Additional Information Regarding Ultrasound Fetal Monitoring - English

This addendum provides additional information for all Avalon FM20/FM30/FM40/FM50 Fetal Monitor Instructions for Use, regarding Ultrasound Fetal Monitoring.

Artifact in Fetal Heart Rate Measurement - How to Detect It and Reduce Its Occurrence Using the Avalon Fetal Monitor

The ultrasound derived FHR measurement technique in Avalon fetal monitors, like all other ultrasound fetal monitors’ FHR measurement techniques, has limitations that can lead to misrepresentation of the fetal heart rate pattern and potential misinterpretation of the fetal condition. See Appendix A for an explanation of ultrasound fetal monitoring technology and its limitations. An incorrect interpretation of the trace may lead to either unnecessary interventions or to failure to detect fetal distress and the need for intervention. Therefore, the on-going evaluation of the recorded trace requires regular confirmation that the trace represents true FHR. Specific situations requiring such confirmation include the following:

– After starting a measurement or changing a transducer
– After maternal position changes, for example during pushing with contractions
– When the tracing shows abrupt changes in baseline rate, variability, or pattern (decelerations to accelerations) especially in the second stage of labor
– When the baseline maternal heart rate is within about 15 bpm of the FHR
– When the user is unable to determine a baseline rate and variability occurs between consecutive contractions

There are several ways to verify the source and/or accuracy of the recorded fetal heart rate pattern. These include:

Verification of the FHR with:

– An obstetric stethoscope,
– Ultrasound imaging, or
– A fetal scalp electrode

Verification of the maternal heart rate:

– Using pulse oximetry - for a maternal heart rate pattern displayed simultaneously with the FHR (Cross-Channel Verification (CCV) feature),
– Using Maternal ECG - for a maternal heart rate pattern displayed simultaneously with the FHR (CCV feature), or
– Manual determination of the maternal pulse
It is strongly recommended that the maternal pulse oximeter or maternal ECG be employed to make use of the monitor’s Cross-Channel Verification (CCV) feature, especially during the second stage of labor or when the maternal pulse is elevated over 100 bpm. The Philips Avalon fetal monitor offers maternal pulse oximetry (SpO2) and maternal ECG for maternal pulse detection and the creation of a maternal heart rate pattern plotted on the same recorder as the FHR pattern. When either of these parameters is utilized, the monitor will automatically and continuously perform a CCV of the maternal heart rate pattern against the FHR pattern displayed on the monitor. If the patterns and rates are similar, the CCV provides an alert that both rates are likely to be from the same source (i.e., they both represent the maternal heart rate pattern and the fetus is not being monitored). Repositioning the ultrasound transducer will usually correct this, but it may be necessary to apply a fetal scalp electrode. Advising the mother to temporarily cease pushing during contractions may help to more rapidly resolve any uncertainty in this situation.

Specific artifacts common to fetal monitors include (refer to Appendix B, “Examples of Artifacts”):

- **Doubling:** The autocorrelation algorithm can display a doubled fetal or maternal heart rate if the duration of diastole and of systole are similar to each other and if the heart rate is below 120 bpm. Doubling, usually brief, is accompanied by an abrupt switch of the trace to double the baseline value.

- **Halving:** With fetal tachycardia (above 180 bpm) and some interference from breathing or maternal arteries the autocorrelation algorithm may only recognize every second beat resulting in a halved rate for a limited time. If the actual FHR is above the maximum limit of the monitor (240 bpm), the algorithm will also half-count. Halving is accompanied by an abrupt switch of the trace to exactly half the prior baseline value. This switch may simulate a FHR deceleration and be referred to by clinicians as a “false deceleration.”

- **Switching to maternal heart rate (also referred to as “Maternal Insertion”):** The fetal heart can move partly or fully out of the ultrasound beam and the autocorrelation algorithm may then pick up and display the maternal heart rate. Depending on the signal mix in the ultrasound signal, switching to the maternal heart rate may mimic several conditions with the potential for erroneous interpretation and response as follows:
  - The switch to the maternal heart rate may simulate a FHR deceleration (i.e., a decrease of the fetal heart rate, and be referred to by clinicians as a “false deceleration”).
  - The maternal heart rate may simulate a normal fetal heart rate pattern (i.e., it may mask a FHR deceleration or fetal demise).
    
