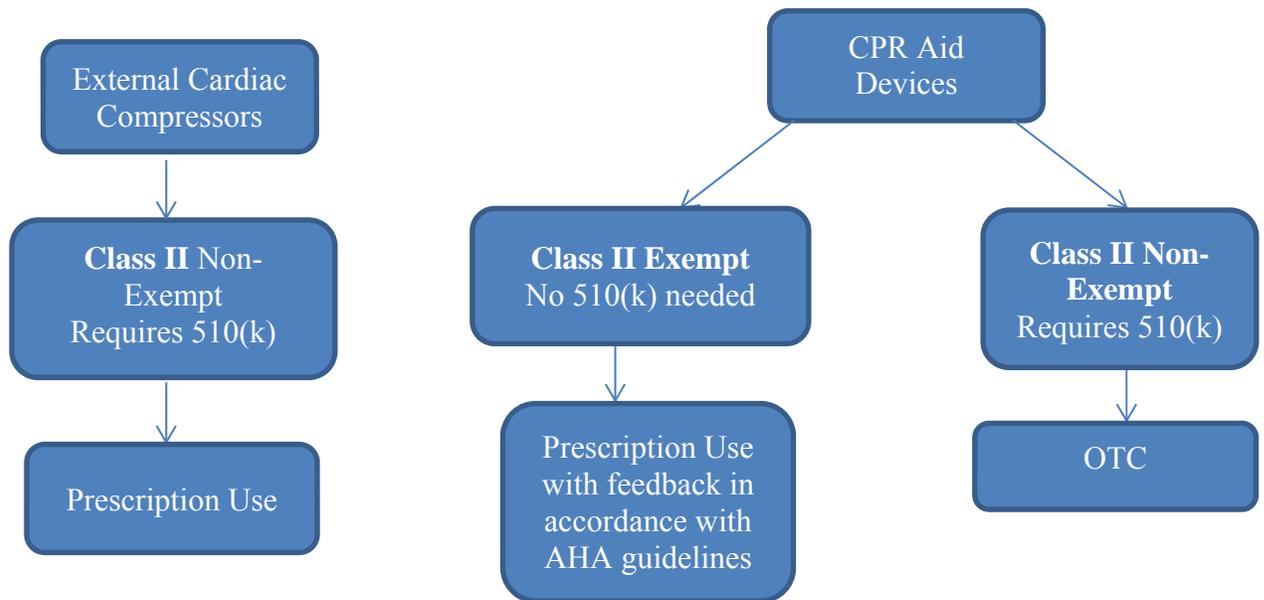
All responses included information in support of reclassifying external cardiac compressors and CPR aids from Class III to Class II (Special Controls.). All responses were based on the following information:

- 1) the advantage of consistent delivery of CPR regardless of the location of care (e.g., transport vehicle) or experience of the caregiver;
- 2) the fact that the risks associated with these devices (with the exception of leakage current), e.g., tissue/organ damage, bone fractures, are the same as for manual CPR, and the events appear to occur at approximately the same rate (device vs. manual CPR); and
- 3) advances in technology permit an acceptable accuracy of delivered compression depth and rate consistent with current AHA recommendations.

January 8, 2013 Proposed Order: Reclassification of External Cardiac Compressors

On January 8, 2013 FDA issued a proposed order [78 *FR* 1162], recommending that external cardiac compressor (ECC) devices be reclassified from class III to class II. FDA believed CPR Aid devices and automated ECC devices, when used as indicated, can supplement the effective delivery of CPR. Responses to this proposal were requested by April 8, 2013. The Proposed Order suggested the following regulatory pathway for external cardiac compressors and CPR Aid devices (Figure 1):

Figure 1: Regulatory Pathways based on January 8, 2013 Proposed Order



These pathways were proposed for the following reasons:

External Cardiac Compressors

ECC devices are intended to replace chest compressions in situations where the alternative is no compression or sub-optimal compressions. In the absence of effective chest compressions, the likely outcome is death. As such, for ECC devices intended to replace chest compressions in situations where the alternative is no compression or sub-optimal compression, FDA believes that a Class II classification is supported by the understanding that compressions performed with the external cardiac compressor in accordance with current accepted guidelines would be effective, and should be applied in situations where suboptimal or no chest compressions would occur.

As evidenced by the original 1979 proposed rule which stated "...the device is not designed to replace manual CPR. The literature seems to recommend it for certain situations such as long-term applications and patient transport," the devices being

covered by the deliberations of this panel are intended for adjunctive use^d. The evidence available for the use of ECC devices *in place of* manual CPR remains unclear with respect to the effectiveness of the use of these devices when *substituted* for manual CPR.^{6, 9-11} As such, devices that seek labeling where the device will be used in place of manual CPR will be a new intended use and are not covered by the existing classification regulation. This indication would require submission and approval of a PMA or *de novo* prior to marketing.

CPR Aid Devices

CPR aid devices are intended to encourage the rescuer to perform consistent and optimal CPR over the duration of needed therapy.

Prescription Use

Those devices labeled for prescription use (Class II, 510(k) exempt) can be of simple design and provide information (prompting and/or feedback) to the *professionally trained rescuer* regarding compression rate, depth and ventilations to help **coach** the rescuer in maintaining a consistent application of CPR over the duration of the rescue attempt. The professionally trained rescuer would already understand all the steps in CPR, thus not need the training prompts to lead the rescuer through the steps of CPR. Additionally, the professionally trained rescuer could always rely on their training, thus continue with effective/optimal CPR, if the device was not accurate (e.g., a metronome beating at 65cpm instead of 100cpm; or compression feedback at only 1” instead of 2”). These devices would be exempt from the 510(k) application process, but would still need to meet the special controls identified for this device type to assure a safe and effective device.

Over-the-Counter Use

Those devices labeled for OTC use (Class II, 510(k) required) will be of a more complex design as they are *intended for untrained lay users*, and will potentially need to both **guide and coach** the rescuer in the application of effective CPR on the spot, during the event. This is a stressful situation and will require these devices to logically lead the rescuer through the steps of CPR, will require an intuitive design (e.g., voice and visual instruction and feedback) and accuracy since the untrained lay rescuer will be relying solely on the instruction from the device, and will most likely not be able to ascertain a failure in accuracy (e.g., a metronome beating at 65cpm instead of 100 cpm; or compression feedback at only 1” instead of 2”), which could translate to the delivery of suboptimal CPR to the victim.

Industry Response

Comments to the January 8, 2013 Proposed Order were received from four sources:

- 2 of 4 agreed with FDA’s proposed reclassification of 870.5200 External Cardiac Compressors and CPR Aid devices;
- 1 of 4 agreed, but had additional suggestions regarding the regulation of a subset of the CPR Aid devices; and
- 1 of 4 disagreed with the recommended reclassification strategy.

An overarching summary of the ECC comments (and FDA responses) to the January 8, 2013 proposed order for reclassification that impacted our classification strategy and discussion for the panel is found below.

