Variable Decelerations: How to interpret them and what to do about them

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Goals

• Describe the process of interpreting variable decelerations in the clinical setting

• Review appropriate interventions

• Apply this knowledge to difficult tracings
## Most Common FHR Tracing Combinations Making Up Category II

<table>
<thead>
<tr>
<th>Category II Characteristic</th>
<th>Time Spent (minutes)</th>
<th>% of Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Decelerations (non recurrent)</td>
<td>134939.7</td>
<td>83.8%</td>
</tr>
<tr>
<td>Late Decelerations (non recurrent)</td>
<td>4826.3</td>
<td>3.0%</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>3125.7</td>
<td>1.9%</td>
</tr>
<tr>
<td>Prolonged bradycardia</td>
<td>2653.2</td>
<td>1.7%</td>
</tr>
<tr>
<td>Absent variability</td>
<td>8.1</td>
<td>0.005%</td>
</tr>
<tr>
<td>Minimal variability</td>
<td>3420.5</td>
<td>2.1%</td>
</tr>
<tr>
<td>Marked variability</td>
<td>1896.9</td>
<td>1.2%</td>
</tr>
<tr>
<td>Variable decelerations and minimal variability</td>
<td>1108.5</td>
<td>0.7%</td>
</tr>
<tr>
<td>Variable decelerations and late decelerations</td>
<td>1419.8</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

Holmgren et. al, Abstract 669, SMFM 2010
Definition of Variable Decelerations

- Visually apparent abrupt decrease
  - Onset of deceleration to low point >30 seconds in the fetal heart rate below baseline
  - at least > 15 beats lasting between 15 seconds to 2 minutes.

- The timing of onset and return to baseline in relation to the contraction is variable

- Timing with respect to contractions is also variable
  - Early position
  - With contractions
  - Ate position or not associated with contractions
Figure III.13. Examples of variable decelerations. Exhibits a variety of possible shapes including U, V, and W.

Figure III.14. This tracing provides an example of variable decelerations with and without pre- and postacceleratory patterns or "shoulders."
Variable Decelerations Causes

- Cord prolapse
- Oligohydramnios
- True knot or short cord
- Nuchal cord
- Unspiraled cord
- Decreased Wharton’s jelly
- Thin cord

- Second stage of labor
- Maternal position
- Fetal position – cord around body
- Monoamniotic multiple gestation
Keys for Interpretation of Variable Decelerations

- What is the clinical setting
- Some babies may be starting from relative hypoxia
Hypoxemia affecting the arterial blood

- Initial phase of oxygen deficiency
- Oxygen saturation of arterial blood decreases
- Cell and organ functions remain intact
- Enhanced uptake of oxygen from circulating blood
- Reduced level of activity
  - Decreases energy requirement and need for oxygen
- May Continue for extended time
  - Results in growth restriction
Hypoxia affecting peripheral tissues
- More defense mechanisms to maintain balance
- Oxygen saturation of tissues decreases
- Surge in stress hormones and decreased peripheral flow
  - Redistribution of blood to brain, heart and adrenals
  - Anaerobic metabolism is initiated in peripheral tissues
    - Fetus can tolerate if oxygen maintained in central organs
- May Continue for only hours
Asphyxia affecting the central organs
- Fetal adaptations to hypoxia fail
- Maximal activation of sympathetic nervous system
  - Stress hormones
- Anaerobic metabolism begins in central organs
  - Fetus uses glycogen stores from liver and heart
  - Metabolic acidosis occurs in central organs
- Major organ failure/damage
  - Tolerated for only minutes
Keys for Interpretation of Variable Decelerations

- What is the clinical setting
  - Some babies may be starting from relative hypoxia
  - IUGR
  - Oligohydramnios
  - Preeclampsia
  - Hypertension
  - IDDM
  - Infection
Keys for Interpretation of Variable Decelerations

- Clinical setting
- Presence of other concerning features – especially features that suggest the presence of hypoxia
  - Tachycardia
  - Minimal or absent variability
  - Absence of accelerations
Keys for Interpretation of Variable Decelerations

- Clinical setting
- Evidence of hypoxia
- Concerning characteristics about the variable itself
  - Are there some types of variables that are more concerning than others?
    - Atypical shape
    - Depth
    - Duration
Variable Decelerations

- **Reassuring characteristics**
  - Duration < 60 seconds
  - Rapid return to baseline
  - Normal baseline rate and variability

- **Non-reassuring characteristics**
  - Prolonged return to baseline
  - Presence of overshoots
    - 20 BPM above the baseline for 20 seconds
  - Tachycardia
  - Absence of baseline variability
  - Persistent to < 60 bpm and lasting > 60 seconds

Krebs et al. 1983
Figure III.13. Examples of variable decelerations. Exhibits a variety of possible shapes including U, V, and W.

