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placenta to the maternal side and the resulting isoantibodies return to cause hemolysis of fetal erythrocytes.¹⁹ There is no evidence that these "holes" are significant in the passage of drugs.

Some endogenous substances are transferred by processes that involve the metabolic conversion of one substance into

another. Glucose is phosphorylated, converted to fructose and then secreted into the fetal compartment.¹⁸ Several other examples similar to this exist. Placental drug metabolism also exists and this point will be discussed in greater detail in the next issue.

Diagnosis and Treatment of Disease in the Turtle

by Pete Henriksen* and David L. Graham,‡ D.V.M.

Closely paralleling the tremendous boom in the cat and dog population in this country is an increased interest in exotic pets. The most commonly kept reptile pets include snakes, alligators, chameleons, iguanas, and turtles.¹³ Of these, turtles are the most popular and it is certainly not unusual for the veterinary practitioner to be presented with an ailing turtle for treatment.

Many problems in turtles are related to poor nutrition. One very common ocular disease results is palpebral edema and hyperkeratosis of the Harderian glands. The nictitating membrane becomes inflamed, thickened, and easily visible with the naked eye. It fails to cover the eyeball completely and engorges with blood. Within a couple of days the upper and lower lids become swollen and fuse so that they cannot be mechanically separated even with a blunt instrument. The turtle, now totally blind, refuses to eat and usually dies of starvation. Recovery has been re-

ported, but untreated cases usually die. Sectioning the eye on post-mortem reveals an extensive change in the Harderian gland. The epithelium changes from glandular to squamous and the acini become dilated and distended by masses of keratin that cannot be expelled. The gland center becomes an accumulation of eosinophilic granulocytes forming a kind of abscess. The cause of this disease is generally thought to be a vitamin A deficiency. Other possible etiologies include: obstruction of the gland duct by bacteria or nematodes, faulty temperature regulation, or improper lime levels in the water.⁹

Treatment of this glandular disease usually consists of vitamin A supplementation in the form of cod liver oil (two drops daily). Success is reported in all but chronic cases.¹³ Other remedies include sulfathiazole ointment daily, warm boric acid bath, or an hour a day swim in warm tea or aquarium salts.⁴

Another condition in turtles thought to be caused by vitamin A deficiency manifests itself as a patchy white discoloration of the carapace accompanied by listless-

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ness and refusal to eat. Adequate heat, light and a variety of live foods help prevent this disease. Treatment with multiple vitamin preparations is also helpful.⁹

Because of their shells, turtles have a high demand for vitamin D, calcium, and phosphorus to prevent rickets. It is very common to see soft shells, distorted shells or kyphosis due to vitamin D or mineral deficiency. Young growing turtles are more susceptible, and therefore they should receive adequate exposure to sunlight or ultraviolet light and mineral supplementation. Suggested methods of supplementing calcium and phosphorus include feeding ground egg shells in hamburger, ground fish, or placing a lump of plaster of paris in the terrarium.² Normal commercial turtle foods are usually inadequate in minerals. Two of the three turtles presented to the I.S.U. clinic in the past one and a half years had shell deformities. Treatment in these cases was with calcium gluconate tablets.⁵

It is also possible to produce hypervitaminosis D with oversupplementation or overexposure to ultraviolet light. Calcification of the vascular tree, visible on radiography, results in extreme cases.

Painting designs on young turtle's backs is a practice that can lead to deformed shells. The foreign substance interferes with normal shell formation and should be carefully chipped off (solvents are contraindicated since they may be toxic).

Low vitamin E levels in the diet can be caused by oily fish such as mackerel, and skeletal muscle atrophy and anorexia may result.¹³

Goiter has been precipitated by the goitrogenic effect of potassium nitrate in overfertilized grass, hay, lettuce, kale, or spinach. The diet should be varied to avoid extensive feeding of any one of these materials. Treatment includes supplementation with iodized salt at .5% of the diet.¹³

Infectious diseases in turtles have not been thoroughly studied. As a result there is some controversy regarding frequency of specific infections. The conditions that were the most consistently mentioned as significant in turtles are listed below. Individual references may vary somewhat.