Laerdal Comments

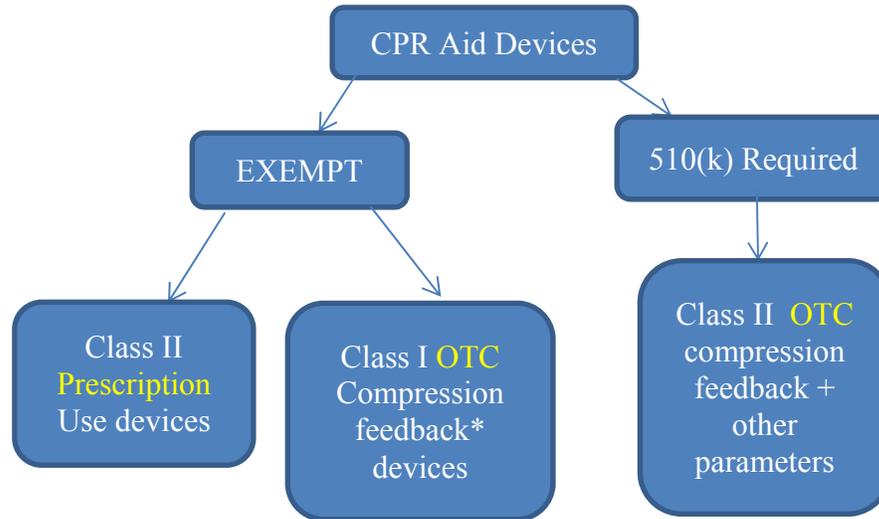
1. A regulatory distinction should be made between compression and CPR aid devices.

[FDA Response: FDA agrees with this recommendation and as such has modified the recommended regulatory approach as part of this Summary:](#)

[870.5200 External Cardiac Compressor](#)
[870.5210 Cardiopulmonary Resuscitation \(CPR\) Aid Device](#)

2. Compression feedback only OTC devices should be made Class I and exempt from premarket review (as denoted in Figure 2 – FDA interpretation of response), based on the following:
 - a. Low risk device
 - b. General controls are sufficient to mitigate the risks to health
 - c. AHA Guidelines “All rescuers, regardless of training, should provide chest compressions to all cardiac arrest victims...”

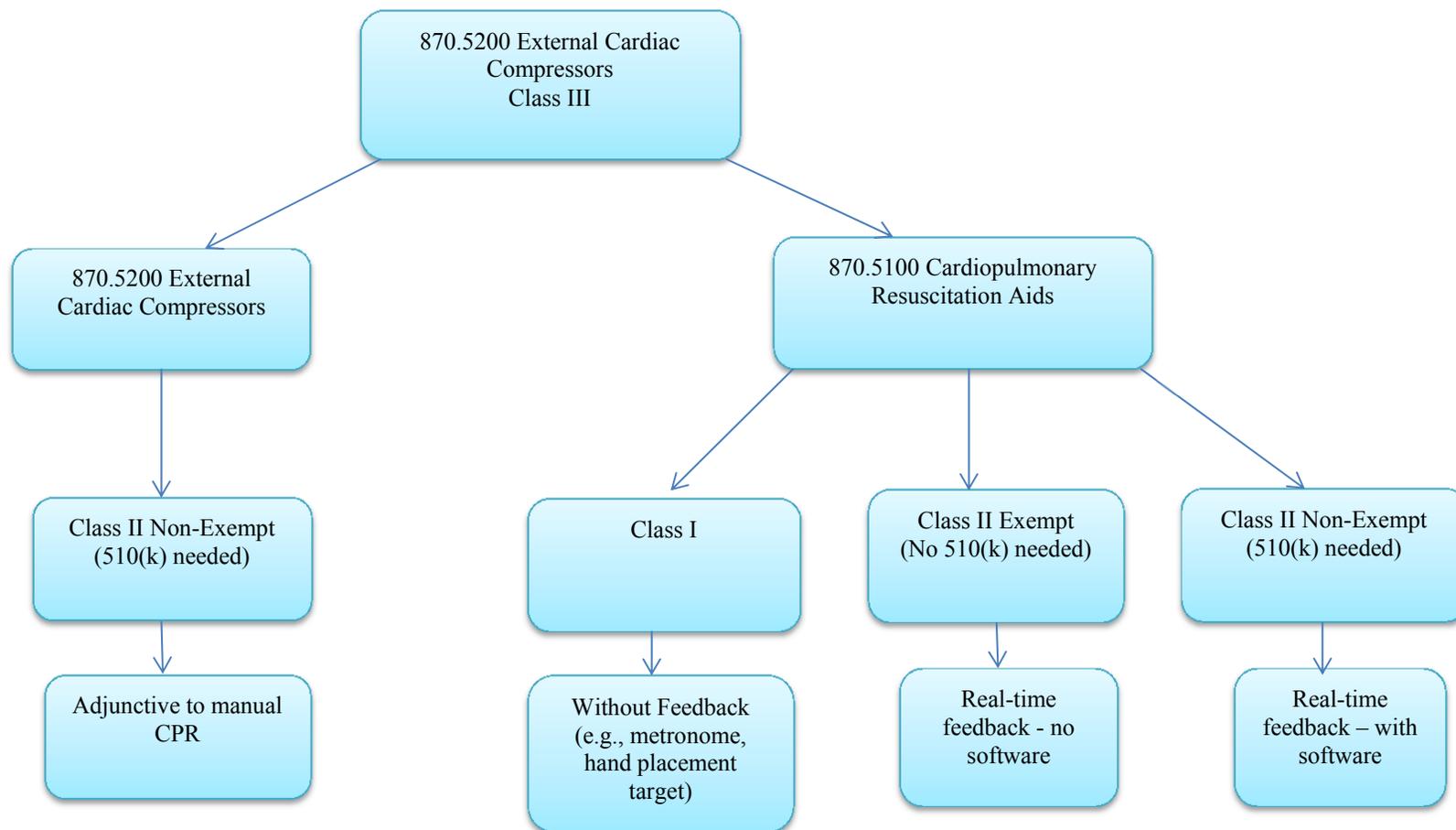
Figure 2: Industry Proposed Regulatory pathway for CPR Aid Devices



*Compression feedback = provide feedback only on compression quality, e.g., rate, depth.

FDA Comment: FDA discussed the merits of regulating the devices by device design/technology, as opposed to how the device would be used by the end user (i.e., regulating based on prescription or OTC use). In reconsidering the stratification of devices within the CPR aids, FDA determined that a logical division could be made, and appropriate levels of regulatory controls applied, to devices based on the technology of the device. Complex software-driven devices require greater regulatory scrutiny given the level of coaching and feedback that may be integrated into these devices and the fact that they may be heavily relied upon by less experienced lay users during CPR. **As such, FDA has revised the proposed regulatory strategy as follows (discussed above and provided in Figure 3 below):**

Figure 3: Diagram of Revised Proposed Regulation(s)



Public Citizen

In general, Public Citizen indicated that they had no comment on the CPR Aid devices, but states that there is not sufficient evidence to support reclassification of the ECC devices to replace manual CPR.

FDA Comment: FDA agrees. As FDA identified in the proposed order “*These devices should not be used as a replacement for manual CPR*”, so this comment is consistent with FDA’s original intent.

Discussion of Risks to Health

In **Table 1** below (and also identified in the January 8, 2013 Proposed Order), FDA has identified the risks to health generally associated with the use of ECC.

