Investigation of unexpected death in cattle and sheep

Fraser Hill I Gribbles Veterinary I 840 Tremaine Avenue I Palmerston North

Introduction

Unexpected death is a situation where sheep and cattle have died when the farmer didn't expect them to. They should have been healthy and for one reason or another, when the animals or mob are inspected at regular or irregular intervals dead, and/or affected animals are noticed. Then you get called in to investigate.

What are the most common causes of unexpected death?

A review of Gribbles Veterinary's quarterly reports to the Surveillance magazine for the period 2000 - 2010 was undertaken. Cases selected needed to include a history of unexpected death and sufficient information to confirm a diagnosis. The diagnoses are shown in Table 1. These diagnoses were then grouped into ten diagnostic categories as listed in Table 2.

Table 1 Diagnoses reached by Gribbles Veterinary pathologists in cases of unexpected death as published in the Surveillance magazine quarterly reports 2000 - 2010

Cattle	No. cases	Sheep	No. cases
Polioencephalomalacia	41	*Salmonella* Hindmarsh	37
Lead toxicity	16	*Leptospira pomona*	16
Copper toxicity	15	*Listeria* (enteric)	9
Enteric adenovirus	13	Polioencephalomalacia	9
Acorn toxicity	11	Copper toxicity	7
Monensin toxicity	10	Enterotoxaemia	7
Mucosal disease	8	Parasitism	7
Malignant catarrhal fever	7	*Listeria* (encephalitis)	6
Nitrate toxicity	7	*Mannhemia haemolyticum*	6
Salmonella Typhimurium	7	Selenium toxicity	6
Hypocalcaemia	6	Haemophilus/histophilus	5
Haemophilus somnus	6	White muscle disease	4
L-Tryptophan toxicity	6	Nitrate toxicity	3
Pasteurella multocida	6	Staggerweed	3
Salmonella Brandenburg	5	Acorn toxicity	2
Lungworm	5	Black disease	2
Adenoviral pneumonia	4	*Clostridium sordellii*	2
Hypomagnesasemia	4	*Eperythrozoon ovis*	2
Listeria (encephalitis)	4	Hypocalcaemia	2
Yersinia pseudotuberculosis	4	Post vaccination	2
Congenital disease	3	*Salmonella* Brandenburg	2
Enteric parasitism	3	Superphosphate toxicity	2
Selenium toxicity	3	Tutu toxicity	2
Superphosphate (F) toxicity	3	1080 toxicity	2
1080 toxicity	3		
Acidosis	2		
Amaranthus toxicity	2		
Arsenic toxicity	2		
Bovine respiratory syncytial virus	2		
Bracken fern toxicity	2		
Clostridium chauvoei	2		
Clostridium haemolyticum	2		
Clostridium sordellii	2		
Cyanobacteria	2		
Fungal encephalitis	2		
Leptospira ballum	2		
Acute mastitis	2		
Mortierella pneumonia	2		
Portocaval syndrome	2		
Urea toxicity	2		
Zinc toxicity	2		

Cattle – other diagnoses
Toxins – Arsenic, Digitalis, Himalayan honeysuckle, Kowhai, Mycotoxin, Ngaio, Oleander, Phorate, Salt, Vetch, Yew.
Infectious – *Clostridium perfringens, Fusobacter*, meningitis, *Sarcina, S.* Enteriditis
Non-infectious – abomasal ulceration, bloat, jejunal haemorrhage, myopathy, neoplasia, white muscle disease,

Sheep – other diagnoses
Toxins – *Amaranthus* (red root), Cyanide, Poroporo, SMCO
Infectious – *Actinomyces pyogenes, Actinobacillus seminis, Clostridium septicum*, coccidiosis, E coli, FSE, *H somnus, L hardjo, Yersinia*
Non-infectious – abomasal bloat, congenital disease, faulty drench capsule insertion, vitamin E deficiency

The data is indicative only as cases published tend to be selected for interest or if sufficient information was provided i.e. there needed to be a history and a diagnosis.