Pseudomonas spp. and *Proteus* spp. appear to be the most common bacterial disease agents, followed by *E. coli*, *Citrobacter* spp., *Pasteurella* spp., *Bartonella* spp., *Erysipelothrix insidiosa*, *Clostridium novyi*, and *Mycobacterium* spp.¹³

Mycobacterium thamnopheos is the tuberculosis organism usually recovered from turtles. It is usually pulmonary and commonly affects the land tortoises. Tubercles form in the lungs and the clinical course of the disease is similar to pulmonary tuberculosis in mammals. Diagnosis may be made by isolation of acidfast bacilli from nasal exudate or feces. The organism is resistant to most antibiotics.²

Citrobacter freundii (referred to as *E. freundii* by Marcus) can be a serious problem in large turtle operations. The disease may spread through an entire turtle farm within a week. Clinical signs include lethargy, cutaneous ulcers, film over the eyes, limb paralysis, muscle necrosis, and loss of toes. Septicemia results in hemolysis with focal necrosis in the heart, kidney, liver, and spleen. The organism is quickly transferred through cuts or abrasions and is often fatal. Chloramphenicol (6 mg./100 gms. soft tissue weight on the first day followed by 3 mg./100 gms. twice daily for seven days) has been successful in reducing the mortality from 48% to 17%. Complete recovery was increased from 12% to 56%. The shell is considered to comprise 25% to 50% of the total body weight (for use in dosage calculations).²

Pseudomonas spp., *Proteus* spp., *E. coli* serotypes, *Pasteurella* spp., and *Erysipelothrix insidiosa* cause similar syndromes which may manifest themselves as gastroenteritis, diarrhea or constipation, anorexia, or pneumonia. Septicemic forms are brief and usually lead to depression, contortions, and death. Survivors often have milliary abscesses and/or chronic pericarditis. If treated early, Na sulfathiazine (1 oz. per gallon of water for ten days) or chloramphenicol (same regimen as for *Citrobacter* spp. infections) have been successful.¹³

Amoebic dysentery, caused by *Entamoeba invadens*, is reported to be very common in turtles. Enteritis leads to mucosal ulceration, serosal adhesions,

and eventual invasion of the portal vein to the liver causing massive infarction. Rapid death follows. Spread of the organism to other susceptible hosts is also rapid. Emetine HCL has been used in therapy at 40 mg/kg. body weight.²

Although not common among reptiles in general, mycotic infections are prevalent in the turtle. Aspergillosis regularly affects the lungs of captive tortoises. Reichenbach-Klinke estimates 3% of all deaths in these tortoises are due to pulmonary mycosis. Fungal infections may also extend to the carapace, particularly in debilitated specimens. Where the shell is affected, *Mucor* spp. has been isolated.⁹ One tablespoon of KMnO₄ per gallon of water has been recommended for topical treatment of fungal infections.²

Pneumonia can also be caused by many of the bacterial agents known to infect turtles. Clinical signs accompanying pneumonia include nasal discharge, gaping of the mouth, dyspnea, wheezing respiration, listlessness, and anorexia. The course of the disease is variable depending on the pathogen, but often terminates fatally in untreated patients. Tetracyclines (50–100 mg/lb. daily, orally) are effective.⁸

As in most wild animals adapted as pets, parasites may be a problem. Turtles harbor dozens of different intestinal parasites most of which are harmless unless numbers are great.

Six different species of oxyurids have been isolated from the colon of a single tortoise. In this case the tortoise was living in temperatures much lower than in its natural habitat and parasite numbers were allowed to multiply. Unnatural environment and debilitation are often responsible for heavy parasite loads. Ova are similar to those of mammalian nematodes. Whether the worms cause outright disease or just debilitation is unknown. DDVP granules (12.5 mg/kg for 2 days) are recommended for treatment. Another treatment is one gram santonin and one gram calomelol followed in 24 hours by one teaspoon of castor oil.²⁻¹³

Flukes inhabit the mouth, urinary bladder, gastrointestinal tract and lungs but are not pathogenic. Turtles carry tapeworms also but there are no deleterious

effects unless numbers are excessive.²

Numerous species of filariads inhabit the vascular system. They are most often found in mesenteric arteries and in the posterior vena cava causing generalized edema and thrombosis. Since the thermal death point of these worms is 96.8° F. all that is necessary for treatment is to raise the tank temperature to 98.6° F. slowly and allow the parasites to be overheated.¹³

