Avian reproductive tract diseases and surgical resolutions

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Abstract

Reproductive tract disease is a commonplace in avian practice, particularly among female birds. Unique anatomy and physiology of the avian reproductive tract results in a highly productive but poorly accessible organ system. Affected hens are commonly presented with nonspecific lethargy, coelomic swelling and sometimes laying abnormal eggs. Reproductive diseases are less common in male birds; however, they are well described. Although many reproductive tract diseases can be managed medically, there is a definite need for surgical intervention in some cases. Because of internal location, various disease processes and even normal physiologic processes can dramatically alter patient presentations. For this reason, a clear understanding of avian female anatomy and male reproductive tracts is vital to diagnose and treat disorders. This manuscript focuses on recognition and treatment (emphasizing surgical management) of avian reproductive tract diseases. Because of the unique avian reproductive anatomy and frequent need for surgical correction of disorders, the organization of the manuscript starts with descriptions of coelom and basic surgical principles.

Keywords: Birds, reproductive anatomy, ovarian and oviductal problems, testicular disease, surgical and medical treatments

Introduction

Primarily due to high egg producing hens, reproductive tract diseases are common in pet and even commercial avian practice.[1] With advances in diagnostics and therapeutics available to birds, many reproductive tract diseases can be medically managed. However, several diseases can only be treated surgically. Because of past literature describing procedures such as salpingohysterectomy as 'difficult and risky', many practitioners are rightfully cautious about performing avian reproductive tract surgery.[1] As with diagnostics and therapeutics, anesthetic techniques, instrumentation, pain management, a better understanding of respiratory physiology and surgical techniques have all advanced in avian medicine. Due to medical and surgical progress and public awareness, avian practitioners are being called upon to manage more complex behavioral, medical, and surgical related problems in birds with greater success.[1]

Surgeon's experience and proper instrumentation are vital to minimize tissue trauma, bleeding, and anesthetic time and to improve outcomes. Analgesics should be considered in all surgical cases. Description of anesthetic management, postsurgical care, and analgesics are beyond the scope of this manuscript and are adequately described.

Coelomic anatomy of birds

Because of avian reproductive tracts' location, a basic understanding of the coelom is beneficial.[2,3] Coelom refers to the primordial body cavity lined by mesoderm and formed by fusion of lateral body folds early in embryonic development. Within the coelomic cavity are individual and unique compartments, each lined by mesothelium and capable of producing serosal fluid. 'Lower' reptile species have 2 cavities (pericardial and pleuroperitoneal) and more highly developed reptiles have 3 (pericardial, pleural, and peritoneal), whereas birds have 8 distinct coelomic cavities. Interrelationship of these cavities with the respiratory tract is complex.

Eight coelomic cavities of birds include, 1 pericardial and 1 intestinal peritoneal cavity (IPC), 2 pleural cavities, and 4 hepatic peritoneal cavities. All visceral organs except right and left liver lobes are contained within IPC.

Pericardial cavity is situated ventrally on the midline, just dorsal to sternum and is restrained by fibrous attachments to surrounding structures, most notably sternum. Apex of the sac is intimately associated with and positioned between 2 liver lobes.

Parietal pleura surrounding each lung and mesothelial coating of visceral pleura applied to the lung itself form a small, potential pleural cavity due to fixed dimensions of avian lung in most species. Parietal and visceral pleura develop fibrous cross connections starting along lung's ventromedial surface.[2]

Birds have 5 distinct peritoneal cavities. Four hepatic peritoneal cavities (HPC) surround right and left liver lobes. A single, midline IPC contains most of the gastrointestinal tract, gall bladder (if present), reproductive tract, and spleen.

Hepatic peritoneal cavities are composed of 2 paired structures, larger left and right ventral hepatic peritoneal cavities, and much smaller right and left dorsal hepatic peritoneal cavities. HPCs are divided on the midline into right and left entities by the ventral mesentery. In chicken, left dorsal hepatic peritoneal cavity communicates with intestinal peritoneal cavity via a small opening that is covered on the IPC side only by abdominal air sacs.

A single IPC is centrally located in mid to caudal coelom and contains proventriculus, ventriculus, gall bladder (if present), spleen, intestines, and male or female reproductive tracts. The only coelomic cavity containing air sacs (left and right abdominal) is IPC. A ventral midline incision made caudal to the ventriculus leads directly and specifically into IPC, not into 'coelom' or 'coelomic cavity', and not into respiratory tract.

Right and left subpulmonary cavities (air sacs) are structures unique to birds and strictly speaking, are not true coelomic cavities as they are not lined by mesothelium. Their intimate relationships with coelomic cavities, however, require understanding for the purposes of surgical intervention. Subpulmonary cavities predominately include air sac system of birds; cervicocephalic, clavicular, cranial thoracic, and caudal thoracic air sacs.

Surgical principles and patient preparation

For coeliotomy, the patient is usually placed in lateral or dorsal recumbency. Birds have a very thin epidermis that is diffusely supplied by capillaries in the dermis, unlike what is observed in mammals. There is less subcutaneous tissue, and dermis is firmly attached to the underlying muscle fascia. Compared to mammals, most blood vessels are comparatively less protected by surrounding tissues, leaving more potential for hemorrhage. Body contour feathers are easily plucked in the direction of their growth once the patient is anesthetized. Some species of bird may have particularly thin skin, predisposing them to iatrogenic tears when feathers are plucked. Water soluble gel or masking tape may be used to keep down and contour feathers under control. Surgical preparation of the skin is performed with betadine, chlorhexidine, and/or isopropyl alcohol. Patient preparation with excessive amounts of saline or alcohol can predispose the patient to hypothermia. Draping the patient as quickly as possible with clear plastic drapes helps to retain heat better than using cloth drapes. Clear, transparent plastic drapes also allow respiration to be monitored during the procedure. Supplemental heat (warm water bottles, circulating warm water blankets, heat lamps, and forced warm air) should be provided to the patient.

Surgical instruments

Magnification is a common and important component of many coelomic procedures, viewing the frequent small patient size and resultant needs for fine instrumentation and microsurgical skills. Magnification makes hand tremors more apparent, and necessitates slow, deliberate motions for greatest efficiency. This in turn can result in a slower surgical pace for the procedure(s) that may require increased detail to anesthesia protocols and patient support methods used during the procedure. Although magnification greatly adds to visualization of the direct surgical field, it limits surgeon's ability to visualize peripheral fields. This makes an assistant necessary when utilizing the operating microscope, and helpful when utilizing magnifying loupes.

