

# DVM Dx: bridging the diagnostic gap

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## Abstract

“True knowledge lies at the dead pile.” First heard from Dr. Eugene Janzen, but likely quoted many times by cattle veterinarians! The digital revolution provides new tools with the potential to change how necropsies are conducted; however, these tools’ validity must be tested. As a project of Merck Animal Health, a mobile and web-based application was designed to systematically collect digital necropsy images, making them available to diagnosticians. DVMDx is based on proprietary digital and web-based diagnostic systems used for 20 years by Feedlot Health Management Services Ltd. To validate this system, trained veterinary students followed a prescribed digital necropsy protocol on 192 cattle from feedlots and calf ranches with clinical respiratory disease. In parallel, tissues samples were submitted to a diagnostic laboratory for histopathological and microbiological evaluation. Veterinarians experienced in interpreting digital images provided a single “most likely” syndromic diagnosis which was compared to laboratory and microscopic findings. An antemortem diagnosis of respiratory disease was confirmed by gross image analysis in 90%, and by laboratory testing in 94%, of the cases. Digital and laboratory diagnoses agreed in 79% of the cases when the primary diagnoses were compared, and 88% when all diagnoses were compared. When the syndromic diagnosis predicted the etiology based on digital images, *Histophilus somni* and *Mycoplasma bovis* were confirmed in 25% and 100% of the cases, respectively. These data support the further refinement of this tool, which has the potential to significantly increase the number of animals receiving cost-effective and diagnostic postmortem inspections.

**Key words:** cattle, feedlot, digital imaging, DVMDx

## Résumé

“Connaissance véritable se trouve au point mort.” D’abord entendre de pieux du Dr Eugene Janzen, mais probablement cité à maintes reprises par les bovins les vétérinaires ! La révolution numérique offre de nouveaux outils avec le potentiel de changer la façon dont les autopsies sont effectuées; toutefois, ces outils “ validité doit être testé. En tant que projet de Merck de la santé animale, un mobile et une application web a été conçu pour recueillir systématiquement numérique des images de l’autopsie, les rendant ainsi disponibles pour diagnostiqueurs. DVMDx est par des droits

de propriété numériques et systèmes de diagnostic sur le web utilisé pour 20 ans par Feedlot Health Management Services Ltd. pour valider ce système, formé des étudiants en médecine vétérinaire ont suivi un protocole d’autopsie numérique prescrite sur 192 bovins des parcs d’engraissement et veaux ranchs avec maladie respiratoire clinique. En parallèle, les tissus des échantillons ont été soumis à un laboratoire de diagnostic pour histopathologiques et évaluation microbiologique. Les vétérinaires expérimenté dans l’interprétation des images numériques a fourni un seul “vraisemblablement” le diagnostic syndromique qui a été comparé au laboratoire et les résultats microscopiques. Un diagnostic ante-mortem de maladies respiratoires a été confirmée par analyse d’image brute dans 90 %, et par les tests de laboratoire dans 94 %, des cas. Digital et diagnostics de laboratoire convenues dans 79% des cas, lorsque les diagnostics principaux ont été comparés, et 88 % lorsque tous les diagnostics ont été comparés. Lorsque le diagnostic syndromique prédit l’étiologie basée sur des images numériques, de *Histophilus somni* et *Mycoplasma bovis* ont été confirmés dans 25 % et 100 % des cas, respectivement. Ces données appuient l’affinement de cet outil, qui a la possibilité d’augmenter considérablement le nombre d’animaux recevant rentable et inspections post mortem de diagnostic.

## Introduction

Despite its recognized value in enhancing food security by aiding in the early and accurate identification of important health issues, post-mortem (necropsy) examinations are sporadically utilized as a diagnostic tool in the livestock industry. In fact, tracking of causes of mortality in the livestock industry is underwhelming and when done, is often based on clinical signs and is far from definitive. The recognition of lesions and disease processes during gross necropsy is a mainstay of traditional diagnostic medicine and has stood the test of time, staying relevant, efficient, and economically viable today when livestock producers have ready access to quality facilities and service. However, it is estimated that less than 1% of cattle that die before slaughter are given even a rudimentary postmortem examination. The extra time involved in transporting the carcass to a diagnostic laboratory or waiting for a diagnostician to come to the farm, lack of perceived value of a gross necropsy, lack of available services, or a subjective distaste for postmortem examinations can impact a producer’s willingness to invest in diagnostic

services. Accurate postmortem diagnosis has an immediate impact, however, on treatment or management changes for the remaining animals in the herd, monitoring for emerging and foreign animal disease, and identification of zoonotic diseases. Recently, the identification and monitoring of antimicrobial resistant bacterial infections in livestock herds has taken on greater importance. These benefits can affect not only the economic viability of an individual producer, but the food security of an entire industry. Diagnostic laboratories across the United States, with variable levels of state and federal support, have striven to provide these services in an economical and efficient manner for livestock producers, but it is clear there is still significant unmet need for even minimal evaluation of livestock deaths.

