

CHAPTER

41

SOFT TISSUE SURGERY

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Soft tissue surgical techniques that can be performed in birds have increased substantially over the last decade because of the widespread use of isoflurane anesthesia, the introduction of microsurgical techniques to the avian practice, improvement in microsurgical instrumentation, improvements in bipolar radiosurgical instrumentation and the growing expertise of avian surgeons. Board certified surgeons are becoming attracted to the field for the purpose of developing and refining avian procedures. Procedures that were once considered impossible are now performed on a routine basis.

The most substantial limitation to soft tissue surgery of the abdomen is the small size (<100 grams) of many avian patients. Some of these problems can be overcome with the use of magnification, but others are a result of having limited surgical access to an area, and are difficult to overcome. Surgery of the thoracic area, even in large companion birds, presents a similar problem, in that the organs of interest are covered by the sternum and heavy musculature. Continued improvements in the endoscopic surgical equipment available in human medicine will undoubtedly improve the surgeon's ability to perform surgery in difficult-to-reach areas of the avian body.

The avian surgeon should practice surgical techniques on cadavers prior to performing the procedures on clinical patients. The delicate avian tissues tear in the presence of slight autolysis; therefore, the use of fresh specimens will give the surgeon an appreciation of avian tissue characteristics and allow the surgeon to explore the capabilities of surgical instrumentation.

When necropsies are necessary, the clinician should approach this procedure from the perspective of a surgeon rather than of a pathologist, by dissecting and reviewing anatomy from a regional approach rather than by performing the necropsy strictly from the traditional ventrodorsal approach.

Surgery of the Skin

The skin and subcutaneous tissues of birds differ from those of mammals. Birds have relatively thin, dry epidermis, and the dermis is attached to the underlying muscle fascia with little subcutaneous tissue.^{19,33} In feathered areas, the skin is generally only ten cells thick. Compared to mammals, the skin is only loosely attached to underlying structures, except in the distal extremities where it is firmly adherent to underlying bone.

Passerine Leg Scales

Passerine leg scale syndrome is characterized by the development of abnormally large scales of the legs and feet, possibly as a result of mite infection or malnutrition (see Chapter 43). These scales can coalesce and act as a constricting band. They also predispose the bird to bacterial pododermatitis (usually *Staphylococcus* spp). If present, the shiny, convex carapace of the female *Knemidoptes* mite can usually be visualized, with the aid of the operating microscope, inside the burrows they create. In most instances, lesions resolve after treatment with ivermectin or correction of nutritional deficiencies. In severe cases, it may be necessary to surgically debride the proliferative scales to prevent vascular compromise. A 22 or 25 ga needle with the point bent to a 90° angle can be used to lift the scales and scabs, which can then be grasped with the micro-forceps. Skin softeners may also be beneficial.

Toe Necrosis (Constricted Toe Syndrome)

Avascular necrosis of digits may occur secondary to circumferential constriction caused by fibers, scabs or necrotic tissue (see Color 24). These constrictions cause edema and if untreated, sloughing of the digit distal to the constriction.⁴ This condition is generally not life-threatening, and amputation should be considered only after less aggressive therapies have failed. Removal of the offending tissue or fibers and supportive care are frequently successful. Avascular necrosis of the digits has been described in passerine birds and Amazon parrots. Scabs should be debrided or incised to prevent vascular compromise, and hydroactive dressings should be applied to the affected

digits to prevent the formation of additional scabs. Complete healing may require weeks to months.

In small birds (eg, Passeriformes), constricting fibers may be visualized using the operating microscope (see Figure 43.4). A bent 25 ga needle is helpful for removing constricting fibers. The tip can be used to elevate the fiber, which can then be cut by gently rolling the needle such that the beveled edge severs the fiber. Microsurgical forceps may be used to untangle the fibers. Even severely swollen digits with exposed tendons may heal without incident once the fibers are removed. A hydroactive dressing should be placed on any wounds created by the fibers to prevent desiccation and the formation of a constricting scab.

Neonates (especially macaws and Eclectus Parrots) may develop constrictive toe lesions that can result in avascular necrosis of the digit (see Color 30). Proposed etiologies for these include low humidity, egg-related strictures or ergot-like intoxication.²⁵ Increasing the environmental humidity or providing hot moist compresses and massage may be effective in resolving lesions in the early stages.²⁵ More advanced lesions require surgical intervention. The circumferential indentation is treated using magnification to remove the constricting tissue (Figure 41.1).

A tourniquet fashioned from a rubber band held tightly with a mosquito hemostat may be used to control hemorrhage for short periods until the injury is properly treated. Hemostatic agents including radiocoagulation should be avoided. The blood supply to the digits is minimal, and anything that interferes with proper blood flow may predispose the digit to postoperative necrosis.

A circumferential anastomosis of the skin is then performed by placing one or two sutures in the subcutaneous tissues to provide skin apposition without tension. Skin sutures should be placed shallow below the epidermis and be sufficiently tight to appose the skin edges without disrupting the blood supply. Sutures placed too deeply will cause the skin edges to evert, exposing subcutaneous tissue and delaying healing. When the skin edges are apposed, a two to three millimeter release incision should be made at the site of the anastomosis on both the lateral and medial aspects of the digit. These incisions allow swelling without constriction. A hydroactive dressing is applied to prevent scab formation, which could result in reformation of the constriction.

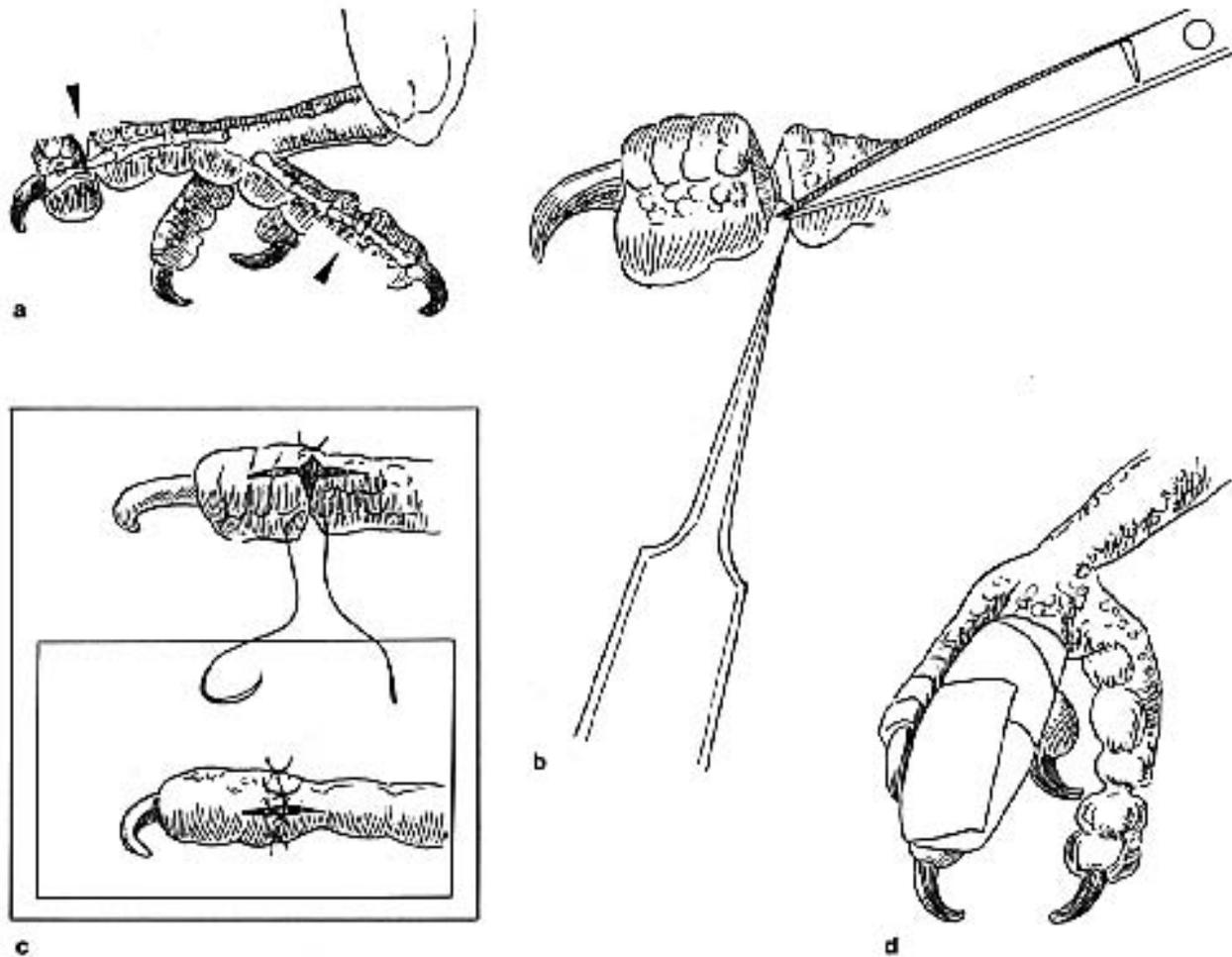


FIG 41.1 a) Constriction of the digits (arrows) is common in some macaw and Eclectus Parrot neonates. b) The lesion is repaired by using an operating microscope to remove the circumferential scab and create a fresh tissue margin. c) The wound edges are then apposed with shallowly placed sutures, and longitudinal incisions are made through the constriction on the medial and lateral sides of the digit to compensate for swelling and growth. d) The wound is covered with a hydroactive dressing to keep it clean and prevent dehydration.

Feather Cysts

Feather cysts are generally the result of trauma to the feather shaft, feather follicle or, as in the case of “soft-feathered” canaries, the result of abnormally developed feathers (see Color 24).

Feather cysts may occur within any feather follicle, but those on the wing and tail are the most challenging to the surgeon. In canaries, feather cysts are most common in Norwich, Gloucester and their cross-breeds. These birds have been genetically selected to produce an extra downy type of feather (soft feathering) that may predispose them to this syndrome (see Color 24).³ In other birds, malformed and cystic feather development have been associated with trauma, malnutrition and viral, bacterial or parasitic infections. If damage is sustained to one side of the

follicle, feather growth becomes asymmetrical and the feather may grow in a curled fashion inside the follicle, resulting in a feather cyst.

Feather cysts on the wing that are treated by lancing and curettage frequently recur. Fulguration with a radiosurgical unit has been reported to be successful in some cases; however, the depth of destruction is difficult to control, resulting in damage to adjacent follicles. These damaged follicles can then develop feather cysts. Use of laser for follicle excision does not appear to improve the long-term clinical results.

Blade excision appears to be the treatment of choice. A tourniquet can be applied to aid in hemostasis. The entire follicle, including any bony attachments, should be excised. Adjacent follicles and their blood supply should be carefully avoided. In the postop-

erative period, the wing should be bandaged to prevent movement at the site of follicle excision while healing occurs by second intention. As adjacent feathers begin to regrow, debris should be gently removed by flushing with warm sterile saline several times daily.

With a single cyst or a large feather, the follicle may be saved by marsupializing the lining of the cyst with the skin surrounding the follicle. An incision is made centered on the cyst, parallel to the direction of feather growth. Hemorrhage is controlled with 6-0 ligatures, not with radiocautery. The lining of the cyst is cultured and the debris is removed. Redundant tissue is excised and the follicle is thoroughly lavaged with sterile saline. The margin of the cyst is then sutured to the skin using a simple continuous pattern of fine suture. New feather growth must be closely monitored.

Feather cysts of the tail may be severe and disfiguring, requiring amputation of the pygostyle. Blunt dissection to the coccygeal vertebrae allows disarticulation at the sacrococcygeal junction without entering the cloaca. Soft tissues are closed routinely.

Feather cysts on the body are easily removed using elliptical or fusiform excision followed by primary skin closure.³ Treatment of individual feathers is generally unrewarding in cases where an entire feather tract is involved. A technique for radical excision of an entire pterygia of affected feathers in canaries has been described.³ A fusiform incision is made from the flank to the thoracic inlet around the affected pterygia. The main vascular supply to the tract is located centrally at the cranial third of the pterygia. Large cysts may be supplied by relatively large individual vessels that should be coagulated or ligated. Despite the significant-sized defect, skin apposition is easily accomplished using a monofilament suture in a simple continuous pattern (braided material may damage the skin). Removal of one or more pterygiae from the body wall does not seriously affect the cosmetic appearance of the bird.

CLINICAL APPLICATIONS

- Feather cysts are particularly common in line-breed canaries.
- Feather cysts may occur secondary to any factor that damages the follicular epithelium.
- For feather cysts on the wing, blade excision appears to be the treatment of choice.
- Feather cysts of the tail may require amputation of the pygostyle.
- Feather cysts on the body are removed using elliptical or fusiform excision followed by primary skin closure.

Xanthomas of the Wing Tip

Xanthomatosis is characterized by the deposition of a rubber-like proteinaceous material within the skin and is frequently associated with inflammation of underlying tissues (see Color 25). Xanthomas at the wing tip may cause the wing to droop, resulting in trauma to the mass. Probuco (25 mg/day for an Amazon parrot) and dietary management should be used in combination with surgical excision of the mass. Medical management is ineffective alone but may help prevent recurrence. Serum cholesterol levels should be closely monitored because they are usually elevated in birds with xanthomatosis and should be medically reduced to a normal level prior to surgery. The diet should be low in protein (13%) and fat (5.5%).

A monopolar, wire electrode functions well for removal of xanthomatous masses. The wound is left to heal by second intention. The wound may be protected with tissue adhesive or a hydroactive dressing, which should be changed every three to five days. Complete healing often requires several weeks. If subcutaneous tissues are involved (especially bone), the affected wing may require amputation.

Excision of the Uropygial Gland

Impaction of the uropygial gland may respond to medical management using hot, moist compresses and gentle expression of the contents. In some cases, the gland may rupture, causing inflammation and scar tissue formation in the surrounding tissues. Chronic debilitation and death may follow.³¹ Excision of the gland should be considered in cases where impaction recurs, the gland has ruptured, a tumor is present or chronic infection of the gland is not responsive to medical management.

A fusiform incision is made along the dorsal midline to incorporate the papillae of the gland. The skin is reflected with the aid of blunt dissection and radiocoagulation of damaged vessels. The gland is bilobed, and each lobe receives its blood supply from a vessel that branches at the cranial, middle and caudal portions of the gland. The gland may extend deeply to the synsacrum and caudally to the insertion point of the tail feathers. The vessels are identified and coagulated or ligated. Bipolar coagulation should be used to minimize damage to the follicles of the rectrices. Dissection is continued, beginning at the cranial extent of the gland proceeding circumferentially until its removal is possible. The deep fascia is closed

with monofilament absorbable material in a continuous or interrupted pattern, depending upon the amount of tension present. Subcutaneous and skin closures are routine.

Extensive dissection and debridement are necessary if the gland has ruptured. An additional caudal incision perpendicular to the dorsal midline incision may be necessary.³¹ In these cases, extensive tissue trauma increases the likelihood of postoperative dehiscence and damage to the follicles of the rectrices.³¹ Dehiscence usually occurs at the junction of the two perpendicular incisions. If possible, it is preferable to remove a diseased uropygial gland prior to its rupture.

Surgery of the Eye

Lateral Canthoplasty for Inferior Ectropion

Idiopathic paralysis of the inferior eyelid occurs with some degree of frequency in cockatiels and occasionally in Umbrella Cockatoos (see Color 26). Clinical signs generally include exposure keratitis with secondary epiphora and corneal ulceration. Symptomatic treatment involves the use of ophthalmic ointment to lubricate and protect the cornea. A lateral canthoplasty will create a smaller aperture, reducing the risk of exposure keratitis and associated conditions (Figure 41.2). Postoperatively the eye is medicated with an antibiotic ophthalmic ointment TID to QID, and the eye is cleaned as needed with an appropriate eye wash solution.

Conjunctival Masses

Masses involving the palpebral conjunctiva occur with some frequency in cockatiels. These may be the result of tissue edema, cyst formation or discrete masses. They are usually easy to remove with radio-surgical bipolar forceps. These masses may be secondary to chlamydiosis, mycoplasmosis, eyelid paralysis or oropharyngeal abscessation from hypovitaminosis A (see Chapters 22, 26).

Indolent Corneal Ulcers

Successful treatment of indolent corneal ulcers in birds appears to require debridement of the entire superficial layer of the cornea. Under the operating

microscope, a cotton-tipped applicator moistened with 10% acetylcysteine^b is used to gently debride the edge of the ulcer toward the limbus. Once the affected epithelium has been debrided, it should be excised using a #11 scalpel blade or a corneal knife. Standard ulcer treatment is instituted postoperatively. The corneal surface will re-epithelialize from the limbus.

Lens Removal

Trauma (blunt or penetrating) and senile lenticular degeneration have been speculated as causes for cataract formation in birds.^{7,27} In canaries, cataracts are inherited, and surgical removal has been recommended.⁵⁰ The avian eye is large, conforms closely to the orbit and has limited mobility.⁵² Scleral ossicles help support the eye and prevent collapse during surgery.

In a study of older macaws, immature cataracts were present in at least one eye of most birds over the age of 35.⁷ In many cases, the cataracts remained immature for several years without completely obstructing vision. The change from an incomplete, immature cataract progressed rapidly to a complete, mature cataract seemingly skipping a complete, immature stage. Those birds with rapidly developing cataracts frequently became blind due to phacolytic uveitis. Lens removal was performed on 13 eyes in 8 birds because of visual impairment or uveitis.⁷

For lens removal in these macaws, no attempt was made to dilate the pupil preoperatively. The macaw cornea is approximately seven millimeters in diameter, which is too small for phacoemulsification instrumentation, and the cataracts were removed using standard surgical technique (Figure 41.3). In the immediate postoperative period, the eyes were treated with a topical steroid-antibiotic ointment,^c followed by weekly subconjunctival injections of triamcinolone^d for up to a total treatment period of four weeks. Hemorrhage, synechiae of the iris and sloughing of the corneal epithelium were reported complications; however, postoperative inflammation was minimal in most cases.