- All *italicized* information was prepared from the list of risks identified in the original proposed rule –March 9, 1979, Vol 44, 13424 – Proposed Rule Classification of External Cardiac Compressors.
- The item(s) in normal font have been identified since the original classification panel and were included as part of our proposed order.

The measures recommended to mitigate these identified risks to health are given in **Table 6** found below in the section of this summary titled “Summary of FDA Recommendation.”

Table 1: Risks associated with External Cardiac Compressors

Identified Risk	Due to...
<i>Cardiac arrhythmias or electrical shock</i>	<i>Excessive leakage current</i>
<i>Tissue/organ Damage</i>	<i>Poor mechanical design, e.g., improper surface area of the plunger, improper vertical excursion of the plunger, improper force applied by the plunger, improper energy transmission by the device.</i>
<i>Bone breakage (ribs, sternum)</i>	<i>Poor mechanical design, e.g., improper surface area of the plunger, improper vertical excursion of the plunger, improper force applied by the plunger, improper energy transmission by the device.</i>
<i>Inadequate blood flow</i>	<i>Poor mechanical design, e.g., improper surface area of the plunger, improper vertical excursion of the plunger, improper force applied by the plunger, improper energy transmission by the device.</i>
Adverse skin reactions	Non-biocompatible materials*

* *Given the benefit/risk profile, we believe this risk can be adequately mitigated in this patient population by the general controls*

In **Table 2** below, FDA has identified the risks to health generally associated with the use of CPR Aid devices. The measures recommended to mitigate these identified risks are provided in **Tables 7 and 8** found below in the section of this summary titled “Summary of FDA Recommendation.”

Table 2: Risks associated with CPR Aid Devices

Identified Risk	Due to...
Suboptimal CPR delivery	Inaccurate rate/depth/ventilation feedback and/or prompts Inaccurate labeling
Adverse Skin Reactions	Non-biocompatible materials*

** Given the benefit/risk profile, we believe this risk can be adequately mitigated in this patient population by the general controls*

The panel will specifically be requested to comment on the risks to health identified by FDA and whether these risks are appropriate, and/or whether there are additional risks to health that should be considered for these devices.

Summary of Evidence

Medical Device Report (MDR) Analysis

The following is a summary of the MDRs and device recalls for ECC devices (Table 3) and CPR Aid devices (Table 4) product codes (both regulated under 21CFR 870.5200 External Cardiac Compressor). There are a total of 138 MDRs since 2001 for these product codes. There have been a total of five recalls since 2001, four Class 3 recalls, and one Class 2 recall.^e

^e Please refer to FDA’s website for more information about recalls (<http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/PostmarketRequirements/RecallsCorrectionsAndRemovals/default.htm>)

Table 3: MDRs for External Cardiac Compressors (DRM)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
510(k) [by SE decision date]	1	1	1	2		4		2	1	1		1	14
# MDR deaths							2	1			4	7	14
# MDR injury						1		2	4	4	3	6	20
# MDR invalid data											1	2	3
# MDR malfunction			1	11	10	1	5	6	5	3	8	38	88
# MDR other						3	1	3				2	9
Total MDRs			1	11	10	5	8	12	9	7	16	55	134
Recalls - class 1													
Recalls - class 2												1	
Recalls - class 3						2				1	1		
Total recalls class 1, 2, 3						2				1	1	1	

Table 4: CPR Aid Devices (LIX)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
510(k) [by SE decision date]	2						1		1			2	6
# MDR deaths													
# MDR injury									1				1
# MDR malfunction												3	3
Total MDRs									1			3	4
Recalls - class 1													
Recalls - class 2													
Recalls - class 3													
Total recalls class 1,2,3													

The numbers presented above are small compared to the numbers of patients presumably treated with these devices (e.g., 14 total deaths reported for patients treated with external cardiac compressors over 12 years). The malfunctions had a slight uptick in 2012 which can be attributed to an increase in reported problems for one particular device that eventually resulted in a recall. FDA believes that the observed MDRs (accuracy, battery power, proper use, etc.) are consistent with the above identified risks to health, and that

these risks can be adequately mitigated with special controls.

Literature Review

(Note: References cited in this section correspond to the bibliography listed in Appendix A)

The current literature search in the PubMed database was conducted to assess whether ECCs and/or CPR aid devices are safe and effective at assisting in CPR delivery among the US population. Overall, there have been few clinical studies of ECC devices published in the PubMed database and even fewer articles for CPR Aid devices.

Strengths and Limitations

The major strength of this review is that all articles reviewed focused on the US population. The restriction helps prevent the analysis from the confounding effect of different clinical guidelines or practice of medicine between the US and areas outside of the US.

There were a number of limitations in the studies included in this review. First, there have been very few studies published in assessing safety and effectiveness of ECC and CPR Aid devices. Lack of randomized controlled trials (RCTs) with enough power makes it difficult to detect differences in clinically meaningful outcomes (i.e., safety and effectiveness) between patient groups. Second, the sample sizes of the current available studies were often small ($n \leq 50$), and thus it was hard to draw any solid conclusion based on the findings from these studies due to inadequate power. Third, most studies included in this review often failed to include survival and neurologic status at discharge as endpoints. Fourth, inadequate reporting of adverse events is a common shortcoming across the available studies. Fifth, the mechanical CPR should be compared with high quality manual CPR; however, most studies failed to measure quality of manual CPR which may bias the outcomes. Sixth, only one style of feedback (i.e., audio feedback) was evaluated in the included studies for the CPR Aid devices.

Methodology

As there are two types of devices included in §870.5200, the literature searches were conducted separately for the product codes DRM (ECC devices) and LIX (CPR Aid devices) using PubMed. The searches yielded 440 and 61 articles in PubMed for DRM and LIX, respectively. A total of 256 and 22 articles were excluded* in the screening for DRM and LIX, respectively, and the yield was 184 articles for DRM and 39 articles for LIX. The title and abstracts of the remaining total of 223 articles were reviewed and assessed for their eligibility for inclusion in the full text review. The final assessment includes 14 studies (i.e., 11 for DRM (ECC devices) and 3 for LIX (CPR Aid devices)). Figure 5 presents the full diagram of article retrieval and selection, and Table 5 provides a listing of the final 14 studies:

* *Exclusion criteria:* Articles were excluded if they were case reports, case series <10 patients, non-clinical research (non-systematic review, letter to the editor, protocol, non-clinical methods

paper, editorial, etc.), articles without human data (i.e., manikin study), only animal data, articles irrelevant to the devices (DRM/LIX), only has data on roller pumps, only has data on active compression/decompression compression (i.e., product code OVM), non-English article, no safety/efficacy/effectiveness endpoints related to the use of DRM and/or LIX devices, or outside of United States (OUS) data. OUS data were excluded as the practice guidelines for these devices are different between US and OUS.

