Liver Abscesses: New Thinking on an Old Topic

Dr. Scott Laudert
Liver Abscesses: On Radar Screen a Long Time

- Concern of beef industries for 70 yrs
- 1944 research report on ulcerative rumen lesions
  - Then 1954 - antibiotic reduces abscesses in fattened cattle and association of rumenitis-liver abscess complex
- Tylan® approved for reduction of incidence in 1973
- Research efforts continue: Universities & Corporate
Why are Livers Condemned?

• Abscess
• Parasite
• Disease
• Contamination
Liver Condemnation

• Concern among beef packers: “Condemnation rate too high”
  • Number 6 and number 2 concerns in ‘91 and ‘95 NBQ Audits

• Averaged 24% in first 5 Audits, increasing to 31% in 2016
  • Holstein steers in 2016 = 20% vs 6% from 1991 to 2011

• Liver Abscesses = 46% of condemnations in 1991 NBQA but increased to 66% (Herrick, 2018)
Degree of Severity

• Normal or none

• Minor
  • Smaller than a pencil eraser to size of golf ball
  • All abscesses are condemned, No trimming

• Severe
  • One or several large abscesses (size of a hen’s egg and up to size of a softball)
Liver Abscess Severity Categories

- Normal, healthy, edible
- Minor
- Minor
- Severe
Nasty Severe Abscesses
Negative Effects of Abscesses on Packer

• Severe abscesses at evisceration
  • Frequently rupture, contaminating viscera and surrounding tissues with pus
  • Often adhere to the diaphragm, rumen and/or peritoneum
  • Carcasses can be trimmed of 15+ lb of saleable weight

• Loss of entire viscera

• Entire slaughter process stopped to trim or bag to contain contamination

• Carcasses often required to be railed-off
  • Additional time required for zero tolerance trimming

• Losses are a combination of time, labor and saleable product

• Total annual liver and viscera loss ~ $60 million (Herrick, 2018)
Performance of Animals with Liver Abscesses

- Performance of animals with **Minor** abscesses is not different
  - Equal to No abscess
- Performance of animal with **Severe** abscess can be greatly affected
  - Feed intake: -5%
  - Daily gain: -10%
  - Carcass weight: -10%
  - Dressing percent: -2%
    - Marbling score: Inconsistent reduction
    - Quality Grade: Not greatly different
Liver Abscess Incidence in Feedlot Cattle

<table>
<thead>
<tr>
<th>Time Period</th>
<th>% Total</th>
<th>% Severe</th>
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<th>% Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999 to 2008</td>
<td>13</td>
<td>5</td>
<td>17</td>
<td>8</td>
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<tr>
<td>2014 to 2018</td>
<td>18</td>
<td>8</td>
<td>46</td>
<td>29</td>
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*EAH Liver Check Service*

Wow, why such a big Holstein increase?

- Beef steers average 2-3% higher than heifers
- Calf-fed Holsteins 2.5x beef steers
Calf-fed Holsteins – Why Abscesses so High

• Yearlings vs Calf-fed
• Lack of colostrum quantity and quality; fed to replacements not bulls
• Calves receive little roughage, critical to rumen development
• Many get a late start on control measures, day 1 is not to soon
• Fed a milk and concentrate diet prior to entering the feedlot
• Lack of knowledge about how calf-feds are raised and cared for
• A common explanation is days on feed, 350+ vs +/-200 days
• Bacteria from Holstein and beef steers are not different and not the reason for higher prevalence and severity in Holsteins (Amachawadi et al, 2017)
Liver Abscess Incidence in Feedlot Cattle

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*EAH Liver Check Service*

- Beef steers average 2-3% higher than heifers
- Calf-fed Holsteins 2.5x beef steers
• Could the recent abscess increases in beef steers be the result of genetic selection for increased performance and improved carcass traits also selecting for increased feed intake and liver abscesses
• Liver abscess is a sort-of silent disease
• Impossible to detect in a live steer or heifer
• Extremely rare for an animal to die from abscess
• Only detected with necropsy
Colorado State researchers found no differences in stress-related physiological parameters or mobility score of steers with no or varying degrees of abscesses; demonstrating no effect of liver abscess on the welfare or well-being of feedlot cattle (Baier F., et al, 2019)
Liver Abscess Development

What Causes Abscessed?
A must know to implement or develop new control measures.