Ten of the 13 eyes were visual after surgery. One bird had bilateral posterior synechiae and pigment migration that obstructed vision. A third eye remained blind because of a pre-existing intraocular inflammation that caused a change in consistency of the lens material and retention of the lens protein.⁷

Ultrasonic phacoemulsification may be successful in removing the lens of birds with large eyes (such as

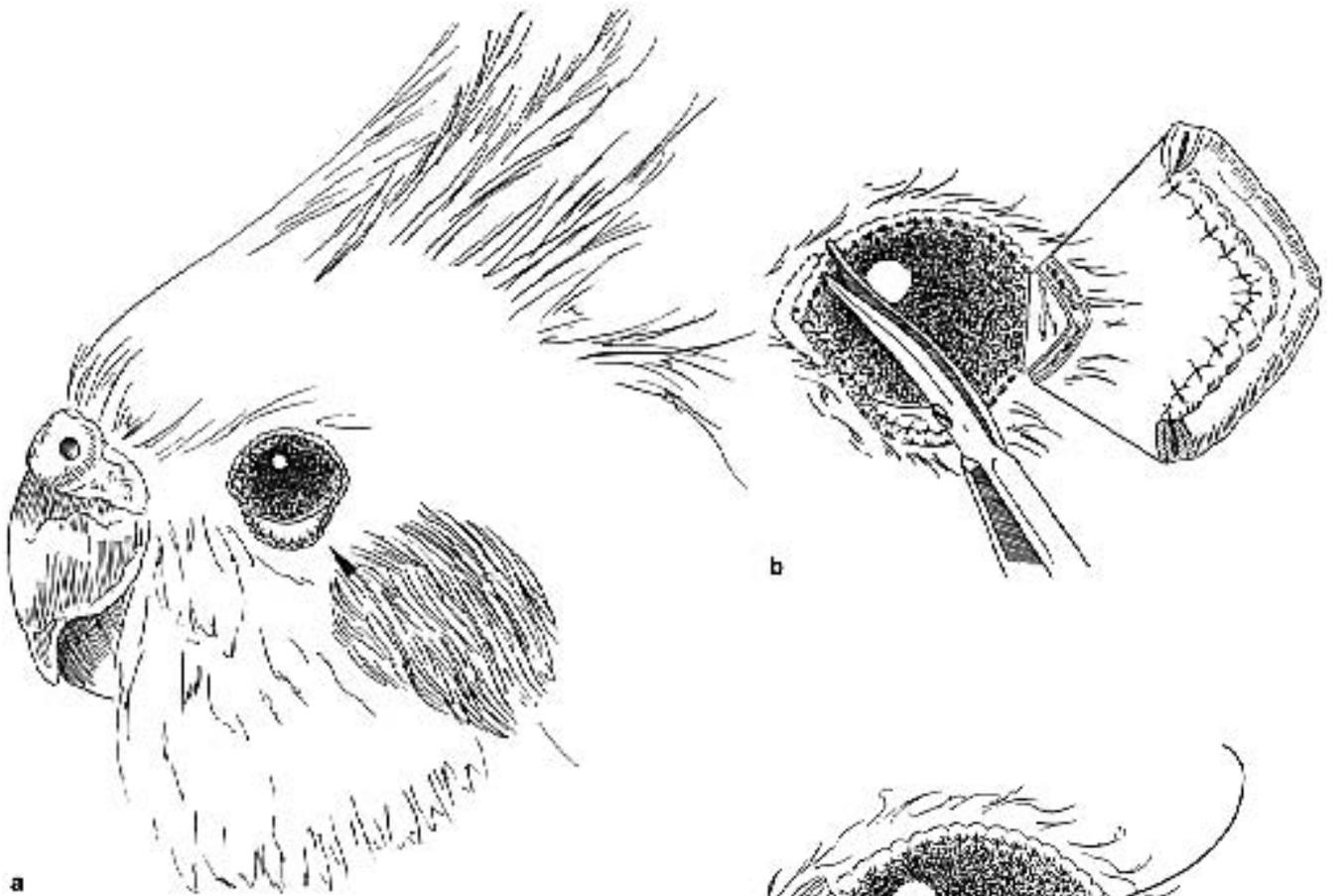
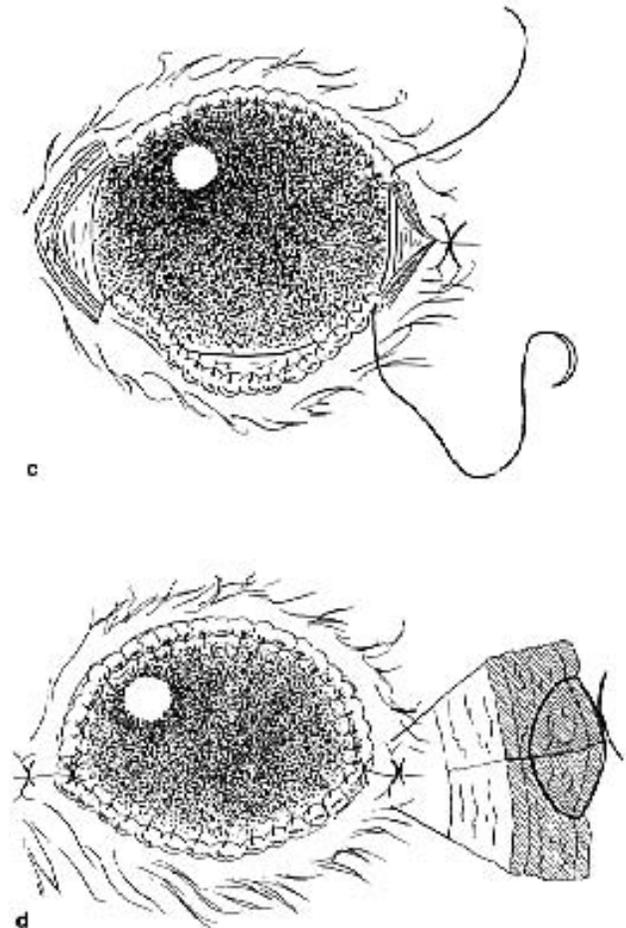


FIG 41.2 **a)** Idiopathic paralysis of the eyelid (arrow) may result in exposure keratitis and epiphora that can be corrected with a canthoplasty. **b)** The superior and inferior eyelids are incised using scissors to remove the lid margin and associated glandular tissue. A thin strip of eyelid is removed for a distance approximately one-fourth the total eyelid length. **c)** The eyelids are sutured together starting at the lateral canthus and extending toward the medial extent of the incision. **d)** Only the skin surface requires suturing, as the conjunctival surface will be held in apposition. Monofilament nylon sutures (8-0 to 10-0) are placed in a simple interrupted pattern.

raptors).²⁷ Phacoemulsification is a form of extracapsular lensectomy achieved by ultrasonic fragmentation of the lens cortex and nucleus. Medical therapy is instituted preoperatively using a neomycin, polymyxin B and dexamethasone solution applied topically to the eye at least TID for one to three days. Periocular skin and feathers are prepared aseptically, and a wire, self-retaining eyelid speculum is positioned. A lateral canthotomy is performed using scissors. Because the avian eye has limited mobility within the globe, perilimbal stay sutures are not required. Mydriasis may be induced with 0.045 to 0.09 mg d-tubocurarine chloride injected into the anterior chamber.



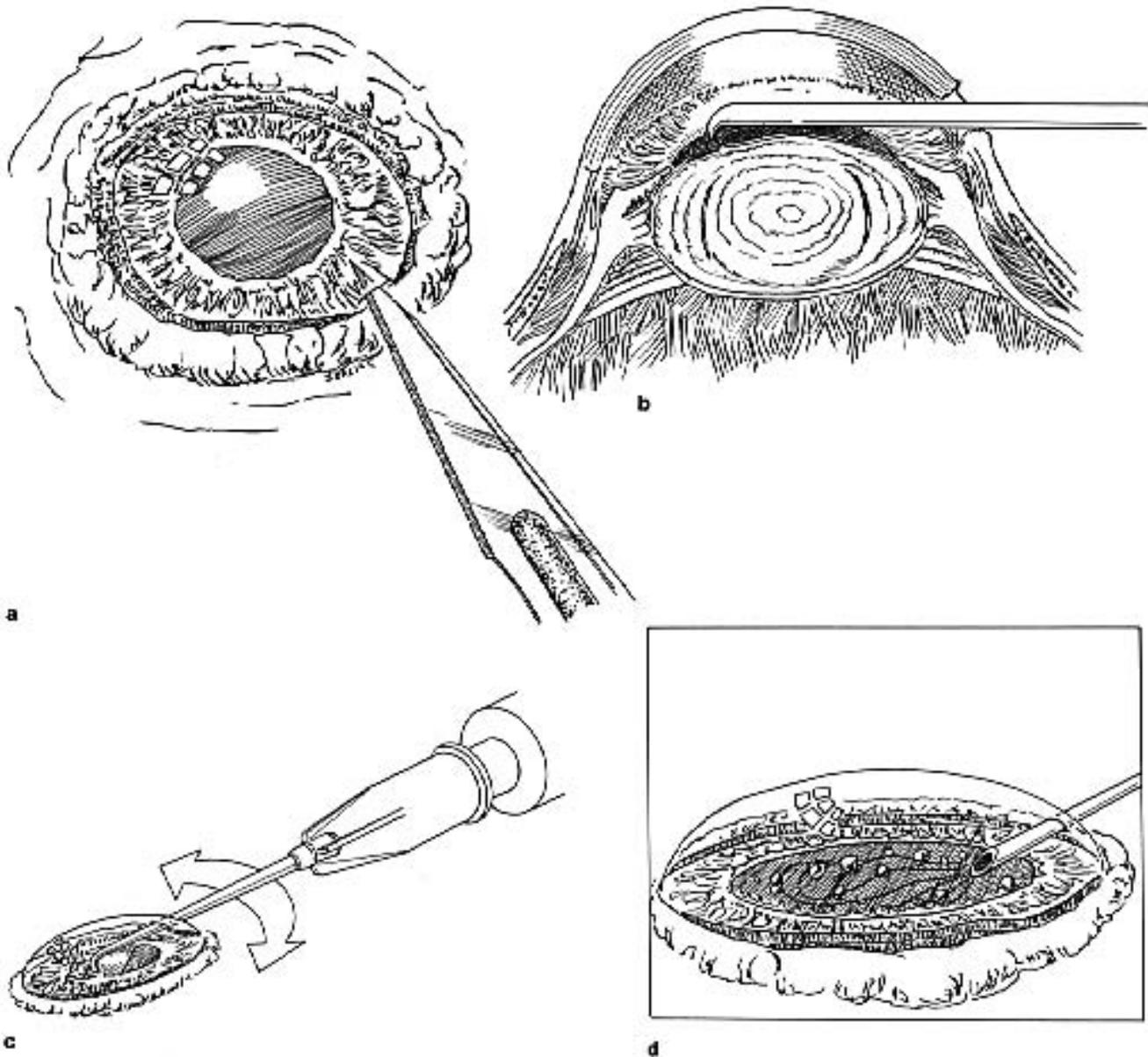


FIG 41.3 Cataract removal can be performed using phacoemulsification in most raptorial birds with large eyes. For most companion birds with small eyes, standard surgical techniques are used. **a)** Under the operating microscope, a small corneal incision is made. **b)** A 26 ga one-inch needle with the tip bent is inserted into the anterior chamber and used to tear the anterior lens capsule. **c)** A needle is then inserted into the lens through the anterior capsule to break down the lens and **d)** it is flushed out of the anterior chamber with lactated Ringer's solution. The corneal incision is closed with one or two simple interrupted sutures.

The phacoemulsification tip requires a 3 mm incision at the limbus or perilimbus at approximately the 10 and 3 o'clock positions. A #11 scalpel blade or a von Graefe cataract knife is used to make these incisions. Prior to making the second incision, a 22 ga needle connected to an IV set (containing lactated Ringer's solution supplemented with aqueous sodium bicarbonate without preservative to a final concentration of 25 mEq/l) is inserted through the first incision.

The depth of the anterior chamber is maintained using a continuous infusion of this solution while the second incision is made.

A cystotome or 27 ga needle with a bent tip is inserted through the second incision and used to create a tear in the anterior lens capsule at its periphery. The anterior capsule is not removed in order to help contain the fragments of lens material. After the capsulotomy is created, the needle is removed and

the phacoemulsification tip is inserted through the second incision, through the capsulotomy incision and under the anterior capsule. The tip is hollow with a 0.75 mm internal diameter and is used to aspirate materials or vibrate at 40,000 cycles/second. It is preferable for the lens to be removed without the use of ultrasonic waves. The posterior lens capsule is left intact. Once the entire lens is removed, the anterior capsule is removed by grasping it with Colibri forceps or the cystotome and tearing it from its attachments. The incisions are closed with 8-0 polyglactin 910 in a simple interrupted pattern. The first incision is closed while the infusion needle is maintained. Some fluid is lost during closure of the second incision but the depth of the anterior chamber is reestablished within a few minutes. The lateral canthotomy is closed using 5-0 polyglactin 910 in a simple interrupted pattern. At present, lens replacement devices are not commercially available in a size appropriate for avian patients.

Postoperatively, topical neomycin-polymyxin B-dexamethasone is applied at least TID for approximately 14 days and exercise is restricted for several weeks. Minimal evidence of uveitis has been noted in the postoperative period.^{27,38} Corneal edema generally occurs only at the corneal incision sites. Optimum results are achieved when minimal surgical trauma occurs. The corneal endothelium must not be disturbed by touching the inner corneal surface with instruments or by directing the flow of the irrigation solution toward the cornea.

The ciliary processes fuse to the lens capsule in the region of the annular pad (see Chapter 26). The posterior capsule is adhered to the anterior vitreous. Care must be taken to avoid shearing the fused ciliary processes and producing hemorrhage. Posterior capsule opacification may occur as a sequela to extracapsular lensectomy, possibly due to retained lens cortex or iris pigment migration from synechiae.

Enucleation

Enucleation is indicated for treatment of conditions that cannot be managed by other methods, such as neoplasia, overwhelming infection and severe trauma (Figure 41.4). The technique is similar to that described for mammals, except that birds have a very short optic nerve, and excessive traction on the globe can result in pressure trauma to the brain. Visualization of the muscles and blood vessels is enhanced by collapsing the globe at the start of the procedure. After the cornea is incised, the lens and vitreous are expressed through

the incision. The lid margins must be excised to eliminate glandular tissue and provide a cut edge for the blepharoplasty. It is also important to remove all conjunctival tissues and any secretory tissue.

One enucleation technique involves suturing the eyelids together to improve the precision of the incision of the skin, which needs to be made a few millimeters from the lid margin circumferentially (Figure 41.5). The dissection is continued subcutaneously around the globe such that the palpebral conjunctiva will be excised with the globe. Hemorrhage is controlled with the bipolar radiosurgical forceps. Once all attachments have been transected except for the optic nerve and associated vessels, hemostatic clips are placed on this neurovascular bundle. Two clips should be applied to assure hemostasis. Curved applicators facilitate placement of the clips caudal to the globe and minimize traction on the optic nerve. The optic nerve is severed and the globe is removed. Any remaining hemorrhage is controlled using radiosurgery. An ocular prosthesis may be used to prevent the sunken appearance characteristic of avian enucleation. The skin margins are sutured together routinely. Drains or bandages are not indicated in most cases.



FIG 41.4 A mature female cockatiel was presented several days after a traumatic injury that resulted in rupture of the globe. The eye was necrotic, and multiple gram-negative bacteria were detected by cytologic examination of periocular discharge. The eye was not salvageable and was removed. Enucleation is a cosmetic solution to ocular neoplasia and severe unresponsive ocular infections.

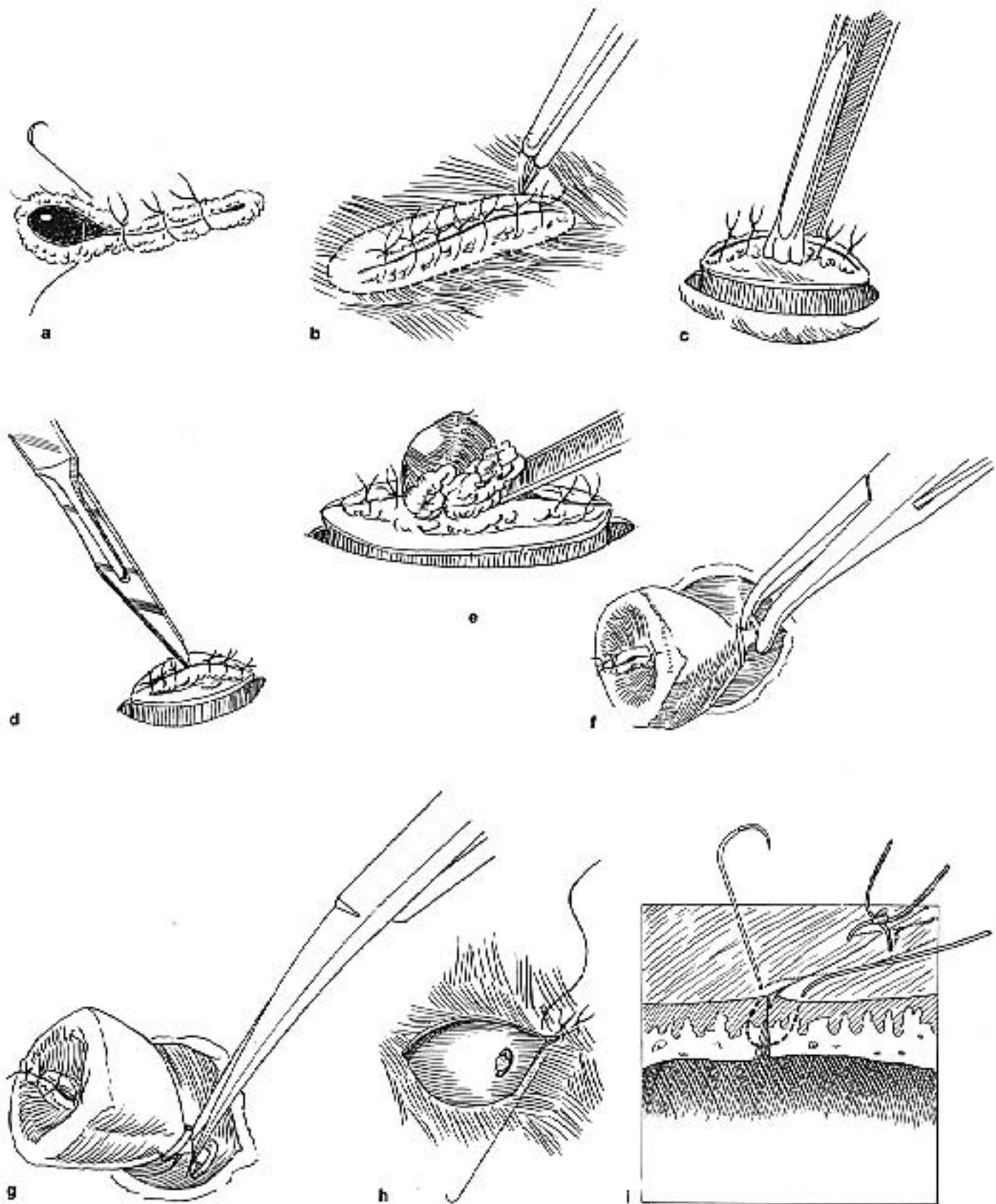


FIG 41.5 A technique for enucleation in birds: **a**) The eyelids are sutured together. **b,c**) The lid margins are incised circumferentially so that the palpebral conjunctiva are excised with the globe. **d,e**) The globe is collapsed and eviscerated. **f**) Two hemostatic clips are placed around the neurovascular bundle at the base of the globe. **g**) The optic nerve is then cut between the clips. **h,i**) The skin margins are closed.

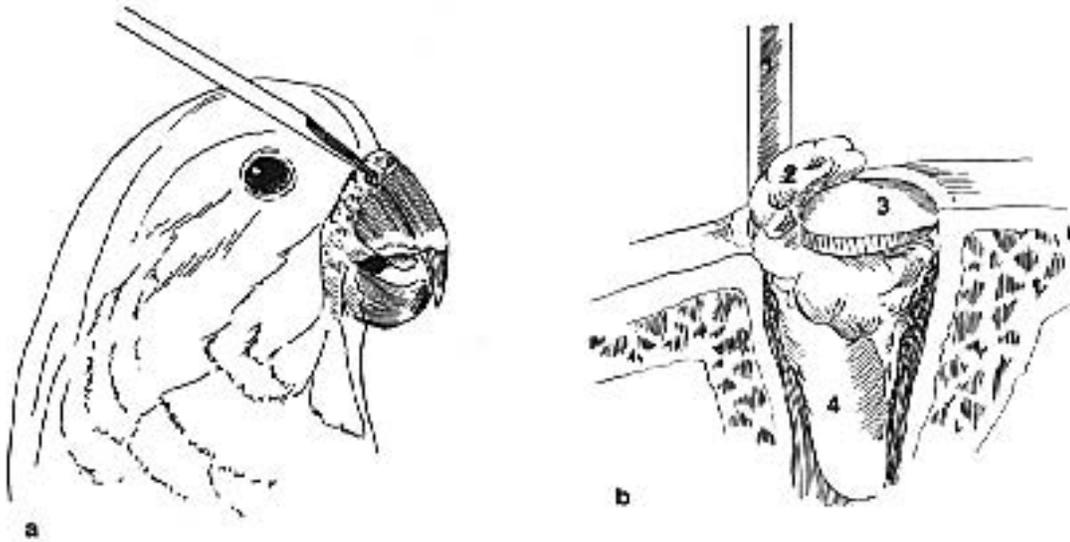


FIG 41.6 **a)** A feathered wooden applicator stick can be used to gently break apart and remove rhinoliths. **b)** These masses start as an accumulation of debris frequently located caudal to the operculum. 1) probe 2) rhinolith 3) operculum 4) conchae.

Surgery of the Respiratory System

Rhinoliths

Rhinoliths may occur secondary to chronic malnutrition and rhinitis (Figure 41.6). These masses, formed of desiccated secretions and debris, cause a physical obstruction to respiration, which may result in respiratory distress and disfiguring atrophy of the nares (Figure 41.7). Clinical signs include sneezing, upper

respiratory sounds and inflation of the infraorbital air sac during expiration. Rhinoliths are difficult to diagnose, and identification requires probing under magnification and a strong light source. Once the technique for visualizing these concretions has been mastered, their occurrence will seem quite common.