Fine and delicate instruments are essential for avian surgery. Gauze pads (2 x 2) can be cut from standard 4 x 4 sponges or can be specifically purchased. A basic surgery pack should contain a long jeweler's forceps with fine delicate tip but flat handles, round handled microsurgical forceps, a Castroviejo pen needle holder of at least 5.25 inch length, with fine jaws and rounded handles, and a spring-loaded microsurgical scissors of at least 7 inches with rounded handles. Sterile cotton tipped applicators should also be available for point hemostasis and blunt tissue retraction. Hemostatic clips are also useful and come in a variety of sizes. Right angled appliers are also available for special applications in deep cavities. Heiss blunt retractors, Alm retractors and Ring retractors are suitable for use in medium to smaller species.[4]

Halsted's principles of surgery should be followed when performing surgery in any species. These principles are itemized below:

Gentle handling of tissue
Meticulous hemostasis
Preservation of blood supply
Strict aseptic technique
Minimum tension on tissues
Accurate tissue apposition
Obliteration of dead space

Surgical approaches to coelomic cavities

Approaches commonly made include a ventral midline approach, a midline-L approach, a midline-T approach, and left and right lateral approaches that may or may not include L flaps. Modifications of these basic approaches also can be used, depending on the patient and desired exposure of surgical site. These surgical approaches generally require the bird to be in dorsal or lateral recumbency. If ascites or substantial organomegaly is present, elevating the proximal half of the body may help reduce pressure on heart, lungs, and more cranial air sacs, improving ventilation.

To specifically enter the IPC directly from the body wall without penetrating an air sac, use 1 of 2 approaches. A midline, paramedian or transverse incision in the ventral body wall will enter the IPC when made caudal to posthepatic septum end and medial to distal limits of caudal thoracic and abdominal air sacs. The other site for direct entry from the body wall to IPC is the left or right postischial approach. A small skin incision dorsal to pubis and just caudal to ischium allows a blunt puncture through the thin body wall dorsolateral to coprodeum.[2,3]

Female reproductive tract diseases

Understanding the avian female reproductive tract anatomy, especially, its blood supply and drainage, is vital to proper diagnosis and treatment (especially surgery). During sexual and egg laying activity, blood supply to ovary and oviduct can be substantial. Due to potential vascularity, being mindful of local blood supply and minimizing bleeding can often determine the outcome. Focus will be given to basic structure and vasculature of ovary and oviduct. If possible, the following surgeries should be performed when the female is reproductively inactive as blood supply is often reduced.

Ovarian anatomy

A right and left ovary and oviduct are present in the embryologic stages of all chicks, but the right half regresses due to Müllerian inhibiting substance action prior to hatch. Although a persistent right oviduct with or without a functional right ovary is present in some birds, most birds only have a left female reproductive system. Brown kiwi is an exception and normally has a functional left and right ovary. Interestingly, in chicken about 480,000 oocytes develop by hatching. Of these, ~ 2,000 are visible as a mass of small ova and only 250 - 500 reach maturity and ovulate within the lifespan of domestic species and even fewer mature in wild species.[1] Ovarian follicles are arranged hierarchically. Largest follicle (F1) will ovulate on the next day, second largest (F2) on the following day, and so on.

Ovary is attached to the cranial renal division and dorsal body wall by the mesovarian ligament and receives its blood supply from ovarian artery that originates off the left cranial renal artery or directly off the aorta. Accessory ovarian arteries may also arise from other adjacent arteries. Ovarian artery further divides into many branches with the greatest blood flow directed to any large preovulatory follicles present. Ovarian veins unite into main anterior and posterior veins that drain into the overlying vena cava. Multiple left ovarian veins may exist and drain into the cranial oviductal vein that enter the common iliac vein and finally into the caudal vena cava.[5] In first author's experience, the cranial oviductal vein is too short or poorly developed to recognize grossly. Instead, multiple short veins seem to enter the common iliac vein over the length of its contact with the dorsum (base) of the ovary.

Ovarian diseases

Cystic ovarian disease

Although the cause is often unknown, cystic ovarian disease has been reported in several bird species. Cystic ovaries are sometimes secondary to neoplasia. Depending on their size ovarian cysts can be observed incidentally; small ovarian cysts can cause none to mild coelomic distension whereas large and/or numerous cysts can be associated with readily identifiable ascites. Many cysts are large and can often be diagnosed noninvasively using ultrasonography, CT, and/or MRI. Cysts can be treated by ultrasonography guided transabdominal aspiration or more directly via celiotomy or endoscopy. If collected, evaluate the fluid for evidence of infection or other abnormalities. Severe cystic disease may require partial or complete ovariectomy and should include biopsy for histopathological evaluation. Leuprolide acetate has also been suggested to reduce or resolve ovarian cysts in birds and may offer a noninvasive treatment option.[1] Use of desorelin (a GnRH agonist) has also been recommended anecdotally.[6] It is important to note that no peer reviewed publications have documented the benefit of using either leuprolide acetate or deslorelin to treat ovarian cysts in birds. In authors' experience, aspiration or physical removal is the only means to remove ovarian cysts, if clinically indicated.

Oophoritis

Ovarian infections can be life-threatening and are often associated with septicemia. *Salmonella pullorum* is the etiologic agent of pullorum disease of poultry and most frequently affects ovary.[1] Clinically affected birds usually have more severe, albeit general signs of illness and if not treated quickly, peritonitis and death may result. Irregular follicular shapes and sizes noted on ultrasonography, MRI or CT may be related to infectious oophoritis or neoplastic disease. Abnormally shaped, colored or partially ruptured follicles identified during celiotomy or endoscopy should be carefully aspirated for cytological and microbiological analysis and patients treated with broad-spectrum antibiotics, initiated pending culture results. Storz injection needle with Teflon guide (Karl Storz Veterinary Endoscopy America, Goleta, CA) is particularly useful as an endoscopic means to aspirate ovarian follicles. If possible, completely drain the abscessed follicle(s), being careful not to contaminate coelom. Partial or complete ovariectomy may be required for chronically infected and caseated follicles.