Adapted from Nagaraja and Chengappa, 1998
Liver Abscess Development

High-grain feeding

DOF
Grain type
Weather
Cattle type
US location
Time of year
Roughage Level
Bunk management
Inadequate control measures

Adapted from Nagaraja and Chengappa, 1998
High Grain Diets

• Often lead to production of vast quantities of lactic acid and volatile fatty acids
• Lactic acid and VFAs result in low rumen pH or acidosis
• Acidosis: Adverse condition unfavorable for efficient bacterial growth and function
• Acidosis: Causes cell damage, erosion and ulceration of the rumen wall; **Rumenitis**
Liver Abscess Development

Adapted from Nagaraja and Chengappa, 1998

High-grain feeding → Rumen → Acidosis → Rumenitis → Bacteria → Rumen wall → Portal Blood → Liver Abscesses
Bacteriologic Studies

- Well documented that 2 bacteria cause liver abscesses; *Fusobacterium necrophorum* and *Trueperella pyogenes*

- Lactic acid is primary energy source *F. necrophorum*

- *F. necrophorum* possess strong leukotoxin and virulence; cell surface proteins allow rumen wall attachment

- *F. necrophorum* ideally suited to cause abscesses
Liver Abscess Development

High-grain feeding → Rumen → Acidosis → Rumenitis → Rumen wall → Bacteria → Portal Blood → Liver Abscesses

Adapted from Nagaraja and Chengappa, 1998
Rumen Wall

• Bacterial infection leads to rumen wall abscesses
• Bacterium from rumen wall abscesses enter the liver via portal blood circulation and are filtered out
• Liver is a very defensive and resilient organ
• Liver abscesses number and size are dependent on the number of bacteria entering the liver at a given time
Liver Abscess Development

High-grain feeding → Rumen → Acidosis → Rumenitis → Bacteria → Portal Blood → Liver

Abscesses in Rumen wall

Adapted from Nagaraja and Chengappa, 1998
*F. necrophorum* recovered from liver abscesses, fingerprint closely with *F. necrophorum* isolated from rumen wall abscesses but not with those isolated from rumen contents.
Liver Abscess Development

- High-grain feeding
- Acidosis
- Rumenitis
- Bacteria
- Rumen wall Abscesses
- Portal Blood

Adapted from Nagaraja and Chengappa, 1998
Other Factors

• Cattle are predisposed to abscess development early in the feeding period
• Abscesses likely form during the middle third of the feeding period
• It is critical to implement management practices and control measures at the very beginning of finishing
• Calf-fed Holsteins should be started on control as early as possible
• Growing cattle fed a limited intake high-energy ration are at risk
Strategic use of Tylan to control liver abscess condemnation in finishing beef cattle

<table>
<thead>
<tr>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 days (No Tylan)</td>
<td></td>
</tr>
<tr>
<td>First 42 days</td>
<td></td>
</tr>
<tr>
<td>First 84 days</td>
<td></td>
</tr>
<tr>
<td>Last 84 days</td>
<td></td>
</tr>
<tr>
<td>First 126 days</td>
<td></td>
</tr>
<tr>
<td>All 164 days (Tylan)</td>
<td></td>
</tr>
</tbody>
</table>

Liver abscess incidence

Effect of strategic use of Tylan on total abscess incidence, %

- None: 15.69%
- First 42: 13.17%
- First 84: 12.97%
- First 126: 10.36%
- All: 10.29%
- Last 84: 16.50%

↓ 34%\(^a\)
↓ 21%\(^b\)

\(^a\) Means differ, P < 0.05
\(^b\) Means tend to differ, P < 0.10.