Figure 5: Flow diagram of article retrieval and selection

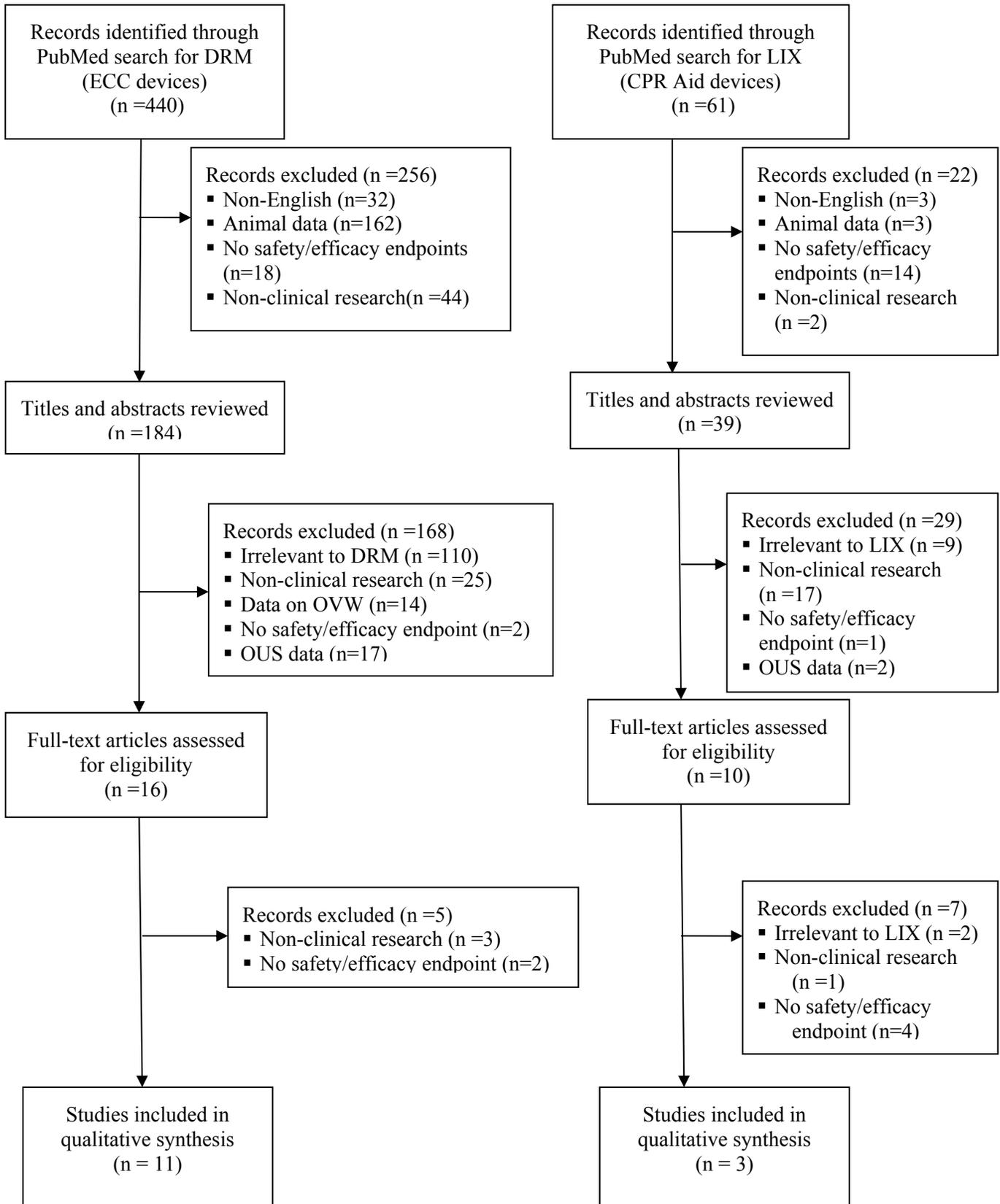


Table 5. Study design of all publications included within this report (n=14)

AUTHOR	YEA R	STUDY DESIGN	LOCATION	Product Code *
Westfall M ¹	2013	Meta-analysis	US, Canada, Denmark, Sweden, Netherlands	DRM
Ong ME ²	2012	Systematic review	US, Sweden	DRM
Brooks SC ³	2011	Meta-analysis	US	DRM
Lerner EB ⁴	2011	Randomized Clinical Trial	US	DRM
Paradis NA ⁵	2010	Post hoc analysis	US	DRM
Hallstrom A ⁶	2006	Randomized Clinical Trial	US	DRM
Ong ME ⁷	2006	Cohort Study	US	DRM
Casner M ⁸	2005	Case-control Study	US	DRM
Dickinson ET ⁹	1998	Randomized Clinical Trial	US	DRM
Ward KR ¹⁰	1993	Randomized Clinical Trial	US	DRM
Taylor GJ ¹¹	1978	Randomized Clinical Trial	US	DRM
Hostler D ¹²	2011	Randomized Clinical Trial	US	LIX
Abella BS ¹³	2007	Cohort Study	US	LIX
Abella BS ¹⁴	2005	Cohort Study	US	LIX

Abbreviations: US – United States

*DRM: ECC devices; LIX: CPR Aid devices

External Cardiac Compressor (DRM)

Eleven articles were found that reviewed the safety and effectiveness of ECCs in human patient populations. There were five randomized controlled trials,^{4,6,9-11} two meta-analysis,^{1,3} one systematic review,² two observational studies,^{7,8} and one post-hoc analysis.⁵ Articles were published between the years 1978 – 2013. All studies were conducted in the United States.

Review

Safety (Adverse Events) of devices under DRM code

Of 11 articles reviewed, only Taylor et al. (1978) reported the occurrence of rib or sternal fractures in 18 patients. Taylor's study suggests increased relative harm with mechanical compressions (RR 1.63, 95% CI 0.91 to 2.94) but a decreased occurrence of internal organ injury with mechanical chest compressions (RR 0.26, 95% CI 0.01 to 4.94).¹¹ Taylor's study was also included in the Cochrane review.³

Effectiveness of devices under DRM code

The ECCs involved in the included articles were used for the indication of cardiac arrest including out-of-hospital and in-hospital cardiac arrest. To facilitate the following assessment, the articles included are summarized by study design. Also note that efficacy of devices will be evaluated in the setting of clinical trials regardless of randomization, and effectiveness of devices will be evaluated in the setting of observational studies.

Randomized Controlled Trials (RCTs) or meta-analysis of RCTs

Five RCTs^{4,6,9-11} evaluated efficacy data of ECCs (Table 2 and Appendix A). Of five RCTs, two were multicenter, prospective, randomized trials,^{4,6} comparing CPR delivered by a load-distributing band ECC (LDB-CPR) (AutoPulse, Zoll Circulation) with CPR delivered manually (manual CPR). They were the AutoPulse Assisted Prehospital International Resuscitation (ASPIRE) trial⁶ and the Circulation Improving Resuscitation Care (CIRC) trial.⁴ The ASPIRE trial was halted by an independent data and safety monitoring board after the first planned interim assessment of 1,071 out-of-hospital subjects (with 767 subjects in the primary population meeting enrollment criteria after exclusions).⁶ No significant difference had been shown in the primary endpoint of survival to four hours, but among the primary population, survival to hospital discharge was 9.9% in the manual CPR group and 5.8% in the LDB-CPR group, a trend that approached statistical significance (P=0.06, adjusted for covariates and clustering). Those in the LDB-CPR group were more likely to have worse neurological outcomes at hospital discharge, with only 3.1% of subjects in the LDB-CPR group demonstrating a cerebral performance category (CPC) score of 1 or 2 at hospital discharge versus 7.5% of subjects in the manual CPR group (P=0.006).⁶

