Philips Fetal Monitoring

Monitoring Triplets

Application Note

For Avalon Fetal Monitors Rev. J.3x.xx onwards

The Philips Avalon FM20, FM30, FM40, and FM50 Fetal monitors offer the ability to monitor and document up to three fetal heart rates (FHRs) externally using ultrasound, and internally using DECG. In this application note the focus is on external monitoring with ultrasound. Not only was this solution the very first industry-wide, using a single Fetal monitor, but now with the Avalon CL Transducer System we are also the first to monitor triplets cableless. There are currently no comparable set-ups for monitoring triple fetal heart rates cableless.

The problems encountered when monitoring triplets using several devices are overcome by this integrated solution. This application note provides an overview of monitoring triple fetal heart rates both cabled and cableless, and describes the features and technologies Philips builds into its Avalon Fetal monitors and the Avalon CL Transducer System to make reliable triplets monitoring possible.

PHILIPS

Monitoring Triplets

While offering a ground-breaking solution to monitor triplets cableless using only one Fetal monitor, the methods Philips uses to achieve this are essentially an extension of the methods used for monitoring twins. What applies to twins monitoring also applies to triplets, and what applies to cabled transducers applies as well to the CL transducers:

- Each fetal heart rate is monitored by a separate ultrasound transducer.
- You can plug Avalon ultrasound transducers into any of the four sensor sockets on the monitor, the order in which you do this does not matter. The monitor recognizes the transducer and allocates a channel to it automatically.
- When monitoring cableless, the Avalon CL base station can be connected just like a cabled transducer to any of the four sensor sockets, or using an FM40/50 Fetal monitor to the Telemetry socket in the rear of the Fetal monitor. The CL base station can have up to four CL transducers assigned.
- You can choose to listen to the fetal heart sound coming from each transducer, for one transducer at a time (see "Fetal Heart Sound Source Selection" on page 2).
- Each fetal heart channel has its own numeric display on the monitor's screen.
- Each heart rate is documented as a separate trace on the fetal recorder.
- All traces are transmitted to a Philips OB TraceVue/IntelliSpace Perinatal obstetrical information and surveillance system.

However, it is important to be aware that monitoring three FHRs is more difficult than monitoring single or twin FHRs. The nature of the application increases the likelihood that the same heart rate is being recorded by more than one transducer. See "Cross-Channel Verification" on page 3 to see how Philips addresses this issue.

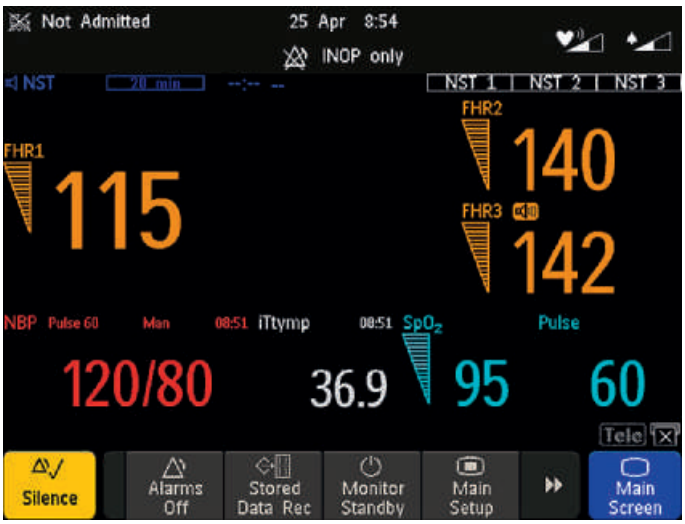
We recommend you also monitor the maternal pulse via SpO_2, or with a Toco MP or CL Toco$^+$MP transducer to avoid the possibility of mistaking the maternal heart rate (MHR) for the FHR.

Helpful Features

In this section, we look at the helpful features built into Philips Fetal monitors responsible for making the monitoring of triplets both accurate and convenient.

