Salmonella dublin infections in dairy cattle

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Outline

- Review the clinical presentation and pathology of Salmonella dublin infections in cattle.
- Examine the “Quorum sensing” features of Salmonella spp.
- Review Salmonella dublin infections on four calf farms over 10 years.
- Summarize and describe prevention methods on farms.
**S. dublin – Clinical presentation**

- Acute onset of lethargy and pyrexia (up to 108F)
- Increased respiratory rate and effort without coughing that “looks like viral pneumonia.”
- Poor response to treatment
- Often presents WITHOUT diarrhea
- High mortality, variable morbidity

**S. dublin - Necropsy**

- Diffusely icteric... “School-bus yellow”
  - Yellow calves are Salmonella until proven otherwise
- Enlarged liver and spleen (Hepatosplenomegally)
- Diffuse pulmonary congestion (interstitial pneumonia)
- Serofibrinous peritonitis and pleuritis
- Often have normal intestines, colon and formed colon contents.
Icterus and splenomegally

Icterus and Hepatomegally
Diffuse interstitial pneumonia and serofibrinous pleuritis

Lung – Interstitial pneumonia

Clear airways

Fibrin pool

Inflammation & Hemorrhage
Liver – Necropurulent hepatitis

- Fibrin, neutrophils, necrotic hepatocytes (“Typhoid nodules”)
- Bacteria (Salmonella)

S. dublin – Ancillary test

- Bacteriology
  - Often isolated in pure cultures from liver, spleen and lung by direct methods (no enrichment needed).
  - Inconsistently isolated from feces, intestines and colon
  - Antemortem Diagnosis??
**Most Common Salmonella Serotypes**

**Trends 2005 - 2010**

- **Dublin**
- **Montevideo**
- **Newport**
- **Typhimurium**

**Number of positive cultures**


**Age Distribution of S. dublin cases**

- **Age class distribution of Salmonella dublin cases**
  
  (n = 45, 2012 – 2013)

- **Percent of submission**
  
  - Fetus: 4%
  - Nursing calf Grower (2-5 mo.): 20%
  - 5 mo +: 60%
  - Adult: 7%
  - Unknown: 9%

**Age Class**
S. dublin antibiotic susceptibilities

Salmonella dublin in vitro antibiotic susceptibilities.
(42 isolates, 2012 – 2013)

- Ampicillin: 17%
- CTC: 2%
- Florfenicol: 2%
- Neomycin: 48%
- OTC: 2%
- Albon: 0%
- Micotil: 0%

Salmonella prevention and control methods

1. Decrease exposure
2. Increase immunity
3. Recognize “Quorum Sensing”
Salmonella prevention and control methods

Decrease exposure
1. All in – all out or closed herd
2. Disinfect waterers (dilute bleach 2x daily)
3. Remove manure, organic debris
4. Clean, disinfect, non-porous surfaces
5. Minimize fecal contamination
6. Drain areas that collect water
7. Limit bird, rodent, feral cat and waterfowl exposure
8. Isolate the entire group if one animal is affected
9. No shared bunk

Salmonella dublin and vaccination

- Increase or enhance immunity by vaccination
  - Effectiveness?
  - Anaphylactic reactions?
  - Attenuated strains?
  - Cell mediated or humoral immunity?
  - Gram negative core antigens?
Recognize Quarum Sensing?

- The mammalian intestines is a complex, dynamic environment of micro-organisms.
- Quarum Sensing is communication, or “cross talk,” between bacteria and host to coordinate a variety of adaptive processes.
- Bacteria sense host stress hormones and respond by proliferating and increasing motility.
  - Bacteria sense stress in the host and conclude “now’s the time to mobilize and strike.”
  - Poultry = Increased Salmonella shedding when molting
  - Swine = Increased Salmonella shedding during transportation and other stressors.

Quarum sensing example in swine

- In swine, *S. typhimurium* responds to host norepinephrine (stress hormone) by increasing pathogen motility.
- Genetically mutated bacteria with *INACTIVATED* hormone receptor genes shed significantly fewer pathogens.
- If norepinephrine is blocked with a drug (phenolamine), *S. typhimurium* motility slowed.
- Salmonella clearly recognizes mammalian stress hormones, “Bacterial endocrinology”
**S. dublin control: 4 farms, 10 years**

- All four farms buy bull calves from sale barns and/or “order buyers”
- Most come from Wisconsin
- *S. dublin* has been confirmed on all 4 farms.
- **Exposure** to *S. dublin* prior to arrival on these farms is **expected** and **inevitable**.
- Although exposure is expected, clinical disease is **sporadic**
- Manipulating immunity though vaccination has been unrewarding.
- Control has focused on the recognition of Quarum sensing and to limit the stressors, or “triggers,” that result in clinical disease.