Historically, many producers have relied on clinical diagnoses or even pharmaceutical use as a proxy to track trends in the health of their herds; i.e., animals treated for Bovine Respiratory Disease (BRD) are considered to have bronchopneumonia with or without postmortem confirmation. Such practices may provide some economic value, but their validity has not been rigorously tested, and in other health care systems (e.g. human medicine), the accuracy of clinical diagnoses has been exaggerated when compared to autopsy data.

The need for the development and deployment of new ways to recognize devastating diseases can be highlighted by the 2001 Food and Mouth Disease outbreak in the United Kingdom and more recently the Porcine Epidemic Diarrhea Virus outbreak in the USA. In both cases, earlier identification of the disease may have reduced their devastating effects. In fact, the FMD outbreak, which was traced to 1 farm, could have been completely avoided if appropriate diagnostics, including gross necropsies, had been initiated on this farm of origin.

Clearly, the accurate categorization of livestock deaths is important for early identification and appropriate intervention into animal health events. Development of tools to facilitate the routine necropsy of livestock that die on farms would facilitate livestock health surveillance efforts and further ensure food security. The digital revolution and cloud-based computing have provided new tools with the potential to change how and when necropsies are conducted. Digital necropsies have been in use by some veterinary practices in the feedlot industry for over 20 years with significant success. In these practices, trained feedlot employees or veterinary technicians conduct standardized necropsy dissections and take predetermined digital images, and can typically conduct necropsies on 100% of the mortalities in their facilities. These images are subsequently uploaded to the web, transferred to veterinary diagnosticians at a remote location, and these diagnosticians make a syndromic diagnosis. These diagnoses are then collected and disease trends monitored by the feedlot and the veterinary practice. In these feedlots, the digital necropsy has provided value to the producers and been well-accepted. However, these tech-

niques have not been widely used throughout the industry and application to other livestock industries, such as dairy, swine, or poultry, has been slow or non-existent. In addition, the rigorous validation of these syndromic diagnoses has not been conducted, although the feedlot producers perceive significant economic impact.

As a project of Michigan State University and Merck Animal Health,<sup>a</sup> a mobile and web-based application<sup>b</sup> was designed to systematically collect digital necropsy images, making them available to diagnosticians. DVM Dx is based on a proprietary digital and web-based diagnostic systems used for 20 years by Feedlot Health Management Services Ltd.<sup>c</sup> This system was initially designed for feedlot use, but modules for dairy calf, abortions, and adult dairy cattle have also been built. The goal of this proposal is to validate this digital necropsy application as a tool for the diagnosis of dairy calf enteric diseases with significant economic and zoonotic importance.

While digital necropsies have been performed by a few feedlots and veterinary practices, the techniques have not been widely disseminated or accepted. The development of a novel “user-friendly” portable device application we feel will make this technology much more accessible to producers and encourage postmortem examinations and the more accurate collection of mortality data.

### Industry Wide Diagnostic Gaps

It is becoming more apparent that the animal health industry could be significantly more effective if it was equipped to embrace a systematic and sustained approach to syndromic diagnosis and disease surveillance aided by a consistent diagnostics platform. Any platform utilized must empower all relevant parties, but it especially must position the veterinarian at its core, enabling them to advance and sustain increased relevancy within the industry.

There are a number of key diagnostic deficiencies in the field evaluation and monitoring of disease.

- Disease surveillance is uncoordinated and inconsistent
- Routine necropsy is sporadic
- Determining the monetary value of applied diagnostics is incomplete
- There is no agreed-upon protocol for necropsies and related diagnostics
- Disease tracking is subject to inconsistent interpretation
- Little or no consistent data currently exists on emerging disease trends

Based on these findings it can be concluded that the animal health industry would be significantly more effective if it would embrace a sustained approach to syndromic diagnosis and disease surveillance aided by a consistent diagnostics platform.

## What is DVM Dx

At its core, DVM Dx is a Software-as-a-Service (SaaS) system designed for remote and digital diagnosis of sick or dead animals. Features include: Web and smart mobile technology use to gather photos, notes, and other related data fields needed to properly diagnose a case remotely.