    Especially during pushing with contractions in the second stage of labor, the maternal heart rate may increase to the point where it may equal or exceed the fetal rate. Here the maternal trace may mimic a normal fetal trace while the fetus may be having decelerations or fetal demise has occurred. This change from fetal to maternal heart rate pattern may not be at all obvious unless CCV is used and represents the most dangerous pitfall of all the artifacts because fetal distress may go unrecognized.

  - The maternal heart rate may simulate a FHR acceleration, which is an increase of the fetal heart rate.

    During expulsive efforts, the maternal heart rate normally accelerates and may be at or above the normal FHR range.

  - The FHR may display gradual appearing decelerations. Generally, the “false decelerations” described above are abrupt. Rarely, combinations of “noisy/erratic signal” associated with changes in maternal and/or fetal rate or movement will produce more gradual appearing “false decelerations” but these are usually short-lived with an abrupt return to an obviously stable FHR baseline.
• “Noisy/Erratic” signals: With mixed or weak signals the tracing may reveal very brief episodes of erratic recorded traces. These represent the autocorrelation algorithm finding brief sequences of apparent and persistent heartbeats amidst a mixed or weak signal. These erratic recorded traces are commonplace, especially in association with fetal or maternal movement. During prolonged periods of such noisy/erratic signals, the fetus is not being adequately monitored.

• Drop out: With mixed or weak signals there may be no heart rate tracing at all. These episodes reflect that if the algorithm does not find an apparent and persistent heartbeat amidst a mixed or weak signal, it will not print a heart rate on the tracing. Brief episodes of drop out are commonplace, especially in association with fetal or maternal movement. During prolonged periods of drop out, the fetus is not being adequately monitored.

Multiple Fetuses

With multiple fetuses, the potential to experience these artifacts is increased. Positioning of the transducer is even more critical. Ultrasound scanning should be used to help with positioning of individual transducers.

Obtaining a Good Fetal Heart Signal with the Avalon Fetal Monitor

To successfully position the ultrasound transducer, first determine the fetal position using palpation. Position the transducer over the strongest audible fetal heart sound from the monitor’s speaker and wait at least six seconds after each transducer adjustment to verify a good signal quality displayed on the Signal Quality Indicator and a consistent FHR numeric display. Having determined the position that provides a strong fetal signal, fix the transducer on the abdomen with the belt.

If the quality of the signal or the appearance of the heart rate trace from the ultrasound transducer is questionable, the transducer should be repositioned as described above. Alternatively, the use of an ultrasound scanner will greatly facilitate the determination of the optimal site for the ultrasound heart rate transducer. Factors during the second stage of labor that may influence the quality of the FHR tracing obtained with ultrasound include:

- Uterine contractions
- Changing contour of the maternal abdomen
- Maternal body movement - positioning
- Maternal expulsive efforts - pushing
- Maternal tachycardia/accelerations with contractions
- Fetal decelerations, Fetal tachycardia
- Delayed return of the fetal heart rate from a deceleration
- Descent of the fetus in the birth canal
- Rotation of the fetus in the birth canal

In some cases during the second stage of labor, a good and reliable ultrasound FHR signal may not be obtainable, and the use of a fetal scalp electrode must be considered (fetal ECG).
Audio Output

The audio output from the device is an aural representation of movement that, in most cases, permits accurate auscultation of the FHR corresponding to the FHR displayed on the monitor and rate pattern depicted on the trace recording. On occasion, the user may hear a FHR in the audio output that differs from the FHR display and the recorded trace. This may occur in situations where the fetal heart moves partly out of the transducer ultrasound beam. In these cases, the user may still audibly recognize the FHR in the audio output of the monitor’s speaker, even though another periodic signal (usually the maternal heart rate) has become stronger. The autocorrelation algorithm will display the stronger maternal heart rate, despite the persistence of a weaker fetal signal. These occurrences are usually very brief and, if persistent, can be addressed by repositioning the transducer.