Removal of rhinoliths requires magnification. Nasal tissues are friable and bleed easily when traumatized, which also predisposes the mucosa to infection. A wooden applicator stick broken to create a long bevel works well to begin the gentle removal of the mass (Figure 41.6). The beveled applicator stick is used to elevate the concretion from the margin of the naris followed by slow, precise, gentle probing with pressure to separate the mass from the wall of the



FIG 41.7 **a)** A conure was presented with a three-week history of progressive dyspnea and inflation of the sides of the face on expiration. The right nostril was partially occluded with dried crusty material, and the area around the nostril was hyperemic; the left nostril shown in this view is relatively normal. **b)** The necrotic material was removed and the nostrils were flushed daily with sterile saline. **c)** Rhinoliths that are allowed to persist can cause disfiguring atrophic rhinitis-type lesions.

nasal cavity. Once the margins of the mass are clearly identified, a slightly thicker metal spatula may be used to finish the dissection. The lith usually breaks during manipulation and is retrieved in fragments. Fragments may fall caudally into the nasal cavity and must be flushed from their resting place behind the turbinates.

Once the rhinolith is removed, the lining of the nasal cavity should be swabbed and evaluated cytologically and by culture for mycotic and bacterial pathogens. The nares should be flushed with dilute chlorhexidine, and any fungal or bacterial component should be treated systemically with appropriate antimicrobial medications.

■ Infraorbital Sinusitis

Infraorbital sinusitis in birds may lead to secondary lacrimal and conjunctival infections, chronic rhinorrhea and other upper respiratory problems. Effective treatment requires a definitive diagnosis. Frequently, nutritional problems such as hypovitaminosis A predispose a bird to secondary infections with bacteria, yeast and fungi. A sinus flush technique can be used to obtain samples for cytology and cultures (see Chapters 10 and 22).

If untreated, mild infraorbital sinusitis may progress to abscessation that requires surgical exploration and curettage (see Color 22). Clinical signs may include sneezing, rhinorrhea, swollen eye, other ocular diseases, periorbital swelling and conjunctivitis. In some cases, purulent material can be visualized below the conjunctiva of the eyelid or the globe itself (Figure 41.8).

The infraorbital sinus is initially opened in the same location described for sinus flushing (see Chapter 10). This area is highly vascular, and laser, if available, is best for providing hemostasis. Bipolar radio-surgical units on higher coagulation settings may also be effective. Pressure may be applied to the area with a cotton-tipped applicator to allow visualization of the vessels. The sinus must be thoroughly and deeply explored, as purulent debris may be located within the nasal cavity, the recesses of the beak and even between the sinus and the nasal cavity caudal to the turbinates. It may be necessary to remove affected portions of the periorbital bone.

Supraorbital sinus trephination may be used to gain access to the dorsal and caudal-most areas of the sinus that cannot be accessed using nasal flushes and



FIG 41.8 If left untreated, infraorbital sinusitis can progress to abscessation with necrosis and discharge from the side of the face as noted in this **a)** Sulphur-crested Cockatoo and **b)** Green-winged Macaw.

sinus injections.⁴⁶ The purpose of sinus trephination is to create an opening in the sinus through which irrigation and antimicrobial solutions may be instilled over a long period of time. Its major disadvantage is the risk of ocular injury. The site for trephina-

tion varies with the species, and the anatomy should be carefully studied prior to attempting this procedure.

To create an opening in the supraorbital sinus, the skin is incised exposing the frontal bone. Holes are made in the bone with a sterile rotary tool about one-half to two-fifths the distance between the rostral-most plane of the eye and the naris. The hole is angled toward the midline. Cortical bone is removed until the cancellous bone above the supraorbital sinus is visualized. Drilling proceeds into the supraorbital sinus and may then be widened to an appropriate diameter. Samples for cytology and culture are obtained, and the sinus is flushed with irrigation solution. The passage of irrigation solution through the choana and into the oral cavity confirms that the hole is properly placed. The periorbital tissue will bulge when fluids are introduced, and these tissues should not be over-distended. If indicated, this procedure may be performed bilaterally in some Passeriformes, whereas a single trephination site is sufficient in Psittaciformes in which the infraorbital sinuses communicate (see Chapter 22).

The trephination sites may be irrigated as often as indicated with appropriate antimicrobial solutions. The incisions heal rapidly and may need to be opened periodically. When therapy is no longer indicated, the trephination sites heal with minimal scarring.

Hyperinflation of the Cervicocephalic Air Sac

This condition is thought to occur secondary to trauma, but the location of leakage of air into the subcutaneous space is generally not identifiable. Generalized subcutaneous emphysema usually occurs in small birds, while in larger species the emphysema is generally confined to the dorsum of the neck (see Figure 22.11). A procedure for surgically implanting a cutaneous stent at the poll of the head to allow the air to escape (in a location where the bird cannot remove the device) has been described.¹² A Teflon stent,^h with a 5 mm outer rim that allows the skin to be placed under its edge to prevent the dermis from closing over the opening, is used for the procedure.

A skin incision is made just large enough for the insertion of the stent. Sutures are pre-placed through the four pairs of holes in the flange of the stent such that the suture enters one hole from the external side, doubles back and passes through the other hole from the internal side. Once all four sutures are placed, the stent is implanted. A 22 ga needle is inserted through the skin at the proper location for

one tail of suture material to be inserted through the needle to be exteriorized through the skin. This procedure is repeated so that each of the four sutures passes through the skin, one hole of the stent, doubles back, passes through the other hole of the stent and exits the skin. The four sutures should be placed one on each of the four sides of the incision. The sutures can then be tied. The main postoperative problem is a transient occlusion of the stent with dried tissue fluids, which is easily resolved using a swab or needle.

This syndrome has also been treated in an Amazon parrot using a one-way valve connecting the cervicocephalic air sac to the clavicular air sac. The approach is through the left lateral thoracic inlet, and the tube is inserted into the hyperinflated air sac. It is then directed caudally along the esophagus, through the thoracic inlet and into the cranial aspect of the clavicular air sac. The tube is sutured to the longus coli muscles to prevent migration. No attempt is made to suture the air sac around the tube. Skin closure is routine.

Thoracic Surgery

Tracheal/Syringeal Obstruction

Seed or other foreign body aspiration,^{9,19} fungal granulomas resulting from aspergillosis or candidiasis³⁶ or concretions of epithelial cells and mucus may occlude the trachea or syrinx resulting in respiratory distress. Some birds present with no premonitory signs, while others have a history of voice change and a more gradual onset of dyspnea.

Therapy depends upon the size of the patient and the configuration of the trachea. The trachea of some birds such as swans and cranes is coiled and encased within the sternum, making retrieval of distal tracheal foreign bodies extremely difficult (see Figure 12.17).¹⁹ Care must be taken not to push the foreign body into the sternal portion of the trachea. In a Sarus Crane, a 22 ga spinal needle was passed transversely through the trachea to prevent a kernel of corn from migrating farther down the trachea while it was being surgically removed.¹⁹ The avian trachea is composed of complete tracheal rings, which are generally cartilaginous, although calcified rings have been reported in adult Amazon parrots and adult cranes.¹⁹ Annular ligaments connect adjacent rings.⁴⁰ In some species, the pessulus (a midline laryngeal cartilage) may be present, providing an additional challenge to foreign body retrieval.¹⁹

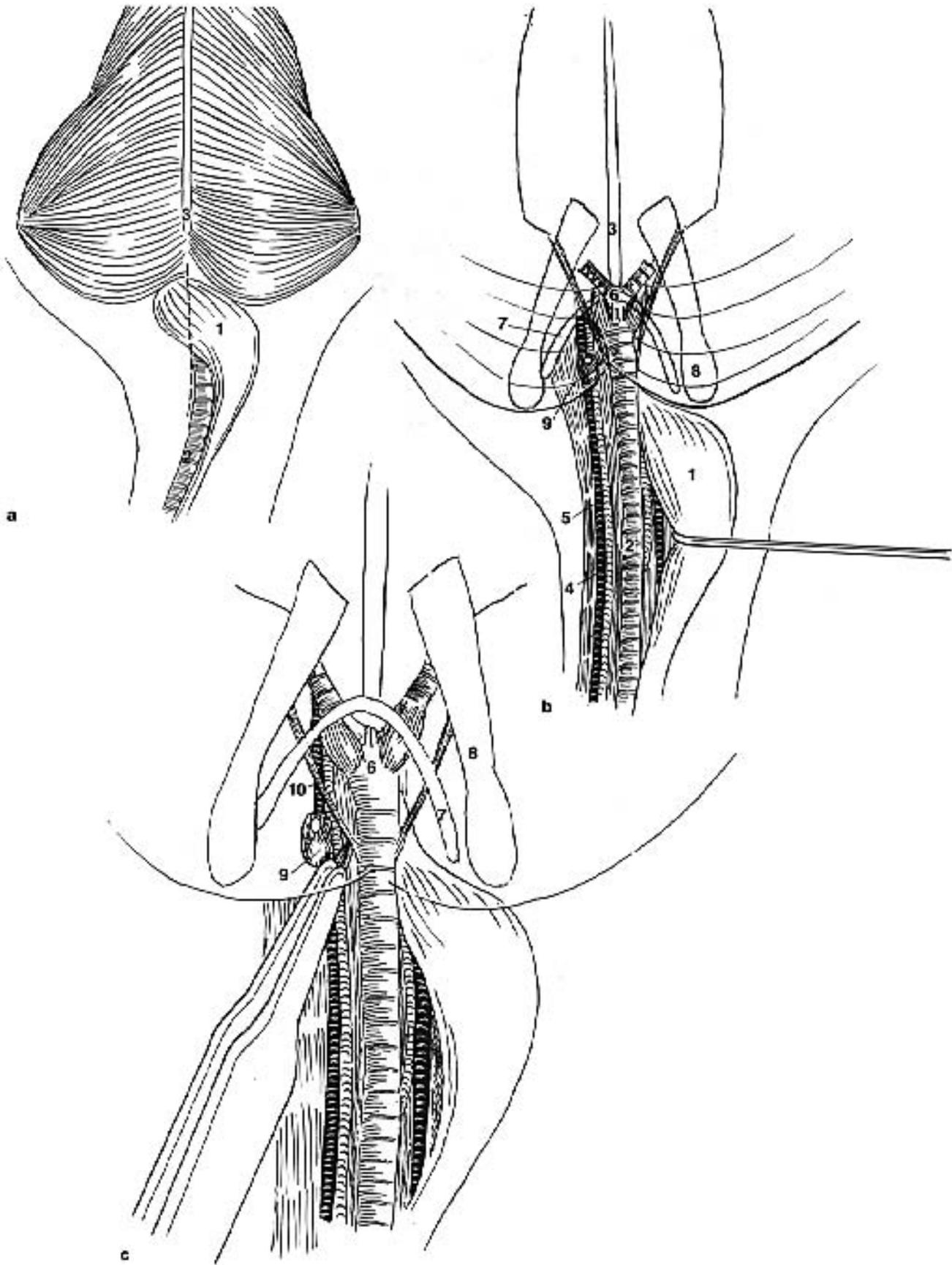
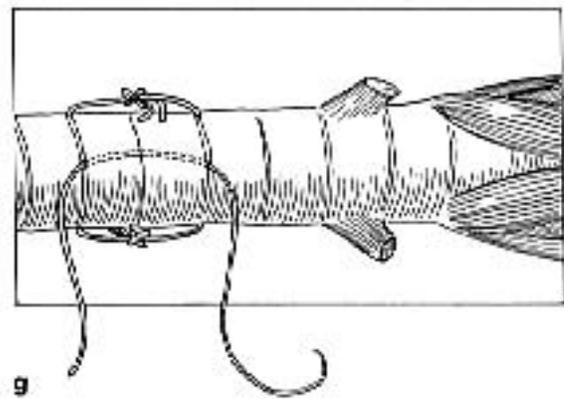
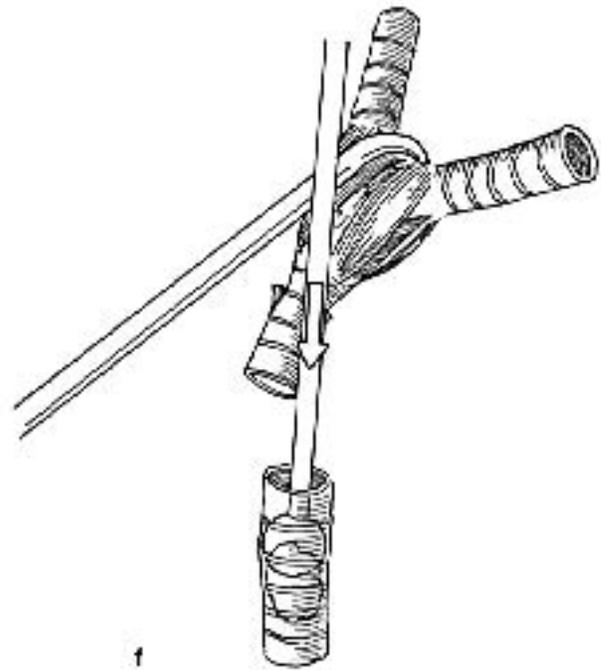
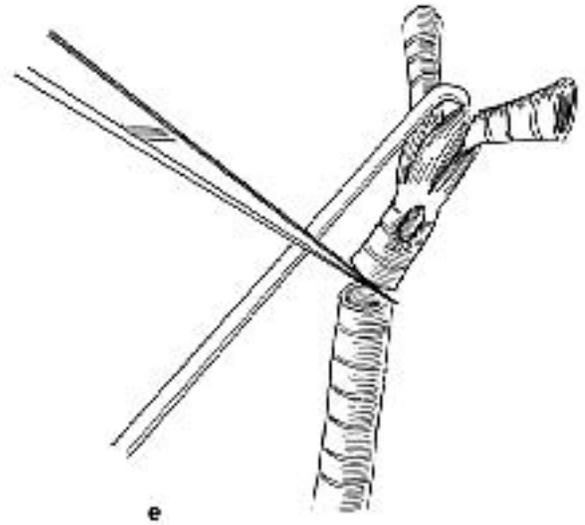
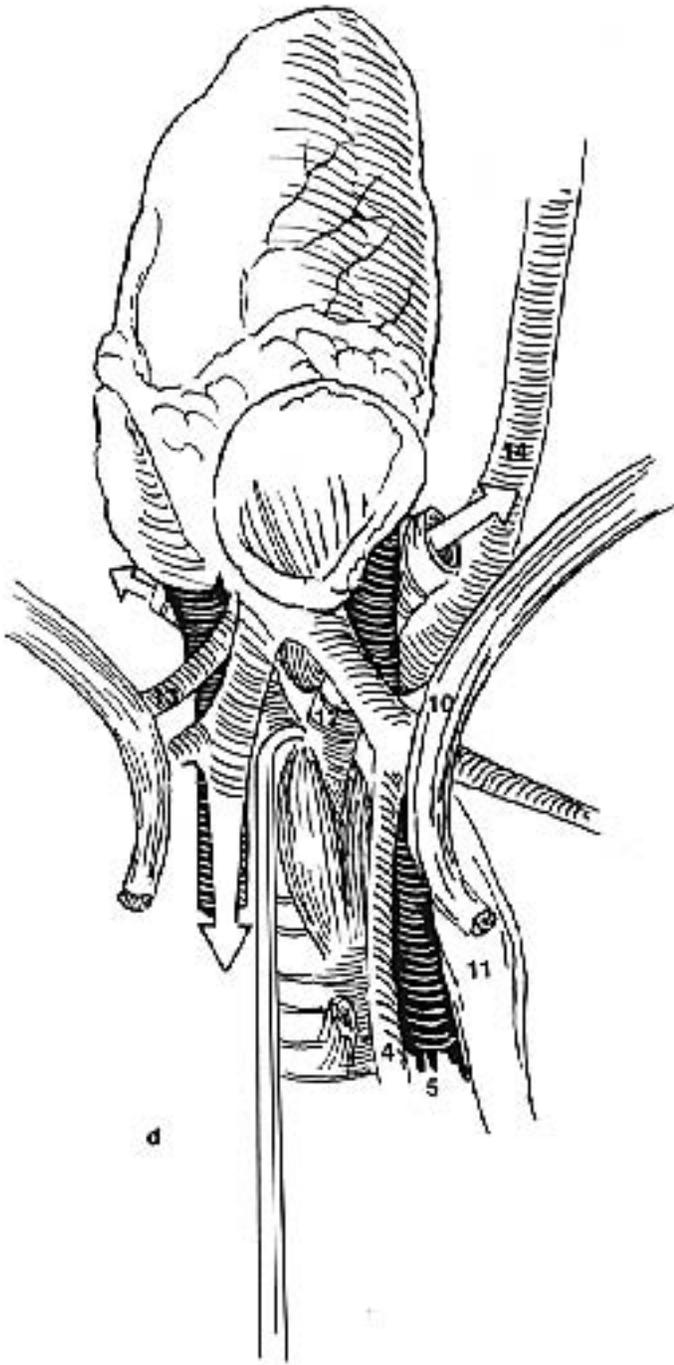


FIG 41.9 If all other techniques for removal fail, some foreign bodies and granulomatous plaques can be removed from the trachea and syrinx using a tracheotomy. **a)** An incision is made over the crop on the ventral midline. **b)** The crop is retracted laterally to the right. **c)** The tracheal muscles are transected using bipolar radiosurgery. (continued on next page)



d) A spay hook is used to gently pull the syrinx into the thoracic inlet. **e)** The trachea is transected. **f)** A blunt probang or suction device can be used to remove debris. **g)** Closure is completed by apposing the tracheal rings. 1) crop 2) trachea 3) sternum 4) internal carotid artery 5) jugular vein 6) syrinx 7) clavicle 8) coracoid 9) thyroid 10) sternotracheal muscle 11) esophagus 12) primary bronchi 13) pulmonary artery and 14) aorta; lateral arrows show primary bronchi to lungs.

Establishment of a patent airway is crucial. Placement of an air sac cannula will allow the patient to ventilate through an alternate airway until the obstruction can be removed. It may be beneficial to place the bird in an oxygen-enriched environment prior to manipulating the patient for placement of the air sac cannula.

In small birds (cockatiels and smaller), the tracheal diameter (approximately 1.5 mm for cockatiels) precludes use of an endoscope to retrieve a foreign body or granuloma. If the obstruction is the result of a granuloma or inspissated cells and mucus, a suction tube (urinary catheter) slightly smaller than the diameter of the trachea may be utilized to remove material from the trachea and syrinx (see Chapter 22).³⁰ By maintaining anesthesia with an air sac cannula, the trachea may be occluded with the suction tube without compromising respiration. If squamous metaplasia secondary to hypovitaminosis A is suspected, dietary modification and vitamin A supplementation should be instituted.

In medium to large birds, a rigid or flexible endoscope can be used to evaluate the cause of an obstruction and potentially aid in its removal. In some cases, the endoscope may allow visualization of the object, but the tracheal diameter may be too small to use a wire basket or grasping forceps to remove the object.¹⁹ In these cases, the endoscope can be used to brush off plaques or physically alter lesions sufficiently to open the airway, and the loosened plaques can be removed with a suction tube. Cytologic evaluation of samples obtained from the suction tube, or the end of the endoscope, may be used to determine the identity of an etiologic agent. Following this procedure, the patient should be treated using nebulization, intratracheal medications and systemic therapies as indicated (see Chapter 22).

In some cases, tracheal foreign bodies may be retrieved using grasping forceps, a Foley catheter⁴ or a Fogarty catheter²⁸ with the aid of an endoscope. The size of the patient's tracheal diameter will determine which catheter is most appropriate. The catheter is passed beyond the foreign body and the balloon is inflated sufficiently to occlude the airway but not to prevent it from being withdrawn. With the balloon inflated, the catheter is withdrawn, resulting in removal of the foreign body.^{19,28}

As a last ditch effort in medium- to large-sized birds (parrots, raptors, doves, pheasants and peafowl), the thoracic inlet may be approached surgically for re-

moval of tracheal or syringeal foreign bodies (Figure 41.9). The patient is positioned in dorsal recumbency on a surgical restraint board. A tube should be placed in the esophagus to allow for its easy identification to prevent iatrogenic trauma. The skin is incised from the right clavicular/sternal junction to the clavicular/coracoid junction just cranial to the crop. The skin is elevated from the crop, and the right lateral aspect of the crop is gently dissected from surrounding tissues. Major blood vessels are easily avoided using blunt dissection. Once the crop is freed from its clavicular attachments, it should be reflected to the right. The trachea is identified by its complete cartilage rings. The sternotracheal muscles are identified traversing obliquely to their caudolateral attachments, and both sets of sternotracheal muscles are transected. A large blood vessel between the muscle bellies should be coagulated prior to transection of the muscles. A small canine vaginal speculum may aid in visualization.

