Journal of Zoo and Wildlife Medicine 23(1): 55–61, 1992

INDICATIONS AND TECHNIQUE FOR THE SURGICAL REMOVAL OF THE AVIAN YOLK SAC

David Kenny, V.M.D., and Richard C. Cambre, D.V.M.

Abstract: Following the deaths of chicks of numerous avian species with retained yolk sacs due to infection or unknown causes, surgical removal of the yolk sac was attempted in 10 chicks of five species: four double-wattled cassowaries (*Casuarius casuarius*), three emus (*Dromaius novaehollandiae*), one bar-headed goose (*Anser indicus*), one lesser Magellan goose (*Chloephaga picta*), and one canvasback duck (*Aythya valisineria*). Candidates for surgery demonstrated one or more of the following clinical signs: swollen abdomen, dyspnea, exercise intolerance, inability to stand or walk, inappetence, weight loss, or failure to grow. Diagnostic tests included abdominal palpation and radiography. A doughy abdominal mass was usually palpable. Radiographs demonstrated an enlarged mass displacing the abdominal viscera cranially into the thorax. Seven of 10 chicks (70%) survived yolk sac removal and resumed normal development. Earlier recognition of surgical candidates would likely result in higher survival rates.

Key words: Yolk sac infection, yolk sac retention, surgery, avian species, ratites, waterfowl.

INTRODUCTION

In the egg, nourishment is provided to the embryo by the uptake of yolk. The yolk sac, which is a diverticulum of the intestine, is attached via a yolk stalk and accompanying vasculature to the intestine and is internalized into the abdomen just prior to hatching.[2,4] Yolk is aborbed through the endodermal cells of the yolk sac and in the chicken the developing chick can also obtain yolk through a duct in the yolk stalk that leads into the intestine.[2,9] The yolk provides nourishment, minerals, fat soluble vitamins, and maternal immunoglobulins to the chick during its first days of life.[2,4] After the yolk has been consumed, the remnant yolk sac is converted to scar tissue and is called the vitelline or Meckel's diverticulum.[9,11]

Among the factors known to affect the yolk sac during the incubation process are temperature and humidity. Low temperature or high humidity may lead to failure to retract the yolk sac prior to hatching.[4] Low incubation humidity has been associated with infected yolk sacs.[7] Incubation can also affect the degree of hydration of the yolk.[5] In in vitro experiments, yolk that had been diluted provided a more favorable environment for bacterial growth than undiluted yolk.[5] The normal yolk is a greenish yellow liquid, whereas infected yolk can appear as a thick brownish or yellow coagulated mass.[5] Not all bacteria are capable of infecting the yolk. Only those bacteria that possess enzymes necessary to degrade yolk protein can initiate a yolk sac infection. These same bacteria may normally be nonpathogenic to other tissues in the chick.[5,6] Bacteria can be transferred to the egg by several mechanisms, including ovarian infection, salpingitis, omphalitis, contaminated incubator, direct contamination of the shell with feces from the hen, or, most commonly, contamination of the egg shell with bacteria from improper handling.[5,6] Chicks may also become infected by enteric bacteria that have migrated to the yolk from the newly colonized gut.[5] For unknown reasons, some birds fail to absorb even a noninfected yolk. Either scenario may lead to malnourishment and immune incompetence due to failure of immunoglobulin transfer.[4,8]

In domestic chickens, infections of the yolk sac, particularly with gram-negative bacteria such as *Escherichia coli,* can lead to retention of the yolk sac and a variety of syndromes known to laymen as "mushy chick disease." The clinical picture can range

From the Denver Zoological Gardens, City Park, Denver, Colorado 80205, USA.