Neoplasia of ovary and oviduct

Ovarian neoplasia is reported with some frequency in birds and can be associated with egg retention, ascites, cystic ovarian disease, medullary hyperostosis, coelomic hernias, oviductal impaction, and general malaise. Thirty eight percent of USDA inspection service mature fowl condemnation is the result of neoplastic disease, with most from the genital tract; 'there is indeed a unique propensity for hens (poultry) to develop cancer of the reproductive system in the almost total absence of tumors at other sites'.[7] Granulosa cell tumors and ovarian adenocarcinomas are most frequently reported but carcinomas, leiomyosarcomas/leiomyomas, adenomas, teratomas, dysgerminomas, fibrosarcomas, lipomas, and lymphomatosis have all been identified in bird ovaries. Oviductal tumors are less common than ovarian neoplasia and include adenocarcinomas/adenomas, adenomatous hyperplasia, carcinoma, and carcinomatosis.[1]

Granulosa cell tumors and possibly other reproductive tract neoplasms may be functional and cause increased plasma hormone concentrations. Granulosa cell tumors are common in older female budgerigars (*Melopsittacus undulatus*) and may be functional resulting in hyperestrogenism.[8] Polyostotic (medullary) hyperostosis may also result as a paraneoplastic syndrome with functional ovarian and oviductal neoplasms. Interestingly, hyperestrogenism did not cause polyostotic hyperostosis in several species of birds with various neoplastic and nonneoplastic reproductive tract diseases.[9]

Clinical signs vary and are nonspecific for most reproductive tract diseases and include coelomic swelling, dyspnea, ascites, poor or altered reproductive performance and lethargy. If the mass compresses the overlying lumbar or sacral nerve plexuses, lameness (usually left sided) may be observed. Diagnosis can be further supported using radiography, ultrasonography, MRI, CT, exploratory celiotomy, endoscopy, and biopsy. Once a definitive diagnosis is made, options for therapy include chemotherapy, radiation therapy, and partial or complete ovariectomy, but all carry a guarded prognosis if the neoplastic tissue cannot be completely removed.

Ovarian surgery

Partial and 'complete' ovariectomy

Ovariectomy in hens is a challenging and oftentimes high-risk procedure. Ovariectomy has been used in many poultry studies and this procedure is mentioned throughout literature. Unfortunately, most papers poorly describe specific details of ovariectomy or its complications. To cite a few examples; it was stated that ovariectomized birds 'lost considerably more blood than sham-operated hens'.[10] Incompletely ovariectomized turkeys (number not provided) were excluded.[11] Ovariectomy has also been described by 'destroying ovarian tissue by local application of small pieces of dry ice.'[12]

Although it has been stated that the short stalk of cranial renal artery is what makes ovariectomy difficult, first author suggested that the intimate and lengthy attachment to the overlying common iliac vein is what makes this procedure risky.[1] As discussed, multiple small veins often connect directly into the common iliac vein. It is often venous, and not arterial, bleeding from a lacerated common iliac vein that usually causes life-threatening hemorrhage during ovariectomy. As with oviduct, ovary can dramatically change in size and vascularity with sexual and egg laying activity. As a result, every attempt should be made to medically or behaviorally downregulate bird's reproductive activity to reduce vascularity to ovary. Oftentimes, diseases requiring ovariectomy do not allow attending clinician's time to 'condition' the avian patient prior to surgery.

Ovariectomy should be reserved for ovarian diseases such as cancer, chronic recurring cysts, persistent follicular activity, oophoritis and other diseases that cannot be managed medically and are life-threatening without further treatment. Whereas some birds such as cockatiels appear to stop ovulating after the salpingohysterectomy, other species such as ducks may continue chronic and possibly life-threatening ovulation necessitating hormonal therapy or ovariectomy.[13] Behavioral and/or medical management, discussed elsewhere in literature, is necessary after a partial ovariectomy, to prevent internal or ectopic ovulation.

A cranial left lateral celiotomy often provides the best left ovary exposure. Clean the surgical field of fluid and debris to best visualize the ovary and its vasculature. Surrounding organs may need to be gently retracted using moistened cotton-tip applicators or other nontraumatic instruments. A ventral midline, singly or combined with a transverse approach, can also be used to reach the ovary from a caudal approach.

First step to ovariectomy is to debulk its mass, regardless of size, in order to visualize the ovarian attachment to the overlying common iliac vein and any other vessels. If the ovary is inactive or juvenile, little debulking is needed. If present, remove large preovulatory follicles by twirling as discussed below. Aspirate and drain any cystic follicles present, being careful not to spill contents into the coelomic cavity, especially if there is concern of oophoritis. When aspirating follicles, guide a small gauge (23 - 25) butterfly catheter needle into the most visibly avascular portion to reduce hemorrhage and have an assistant provide distant suction. Using this aspiration technique, a substantial amount of an active and/or cystic ovary can be debulked. Blood filled follicles may represent previously ruptured blood vessels from an invasive mass and warrants caution when attempting debulking.

Alternatively, large ovarian follicles can be twirled using cotton tip applicators. Use the cotton tip applicators to rotate the follicle in 1 direction continuously until it separates from its pedicle. This may require 15 - 30 full rotations until the follicle is free. Once free, simply remove the follicle.

Once the fluid component is minimized, progressively clamp or hemostatically clip the ovarian mass closer to its base. When used properly, angled DeBakey neonatal vascular clamps are atraumatic, will rest in the surgical site without obstructing view and seem to provide some hemostasis to the ovarian mass. Once a section of the mass is hemostatically clipped or clamped, surgically excise or cauterize and remove the ventral-most ovarian segment. Reassess the mass and move the clamp (or place new hemostatic clips) closer to the base and repeat the excision process. This process is repeated until the overlying vasculature is clearly identified, and the course of the common iliac vein is observed.

Once the mass has been debulked, several options exist for complete or partial ovariectomy. An electrocautery ball electrode was used effectively to coagulate ovarian follicles in immature females.[14] Similar procedure resulted in ovarian regeneration and subsequent ovulatory activity in mature hens. Some juvenile bird ovaries were gently 'peeled' in toto from caudal to cranial off its dorsal attachments with no or minimal bleeding.[6] In these cases, ovarian caudal end is grasped with angled hemostats and pulled in a cranial direction with a clear separation, and minimal effort, from the dorsally located common iliac vein. If attempting this procedure, stop if any resistance is noted to prevent tearing the overlying vein.

Another technique with juvenile or sufficiently debulked ovaries is to place hemoclips in the potential space between the ovarian base and the common iliac vein. Gently lift the ovarian caudal pole and place a small to medium hemostatic clip from caudal to cranial across the ovarian vascular supply. Although difficult without good exposure, a last hemostatic clip can be placed from cranial to caudal in the same manner in an attempt to ligate the more cranially located ovarian artery. With the blood supply adequately clamped, the ovary can be gently shaved off with precise radiosurgery using an Ellman B 'loop' series or blade electrode (Ellman International, Inc., New York, NY) or left to die without a blood supply. First author has successfully performed ovariectomies in adult hens using this technique. Obvious complications include hemorrhage when trying to remove the hemostatically clipped ovary and inadequate, blind, placement of the hemostatic clips. Second author has used another approach when the ovarian attachment to the overlying common iliac vein is too long to hemoclip or there is erosion into the overlying vessel and the entire ovary must be removed for the bird's survival (as with otherwise untreatable cancer).[6] Debulk the ovarian mass as described above. Once clearly identified, hemostatically clip the common iliac vein just caudal to the ovary and cranial to its junction with caudal renal vein. Next, hemostatically clip the common iliac vein just cranial to the ovary and caudal to its junction with caudal vena cava. If performed properly, the ovarian artery and common iliac veins are effectively clamped, allowing one to carefully dissect the entire ovary from the overlying vessel(s). If needed, the ventral wall of the common iliac vessel can be safely removed. There is the real potential of damaging left adrenal gland, substantially altering blood flow through the renal portal system and the cranial renal division and causing physical damage to overlying kidney and lumbar and/or sacral nerve plexus(es).