Architecture: Avalon FM compared with its predecessor, Series 50

The autocorrelation algorithm for the Avalon fetal monitors was designed to have data handling characteristics similar to those of the Series 50. Compared to the Series 50 (designed in the 1990s) the technology has changed. Therefore, the architecture of the ultrasound parameter of the Avalon fetal monitors has a few differences that are visible to the user.

- The User Interface has been updated with some specific changes to the Signal Quality Indicator and Cross-Channel Verification displays (see details described below).
- Typically, the Avalon fetal monitor takes a few seconds longer to display the Signal Quality Indicator and the fetal heart rate numeric after placement of the transducer. Refer to the section above entitled “Obtaining a Good Fetal Heart Signal.”
- When the ultrasound Doppler signal gets weak or ambiguous (mixed fetal/maternal signal), the recorded trace of the Avalon monitor may not be identical to how the Series 50 recorded trace would have appeared. Figure 1 shows an example of how both monitors may display double-counting in a slightly different manner.

![Figure 1: Example of double-counting, showing how the Avalon and Series 50 recorded traces may not identically respond to the same FHR input.](image-url)
Figure 2 shows the same tracings with the double-counting suppressed. While double-counting is no longer visible, there are clearly periods of dropout during these times. Whether the artifact is included or not, the clinical interpretation of the tracing does not change whether the tracing is from the Avalon or the Series 50 fetal monitor.

User Interface: Avalon compared with its predecessor, the Series 50

Signal quality indicator on Avalon fetal monitors

Instead of a traffic light-like design (red – yellow – green) used on the Series 50, the signal quality on the Avalon fetal monitor is indicated by a triangle on the touch screen that is displayed in one of three ways (see Figure 3):

1. Completely filled triangle, indicating good signal quality.
2. Half-filled triangle, indicating limited signal quality. This condition may indicate a weak or ambiguous signal. If this status persists, reposition the transducer.
3. Empty triangle, indicating insufficient signal quality. No FHR is displayed on the monitor’s numeric display or the recorded trace. If this status persists, reposition the transducer.
**Cross-Channel Verification (CCV) indication on Avalon fetal monitors**

If the Cross-Channel Verification detects a probable duplication of information from both the MHR channel input device (maternal ECG or pulse oximeter) and the fetal transducer, the corresponding recorded trace segment is annotated with question marks at the upper edge of the heart rate grid. This is the same for the Avalon fetal monitor and the Series 50. In addition, the Avalon fetal monitor provides an annotation on the recorded trace to indicate which heart rates coincide. The Avalon fetal monitor also identifies coincidence with a question mark on the FHR numeric display, indicating that the FHR being displayed may actually be the maternal heart rate (see Figure 4).

When multiple fetuses are monitored, the Avalon will identify and label apparent CCV between either two fetuses or a fetus and the mother.

1. FHR1
2. Pulse
3. FHR1 Pulse

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**Figure 4: Avalon CCV numeric display and recorded trace showing coincident alerts**

When monitoring the maternal ECG, a beat-to-beat maternal heart rate trace is printed alongside the FHR recorded trace. When monitoring the maternal SpO₂ derived pulse rate, a filtered and averaged heart rate trace is printed.
Appendix A -- Ultrasound Fetal Monitoring

Technical Description

Fetal monitors use the ultrasound Doppler method for externally monitoring the fetal heart rate. Using the Doppler method, the transducer (in transmitter mode) sends sound waves into the body which are then reflected by different tissues. These reflections (Doppler echoes) are picked up by the transducer (in listening mode). These Doppler echoes are amplified and sent to the monitor’s speaker through which the fetal heart signal can be heard. In parallel the Doppler echoes are processed through an autocorrelation algorithm to determine the fetal heart rate (FHR). The FHR is displayed on the monitor’s numeric display and on the recorded trace.