At this point, the use of the operating microscope becomes essential. The restraint board should be elevated at the cranial end such that the operating microscope can be used to visualize the structures deep in the thoracic inlet. It may take some time and patience to achieve proper positioning and focus, but this technique allows the surgeon to visualize critical structures while having both hands free for manipulations.

The interclavicular air sac is bluntly dissected to expose the syrinx. A blunt hook is looped over the syrinx, which is gently pulled into view. In Amazon parrots, small macaws and smaller birds, this procedure may result in avulsion of the bronchi from the lung. For these patients, a left lateral approach to the syrinx is recommended as a last desperate attempt.

A transverse tracheotomy (50% of diameter) can also be created on the ventral surface to allow retrieval of the foreign material. Foreign bodies have been removed through longitudinal tracheal incisions;^{35,36,44} however, these incisions provide limited visibility and access due to the inward twisting of the cut rings, and are more prone to iatrogenic trauma during manipulation, are more difficult to close than a transverse tracheotomy and are more prone to stricture formation.^{15,46} Unless absolutely mandatory, the trachea should not be completely transected in order to maintain its alignment, reduce tension on the closure and prevent complete disruption of the blood supply.¹⁹ Stay sutures placed around the tracheal rings adjacent to the tracheotomy allow atraumatic manipulation of the trachea. Foreign materials located

cranial to the tracheotomy site can be pushed out of the trachea with a sterile probang. Those located caudal to the tracheotomy site can be removed by suction. If the trachea completely separates during manipulations, anastomosis may be performed. The incision should be closed with a small-sized, monofilament, absorbable suture material encompassing at least one tracheal ring on each side of the tracheotomy incision.¹⁹ A simple interrupted pattern is best performed by pre-placing the encircling sutures. Knots should be placed external to the tracheal lumen. Intraluminal granuloma formation at the sutures is common. Soft tissue, skin and subcutaneous closure are routine.

A lateral thoracic approach to the trachea can be used in very small birds where there is no other means to approach and evaluate the syringeal area. Practice and microsurgical techniques are essential for this procedure. The patient is positioned in right lateral recumbency. An incision is made over the second and third ribs. These ribs are exposed using blunt dissection, and they are transected at both ends to allow their complete removal. This will expose the cranial portion of the lung. Using a moistened cotton-tipped applicator, the cranial extent of the lung is gently dissected and reflected from its attachments. The jugular vein, pulmonary artery and branches of the subclavian artery may be identified and should be avoided. Dissecting between these vessels allows visualization of the syrinx, which is incised (2 to 3 mm) using bipolar radiosurgical forceps at its junction with the left primary bronchus. A foreign body may then be removed using a combination of tracheal endoscopy, visualization and suction through the syringeal incision.

The syringeal incision is allowed to close by second intention. The ribs are not replaced. The lung is repositioned in its normal location. Soft tissues are apposed and the remainder of the closure is routine. This is a difficult procedure that should be used only as a life-saving technique when all other methods for foreign body removal have failed.

Devocalization

The authors and editors consider devocalization a cruel and unethical practice; therefore, a procedure will not be described. Birds with vocalization patterns that are unacceptable to a client should be placed in new homes.

Pneumonectomy

Removal of lung tissue may be indicated in the treatment of abscesses or granulomas. In some instances,

a surgical lung biopsy may be required instead of an endoscope-guided biopsy for diagnosis of a respiratory disease.²⁰

In birds, there is no distinct pleural space, and the visceral and parietal pleura are in close approximation. The pulmonary parenchyma is contoured to the dorsal aspect of the ribs and the intercostal spaces. This makes the lungs easy to approach surgically. Compared with mammalian lungs, those of birds are more vascular and the intrinsic clotting mechanism appears to be less efficient.

The lungs can be approached through the caudal thoracic air sac or the intercostal space by removing one or more ribs as described for the lateral approach to the syrinx. The affected lung tissue is elevated from the ribs and surrounding structures using a moistened cotton-tipped applicator or a spatula. The affected area is isolated using vascular clips, and the tissue to be removed is incised such that the clips remain with the viable portion of lung. No studies have been conducted to determine the amount of lung that may be removed or the physiologic effects of partial pneumonectomy; however, clinically, partial pneumonectomy patients appear to function normally.²⁰

Closure is accomplished using wire suture to oppose the intact ribs on each side of the thoracotomy site. For a caudal thoracotomy, the pubis may be utilized to aid in closure of the gap created by the removal of ribs.

Surgery of the Gastrointestinal System

Pharyngostomy Feeding Tube

Pharyngostomy feeding tubes are indicated when it is necessary to aliment the patient while bypassing the oral cavity, esophagus or crop. The technique is simple and straightforward. The right side of the neck at the caudal extent of the lower mandible is prepared for surgery. A small incision is made through the skin, and the esophagus is identified. A moistened cotton-tipped applicator is inserted per os into the esophagus to aid in identification and to prevent the incision from penetrating the opposite side of the esophagus. A small (1 to 2 mm) stab incision is made into the esophagus to allow passage

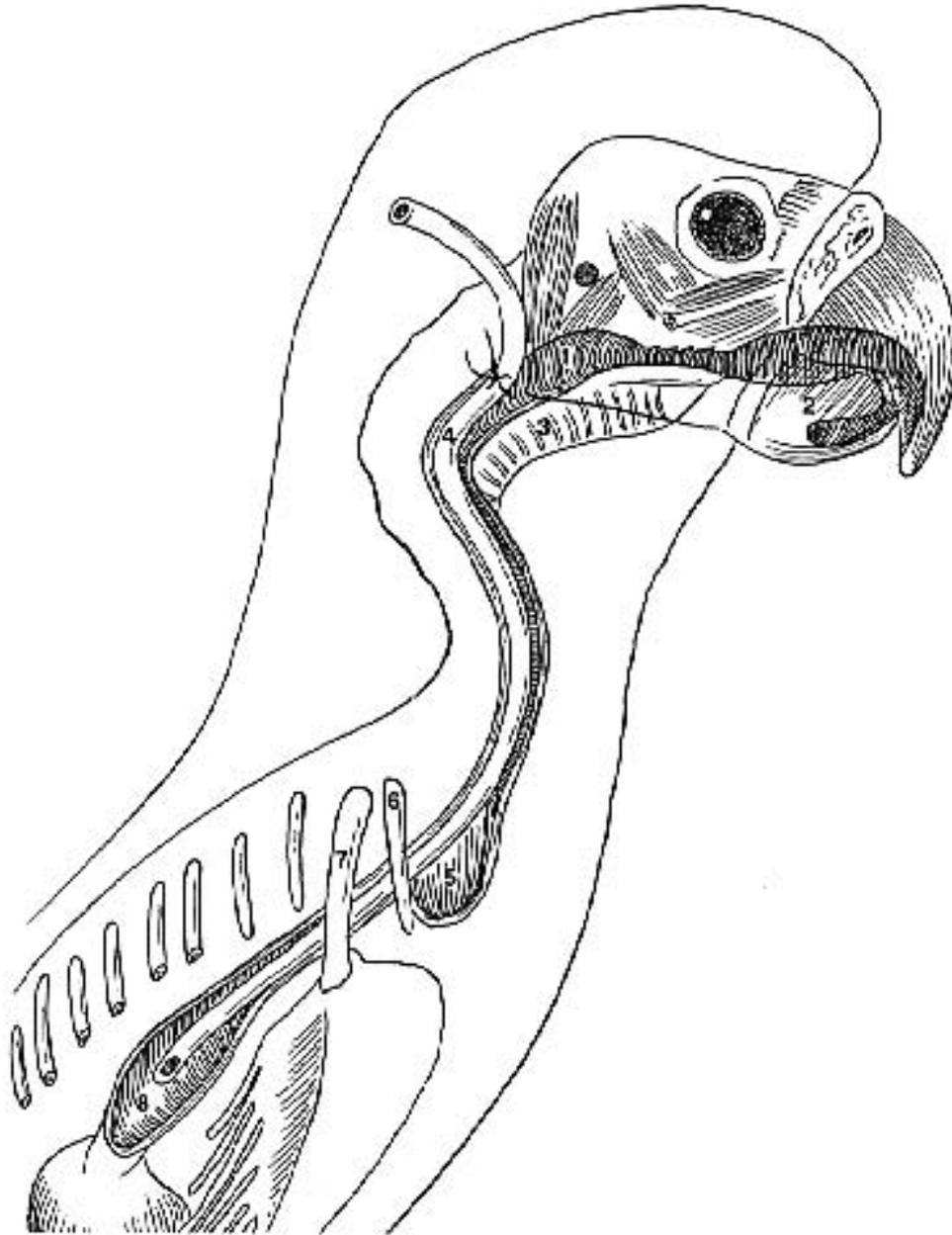


FIG 41.10 A pharyngostomy tube can be used to supply food to the proventriculus and bypass the oral cavity, esophagus and crop. 1) pharynx 2) tongue 3) trachea 4) tube in esophagus 5) crop 6) clavicle 7) coracoid and 8) proventriculus.

of a feeding tube. The tube is advanced into the crop or lower esophageal sphincter and sutured in place (Figure 41.10). A bandage is used to protect the site and to direct the tube to the dorsal cervical area away from the patient's field of vision. When it is no longer needed, the tube is removed, and the esophagus and skin defects are allowed to heal by second intention.

■ Oropharyngeal Abscesses

Oropharyngeal abscesses in birds frequently occur secondary to hypovitaminosis A (see Color 13). Abscessation occurs following squamous metaplasia and the development of a bacterial infection. These may be located at the base of the tongue, the intermandibular space, the choana, the pharynx or the larynx (see Color 8). These abscesses are often highly

vascular necessitating careful dissection and hemostasis for removal.

Surgical management of an oral abscess involves pretreatment with antibiotics and vitamin A (if indicated). A fine-needle aspirate may be used for culture and sensitivity. In cases of hypovitaminosis A, parenteral vitamin A administration will help encapsulate the abscess and reduce inflammation and vascularization. In some cases, beta carotene therapy has resulted in complete resolution of the abscess without the need for surgical intervention.

Abscesses that are lanced and curetted frequently recur because minute fragments of material may be located within the tissue surrounding the abscess. The abscess will reform when the mucosa heals over the trapped necrotic debris. Removing the tissue surrounding the abscess is preferable. In some locations, such as with intermandibular abscesses, the abscess and its capsule may be removed intact. Dissection is meticulous and time-consuming, and accurate hemostasis is imperative.

Choanal abscesses must be lanced to remove necrotic material followed by surgical removal of the abscess. Laser or radiosurgery are best for controlling hemorrhage in this highly vascular area. Invasive abscesses may erode the palatine artery and result in severe hemorrhage.

■ Oropharyngeal Papillomas

Oral papillomas are uncommon except in some macaw species. These masses can be removed using cryosurgery, radiosurgery or chemical cautery (silver nitrate). Papillomatous growths that extend into the crop and proventriculus are currently considered untreatable, and are eventually fatal.

■ Esophageal Perforation

Esophageal perforation may occur from using a rigid feeding tube for supportive alimentation in a struggling bird, in enthusiastic, violently bobbing neonates or from feeding overheated formula (see Color 30). As the tube penetrates the esophagus, food or medication may be deposited in the subcutaneous tissues (Figure 41.11). Additional material may accumulate during subsequent feedings. Edema, sepsis and toxemia occur in response to the foreign material. Emergency and supportive care should be instituted. A proventricular feeding tube should be placed to bypass the damaged esophageal tissue. Fascio-

tomy, copious irrigation, debridement, topical antiseptics and systemic antimicrobials are indicated. Surgical debridement and closure may be possible in three to five days when the affected tissues begin to granulate and appear healthy. Extensive fasciotomy and copious irrigation are probably the most important portions of the initial treatment.

■ Esophageal Strictures

A case of esophageal stricture of undetermined etiology in a Hyacinth Macaw was successfully treated by bougienage.⁵⁶ The stricture was located in the thoracic esophagus and was believed to be obstructing the flow of ingesta to the proventriculus. Initially a 5 Fr rubber feeding tube was the largest bougie that could be inserted. Three sessions of bougienage separated by a few months produced an increase in lumen size to accommodate an 11 Fr bougie. Attempts to pass larger tubes produced an intense vagal response. Following this treatment, the patient was able to eat solid food. No steroids were administered; however, the owner instituted therapy involving non-steroidal anti-inflammatory medications (ibuprofen and naprosyn).

■ Crop Fistula Repair

The primary function of the crop is storage of food. When the crop is full of food, it is often prominent and pendulous, making it more susceptible to trauma.¹⁶ Penetrating wounds can result in the formation of a fistula in the crop. Such wounds are often the result of animal bites, improperly assisted feeding technique, foreign body ingestion, trauma and consumption of excessively hot food items.¹⁶ A permanent fistula may form because food will pass continuously from the crop through the defect in the crop and skin and out into the environment (see Color 30).

Crop fistulae occur most commonly in neonates being hand-fed. The crop of neonates is more fragile and susceptible to injury than the adult ingluvies.¹⁶ One source of injury to the neonatal crop is penetration resulting from improper or careless gavage tube-feeding. This allows food to escape from the esophagus or crop and collect under the skin, creating an abscess and potential toxemia. Early diagnosis and treatment are essential for optimum recovery.^{1,16,25} Crop burns may also occur if a hair dryer is used to dry a wet bird.¹ Crop burns most frequently occur when food is warmed in a microwave oven and not thoroughly mixed.^{1,4,25} Microwave ovens do not heat

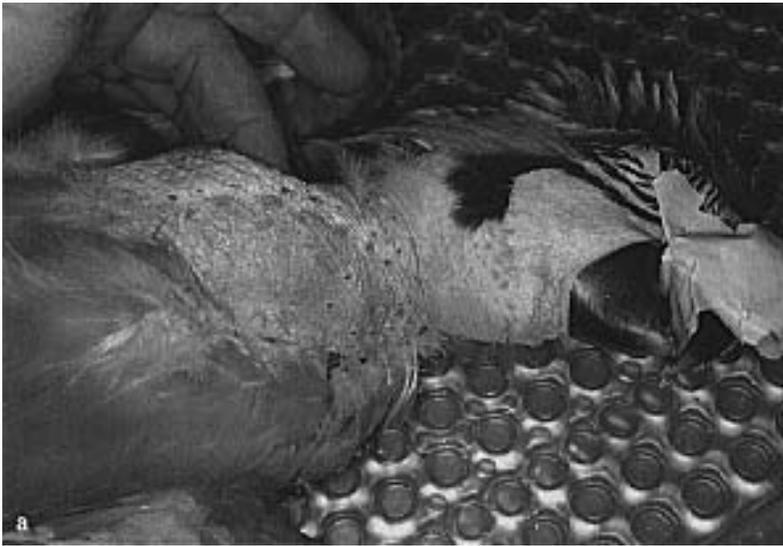


FIG 41.11 a) A 15-week-old Blue and Gold Macaw chick that was still being tube-fed was presented with a soft, mobile swelling of the right lateral neck area and thoracic inlet. The bird was depressed, regurgitating and losing weight. **b)** An esophageal tear that was allowing food to collect subcutaneously was located in the mid-neck area. The skin tissues overlying the accumulated food were excised, and the subcutaneous tissues were flushed with copious amounts of warm LRS. Penrose drains were placed to facilitate flushing of the subcutaneous tissues.



food uniformly and generate areas where the food is excessively hot.

Crop burns may be small or very extensive. Immediate treatment consists of removing the hot food and replacing it with cool water.²⁵ The patient should be placed on antifungal medication and a systemic antibiotic. Small frequent feedings should be used to minimize the stretching force placed on the crop. Small burns may not be noticed immediately and may develop fistulae. Birds with crop burns may present in the acute phase when it is difficult to determine the extent of the injury, or in the chronic stage when a well developed fistula is present.

Chronic crop fistulae are generally easier to deal with than acute crop burns (Figure 41.12). Because a fistula has developed, the serosa of the ingluvies and the skin have healed together as one tissue. These must be separated using scissors to circumferentially excise the edge of the fistula. Using meticulous dissection, the tissue plane between the ingluvies and the skin is identified and separated. The skin is normally adherent to the crop, being attached by two layers of striated muscle that form a sling-like support for the diverticulum of the crop.^{1,37} Once the two tissues are separated, closure is as described for ingluviotomy. It is important to repair the crop as a

separate structure from the skin to minimize the chance of dehiscence, which is more likely to occur if the two are closed as one tissue. Placement of a tube from the mouth through the crop into the distal esophagus or into the proventriculus will aid in identifying the crop lumen.

In some cases, the crop may develop a defect while the skin remains intact,¹⁶ causing an accumulation of food in the subcutaneous space that may be misdiagnosed as crop stasis (Figure 41.11). The affected skin should be opened, the subcutaneous tissues debrided, the crop and esophagus closed and the skin defect managed as an open wound. The wound should be evaluated periodically and debrided of any food material or necrotic tissue accumulates. Once the subcutaneous tissues are healthy, the skin defect may be closed or it may be left to heal by second intention.

Cases of acute crop burn are significantly more challenging than chronic crop injuries. Severe cases of crop burn may be fatal as a result of metabolic changes, sepsis and absorption of toxins from necrotic tissues. Initial treatment should be supportive and should include shock therapy, broad spectrum antibiotic therapy and antifungal medication. In cases of severe burns with significant edema, fasciotomy may be beneficial.¹³ The affected area should be

liberally opened, copiously irrigated and left to heal by second intention or a delayed closure performed at a later date. In less severe cases, clinical signs may simply be consistent with a “sick bird:” lethargy, anorexia and fluffed appearance.¹⁶

The feeding regimen will need to be changed in order to bypass the damaged tissues. This can be accomplished using a needle catheter intestinal feeding tube¹¹ or by tube-feeding directly into the proventriculus. It is important to instruct the owner on proper methods for tube-feeding, and it must be stressed that the proventriculus cannot hold the same volume of food as the ingluvies; therefore, feedings will be more frequent and of smaller volume.

In most cases, it will be three to five days before the delineation between healthy and devitalized tissues becomes apparent,¹ and it may take as long as 7 to 14 days.⁴⁵ Prior to this, it will be difficult to determine what tissue should be removed and what is viable and should remain. Burned tissue becomes pale and edematous and then becomes dry, dark and leathery. Eventually, the devitalized tissue will separate from viable tissue and the edges of the crop and skin will heal together, forming a fistula (see Color 30).

Any tissue that is obviously necrotic should be debrided to reduce the body’s burden of necrotic tissue. If a skin and crop defect result from this debridement, this defect can be used to intubate the proventriculus for nutritional support and also to cleanse and apply topical antiseptics to reduce the chances of developing fungal or bacterial infections.

The definitive correction should be postponed until approximately five days after the injury when the demarcation between healthy and devitalized tissue is apparent.¹ It is often beneficial to endoscopically examine the crop prior to planning the surgery. A small catheter can be used to inject air and dilate the crop, and an endoscope can be used to detect avascular, darkened areas. It is important to evaluate the entire crop, because devitalized mucosa may occur away from the primary burn. The aboral extent of the crop at the thoracic inlet is a location where devitalized areas are often missed.

At surgery, all necrotic tissue must be removed and the tubular structure of the esophagus and ingluvies reestablished. In some cases this may be very challenging, as major portions of crop may be devitalized. If possible, the length of the crop should be maintained even if only a thin strip of esophageal tissue remains. Esophageal strictures are more likely to

occur if a resection and anastomosis have been performed than if a thin strip of normal esophagus is preserved and allowed to granulate over a stent. If enough viable tissue remains, it may be sutured around a pharyngostomy feeding tube, through which the patient can receive alimentation while the crop is healing. The crop will stretch in time, but the patient must be fed frequently small volumes of soft or liquid diets until the capacity of the ingluvies increases.¹ Where indicated, a Penrose drain may be placed to provide postoperative local drainage and may also be used for wound irrigation.¹⁶

In cases where there is extensive tissue loss, the defect may be allowed to heal by second intention while maintaining the patient with a pharyngostomy feeding tube. If the defect is so large that wound contraction cannot occur, a dermoplasty may be performed once there is a healthy bed of granulation tissue. A rotating skin flap will generally provide tissue to cover the defect.