## The Objective of DVM Dx

For progressive veterinarians looking to provide more value to their producers, DVM Dx gives veterinarians the ability to collect, analyze, store and share diagnostics information from any location, making it easy to collaborate with laboratories and producers so vets can improve cattle health through rapid disease identification and tracking.

## How the Platform Works

A basic overview of how DVM Dx would be applied in a “typical” necropsy-case fashion: When an animal dies, the on-ground user (veterinarian, producer, producer employee or veterinary technician) would initiate DVM Dx and log that animal in as expired. Key data is gathered, such as tag number, environmental notations, approximate age, weight, breed, etc. The DVM Dx application would then walk the user through the necropsy steps needed to gather the relevant data. Similar to GPS-based turn-by-turn directions, DVM Dx prompt the user to proceed through a series of steps then prompt them to capture an image at each relevant step. After the pre-programmed steps are completed, the user uploads the images and data, easily via the app, to the web-based portal that is managed by the veterinarian. Once the veterinarian reviews the case, they issue a diagnosis or submit it to a diagnostic lab. Below is a simplistic overview of the system.

## Applications of Digital Necropsy

Conducting necropsies represent an enormous opportunity for veterinarians to provide value added services to their clients, to understand how large that opportunity might be, one only needs to consider how many actual necropsies are done on an annual business. Consider this:

- NAHMS Dairy 2007 survey reported that 5.7% of dairy cows die on-farm annually [http://www.aphis.usda.gov/animal\\_health/nahms/dairy/index.shtml#dairy2007](http://www.aphis.usda.gov/animal_health/nahms/dairy/index.shtml#dairy2007).
- There are ~381,000 lactating cows in Michigan, therefore 21,717 die annually.
- DCPAH necropsies or looks at tissues from 365 dairy cows/year – 1.5% of cow deaths
- A survey of local practitioners suggest that they may look at 1% of deaths or 217 deads therefore  $(217 + 365) / 381,000 = 2.5\%$  of dead cows get necropsied

- 21,135 cows die annually in Michigan without being necropsied.

### *Opportunities of using Digital Necropsies in Practice*

- Outbreak investigations - facilitation of disease outbreak investigations
- Syndromic surveillance - surveillance for and documentation of routine production diseases. Helps to answer the question “when does normal morbidity/mortality become abnormal
- Surveillance for “zebra’s” - monitoring for foreign animal diseases or emerging diseases or unknown diseases
- Facilitation of herd health program - by conducting routine necropsies, there is an increased engagement with ownership and employees. Also can serve as a teaching or reinforcement moment
- Problem solving - necropsies provide added data to solve herd health problems
- Protocol support - necropsies can provide data useful in monitoring of protocol adoption/drift
- Remote service - facilitation of health delivery in remote areas
- Other opportunities
- Research - animal health research facilitation
- Public health support - early detection of “bovine tb” or prudent drug use
- Education - image data bank for teaching
- Global disease detection - early detection and monitoring of developing diseases
- Wildlife disease detection - facilitation of identifying wildlife disease of importance to livestock and humans

### *Opportunities for using digital necropsy data Diagnostic Labs*

- Improved interaction with customers submitting samples
- Increased use of diagnostic tests profitable to the laboratory
- Targeted laboratory diagnostics vs whole-animal
- Better insight into the sample submitted
- Initial opportunity for students involved in Beta-testing period

### *Opportunities for Producers*

- Tracking of operational losses
- Identify areas of improvement in their operation
- Retrievable database
- Documentable disease surveillance for product consumers
- Potential for better products
- Has visibility to all details related to events on their operation

## Tips for Taking Necropsy Pictures in the Field

### Equipment Needed

#### Protective clothing

- Coveralls
- Rubber gloves (some people prefer to wear multiple pairs to be more efficient and keep their camera/phone clean)
- Rubber boots
- Eye protection
- Hat (to protect head and tie hair back)

#### Sharp knives

- A straight back. 6 inches or more. Not easily bent. You more likely to hurt yourself with a dull knife trying to “power through” a cut versus a sharp knife that is used with finesse and control.

#### Sharpening steel (or other knife sharpener)

- Proper training with a steel or sharpener is necessary to keep a sharp edge. Knife should always be sharpened after cutting through hide, tough cartilage, or bone. Steel frequently!!

#### Rib cutters (or reciprocating saw, axe)

- Use caution when sawing or swinging an axe and be sure to keep your legs away from the cutting path.