Figure III.14. This tracing provides an example of variable decelerations with and without pre- and postacceleratory components or "shoulders."
Variable Decelerations
Do Size and Shape Matter?

- Last 4 hours of tracing compared for 3 groups
  - Normal (N) – 3,320 babies with normal BD
  - Metabolic acidemia (MA) – 316 with BD > 12 mmol/L
  - Abnormal (Ab) – 59 babies with abnormal gas and neonatal course

Baseline value after the deceleration is at least 15 bpm lower than the baseline value immediately preceding it.

The deceleration meets two of the following:
- Duration is 60 seconds or longer
- Lowest value is 60 bpm or lower
- Depth is 60 or more bpm
Prolonged

The deceleration lasts > 120 seconds

Biphasic shape

The deceleration demonstrates a trough-peak-trough sequence where the peak is prominent, lasting at least 10 seconds or more than 20% of the deceleration duration.
Prolonged secondary rise
Overshoot

The first 20 seconds after a deceleration contains a smooth rise greater than 10 seconds over the baseline.

Slow return to baseline

The time to return from nadir is twice the time to fall to the nadir and lasts 60 seconds or more.
Loss of internal variability

Both the size and number of oscillations of the fetal heart rate within a deceleration is small given the length of the deceleration outline.

Loss of rise in heart rate before and after deceleration

Absent fetal heart rate increases before and after the deceleration region, considering expected variations given ambient baseline variability.
Atypical variables including the sixties, loss of internal variability and prolonged duration were associated with Metabolic Acidemia and Abnormal neonatal outcomes.
Variable Decelerations
Significance of Atypical Features

- Goal - estimate the incidence of atypical FHR deceleration characteristics in term labor and their association with acidemia

- 5-year retrospective cohort study
  - All singleton,
  - Non-anomalous gestations
  - ≥ 37 weeks gestation

- Last 30 minutes of monitoring interpreted by two formally trained research nurses

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Variable Decelerations

- Features analyzed
  - Overshoot – gradual acceleration after a deceleration
    - Gradual, smooth shape lasting 60-90 seconds
    - Usually increase 10-20 bpm

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Variable Decelerations

- Features analyzed
  - Shoulders – acceleration before or after deceleration
  - < 20 bpm and lasts < 20 seconds

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Variable Decelerations

- Slow return - any recovery from nadir to baseline that was 30 seconds or greater longer than duration of onset to nadir

Fig. 1. Example of a “slow return” deceleration, a deceleration for which the return time from nadir to baseline is more than 30 seconds longer than the time from onset to nadir.

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Variable Decelerations

- Features analyzed
  - Presence of variability within the deceleration

Fig. 2. Examples of variability within deceleration nadirs. Deceleration A has minimal variability at the nadir, whereas deceleration B has moderate variability at the nadir.

Variable Decelerations

- 5,388 tracings were evaluated
  - 50 had acidemia (pH ≤ 7.10 and BD ≤ -8.0)
  - 5,063 had no acidemia

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### Table 2. Incidence of Deceleration Characteristics and Risk of Acidemia