Automatic Screen Layout

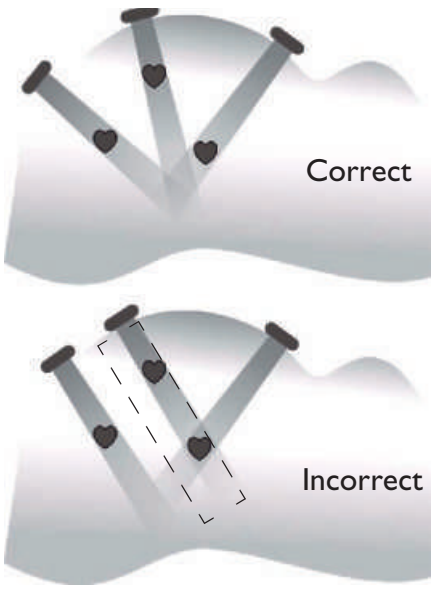
The Avalon Fetal monitor automatically recognizes which transducers are connected and adjusts the screen layout to ensure that all measurements, both maternal and fetal, are displayed optimally. No user interaction is required.



Typical Triplets Screen Layout

Fetal Heart Sound Source Selection

Position the transducers using the fetal heart sound on the monitor's loudspeaker. Make sure that each transducer picks up the signal from only one fetal heart. If necessary, identify the FHRs using independent means, such as an ultrasound imaging.



Positioning of Ultrasound Transducers

Avalon Fetal monitors let you select the fetal heart sound coming from each transducer. You can do this for one transducer at a time. Being

able to listen to the sound of each transducer separately lets you position the transducer more accurately than if the sound output from the loudspeaker allowed a mixture of more than one heart rate sound.

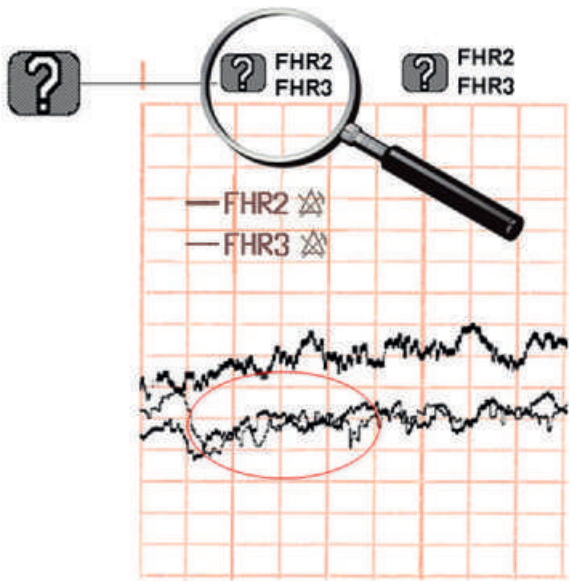
Cross-Channel Verification

The monitor's **Cross-Channel Verification** (CCV) feature can help significantly to reduce the possibility of mistaking one heart rate for another, for example, the maternal heart rate (MHR) for the FHR or another FHR.

CCV indicates when the same heart rate is being recorded by different transducers. On the screen, the coincidence indicator ? is displayed next to the two numerics on the screen that are picking up the same heart rate.

Coincidence Indication on the Screen

...and ? is repeatedly printed on the trace after about 30 seconds after detecting the coincidence, showing which heart rate channels are coinciding.



Coincidence Indication on the Trace

CCV compares all fetal and maternal heart rates continuously and indicates when multiple channels are picking up the same signal. This means when monitoring triplets and maternal heart rate simultaneously, CCV will compare the values from all fetuses and each of these values with the maternal heart rate.

When the maternal heart rate and fetal heart rate are being monitored, CCV will alert you when the values could be from the same source. This may happen following fetal or maternal movement, where the fetal heart is no longer within the ultrasound beam, and the transducer is picking up a signal from another source, most likely from a large maternal blood vessel or another fetal heart.

Note: Be aware that a maternal heart rate trace can exhibit features that are very similar to those of a fetal heart rate trace, even including accelerations and decelerations. Do not rely solely on trace pattern features to identify a fetal source.