Properly representing the fetal heart rate using a device that derives heartbeats from motion is a formidable task and the limitations of the technology will be discussed shortly. Basic fetal cardiac physiology may contribute to difficulties in obtaining a reliable ultrasound signal. A heart rate pattern of a fetus is capable of extraordinary variation, ranging from a quiet stable pattern with minimal variation while the fetus is “asleep” to robust accelerations of 40-60 bpm above baseline rate over a few seconds or exaggerated variability when the fetus is active. Decelerations of the rate 60-80 bpm below baseline may develop even more abruptly than the accelerations. Beat-to-beat arrhythmias may further exaggerate the amount of “variability” and be seen at the bottom of variable decelerations, or in the presence of fetal breathing movements which also tend to lower the fetal heart rate. The recognition of these normal variations in fetal heart rate patterns will greatly assist in the separation of genuine fetal information from the artifact discussed earlier.

Limitations of the Technology

All tissues moving towards or away from the transducer generate Doppler echoes. Therefore, the resulting signal that is provided to the monitor’s speaker, and for further fetal heart signal processing, can contain components of the beating fetal heart wall or valves, fetal movements, fetal breathing or hiccup, maternal movements such as breathing or position changes, and pulsating maternal arteries.

The fetal heart signal processing uses an autocorrelation algorithm to obtain periodic events such as heart beats. If the signal is erratic such as from a fetal arrhythmia, the ultrasound device may have trouble tracking the abrupt changes and may misrepresent the true FHR pattern.

Signals such as those from moving fetal limbs are usually very strong, thereby masking the fetal heart signal. During prolonged movements where the fetal heart signal is masked, the FHR appears blank on the numeric display and as a gap on the recorded trace.

Fetal position changes, maternal position changes, or uterine contractions can move the fetal heart partly or fully out of the ultrasound beam resulting in signal loss or even picking up Doppler echoes from pulsating maternal arteries. In these cases a maternal heart rate or sometimes even a rate resulting from the mixture of fetal and maternal signals may be displayed on the monitor’s numeric display and on the recorded trace.

In contrast to the timely well-defined R-peak of an ECG signal obtained with a fetal scalp electrode, the ultrasound Doppler signal from a fetal heart consists of multiple components from atria (diastole), ventricles (systole), valves, and pulsating arteries. These components vary depending on fetal and transducer position and angle, and are further modulated by factors such as fetal or maternal breathing. These effects may produce what is called “artifact”. Optimal transducer positioning therefore is key to minimizing these effects and thereby minimizing artifact.
Appendix B -- Examples of Artifacts

Following are recorded trace examples of complaints received regarding inaccurate output from the Avalon monitors. Scaling is 3 cm/min and 30 bpm/cm.

<table>
<thead>
<tr>
<th></th>
<th>Double-Counting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Rate</td>
<td>120</td>
</tr>
<tr>
<td>Baseline Variability</td>
<td>Moderate</td>
</tr>
<tr>
<td>Accelerations</td>
<td>Present</td>
</tr>
<tr>
<td>Decelerations</td>
<td>Not apparent</td>
</tr>
<tr>
<td>Contractions</td>
<td>Excessive, coupling, hypertonus</td>
</tr>
<tr>
<td>Artifact</td>
<td>Double-Counting</td>
</tr>
<tr>
<td>Comment</td>
<td>Reassuring tracing. The excessive uterine activity should prompt discontinuation of any oxytocic agent.</td>
</tr>
<tr>
<td>Remediation</td>
<td>The true fetal rate can be confirmed by auscultation or by fetal scalp electrode.</td>
</tr>
</tbody>
</table>
### Half-Counting