None of the above described ovariectomy procedures have been satisfactorily studied in pet bird species and each carries a marked risk to patient. With each procedure, closure is routine. More often, a partial ovariectomy is performed and only the abnormal ovarian tissue is removed.

Oviductal anatomy

Oviduct, or salpinx, develops from the left Müllerian duct and can be divided into 5 regions.[15] Cranial most region is the infundibulum (site of fertilization) that engulfs the ovulated ovum. Next, ovum moves into the largest region, the magnum. Magnum produces albumin that surrounds the developing egg. As the ovum progresses caudally it enters the isthmus where the inner and outer shell membranes are formed. Egg is 'plumped' with water and solutes, calcified to form a shell and pigments are deposited during its prolonged stay in the shell gland or 'uterus'. Shell gland transfers the complete egg through the uterovaginal sphincter and into vagina. Uterovaginal area contains sperm storage tubules allowing many species to store viable sperm for prolonged periods (> 21 days in turkey hens).[15] Vagina terminates at cloaca and coordinates with shell gland to ultimately expel egg.

Oviduct is suspended within the coelomic cavity via a dorsal and ventral ligament.[15,16] Cranial, middle, and caudal oviductal arteries running in the dorsal mesentery, supply blood to oviduct. Origins of each vessel vary between species, but some generalization can be made.[16] Cranial oviductal artery arises from the left cranial renal artery, aorta, or external iliac artery. Middle oviductal artery arises from the left ischiatic artery or its branch, the medial renal artery. Finally, the caudal oviductal artery arises from the left internal iliac artery or the pudendal artery. Veins draining the cranial oviduct empty into caudal vena cava (via common iliac vein), whereas those draining the caudal oviduct enter the renal portal or hepatic systems.

Oviductal diseases

Congenital defects

Congenital defects have been identified in birds and include large cysts on a rudimentary oviduct of a budgerigar and discontinuous or atretic oviducts in domestic fowl. Persistence of right ovary and/or oviduct has been reported in numerous species.[1] First author has observed an association between the presence of right oviducts and nonspecific reproductive tract problems in hens (e.g. cystic ovarian follicles, and excessive egg laying). Cystic dilatation is common with persistent right oviducts in poultry species. Each defect should be evaluated on a case-by-case basis and may require surgical modification or removal based on associated clinical signs.

Ectopic ovulation, ectopic eggs, and egg yolk peritonitis

Ectopic ovulation occurs when infundibulum fails to engulf an ovum or fails to retain ovum because of oviductal rupture or reverse peristalsis. Ectopic ovum is not well developed. Potential causes include infundibulum failure from oviductal fat, trauma or disease, exuberant reverse peristalsis, and oviductal disease. Ectopic ovulation occurs frequently and has been reported in 28.6% of necropsied birds from 9 orders.[17] Authors have also observed ectopic ovulation associated with a persistent right oviduct in several avian species. Ectopic ovulation usually results in mild, self-resolving, sterile yolk coelomitis and usually requires no or minimal supportive therapy (fluid therapy, anti-inflammatories, and others).

Partially and completely shelled ectopic eggs result when a developing egg enters the ceolomic cavity through an oviductal rupture or via reverse peristalsis from oviductal or even cloacal disease. Anything affecting the oviduct function such as cloacal or oviductal masses (including egg binding, impactions, and neoplasia), salpingitis, cystic hyperplasia, and oddly shaped or large eggs can result in ectopic eggs. A large ectopic egg can cause a penguin-like stance and is often associated with ascites and varying degrees of depression in many birds. Diagnosis can often be suspected using radiography, ultrasonography, MRI, CT, and sometimes endoscopy (depending on how much debris is in the coelom); however, celiotomy is often required for definitive diagnosis. Ectopic eggs should always be considered when conservative therapy for egg binding fails. Partially and fully formed ectopic eggs should be surgically removed after stabilizing the patient and determining underlying cause(s).

Severe sterile and life-threatening septic egg yolk peritonitis may also result from ectopic ovulation or eggs. Acute egg yolk peritonitis may result in marked depression, anorexia, and ascites and rarely, respiratory distress and death. Secondary diseases resulting from sterile and septic yolk peritonitis include pancreatitis, splenitis, yolk-thromboembolic' disease, hepatitis, nephritis, and coelomic adhesions. Septic yolk peritonitis may obviously result in or from septicemia and has been most noted with coliforms such as *Escherichia coli*, *Yersinia pseudo-*

tuberculosis and *Staphylococcus* spp.[18] Coelomocentesis and cytologic fluid analysis and culture are used to definitively diagnose yolk peritonitis. If needed, celiotomy and endoscopy can be used to assess the associated internal pathology. Severe egg yolk peritonitis, especially when associated with bacteria, includes aggressive supportive care, antimicrobials, identifying and resolving causative factors if possible and occasionally may require surgical removal, irrigation of the caudal coelomic cavity and placing a drain tube. If irrigation is used, be careful to prevent fluid from entering the respiratory system.

Egg binding and dystocia

Egg binding, dystocia and other reproductive tract diseases (e.g. egg yolk peritonitis and cystic ovary) are common problems in pet bird medicine. Oviposition is the expulsion of egg from the oviduct and is conducted by vigorous contraction of the uterine muscles and peristalsis of the vagina. Egg binding is simply defined as prolonged oviposition (egg is arrested in oviduct longer than normal for the given species) whereas dystocia implies the developing egg is within the distal oviduct either obstructing the cloaca or prolapsed through the oviduct-cloacal opening. Dystocia is often more advanced than egg binding alone, has many potential causes and is commonly associated with functional (malformed eggs, cloacal masses, and obesity), metabolic (calcium imbalance and nutritional deficiencies), environmental (temperature changes, lack of exercise and other stressors) and hereditary diseases.

Captive conditions (readily available food, water, light, appropriate temperature, and frequently a constant mate) tend to promote reproductive activity in pet birds. As a result, excessive egg laying, prolonged broody behavior and reproductive tract disease are common, especially, in smaller birds such as cockatiels and budgerigars. Secondary complications of excessive egg laying include egg binding, dystocia, egg yolk peritonitis, acquired metabolic bone disease, pathologic fractures, prolapsed cloaca and oviduct, and salpingitis. Additionally, some of these 'over productive' hens are on a poor diet, are nutritionally depleted and have other underlying diseases complicating their reproductive problem.