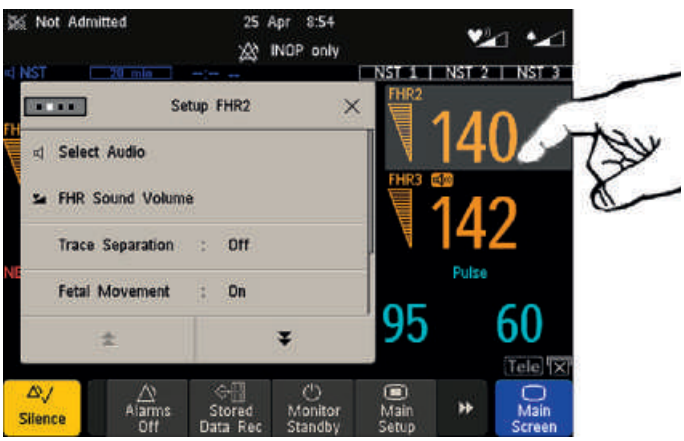
CCV technology helps reduce potential legal liability associated with continuing to monitor an incorrect heart rate. The INOP **Coincidence** is now by default a yellow INOP with tone that is issued immediately when the coincidence situation is detected. It has a configurable delay that can be set to either 30 seconds or 60 seconds. If a delay is configured, the INOP Coincidence is issued first in cyan without tone, and after the configured delay, it turns into a yellow INOP Coincidence that is issued with tone.

When CCV detects coinciding heart rate signals, you are alerted within approximately 30 seconds to check the traces and potentially reposition the transducers as appropriate to detect all three FHRs correctly. If necessary, identify the FHRs using independent means, such as a stethoscope or an ultrasound imaging.

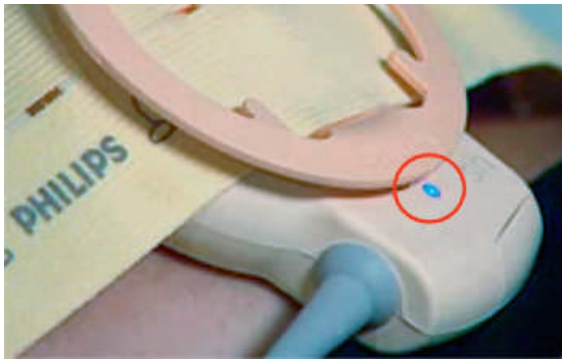
Easy Transducer Repositioning

When monitoring triplets, the need may arise to reposition the ultrasound transducers relatively often compared to when monitoring a single fetus. To allow rapid transducer identification, and therefore correspondingly quick transducer repositioning, each transducer is equipped with a **Finder LED**.

Touching an FHR numeric on the screen...



...illuminates the bright, blue Finder LED on the corresponding transducer.



Transducer Finder LED

This allows you to identify at a glance which transducer is monitoring which heart rate channel. Reposition the transducer using sound, and fix in place when the signal quality indicator shows a good signal.

Position each transducer so that it picks up the signal from only one, distinct fetal heart.

Trace Separation

The baselines of multiple FHR traces are often very similar, and when this occurs, independent trace interpretation can be challenging. Philips Fetal monitors have two complementary features to help: Configurable Trace thickness and Trace Separation.

To ensure that the three heart rates are easily distinguishable on the trace recording, Philips uses a configurable Trace thickness. With this feature, you can configure the fetal heart rate trace recorded for the first fetus (FHR1) thicker (darker) than that recorded for the second fetus (FHR2), which in turn is thicker than that for the third fetus (FHR3), with no loss in variability.

The Trace Separation feature separates the baselines on the recording. You can choose to separate the baselines on the recorder print-out by an offset of 20 bpm, so that the trace for FHR2 is shown 20 bpm higher than it really is, and the trace for FHR3 is shown 20 bpm lower than it really is. The value for the fetal heart rate displayed on the screen is, of course, the real fetal heart rate. Here you can select if you either want to set the Trace Separation to the **Standard** or **Classic** offset setting.

With the **Standard** setting, the FHR2 trace is shifted up by 20 bpm (it is recorded 20 bpm higher than it really is). No offset is ever applied to the FHR1 trace - it stays where it is, and the FHR3 trace is shifted down by 20 bpm.