■ Inguvotomy

Neonates are susceptible to ingestion of foreign objects such as substrate materials, especially if they are underfed. Feeding tubes, small toys and unhulled seed may also be ingested.⁴ These objects may interfere with the passage of food and may irritate the lining of the ingluvies.⁴ Palpation of a persistent lump in the crop, food retention, delayed crop emptying and regurgitation are clinical signs associated with crop foreign bodies.

Small objects may be retrieved from the crop using a flexible endoscope and a biopsy instrument. Many foreign bodies including feeding tubes can be pal-

CLINICAL APPLICATIONS

How to Repair a Crop Fistula (Figure 41.12)

- Intubate the patient and pack the esophagus with moistened gauze to prevent flush solution from entering the pharyngeal area.
- Remove any necrotic tissue and thoroughly clean the underlying bed of granulation tissue with a dilute chlorhexidine solution.
- Once the tissue defect is thoroughly cleaned, debride the edges of the fistula to remove granulation tissue and completely separate the crop from overlying skin.
- Separate the skin and crop further by careful blunt dissection with strabismus scissors.
- Perform the closure in two layers. The crop is initially closed with an inverting suture pattern making certain that the incision line extends past the defect on both ends. The skin can be closed in a simple interrupted pattern.

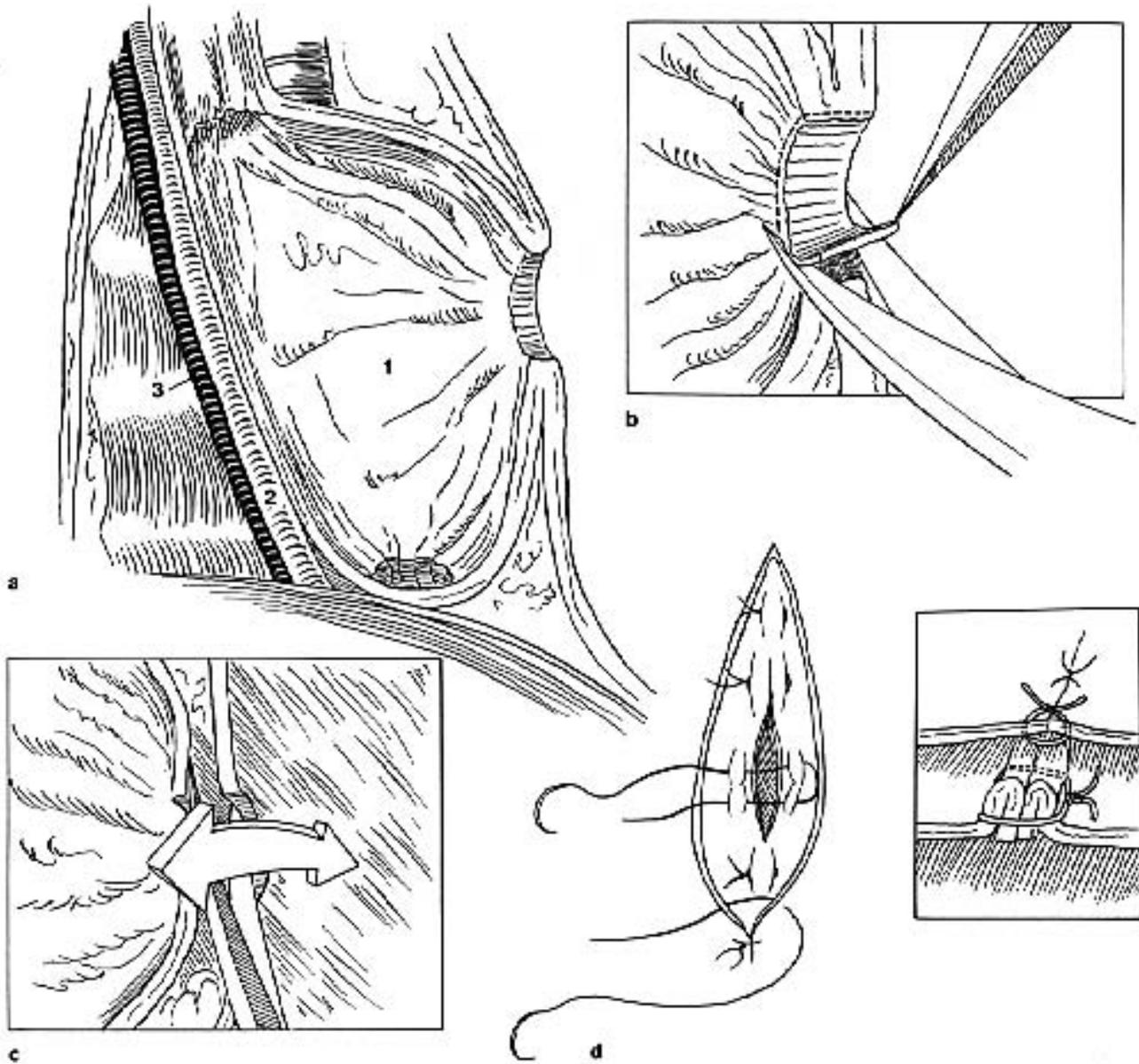


FIG 41.12 Crop burns frequently result in the formation of fistulas that must be surgically repaired. The surgical closure of a burn should be delayed as long as possible to allow the body to differentiate between healthy and devitalized tissue. **a)** Fistula in the crop. **b)** The wall of the fistula is debrided and **c)** the skin and crop are separated by blunt dissection. **d)** The crop is sutured with an inverting suture pattern and the skin is closed with a simple interrupted pattern. 1) crop 2) internal carotid artery and 3) jugular vein.

pated and removed using a hemostat. Instilling a dilute water-soluble lubricant into the crop may help prevent iatrogenic injury to the crop and esophageal wall.²⁵ If the object is to be digitally manipulated out the pharynx, traction on the head can be used to stretch the neck, allowing the object to be pushed into the pharynx. This is not as easy as it sounds, and care must be taken to prevent iatrogenic injury to the crop, esophagus and mouth.⁴

Indications for ingluviotomy include foreign body removal,^{1,29} placement of a feeding tube and gaining endoscopic access to the proventriculus and ventriculus.⁵⁵ To perform an ingluviotomy (Figure 41.13), the patient is positioned in dorsal recumbency with the head elevated and the esophagus occluded with moist cotton to prevent fluids from refluxing into the oral cavity. An incision is made through the skin, only over the cranial edge of the left lateral sac of the crop. The skin incision can be made using a radiosurgical

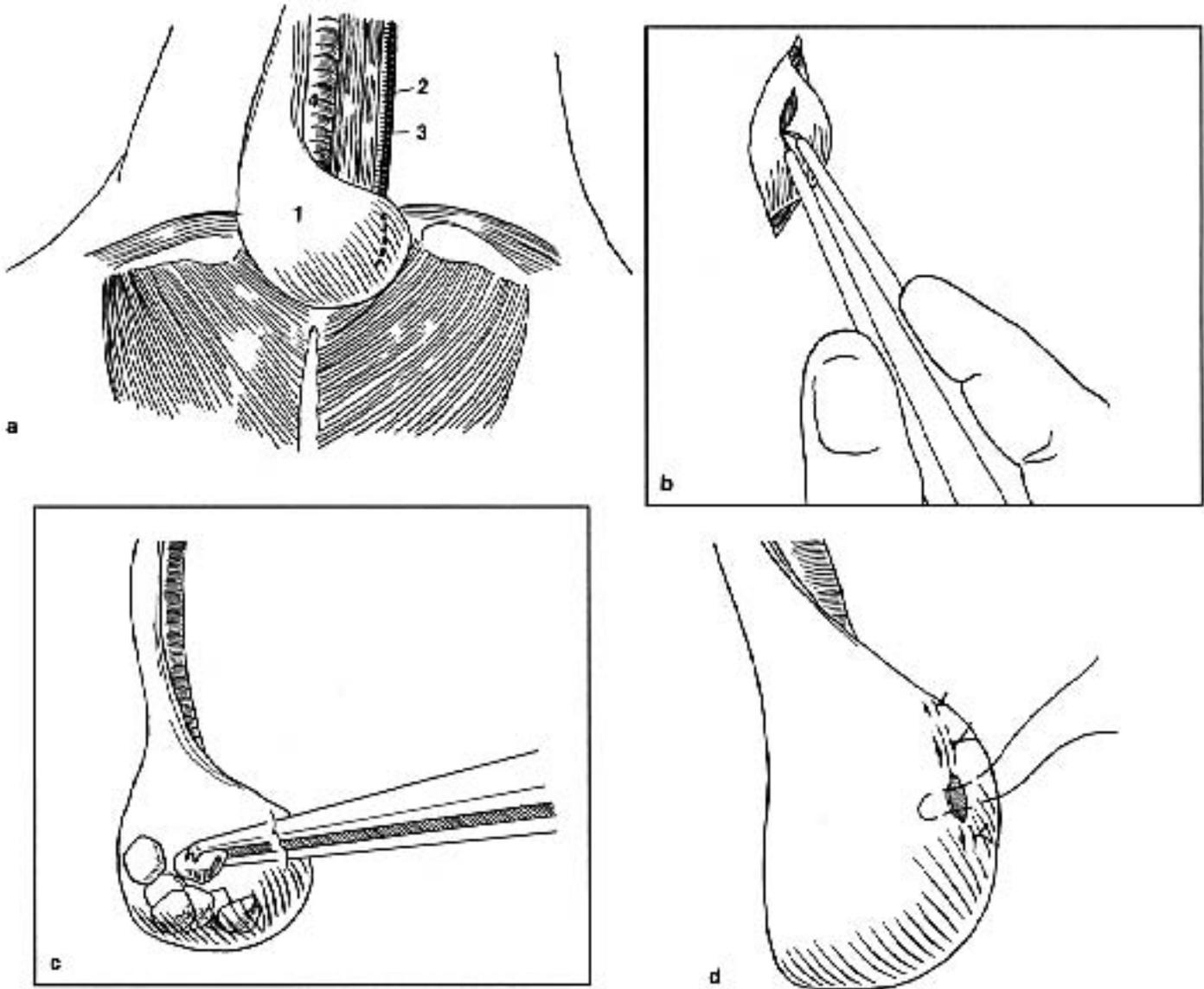


FIG 41.13 Ingluviotomy may be indicated to remove foreign bodies or to gain endoscopic access to the proventriculus and ventriculus. **a)** A skin incision is made over the left lateral portion of the distended crop. **b)** A sharp incision is made into the crop. Specific bleeding can be controlled with radiosurgery, but the incision in the crop should not be made using this unit. **c)** Foreign materials can be removed with forceps or by flushing with dilute chlorhexidine. **d)** The crop and skin are closed in separate layers. 1) crop 2) internal carotid artery 3) jugular vein and 4) trachea.

unit. This area of the crop is less subject to stress as the crop fills and is out of the path of a feeding tube. Because of the ability of the ingluvies to stretch, the incision should be made only about half the size necessary to accomplish the procedure; however, having adequate exposure is more important than having a small incision, and retrieval of large foreign bodies through small ingluviotomy incisions should not be attempted. The crop generally heals without complication. The crop incision should be made with a blade in an avascular area. Radiosurgery should be used to seal only specific vessels. Use of the radiosur-

gical forceps will result in unnecessary tissue trauma. The opening can be enlarged as needed. The incision is closed using an inverting technique with an absorbable material swaged on an atraumatic needle. Two-layer inverting patterns are frequently recommended;⁴ however, one layer of simple continuous appositional sutures over-sewn with an inverting pattern is effective and is less compromising on the size of the crop lumen. The crop may be inflated with saline or air to check for leakage prior to skin closure. Foreign bodies can be removed manually or impacted material can be removed by flushing.

■ Celiotomy

Surgical approaches to the abdomen involve invasion of the air sac, allowing anesthetic gas to escape through the celiotomy site. This effect can be minimized by packing the borders of the incision with saline-moistened gauze sponges. Additionally, an air sac cannula may be introduced into the abdominal air sac on the side contralateral to the surgical incision. This will allow anesthetic gas to enter an intact air sac, pass through the lung and out the trachea. Using this technique, anesthetic gas does not escape from the surgery site, and waste gas can be scavenged from the trachea. For any celiotomy, the patient should be positioned with the cranial part of the body elevated 30 to 40° to prevent irrigation fluids from flowing cranial and entering the lungs following incision of the air sacs. Similarly, patients with ascites should have the fluid removed from the coelomic cavity prior to opening the air sacs. Moistened cotton may be placed in the caudal pharynx to occlude the esophagus and prevent proventricular reflux from entering the oral cavity and causing aspiration pneumonia. The celiotomy approaches used for access to the avian abdomen include left lateral, ventral and transverse. Skin incisions can be made in varying arrangements and combinations depending on the surgical procedure and the degree of abdominal exposure that is required (Figure 41.14).

Left Lateral Celiotomy

A left lateral celiotomy provides the best exposure of the proventriculus, the ventriculus, the female reproductive tract and the left kidney (Figure 41.15).^{15,24} With the patient in right lateral recumbency, the caudodorsal border of the sternum can be palpated. The pelvic bones, including the cranial extent of the pubis, should be identified. The left leg should be retracted as far caudally as possible, creating a fold of skin (knee web) in the flank extending from the stifle to the lateral margin of the sternum. In small patients, lung tissue can be visualized per cutaneously through the intercostal spaces between the fifth, sixth and seventh ribs. In larger birds, the latissimus dorsi and iliotibialis cranialis muscles obscure visualization of the lung. The skin incision will extend from the cranial extent of the pubis to just dorsal to the uncinat process of the fifth or sixth rib. The incision is started in the knee web and continued ventral and caudal following the boundaries of the postventer and postlateral regions, passing through the groove of the groin web caudally to the region of the pubic bone. Care should be taken to incise only the skin, which is easily accomplished using the

modified bipolar radiosurgical forceps. Once the skin is incised, the left leg may be further retracted caudally and somewhat dorsally to expose the abdominal wall. A branch of the superficial medial femoral artery and vein should be identified passing over the lumbar fossa toward the pubis. These vessels should be sealed or ligated prior to incising the musculature. The radiosurgical body wall incision is initiated in the external abdominal oblique muscle, just caudal to the last rib. The incision is extended caudally through the internal abdominal oblique and transversus abdominis muscles to the cranial extent of the pubis.

The intercostal vessels coursing along the cranial border of the last two or three ribs should be ligated or coagulated. In small birds, these vessels may be sealed by inserting the indifferent electrode inside the thoracic wall, lightly opposing the electrodes, withdrawing the electrodes until the cranial aspect of the rib is encountered, then activating the electrodes. In larger birds, it is best to cut the rib, clamp the vessel cranial to the rib to achieve hemostasis, then identify the vessel visually and apply a hemostatic clip. In larger birds, the caudal-most two or three ribs will need to be transected at their dorsal and ventral extents and removed to achieve adequate visualization of the viscera. In small birds, excision of the ribs may not be required. They may be fractured and retracted dorsally to provide proper exposure. This method is preferred, because closure of the incision is easier. Once the incision is made through the musculature, the shiny surface of the caudal thoracic or the abdominal air sac is visualized. In some patients, the lung extends caudally as far as the seventh rib. Care must be taken to prevent lacerating the lung, which can be gently elevated using a moistened cotton-tipped applicator if necessary.

A Heiss, Alm or mini-Balfour retractor should be positioned to maintain retraction of the body wall. Entering the air sac, the surgeon can visualize the lung parenchyma and the hilus of the caudal thoracic air sac entering the lung at its craniodorsal extent. Dorsally, the liver lobes become thin at their margins, and the wall of the proventriculus can be observed. If the abdominal air sac is entered instead of the caudal thoracic air sac, the lung is not visible, but will lie dorsolateral to the incision rather than cranial as observed when entering through the caudal thoracic air sac. Medially, the proventriculus can be seen suspended by the air sacs and suspensory ligaments. Often the intestines are the first structures encountered. They can be gently retracted using a cotton-

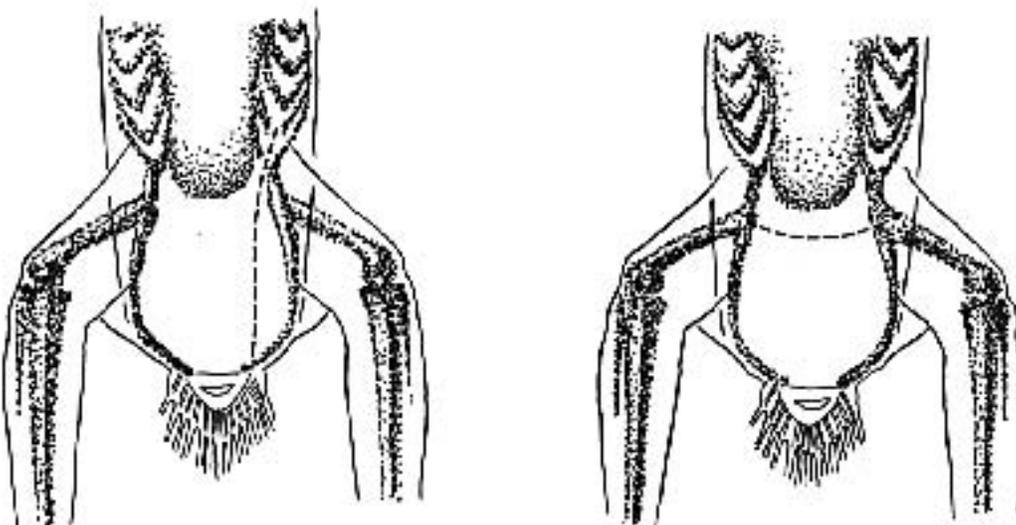
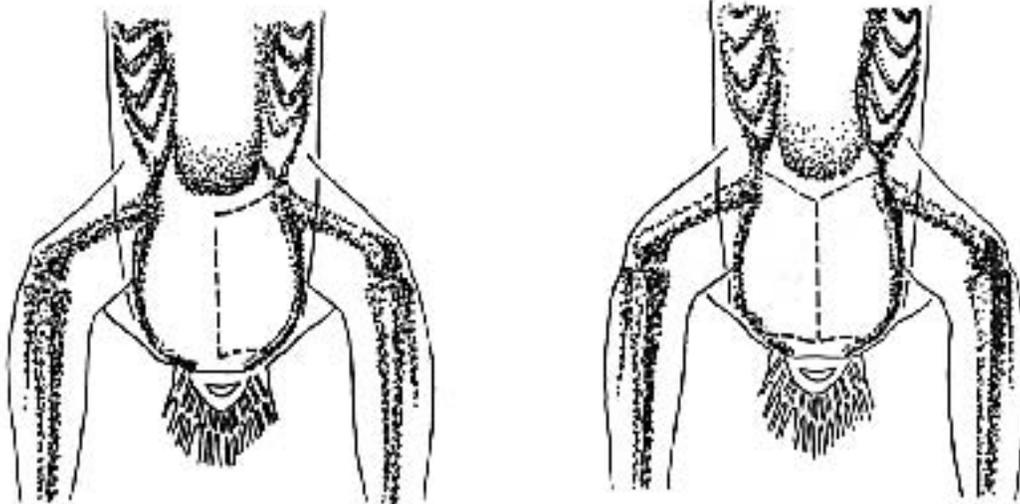
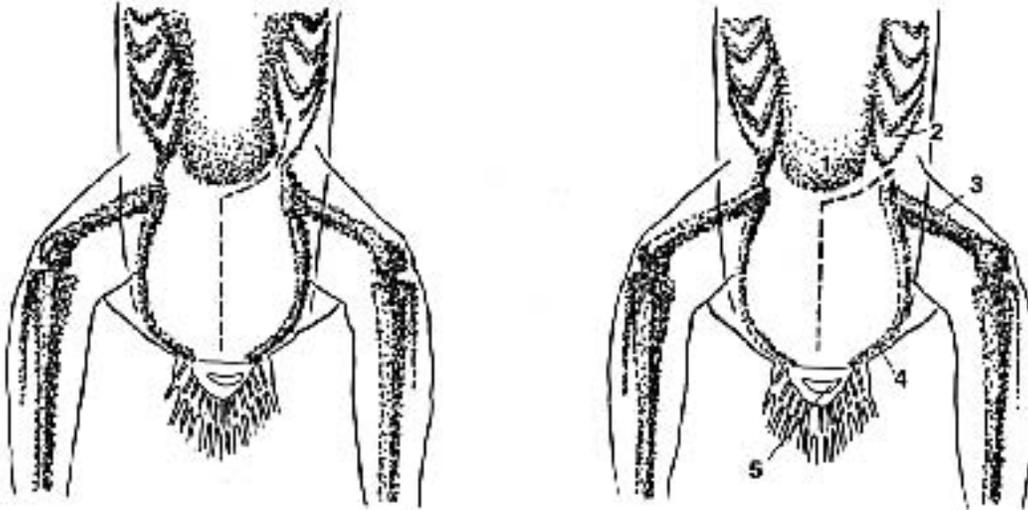


FIG 41.14 Several different celiotomy incisions can be used to gain access to the abdomen of birds. 1) sternum 2) eighth rib 3) femur 4) pubis and 5) vent.