Several options are available for treatment of eggbound birds. Most birds can produce a shelled egg from a follicle in < 24 hours. Although knowledge of individual species is important, most birds that have an egg present for > 24 hours are considered 'egg bound'. Eggs place pressure on surrounding organs, especially the kidneys, and can cause progressive problems the longer egg binding continues. Smaller the bird, the more serious egg binding becomes. Stable birds can often be managed conservatively (pain management, fluid therapy, supplemental heat, nutritional and hormonal support, and others) to help the patient deliver the bound egg.

If needed, the egg can be manually manipulated or crushed to facilitate removal. Following techniques should only be considered if more conservative therapy fails, or pressure must be relieved immediately. Due to the potential for substantial tissue damage, antibiotics are often indicated. One can gently push the egg toward the cloaca and (hopefully) out. Prelubricate the cloaca with a water-soluble lubricant (H-R Lubricant, Carter Products, New York, NY) to facilitate the egg's removal. Another option is to aspirate the egg's contents (pass an 18 - 20 gauge needle through the cloaca if the egg is visualized, and aspirate) and then crush the egg with digital pressure. If no adhesions or oviductal torsion, masses or tear(s) are present, the bird will oftentimes pass the crushed egg within 24 hours. Aspirating the egg through the coelomic wall results in minimal to severe (laceration) trauma to the oviduct and is not recommended. Salpingohysterectomy is needed in otherwise nonresponsive cases.

Once egg binding has been resolved, every attempt should be made to downregulate the bird's reproductive system. Simple methods include removing the mate, nest box(es) or favorite toy(s) when present, changing the diet (usually improving quality), decreasing the photoperiod to a maximum of 10 - 12 hours a day, modifying the cage setup and toys and in general, altering the bird's normal daily activities. GnRH agonists (leuprolide acetate and deslorelin) may also be beneficial. The intent herein is to limit environmental influences on reproductive activity and stop the bird's desire to breed.

As supported in domestic fowl, once incubation behavior is established, the ovarian hormones are not required for maintenance or the readiness to brood day-old chicks.[19] This implies that drugs intended to decrease production of ovarian hormones, such as leuprolide acetate, alone may not be sufficient to stop a bird's reproductive behaviors. This further supports the need for environmental, dietary, and other behavioral modifications with leuprolide acetate use to decrease reproductive activity in birds.

Oviductal cystic hyperplasia

Cystic oviductal hyperplasia or dilatation has been reported in budgerigars, other psittacines and poultry.[1] Although little etiologic information is forwarded, cysts may occur secondary to improper formation of the oviduct. Affected oviducts are often thickened with white to beige masses and distended with brown or white mucoid fluid. Affected birds may show no signs (and the oviductal hyperplasia is discovered incidentally) or signs typical of reproductive tract disease. Antimicrobials may be tried if organisms are recovered from aspirated samples, otherwise salpingohysterectomy is indicated.

Oviductal impaction

An impacted oviduct is usually distended and simply contains caseated material and misshapen, ruptured, soft-shelled, partially, or fully formed eggs. Potential causes include excess mucin and albumin secretion secondary to inspissated egg material and cystic hyperplasia. Salpingitis is often found concomitantly, especially in older birds. Metritis, salpingitis, egg binding, dystocia and neoplasia commonly precede oviductal impactions.

Typical of most reproductive tract diseases, vague clinical signs with or without coelomic swelling and ascites are common with oviductal impaction. Some birds may show persistent 'broodiness' with recent cessation of egg laying. Oviductal impactions have been reported in budgerigars, cockatiels, canaries, African grey parrots (*Psittacus erithacus*) and poultry.[1] Definitive diagnosis is made at celiotomy or sometimes via ultrasonography, MRI, CT, and endoscopy with aspiration of the oviductal contents. Chronic oviductal impactions may be observed incidentally during exploratory celiotomy and are often associated with a history of sudden cessation of egg laying several months or years prior to presentation. Acute impactions may be treated by salpingotomy, culture and appropriate antibiotic use and oviductal flushing, whereas severe or chronic disease are best treated with salpingohysterectomy.

Oviductal prolapse

Powerful coelomic contractions combined with the process of oviposition can result in oviductal prolapse which is often secondary to dystocia. Predisposing factors may include large or abnormally shaped eggs, malnutrition, general debilitation and systemic illness, disease of the oviduct and sometimes, normal egg laying. In turkeys selected for high meat yield, decreased vaginal collagen has been associated with uterine prolapse.[1] Uterus is most commonly prolapsed; however, vagina and other portions of oviduct may also prolapse. Cloacal prolapsed tissue, if present, should be distinguished from the oviductal prolapse.

Because the exposed tissue can rapidly become devitalized and infected, aggressive treatment with warm saline flushes, antibiotics and replacement of the prolapsed oviduct is warranted. If the prolapsed oviduct is edematous, topical dextrose, dimethyl sulfoxide (DMSO) and/or steroids may be needed to reduce the swelling. If an egg is present in the prolapsed or coelomic oviductal tissue, ovocentesis and digital crushing is often needed to reduce associated pressure and aid in egg-shell removal. After stabilizing the bird, remove the egg medically if possible and replace the prolapsed tissue. Two transcloacal sutures may be required to prevent the immediate recurrence of prolapsed tissue.

Surgical removal is indicated when the oviduct is necrotic and/or the egg (or its fragmented shell) cannot be removed medically or pass on its own. If an oviductal torsion is present caudal to egg (within the oviduct), attempting to force deliver the egg will often result in further damage. Oviductal torsion, neoplasia, adhesions, and other anatomic disorders should be considered if a bound egg cannot be delivered without forceful techniques and surgical options should be pursued.

Oviductal torsion

Oviductal torsion has been reported infrequently as a cause of egg binding. Oviductal torsion may occur after a tear of the dorsal, and possibly ventral, oviductal ligament(s). In 4 reported cases, all birds presented with signs of egg binding and/or general lethargy and had a history of previously laying 'many eggs' prior to the oviductal torsion.[20] A cockatiel presented thin with lethargy, depression and coelomic distension, and died despite emergency therapy. Of the 3 birds presented live, 2 cockatiels were treated with salpingohysterectomy and 1 eclectus parrot (*Eclectus roratus vosmaeri*) was treated with a hysterotomy (salpingotomy), egg removal, torsion correction, and subsequent closure of the oviductal ligament tear. All birds recovered uneventfully from surgery. Eclectus parrot successfully laid normal clutches after surgery.