#### Camera (or phone)

- Quality pictures are essential. A camera or phone with at least 5 megapixel capabilities is preferred.

### Tips on Performing the Digital Necropsy

- Animal must be placed left side down.
- The ear tag must be removed and placed so as to be easily visible in every photo.
- Make smooth, efficient cuts.
- Develop an orderly routine of taking pictures and opening the animal.
- Make sure the camera is set up properly.
- Take quality, standardized photos.
- Stand close enough to the animal so the entire area of interest fills the viewfinder.
- Always try and use the same picture orientations (such as keeping the animal’s spine to the top of the picture and the head to the right side of the picture).
- Pictures need to be taken in either full sun or full shadow (poor quality otherwise).
- Special circumstances will require you to get creative with some photos (such as trying to block light to negate shadows, taking pictures with 1 hand while holding a point of interest, etc.).
- Use WiFi to upload DVM Dx cases. Usually faster and does not use phone data.
- Cases should be uploaded in a timely manner (preferably at the end of the day).
- Take additional pictures if necessary. Pictures of a sick or injured animal prior to death, or perhaps

other lesions that would not otherwise show up in the required photos are helpful and may aid the veterinarian in making a diagnosis.

Performing a quality postmortem exam requires a thorough methodology that is practiced and complete. Remembering the proper cuts and photos will become easier the more necropsies you perform. If using the mobile version of DVM Dx, the required photos are listed and contain prompts on how to obtain them.

### Rediscovering Your Senses: The Gross Post-Mortem Revisited

Veterinarians are trained to use many diagnostic modalities and tools: radiology, ultrasonography, biochemistry, auscultation, to name a few, but arguably the first and most basic is recognizing gross variations from normal anatomy, or gross pathology. When an animal walks into the examination room, when a surgeon opens up the abdomen or a joint, or when an animal dies and a thorough postmortem examination is performed, veterinarians are trained to recognize, describe, and interpret the cues provided by the eyes, hands, ears, and nose and make a tentative diagnosis. As needed, additional diagnostic tests can confirm gross interpretations. With the advent of new digital imaging technologies (such as DVM Dx), these “classical” skills will become increasingly important as producers, veterinarians, and pathologists interact in innovative and effective ways using images that capture the gross features of a diseased animal.

Skills in using descriptive terminology is key to not only effectively communicating the gross lesions observed to others, but also correctly processing the objective information a gross examination provides in order to formulate a subjective, but useful, interpretation. Thus it is critical that veterinarians continually hone their descriptive skills in gross pathology. Even when using a digital photograph for a gross examination, a keen understanding of descriptive techniques will help choose the best images and allow accurate processing of the information. Some guidelines for an effective description are detailed below.

The most important principle to keep in mind when writing a description, and often the most difficult to follow, is to BE OBJECTIVE; that is, objectively record your observations. Although the prosector cannot help but interpret as he proceeds, the records should primarily give a clear description of what is observed; the prosector’s interpretations are of secondary importance. Objective descriptions of the lesion or organ must never be omitted, but interpretations are not always essential. The writer must guard against using the names of lesions instead of describing their appearance.

The following salient features should be covered as fully as is applicable for each lesion: location, size or volume, shape, number, distribution, color, consistency, cut surface appearance, odor (occasionally).

*Location* – Use anatomical terms, e.g. medial, lateral, cranial, caudal, etc. localize the lesion as closely as possible while still being practical. If a skin lesion is being described, you should be sure to indicate which body region is affected. Relate internal lesions to body cavities, lobes of viscera, surfaces, etc. Examples: the lesion is on the right lateral thorax just behind the elbow; the lesion is on the medial aspect of the right hind leg, halfway between the stifle and groin; the lesion is on the diaphragmatic surface of the right lateral liver lobe; or the lesion is on the serosal surface of the terminal ileum, 5 cm from the cecum.

*Size or Volume* – Use measurements, preferably metric. Estimates are acceptable. Do not use cookbook terms like “the size of a hen’s egg or pea or orange or softball.” Remember to give 3 dimensions when appropriate. To say “the tumor is 3 x 5 centimeters” tells nothing about its third dimension. Estimate the volume of fluids in body cavities. To say “the abdomen was filled with fluid” does not tell how much fluid it was filled with. Was it 50ml, 500ml, or 5 liters? Words like large or small are too vague. The percent of parenchymal involvement is often useful when referring to the lung, liver, or kidney. To indicate organ enlargement or shrinkage, you may weigh the organ and express the weight as a percentage of the animal’s body weight. When, compare to establish normal ranges for the organ in question. Some pathologists may indicate organ enlargement or shrinkage by comparing to normal size. For example, a spleen may be 2 x normal size or a testicle ½ normal size.