The CIRC trial is ongoing and no study results have been published yet. The CIRC trial compares mechanical-CPR (AutoPulse) to manual-CPR. The primary endpoint is survival to hospital discharge. Secondary endpoints include sustained ROSC, survival to 24 hours, and neurologic status at hospital discharge.⁴

The other three small sample-sized randomized studies⁹⁻¹¹ compared manual-CPR to mechanical-CPR (Thumper, Michigan Instruments). The results showed that patients receiving mechanical CPR were more likely to have a higher level of end-tidal CO₂ (ETCO₂) but no difference in survival. Dickinson et al. (1998) reported that ETCO₂ decreased in 80% of patients in the manual CPR group while none in the mechanical-CPR group (P<0.04); there was no difference in ROSC and survival.⁹ Ward et al. (1993) reported that the mean level of ETCO₂ was significantly higher in the mechanical CPR group as compared to the manual CPR group (6.7 mmHg, P<0.001), and there also was no difference in survival.¹⁰ The results of the study by Taylor et al. (1978) were in concordance with the other two studies (i.e., no difference in survival), but were not analyzed for statistical significance.¹¹

A meta-analysis of four randomized trials^{9-11,15} compared any type of powered, mechanical chest compression device to standard manual chest compressions in patients suffering cardiac arrest that reported on survival or other outcomes.³ AutoPulse, Thumper, and a vest compressor developed by the investigators were evaluated in these studies. No study reported long-term survival (>30 days). The pooled results of 2

studies^{9,15} suggested a nonsignificant trend toward increased return of spontaneous circulation (N = 51, pooled relative risk 2.81[95% CI, 0.96, 8.22]). The ASPIRE study, Taylor et al.,¹¹ and Dickinson et al.⁹ were already summarized above.

Halperin et al. (1993) was excluded from the current literature review as the device used in the study (a vest compressor developed by the investigators) was not a device under the relevant product code (DRM). The results of Halperin et al. showed an increase in short-term survival in the mechanical compression group (Table 2). However, these results should be interpreted cautiously due to low study power associated with small sample size.

Meta-analysis using concurrent controls without true randomization

There were two meta-analyses conducted using controlled studies without randomization. Twenty two studies were included with a total sample size of 9,149. Of which, only one study estimated the pooled odds ratio of return of spontaneous circulation comparing manual-CPR to mechanical-CPR.

Westfall's meta-analysis included a total of 12 studies in the out-of-hospital cardiac arrest setting (load-distributing band cardiopulmonary resuscitation [LDB-CPR, AutoPulse, Zoll Circulation] versus manual cardiopulmonary resuscitation = 8, piston-driven cardiopulmonary resuscitation [PD-CPR, LUCAS, Jolife AB] versus manual cardiopulmonary resuscitation = 4). Westfall reported that (1) LBD-CPR vs. M-CPR: odds ratio (OR), 1.62 [95% CI, 1.36, 1.92]; (2) PD-CPR vs. M-CPR: OR, 1.25 [95%CI, 0.92, 1.68]; and (3) combined mechanical CPR vs. M-CPR, OR, 1.53 [95%CI, 1.32, 1.78] in favor of higher odds of return to spontaneous circulation (ROSC) with mechanical CPR¹(Table 2). Ong et al. (2012) conducted a systematic review including 10 studies. The research question addressed in this study² was as follows: "In pre-hospital adult cardiac arrest (asystole, pulseless electrical activity, pulseless Ventricular Tachycardia and Ventricular Fibrillation), does the use of mechanical Cardio-Pulmonary Resuscitation (CPR) devices compared to manual CPR during Out-of-Hospital Cardiac Arrest and ambulance transport, improve outcomes (e.g., Quality of CPR, Return Of Spontaneous Circulation, Survival)." Four studies evaluated the quality of CPR in terms of compression adequacy while the remaining six studies evaluated on clinical outcomes in terms of return of spontaneous circulation (ROSC), survival to hospital admission, survival to discharge and Cerebral Performance Categories (CPC). Out of the ten included studies, seven supported the superiority of the use of mechanical CPR, one was neutral and two supported the superiority of the use of manual CPR.² Of seven studies favoring mechanical CPR in terms of quality of CPR, ROSC, and survival, four articles used OUS data, and thus were excluded from this review. The details of the other three articles are presented in the previous section⁹ and the immediately following section.^{7,8} The study holding the neutral opinion and one study against using mechanical CPR were excluded from the current review as they used OUS data. The other study against using mechanical CPR was previously discussed .⁶

Observational studies

There were three retrospective observational studies.^{5,7,8}

Ong et al (2006) compared both types of CPR in a phased, nonrandomized, observational study (N= 783) of clinical outcomes of patients treated before and after transition from manual CPR to mechanical CPR. The use of mechanical CPR had higher rates of ROSC (34.5% vs. 20.2%, $p < 0.05$) and survival to hospital admission (20.9% vs. 11.1%, $p < 0.05$). For survival to hospital discharge, mechanical CPR was better than manual CPR and there was no significant difference in CPC categories ($p = 0.36$) and Overall Performance Categories ($p = 0.40$) between both groups.⁷

A retrospective case–control study (N= 262) conducted by Casner et al. (2005) found that for mechanical CPR, higher rates of ROSC were observed in patients overall (39% vs. 29%, $p < 0.05$) and in asystole (37% vs. 22%, $p < 0.05$) upon arrival at the emergency department. There was no significant difference in ROSC for subgroups with shock-able rhythms and pulseless electrical activity (PEA).⁸

Paradis et al. (2010) conducted a post-hoc subgroup analysis of the ASPIRE data on participating sites and found that one participating study site (site C) was significantly different ($P = .008$) from the remaining participating sites favoring manual CPR with respect to survival in the logistic regression analysis. Site C made a protocol change (i.e., resuscitation starting from a 2-minute session of manual-CPR before receiving randomized treatment) midtrial that appeared to have resulted in delayed application of AutoPulse-CPR. Unlike site C, the other sites actually showed an increase in the primary end point of 4-hour survival ($P = .008$) favorable to AutoPulse-CPR⁵ (Table 2).

Assessment

Safety

Only the Taylor et al. (1978) study reported the occurrence of rib or sternal fracture and suggested increased relative harm with mechanical compressions, whereas other studies did not include adverse events as endpoints. Inadequate reporting of adverse events was a common shortcoming across the available published data.

Effectiveness

As for efficacy of ECCs in settings of cardiac arrest, these included RCTs or meta-analysis of RCTs and observational studies. Regardless of the varying quality of the randomized studies,^{3,6,9-11} the results were mixed. The only available large (767 patients), multicenter, randomized controlled clinical trial (ASPIRE trial)⁶ provided the strongest evidence against the efficacy of ECC in the setting of out-of-hospital cardiac arrest, whereas other studies of small sample size (20 – 50 subjects) demonstrated non-significant trends toward increased return of spontaneous circulation and survival to hospital admission³ or no difference in survival between groups.⁹⁻¹¹

Two meta-analyses of non-randomized studies^{1,2} were articles published in 2013 and included both US and OUS data. The results of these two articles also differed as one was in favor of higher odds of ROSC with mechanical CPR¹ and the other found insufficient evidence to support or refute the use of mechanical CPR devices in settings of out-of-hospital cardiac arrest and during ambulance transport.² Two of the remaining three observational studies evaluated the effectiveness of ECC suggesting that the use of mechanical CPR had higher rates of ROSC, but demonstrated no significant difference in neurologic status at hospital discharge.^{7,8} The last observational study observed a temporal trend that the treatment arm was showing a steadily improving 4-hour survival.⁵ However, the robustness of these findings from studies of non-randomized studies should be tested in large randomized clinical trials. Findings from current available published human clinical research are insufficient to support or refute the use of mechanical CPR in settings of cardiac arrest.