<table>
<thead>
<tr>
<th></th>
<th>Acidemia (pH 7.10 or less) (n=57)</th>
<th>No Acidemia (pH greater than 7.10) (n=5,331)</th>
<th>P</th>
<th>Relative Risk (95% CI)</th>
<th>Adjusted Odds Ratio (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. of decelerations</strong>*</td>
<td>9 (1–17) [6–12]</td>
<td>6 (0–22) [3–9]</td>
<td>&lt;.01</td>
<td>1.17 (0.69–1.97)</td>
<td>1.06 (0.63–1.81)</td>
</tr>
<tr>
<td><strong>Shoulder</strong></td>
<td>33 (57.9)</td>
<td>2,881 (54.1)</td>
<td>.60</td>
<td>1.02 (0.61–1.71)</td>
<td>0.91 (0.54–1.53)</td>
</tr>
<tr>
<td><strong>Overshoot</strong></td>
<td>0 (0.0)</td>
<td>1 (0.02)</td>
<td>&gt;.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Slow return</strong></td>
<td>28 (49.1)</td>
<td>2,590 (48.6)</td>
<td>.94</td>
<td>1.43 (0.81–2.52)</td>
<td>1.24 (0.70–2.20)</td>
</tr>
<tr>
<td><strong>Mean (median) atypical score</strong></td>
<td>4.6 (4.7)</td>
<td>3.6 (3.8)</td>
<td>.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Atypical overall score greater than 5</strong></td>
<td>17 (29.8)</td>
<td>1,216 (22.8)</td>
<td>.21</td>
<td>1.03 (0.62–1.69)</td>
<td>0.88 (0.52–1.49)</td>
</tr>
<tr>
<td><strong>Variability in decelerations†</strong></td>
<td>All moderate</td>
<td>37 (64.9)</td>
<td>.42</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>Any minimal</strong></td>
<td>13 (26.0)</td>
<td>1,317 (29.5)</td>
<td>.64</td>
<td>0.84 (0.45–1.58)</td>
<td>0.82 (0.43–1.55)</td>
</tr>
<tr>
<td><strong>Any absent</strong></td>
<td>0 (0.0)</td>
<td>4 (0.1)</td>
<td>&gt;.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Any marked</strong></td>
<td>6 (14.0)</td>
<td>679 (17.7)</td>
<td>.69</td>
<td>0.76 (0.32–1.79)</td>
<td>0.65 (0.27–1.55)</td>
</tr>
<tr>
<td><strong>No. of decelerations with minimal, absent, marked variability</strong>*</td>
<td>0 (0–16) [0–2]</td>
<td>0 (0–17) [0–1]</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cl, confidence interval.
Data are median (range) [interquartile range] or n (%) unless otherwise specified.
* Adjusted for parity, body mass index of 30 or greater, and regional anesthesia.
† Only patients with decelerations with interpretable variability were included: acidemia (n=56) and nonacidemia (n=5,150).
Variable Decelerations

- 5,388 tracings were evaluated
  - 50 had acidemia (pH ≤ 7.10 and BD ≤ -8.0)
  - 5,063 had no acidemia

- No association between variable features and acidemia
  - Shoulders (adjusted odds ratio [OR] 1.06, 95% confidence interval [CI] 0.63-1.81)
  - Slow returns (adjusted OR 0.91, 95% CI 0.54-1.53)
  - Minimal variability (adjusted OR 0.82, 95% CI 0.43-1.55) nor
  - Marked Variability (adjusted OR 0.65, 95% CI 0.27-1.55)

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Variable Decelerations

What is the significance of depth and duration of variable decelerations?
- NICHD Consensus states undetermined

One study compared depth and duration to fetal pulse oxygenation data
- 620 infants with variable decelerations and concomitant fetal pulse ox
- Compared the 2 minutes before, deepest point, recovery phase and 2 minutes after deceleration
- Significantly lower levels of fetal oxygenation at the moment of greatest decrease in heart rate and during recovery phase

Puertas et al. Int J Gyn OB 2004
# Variable Decelerations

<table>
<thead>
<tr>
<th>Severity</th>
<th>Duration of deceleration</th>
<th>Absolute depth of nadir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>&lt; 30 seconds</td>
<td>Any depth</td>
</tr>
<tr>
<td></td>
<td>&lt;60 seconds</td>
<td>70-80 bpm nadir</td>
</tr>
<tr>
<td></td>
<td>Any duration</td>
<td>&gt; 80 bpm nadir</td>
</tr>
<tr>
<td>Moderate</td>
<td>30-60 seconds</td>
<td>&lt; 70 bpm nadir</td>
</tr>
<tr>
<td></td>
<td>&gt; 60 seconds</td>
<td>70-80 bpm nadir</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt; 60 seconds</td>
<td>&lt; 70 bpm nadir</td>
</tr>
</tbody>
</table>
Variable decelerations
Depth of variables

- Baseline does not drop below 55-60 bpm during variable
- Full activation of the parasympathetic nervous system is similar to complete fetal heart block
- 50-60 bpm is the typical rate of ventricular rate set by the AV node
- If the heart rate is below 50 bpm think hypoxia
Diagnostic Accuracy of EFM

• Retrospective study
  • Cases (39) had HIE
  • Controls (78) normal pH

• 3 reviewers read last hour of tracing
  • Assigned characteristics and categories
  • Calculated the debt 30 and debt 60
    • \( \frac{1}{2} \) (width x depth of variables) essentially how long and severe are the variables

Oxygen Debt

\[ \frac{1}{2} \times \text{height} \times \text{duration} = \text{Oxygen debt} \]
### Fetal heart rate characteristics in the last hour monitoring prior to delivery