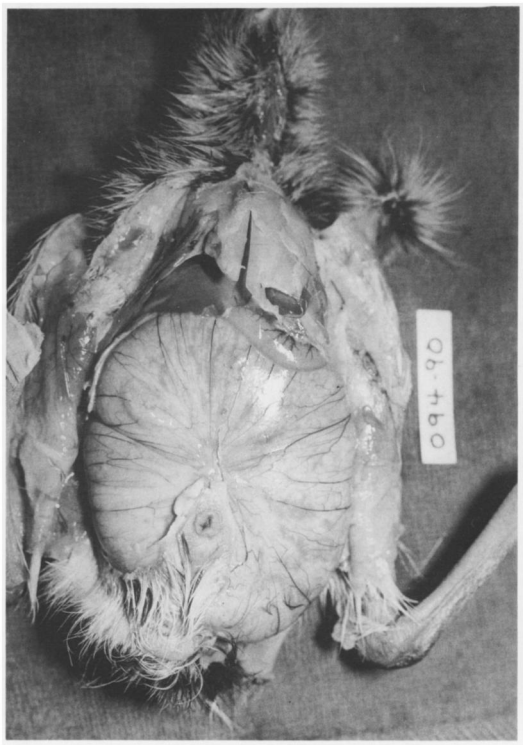

Figure 1. A 6-day-old double-wattled cassowary (*Casuarius casuarius*) that died with a retained yolk sac from which *Escherichia coli* was cultured. The large size of the yolk sac resulted in presenting signs of dyspnea and inability to stand and walk.

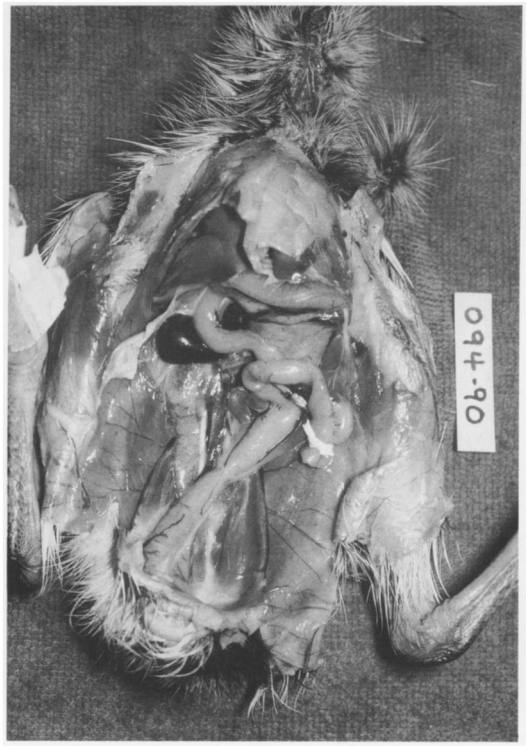

Figure 2. A 6-day-old double-wattled cassowary (*Casuarius casuarius*) with retained yolk sac removed, demonstrating cranial displacement of abdominal viscera into the thoracic area.

from chicks that die in the shell late in incubation to those that hatch weak, survive only a short time, or survive as "poor doers" for 2–3 wk before succumbing.[1] Day-old turkey poults experimentally inoculated with *E. coli* directly into the yolk sac had poor feed conversion, depressed weight gain, and higher mortality compared with poults given the same inoculum orally.[12] As early as 1972, bacterial yolk sac infections were recognized as a problem in 1–2-day-old ostrich (*Struthio camelus*) chicks in the United States.[3] More recently, yolk sac infections have been acknowledged as a common problem in the burgeoning ratite ranching industry. An article in an industry magazine commented that *Serratia* spp., *Citrobacter* spp., and *E. coli* were the most frequently recovered organisms on culture.[10]

A study on the effects of surgical removal of the yolk sac was prompted by repeated annual losses of large numbers of chicks of many species in the avian collection of the Denver Zoological Gardens (DZG) between 1980 and 1990. Retention, with or without documented infection, of the yolk sac was considered a contributory factor in these deaths.