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Rate</td>
<td>120</td>
</tr>
<tr>
<td>Baseline Variability</td>
<td>Moderate</td>
</tr>
<tr>
<td>Accelerations</td>
<td>Present</td>
</tr>
<tr>
<td>Decelerations</td>
<td>Not apparent</td>
</tr>
<tr>
<td>Contractions</td>
<td>Minimal</td>
</tr>
<tr>
<td>Artifact</td>
<td>Half-counting, noise, drop out</td>
</tr>
<tr>
<td>Comment</td>
<td>Reassuring tracing. The half-count at 4-5 minutes into the tracing may simulate a fetal deceleration, but the abruptness and the lack of any compensatory changes when the normal rate returns suggests that this is half-counting. Insertion of the maternal heart rate (see below) may produce a similar pattern. Note also very brief episodes of half-counting, maternal insertion, and signal drop out.</td>
</tr>
<tr>
<td>Remediation</td>
<td>Auscultation or the application of a direct scalp electrode, if feasible, will reveal the true fetal heart rate.</td>
</tr>
</tbody>
</table>
### Maternal-Switching (Maternal Insertion)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline Rate</strong></td>
<td>170 - Tachycardia</td>
</tr>
<tr>
<td><strong>Baseline Variability</strong></td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Accelerations</strong></td>
<td>Unable to determine</td>
</tr>
<tr>
<td><strong>Decelerations</strong></td>
<td>Absent</td>
</tr>
<tr>
<td><strong>Contractions</strong></td>
<td>Absent</td>
</tr>
<tr>
<td><strong>Artifact</strong></td>
<td>Maternal insertion, noise</td>
</tr>
<tr>
<td><strong>Comment</strong></td>
<td>The fetus has an elevated baseline rate of about 170 bpm with minimal to moderate variability. The ability to assess fetal status is limited because about half of the tracing displays the maternal heart rate.</td>
</tr>
<tr>
<td><strong>Remediation</strong></td>
<td>The application of a maternal transducer (ECG or pulse oximeter) will likely resolve any possible confusion with the tracing. Repositioning the transducer may produce a more reliable tracing. Consideration must also be given to applying a fetal scalp electrode.</td>
</tr>
<tr>
<td>Noisy/Erratic Signal and Dropout</td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Baseline Rate</strong></td>
<td>140</td>
</tr>
<tr>
<td><strong>Baseline Variability</strong></td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Accelerations</strong></td>
<td>Present</td>
</tr>
<tr>
<td><strong>Decelerations</strong></td>
<td>Absent</td>
</tr>
<tr>
<td><strong>Contractions</strong></td>
<td>Minimal</td>
</tr>
<tr>
<td><strong>Artifact</strong></td>
<td>Noisy signal, drop-out</td>
</tr>
<tr>
<td><strong>Comment</strong></td>
<td>Reassuring tracing. Note that there is episodic drop out of the signal with discontinuity of the fetal tracing.</td>
</tr>
<tr>
<td><strong>Remediation</strong></td>
<td>Either improving the position of the transducer or the application of a fetal scalp electrode will reduce the amount of artifact in the tracing.</td>
</tr>
</tbody>
</table>
Appendix C -- Excerpts from Instructions for Use

As a convenience, the appropriate sections of the "Instructions for Use, Avalon Fetal Monitor FM20 / FM30 / FM40 / FM50, Release F.0" (Part no. M2703-9001D) are repeated here:

Confirm Fetal Life Before Using the Monitor

Fetal monitoring technology available today is not always able to differentiate a fetal heart rate (FHR) signal source from a maternal heart rate (MHR) source in all situations. Therefore, you should confirm fetal life by independent means before starting to use the fetal monitor, for example, by palpation of fetal movement or auscultation of fetal heart sounds using a fetoscope, stethoscope, or Pinard stethoscope. If you cannot hear the fetal heart sounds, and you cannot confirm fetal movement by palpation, confirm fetal life using obstetric ultrasonography. Continue to confirm that the fetus is the signal source for the FHR during monitoring.

Be aware that:

• a MHR trace can exhibit features that are very similar to those of a FHR trace, even including accelerations and decelerations. Do not rely solely on trace pattern features to identify a fetal source.

• Fetal Movement Profile (FMP) annotations on a fetal trace alone may not always indicate that the fetus is alive. The body of a deceased fetus can move and cause the monitor to annotate fetal body movements.

Here are some examples where the MHR can be misidentified as the FHR.

• When using an ultrasound transducer:
  – It is possible to pick up maternal signal sources, such as the maternal heart, aorta, or other large vessels.
  – Misidentification may occur when the MHR is higher than normal (especially when it is over 100 bpm).

WARNING Performing ultrasound imaging or Doppler flow measurements together with ultrasound fetal monitoring may cause false FHR readings, and the trace recording may deteriorate.