<table>
<thead>
<tr>
<th>Category</th>
<th>Cases n=39</th>
<th>Controls n=78</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>4 (10.3%)</td>
<td>7 (9.0%)</td>
<td>0.18</td>
</tr>
<tr>
<td>II</td>
<td>30 (76.9%)</td>
<td>70 (89.7%)</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>5 (12.8%)</td>
<td>1 (1.3%)</td>
<td></td>
</tr>
<tr>
<td>Baseline (bpm)</td>
<td>148±18</td>
<td>141±14</td>
<td>0.054</td>
</tr>
<tr>
<td>Time baseline &gt; 160 bpm (min)</td>
<td>0,0</td>
<td>0,0</td>
<td>0.11</td>
</tr>
<tr>
<td>Time baseline &lt; 110 bpm (min)</td>
<td>0,2</td>
<td>0,0</td>
<td>0.22</td>
</tr>
<tr>
<td>Decreased variability</td>
<td>13 (33.3%)</td>
<td>15 (19.2%)</td>
<td>0.17</td>
</tr>
<tr>
<td>Reactive</td>
<td>16 (41.0%)</td>
<td>48 (61.5%)</td>
<td>0.047*</td>
</tr>
<tr>
<td>Accelerations</td>
<td>1,3</td>
<td>2,4</td>
<td>0.34</td>
</tr>
<tr>
<td>Total Decelerations</td>
<td>8,11</td>
<td>6,7</td>
<td>0.18</td>
</tr>
<tr>
<td>Late decelerations</td>
<td>1,6</td>
<td>1,2</td>
<td>0.01*</td>
</tr>
<tr>
<td>Variable decelerations</td>
<td>3,5</td>
<td>3,4</td>
<td>0.85</td>
</tr>
<tr>
<td>Severe variables</td>
<td>0,1</td>
<td>0,0</td>
<td>0.50</td>
</tr>
<tr>
<td>Early decelerations</td>
<td>0,0</td>
<td>0,1</td>
<td>0.06</td>
</tr>
<tr>
<td>Prolonged decelerations</td>
<td>1,1</td>
<td>0,1</td>
<td>0.11</td>
</tr>
<tr>
<td>Nadir (bpm)</td>
<td>62,29</td>
<td>70,35</td>
<td>0.60</td>
</tr>
<tr>
<td>Length (min)</td>
<td>4,3</td>
<td>3,3</td>
<td>0.17</td>
</tr>
<tr>
<td>Contractions/Hour</td>
<td>16.5±9.8</td>
<td>16.9±7.7</td>
<td>0.80</td>
</tr>
<tr>
<td>Lates/Contraction</td>
<td>0,1,0,3</td>
<td>0,0</td>
<td>0.21</td>
</tr>
<tr>
<td>Variables/Contraction</td>
<td>0,2,0,4</td>
<td>0,0,2</td>
<td>0.48</td>
</tr>
<tr>
<td>Debt 30 (sec bpm)</td>
<td>9,458; 14,019</td>
<td>3,942; 6,630</td>
<td>0.008*</td>
</tr>
<tr>
<td>Debt 60 (sec bpm)</td>
<td>13,347; 20,612</td>
<td>6,082; 8,871</td>
<td>0.003*</td>
</tr>
</tbody>
</table>

* indicates P < 0.05
Evolving Fetal Compromise

- Recurrent variable/late decelerations
- Progressively deeper decelerations
- Reflexive fetal tachycardia (+/-)
- Progressive reduction in variability moderate to minimal to absent
- Terminal bradycardia

Repetitive Cord Occlusion Frequency of Decelerations

• Near term fetal sheep – exposed to cord occlusion
  • Mild – 1 minute occlusion every 5 minutes
  • Moderate – 1 minute occlusion every 3 minutes
  • Severe – 1 minute of occlusion every 2 minutes
• Continuous measurement of base deficit (BD) as a marker of metabolic acidosis

Frasch, MG, et al. AJOG 2009;200:200
Deceleration

- Fetal sheep cord occlusion studies
- 1:5 occlusion series – 1 minutes occlusion every 5 minutes
  - Onset of each occlusion was accompanied by a variable FHR deceleration, with rapid return to baseline levels
  - Small fall in pH and a rise in BD and lactate occurred in the first 30 minutes of occlusions
    - (pH, 7.34 $\pm$ 0.07; BD, 1.3 $\pm$ 3.9 mmol/L; lactate, 4.5 $\pm$ 1.3 mmol/L)
  - Values remained stable, despite a further 3.5 hours of occlusions
Deceleration