MATERIALS AND METHODS

Birds selected for surgical yolk sac removal were hatched, artificially or naturally, at the DZG. Ten chicks of five species, including four double-wattled cassowaries (*Casuarius casuarius*), three emus (*Dromaius novaehollandiae*), one bar-headed goose (*Anser indicus*), one lesser Magellan goose (*Chloephaga picta*), and one canvasback duck (*Aythya valisineria*), were chosen for the procedure. At surgery the cassowaries ranged in age from 5–11 days, emus 5–

Figure 3. Ventrodorsal radiograph of a 5-day-old double-wattled cassowary (*Casuarius casuarius*) with a retained yolk sac that was unable to stand and walk. Note the greatly enlarged abdomen and displacement of gas-filled viscera craniad. The yolk sac was successfully surgically removed.

Figure 4. Ventrodorsal radiograph of a normal 6-day-old emu (*Dromaius novaehollandiae*). Note the distribution of abdominal viscera and the tapered body contour as compared with Figure 3.

15 days, lesser Magellan goose 14 days, canvasback duck 2 days, and the bar-headed goose a few hours old. Depending on species, chicks were either individually or group housed and withheld from food from 2 (ducks and geese) to 4 (cassowaries and emus) days to encourage yolk absorption.

Candidates for surgery manifested one or more of the following clinical signs: swollen abdomen, dyspnea, exercise intolerance, inability to stand or walk, inappetence, weight loss, or failure to grow (Figs. 1, 2). Further selection criteria included results of abdominal palpation and radiography. A ventrodorsal radiograph (Fig. 3) of a 5-day-old double-wattled cassowary that was presented unable to stand and splay legged showed a greatly distended abdomen resulting from the retained yolk sac when compared with the ventrodorsal radiograph of a normal 6-day-old emu chick (Fig. 4).

All birds were anesthetized using isoflurane (Aerrane, Anaquest, 2005 West Beltline Highway, Madison, Wisconsin 53713, USA) delivered by mask at 4% in oxygen and maintained at concentrations of 1.5–2.0% by mask or through endotracheal intubation. Chicks were placed in dorsal recumbency with the legs pulled caudally and taped to the table. A 50/50 mixture of 5% dextrose in lactated Ringer's and 0.9% sodium chloride solutions (0.016 ml/g body wt) was administered s.c. to compensate for any blood loss during surgery. Abdominal feathers were plucked from flank to flank and from the keel to the cloaca, providing ample access to the area around the umbilicus. The area was surgically prepared with povidone iodine and alcohol scrubs. Patients were