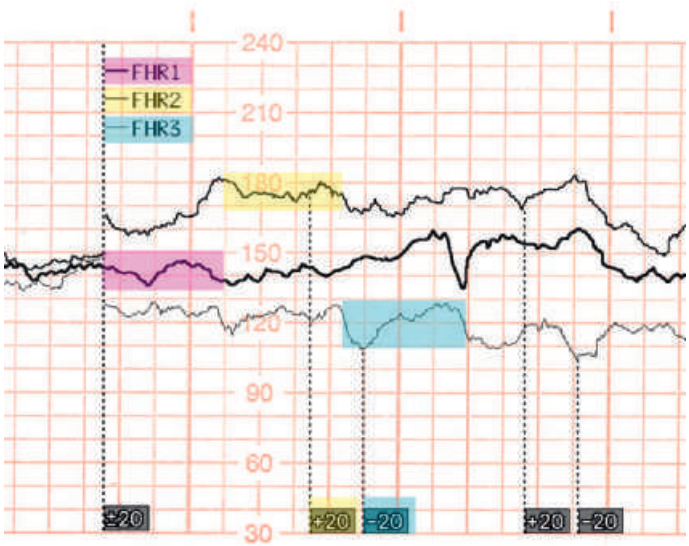
With the **Classic** setting, the FHR1 trace is shifted up by 20 bpm. No offset is ever applied to the FHR2 trace - it stays where it is, and the FHR3 trace is shifted down by 20 bpm.

You can turn off the trace separation feature and return the FHR trace to its original baseline anytime you wish.

When trace separation is turned on (Standard offset):

- The recorder prints a dotted line labeled with the three FHRs at the top, and ±20 at the bottom.
- The trace FHR2 is offset by +20 bpm, and the trace for FHR3 is offset by -20 bpm.
- The recorder prints a dotted line labeled +20 across the FHR scale, to identify the trace for FHR2, about every 5 cm..
- The recorder prints a dotted line labeled -20 across the FHR scale, to identify the trace for FHR3, about every 5 cm.
- The FHR trace is labeled +20 and -20 every 5 cm.

The following trace shows trace separation switched on:



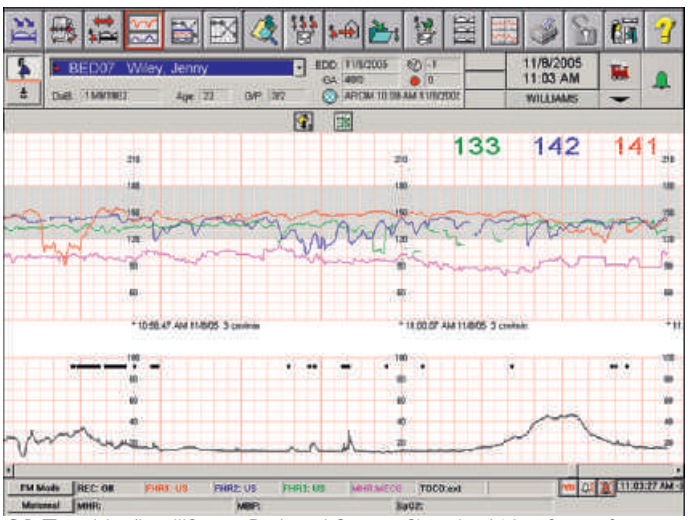
Trace Separation Switched On

Even though the traces for FHR2 and FHR3 are offset, the numerical FHR values displayed on the monitor remain unchanged. Subtract 20 from the recorded trace for FHR2 to manually determine the true FHR2. For example, if the recorded trace shows 160, then the true FHR is 140. Similarly, add 20 to the recorded trace for FHR3 to obtain the true FHR3.

Triplets and OB TraceVue/ IntelliSpace Perinatal

Triplets Surveillance, Alerting, and Trace Archiving on OB TraceVue/IntelliSpace Perinatal

The connection of an Avalon Fetal monitor to a Philips OB TraceVue/ IntelliSpace Perinatal system supports triplets surveillance and complete archiving, including Cross-Channel Verification[1].