Table 2 Ranking of the most common causes of death reported by Gribbles Veterinary pathologists in the Surveillance magazine for the period 2000 - 2010

Cause of death	Cattle	Sheep
Chemical toxin	1	2
Bacteria/fungi [1]	2	1
Deficiencies [2]	3	4
Plant toxin	4	3
Viral	5	10
Metabolic	6	8
Parasitic	7	5
Dietary [3]	8	6
Congenital	9	9
Other	10	7

Notes:
- *Bacteria and fungi includes Mortierella pneumonias, E coli mastitis, and Listeria encephalitis*
- *Deficiencies included trace element deficiencies, and vitamin deficiencies. Polioencephalomalacia is included as this is a deficiency of Vitamin B1*
- *Dietary includes portocaval syndrome, acidosis and dietary indiscretions*

The causes of death were then grouped into broad categories of; toxicity, infectious (bacterial, viral, parasitic, and fungal), deficiency, and non-infectious (metabolic, congenital, dietary). This data is shown graphically in Figure 1.

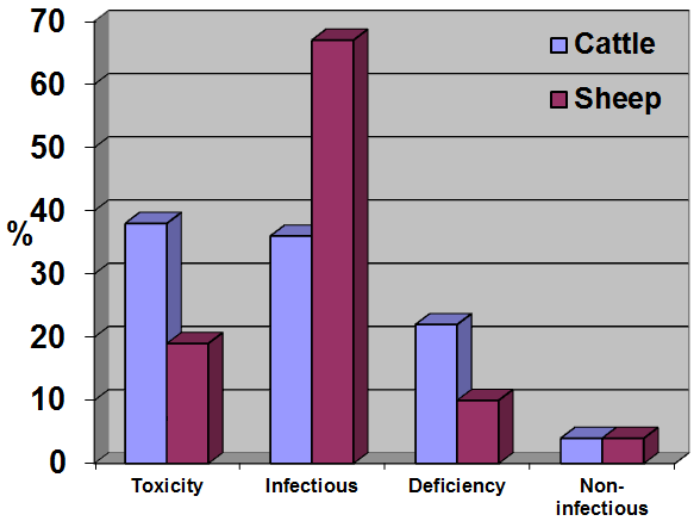

Figure 1 Broad categories illustrating the cause of death reported to Gribbles Veterinary

This data indicates toxicity is the most likely cause of unexpected death in cattle reported to the laboratory, while infectious disease is more likely in sheep. Similar conclusions have been reached by others (Fairley, 2011). Salmonellosis in adult ewes dominates the cause of death with leptospirosis in lambs not far behind. But this data only reflects cases where samples were submitted to a laboratory. Gross diagnoses made in the field when post-mortem findings suggested a diagnosis are not included in these figures. Hence in your practice experience, you may have a different list.

Early in the 2000's Clostridial disease was thought to be a significant cause of unexpected death (Cook, 2003; Lee, 2003) but a year later multiple authors reported diagnosing bloat as a cause of death in similar cases (Pickering, 2004; Walshe, 2004; West, Collett, Van Rensburg, 2004). Recommendations to check cattle about 90 minutes after shifting to a new break or feed source were made by the authors. Submissions of samples suspecting Clostridial disease fell away after this time although this also coincided with the release of a widely used 10-strain vaccine.

Investigating unexpected deaths

The time of year influences the likely diagnoses you might consider. If ewes are dying before lambing, potential problems are mainly metabolic disease related to feeding levels, procedures removing ewes from feed, and any of the problems that can affect sheep through the winter.

At lambing deep wounds from parturition, or injury might be found associated with severe oedema, bubbles of gas, crepitus, discolouration of the skin, cooling of the affected part, toxaemia, collapse and sudden death. Consider gas gangrene (*Clostridium chauvoei, C. septicum, C. novyi, C. sordellii).* Marked pulmonary congestion will be seen immediately after death and within a few hours there is extensive gas formation in all organs. Tissues have a rancid odour progressing to a foul odour of putrefaction. Gram stains of affected tissues and anaerobic culture confirm the presence of gram-positive bacterial rods. Histopathology reflects necrosis, oedema, gas formation, and vascular damage.

A probable post lambing diagnosis would be hypomagnesaemia, most commonly occurring in ewes on inadequate feed.