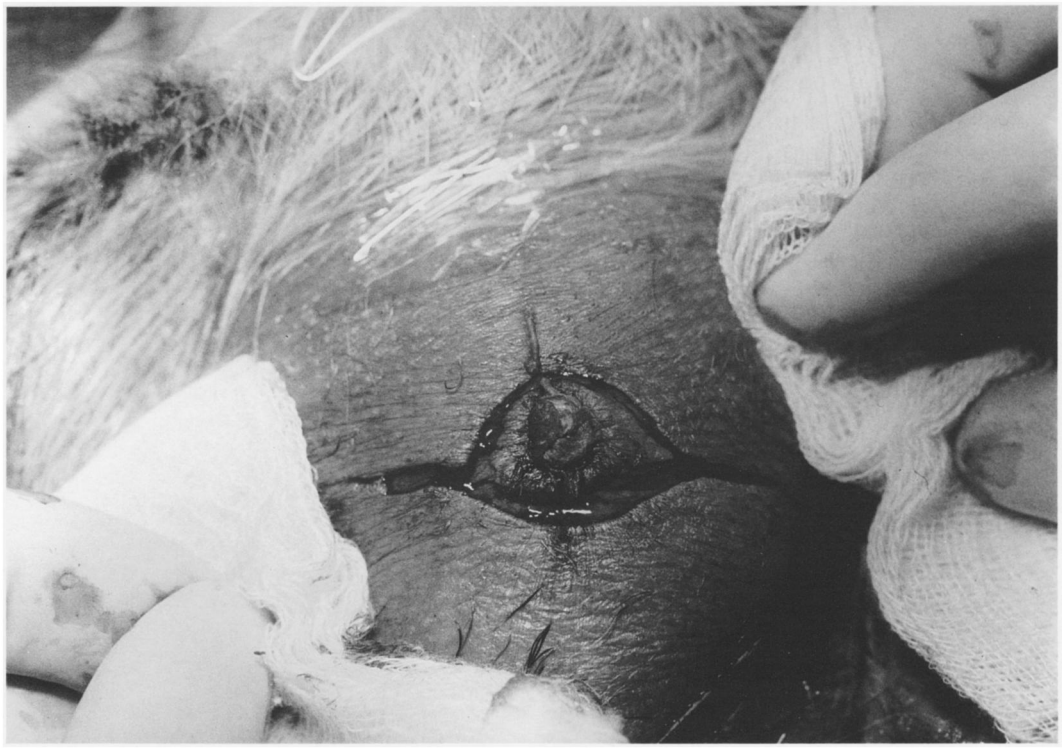

Figure 5. Surgical approach of an 11-day-old double-wattled cassowary (*Casuarius casuarius*) with a retained yolk sac illustrating the circumferential incision of the umbilicus extending laterally at the 3 and 9 o'clock positions.

covered with a sterile clear plastic drape that provided better visualization for anesthetic monitoring.

A skin incision was made circumferentially around the umbilicus and extended laterally at the 3 and 9 o'clock positions to an appropriate length to allow for removal of the yolk sac without rupturing it (Fig. 5). An incision was then made through the remaining layers of the body wall until the abdominal cavity was entered, following the lines of the previously made skin incision.

The yolk sac was exteriorized by applying traction on the umbilical stump with forceps while manipulating it from within the abdomen with a finger or a scalpel blade handle (Fig. 6). The yolk stalk and associated vasculature were ligated as close as possible to the intestine (Fig. 7). The body wall was closed in a simple continuous pattern with an absorbable suture material. The skin was closed in the same manner. Yolk was submitted for bacterial culture. Broad spectrum antibiotics were administered daily postoperatively pending bacterial culture results. Sections of yolk sac wall were fixed in 10% neutral buffered formalin and submitted for histopathologic evaluation.

RESULTS

Three double-wattled cassowary chicks survived the surgery, and a fourth chick was euthanized intraoperatively for peritonitis from a preoperative yolk sac rupture. Yolk sacs from three cassowary chicks were 15, 27, and 40% of the total body weights. Two emu chicks also survived the surgical procedure. A third emu, which was extremely dyspneic prior to surgery, died postoperatively. The yolk sacs from the two emu survivors were 31 and 37% of the total body weight of the chicks. The bar-headed goose