PM-US-19-0262
Effect of Tylan on F necrophorum in Rumen Contents, MPN $10^5$ per ml

Nagaraja, et al, 1999. Tylan vs. control: P<.01 for all non-zero days.
Effectiveness of Tylan feeding program and roughage source to control liver abscess condemnation in beef steers

0 days (No Tylan) – Corn Silage

21 days  96 days (Defined Period)  30 days

21 days  126 days (Tylan)

Corn Silage vs. Corn Stalks formulated at equal NDF

8 replications/trt; 235 hd/pen; 1880 hd/trt;
Analyzed as a 2 x 2 + 1 factorial;
## Ration Composition

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Silage</th>
<th>Stalks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam-flaked corn</td>
<td>73.9</td>
<td>77.3</td>
</tr>
<tr>
<td>Corn silage</td>
<td>11.1</td>
<td>-</td>
</tr>
<tr>
<td>Corn stalks</td>
<td>-</td>
<td>7.2</td>
</tr>
<tr>
<td>Corn steep liquor</td>
<td>4.1</td>
<td>4.7</td>
</tr>
<tr>
<td>Corn steep liquor/urea</td>
<td>3.5</td>
<td>3.4</td>
</tr>
<tr>
<td>Tallow</td>
<td>5.0</td>
<td>5.1</td>
</tr>
<tr>
<td>Supplement</td>
<td>2.4</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Liver abscess incidence

Effect of strategic use of Tylan on total abscess incidence, %

- Silage/No Tylan: 32.8%
- Silage/Defined: 19.7%
- Silage/Tylan: 17.1%
- Stalks/Defined: 21.9%
- Stalks/Tylan: 21.0%

↓ 48%<sup>a</sup>
↑ 14%<sup>a</sup>

<sup>a</sup>Means differ, P < 0.05.


PM-US-19-0262
Effects of removing tylosin from diets with increasing roughage concentration on growth performance, carcass characteristics, and prevalence of liver abscesses of finishing cattle

• Crossbred steers, initial wt = 854 lb, 161 DOF

• Treatments:
  • 7.1 TYL: 7.1% corn stalks with tylosin
    • Tylan added when cattle were on ~65% Finisher (18 DOF)
  • 7.1 NT: 7.1% corn stalks without tylosin
  • 13.1 NT: 13.1% corn stalks without tylosin
  • 19.1 NT: 19.1% corn stalks without tylosin
## Ration Composition, % DM

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>7.1 TYL</th>
<th>7.1 NT</th>
<th>13.1 NT</th>
<th>19.1 NT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam-flaked corn</td>
<td>57.67</td>
<td>57.67</td>
<td>51.42</td>
<td>45.22</td>
</tr>
<tr>
<td>Corn distillers grain, wet</td>
<td>17.25</td>
<td>17.25</td>
<td>17.26</td>
<td>17.26</td>
</tr>
<tr>
<td>Sweet Bran Plus</td>
<td>17.02</td>
<td>17.02</td>
<td>17.04</td>
<td>17.04</td>
</tr>
<tr>
<td><strong>Corn stalks</strong></td>
<td><strong>7.09</strong></td>
<td><strong>7.09</strong></td>
<td><strong>13.07</strong></td>
<td><strong>19.07</strong></td>
</tr>
<tr>
<td>Fat, yellow grease</td>
<td>0.94</td>
<td>0.94</td>
<td>1.19</td>
<td>1.39</td>
</tr>
<tr>
<td>Micro ingredients</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Liver abscess incidence

Effect of Tylan and roughage on total abscess incidence, %\textsuperscript{a,b}

7.1TYL 13.03
7.1NT 19.18
13.1NT 11.88
19.1NT 14.4

\(\downarrow 32\%\)