Conclusion from ECC Literature Review

For the ECC devices (DRM), the lack of data available in large well-designed multicenter randomized controlled trials and the current conflicting information from the studies that are available cannot provide reasonable assurance that the devices are safe and effective when used *in place of* standard manual CPR.

CPR Aid Devices (LIX)

Three articles were found that reviewed the safety and effectiveness of LIX devices in human patient populations. There were two observational studies^{13,14} and one randomized controlled trial.¹² Articles were published between the years 2005 – 2011. All studies were conducted in the United States.

Review

Safety of device under LIX code

All four articles reviewed did not report device-related adverse events.

Efficacy/Effectiveness of devices under LIX code

The studies included in the current literature review are summarized by study design.

Randomized Controlled Trials (RCTs) or meta-analysis of RCTs

There was one RCT identified in the current review. Hostler et al (2011) conducted a cluster-randomized trial to investigate whether real-time audio and visual feedback during cardiopulmonary resuscitation outside the hospital increases the proportion of subjects who achieved pre-hospital return of spontaneous circulation from 2007 to 2009. CPR feedback was provided through proprietary Q-CPR software operating in the Philips

MRx monitor defibrillator (Philips Medical Systems). Compared with CPR clusters lacking feedback, clusters assigned to feedback were associated with increased proportion of time, increased compression depth, and decreased proportion of compressions with incomplete release. However, frequency of pre-hospital return of spontaneous circulation did not differ according to feedback status (45% v 44%), nor did survival to discharge (12% v 11%), or awake at hospital discharge (10% v 10%).¹²

Observational study

There were two observational studies evaluating an audiovisual feedback device (Heartstart 4000SP, Philips Medical Systems),^{13,14} Abella et al (2007) reported that, in the setting of in-hospital cardiac arrest, there was some improvement in the mean values of CPR variables in the feedback group with a statistically significant narrowing of CPR variable distributions including chest compression rate and ventilation rate. There were no statistically significant differences between the groups in either return of spontaneous circulation or survival to hospital discharge.¹³ A prospective observational study recorded the parameters of CPR quality by the device. The results showed the quality of CPR often did not meet published guideline recommendations (Table 2).¹⁴

Assessment

Safety

None of the three studies reported adverse events, therefore the presence or absence of adverse events could not be evaluated.

Effectiveness

The randomized trial conducted by Hostler et al. (2011) evaluated the efficacy of the device (Q-CPR, Philips Medical Systems) and found the increased quality of CPR did not affect clinical outcome measures.¹² Effectiveness of the devices was evaluated in the observational studies. The sample size of the observational study that was conducted by Abella et al. (2007)¹³ using a historical control was relatively small (101 patients) as compared with Hostler et al.¹² Findings from the RCT and observational study were consistent although two audio feedback CPR aid devices (i.e., Q-CPR and HeartStart 4000SP [Laerdal Medical Corporation]) had been tested in these studies. Both evaluations of efficacy and effectiveness based on current human studies did not support conclusion that the use of CPR aid device can improve clinical outcomes.

Conclusion from CPR Aid Literature Review

For the CPR aid devices (LIX), the available data suggest that CPR can be applied more consistently when the device is used by professionally trained rescuers, as compared to when the device is not used; however, this effect did not translate into any net difference in the clinical outcomes assessed for those suffering from a cardiac arrest.

Clinical Perspective

In its review of the available literature for both ECC and CPR aid devices, FDA was not able to identify valid scientific evidence to support the reasonable assurance of effectiveness as measured by discrete endpoints such as survival to hospital discharge with good neurological function. Similarly, quantifiable adverse event rates from the available data do not readily support or refute the safety of these devices. As indicated above, FDA believes the acuity of cardiac arrest situations and the inherent limitations of resuscitation research are likely to be significant contributory factors regarding the ambiguity of interpreting the devices' safety and effectiveness. Nonetheless, FDA recognizes that the principal intended use for these devices is to facilitate the appropriate execution of cardiopulmonary resuscitation. Accordingly, it is important for FDA to also consider the overall safety and effectiveness of ECC devices and CPR aids in the context of a comparison to absent or sub-optimal CPR as well as the benefit/risk profile.

FDA recognizes the current thinking for resuscitation efforts as put forth by the American Heart Association's 2010 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care^f. FDA specifically acknowledges these aspects of the Guidelines as we consider regulation paradigms:

- “to be successful, the actions of bystanders and other care providers must occur within a system that coordinates and integrates each facet of care into a comprehensive whole, focusing on survival to discharge from the hospital.”
- “Encourage Hands-Only (compression only) CPR for the untrained lay rescuer...”
- “There is an increased focus on methods to ensure that high-quality CPR is performed. Adequate chest compressions require that compressions be provided at the appropriate depth and rate, allowing complete recoil of the chest after each compression and an emphasis on minimizing any pauses in compressions and avoiding excessive ventilation...”
- “Minimize interruptions in effective chest compressions until ROSC or termination of resuscitative efforts.”
- “CPR prompt and feedback devices can be useful as part of an overall strategy to improve the quality of CPR during actual resuscitations...”
- “ACD-CPR may be considered for use when providers are adequately trained and monitored...Mechanical piston devices may be considered for use by properly trained personnel in specific settings for the treatment of adult cardiac arrest in circumstances (e.g., during diagnostic and interventional procedures) that make

^f Circulation. 2010;122:S640-S656

manual resuscitation difficult...”

- “These 2010 AHA Guidelines for CPR and ECC recommend compressions at a rate of at least 100/min. There is insufficient evidence to recommend the routine use of high-frequency chest compressions for cardiac arrest. However, high-frequency chest compressions may be considered by adequately trained rescue personnel as an alternative...”
- “It is important to reduce time to first chest compressions...”
- “The quality of rescuer education and frequency of retraining are critical factors in improving the effectiveness of resuscitation.”

FDA believes the current re-classification initiative provides a unique opportunity for the Agency in this important area. After fully considering the available data and comments received (public and private), FDA proposes modifications (presented below) to the regulation of these devices. These proposed changes rely on the benefit/risk profiles^g of these devices and that the proposed levels of controls, either Class I (general controls) or II (special controls) are sufficient to mitigate the identified risks to health. FDA is justified in taking these steps to encourage and optimize the application of CPR.