OB TraceVue/IntelliSpace Perinatal Screen Showing Waveforms for Triplets and Maternal Heart Rate

Triplets monitoring with the Avalon Fetal monitor in combination with OB TraceVue/IntelliSpace Perinatal, addresses the legal requirements for the complete archiving of traces for all three fetuses together with the mother.

Automatic Upload of Triplets Trace Data on an OB TraceVue/IntelliSpace Perinatal System (LAN Only)

An Avalon Fetal monitor stores trace data, including annotations, in its internal backup memory for up to min. 7 hours[2], and this applies for single, twins, or triplets monitoring. This allows the monitor to recover trace data that would otherwise be lost under certain circumstances. This trace data can be automatically retrieved and printed in the event of the paper running out, or automatically uploaded to an OB TraceVue/IntelliSpace Perinatal system (OB TraceVue/IntelliSpace Perinatal Revision E.00.00 or higher) connected via LAN, allowing the continuity of data.

When the OB TraceVue/IntelliSpace Perinatal system reconnects to the Avalon Fetal monitor and detects that there is trace data in the monitor's backup memory that has not yet been transmitted to the system, this data is transferred at high speed to the system. No user action is required.

The exact length of the recovered trace will vary depending upon the amount of trace information, but will cover at least 7 hours of trace data, regardless of how many parameters are being measured.

The Technological Challenge

Monitoring multiple fetal heart rates accurately and reliably poses a number of technological challenges. For example, several ultrasound transducers applied to the same patient can interfere with each other, generating noise on the loudspeaker output and preventing the correct calculation of the heart rate. Sometimes, even an artificial heart rate can result.

There are three quite different approaches to try to solve the problem of interference:

Method A: Using significantly different ultrasound frequencies for each transducer.

Method B: Alternating the operation of all ultrasound transducers (all transducers are transmitting and receiving at different times).

Method C: Using fully synchronized ultrasound transmission for all transducers.

Method A

Method A requires different sensors (containing different ultrasound crystals) for each fetus. This makes application complicated for the user, as each heart rate channel requires a different transducer. Finding the right transducer and sharing transducers within a hospital becomes problematic, more transducers are needed per hospital, and more spare parts need to be stocked. Consequently, Philips does not use this method.

Method B

Method B alternates operation of all the ultrasound transducers, so the higher the number of fetal heart rates you measure, the shorter the time that any specific transducer is active. This means that when monitoring twins, each ultrasound transducer is active only half as long as when monitoring a single fetus. Extend this to triplets, and each transducer is active only one-third of the time. The result is a dramatic reduction in sensitivity, signal quality, and therefore performance, with the consequence that weak ultrasound signals may not be detectable. In view of these drawbacks, Philips takes a different approach.

1. OB TraceVue/IntelliSpace Perinatal Revision E.00.00 or higher.

2. With main board hardware revision A.00.18 or greater

Method C: The Philips Solution

Philips Fetal monitors use fully synchronized transmission for all ultrasound transducers, and this approach avoids all the disadvantages associated with methods A and B. Philips ultrasound transducers are fully synchronized in terms of ultrasound frequency, burst repetition frequency, and the timing of transmission and reception.

Synchronized ultrasound frequency: Even a small difference in the ultrasound frequency between transducers can result in clearly audible noise. To avoid this problem, all Philips ultrasound transducers utilize exactly the same frequency. In fact, all Avalon ultrasound transducers can be interchanged and combined for triplets monitoring. You can take any three Avalon ultrasound transducers in your hospital without having to worry about where they come from or how they are combined. The Philips solution makes handling transducers simple, and means that fewer transducers are required in total, making triplets monitoring convenient and efficient, saving you time.

Burst repetition frequency and timing: When ultrasound transducers are transmitting and receiving at different times, a strong transmitter signal can mask a weak echo of another transducer when one transducer is transmitting while the other is receiving. To avoid this, all ultrasound transmission bursts have exactly the same burst repetition frequency, and are started at the same time. So all transducers are transmitting at the same time, and receiving at the same time.

