Freckle on Her walk
PICKLE
THE
PUG
The Newest
Holt Family
Member
Tugg
Pug Pug
Roo
The Newest Holt Family Member
Bovine High Mountain Disease

“Brisket Disease”

Feedlot Cardiac Failure

Pulmonary Hypertension

BIF

Calgary, Canada

2023

Obesity

Coronary Vascular Disease?

Tim Holt, DVM
1913-First Formal Description of “Dropsy of High Altitude”
PAP Testing at this Elevation

9520 feet

2901.7 meters
Bovine High Mountain Disease
Vs.
Feedlot Cardiac Death

Alamosa Colorado
8000 feet

Nebraska Feedlot
3000 Feet
Background
Pulmonary Hypertension
Human Aspect

• Hypoxic pulmonary hypertension is the most common cause of cor pulmonale.
• Occurs with alveolar hypoxia, in conditions such as emphysema, sleep apnea. A specialized cause is generalized alveolar hypoxia of altitude, high altitude pulmonary hypertension.
• Early human research
PH and the WHO Classification

- Group I pulmonary arterial hypertension, Congenital (PAH)
- Group II PH due to left heart disease
- **Group III PH due to lung diseases and/or chronic hypoxia**
- Group IV chronic pulmonary thromboembolic PH
- Group V PH with unclear multifactorial mechanisms

The bovine model recapitulates important features of Group III PH, the second largest group of PH human patients (Gretta)
Pathophysiology

BHMD

Most Critical Part
Genetics
Environmental

Don’t Forget Donnie
Another Genetic Aspect, To Die or Not to Die

Alveolar Hypoxia
Pulmonary Vasoconstriction
Pulmonary Remodeling
Pulmonary Hypertension
Right Ventricular Hypertrophy
Right Ventricular Dilation
Right Heart Congestive Failure
Normal Pulmonary Artery PAP = 40 mmHg

Hypertrophy of Pulmonary Artery Smooth Muscle PAP = 80 mmHg
Pulmonary Artery Hypertrophy

Normal Pulmonary Artery
40 mmHg PAP
(Normal)
Pulmonary Vasculature

80 mmHg PAP
(Vasoconstriction)
Pulmonary Hypertension
1. Alveolar hypoxia
   Altitude

2. Pulmonary arterial vasoconstriction and shunting

3. Pulmonary arterial remodeling and arterial smooth muscle hypertrophy
Pathophysiology

4. Pulmonary hypertension

5. Right ventricular hypertrophy

6. Right ventricular dilation

7. Right congestive heart failure
Clinical Signs
Congestive Right Heart Failure
BHMD, Feedlot Cardiac Death

- Lethargy, weakness, collapse
- Jugular Distention/Pulsation
- Diarrhea
- Subcutaneous Edema
  Brisket Region
  Intermandibular
  Ventral Abdomen

- Fluid Within
  Abdomen
  Thorax
  Pericardium
- Bulging eyes
- Death
Jugular Distension, BHMD
27% Death Loss in One Year
117/435 calves >$100,000.00 Loss

Wyoming Ranch
Elevation
7200 feet Home Ranch

All Calf losses Out of
Two Sire Groups

Photo:
Thank you, Dr. Knight
Variation in Response to **Hypoxia**

**Hyper-Reactive**
- Bovine, Porcine

**Moderate-Reactive**
- Equine, (Humans)

**Hypo-Reactive**
- Ovine, Caprine, Canine,
  - Llama, Alpaca

**YAK!!!**

**Breed Susceptibility?**
Very Near Death Necropsy
Necropsy of Clinical Case Of Bovine High Mountain Disease
Brisket Edema, Swelling
Fluid and Adhesions
Congested Liver
Swollen Rounded Edges
Necropsy Findings

Enlarged Right Ventricle
GRADE 5
Cardiac Collapse

Congested Liver
“Nutmeg Liver”
Enlarged Right Ventricle and Atrium

Dilated Pulmonary Artery

GRADE 5
Grade 1—Normal Heart

Grade 4—Heart, Severe Cardiac Disease
Can we use cardiac anatomical changes to track Cardiac disease

ABSOLUTELY
Hypertrophy → Dilation
Why do the Heart Scoring?