Investigations of unexpected death in cattle can be a frustrating exercise. Often one or more dead animals are found in a paddock some time after death, leaving you to deal with a pile of rotting carcasses. In other cases, weather or the disease process has led to rapid putrefaction, gas formation and an unpleasant task. In these situations if the animal has been dead less than 24 hours, and the conditions are favourable, proceed to necropsy (appendix 1). If the time of death is unknown, or the animal is obviously autolysed consider a modified examination possibly collecting only vitreous humour. Rumen content could be inspected for obvious toxic agents or chewed plant remnants. Tissues for histopathology or microbiology are probably unsuitable, but it is probably better to collect and store them, even if they ultimately can't be used.

Ocular fluid is a valuable sample

A useful sample to collect when investigating sudden death in is ocular fluid. Use a vacutainer to aspirate the fluid (see Figure 2). Possible analyses and the reference ranges are given in Table 3. These need to be interpreted with clinical signs, history and particularly with hypomagnesaemia, blood sampling of cohort animals to establish a diagnosis.

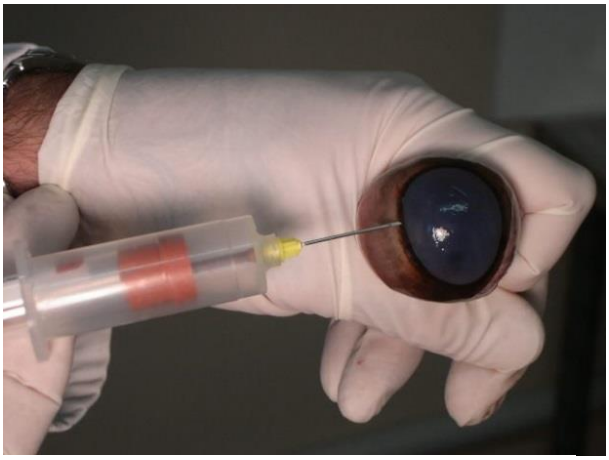

Figure 2 Insert vacutainer needle through the limbus

If the time since death is known and likely to be less than 24 hours collect aqueous humour. Insert the needle through the limbus and angle towards the cornea keeping the point in front of the lens. Once the tip is free in the aqueous push the vacutainer onto the needle. Aspirate 0.5-1 mL of fluid. Collect vitreous humour if the time since death is not known. Insert the needle through the limbus and uvea into the vitreous behind the lens. If the sample is contaminated with blood, discard it and collect from the other eye. This technique can be carried out while the eyeball is still in the carcass.

Table 3 Concentrations of analytes following ocular fluid testing for diagnosis of sudden death in cattle and sheep.

	Aqueous humour		Vitreous humour	
	Reference range (mmol/L)	Recommended sampling time	Reference range (mmol/L)	Recommended sampling time
Calcium - sheep and cattle	< 1	Immediately following death	< 1	< 48 hours
Magnesium - cattle	< 0.25	< 24 hours	< 0.55	< 48 hours
- sheep	< 0.33	< 24 hours	< 0.65	< 48 hours
Urea - sheep and cattle	> 30	None given	> 6.6 (sheep) > 7.3 (cattle)	< 36 hours
BOH - sheep	> 2.5	None given	No verified data	
Nitrate	Presence	< 60 hours	Presence	< 60 hours

Look for a bloat line

Another essential task is to search for the presence or absence of the bloat line. If it is present a gross diagnosis can be made, alleviating the need for any further sampling. The bloat line is found in the oesophagus at the thoracic inlet. Open the carcass including the thorax, then run a knife the length of the oesophagus. Where the oesophagus passes through the thoracic inlet check if a demarcation line between blanched [white] and congested [red] tissue is present. In a bloated animal prior to death, intra-thoracic pressure forces blood out of the thoracic oesophagus, blanching it up to the level of the thoracic inlet. Cranial to the thoracic inlet the ventral neck oesophagus is markedly congested and red. Once you have collected these samples and ruled out bloat then you are faced with a full post-mortem.