\textsuperscript{a}7.1Yes vs 7.1No (\(P < 0.01\)).
\textsuperscript{b}Linear effect of roughage among No Tylan, \(P < 0.01\).
Increasing Roughage Concentration

- Increasing roughage level 2x resulted in equal abscess control to antibiotic feeding
  - BUT intake increased 1 lb per day, feed efficiency became 5.1% poorer and HCW decreased 8 lb
- 3x forage resulted in 1.3 lb per day intake increase, 9.5% poorer feed efficiency and 23 lb less HCW
Weather, Cattle type, US location, Time of year
Total Abscesses by Month, Tylan-fed Steers
Monthly Average DMI, lb
January 1985 to December 2008

Steer Average = 19.3
Heifer Average = 18.3

Monthly Photoperiod, hours per day
Latitude 40° N

<table>
<thead>
<tr>
<th>Month</th>
<th>Photoperiod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb</td>
<td>10:45</td>
</tr>
<tr>
<td>Mar</td>
<td>12:00</td>
</tr>
<tr>
<td>Apr</td>
<td>13:15</td>
</tr>
<tr>
<td>May</td>
<td>15:30</td>
</tr>
<tr>
<td>Jun</td>
<td>15:00</td>
</tr>
</tbody>
</table>

Source: Bos Technica Research Services
<table>
<thead>
<tr>
<th>Area</th>
<th>Sex</th>
<th>No. Lots</th>
<th>No. Head</th>
<th>% A</th>
<th>% A+</th>
<th>% Total</th>
<th>% Distoma</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW Kansas</td>
<td>Steer</td>
<td>2,506</td>
<td>304,473</td>
<td>8.8</td>
<td>6.0</td>
<td>14.8</td>
<td>2.9</td>
</tr>
<tr>
<td>TX Panhandle</td>
<td>Steer</td>
<td>1,878</td>
<td>280,629</td>
<td>7.1</td>
<td>4.0</td>
<td>11.1</td>
<td>6.1</td>
</tr>
<tr>
<td>Colorado</td>
<td>Steer</td>
<td>470</td>
<td>68,938</td>
<td>10.2</td>
<td>6.4</td>
<td>15.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Nebraska</td>
<td>Steer</td>
<td>1,563</td>
<td>225,918</td>
<td>10.2</td>
<td>3.3</td>
<td>13.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Desert SW</td>
<td>Steer</td>
<td>20</td>
<td>1,186</td>
<td>3.9</td>
<td>3.8</td>
<td>7.7</td>
<td>3.5</td>
</tr>
<tr>
<td>Pacific NW &amp; ID</td>
<td>Steer</td>
<td>1,374</td>
<td>150,832</td>
<td>15.2</td>
<td>7.4</td>
<td>22.6</td>
<td>11.3</td>
</tr>
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</table>
Control and Prevention Methods

• Approved feed-grade antibiotics
  • Chlortetracycline, Oxytetracycline, Tylosin and Virginiamycin
  • Tylan is the most widely used, +/-70% control

• Pro and pre-biotics, essential oil, zinc & proprietary products
  • S cerevisiae fermentation product: low and variable abscess control

• Vaccines: have been ineffective
  • KSU microbiologists identified protein allowing *F necrophorum* to attach to cells and colonizing the rumen wall. Research will determine the effectiveness
Vaccinated with Control, Fusogard® (FNB) or Centurion™ (APFNT)

- 1307 steers and heifers
- 613 lb initial weight
- 237 days on feed
- Vaccine per label
- No antibiotic
Next Steps

• The multi-factorial causes of liver abscesses will likely avert absolute prevention or control from occurring any time soon

• New control measures should target:
  • *F. necrophorum* control early in feeding period
  • Reduced lactic acid production
  • Enhanced lactic acid utilization

• “Outside the Box Thinking”

• Support those who support