Estimated loss of $250,000.00 per feedlot, incidence continues to rise and is increasing even now

Etiology **genetic driven**, growth, performance area in which to control loss, selection, etc

PAP score has a positive correlation to Higher Heart scores thus **Pulmonary Hypertension**
Why do the Heart Scoring

*Evaluate relationship between healthy heart scores and abnormal heart scores by evaluating phenotypic differences seen in fattening cattle

*Better understand the relationship of heart scores in the estimation of heritability for the trait

Genetics vs. Phenotypic

CSU study in genetics
USMARC study, phenotype
Simplot Genetics
High Altitude Disease

- Condition affecting cattle at altitudes of >5,000 ft.
- Pulmonary arterioles begins to constrict and thicken in response to low oxygen being transported.
- Selecting bulls with lower PAP has been successful in producing progeny with lower PAP scores thus more adapted to elevation.

Feedlot Heart Disease

- Condition affecting feedlot cattle at low to moderate altitudes.
- Direct cause is currently unknown, but these individuals experience heart remodeling similar to animals experiencing brisket disease.

HYPOXIA

PAP is currently used as a decision factor for culling animals in the herd who display high PAP at early ages.

Kukor et al., 2021
Epicardial fat has been shown to have relationships with pulmonary hypertension in humans.
Tracking and Evaluating Incidence of Cardiac Failure

Gross Visual
External Cardiac Evaluation
Grading system

GRADE: 1, Normal Heart

- Normal conical shape
- Normal left ventricle apex, easily visible
- Right ventricle smaller than left and in normal portion, fitting on the side of left ventricle
- Normal Atrial Anatomy, right atrium smaller than left
- No clinical evidence of infarction or aneurysm pending, no thinning of vessel wall
- Normal Pulmonary Artery size
- May appear as 2 but with rigor may develop and shrink to 1
GRADE: 2, Mild Change

- Normal conical shape
- Blunting of left ventricle apex, visible but losing apex point
- Right ventricle becoming larger than left, right ventricle becoming pronounced.
- Right Atrium beginning to enlarge, same size or slightly larger than left.
- No clinical evidence of infarction or aneurysm pending, no thinning of vessel wall
- Pulmonary artery beginning to show mild enlargement.
- Cardiac muscle when palpated is stiff and suggestive of hypertrophy and loss of lumen space, may be biventricular
- 2+, Right Ventricle enlarged but not complete reverse D, flaccid
Gross Visual
External Cardiac Evaluation
Grading system
1-5

GRADE: 3, Moderate Change

- Beginning to lose conical shape
- Blunting of left ventricle apex, visible but losing apex point and deviating, beginning of reverse “D”
- Right ventricle larger than left, right ventricle becoming more pronounced.
- Right Atrium enlarged, Atrium larger than left
- Can be clinical evidence of infarction or aneurysm pending, thinning of vessel wall apparent
- Pulmonary artery enlarged.
- Cardiac muscle when palpated is stiff and suggestive of hypertrophy and loss of lumen space, may be biventricular, after removal muscle may be severely flaccid
GRADED: 4, Severe Changes

- Loss of cardiac conical shape
- Left ventricle apex has been lost due to ventricular rounding. Reverse “D” is apparent.
- Right ventricle larger than left, right ventricle becoming more pronounced and taking on rounding shape.
- Right Atrium enlarged, Atrium larger than left and remains congested.
- Can be clinical evidence of infarction or aneurysm pending, thinning of vessel wall apparent.
- Pulmonary artery enlarged greatly.
- Cardiac muscle when palpated is becoming soft and without shape but still has some muscle tone.
Gross Visual
External Cardiac Evaluation
Grading system
1-5