Salpingitis and metritis

Salpingitis, inflammation of the oviduct or salpinx, is common in birds. In poultry, salpingitis has been listed as the most prevalent form of reproductive tract disease. *E. coli* infections are common in poultry and can cause salpingitis, but *Streptococcus* spp., *Mycoplasma gallisepticum*, *Acinetobacter* spp., *Corynebacterium* spp., *Salmonella* spp., and *Pasteurella multocida* have all been implicated from various species.[1] Some ground-nesting species, such as Anseriformes and emus, may develop nonlactose fermenting, gram negative (*Pseudomonas aeruginosa*, *Proteus mirabilis*, *P. vulgaris*) salpingitis. Noninfectious salpingitis can also occur, especially with chronic, sterile oviductal impactions. Metritis is inflammation within the uterine portion of the oviduct and may result from or cause egg binding, chronic oviductal impaction and rupture, coelomitis, and septicemia. *Prosthogonimus ovatus* and other related trematodes (flukes) can inhabit the oviduct of Anseriformes and Galliformes and result in salpingitis with heavy infestations. Other infectious agents ascending from the vagina or cloaca or descending from air sacculitis, pneumonia and septicemia can also cause salpingitis. Specifically, in poultry, vent cannibalism has been implicated as a precursor to salpingitis.

Birds with nonseptic salpingitis or metritis often have vague signs of illness, whereas septic birds are usually clinically very ill. A distinctive feature is that egg-shell deformities and embryonic and neonatal infections are often secondary to metritis. Presumptive diagnosis may be made with ultrasonography, MRI, CT, and occasionally with endoscopy. Definitive diagnosis is made during celiotomy or endoscopy with aspiration of oviductal fluid for cytologic and microbiologic analysis or if the oviduct has no liquid contents, biopsy with culture. Base antibiotic use on culture and sensitivity results. If trying to spare the oviduct, repeated endoscopic evaluation, direct and indirect oviductal flushing, and long-term antimicrobials are recommended. Salpingohysterectomy is indicated for severe cases or those nonresponsive to appropriate antimicrobials.

Oviductal surgery

Salpingohysterectomy

Salpingohysterectomy, is the surgical removal of oviduct, from infundibulum to uterus, and is indicated for chronic egg laying and any oviduct disease that cannot be medically managed and is reported as the 'therapy of choice for overproduction of eggs.'[1] Every attempt should be made to understand the bird's overall health status prior to surgery, as the patient should ideally be stable. Birds with septic yolk-peritonitis generally carry a poor prognosis. Patients with underlying health problems such as various lung, liver, and kidney diseases, can also complicate surgery. Otherwise, healthy salpingohysterectomy candidates typically do well and surgery is often straightforward especially when the oviduct is small and inactive. Oviductal hypertrophy occurs secondary to elevated estrogen concentrations during sexual activity and can take up most of the left side of the IPC. This oviductal hypertrophy includes increased vascularity and risk of bleeding during surgery. If the patient is stable, time permits, and increased reproductive tract vascularity is suspected, the authors will 'condition' the bird prior to surgery. 'Conditioning' includes improving nutritional status (if necessary) and attempting to downregulate the bird's sexual cycle as discussed under 'egg binding and dystocia'. This process may take weeks to months and often results in decreased vascularity and lower patient morbidity.

In first author's experience, a left lateral approach offers the best exposure to the left ovary and oviduct, however a ventral midline approach can also be used and is best for overall reproductive tract evaluation.

Perform a left lateral celiotomy. After incising through the left abdominal air sac, ovary and oviduct are readily visible. Gently retract the cranial oviduct (infundibulum area) out the incision and hemostatic clip or cauterize suspensory ligament vessels as needed. Closer the bird is to laying, the larger the vessels present. Depending on the size, the cranial, middle and/or caudal oviductal artery(ies) may need to be hemoclipped or cauterized. Once visualized, hemoclip the base of the oviduct just proximal to its junction with the cloaca. Excise the oviduct.

Well-developed preovulatory follicles (F1 and F2 +/- F3, and F4) may pose a risk for intra-coelomic ovulation and can usually be easily removed as described for 'ovarian surgery.' If the follicle has a well-developed vascular pedicle, use hemoclips and then excise the follicle or twirl the follicle. Domestic chickens have a pause in laying that increased with the number of follicles removed compared to sham operated hens.[21]

Cystic follicles should either be aspirated (drained) or removed. Whereas normal follicles have a yellow appearance and are filled with thick yolk, cystic follicles are pale to translucent and generally contain clear watery fluid. If the follicle is accidentally incised, yolk will leak into the coelom. Simply 'mop up' excess yolk and other fluid if present. Collect culture and samples for histopathologic evaluation as needed.

An endoscopic approach to salpingohysterectomy of juvenile cockatiels has been described.[22] A left lateral coelomic endoscopic approach (left leg pulled caudally) was performed on juvenile (3 - 11 months) cockatiels. Once visualized, the supporting ligament of the infundibulum was carefully pulled laterally toward the coelomic entry site using flexible endoscopic grasping forceps (Karl Storz Veterinary Endoscopy, Inc., Goleta, CA). This action broke down the supporting structures (ventral and dorsal suspensory ligaments of the cranial oviduct and uterus) and separated the salpinx (oviduct) from the overlying kidney, caudal vena cava and left ureter. Next, a cotton-tipped applicator was placed in the cloaca and was used to better visualize the uterus-cloacal junction and ensure the salpinx was 'peeled' from the surrounding tissues. Salpinx was exteriorized and then crushed and cut with microsurgical forceps and scissors, respectively, at the point of exit from the coelomic cavity, just cranial to the uterovaginal sphincter. Endoscope was replaced to check for hemorrhage and closure was routine.

Endoscopic salpingohysterectomy has several distinct benefits and limitations. As indicated,[22] this procedure was acceptable in juvenile birds due to a poorly developed blood supply of the oviduct and that if attempted in mature, egg-producing cockatiels, may result in fatal hemorrhage. Additionally, this procedure required an endoscope and 2 surgeons. Although the endoscopic surgery was limited to young birds, there was minimal hemorrhage and could be performed safely and quickly (estimated to take < 10 minutes with experience) and offers an option for juvenile salpingohysterectomy.[22]

Caesarian section and reproductive tract sparing

Caesarian section is indicated when the bird's reproductive capabilities need to be spared and is typically limited to egg binding with an otherwise normal, or minimally diseased oviduct. Depending on the location of the egg, a caudal left lateral or ventral midline approach is used. Oviduct should be incised directly over the bound egg and away from prominent blood vessels. After removing the egg, inspect the oviduct for other abnormalities and collect biopsies and cultures as needed. Close the oviduct in a single simple interrupted or continuous layer using fine (4 - 0 or smaller) absorbable suture material. Coelomic closure is standard. Authors recommend resting the hen from reproductive stimuli for 2 - 4 weeks or longer as dictated by culture and/or histopathologic results.

Male reproductive tract diseases

Compared to females, male reproductive diseases are less frequently reported; however, they are well described. A clear understanding of the anatomy is essential to make a diagnosis and to properly treat conditions identified. Medical and surgical management of male reproductive tract diseases, caponization, and vasectomy are described.