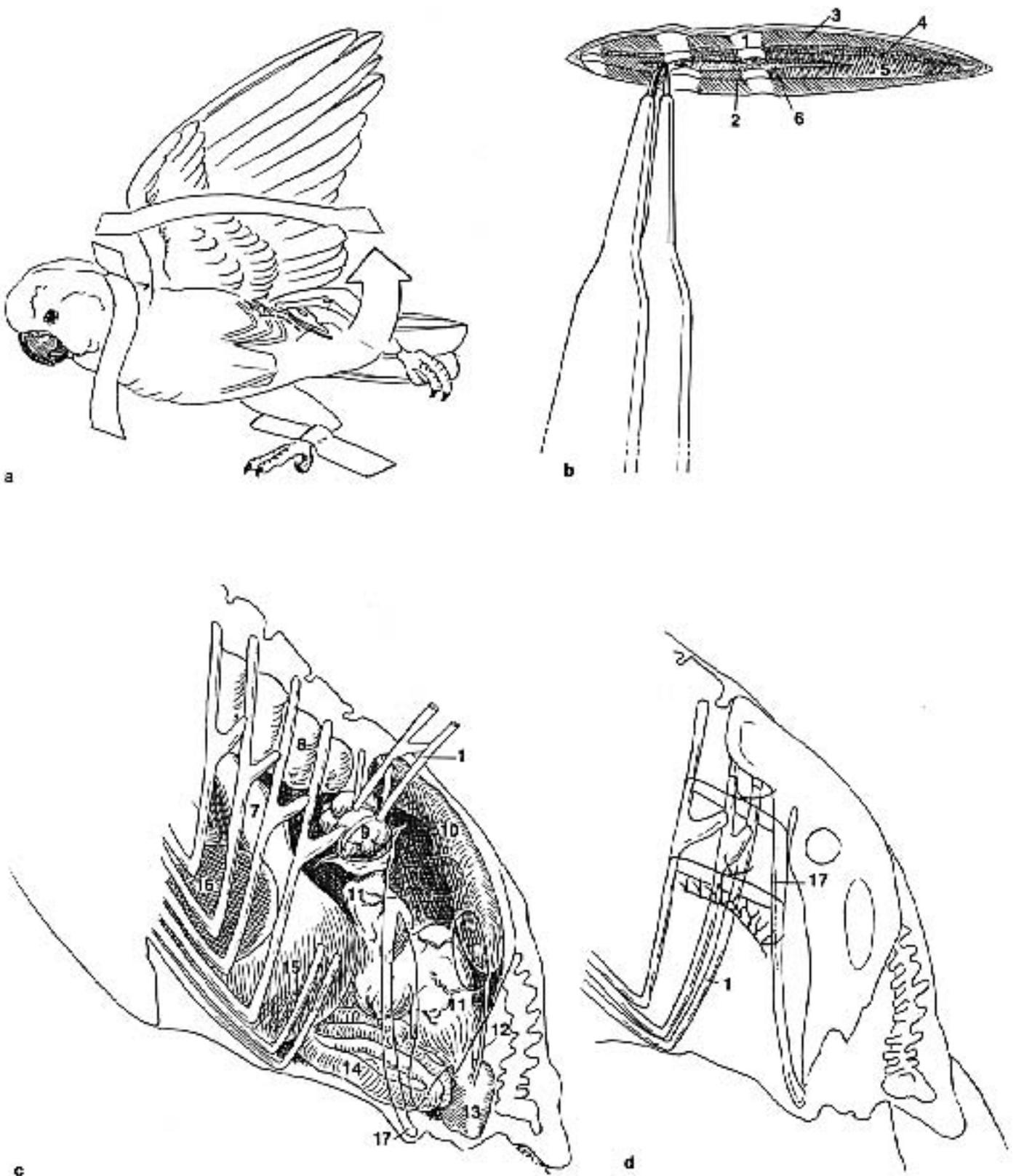


FIG 41.15 a) To perform a left lateral celiotomy, the bird is placed in right lateral recumbency, the leg is retracted caudally and a skin incision is made as shown. b) The intercostal vein and artery on the edge of the ribs are coagulated using bipolar radiosurgery. c) This approach provides the best access to the proventriculus, ventriculus, female reproductive tract and left kidney. d) Closure of the skin and muscles can be facilitated by placing sutures between the rib and the pubis to reduce pressure on the incision line. 1) eighth rib 2) intercostal artery, vein and nerve 3) external oblique muscle 4) internal oblique muscle 5) transversus abdominis muscle 6) air sac 7) proventriculus 8) lung 9) ovary 10) kidney 11) oviduct 12) ureter 13) cloaca 14) intestine 15) ventriculus 16) liver and 17) pubis.

tipped applicator. The intestines are fragile and should not be manipulated with toothed forceps, which will create severe bruising and potential perforation. Once the intestines are retracted caudally, the kidney may be identified at the dorsomedial aspect of the coelom. The ovary or left testicle should be encountered at the cranial division of the kidney. The adrenal gland is located between the gonad and the cranial division of the kidney, but may be obscured if the gonad is large. Obesity and hepatomegaly result in topographical changes in the abdominal anatomy, emphasizing the need to practice on a variety of cadavers with a variety of conditions prior to performing a celiotomy in a clinical patient.

If the seventh and eighth ribs have been removed, closure will require the placement of tension sutures from the abdominal musculature to the sixth rib. Sutures passed around the pubic bone may be necessary when closing large incisions.

Ventral Midline Celiotomy

A ventral midline celiotomy is used primarily for surgery of the small intestines, liver biopsy, egg-related peritonitis, abdominal masses, egg binding and repair of a cloacal prolapse. This approach provides access to both sides of the coelomic cavity.

The skin is incised in the midpostventer region from the sternum to the interpubic space (see Figure 41.14). The linea alba is usually broad and easily identified. It must be incised carefully because the duodenum crosses from left to right just inside the body wall. It is best to initiate the incision between the pubic bones over the cloaca. Once a two millimeter incision is initiated, it may be extended cranial to the level of the sternum. If exposure is limited, the incision may be extended to one or both sides approximately two millimeters from the sternal border creating a muscular flap. Further exposure is achieved by extending the incision along one or both sides of the pubic bones in a similar fashion. This approach provides the best exposure to mid-abdominal masses, uterine masses and generalized abdominal disease (peritonitis). The size of the incision should be sufficient to allow a procedure to be performed, but as small as possible to minimize tissue damage and air sac disruption, and to make it easier to maintain anesthesia. If it is necessary to approach a large area of the abdomen, it is often best to open and close each area before proceeding on to another area.

Closure of the body wall is accomplished using simple interrupted or simple continuous, monofilament, synthetic, absorbable suture material. Skin closure is routine.

Transverse Celiotomy

Transverse celiotomy provides exposure to a large area of the abdomen.^{1,24,51,53} The bird is positioned in dorsal recumbency and the postventer region is prepared. A transverse skin incision is made midway between the sternum and the vent (see Figure 41.14).¹ The abdominal wall is lifted and incised with care to avoid lacerating the underlying intestines. The ventriculus and duodenum are the first organs encountered, but may be reflected to expose the cranial aspect of the cloaca, the middle and caudal lobes of the kidneys and the lower reproductive tract of hens. The abdominal wall and skin are sutured separately using 4-0 to 6-0 synthetic, monofilament, absorbable material in a continuous or interrupted pattern.

Proventriculotomy and Ventriculotomy

The stomach of birds is divided into an orad, glandular portion (the proventriculus) and the aborad muscular ventriculus (gizzard). The isthmus or intermediate zone separates these two structures, and the pylorus controls the emptying of ingesta from the ventriculus into the duodenum. In carnivorous birds, the crop is underdeveloped so the bird relies on the stomach for digestion and as a storage organ. These birds often have a large, thin-walled stomach with a poorly developed isthmus and little distinction between the proventriculus and ventriculus. The proventriculus tears easily when excessive tension is applied. The ventriculus is composed of dense muscle and fascia and holds sutures well, but is more difficult to seal with suture and cannot be inverted.

Proventriculotomy is most often indicated for the removal of foreign objects or toxic materials (such as lead or zinc-containing coins) from the proventriculus or ventriculus that cannot be retrieved using rigid or flexible endoscopes.¹⁰ A definitive diagnosis of neuropathic gastric dilatation requires a ventricular biopsy, although there are some discussions that biopsies of the crop may provide similar information. In an Umbrella Cockatoo that had ingested sticks, the proventriculus was determined to be distended based on radiographs.²¹ The tentative diagnosis of neuropathic gastric dilatation could not be confirmed by biopsy of the ventriculus. Several pieces of glitter and 72 small green sticks were surgically removed. Although techniques for ventriculotomy have been de-

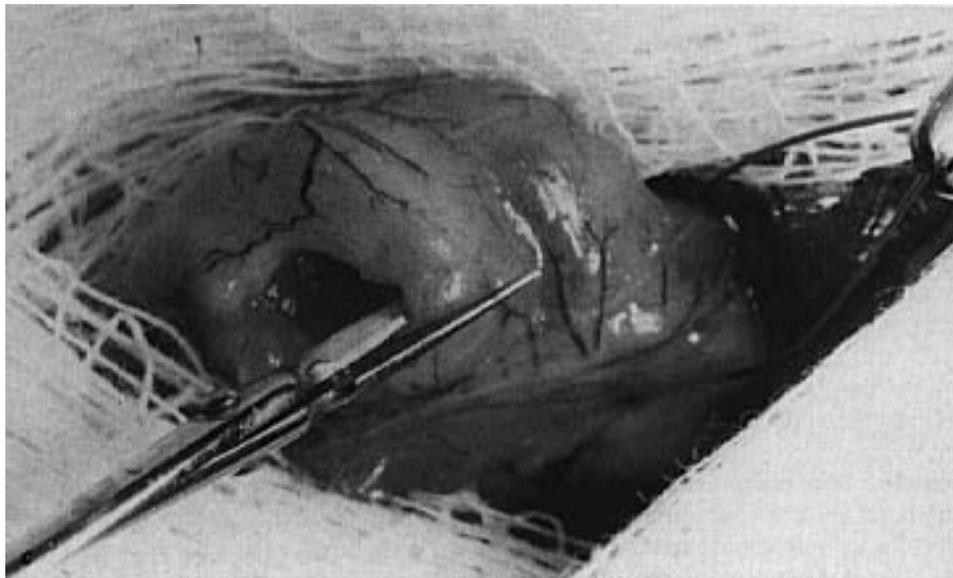
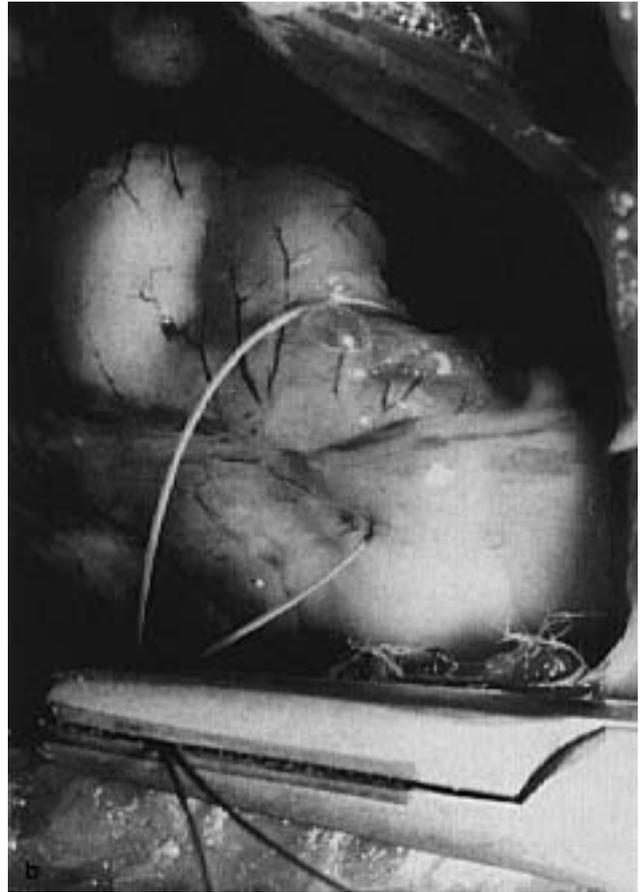
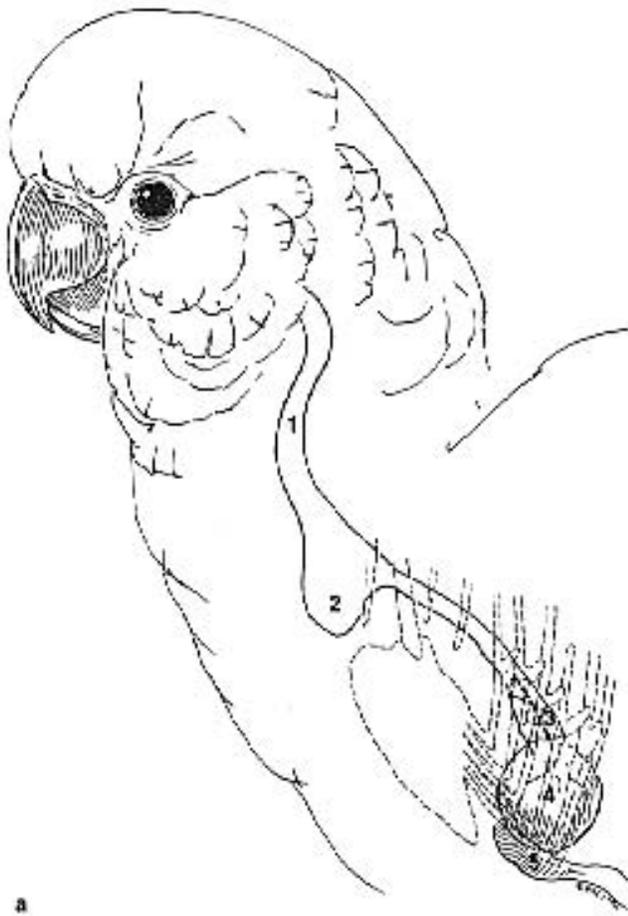
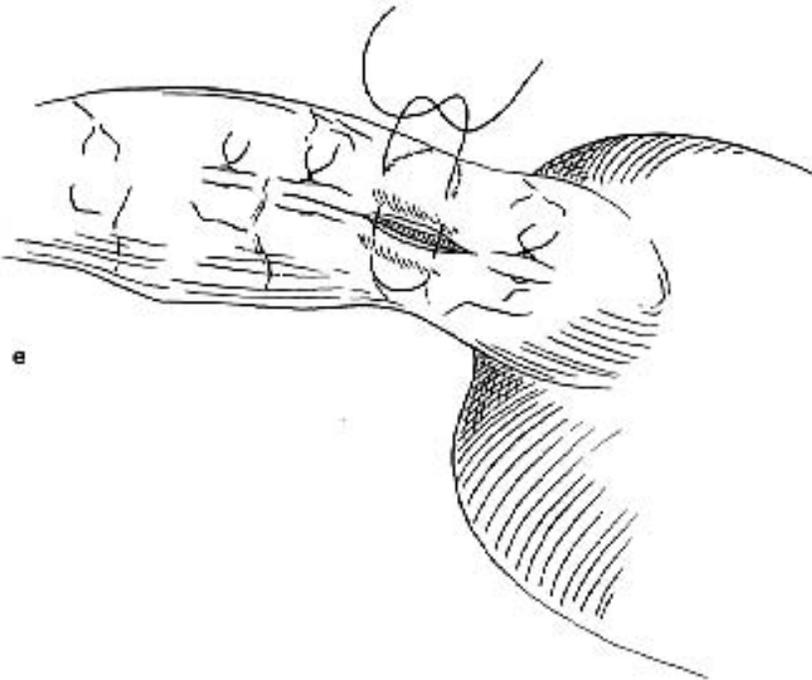
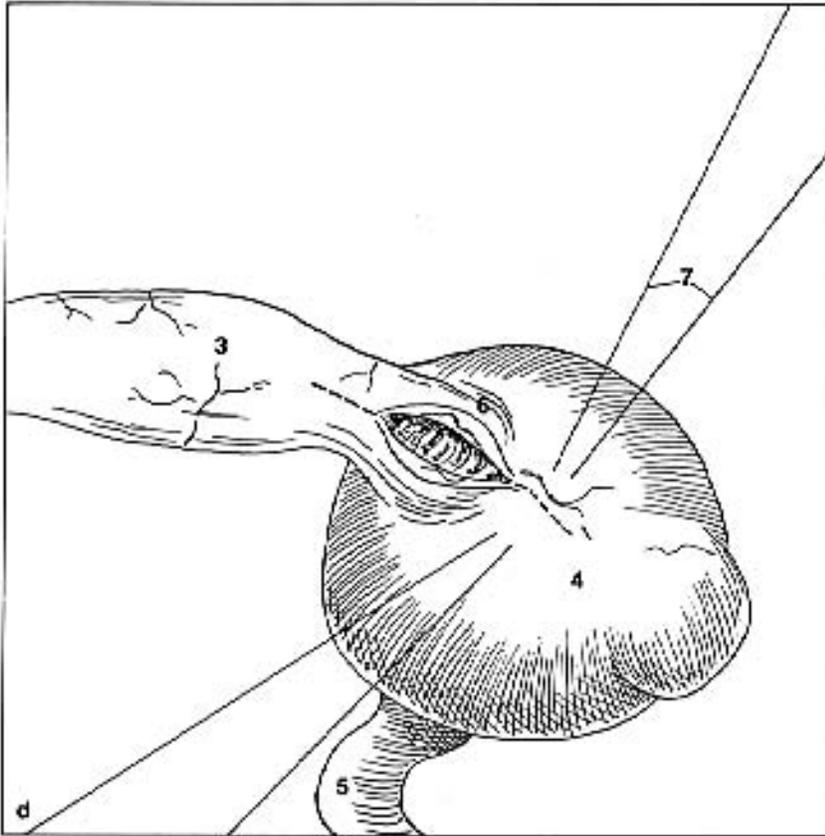


FIG 41.16 a) A proventriculotomy is indicated in patients with foreign bodies that cannot be removed by lavage or endoscopy. The proventriculus is approached through a left celiotomy incision site as shown. b) Stay sutures can be placed in the ventriculus (not the proventriculus) to improve control over the position of the organ. c) The incision into the proventriculus should be made with a blade and extended into an avascular area with scissors. Note that stay sutures are used to exteriorize the proventriculus, and the abdomen has been isolated with moistened gauze pads. (continued next page)



d) Radiosurgical forceps should be used only for controlling hemorrhage and not for making incisions into viscera. **e)** Closure is routine, using an inverting suture pattern. 1) esophagus 2) crop 3) proventriculus 4) ventriculus 5) duodenum 6) isthmus 7) stay sutures.

scribed they are generally avoided because of the vascularity and slow healing characteristic of this organ.^{1,5,6,10,22}

A left lateral celiotomy approach will provide exposure of the ventriculus and proventriculus (Figure 41.16). The ventral suspensory structures are bluntly dissected to allow the proventriculus to be retracted caudally. The proventriculus in some birds is quite fragile and toothed forceps should be avoided. Stay sutures may be placed in the ventriculus to aid with exteriorization and manipulation of the proventriculus. Stay sutures should not be placed in the proventriculus. The coelomic cavity should be packed off with moist gauze sponges to prevent contamination of the abdominal cavity with gastric contents.