**Farm A**

- U of MN Animal Science Department buys 40 bull calves from Wisconsin for a study to examine the effect of adding oregano to the feed.
- All 40 calves have total proteins above 5.5 mg/dl.
- **At one week post placement, 50% of the calves develop diarrhea.** High numbers of rotavirus, bovine coronavirus and *Cryptosporidium sp.* were detected. No *Salmonella sp.* were culture from the feces.
- 11 calves were treated with IV fluids and survived. One calf died despite treatment.
Farm A:

- The calves are retained in new hutches, in a naïve pasture, and raised individually.
- At seven weeks, 8 calves get sick and die despite treatment. Multi-drug resistant *Salmonella dublin* isolated from multiple tissues.
- Question? Where and when did exposure to *S. dublin* happen?

Farm A:

- Important Event – At six weeks the calves were weaned from milk and offered a moldy starter with excessive amounts of mold and added oregano which the calves did not eat.
- Conclusion – *S. dublin* exposure had happened prior to arriving in St. Paul. The intestine may have been colonized for weeks and the negative energy balance initiated by failure to consume moldy feed initiated clinical disease.
Farm B

- Farmer buys 170 bull calves from sale barn every 3 months.
- Feeds milk for 6 weeks.
- Moves calves from stalls to outside feedlot at 8 weeks.

Farm B: Feedlot

- 80 larger calves are placed in one large lot.
- *Salmonella dublin* morbidity is approximately 20% and mortality is approximately 5%.
Farm B: Strategy

- Nothing in this picture is ever cleaned or disinfected. The producer will not make smaller groups.
- Intervention = Expand the time between weaning from milk and grouping from 2 weeks to 3 + weeks. Group at 9 or 10 weeks of age instead of 8 weeks.
- Result – Bigger, more aggressive, calves when grouped.
- No clinical cases of *S. dublin* in 2 years.

Farm C

- Buys 170 bull calves every 3 months.
- Feeds **28 lbs.** of milk replacer and starts **weaning from milk at 4 weeks.**
- Calves develop Salmonellosis at 5 weeks.
Farm C – “The picture”

- Feeding 40 lbs. of milk replacer for at least 36 days has eliminated the problem for more than 8 years.
- BRDC and *Mycoplasma sp.* ear infections also dropped significantly
Farm C: Older calves

- Successfully raised 1,000's of weaned calves for decades.
- One group “didn’t do as well,” and one calf was euthanized.
- *S. dublin* was isolated from multiple tissues.
- Toxic levels of copper were also detected in the liver of the euthanized calf.
- The feed was fixed and the next group was fine.
- The manure was hauled, but nothing was washed between groups.
- No clinical cases in 5 years.

Farm D

- Calves raised in hutches and weaned into groups of 20.
- The farm has had two significant outbreaks of *S. dublin* in the summer of 2009 and 2011.
- Unlike farm B, the time between weaning from milk (6 wks) and grouping (8 wks) can not be extended because the calves jump out of the hutches and the producer doesn’t want to scoop 1 ton of starter each day (325 calves X 6 lbs. of starter).
Farm D:

- In the summer of 2012, 5-week-old calves were vaccinated with autogenous S. dublin vaccine, SRP (extra-label), and 1/3 were negative controls.
- One calf vaccinated with autogenous vaccine died of anaphylaxis. All other vaccinated calves were stressed resulting in delayed weaning.
- At 4.5 months, the non-vaccinated calves weighed 353 lbs., the autogenous calves weighed 355 lbs. and the SRP calves weighed 342 lbs.
- The producer has no intentions of vaccinating again.

Farm D: Intervention?

- High feed cost ($550 / ton for protein pellets) drove him to feed less protein than the growing calves required producing a perceived protein deficit.
- He increased protein in the diet by adding home-grown stream-crushed soybeans
- Also adds Neomycin to the feed at grouping. The only farm to add Neomycin.
- No cases in 1.5 years.
- Facility was never cleaned.
“Triggers” in *S. dubin* cases

- Ranked from most common to less common
  - Apparent negative energy balances driven by diet, social and environmental changes
  - Rumen acidosis has been observed as the ‘trigger’ on other farms. Textured feeds with minimal fines is critical for rumen development.
  - Concurrent trace mineral toxicity has been documented in two cases.
  - Concurrent bacterial and viral infections are noticeable uncommon. Calves that die of *S. dublin* Salmonellosis often don’t have other infectious diseases (BRDC pathogens, Coccidiosis, etc.)

Summary

- On many farms, exposure to Salmonella appears inevitable and it’s unrealistic to eliminate it.
- Methods to successfully enhance immunity through vaccinations is not clear and vaccination attempts in calves have been unrewarding in my experiences.
- *S. dublin* control on these farms involves limiting the length and severity of negative energy balance routinely seen...
  - When calves are weaned from milk (6 weeks)
  - When grouping calves (8 weeks)
  - When poorly palatable feed is offered.
Comments and/or Questions?