Misidentification of MHR as FHR

FHR detection by the monitor may not always indicate that the fetus is alive. Confirm fetal life before monitoring, and continue to confirm that the fetus is the signal source for the recorded heart rate (see “Confirm Fetal Life Before Using the Monitor” on page 2).

Here are some examples where the MHR can be misidentified as the FHR.

• When using an ultrasound transducer:
  – It is possible to pick up maternal signal sources, such as the maternal heart, aorta, or other large vessels.
  – Misidentification may occur when the maternal heart rate (MHR) is higher than normal (especially when it is over 100 bpm).
Cross-Channel Verification

To reduce the possibility of mistaking the MHR for FHR, it is recommended that you monitor both maternal and fetal heart rates (see Chapter 17, “Monitoring Maternal Heart / Pulse Rate”). The monitor’s cross-channel verification (CCV) facility can help by automatically detecting when the same heart rate is being recorded by different transducers.

When the MHR and FHR are being monitored, CCV will alert you when the values are the same. This may indicate fetal demise, and the transducer may be picking up a signal from a maternal source. CCV can compare all monitored heart rates and indicates when any two channels are picking up the same signal.

When CCV detects two heart rates that coincide, you are alerted within approximately one minute to check the tracings and potentially to reposition the transducers.

What You Need

- Ultrasound transducer.
- Ultrasound gel.
- Transducer belt (and optional butterfly belt clip, if applicable).

Preparing to Monitor

Prepare for ultrasound monitoring using the list below. The standard procedures in use in your facility determine the sequence of actions.

- Determine fetal position.
- Fasten the belt around the patient.
- Switch on the monitor and the recorder.
- Connect the transducer to a free socket. Note that the signal quality indicator for the heart rate initially displays an invalid signal.
- Apply a thin layer of ultrasound gel to the underside of the transducer.

**CAUTION** Using ultrasound gel not approved by Philips may reduce signal quality and may damage the transducer. This type of damage is not covered by warranty.

- Place the transducer on the abdomen, if possible over the fetal back or below the level of the umbilicus in a full-term pregnancy of cephalic presentation, or above the level of the umbilicus in a full-term pregnancy of breech presentation. Work the transducer in a circular motion to ensure the gel layer makes good contact.

  When the sensor is connected correctly and a good signal is being received, the signal quality indicator should be full. If an inadequate signal is being produced, the signal quality indicator will indicate a poor signal, and no numeric will appear on the screen.

- Adjust the audio volume of the monitor’s loudspeaker to a clearly audible level, while moving the transducer over the abdomen. When you have a good signal, secure the transducer in position below the belt.
**WARNING** Periodically compare the mother’s pulse with the signal coming from the monitor’s loudspeaker to ensure that you are monitoring fetal heart rate. Do not mistake a doubled or elevated MHR for FHR.

## Troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Causes</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erratic trace. Erratic display.</td>
<td>Fetal arrhythmia.</td>
<td>Consider monitoring FHR using DECG after the rupture of membranes.</td>
</tr>
<tr>
<td></td>
<td>Obese patient.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transducer position not optimal.</td>
<td>Reposition transducer until signal quality indicator shows a good signal (at least two-thirds full).</td>
</tr>
<tr>
<td></td>
<td>Belt loose.</td>
<td>Tighten belt.</td>
</tr>
<tr>
<td></td>
<td>Too much gel.</td>
<td>Remove excess.</td>
</tr>
<tr>
<td></td>
<td>Very active fetus.</td>
<td>None.</td>
</tr>
<tr>
<td></td>
<td>Insufficient gel.</td>
<td>Use enough gel to ensure the transducer makes good contact with the mother’s skin.</td>
</tr>
<tr>
<td></td>
<td>Signal quality indicator is continuously poor.</td>
<td>Reposition transducer until signal quality indicator shows a good signal (at least two-thirds full).</td>
</tr>
<tr>
<td></td>
<td>FHR less than 50 bpm (and the FHR is audible).</td>
<td>If membranes are ruptured, using a fetal scalp electrode (FM30 and FM50 only) allows measurement of FHR down to 30 bpm.</td>
</tr>
<tr>
<td>Questionable FHR.</td>
<td>Recording MHR by mistake.</td>
<td>Reposition transducer. Confirm fetal life.</td>
</tr>
<tr>
<td></td>
<td>Recording periodic signals when the transducer is not applied to the patient.</td>
<td>Disconnect all NON-USED ultrasound transducers, as continuous, regular mechanical or electromagnetic influences can result in an artificial trace.</td>
</tr>
<tr>
<td></td>
<td>Recorded FHR appears to be suspiciously higher, or suspiciously lower, than real FHR. In very rare cases, half- or double-counting of the FHR can occur.</td>
<td>If you have reason to question the validity of the recorded FHR, always verify FHR by independent means (by auscultation, for example). Measure maternal pulse by independent means.</td>
</tr>
<tr>
<td>FHR not recorded.</td>
<td>FHR is less than 50 bpm or over 240 bpm.</td>
<td>If membranes are ruptured, using a fetal scalp electrode (FM30 and FM50 only) allows measurement of FHR down to 30 bpm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If FHR is outside of the specified range, verify FHR by independent means.</td>
</tr>
</tbody>
</table>
Important Considerations