External parasites include ticks (*Ixodid* spp.) and mites. Mites can be removed with castor oil and 90% alcohol. Ticks should be painted with paraffin or methylated spirits and removed with forceps. Flies (especially *Sarcophaga cistudinis*) lay their eggs in the cloacal region of the land tortoise and the larvae penetrate under the carapace causing necrosis and exudation. Leeches can be a problem in the aquatic turtles. Overgrowths of algae on the shell produce flaking and necrosis. Iodine preparations and good sanitation will take care of this condition.⁸

Being an object of considerable curiosity and, at the same time, defenseless and awkward, the turtle may find himself under attack by frustrated pets or overly zealous children. As a result fractured shells are a major medical problem to be dealt with by the veterinarian. Turtles are amazingly sturdy and usually weather all but the most savage attacks. Care must be taken in shell repair since nothing separates the carapace from the lungs but a very thin pleuraperiostium. Rough edges should be debrided and loose pieces removed. Holes can be patched with epoxy glue, denture repair material, or hoof repair adhesive. For large holes, stainless steel or nylon mesh may be necessary as a foundation for the wet prosthetic material.¹³

It may become necessary for a surgical procedure to anesthetize the patient. One method is by placing the turtle in a covered container with a methoxyflourane soaked sponge. When he becomes relaxed a cone is placed over his head and sealed against his shell to complete induction. In one case induction using this method was accomplished in thirty minutes. During the operation itself, a methoxyflourane

sponge had to be held over the patient's nostrils.⁷ Halothane has met with variable success. Because it is more volatile than methoxyflourane a faster induction can be anticipated; only two or three breaths are necessary for induction. The major problem encountered with any inhalant anesthetic is the ability of the turtle to hold his breath for prolonged periods of time.¹³ Pentobarbitol sodium has been successfully used at 18 mg/kg I.P. and is effective for 2-4 hours. An opium derivative, M-99 or etorphine, can also be used at a dosage of .5 - 5 mg for a 4 lb. turtle I.M.¹³

Turtles have been shown to be carriers of some human and domestic animal pathogens. The most significant of these from a public health standpoint is *Salmonella*. Within the last few years outbreaks of human Salmonellosis have been repeatedly traced to turtle carriers. The most common serotype is *Salmonella panama*.³ An example of a family outbreak was recorded in 1965 in the New England Journal of Medicine. Of the five members of the family clinical signs were observed in three.

<u>age</u>	<u>symptoms</u>	<u>isolation</u>
29 yrs.	abdominal pain	<i>Salmonella java</i>
8 yrs.	fever and bloody diarrhea	<i>Salmonella java</i>
7 yrs.	fever and bloody diarrhea	<i>Salmonella java</i>
4 yrs.	asymptomatic	no isolation
3 yrs.	asymptomatic	no isolation

The patients were treated with ampicillin and recovered. Since *Salmonella java* is a rare serotype, health officials were able to trace the source of the infection by culturing the organism from newly acquired red-eared terrapins from a Louisiana turtle farm. They were not successful, however, in recovering the organism from a water sample from the local store from which the turtle had been purchased. At the Louisiana farm adult turtles may have been infected by contaminated raw meat scraps which were incorporated into their diet.¹¹ Similar studies in Minnesota also found pet turtles (mostly of the southern variety) to be infected.

Of lesser public health significance is the infestation of some turtles with the Ixodid tick which can transmit the spirochete (*Coxiella burnetti*) responsible for Q fever in man.⁸ Antibodies to *Leptospira* spp. have been found in turtles and snakes. Snakes are capable of transmitting the disease—turtles, as yet, have not been shown to have this capability. The significance of reptiles as a reservoir for western equine encephalitis is not yet clear. The survival of the virus through the winter may depend on its persistence in hibernating reptiles. The virus has no harmful effect on the reptilian host.⁸

The major turtle diseases and disease conditions have been reviewed. Those of most interest to the veterinary practitioner not associated with a zoo are nutritional deficiencies (vitamin A, calcium and phosphorus), fractured shells, pneumonia, and topical fungus infections. Knowledge of these very basic conditions is usually adequate in a general practice.

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