Search the surrounds and collect samples

At some stage, the paddocks and surrounding environment animals could have accessed, should be searched and examined. Any potential toxic materials or plants the animals could have accessed should be sampled. Powders, residues, suspicious metals e.g. lead or zinc should be sampled into a labelled screw top container. Any unidentified plants animals could have been grazing should be sampled and representative sections of leaves, stems and flowers collected into labelled paper bags for identification, or dried for later identification. Consider seasonal toxic plants such as acorns from oak trees and note their presence or absence. Once you open the rumen, hunt through for any unusual plants or objects you may be able to incriminate as a cause.

Proceed to post-mortem

After these main rule outs have been eliminated then proceed to a full post-mortem, examining all tissues and collecting appropriate samples. If a diagnosis is not reached by the end of the post-mortem, remember to collect the brain.

Non-lesions at post-mortem

Probably the biggest challenge at post-mortem is to determine if lesions are due to necrosis or autolysis, and what changes are artefact. Once death occurs, smooth and skeletal muscle continues to contract, segmentally trapping blood in mobile tissues like gut and bladder. These tissues may seem intensely reddened or have linear red regions looking like haemorrhage. Gas build-up in the carcass can force ingesta up the oesophagus and tissues to bulge from the anus and vulva. A list of the more common non-lesions is given in table 4.

Table 4 Non-lesions at post-mortem

Artefact	Due to
Bloody nasal discharge	Nasal congestion at death, subsequent rupture of congested vessels
Gastrointestinal nasal and/ or oral discharge	Gastric sphincter relaxation, abdominal gas or carcass handling causing the discharge
Rectal or vaginal prolapse	Gas distention of abdominal viscera
Liver mortis	Fluid blood distributing unevenly in dependent portions
Melanosis	Deposition of melanin
Pseudomelanosis	Post-mortem decomposition of blood by bacterial action forming hydrogen sulphide. Most commonly seen on the kidneys, liver, or spleen in contact with the gut
Pseudoicterus	Increase of normal yellow colour of certain tissues of Jersey cattle
Haemal nodes	Found only in ruminants. Dark-red, lymphatic tissue with blood filled sinuses along dorsal mediastinum and abdominal mesenteric fat
Thoracic inlet pseudomalignant oedema	Most common in cattle. Oedema and emphysema at the thoracic inlet, neck, and cranial shoulder region in autolysed carcasses. Can be misdiagnosed as clostridial disease
Pseudoinfarcts of the spleen	Unequal expulsion of blood
Tension lipidosis	Yellow or pale foci in the liver near the edges caused by chronic tension on the liver
Gall bladder enlargement	Failure to empty associated with inanition from dental problems, starvation and malnutrition
Thickened urinary bladder wall	Contracted bladder
Pulmonary emphysema	Terminal gasping. Pathology if presented with a history of dyspoena.
Meningeal congestion	Body position and gravity after death
Rumen mucosal sloughing	Soon after death, the rumen lining peels off in large patches leaving a reddened submucosa, that may be mistaken for inflammation
Segmental intestinal hyperaemia	Mucosal vessels may break down with resulting haemorrhage-like blood in the lumen
Mucosal linear haemorrhage - tiger striping	Blood trapped and clotted as the animal terminally strains to urinate or defecate

Using smell to make a diagnosis

Distinctive smells may assail you while you undertake the post-mortem and you can use odour to assist with a diagnosis. The actual description of an odour is difficult and is best identified by comparison as described in table 5.

Table 5 The most likely diagnosis when distinctive odours are smelt in a carcass

Odour	Disease
Billy goat or rancid butter	Blackleg
Septic tank	Salmonellosis
Fermentation	Septic mastitis
Ammonia when rumen opened	Urea poisoning
Onions	Onion poisoning

What samples should you collect?

Once you've formulated a differential diagnosis from the history and post-mortem findings then what samples should you take? Table 6 is a sampling guide based on the probable diagnosis.