- 1:2.5 occlusion series – 1 minutes occlusion every 2.5 minutes
- Rapid occlusion frequency provided only a brief period of recovery between occlusions
- After 1 hour
  - All animals had a severe metabolic acidosis, with pH 6.92 ± 0.03; BD, 19.2 ± 1.5 mmol/L, and lactate 14.6 ± 0.8 mmol/L by the end of the occlusions
1:5 Occlusion Group

A

Occlusions

- Interocclusion baseline
- Nadir of deceleration

Mean arterial pressure (mmHg)

FHR (bpm)

Time (min)

first 30 min, mid 30 min, last 30 min

---

1:2.5 Occlusion Group

B

Occlusions

- Interocclusion baseline
- Nadir of deceleration

Mean arterial pressure (mmHg)

FHR (cpm)

Time (min)

first 30 min, mid 30 min, last 30 min
Repetitive Cord Occlusion

- The rate of BD decline was similar for mild, moderate and severe occlusion periods
  - BD drops at rate of 0.56 mmol/L for every minute of cord occlusion

- Recovery is much slower
  - 0.09 mmol/L per minute over the first 2 hours of recovery
Repetitive Cord Occlusion
Depth of Decelerations

- Near term fetal sheep – exposed to cord occlusion
  - Mild – 30 bpm decrease in FHR
  - Moderate – 60 bpm decrease in FHR
  - Severe – 90 bpm decrease to baseline < 70 bpm

- 1:2.5 occlusion series – 1 minutes occlusion every 2.5 minutes for 1 hour at each severity

- Continuous measurement of base deficit (BD) as a marker of metabolic acidosis

Repetitive Cord Occlusion
Depth of Deceleration

Repetitive Cord Occlusion
Depth of Deceleration

- Increase in fetal base deficit
  - Mild – $0.21 \pm 0.03$ mEq/L per minute
  - Moderate – $0.27 \pm 0.03$ mEq/L per minute
  - Severe – $0.54 \pm 0.09$ mEq/L per minute

- During recovery fetal base deficit cleared at a rate of $0.12 \pm 0.03$ mEq/L per minute

Repetitive Cord Occlusion
Depth of Deceleration


UCO, umbilical cord occlusion.
Repetitive Cord Occlusion Hypoxic Fetuses

- Near term fetal sheep
  - Normal fetus – normal SaO2 > 55%
  - Hypoxic fetuses – SaO2 ≤ 55%

- Exposed to cord occlusion
  - Mild – 30 bpm decrease in FHR
  - Moderate – 60 bpm decrease in FHR
  - Severe – 90 bpm decrease to baseline < 70 bpm

- 1:2.5 occlusion series – 1 minute occlusion every 2.5 minutes for 1 hour at each severity

- Continuous measurement of base deficit (BD) as a marker of metabolic acidosis

Amaya, KE et al. AJOG 2016;214:270
During recovery, hypoxic fetuses cleared fetal base deficit at a slower rate compared to normal fetuses (0.12 ± 0.03 mEq/L per minute versus 0.08 ± 0.03 mEq/L per minute).
Timecourse to Acidemia

- With minimal/absent variability and recurrent decelerations, acidemia evolves over ~60’
- In the setting of a previously normal tracing
- Can occur more quickly with acute events
- Abruption, uterine rupture, cord prolapse
- Sudden and profound fetal bradycardia

Low JA Obstet Gynecol 1999;93:85-91
Williams KP Am J Obstet Gynecol 2003;188:820-3
Eilimian A Obstet Gynecol 1997;89:373-6
Clark S Am J Obstet Gynecol 1982
Interventions for Variable Decelerations

- Reposition the patient
- Perform a cervical exam
  - Cord prolapse
  - Rapid labor progress
  - Consider internal monitors
- Slow the contractions
  - Reposition
  - Fluid bolus
  - Stop or decrease the pitocin
  - Stop pushing
Interventions for Variable Decelerations

- Contact the attending provider
- Risk factors – infection, VBAC
- Recurrent
- Severe
- Unresponsive to interventions
- Consider amnioinfusion
Amnioinfusion for Variable Decelerations

- Meta-analysis of 12 randomized controlled trials

- Amnioinfusion vs. expectant management
  - Rate of decelerations – RR 0.54; 95%CI 0.43-0.68
  - Rate of cesarean for distress - RR 0.35; 95%CI 0.24-0.52
Conclusion

• In order to appropriately interpret variables you must consider:
  • Clinical setting
  • Presence of concerning findings
    • Tachycardia or minimal/absent variability
  • Frequency - < 3 minutes apart if too much
  • Depth and duration – 60x60
  • How long until delivery
  • Will they resolve?