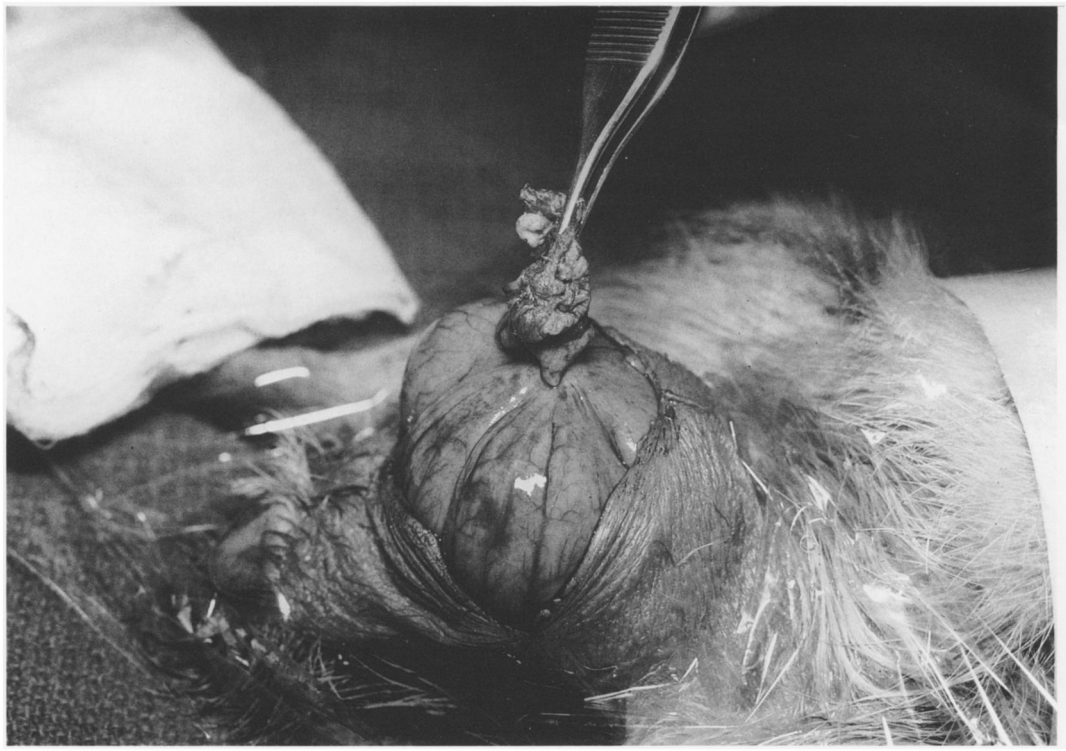

Figure 6. The yolk sac in Figure 5 is exteriorized through the abdominal incision by gently elevating the umbilical stump with forceps.

and canvasback duck both survived surgery, but the lesser Magellan goose died 1 wk postoperatively with no gross abnormalities noted at necropsy.

Some chicks began to eat well and gain weight in 1–2 days postoperatively, whereas others required tube feeding for several days before they would resume normal growth. In one case, a double-wattled cassowary that was splay legged and unable to stand since hatching was able to stand and take its first steps a few hours after surgery.

Culture of yolk from seven of the 10 surgically removed yolk sacs yielded *E. coli.* The lesser Magellan goose that died 1 wk postoperatively had *E. coli* cultured at surgery from the yolk and at necropsy from the liver. This animal had not received postoperative antibiotic therapy. Retrospective review of culture results of yolk sac contents from 59 chicks of 27 species at necropsy between 1980 and 1990 at the DZG revealed the most common organisms found in either pure or mixed culture were *E. coli* (32 isolates), *Proteus* spp. (nine isolates), *Streptococcus faecalis* (seven isolates), and *Clostridium* spp. (four isolates). Eighteen yolk sacs yielded no growth.

Histopathologic evaluation of yolk sacs demonstrated the following lesions: swelling and vacuolation of the villae of the yolk sac epithelium, areas of yolk degeneration, mineralization, and occasional observation of bacteria in the yolk.

DISCUSSION

Altricial species of birds are helpless at hatch and require a great deal of parenting. In an altricial bird, the yolk sac is relatively small because the parents begin feeding the chick immediately. Precocial birds, such as ratites and waterfowl, have a comparatively large yolk sac.[13] Just a few hours after hatching, the chicks are up, out of the nest, and

Figure 7. The exteriorized yolk sac from Figure 6 showing the vascular and yolk duct connection to the small intestine. These structures were ligated close to the small intestine.

following their parents from whom they gradually learn to eat by imitation. The large yolk sac provides nourishment during the first days of life. The majority of birds at DZG dying with retained yolk sacs were precocial species (ratites and waterfowl). Studies done at another institution in 1960 found that the yolk sac in altricial species ranged from 5 to 10% of total body weight, whereas those of precocial species ranged from 12 to 25%.[12] The yolk sacs from our surgical cases in general exceeded the upper limits of 25% for precocial species. One of our ratites had a yolk sac that was 15% of the total body weight, whereas the others were 27, 31, 37, and 40%. The significance of these large yolk sacs is unclear. We do not know if they are part of the cause or one of the effects of a retained or infected yolk sac.

