Metabolic Disorders

- True Metabolic disorder
  - Inherited excess or deficiency of catalyst(s) or enzyme(s)

- Acquired metabolic disorder
  - Primarily management-production related and not due to inborn error in metabolism
  - Increased demands for particular nutrient
  - Inability of the animal’s metabolic reserve to sustain the particular nutrient at physiological concentrations

Transition Period

- Last 3 wk of gestation through first 3 wk of lactation
  - transition from pregnant and dry to non-pregnant and lactating
- Critical period
  - animal welfare
  - economics
- Much research
Extra nutrients: pregnancy to colostrum

Daily fetal demands end of gestation vs colostrum of 22#

Extra nutrients: colostrum to milk

Colostrum production of 22# vs milk production of 65# on day 4

When Cows Leave Leave the Herd During a 5-Year Period in MN DHIA


624,614 Cows Leaving 5,749 Herds
Hypocalcemia

- 5.9% of U.S. Cows (NAHMS, 1996)
- Ketosis: 23.6x
- 3+ dystocia: 7.2x
- Retain placenta: 4x
- Mastitis: 5.4x
- Subclinically present in up to 50-65% of fresh cows

  - ♦ Smooth muscle function
    - rumen, abomasum, uterus
  - Release of cortisol accompanies ♦ immune function
  - K and Na alkalize blood and alter Ca

Milk Fever

- Etiology:
  - Onset of lactation (usually first 72 hr postpartum)
  - Low blood Ca^{2+}
    - Normal: 10 mg/dL
    - Subclinical: <7 mg/dL
    - Milk fever: <6 mg/dL
  - Affects older cows and Jersey breed more often

Milk Fever

- Clinical symptoms:
  - Staggering
  - Downer cow unable to rise
  - Head displacement to the side
  - Anorexia, dry muzzle, cold ears
  - Complications: retained placenta, displaced abomasum, bloat, etc.
  - Delayed treatment:
    - Slower response to treatment
    - Coma and death
Low Blood Ca (below ~ 7 mg/dL)

- Low muscle tone
  >> uterine prolapse, retained placenta

- Low feed intake
- Low rumen fill
  >> rumen position

- High blood cortisol
  >> immunosuppression

- Low blood insulin
  >> lower glucose uptake
  >> exacerbate lipid metabolism
  >> Ketosis

High VFA level to the intestine
>> Displaced abomasum

High blood cortisol
>> immunosuppression

Low blood insulin
>> lower glucose uptake
>> exacerbate lipid metabolism
>> Ketosis

Treatment of Milk Fever

- Restoration of Ca ASAP
  - Ca gluconate (25%), i.v. 250-500 ml
  - Can be administered s.c. in multiple sites
  - Retreat 8-12 hr later, if needed
  - Combination with dextrose in severe cases

- Cows with previous experience
  - Ca gel orally 1 day before and 1 day after calving
    - risk of aspiration pneumonia
    - labor

Blood Ca

Colostrum and milk

PTH

1,25 dihydroxy Vit. D

Kidney

Intestine

pH dependent mechanism
blood and urine pH = Dietary cation and Dietary anion
Balance between [+] charges and [-] charges

Major dietary ions that contribute to blood and urine pH are K⁺, Na⁺, and Cl⁻

Dietary K and Na

High [K⁻] ion in blood
High blood pH
PTH malfunction and low blood Ca ↔ Ca metabolism

Symptoms and problems appear at onset of lactation
But
The problems start during the prepartum period (dry cow and transition period)
Mainly due too much K⁺ intake (cation-anion imbalance)
The problem is less likely due to high Ca²⁺ intake

DCAD (Dietary cation-anion difference) =
(Na⁺ + K⁺) - (Cl⁻ + S²⁻)
or
(Na⁺ + K⁺ + 0.15 Ca²⁺ + 0.15 Mg²⁺) - (Cl⁻ + 0.6 S²⁻ + 0.5 P³⁻)
Contributors to the high dietary K⁺

- Alfalfa and other legumes are high in K⁺
  - The plant needs about 2% K⁺
- Common practice:
  - over fertilization
  - To prevent winter kill
  - Increase in herd size thus land application of manure
- Cool season grass (e.g., orchard, blue grass)
  - Also high in K⁺ compared to 20 years ago (due to land application of manure)

If legumes and winter grasses are high in K, then what should feed our dry cows?