The isthmus or intermediate zone is identified as a constriction between the ventriculus and the proventriculus. The vessels on the surface of the proventriculus are easily identified and avoided. The proventriculotomy incision is initiated at the isthmus and extends orad into the body of the proventriculus. Hemorrhage from the cut edge of the proventriculus may be controlled using radiocoagulation. Thumb forceps may be used to gently clamp the cut edge to occlude the vessel, allowing it to be identified and appropriately coagulated. Proventricular contents should be removed using suction. Small spoons or curettes may be used to remove solid contents. A combination of irrigation and suction is useful to completely evacuate the proventriculus and ventriculus. A small diameter flexible endoscope may be used per os, or through the proventriculotomy to assure that all foreign objects have been removed.

The proventriculotomy is closed using a simple continuous appositional pattern of a fine, synthetic, monofila-

ment, absorbable material over-sewn with a continuous or interrupted inverting pattern such as a Cushing or Lembert pattern. The inverting pattern should extend beyond the actual incision to ensure an adequate seal. The closure may be evaluated for leakage using an orogastric tube to insufflate the proventriculus with air or sterile saline.

Food and water should be offered in the immediate postoperative period. The wound strength immediately following suture placement is stronger than during the debridement phase of wound healing, which occurs three to five days postoperatively. Unless one intends to withhold food until wound strength begins to increase again (the phase of fibroplasia), fasting for one to two days postoperatively is not indicated. Incisional leakage of gastric contents occurs with some frequency in birds.³⁵ The lack of an omentum may be partially responsible for this complication. Meticulous attention to proper closure is vital to prevent leakage. A small, atraumatic needle should be used with a continuous suture pattern to provide the best seal. If the proventricular wall appears thin and friable, the potential for postoperative incisional leakage may warrant placement of a duodenal feeding tube. This will allow enteral alimentation of the patient while bypassing the gastric incision.

The ventriculus is best approached through a proven-triculotomy incision. The incision in the isthmus is extended aborad toward the ventriculus. The opening into the ventriculus can be gently dilated to allow the introduction of instruments appropriate for removal of ventricular contents. Some surgeons suggest that a ventriculotomy (transverse abdominal approach) is easier than a proventriculotomy (left lateral approach). The lighter-colored, elliptical area of the ventriculus, where the muscle is thin and the fibers can be seen to course in a different direction from the remainder of the ventriculus, is the location where the incision is made (see Anatomy Overlay).¹ The incision is made transversely across the muscle fibers into the lumen. At closure, sutures must be placed close together to prevent leakage, because a serosal seal cannot be created by using an inverting suture pattern.

Intestinal Surgery

Surgery on the intestines may be necessary to repair an accidental enterotomy created during a ventral midline celiotomy or to debride necrotic bowel secondary to constrictions caused by adhesions (see Color 14). These cases generally carry a poor-to-grave prog-

nosis. A midline, flap or transverse celiotomy may be appropriate, depending on the location of the lesion. In most circumstances, microsurgical technique is indicated due to the extremely thin nature of the avian intestine. The blood supply to the small intestine is via the celiac artery (to the duodenum) and the cranial mesenteric artery (jejunum and ileum). The technique used to anastomose the bowel requires microsurgical manipulation of 6-0 to 10-0 monofilament suture on a one-fourth circle atraumatic needle. Typically, six to eight sutures are used for an end-to-end anastomosis in a simple interrupted appositional pattern. Side-to-side anastomosis may prove to be more appropriate in birds and is easier to perform.

Intestinal Feeding Tubes

Enteral feeding tubes may be indicated for a variety of conditions in which a diseased portion of the alimentary tract must be bypassed to provide nutritional supplementation to anorectic and debilitated patients. A variety of medical and surgical conditions including crop infections, impaction, injury or inflammation, esophageal perforation or laceration, proventricular dilatation, beak disorders, pharyngeal disorders and any condition resulting in hypophagia or anorexia places a nutritional demand on the patient that may not be met by oral alimentation. Proper attention to the patient's nitrogen balance can make the difference between success and failure of therapy (see Chapters 15 and 40).

A technique for placement of a duodenostomy tube has been described in domestic pigeons.¹¹ Four of the five catheterized birds had minor weight loss after 14 days of total nutritional support through the enterostomy tube (4% to 10%). Within seven days of tube removal, all the birds had regained their normal weight.

The catheter is placed through a ventral midline incision. The ascending duodenum is easily identified by its close association with the pancreas (see Anatomy Overlay). A "through-the-needle" catheter (indwelling jugular catheter) is used with the needle passing first through the left abdominal wall, then into the descending loop of duodenum. The catheter diameter should be less than one-third the diameter of the intestine.¹¹ The catheter is advanced through the descending and ascending loops of duodenum (4 to 6 cm), and the needle is withdrawn from the intestine and body wall. One or two sutures are placed between the left body wall and the duodenum at the entry site of the catheter to secure the intestine to the body wall and allow a seal to form (monofila-

ment 5-0 prolene). The midline celiotomy is closed routinely.

The catheter is secured to the outside left abdominal wall using a “finger trap” technique. The needle is protected within its “snapguard,” and the snapguard is bent to conform to the contour of the bird’s body. The snapguard is then sutured to the skin to secure it in place. The catheter is brought caudal to the leg and under the wing. The excess is coiled and the catheter is secured to the lateral and dorsal body wall using two sutures. The catheter is flushed with saline to assure patency, and an injection cap is placed to create a sealed system for alimentation.

Once the caloric need is calculated (see Chapter 40), the amount of liquid diet required is calculated based on the caloric density of the diet (usually 1 ml = 1 kcal). A variety of liquid diets is commercially available and their compositions have been described (see Chapter 15).⁴¹ The amount should be divided into equal volumes and injected four to six times daily at a rate of approximately 1 ml/15 seconds to allow the intestine to accommodate the volume. The catheter should be flushed with water or LRS (1 to 2 ml) before and after injection of the diet to prevent plugging.

The catheter should be maintained a minimum of five days to allow a seal to form between the intestine and the body wall.¹¹ If the catheter is dislodged prematurely, leakage of intestinal contents may occur. Once the catheter is no longer needed, the finger trap suture is cut, the catheter removed and the defect left to heal by second intention.

Hypertonic diets may cause osmotic diarrhea. Daily weight and biochemistry changes can be used to alter the volume and content of the liquid diet. Patients that have a tendency to disturb the catheter should be fitted with a neck brace.^k

■ Cloacal Prolapse

Cloacopexy is indicated to correct problems with chronic cloacal prolapsing. This condition appears to be most common in Old World psittacine birds, especially cockatoos, and is associated with reduced sphincter tone. Chronic gram-negative enteritis may be an initiating factor,² underscoring the need for cloacal cultures as part of the patient evaluation process. The attachments of the cloaca are damaged, allowing the entire structure to prolapse, which may cause occlusion of the ureters and colon. Minor prolapses may respond to placement of a mattress su-

ture on either side of the cloaca; however, when the entire organ prolapses, this method of treatment is ineffective. If mattress sutures are used, they must allow for the passage of droppings. An alternative method involves the placement of two sutures transversely across the vent. These must be placed close enough together to prevent recurrence of the prolapse, but far enough apart to allow the normal passage of droppings. These sutures may be left in place from a few days to several weeks depending on the clinical situation. Purse-string sutures are contraindicated due to frequent postsurgical cloacal atony secondary to nerve damage.

A percutaneous cloacopexy may be performed as a temporary or definitive treatment for cloacal prolapse.³³ The prolapse is reduced using a moistened cotton-tipped applicator. The applicator is maintained within the cloaca to help identify its limits, and two or three sutures are placed percutaneously through the skin, body wall and urodeum. The sutures should be removed in two to four weeks. This procedure carries the risk of inadvertently entrapping or perforating the ureters, rectum, duodenum and pancreas.

In some cases, prolapse is due to atony of the vent sphincter. This condition may be treated by surgically narrowing the vent opening. One-half to three-fourths of the margin of the circumference of the vent is incised to provide a cut surface for healing. Simple interrupted sutures are placed from one side of the vent to the other in order to partially close the opening. This will decrease the size of the vent opening permanently, preventing prolapse of the cloaca.

A rib cloacopexy is an effective treatment for severe cloacal prolapse.⁴⁷ A ventral midline celiotomy is performed and the cloaca is identified (Figure 41.17). This approach provides exposure to the entire cloaca and its associated structures. It may be necessary to use a moistened cotton-tipped applicator or the finger of a gloved assistant to reduce the prolapse and define its limits intraoperatively. Fat on the ventral surface of the cloaca should be excised. This appears to be crucial for a successful surgery.⁴⁸ The ribs are pushed caudally using the thumb, and the surgical incision is elevated with the index finger, bringing the ribs into view to facilitate suture placement. A suture is placed around the last rib on each side of the bird and passed through the full thickness of the ventral aspect of the cranio-lateral extent of the urodeum. The suture should be tied with enough tension to slightly invert the vent. Large sections of

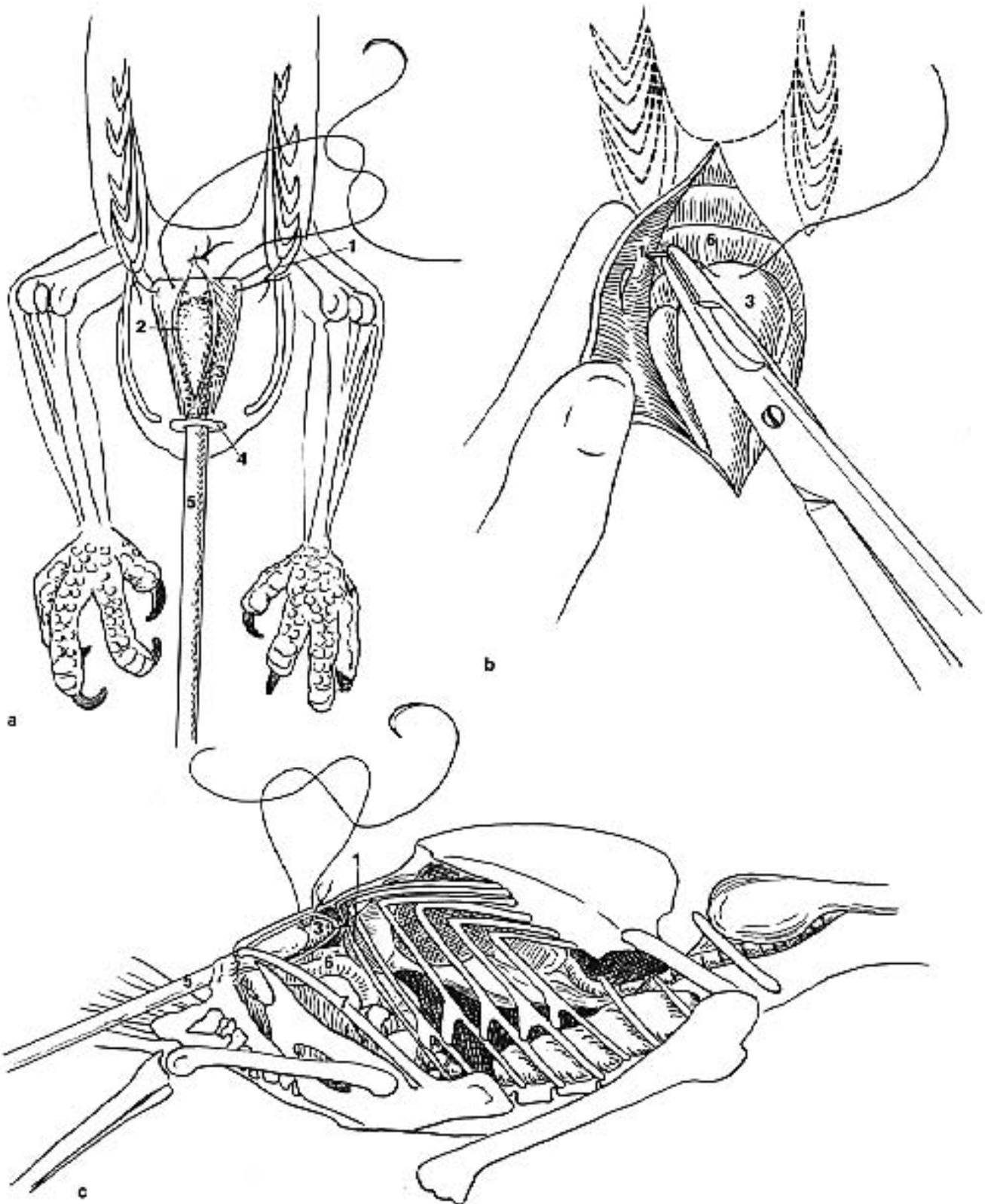


FIG 41.17 A rib cloacopexy is indicated to permanently correct chronic cloacal prolapse. **a)** The cloaca is pushed cranially with a moistened cotton-tipped applicator and sutures are placed between the cranio-lateral border of the cloaca and the eighth rib. **b)** Pushing the eighth rib caudally with a finger will help in the placement of sutures. **c)** Lateral view of the cloacopexy procedure showing the placement of the suture between the cloaca and the eighth rib, and the suturing of the cloaca to the abdominal wall during closure. 1) eighth rib 2) skin incision 3) cloaca 4) vent 5) swab 6) intestines and 7) pubis.

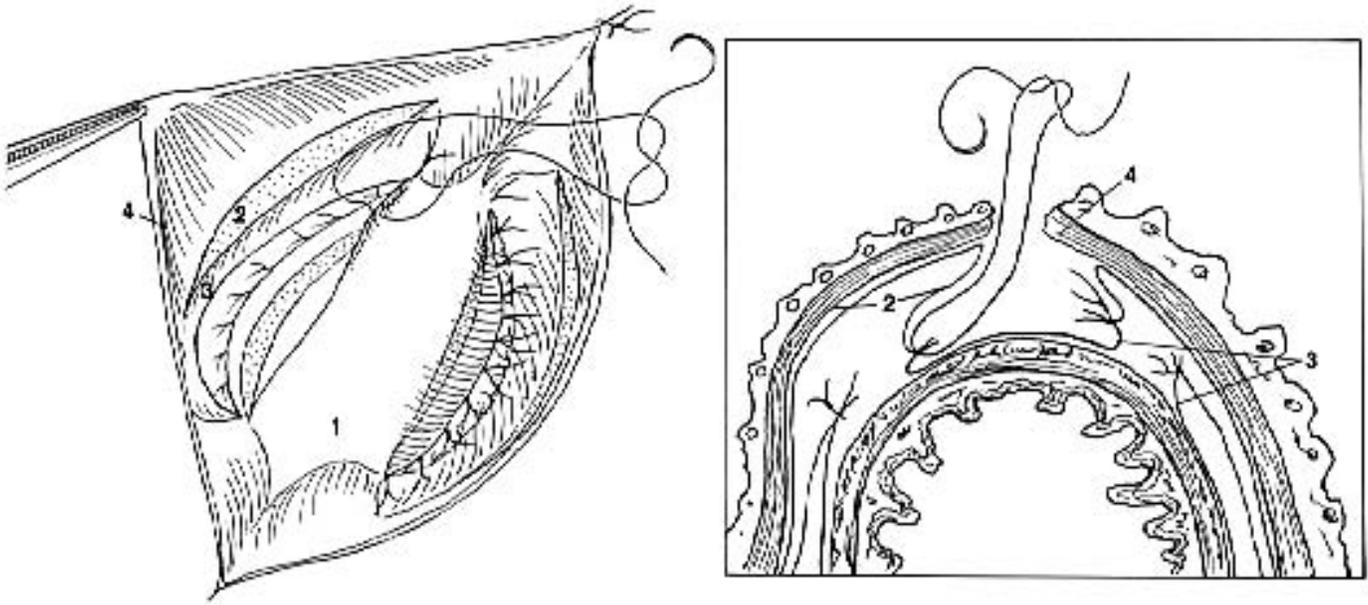


FIG 41.18 An alternative cloacopexy technique is to make a ventral midline incision and place three or four sutures that appose the subserosal surfaces of the cloaca and internal body wall. 1) cloacal wall 2) pleuro-peritoneum 3) seromuscular layer of the cloaca and 4) body wall.

tissue must be used for suture placement, and it appears to be important to penetrate the cloacal lumen. Several other sutures are then placed between the body wall and the wall of the cloaca. The cloaca may be sutured to the caudal border of the sternum instead of the ribs, if the rib sutures place excessive inverting tension on the cloaca. This procedure may not be effective in birds with a thin-walled cloaca.

Another method for performing a cloacopexy has been described.²³ A 2 to 5 mm incision is made in the serosal surface of the coprodeum parallel to its length and 5 to 10 mm from the midline (Figure 41.18). A corresponding paramedian incision is made in the peritoneal surface of the body wall at a point that will maintain the cloaca in a position that will result in slight inversion of the vent. Three or four sutures are placed between each side of the two incisions such that the serosal surfaces are sutured and the subserosal surfaces of the two structures are apposed. This procedure is repeated on the contralateral paramedian side.

Alternatively, a routine ventral midline incision may be made, the cloaca reduced and the associated fat excised. The abdomen is closed incorporating the cloaca. The suture passes through one side of the body wall, through the full thickness of the cloaca and through the other side of the body wall in a

simple interrupted pattern (Figure 41.19). Skin is closed over this layer.

A transverse abdominal cloacopexy may provide more even distribution of tension than a ventral midline approach.² The transverse incision is made

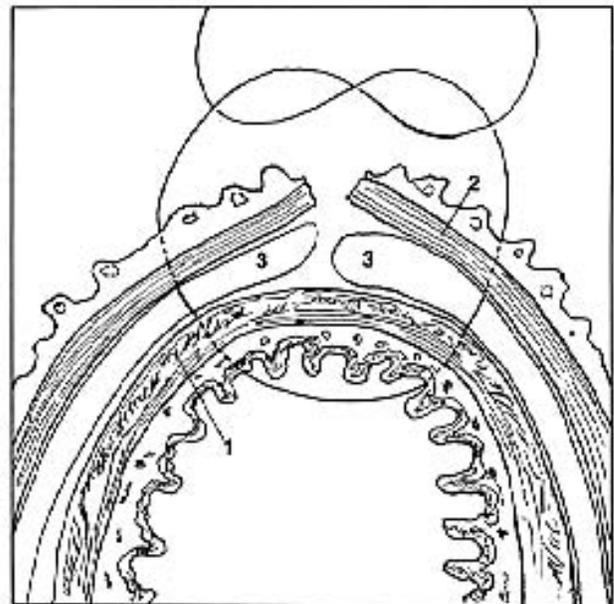


FIG 41.19 A simple cloacopexy technique that involves full-thickness suturing of the cloaca into a ventral midline incision may be effective in resolving mild cases of cloacal prolapse. 1) cloacal wall 2) body wall and 3) peritoneal cavity.

through the skin and abdominal musculature in the postventer region. The cloaca is incised to the level of the submucosa, and the seromuscular layer is then sutured to the incision in the abdominal wall. The abdomen and skin are closed routinely.

Surgery of the Reproductive Tract

Surgery on the female reproductive tract is most often indicated in cases of egg binding, ectopic ovulation, soft-shelled eggs, congenital atresia of the oviduct, damage to the uterus, salpingitis, neoplasia, abnormal egg production, biopsy and culture of the oviduct and egg-related peritonitis.^{8,14,24,42,48,57} Generally, only the left side of the female reproductive tract is functional. The right oviduct may become cystic in older fowl,⁴³ and this condition has been reported in a budgerigar (see Color 29).¹⁸ A left lateral flap or ventral midline celiotomy approach may be used, depending upon which portion of the reproductive tract is to be evaluated.

Egg Binding

Egg binding occurs commonly in companion birds and has been associated with a genetic predisposition, improper nutrition, atony of the uterus, oversized eggs, inexperience of the hen, tumors of the reproductive tract and extraluminal compression of the reproductive tract by abdominal masses.^{14,18,34,48,53} In one case of egg binding, a cystic right oviduct was compressing the left reproductive tract, preventing normal migration of the egg.¹⁸ Both oviducts were successfully removed, relieving the dystocia. In an Isle of Pines Amazon Parrot, an oviduct defect allowed deposition of uncalcified eggs into the abdominal cavity. Five eggs were successfully removed from the coelom. A hysterectomy was performed after two more eggs were deposited into the abdomen and surgically removed the following year.⁵⁷

Egg binding in birds is most commonly the result of malnutrition. If the egg remains in the uterus (shell gland), it will continue to deposit shell material onto the egg, further lowering systemic calcium levels. Any bird presenting for egg binding should be evaluated for hypocalcemia prior to planning surgery, and

any abnormalities should be addressed. Medical management including ovocentesis should be attempted prior to considering surgical intervention.