Testicular anatomy

Reproductive anatomy of most male birds consists of 3 main gross structures: testes, epididymis, and ductus deferens. Some birds also possess a phallus. Paired testes are located ventral to their respective left or right cranial renal division. Mesorchium connects the testes to the dorsal body wall. Left testis is typically larger than the right in most young birds, but this relationship can change as the bird ages. In seasonal breeders, such as some passerines, testes can increase 300 - 500 times in size and should not be interpreted as neoplasia. Large active testes can also be readily evident radiographically. In addition to size, the color of the testes can also change with fluctuating hormone concentrations ranging from black in the sexually immature or inactive cockatoos to white or yellow in the chicken.[1] Epididymis is located at the testicular hilus, or dorsomedial aspect of testis. Ductus deferens continue from epididymis as highly convoluted tubes running lateral to and alongside the ureters and then terminate at the urodeum as a papillae ventral to ureteral ostium.

Testicular artery arises from the cranial renal artery and provides most of the arterial blood supply to testis. An accessory testicular artery may arise directly from the aorta. Venous drainage is returned either directly to caudal vena cava or forms a common stem with adrenal veins. In Pekin drakes (*Anas platyrhynchos*), 2 testicular veins empty directly into caudal vena cava.[23] Given the diversity within the class Aves, it is likely that multiple variations of the testicular vasculature exist.

Although most birds lack a copulatory organ, some birds possess a nonprotrusible (Galliformes) or protrusible (ratites and Anseriformes) phallus. Domestic chickens and turkeys have a nonintromittent phallus, consisting of a median and 2 lateral phallic bodies, on the floor of the lip of the vent. Lymphatic flow through the phallic bodies and their laterally associated lymphatic folds result in tumescence. Because the lymphatic folds and lateral phallic bodies accumulate more fluid than the median body, phallus everts during tumescence producing a groove for semen to travel. Semen is deposited when phallus contacts the hen's everted oviductal opening.

Male avian reproductive system diseases

Orchitis

Inflammation of the testis, or orchitis, is usually due to bacterial infections and may originate from septicemia, renal obstruction, cloacitis or even prolapsed or ulcerated phalli. Affected birds may show signs of septicemia. However, first author has seen cases of focal orchitis with no associated clinical signs or reduced fertility only. Orchitis may be diagnosed via cytology and/or microbiologic analysis via aspiration through endoscopy or celiotomy when whole testis appears abnormal or, biopsy when focal lesions are seen. Ultrasonography and contrast CT or MRI may help isolate lesions within the testis.

Initial treatment for bacterial orchitis should include antibiotics based on culture and sensitivity results. If a focal granulomatous lesion is observed and appropriate antimicrobials have proven ineffective, the testis can be partially ablated. Clamp with hemostats or surgically clip the testicular tissue dorsal (towards the blood supply) to the lesion(s) and remove using cold excision, laser, or radiosurgery. Avian testicular tissue has great regenerative capabilities and may redevelop following partial ablation. Enbloc surgical removal of the affected testicle is indicated for diffuse, nonmedically responsive orchitis.

Testicular neoplasia

Avian testicular neoplasia most commonly includes Sertoli and interstitial cell tumors, seminomas, teratomas, and lymphoproliferative diseases. Sertoli cell tumors appear to be more prevalent testicular neoplasm in birds. Reported neoplasms of epididymis and ductus deferens include leiomyosarcoma and carcinoma. Chronic weight loss, coelomic swelling and unilateral paresis are most commonly associated with testicular cancer. Radiographs, CT, MRI, ultrasonography may all be used to help make a diagnosis. Surgical removal of the affected testis is the treatment of choice and carries a good prognosis if metastasis is not present. As noted in literature and in authors' experience, many testicular tumors are cystic. Cystic testicular masses can be aspirated and drained during surgery to reduce their mass and facilitate removal. Some testicular tumors may metastasize as has been reported in a guinea fowl (*Numida meleagris*) with malignant seminoma.[24]

Cystic testicular disease

Nonneoplastic cystic testicular disease is very infrequently reported, and its importance is unknown.[1] Cystic dilatation of the seminiferous tubules (and testes) has been produced in fowl fed a diet high in sodium. Cystic testes have also been noted in chickens fed egg albumen as a source of protein. Dilatation of seminiferous tubules, but not gross cystic testicular change, has been noted in roosters affected with epididymal cysts and stones of unknown origin. As mentioned above, consider cancer first when cystic testis is diagnosed. Cystic testis should be drained, biopsied and ideally removed.

Disorders of phallus

Male waterfowl have a protrusible phallus, which is highly variable and particularly long and corkscrewed in the Muscovy duck (*Cairina moschata*).[6] Partial and complete phallic prolapses are possible in waterfowl with large phallus and are usually secondary to trauma, local infection, and masturbation. Over exuberant vent sexing and mating, *Neisseria* spp. (suspected to be sexually transmitted in geese and the cause of 'goose gonorrhea') and contamination have all been implicated causes of phallic infections.[1] A prolapsed phallus may become enlarged, ulcerated and/or necrotic compounding the problem. Frostbite and resultant necrotizing dermatitis of a prolapsed phallus has been noted in ostriches. Birds with severe prolapse and infection may be substantially depressed and often lose interest in copulation.

Clean exposed phallus and carefully debride abnormal tissue prior to replacement. Topical antibiotic creams, DMSO and systemic antibiotics may be beneficial, and their use is based on clinical findings. Cloaca may need partial closure (via transcloacal sutures) to prevent recurring prolapses. If the prolapse is prolonged and will not stay when replaced, use 4-0' monofilament absorbable suture to gently tack the phallus to its resting position within the cloacal mucosa. Severely necrotic phallus often needs surgical debridement. Using absorbable suture in an encircling pattern, ligate the phallus proximal to necrotic tissue. It is best if there is a clear demarcation from healthy tissue. Amputate the tissue distal to the ligature ensuring that all necrotic tissue is removed.

Male reproductive system surgery

Castration

Clinical castration is infrequently discussed, especially in comparison to salpingohysterectomy, suggesting that male reproductive tract diseases are relatively uncommon. Although caponization is common in the poultry industry (performed between 1 - 2 weeks or up to 6 weeks of age depending on the breed), routine castration is rare in pet birds. As a result, there is little information regarding the behavior and physiologic altering effects of castration in pet birds.

Caponized chickens (capons) have increased coelomic fat weight, total hepatic lipid content and saturated fatty acid percentage compared to intact birds. Medical consequences, if any, of this body change are not known.