ECC Devices

External Cardiac Compressors are intended to replace manual cardiac compression under specific circumstances (e.g., rescuer fatigue or transport situations). From a regulatory standpoint, FDA considers ECCs to be distinct from CPR aids: whereas a CPR aid’s intended effect is to augment the quality of a responder’s resuscitation effort, an ECC is designed to completely replace blood circulation elicited by manual CPR. Although data from the literature is equivocal regarding the effectiveness of ECCs, FDA recognizes the likelihood of substantial benefit in those situations where effective manual compressions simply cannot be delivered. In such settings, FDA believes that ECC devices can be reasonably considered as life-sustaining. FDA believes a Class II designation is appropriate for these devices, because special controls can be established to adequately mitigate the identified risks to health. However, FDA does not believe there is clinical justification for the use of ECCs to completely replace manual CPR when effective manual CPR can be delivered by the rescuer. FDA further recognizes that

^g Pursuant to 21 CFR 860.7 [emphasis added] “In determining the safety and effectiveness of a device for purposes of classification, establishment of performance standards for class II devices, and premarket approval of class III devices, the Commissioner and the classification panels will consider the following, among other relevant factors:

- (1) The persons for whose use the device is represented or intended;
- (2) The conditions of use for the device, including conditions of use prescribed, recommended, or suggested in the labeling or advertising of the device, and other intended conditions of use;
- (3) *The probable benefit to health from the use of the device weighed against any probable injury or illness from such use; and*
- (4) The reliability of the device.

misbranding/mislabeling of an ECC device or misuse of an accurately labeled ECC device can both carry clinically significant risks for patients. Accordingly, FDA maintains that ECCs should remain as prescription devices to be used only by fully trained professionals in recommended use scenarios (e.g., extended transport times that would otherwise lead to deleterious provider fatigue).

CPR Aid Devices

FDA no longer perceives a public health benefit for requiring prescription restrictions to the CPR aid devices. Rather, we now believe the need for a prescription likely constitutes a barrier to device availability without providing any substantive increase in overall safety or effectiveness. FDA agrees with AHA about the critical importance of expanding the implementation of CPR as broadly as possible; having appropriate CPR aid devices easily available to all potential users can help in this regard. Notably, the absence of a prescription will not fundamentally alter FDA's position on the need for specific labeling regarding the importance of specific training, if necessary for a specific device.

FDA believes that classification of the devices (and FDA's review of submissions) should be guided by the complexity of the device's design and intended clinical effect, and thus the device's benefit/risk profile. Therefore, a device that provides basic, non-individualized information to a user (e.g., a metronome that operates at 100 cycles/minute or a placement aid for hand positioning) could be regulated with general controls (Class I) and design controls if the device contains software. A device that provides patient-specific feedback to a CPR provider (e.g., adequacy of specific depth and/or rate of chest compressions) should include design controls and validation and specific special controls (Class II) to support the claim(s) of the device. If the feedback provided to the user can vary from patient to patient (i.e., device-based software performs real-time data analysis leading to varying device effect (e.g., compression/depth technology that advises a user to give deeper or shallower compressions), such a device would be subject to 510(k) requirements; other Class II CPR aids (e.g., technology that does not utilize software) would be exempted from pre-market notification. FDA believes that CPR aid devices that do not contain software can be exempted from 510(k). Exemption of these devices is consistent with the factors outlined in "Procedures for Class II Device Exemptions from Premarket Notification, Guidance for Industry and CDRH Staff" (<http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/ucm080199.pdf>).^h

^h The following factors are considered when determining whether premarket notification is required to provide a reasonable assurance of safety and effectiveness for a Class II device:

- (1) The device does not have a significant history of false or misleading claims or of risks associated with inherent characteristics of the device, such as device design or materials;
- (2) characteristics of the device necessary for its safe and effective performance are well established;
- (3) changes in the device that could affect safety and effectiveness will either:
 - (a) be readily detectable by users by visual examination or other means such as routine testing, before causing harm, e.g., testing of a clinical laboratory reagent with positive and negative controls; or
 - (b) not materially increase the risk of injury, incorrect diagnosis, or ineffective treatment; and
- (4) any changes to the device would not be likely to result in a change in the device's classification.

Summary of FDA Recommendation

FDA believes that special controls, in addition to general controls, can be established to mitigate the identified risks to health and provide reasonable assurance of the safety and effectiveness of ECC devices when used as an adjunct to manual cardiopulmonary resuscitation (CPR) during patient transport, extended CPR when fatigue may prohibit the delivery of effective/consistent compressions to the victim, or when insufficient EMS personnel are available to provide effective CPR. As mentioned previously in the section titled Discussion of Risks to Health, FDA concurs that the risks to health identified by the original classification panel still remain relevant today and has proposed additional risks to health as summarized previously (Table 1).

FDA believes that general controls, including design controls for devices containing software, can be used to mitigate the identified risks to health and provide reasonable assurance of the safety and effectiveness of CPR Aid devices without feedback when the device offers a simple function such as proper hand placement and/or simple prompting for rate and/or timing of compressions/breathing for the professionally trained rescuer, but offers no real-time feedback related to the quality of the CPR. As mentioned previously in the section titled, Discussion of Risks to Health, FDA has proposed the risks to health related to these devices and has summarized this information previously in Table 2.

FDA believes that special controls, in addition to general controls can be used to mitigate the identified risks to health and provides reasonable assurance of the safety and effectiveness of CPR Aid devices with feedback when the device provides real-time feedback to the rescuer regarding the quality of CPR being delivered to the victim. The feedback consists of audio and/or visual information to encourage the rescuer to continue the consistent application of effective manual CPR in accordance with current accepted CPR guidelines - to include, but not be limited to, parameters such as compression rate, compression depth, ventilation, recoil, instruction for one or multiple rescuers, a guiding function to aid rescuers in all the steps necessary to perform CPR, etc. As mentioned previously in the section titled, Discussion of Risks to Health, FDA has proposed the risks to health related to these devices and has summarized this information previously in Table 2.

Mitigations for Identified Risks (Special Controls)

External Cardiac Compressors

The mitigation measures for ECC devices are identified in Table 6.

Table 6: Risk/Mitigation Measures for ECC

Identified Risk	Mitigation Measure Recommendations
Cardiac arrhythmias or electrical shock	<ul style="list-style-type: none"> ➤ Electrical Safety and Electromagnetic Compatibility Testing (e.g., ISO 60601-1 and ISO 60601-1-2) ➤ Labeling
Tissue/organ Damage	<ul style="list-style-type: none"> ➤ Performance testing: 1) bench studies - testing on a CPR dummy such as “resuscit-annie” to evaluate the reliability of the delivery of specific compression depth and rate (in accordance with current AHA recommendations) over an intended duration of use; 2) software testing. ➤ Labeling: Limiting patient population by size and age (adult). ➤ Training
Bone breakage (ribs, sternum)	<ul style="list-style-type: none"> ➤ Performance testing: 1) bench studies - testing on a CPR dummy such as “resuscit-annie” to evaluate the reliability of the delivery of specific compression depth and rate (in accordance with current AHA recommendations) over an intended duration of use; 2) software testing. ➤ Labeling: Limiting patient population by size and age (adult) ➤ Training
Inadequate blood flow	<ul style="list-style-type: none"> ➤ Performance testing: 1) bench studies - testing on a CPR dummy such as “resuscit-annie” to evaluate the reliability of the delivery of specific compression depth and rate (in accordance with current AHA recommendations) over an intended duration of use; 2) software testing. ➤ Labeling: Limiting patient population by size and age (adult). ➤ Training
Adverse skin reactions	<ul style="list-style-type: none"> ➤ Biocompatible materials*

** Given the benefit/risk profile, we believe this risk can be adequately mitigated in this patient population by the general controls*

CPR Aid Devices

The mitigation measures for CPR aid devices, both without and with feedback, have been identified in Tables 7 and 8, respectively.