Each fully synchronized transducer has its own central processing unit (CPU), so there is a separate processing channel for each heart rate. This means that when monitoring multiple fetal heart rates, the sensitivity for each transducer is not compromised, and the performance is the same as when monitoring a single fetus. The performance of the Fetal monitor remains unaffected regardless of how many heart rate channels are being monitored.

What You Need to Monitor Triplets

To monitor triplets, simply:

- Order the appropriate software option for the Avalon FM20, FM30, FM40, or FM50 Fetal monitor to enable triple FHR monitoring via ultrasound.
- Have three Avalon ultrasound transducers (M2736A) or three Avalon CL ultrasound transducers (866076) available.

For details of measurement and accessory options, contact your local Philips sales representative.

Monitoring Triplets Cableless with the New Avalon CL Transducer System

The methods and technology of monitoring triplets described here apply also to monitoring triplets with the new Avalon CL Transducer System. The CL base station simply plugs like a cabled fetal transducer to a fetal socket at the Fetal monitor, or in case of the FM40 and FM50 also to the Telemetry socket. The CL transducers can be used exactly the same as their cabled counterparts and have the same reliability within their operating range of 100 m (300 ft.) line-of-sight around the base station as the cabled transducers. When a CL transducer is enabled, all cabled transducers are disabled. The mother is able to walk and move around during monitoring and can even be monitored under water.

You can assign up to four CL transducers to the CL base station, 3 CL ultrasound transducer and one CL Toco^{+}MP transducer while monitoring triplets. The CCV feature continuously compares all available fetal and maternal heart/pulse rates. For more detailed information on the Avalon CL Transducer System, see the Instruction for Use of your Fetal monitor revision J.3 or higher.

Avalon CL Transducer System

Frequently Asked Questions

The following frequently asked questions, with their answers, may provide you with some useful information or tips regarding triplets monitoring.

Q. I am finding it difficult to locate the third fetal heart rate using the sound from the transducer. What should I do?

A. Locate the third fetus using palpation and/or an ultrasound scanner to determine the fetal position, and the location of the fetal heart. Then reposition the transducer using sound, and fix the transducer in place when the signal quality indicator is showing a good signal.

Tip: sometimes you may find it helpful to tilt the transducer at the cable boot end to make sure the ultrasound beam stays focused on the fetal heart.

Q. The symbol ? appears on the screen next to a FHR or MHR/mPulse label, and ? is repeatedly printed on the fetal trace recording. What does this mean?

A. This is the monitor's Cross- Channel Verification (CCV) feature indicating that the same heart rate is being recorded by more than one transducer (see "Cross-Channel Verification" on page 3).

On the trace recording, you can see which heart rates are coinciding:

Once you know which heart rate channels are coinciding, reposition one of the transducers using sound to make sure you are monitoring two distinct heart rates.

Q. I can only hear the heart sounds from one FHR channel, and would like to hear the heart sounds from a different fetus. Can I do this?

A. Yes, you can. You can listen to one fetal heart rate channel at a time. When the fetal heart sound is selected for an FHR channel, you see the audio source symbol next to the FHR numeric label for that channel.

To select the audio source for a different FHR channel just touch the numeric of the channel you want to hear, then press **Select Audio**. It may take a few seconds for the audio source symbol to appear.

Q. The signal quality indicator for one of the FHR channels is empty, and the numeric has disappeared from the screen. What should I do?

A. There is signal loss on this FHR channel, and you need to reposition the transducer to obtain a good signal again. Note that fetal movement and maternal position change can cause signal loss.

To identify which transducer needs repositioning, touch the FHR channel's empty numeric on the screen. This illuminates the Finder LED of the relevant transducer, so you can easily find the transducer.

Select the fetal heart sound for this FHR channel, and make sure the audio volume is at a clearly audible level. Reposition the transducer using sound, and make sure that the signal quality indicator is full, indicating good signal quality. Allow about 30 seconds for the signal to stabilize.

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Printed in Germany
4522 991 05031 Aug 2014