Summary

To maximise the chance of a diagnosis in cases of unexpected death apply the following general principles:

- Examine the environment
- Post-mortem as soon after death as possible
- Collect ocular fluid
- Check for a bloat line
- Examine rumen contents thoroughly
- Collect fresh liver and muscle aseptically and store anaerobically
- Collect other fresh tissue and intestinal samples aseptically and store in sterile containers
- Collect a full range of other tissues and fix in formalin
- Send rapidly to the laboratory

Table 6 Sampling guide for investigating unexpected death in sheep and cattle

Probable diagnosis	Samples Live animal	Dead animal
Abamectin toxicity		Fresh liver abamectin concentration
Abomasal ulceration		Fixed ulcer
Acorn toxicity	Serum urea, creatinine; urine USG	Fixed kidney, Check rumen for acorns, oak leaves
Actinobacillus	Affected tissue for culture	Fresh testis, epididymis, brain; fixed brain and major organs plus affected tissue
Actinomyces	Not required	Pus for culture; fixed abscess
Acute mastitis	Milk for culture	Mammary gland, lymph nodes, liver, lung
Acute (atypical) interstitial pneumonia	Not required	Fixed lung
Adenovirus - enteric	Not required	Fixed intestine
Adenovirus - lung		Fixed lung
Amaranthus	Serum urea, creatinine; urine USG	Fixed kidney, Check rumen for plant
Arsenic	Faeces, urine	Fresh liver, kidney; fixed abomasum; suspect source for As concentration
Bloat	Not required	Not required
Blue green algae	Not required	Fixed liver
Bovine respiratory syncytial virus (BRSV)	Not required	Fixed lung; fresh lung for virology
Bracken fern	EDTA, smears, bone marrow for cytology	Fixed liver, kidney, lung, heart, organs with lesions and bone marrow
BVD (mucosal disease)	Serum for ELISA or PCR; ear skin for ELISA	Ear skin for ELISA; fixed organs, gastrointestinal tract especially lesions
Clostridial disease: Blackleg, black disease, bacillary haemoglobinuria, enterotoxaemia, focal symmetrical encephalomalacia (FSE), sordellii, malignant oedema, tetanus	Not required	Fixed – lesions and major organs; fresh – 5cm^3 cubes of liver and affected muscle for anaerobic culture
Coccidiosis	Faeces for coccidia count	Fixed small and large intestine at various places

Probable diagnosis	Samples Live animal	Dead animal
Congenital disease		Young animal full post-mortem examination of organs for abnormalities and full fixed tissue set
Copper toxicity	Serum for Cu concentration; EDTA blood and smears for haematology	Fresh kidney for Cu concentration; fixed liver and kidney
Cyanide toxicity		Rumen contents, fresh liver and muscle for cyanide analysis
Eperythrozoon ovis	EDTA blood and smears for haematology	Fixed liver, spleen
Faulty drench capsule insertion		Post-mortem lesions
Fluoroacetetate (1080)		Fresh liver, muscle, rumen contents for toxin analysis
Goats rue		Plant in rumen (or grazed) for identification. Fixed lung
Haemophilus somnus		Fresh and fixed brain and lung
Hypocalcaemia	Serum	Aqueous/vitreous humour see table 2 for timing and concentrations
Hypomagnesaemia	Serum	Aqueous/vitreous humour see table 2 for timing and concentrations
Ionophore	Serum – muscle enzymes	Fixed skeletal muscle, heart
Jejunal haemorrhage		Post-mortem lesions
Kowhai		Plant in rumen (or grazed) for identification
Lead toxicity	EDTA blood and smears for haematology and lead analysis	Fixed kidney brain; fresh liver and kidney
Leptospirosis	Serum for MAT serology; urine for PCR, culture	Fixed liver, kidney
Listeriosis		Fixed brain
L-tryptophan		Fixed lung
Mannheimia		Swabs of lesions and purulent material; fresh lung; fixed lung and affected tissue
Malignant catarrhal fever		Full fixed tissue set
Neoplasia		Fixed lesions
Ngaio		Plant in rumen (or grazed) for identification
Nitrate	Serum nitrate concentration; grazed feed for nitrate concentration	Aqueous humour nitrate
Nutritional myopathy	Whole blood or serum selenium	Fresh liver selenium concentration. Fixed muscle or heart
Oak	Serum urea, creatinine; urine USG	Fixed kidney; check rumen for oak leaves
Oleander		Plant in rumen (or grazed) for identification
Organophosphates	EDTA blood for cholinesterase	Liver, fat, rumen contents for toxin analysis
Parasitism	Faeces for faecal egg counts, larvae counts; serum pepsinogen	Gastrointestinal tract for worm counts; fixed lung, sections of GIT.
Pasteurellosis		Swabs of affected tissues or surfaces; fresh lung; fixed full tissue set.
Polioencephalomalacia		Fixed brain
Poroporo		Plant in rumen (or grazed) for identification
Post vaccination	EDTA and serum for sick ruminant profile	Fixed full tissue set
Rumen acidosis	Serum for bicarbonate analysis	Fixed rumen and full tissue set
Salmonellosis	Fresh faeces for culture	Fresh intestinal content, lymph node; fixed full tissue set
Salt poisoning		Fixed brain
Selenium toxicity	EDTA for selenium concentration	Fresh liver for Se concentration; fixed lung
SMCO	EDTA blood for haematology	Crop for SMCO analysis; fixed full tissue set
Staggerweed	Serum for muscle enzymes	Fixed muscle
Superphosphate (fluorosis)	Serum urea, creatinine; urine USG	Fixed full tissue set; rumen contents for F analysis