- Timothy hay
- Corn silage
- Mature alfalfa
- 2nd and 3rd cut alfalfa

Additional Management Measures

- Feeding anionic salts (negative DCAD) last 3 wk of gestation (close-up ration)
  - CaCl, ammonium chloride
  - Ca sulfate, ammonium sulfate
  - More palatable, less effective
  - Mg chloride + CaCl (not a bad choice and works)
  - Measure urine pH in close-up cows
    - Should be about 6; 8.0 is BAD
- Dietary P: set at 0.4 (30-50 g/d)
  - High P inhibits 1,25 dihydroxy Vitamin D
- Do not trust K values determined by near infrared analysis
Ketosis

- 4.6% of U.S. cows (NAHMS, 1996)
- Energy demand skyrockets and more often than not cannot be met by intake alone
- Mobilization of body reserves ensues

Ketosis (fresh-cow disease)

- Etiology:
  - Occurs during the first 60 days postpartum
  - Ketone bodies accumulate in the body fluid
  - Gluconeogenesis becomes impaired, resulting in hypoglycemia
  - Affects cows that are over conditioned during dry period

Decrease in feed intake (3 wk before and 4 wk after calving)

\[ \text{Mobilization of body fat} \]

\[ \text{Increase in blood non-esterified fatty acids (NEFA)} \]

\[ \text{Conversion of acetyl-CoA to acetone, acetoacetate and } \beta \text{-hydroxybutyrate} \]

\[ \text{Underutilization of ketones leads to excess protons (H}^+\text{) in blood} \]

\[ \text{Inability to buffer blood pH leads to acidosis caused by ketones “ketoacidosis”} \]
Acetone, acetoacetate and β-hydroxybutyrate are ketones.

**Clinical signs:**
- Abrupt drop in milk production
- Loss of appetite
- Foul smelling breath
- Constipation
- Lack of coordination
- Weight loss

**Diagnosis:**
- Smell of breath
- Measuring ketone level in urine (Ketostix, Chemstrip 9)
- Looking for other problems (e.g., mastitis, indigestion, DA, etc.)

**Treatment**
- Increase blood sugar
  - 500 mL of 50% Dextrose solution (i.v.)
  - Glucocorticoid injection (Dexamethasone)
  - Oral administration propylene glycol
    - 7-10 days before calving
    - Increase glucose, reduces fat mobilization

**Management and Prevention**
- Energy intake must not be compromised before and after calving
  - Keep cows on feed!
- Be aggressive in treating other fresh-cow diseases (e.g., milk fever, retained placenta, etc.)
- Adjusting the diet of close-up cows (3 wk before calving) by increasing appropriate amount of concentrates in the ration.
Management and Prevention of Ketosis Cont.

- Feeding dry cows for a targeted body condition of 3.5-3.75 on a 5-point scale at calving
  - A cow with higher body condition probably has less of an appetite and more metabolic problems
- Provide plenty of fresh and palatable high quality feed
- Drenching cows with propylene glycol during the last 7-10 days before calving (selective cows?)

Displaced Abomasum

- 2.8% of U.S. cows (NAHMS, 1996)
- 53.5x as likely to experience ketosis
- \( \downarrow \) flow and \( \downarrow \) muscle contraction allow the abomasum to float
  - chewing activity, ruminal fill, motility, VFA concentrations
- Higher conditioned cows more often due to \( \downarrow \) intakes prior to calving

Dystocia

- Over-conditioning increases risk substantially
- Due to:
  - High stress, twins, poor technique, etc.
- 12x as likely to retain placenta
- 4.9x as likely to have metritis
- Most often accompanied by the cascade of fresh problems
Retained Fetal Membranes & Metritis

- 7.8% of U.S. Cows (NAHMS, 1996)
- 16.4x as likely to have ketosis
- Retains are 5.7x as likely to develop metritis
- Atony of uterus (i.e., Ca^{2+})
- Impaired immune function: ability to ward off bacteria
- Unsanitary conditions inoculate the uterus

Rumen Acidosis

- Introduction to an energy dense diet will lead to acidosis if not properly adjusted
- Ruminal populations ill-suited to dense rations after ~8 weeks on a dry cow diet
- Poor rumen function
- Hoof and leg issues
- Milk fat depression

- DO NOT YOUR FORGET YOUR DRY COW ESPECIALLY DURING THE 3 WEEKS BEFORE CALVING!!

- THEY ARE GOING TO BECOME YOUR LACTATING COWS!!
### Percentage of cows by producer-identified health problems

<table>
<thead>
<tr>
<th>Health problem</th>
<th>Incidence rate (% of cows)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical mastitis</td>
<td>16.5</td>
</tr>
<tr>
<td>Lameness</td>
<td>14.0</td>
</tr>
<tr>
<td>Retained placenta</td>
<td>7.8</td>
</tr>
<tr>
<td>Dystocia, metritis</td>
<td>3.8</td>
</tr>
<tr>
<td>Milk fever</td>
<td>4.9</td>
</tr>
<tr>
<td>Displaced abomasum</td>
<td>3.5</td>
</tr>
<tr>
<td>Ketosis*</td>
<td>3.7</td>
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NAHMS, 2007 *From Jordan and Fourdraine, 1993