GRADE: 5, Severe Changes, flaccid heart

-Loss of cardiac conical shape, severe
-Left ventricle apex has been lost due to ventricular rounding. Reverse “D” is apparent.
-Right ventricle larger than left, right ventricle becoming more pronounced and taking on rounding shape.
-Right Atrium enlarged, Atrium larger than left and remains congested.
-Can be clinical evidence of infarction or aneurysm pending, thinning of vessel wall apparent
-Pulmonary artery enlarged greatly.
-Cardiac muscle when palpated is soft and without shape, there is no muscle tone and heart lays flat.
Examples of Grade 1
Examples of Grade 2
Examples of Grade 3
Examples of Grade 4
Examples of Grade 5
Examples of Grade 5
Heart Scores Summary
Thus far

Results thus far:
* High Heart Scores correlate with High Heart Fat Scores
* There is a high correlation to sire groups

Conclusions:
Significant score effect, 56 sires accounted for 66% ; scored 1,2 normal
34% ; 3 plus, significant cardiac remodeling
PAP Testing Adventures

• 1980 in Gunnison/Hesperus Colorado
• 1980-Present, >492,000 head
• Ambient Temps -42 degrees to 115 degrees.
• Numerous Breeds with high Pap's in all
• Elevations from sea level to 14,300 feet
Minus 12 degrees F

7800 Feet Elevation
PAP Measurement Catheter Location
PAP of 46 mmHg

PAP of 94 mmHg
Confounding Factors
“Body Condition”

- Excessive body condition increases PAP
  - Bulls on Test
  - Feedlot Cattle, Newest area of Research!

1.4 billion dollar loss per year concerning

Feedlot
Cardiac Death
Broiler (left) and layer (right) at 38 days. Photo courtesy of Australian Chicken Meat Federation Inc.
Average Live Market Weight has Increased 48% since 1944

1953 Angus Steer
950 lb. Live Weight

2015 Angus Steer
1200-1600 lb. Live Weight
The Well-Marbled Heart

Closer Look at Feedlot Cardiac Death
Is It Bovine High Mountain Disease
Feedlot Cardiac Death
Fattening Induces Hypercholesterolemia and Dyslipidemia

Obesity
Hypoxia
PH
Cardiac Death
Coronary Artery Disease
Altitude and Repeatability

• <5000 feet
  Estimated Repeatability
  60% Predictive
  Screening only

• 1-1.5 mmHg increase per 1000 feet elevation rise.

Elevated PAP—Accurate Measurements <41 Questionable predictive value

PAP Hot Topics
Herd Example: Red Angus Bulls
16 months of Age

PAP Test #1, 100 selected
36-41 mmHg

MT
3,200 ft

25 head out
1-4 weeks
12 BHMD

6 weeks

PAP Test #2
75 remaining

Laramie, WY
7,240 ft
Results

Elevation and Repeatability
(3200 <--> 7240 feet)

• 48% (36/75) had PAPs > 46 mmHg
  – 10/75 had PAPs 46-50 mmHg
    • Pulled from sale
  – 26/75 had PAPs > 50 mmHg
    • Pulled from sale and moved to lower elevation

• 52% (39/75) had PAP ≤ 45 mmHg
  • Average increase of +12 mmHg
## PAP Risk Factor

### Low Elevation Test Chart

PAP test conducted at elevation <4000 ft.

(60% Repeatable, Predictive Value)

<table>
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<th>Use at Moderate Elev. (4000-5500 FEET)</th>
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# PAP Risk Factor

## Moderate Elevation Test Chart

PAP test conducted at elevation **4000-5500 ft.**

(70% Repeatable, Predictive Value)

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# PAP Risk Factor

## High Elevation Test Chart

PAP test conducted at elevation **5500-7000 ft.**
(75-95% Repeatable, Predictive Value)

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# PAP Risk Factor

**Very High Elevation Test Chart**

PAP test conducted at elevation >7000 ft.

*(95% Repeatable, Predictive Value)*

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WHY ETHIOPIA?

• Ethiopian highlanders maintain venous hemoglobin concentrations and arterial oxygen saturation within the ranges of sea level populations, despite the decrease in the ambient oxygen tension at high altitude.

• Different from Andean and Tibetan populations
PAP testing in Ethiopia
Elevation 14,300 feet

Tested 325 Head
Highest PAP Measurement 34 mmHg
Questions
Finished

Thank You !!
Questions
Finished

Thank You!!