Probable diagnosis	Samples Live animal	Dead animal
Tutu		Plant in rumen (or grazed) for identification
Urea	History of access; EDTA and serum for sick ruminant panel	History of access; rumen pH - alkalosis
Yersiniosis	Faeces for culture	Fresh intestinal content, lymph node; fixed full tissue set
Yew		Plant in rumen (or grazed) for identification
Zinc	Serum for Zn concentration; water, feeds for Zn concentration	Fixed full tissue set plus pancreas; fresh liver for Zn concentration

Full fixed tissue set includes: brain, lung, liver, heart, lymph node, spleen, kidney, rumen, abomasum, small intestine, large intestine, bladder, skeletal muscle, any lesions

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Appendix 1

Necropsy technique

General points

- All animals are placed on their left side.
- Use at least ten times the volume of 10 percent buffered formalin to the volume of tissue taken for histopathology.
- After fixation it may now be sent with minimal fluid or just formalin soaked cotton to keep it moist.
- Routinely take tissue samples of liver, kidney, lung, heart, gastrointestinal tract and all lesions.
- Sections should be no more than 1cm thick.
- Do not scrape or squeeze section to be taken for histological examination.
- Always take sections with a sharp knife, never with a pair of scissors.
- When taking sections from paired organs, make the left side pieces longer or larger (not thicker).
- Brain should be collected from animals with a history of neurological disease or when no cause of death is found at necropsy.
- Use of the carcass itself as a cutting board is recommended to prevent dulling the knife.
- To prevent cutting hair and thereby dulling the knife, a stab wound in the axilla is the only time the knife cuts hair.

External examination

Following external examination including natural orifices, eyes, and limb and joint palpation, the lymph nodes, nerves, and most vessels are examined when exposed.

Necropsy

After an initial stab incision into the right axilla, extend skin incision cranially to chin and caudally to perineum. Reflect skin on right side and completely abduct right limbs by cutting muscular attachments of scapula and freeing femoral head. Reflect mammary glands or free each testicle separately. Incise along costal arch and dorsal flank down and across pelvic rim. Reflect this flap and examine abdominal cavity.

Stab the diaphragm near the sternum and note inrush of air (or not) as the lungs collapse. Remove ribs by cutting with rib cutters or saw, first close to sternum, then several cm from vertebrae. Check presence and position of all organs. Free a central rib by cutting off adjacent soft tissue close to bone. Check costochondral junction of young animals by cutting along the thin edge. Break or attempt to break rib against curvature for test of general bone strength.

Abdominal cavity examination

Make several inspection slices into spleen. Remove liver leaving diaphragm in place. Incise and inspect gall bladder. Make slices into liver and incise major vessels. Remove kidneys separately after examination of adrenals. The adrenal glands are usually to be found in most species just in front of the kidneys or just medially to the cranial poles of each kidney. Cut each kidney longitudinally to pelvis. Peel away capsule. Take tissue cross section to include cortex, medulla, and pelvis epithelium.