Altricial species use the yolk faster than do precocial birds. For example, starlings (*Sturnus vulgaris*) will absorb their yolk in 4 days, whereas the ostrich requires 8 or more days.[13] A yolk sac can be palpated in an emu or cassowary for at least 1 wk, but it should have significantly decreased in size by then. If it has not, daily monitoring should begin to determine if the chick is a surgical candidate. The bird should be scheduled for yolk sac removal if clinical signs, palpation, and radiography indicate nonabsorption. When surgery has been performed before the bird became dyspneic, the results have been good.

Percutaneous needle aspiration of yolk sac contents through the abdominal wall, either for diagnostic or therapeutic purposes, should not be attempted. The yolk sac wall has shown a great propensity for leakage of contents into the abdomen in cases where aspiration has been tried, increasing the risk of peritonitis. Likewise, installation of antibiotics by direct injection into the yolk sac

is not recommended. Administration of either oral or parenteral antibiotics has failed to halt the progress of a yolk sac infection once it is established.

CONCLUSIONS

Surgical removal of retained or infected yolk sacs is a relatively simple surgical procedure in chicks of several species. Seven out of 10 chicks survived the procedure. Past experience indicated that these chicks would have died without this surgery. Unabsorbed yolk sacs can be successfully addressed with this technique. As in the poultry industry, the presence of this problem strongly indicates that management practices need to be thoroughly reviewed and highlights the importance of performing necropsies on chicks. Identification of live birds with infected or retained yolk sacs early in the course of the disease, while the chicks are still strong, would likely yield higher postoperative survival rates. Caretakers raising chicks should be trained to recognize the sometimes subtle clinical signs that accompany a retained yolk sac and should promptly notify their veterinarian.

Acknowledgments: We thank Susan Haeffner, Gail Chacon, and Avery Bennett for their assistance in the preparation of this manuscript.

LITERATURE CITED

1. Calnek, B. W. 1991. Diseases of Poultry, 9th ed. Iowa State Univ. Press, Ames, Iowa. Pp. 138–144.

2. Cheville, N., and F. Coignoul. 1984. Calcium in turkey yolk sac during late development and postembryonic involution. Am. J. Vet. Res. 45: 2458–2466.

3. Dinnes, M. R. 1972. Medical aspects of an ostrich breeding program. Int. Zoo Yearb. 12: 223–224.

4. Harrison, G. J., and L. R. Harrison. 1986. Clinical Avian Medicine and Surgery. W. B. Saunders Co., Philadelphia, Pennsylvania. Pp. 634–635.

5. Harry, E. G. 1957. The effect on embryonic and chick mortality of yolk contamination with bacteria from the hen. Vet. Rec. 69: 1433–1440.

6. Hungerford, T. G. 1969. Diseases of Poultry, 4th ed. Argus & Robertson Ltd., London, U.K. Pp. 275–280.

7. Jordan, F. T. W. 1990. Poultry Diseases, 3rd ed. Bailliere Tindall, Philadelphia, Pennsylvania. P. 40.

8. Langenberg, J., and R. J. Montali. 1983. Avian neonatal pathology. Proc. Am. Assoc. Zoo Vet. Pp. 172–175.

9. McLelland, J. 1991. A Color Atlas of Avian Anatomy. W. B. Saunders Co., Philadelphia, Pennsylvania. Pp. 60–61.

10. Peters, L. J. 1989. An overview of the '89 hatch thus far. *In:* The Ostrich News Annual, 2nd ed. Ostrich News, Cache, Oklahoma. Pp. 99–102.

11. Petrak, M. L. 1982. Diseases of Cage and Aviary Birds, 2nd ed. Lea and Febiger, Philadelphia, Pennsylvania. P. 149.

12. Schmidt, G. P., C. H. Domermuth, and L. M. Potter. 1985. Dietary protein and yolk sac inoculation with *Escherichia coli* in young turkeys. Poult. Sci. 64: 1343–1349.

13. Welty, J. C., and L. Baptista. 1988. The Life of Birds, 4th ed. W. B. Saunders Co., New York, New York. Pp. 351–354.

Received for publication 1 September 1991.