The procedures and any contra-indications that apply for twins monitoring also apply for monitoring triplets. In addition, when monitoring triplets:

- Be aware that monitoring three FHRs is inherently more difficult than monitoring single or twin FHRs. The nature of the application increases the likelihood that a fetal heart rate is monitored by more than one transducer.

Make sure that you are recording three different fetal heart rates. Pay particular attention to any coincidence of heart rates detected by the monitor’s cross-channel verification feature. The cross-channel verification feature alerts you (by showing a ☢️) if two or more heart rates coincide (that is, if two or more transducers are recording the same FHR, or if a fetal transducer is recording the MHR). If this happens, check the trace, and if necessary, reposition the ultrasound transducers as appropriate to detect all the FHRs correctly. If necessary, identify the FHRs using independent means, such as a fetoscope, stethoscope, or Pinard stethoscope.
Appendix D -- Selection of Literature References on Artifacts

Fetal Monitoring, A Multidisciplinary Approach, Sixth edition
Susan M. Tucker, Lisa A. Miller, David A. Miller

Signal ambiguity resulting in unexpected outcome with external fetal heart rate monitoring
By Duncan R. Neilson Jr, MD; Roger K. Freeman, MD; Shelora Mangan, RNC, MSN, CNS
American Journal of Obstetrics & Gynecology, June 2008:

By Michelle L. Murray, PhD, RNC

Page 2, Table 2: Limitations of Continuous EFM
Item 15: “The US may detect maternal aortic wall movement and the MHR will be printed. A failure to recognize the lack of a FHR may delay appropriate management.”

Page 38, “Solving Equipment Problems”, Table 3: The Ultrasound Transducer

JOGC (Journal of Obstetrics and Gynaecology Canada)
Volume 29, Number 9, September 2007
Chapter 2: Intrapartum Surveillance

Page S35: “Methods of Electronic Fetal Monitoring”
“… Among its disadvantages are the need for readjustment with maternal or fetal movements and the following: the transducer may record the maternal pulse, it may be difficult to obtain a clear tracing in obese women or those with polyhydramnios, artifact may be recorded, and there may be doubling or halving of the fetal heart rate when it is outside of the normal range.”

Maternal of Fetal Heart Rate? Avoiding Intrapartum Misidentification
by Michelle L. Murray

Figure 9 "The recording is of the MHR with occasional doubling."
Maternal Heart Rate Pattern – A Confounding Factor In Intrapartum Fetal Surveillance
Schifrin BS, Harwell R, Hamilton-Rubinstein T, Visser G:
Prenat Neonat Med 2001; 6:75-82.

By Donald Gibb, S. Arulkumaran

Page 65, “False or erroneous baseline because of double counting of low baseline FHR”
Page 66, “Bradycardia: fetal or maternal”

Role of Maternal Artifact in Fetal Heart Rate Pattern Interpretation
Klapholz, Henry M, MD; Schifrin, Barry S. MD; Myrick, Richard RS
Obstetrics & Gynecology, September 1974, Volume 44, Issue 3