Gastrointestinal tract

Lay G.I. tract in relative order to be opened as last major procedure of necropsy to prevent faecal contamination of tissues and instruments, unless investigating calf diarrhoea. In calf diarrhoea cases sample the GI tract as the first step in the post-mortem, preferably from a euthanased animal. To check G.I. tract, cut along greater curvature of stomach, forestomach, and representative lengths of duodenum, jejunum, and ileum. Open ileocecal orifice and cecum, large and small colon and rectum. Incise major vessels when exposed.

Oral cavity

To remove the tongue, cervical and thoracic viscera *en masse,* cut on medial side of both mandibles close to bone and split the symphysis with cutters.
Pull tongue down and back. Cut through prominent joint of hyoid bones on both sides. Continue down the neck removing trachea and oesophagus, and examining the jugular veins.

Thorax

Transect aorta and vena cava at the diaphragm after cutting the pluck and aorta away from the vertebral bodies. Examine tongue by transverse sections. Cut down full length of oesophagus. Check major vessels then cut heart free from pluck at the base. Palpate lungs softly. If it is not firm, it is probably not pneumonia. Cut down trachea and major bronchi and observe cut ends of pulmonary arteries for emboli. Check bronchi for parasites.

To examine the heart cut in the same direction of blood flow using a sharp knife. Open right atrium. Check right atrioventricular valve, orifices of cranial vena cava, caudal vena cava, ovalis, and coronary sinus. Open right ventricle. Extend incision up pulmonary artery, open pulmonary trunk past bifurcation. Check semilunar valves. Open left atrium and ventricle with straight incision. Incise through parietal cusp of left atrioventricular valve. Check left atrioventricular valve and openings to pulmonary veins. To open aorta, insert knife under septal cusp of left atrioventricular valve. Incise through wall of atrium, out and down aorta.

Joints

A quick check of joints is recommended. Hip has already been opened and checked, then stifle, shoulder, and atlanto-occipital (when the head is removed).

Eye and brain

Move head to locate joint. Obtain CSF at this time if required from dorsal or ventral approach. Cut all soft tissues around joint. Insert knife into joint and transect spinal cord and ligaments of joint and transect spinal cord and ligaments of joint dorsally and ventrally. Remove head. If aqueous or vitreous humour is required collect now. If the time since death is known and likely to be less than 24 hours collect aqueous humour. Using a 18G, 25 mm needle on a vacutainer or 5 ml syringe, gently insert the point of the needle through the cornea and aspirate 0.5-1ml of fluid. If the time since death is not known, collect vitreous humour. Insert the needle through the sclera, and uvea into the vitreous behind the eye. Aspirate gently to obtain 0.5-1 ml of fluid. If the sample is contaminated with blood, discard it and collect from the other eye. Transfer humour fluid to a vacutainer for submission.

Look into foramen magnum to note the normal absence of the cerebellar vermis. Suspect a brain lesion if it is seen (prolapsed). Remove cranium. One cut is transverse through the frontal bone caudal to zygomatic process of frontal bone. Place head in a bucket. Next cut is sagittal, just medial to left and then right occipital condyles. Link cuts with 2 more longitudinal cuts. Pry up skull cap. Best to use a screw drive to avoid damaging knife. With head in upright position, tap it lightly on table to loosen brain. Cut olfactory peduncles, internal carotid arteries, and cranial nerves as brain is removed. Tilt head so that the brain will rest on table.

Bone marrow

To make a bone marrow impression smear or obtain a section of marrow, crack open almost any large bone of young animals or the ends of long bone in mature animals by using the rib cutters to obliquely crack the bone. Bone marrow autolyses very quickly. If you are investigating a bone marrow problem preferably electively euthenase the animal and collect your samples at the start of the necropsy.

If the area of bone marrow or other tissues used for touch preparations are too bloody, then touch the surfaces first with absorbent (paper towel) and then make the touch preparation. Remaining core can be put in formalin for fixation.
Just touch glass slide to red marrow at 3-4 contact areas. Air-dry.