Table 7: Risk/Mitigation Measures for CPR Aid Devices without Feedback (Class I)

Identified Risk	Mitigation Measure Recommendations
Suboptimal CPR delivery	<ul style="list-style-type: none"> ➤ Intended for use by professionally trained rescuers ➤ Quality system regulation requirements, including design controls for devices that include software
Adverse Skin Reactions	Biocompatible materials*

** Given the benefit/risk profile, we believe this risk can be adequately mitigated in this patient population by the general controls*

Table 8: Risk/Mitigation Measures for CPR Aid Devices with Feedback (Class II)

Identified Risk	Mitigation Measure Recommendations
Suboptimal CPR delivery	<ul style="list-style-type: none"> ➤ Performance testing under simulated physiological or use conditions must demonstrate the accuracy and reliability of the feedback to the user on specific compression rate, depth and/or respiration over the intended duration of use; ➤ For devices that incorporate electrical components, appropriate analysis and testing must validate electrical safety and electromagnetic compatibility; ➤ For devices containing software, software verification, validation, and hazard analysis must be performed; ➤ Human factors testing and analysis must validate that the device design and labeling are sufficient for effective use by intended users; ➤ Labeling must include the clinical training, if needed, for the safe use of this device and information on the patient population for which the device has been demonstrated to be effective.
Adverse Skin Reactions	➤ Biocompatible materials*

** Given the benefit/risk profile, we believe this risk can be adequately mitigated in this patient population by the general controls*

These identified mitigation measures are the result of several years of FDA application review, technological advances (e.g., accelerometers to measure depth of compression, software), and more specific recommendations from AHA that have emphasized the need

to encourage the use of CPR and has increased our confidence in the ability of devices to assist in the delivery of efficient CPR therapy for cardiac arrest patients.

Based on the grim outcomes for cardiac arrest, the history of use with these devices, and the proposed Special Controls (to include recommendations for performance testing, electromagnetic compatibility, electrical safety, software and labeling, among others), FDA believes there is sufficient evidence to support reclassifying 870.5200 External Cardiac Compressors from Class III to Class II, (Special controls) and CPR Aid devices from Class III to Class II (Special Controls,) and Class I (General Controls.) The proposed regulations are shown below:

Regulation

21 CFR 870.5200 External Cardiac Compressor

FDA recommends that the identification for the regulation (21 CFR 870.5200) for ECC be more clearly defined as proposed below. Additionally, FDA recommends reclassification from Class III to Class II (Special Controls) as supported by the understanding that compressions in accordance with current accepted guidelines are effective, and that the ECC devices, as the proposed identification defines, are intended to replace compressions for situations where the alternative is no effective compression.

Current

870.5200 External Cardiac Compressor

- (1) *Identification.* An external cardiac compressor is an external device that is electrically, pneumatically, or manually powered and is used to compress the chest periodically in the region of the heart to provide blood flow during cardiac arrest
- (2) *Classification.* Class III (premarket approval)

Proposed

870.5200 External Cardiac Compressor

- (1) *Identification.* An external cardiac compressor is an externally-applied prescription device that is electrically, pneumatically, or manually powered and is used to compress the chest periodically in the region of the heart to provide blood flow during cardiac arrest. External cardiac compressor devices are used as an adjunct to manual cardiopulmonary resuscitation (CPR) during patient transport, extended CPR when fatigue may prohibit the delivery of effective/consistent compressions to the victim, or when insufficient EMS personnel are available to provide effective CPR.

(2) *Classification:* Class II (special controls).

The special controls for this device are:

- i. Performance testing under simulated physiological conditions must demonstrate the reliability of the delivery of specific compression depth and rate over the intended duration and environment of use;
- ii. Labeling must include the clinical training for the safe use of this device and information on the patient population for which the device has been demonstrated to be effective;
- iii. For devices that incorporate electrical components, appropriate analysis and testing must validate electrical safety and electromagnetic compatibility; and
- iv. For devices containing software, software verification, validation, and hazard analysis must be performed.

21 CFR 870.5210 Cardiopulmonary Resuscitation (CPR) Aid Devices

FDA is proposing a new regulation for CPR Aid devices [21 CFR 870.5210], which are currently being reviewed and cleared under the same classification regulation as ECC devices [21 CFR 870.5200]. The new regulation will provide distinct identifications between the Class I and Class II [special controls, both exempt and requiring a 510(k)] CPR Aid devices based on device design/technology.

The further distinction within the Class II devices is based on the complexity of the technology utilized, with software technology requiring a 510(k). It should also be noted that different fundamental scientific technology that exceeds the limitations of exemption for the Class II exempt devices that do not contain software would also require the submission of a 510(k).

870.5210 Cardiopulmonary Resuscitation Aid Devices

CPR Aid Device without Feedback

(1) *Identification:* A CPR Aid without feedback is a device that performs a simple function such as proper hand placement and/or simple prompting for rate and/or timing of compressions/breathing for the professionally trained rescuer, but offers no real-time feedback related to the quality of the CPR being provided. These devices are intended for use should be utilized by persons professionally trained in cardiopulmonary resuscitation through a certified CPR training organization, to assure proper use and the delivery of optimal CPR to the victim.

(2) *Classification:* Class I (general controls).

CPR Aid Device with Feedback

- (1) *Identification:* A CPR Aid device with feedback is a device that provides real-time feedback to the rescuer regarding the quality of CPR being delivered to the victim, and provides either audio and/or visual information to encourage the rescuer to continue the consistent application of effective manual CPR in accordance with current accepted CPR guidelines (e.g., to include, but not be limited to, parameters such as compression rate, compression depth, ventilation, recoil, instruction for one or multiple rescuers, etc.). These devices may also perform a guiding function to aid rescuers in all the steps necessary to perform CPR on a victim.
- (2) *Classification:* Class II (special controls). The device is exempt from the premarket notification procedures in subpart E of part 807 of this chapter if it does not contain software (e.g., is mechanical or electro-mechanical).

The special controls for this device are:

- i. Performance testing under simulated physiological or use conditions must demonstrate the accuracy and reliability of the feedback to the user on specific compression rate and/or depth over the intended duration of use;
- ii. Labeling must include the clinical training, if needed, for the safe use of this device and information on the patient population for which the device has been demonstrated to be effective;
- iii. For devices that incorporate electrical components, appropriate analysis and testing must validate electrical safety and electromagnetic compatibility;
- iv. For devices containing software, software verification, validation, and hazard analysis must be performed; and
- v. Human factors testing and analysis must validate that the device design and labeling are sufficient for the intended user.

If the panel believes that Class II is appropriate for ECC and a subset of CPR aid devices (as defined), the panel will be asked to discuss whether the proposed special controls appropriately mitigate the identified risks to health and/or whether additional or different special controls are recommended. Further, the panel will be asked to discuss whether general controls are sufficient for a subset of CPR aid devices that do not provide feedback to the patient.

APPENDIX A

References from Systematic Literature Search for ECC and CPR Aid Devices

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