Castrated Gambel's (*Callipepla gambelii*) and scaled (*C. squamata*) quail have reduced or eliminated courtship behaviors and lower rates of male-male threats.[25] However, the castrates maintained ornate plumage, exhibited overt aggression, and frequently won contests when actually engaged. Yearling European starlings (*Sturnus vulgaris*) castrated when not actively reproductive were more aggressive compared to uncastrated controls.[26] It was suggested that 'nonreproductive aggression in yearling male starlings is independent of gonadal sex steroids and it even increased after castration.'[26]

These limited results suggest that persistent 'male' behaviors are either already learned at castration, result from hormones other than testosterone or another source of testicular hormones is still present postcastration. It is known that some species have an appendix epididymis extending from epididymis into adrenal gland that may secrete androgens after castration. Authors have performed castration in roosters in effort to stop crowing. Castrated roosters did exhibit reduced crowing behavior; however, it did not stop. Authors concluded that castration was not appropriate or effective to eliminate crowing behavior in roosters.

Until further studies are available, castration should be used judiciously to alter avian behaviors, especially in adult birds and should always be considered secondary to more conservative methods of behavior management. However, castration has real benefit with testicular cancer, abscesses/granulomas, cysts, and other conditions that may not respond to medical management alone.

Several methods of castration have been advocated and include simple extraction (caponization), laser ablation, intracapsular suction, enbloc surgical excision and endoscopic orchidectomy. Even with early age caponization, testis regrowth is well documented.[6] This supports the need for complete removal of testis, the reason why the authors prefer enbloc surgical excision.

Caponization is typically performed in young male chickens to create meat that is apparently more tender, juicier, and tastier than in the intact rooster. Heavy chicken breeds are caponized at 2 - 4 weeks, whereas some slow-growing meat-type birds after 6 weeks.[6] As the bird ages, tunica albuginea of the testis becomes hard making caponization more difficult and time consuming. The procedure is typically performed without anesthesia with the bird held or strapped to a table. A sterile preparation is given to the appropriate side and an incision is made between the last 2 ribs through the lateral body wall that is then spread with a 'spreader'. Performed correctly, specialized caponizing forceps are used to enter the incision, delicately hold entire testis, and pull with a twisting motion until testis is free and removed. Wound is disinfected and left to close by second intention. Incompletely caponized birds may regrow testis and the birds tend to develop secondary sex characteristics unlike true capons. A similar technique using standard curved forceps is described in 9 - 10 weeks Japanese quail (*Coturnix coturnix japonica*).[27]

Use a cranial left lateral approach or ventral midline incision with transverse flap to evaluate testis. Due to cranial location, the lateral celiotomy is often extended cranially by cutting the last 2 ribs to improve testicular exposure. With a left lateral approach, puncture through the caudal thoracic and/or the abdominal air sac(s) to expose left testis. Right testis may be exposed through the same incision by cutting through the midline junction of the corresponding air sacs or the process may be repeated with a right lateral celiotomy. With gentle traction, pull the testis ventrally and surgically clip the dorsal blood supply. Use of a right-angle surgical clip often makes the approach easier. If 2 clips can be placed, then incise between the surgical clips and remove the testis. Otherwise, use radiosurgery to carefully free testis from the surgical clip and vascular cord. Cautery should destroy any remaining testicular cells attached to the surgical clip. Be careful to not damage the overlying blood vessels, kidney, or adrenal gland.

Alternatively, if testicular blood supply is small, a hemostat can be temporarily used in the place of a surgical clip and testis is pulled free. Leave the hemostat on the vascular stump for 1 - 2 minutes prior to release. Use direct pressure hemostasis as needed. Diode laser excision can also be used through this approach and may be performed without the need for direct hemostasis. Closure is routine.

Multiport endoscopic orchidectomy has been described in Carneau pigeons.[28] Whereas the details of the procedure are described,[28] endoscopic orchidectomy produced good results in 10 of 11 pigeons with a mean surgical time of 39 minutes. Mild hemorrhage and partial necrosis of the cranial renal pole was noted in 27% of tested birds and represented the most common complication of surgery. Surgical failure (regrowth of testis) in 1 bird was considered due to surgeon's inexperience. When performed using appropriate equipment and techniques, endoscopic orchidectomy was successful and safe in pigeons. This technique could potentially be used in poultry and waterfowl. As expected, large testes are more difficult to remove endoscopically.[28] In authors' experiences, orchidectomy is more often needed for clinically abnormal (cancer, cysts, and others) and often large testes requiring celiotomy.

Vasectomy

Vasectomy is a useful technique to produce 'teaser males' and aid in population control and has been described in small passerines and budgerigars.[29] In anesthetized budgerigars, a 3 mm incision, 7 mm lateral to the cloacal sphincter (vent), was used for the initial approach. Careful dissection was made through the coelomic musculature and fat. An operating microscope was used to find and aid in the removal of a 5 mm section of vas deferens. Only skin incision was closed. It was recommended performing left and right vasectomy 2 weeks apart.[29] Two of 12 birds died postoperatively and 1 had preexisting disease. Other complications were postoperative tenesmus for 2 days and accumulation of droppings around the vent in 3 of the remaining 10 birds. This procedure was successful (no semen upon collection attempts) in 9 of the 10 surviving birds.[30]

Anesthetized Bengalese (*Lonchura striata*) and zebra (*Taeniopygia guttata*) finches have been vasectomized similarly to the procedure described above.[29] In anesthetized finches, a 3 mm incision 5 mm lateral to the cloaca was made using an operating microscope. Muscle and fat were incised to locate seminal glomera (glomus). It was noted that the seminal glomera of Bengalese finch were 'obvious and highly accessible,' and that of the zebra finch was 'less obvious and in some cases difficult to locate.' Vas deferens was carefully separated from the ureter and '1 or more pieces' were removed with no ligature and the skin was closed. A single (14 days apart) and bilateral vasectomies were performed successfully, and was successful in 12 of 12 Bengalese and 14 of 15 zebra finches.[29]

In larger species, vas deferens zig zags lateral to the ureter and can be transected endoscopically or via celiotomy. Either a left, and sometimes right, lateral coelomic approaches are used. Ureter is avoided to prevent damage. In vasectomized (just distal to epididymis) roosters, spermatogenesis ceased within 5 - 7 days.[31]

Authors prefer endoscopic vasectomy in large birds, most commonly, as a means of population control in gallinaceous birds. Ductus deferens is identified endoscopically (as if evaluating kidney) and grasped just distal to the epididymis and ~ 5 - 8 mm is removed with simple traction. At this location, ductus deferens is usually not closely associated with ureter.[32] Depending on the species, both ductus deferens may be approached through 1 endoscopic portal. Alternatively, 2 endoscopic entry points (left and right) can be used. It should be recognized that vasectomy does not stop courtship and copulation.

Conflict of interest

There are no conflicts of interest to declare.

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