### Percentage of cows without various health problems

<table>
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<tr>
<th>Health problem</th>
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<tbody>
<tr>
<td>Clinical mastitis</td>
<td>83.5</td>
</tr>
<tr>
<td>Lameness</td>
<td>86.0</td>
</tr>
<tr>
<td>Retained placenta</td>
<td>92.2</td>
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<tr>
<td>Dystocia, metritis</td>
<td>97.2</td>
</tr>
<tr>
<td>Milk fever</td>
<td>95.1</td>
</tr>
<tr>
<td>Displaced abomasum</td>
<td>96.5</td>
</tr>
<tr>
<td>Ketosis*</td>
<td>96.3</td>
</tr>
</tbody>
</table>

NAHMS, 2007 *From Jordan and Fourdraine, 1993

### Change in health problems 1996 to 2007

[Bar chart showing changes in health problems]
### Percentage of cows by producer-identified health problems

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<tr>
<td>Ketosis*</td>
<td>3.7</td>
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</table>

**54.2%**

NAHMS, 2007  *From Jordan and Fourdraine, 1993*

### Relationships to other health problems

- **Milk fever**
  - Ketosis: 23.6x
  - 3+dystocia: 7.2x
  - RP: 4x
  - Mastitis: 5.4x
- **DA**
  - Ketosis: 53.5x

- **Dystocia**
  - RP: 12x
  - Metritis: 4.9x

- **RP**
  - Ketosis: 16.4x
  - Metritis: 5.7x

Curtis et al., 1985 J Dairy Sci
Gröhn et al., 1989 J Dairy Sci

### Estimated costs of metabolic disorders

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Deaths</th>
<th>Culls</th>
<th>Discarded milk (lbs)</th>
<th>Lost milk (lbs)</th>
<th>Avg. cost per case</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
<td>2.0%</td>
<td>8.0%</td>
<td>308</td>
<td>880</td>
<td>$312</td>
</tr>
<tr>
<td>RP</td>
<td>1.5%</td>
<td>6.0%</td>
<td>330</td>
<td>550</td>
<td>$206</td>
</tr>
<tr>
<td>Milk fever</td>
<td>4.0%</td>
<td>5.0%</td>
<td>0</td>
<td>286</td>
<td>$181</td>
</tr>
<tr>
<td>Dystocia</td>
<td>1.0%</td>
<td>2.2%</td>
<td>352</td>
<td>392</td>
<td>$161</td>
</tr>
<tr>
<td>Ketosis</td>
<td>0.5%</td>
<td>5.0%</td>
<td>0</td>
<td>506</td>
<td>$151</td>
</tr>
</tbody>
</table>

C. Guard, Hoards 2003, W-98; NAHMS, 1996; JDS, 1995;78:1693
Is energy balance important?

- Thought to affect reproductive program, herd health program and response to bST
- Negative energy balance associated with:
  - Peripartum disorders
  - Immunosuppression
  - Increased times to first ovulation

Species Differences

- Humans and rodents have minimal negative energy balance – few body reserves
- True seals, bears and baleen whales have prolonged period of negative energy balance – extensive reserves

30-day lactation
Pup weighs 50 kg at birth
Pup gains 5 kg/d
Mother does not eat or drink
Why Do They Do This?
As part of their reproductive strategy for thermoregulatory maintenance of offspring
- Seals – land or ice platform on which to stay out of water
- Bears – protected den and continual maternal contact
- Baleen whales – whales born with little blubber and move to warm but otherwise uninhabitable waters

Oftedal, 1993

Energy Balance of Cows During Early Lactation
* Adjust zero
Does selection for more milk increase period of negative energy balance?

Dr. B. Crooker, Univ MN
Effect of Selected vs Control Cows on Milk Yield


Effect of Selected vs Control Cows on Milk Yield


Effect of Selected vs Control Cows on Energy Balance

Effect of Selected vs Control Cows on Feed Intake


Summary of 42 Trials in 20 Published Studies Where Days to Positive Energy Balance Were Determined

Mean = 36 days
SD = 19.3
Nadir = 10 days

Negative Energy Balance
- Has little effect on immune system directly
  - May be related to cortisol associated with calving
- Is not related independently to effects on reproduction
  - Except time to nadir and ovulatory function
- Is associated with feet and leg problems and digestive problems
Which Cow is Thin?

Which Cow is in Negative Energy Balance?

Conclusions

- Do NOT equate high production with high stress
- Sick cows produce LESS milk not more milk.
Conclusions

• Cows can use body reserves to supplement energy needs without a significant cost to productivity.
• DMI is THE critical factor in minimizing duration of negative energy balance.
• Selection for milk production results in cows that partition more nutrients to milk.