*Shape* – Use terms like spherical, cylindrical, oval, pedunculated, sessile, rugose, corrugated, smooth, rough, lobulated, broad-based, wedge-shaped, stellate, tapered, streaked, pitted, granular, elevated, depressed, etc.

*Number* – If more than 1 similar lesion is found in a given location, indicate how many. If the number was less than 10, you should count them and give the actual number. If the number of similar lesions is above 10, give an estimate of the number using phrases like: about 25, between 50-100, hundreds, thousands. Words like “multiple” and “many” are too vague. Do not use the phrase “too numerous to count”.

*Distribution* – This part of the description may be hard to separate from number or location. Words like diffuse, disseminated, focal, patchy, irregular, or scattered may be used.

*Color* – Keep it simple!

*Consistency* – Most solid lesions can be described (with modifying adjectives) as soft, firm, or hard. Sometimes words like gritty, greasy, friable, rubbery, turgid, indurated, stringy, gelatinous, rigid, or pliable may be appropriate. Fluids may be watery, viscous, mucoid, caseous, clear, cloudy, opaque, etc.

*Cut surface appearance* – In examining larger organs or tumors, you should slice into them at regular intervals to determine if they are solid, cystic, uniform, or varied on the interior.

*Odor* – Only occasionally do alterations acquire odors distinctive enough to be significant. Words like sweet, sour, fetid, acidic, or putrid may be appropriate.

After creating an objective and succinct description of a gross lesion, it is important to draw accurate conclusions and summarize the lesion. Pathologists use the “morphologic diagnosis” to communicate their conclusions about a lesion or disease process. Typically gross morphologic diagnoses cover 3 general disease processes:

- Inflammatory or degenerative lesions
- Neoplastic lesions
- Traumatic lesions or congenital defects

There are many schools of thought on how a morphologic diagnosis is made. One method is as follows:

For inflammatory or degenerative lesions, first, list the name of the organ followed by a colon (e.g. Organ: or Liver: or Front left leg:). Second, provide a term describing the severity of the disease process:

- Mild
- Moderate
- Severe

Third, provide a term describing the distribution of the disease process:

- Focal
- Multifocal
- Locally extensive
- Segmental
- Diffuse
- Cranioventral

Fourth, a temporal term for the lesion is needed:

- Peracute
- Acute
- Subacute
- Chronic
- Chronic active

Fifth, a process term will help provide more detail. Was the lesion very hemorrhagic, or purulent, or necrotizing. These terms will give the reader a deeper understanding of the lesion described.

And sixth, a term indicating the organ will complete the morphologic diagnosis. Examples are:

- Dermatitis
- Typhlitis
- Hepatitis

Note that “-itis” means “inflammation of”. “-osis” means “a condition of” such as lipidosis (a condition of fat) or coccidiosis (a condition with coccidia).

For neoplastic, traumatic, or congenital lesions, simply list the organ with a colon and then the diagnosis – e.g. brain: meningioma or liver: hepatocellular carcinoma or uterus: lymphosarcoma or brain: hydrancephaly.

### **DVM Dx and Dairy C.A.R.E. 365**

In conclusion, it would seem that the intersection of 3 related technologies makes this the perfect time for the merger of telemedicine and cattle medicine. Due to the improvement of the picture quality of smart phones, the advent of an ever expanding digital cloud to accommodate these high resolution images, coupled with an App that helps organize work flow and many protocols making this a tool that is valuable, inexpensive, and easy to use. The exciting opportunity is that the practicing veterinarian is at the center of DVM Dx at a time when, on some large operations, there is marginalization

of veterinary oversight. DVM Dx will help determine causes of otherwise undiagnosed deaths and diseases, provide an avenue to engage diagnostic labs, and provide rationale for judicious use of antibiotics.

Furthermore it has opportunities to provide new pathways for training veterinary students, utilization of veterinary technicians, and provides new access to remote underserved areas in both the US and abroad.

Finally as the DVM Dx platform is transferred to other species and also is used to provide an aid to ante mortem diagnosis as well as post mortem cases it has potential to change the amount of information we have as we continue down the “evidence based” path in veterinary medicine. With the Dairy Care 365 initiative, it is the goal to provide practicing veterinarians with ideas and tools to both increase their practice reach and provide valuable information to their clients.

### **Endnotes**

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