Prolapse of oviduct or uterine tissue occurs with some degree of frequency in egg-bound birds, especially budgerigars and cockatiels.^{47,48} It may occur following egg binding or from straining. The tissue may have been expelled through the vaginal opening into the cloaca and potentially externalized through the vent. As the tissue protrudes through the cloaca, it undergoes axial torsion, making it difficult to identify the lumen. Exposed uterine tissue becomes dry and necrotic within 30 to 60 minutes.

Ovocentesis

If medical management of egg binding fails, ovocentesis and collapsing the egg may be successful. Under general anesthesia, the opening of the vagina into the cloaca is identified. A blunt probe is used to dilate the opening. Once the egg is visualized, a needle can be inserted into the egg to aspirate its contents. Following ovocentesis, the egg can be collapsed and the shell fragments removed (see Chapter 29). The vagina and uterus should be flushed repeatedly to verify that all egg material has been evacuated. It is prudent to reconstruct the egg to be certain that all shell fragments have been retrieved. Alternatively, a radiograph may be valuable to rule out the presence of another egg or remaining fragments.

If the lumen is not identifiable, the prolapsed tissue may be incised to deliver the egg. Once the egg is removed, the layers of uterine wall should be sutured with a fine (6-0 to 10-0) monofilament, absorbable material on an atraumatic needle in a simple appositional or inverting pattern. If the patient's condition permits, necrotic tissues should be excised and viable tissues reconstructed. With critical patients, the damaged tissue should be replaced into the cloaca after removal of the egg, and debridement should be postponed until the patient's condition improves. If an egg or shell fragments remain in the oviduct, a celiotomy is indicated.

If the egg is near or within the pelvic canal, it may be delivered using an episiotomy-type incision.³³ The incision is made on the ventral midline through the cloacal sphincter extending cranial through the urodeum. If necessary, the incision may extend into the uterus. After the egg is removed, the uterus and cloaca are closed with a simple interrupted or simple continuous pattern of a slowly absorbable material. Closure of the body wall and skin are routine. This is

a radical procedure and is indicated only in critical cases in which the hen is likely to die or the egg is of major importance for species propagational purposes.

In cases where the egg is lodged farther cranial in the oviduct, it may be best to perform a midline celiotomy, and hysterotomy may be the best technique for removing the egg. The hysterotomy incision should be closed with a simple appositional continuous or inverting pattern of a fine monofilament synthetic absorbable material. Postoperatively, hormone therapy or photoperiod regulation should be used to prevent subsequent laying until the hysterotomy has healed. If hysterectomy is indicated, a left lateral approach is preferred to gain access to the entire oviduct.

Salpingohysterectomy

This procedure involves removal of both the uterus (shell gland) and the oviduct; therefore, the term salpingohysterectomy is most appropriate. Although hysterectomy is the term commonly used to refer to this procedure, the ovary is not removed. Salpingohysterectomy is indicated to terminate pathologic egg laying, alleviate egg binding, remove an infected or ruptured oviduct and to treat a prolapsed oviduct and recurring egg-related peritonitis.

Salpingohysterectomy carries a significant degree of risk and is generally not recommended as a preventive measure. Although cockatiels continue to have copulatory, nesting, territorial and egg-laying behavior following salpingohysterectomy, there is no evidence that problems related to the deposition of yolks into the abdomen occur.^{14,34} Presumably, a hormonal feedback loop from the uterus to the ovary prevents follicular development and release of ova.^{15,33,48} In a retrospective study of 30 birds on which salpingohysterectomy was performed, five were evaluated laparoscopically several months postoperatively.³⁴ Follicular development was noted; however, no large follicles were observed. Continued yolk release with subsequent yolk-related peritonitis was reported in a California Quail and a duck following routine salpingohysterectomy.⁴⁸

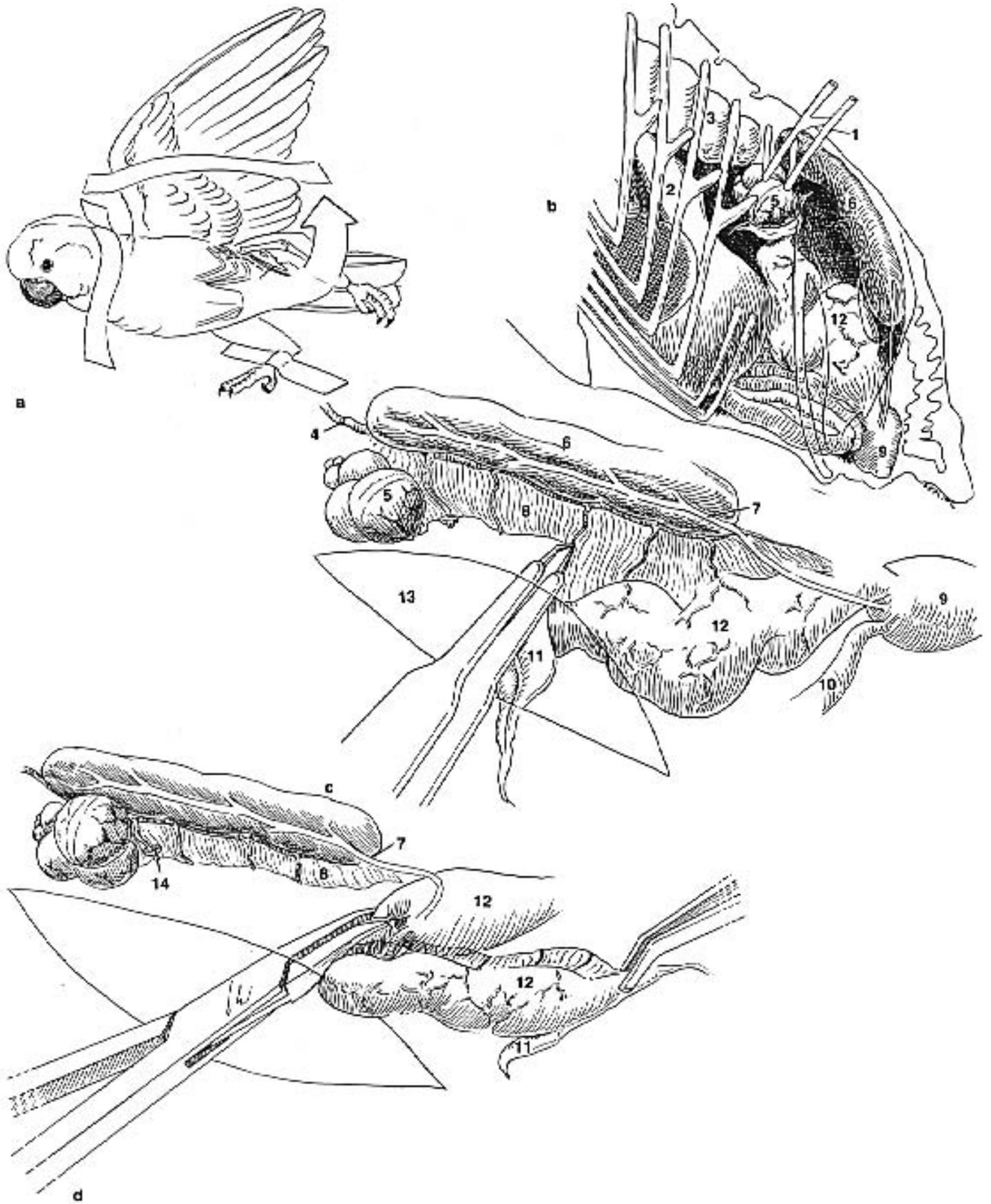
The size of the oviduct and uterus varies with the reproductive and physiologic status of the patient. The reproductive tract of a cockatiel that is not in breeding condition is narrow (2 to 3 mm). A bird in poor condition may also have a small, inactive ovary. A young bird in good condition with exposure to a

male may have a well developed ovary with large follicles and a large reproductive tract.

Salpingohysterectomy may be accomplished through a left lateral celiotomy (Figure 41.20). The ovary may be visualized following lateral and ventral retraction of the proventriculus. The oviduct and uterus lie convoluted along the dorsal aspect of the body cavity. The oviduct is identified and elevated away from the large caudal vena cava. Minor damage to this vessel will result in life-threatening hemorrhage. The ventral ligament causes the convolutions in the uterus and oviduct. The ligament courses caudally and collects as a muscular cord at the vagina. There are no vessels in this ligament, and it should be dissected to allow the oviduct and uterus to be stretched into a linear configuration.

The fibria of the infundibulum lie caudal to the ovary and may be elevated to expose the dorsal attachments. At the base of the infundibulum and coursing caudally along the uterus, the dorsal ligament suspends the uterus and a branch of the ovarian artery. A small blood vessel can be identified coursing from the ovary through the infundibulum. This vessel should be coagulated or a hemostatic clip should be applied to control hemorrhage. If it is inadvertently transected or broken, it will retract under the ovary in a virtually unretrievable location. A small piece of absorbent gelatin sponge^g may be packed against the ovary to achieve hemostasis. The remainder of this suspensory structure may then be dissected with the bipolar radiosurgical forceps.

Once the infundibulum is free, the oviduct is retracted ventrally and caudally, exposing the dorsal suspensory ligament. Several small blood vessels, branches of the ovarian artery, can be seen in this structure perpendicular to the oviduct and uterus. These should be identified and coagulated. Each vascular stump should be inspected for residual hemorrhage before closure. As this dissection is continued caudally toward the cloaca, the ureter can be identified as a white tubular structure extending from the kidney to the cloaca. This structure should be avoided. As the dissection approaches the cloaca, the uterus courses along with the terminal colon and enters the cloaca (see Anatomy Overlay). The uterus should be ligated at its junction with the vagina by placing one or two hemostatic clips a short distance from the cloaca. In cases where the vaginal tissue has been damaged, the clips may be applied at the cloaca, being careful not to entrap the ureter. The clips should be secure with the entire width of the uterus



within the clips to prevent leakage. If the clips become dislodged or do not completely occlude the uterus, feces and urates may reflux into the abdomen.

■ Egg-related Peritonitis

Egg-related peritonitis occurs most commonly in cockatiels, budgerigars, lovebirds, ducks, gallinaceous birds and macaws (see Color 29).⁴⁸ Diagnosis is made by clinical signs, hematology, radiography, abdominocentesis and laparotomy. A severe inflammatory response is typical of the hemogram.

Mild cases may respond to antibiotic therapy and supportive care (see Chapter 29). Surgical intervention is usually necessary to resolve severe cases.^{33,48} In some cases, surgery should be postponed and the patient treated medically until the condition stabilizes. A ventral midline celiotomy is preferred because fluids are easily drained out the incision rather than down into the air sacs, and potentially into the lungs. Once the celiotomy is performed, the intestines should be retracted using moistened cotton-tipped applicators or other suitable atraumatic instruments. Any yolk or tissue debris should be removed. The cavity should be copiously irrigated prior to closure. Implantation of Penrose drains may be indicated in some cases, but do not generally provide adequate coelomic drainage. This condition warrants a guarded-to-poor prognosis. Birds that recover frequently have abdominal adhesions, distention and muscular dysfunction.

■ Removal of the Gonads

Carbon dioxide laser destruction of gonadal tissue has been attempted; however, the procedure is very time-consuming and costly, and controlling damage to surrounding tissues, especially the adrenals, is very difficult. Removal of the gonads with laser in companion birds is often followed by severe hemorrhage either intraoperatively or postoperatively.

Alternatively, the vascular supply to the ovary may be destroyed using vascular clips, but this is a diffi-

cult procedure, performed without being able to visualize vital structures. Microsurgical equipment is essential. Clients should be informed that this procedure is extremely difficult and the possibility of complications is higher. The patient should be treated medically to reduce the size of the ovary and improve visualization. Through a left lateral celiotomy, the ovary is identified. A hemostatic clip is applied dorsal to (under) the ovary to occlude all ovarian vessels. In small birds, one clip applied from a caudal to cranial direction is adequate. Two clips, one from a cranial direction and the other from a caudal direction, may be required for large birds. Angled applicators should be used to place the clips under the ovary parallel to the spine, which reduces the possibility of inadvertently entrapping the aorta or peripheral nerves.

■ Orchidectomy

Neutering a male is theoretically easier than neutering a female because the testicles are not as adherent to deeper structures as the ovary, making clip application easier and safer. However, orchidectomy must be performed bilaterally, making a ventral approach more applicable than a left lateral approach. The placement of vascular clips is similar to that described for the ovary. Orchidectomy in companion birds is extremely difficult and many birds do not survive the surgery.

A technique for orchidectomy in ostriches has been described.⁴⁹ The procedure is indicated to control aggressive behavior in birds that present a danger to keepers, handlers, the public or other birds. The surgical approach is through the costal notch and lumbar fossa on each side. The skin and body wall are incised adequately to allow introduction of a gloved hand. The testicle on the corresponding side is palpated, grasped and twisted until it is torn from any attachments. It is recommended that the procedure be performed at the onset of breeding season when the testicles have begun to increase in size so they can be easily located. If performed during the breeding season, excessive hemorrhage may result from avulsion of the hypertrophied testicular vascular supply. Body wall, subcutaneous tissue and skin are closed routinely. The procedure can be accomplished through a single, lateral celiotomy incision if the surgeon has hands small enough to reach through to the contralateral testicle. Minor postoperative subcutaneous emphysema and occasional incisional dehiscence are the only reported complications.

FIG 41.20 (opposite) **a**) A salpingohysterectomy is performed through a left lateral celiotomy incision and is indicated to terminate pathologic egg laying and to prevent egg-related peritonitis secondary to a diseased oviduct. **b**) Regional anatomy for salpingohysterectomy. **c, d**) Hemostatic clips are shown passing through a left lateral celiotomy incision to provide a more realistic impression of the visibility through the incision site. 1) eighth rib 2) proventriculus 3) lung 4) aorta 5) ovary 6) kidney 7) ureter 8) suspensory ligament of oviduct 9) cloaca 10) rectum 11) infundibulum 12) oviduct 13) celiotomy incision and 14) hemostat clip.

Miscellaneous Surgical Procedures

Abdominal Hernias

Abdominal hernias in birds may be congenital or acquired. They are characterized by a separation of the aponeurosis of the abdominal musculature at the ventral midline. This gives the bird a pot-bellied appearance with the abdominal viscera visible directly beneath the skin (Figure 41.21). Abdominal hernias frequently develop in female budgerigars and cockatiels, which may be related to a hormone imbalance causing a weakening of the abdominal muscles.^{40,48} It has been suggested that altered calcium metabolism in chronic egg-laying hens may contribute to muscular atony and over-distention in the caudal abdomen near the cloaca.³²

In most cases, the hernia is of little clinical consequence. The defect in the body wall is large with little risk of organ entrapment. As a result, herniorrhaphy may carry more risk than the potential benefit. Because of the extensive system of air sacs (on which birds rely heavily for respiration), efforts to close the body wall defects frequently result in respiratory compromise. In birds with chronic or large hernias, the resulting respiratory compromise can be life-threatening. As closure proceeds caudad, the abdominal viscera are forced cranial. This results in compression of the thoracic and abdominal air sacs. In these cases, a mesh implant should be considered. If the hernia is small or acute, primary closure may be successful.

Herniorrhaphy is necessary if secondary clinical problems such as cloacal urolithiasis or egg binding occur. A fusiform section of skin and urodeum was excised and the body wall closed to repair a hernia containing urate concretions in a cockatiel. The hernia recurred, but a second surgery was not attempted, and the owner was instructed to manually express urates out of the cloaca as needed.³²

Abdominal Masses

Surgical excision may be considered for treatment of neoplastic diseases of birds.^{3,54} Removal of abdominal tumors is rarely successful. Their removal requires meticulous attention to detail, strict hemostasis with blood transfusions and a prolonged anesthesia time, predisposing the patient to hypothermia and severe metabolic compromise. Carbon dioxide laser surgery shows the greatest promise for removal of neoplasms.

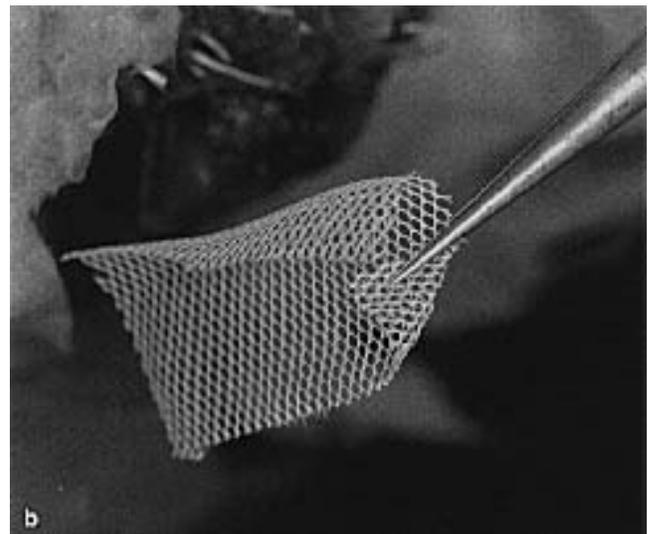


FIG 41.21 a) An adult African Grey Parrot hen was referred for surgical removal of an egg that was thought to be causing a distended abdomen. On physical examination, a sizable abdominal swelling that was soft and contained palpable tubular structures was identified. Contrast radiography indicated that the hen had an abdominal hernia. b) The hernia was repaired using a surgical mesh to add strength to the damaged abdominal wall.

■ Lipomas

Lipomas are frequently the expression of obesity. Central necrosis and ulceration may occur. Some lipomas are covered by xanthomatous skin. Efforts should be made to reduce the size of the mass medically before attempting surgical extirpation. Diet and exercise are effective over a period of several months. Lipomas are generally well encapsulated and shell out easily.

■ Leg Amputation

When a leg must be amputated, it is best performed at mid-femur. If the stump is too long, the bird may continue to use it for ambulation, causing trauma and granuloma formation to the stump. A mid-femoral amputation allows adequate soft tissue coverage of the end of the bone and prevents the patient from traumatizing the surgical site. Because the majority of the femur is contained within the skin of the body wall, a mid-femoral amputation is also cosmetic. Most companion birds with one leg are able to function normally. Psittacine birds compensate particularly well because they use their beak as an aid to ambulation. Pododermatitis of the contralateral foot, as occurs commonly in raptor amputees, is rarely a problem in companion birds on a formulated diet.

The skin incision should be made along the knee web to conform to the contour of the abdomen. A semicircular incision is created both medially and laterally at about the level of the stifle. This will allow adequate skin for tension-free closure. The muscles should be transected at the stifle. Use of the radio-scalpel will aid in hemostasis. The muscles are elevated from the femur to the mid-diaphyseal region using a periosteal elevator. The ischiatic nerve should be injected with lidocaine or bupivacaine prior to transection for temporary postoperative analgesia. The femur may be cut with a bone cutter, an osteotome, a gigli wire, a sagittal saw or other suitable instruments appropriate for the patient's size. Following the osteotomy, the muscles are sutured over the end of the bone to provide padding. Subcutaneous tissues and skin are closed routinely.

■ Toe Amputation

Indications for toe amputation include avascular necrosis, trauma and infection. Hemostasis is aided by the use of a tourniquet. Hemostatic agents should be avoided. The heavily keratinized scale surfaces may be gently debrided exposing the more supple epider-

mis below. This improves tissue handling for suture placement. The site of amputation should be at the joint proximal to the affected area. The skin should be incised distal to the joint to provide adequate skin for closure (Figure 41.22). A hydroactive dressing will promote healing and prevent contamination (see Chapter 16).

■ Wing Amputation

Amputation of the humerus at the junction of the middle and proximal thirds of the bone provides adequate soft tissue coverage and creates a stump short enough to prevent self trauma. The skin incision should be made at the distal humerus, just proximal to the elbow. If additional skin is needed for closure, the patagium may be utilized. The muscles are transected at their musculotendinous junctions near the elbow. The radial and medianoulnar nerves should be injected with lidocaine or bupivacaine for short-term postoperative analgesia prior to their transection. Brachial musculature is mobilized by blunt dissection to remove attachments from the humerus. The humerus should be transected at the proximal third, to provide sufficient muscle distally to be sutured over the stump. Subcutaneous and skin closure are routine.

In situations where use of the wing for balance is important, it may be beneficial to amputate as distally as possible.^{19,39} This function is especially important when working with birds to be used in breeding programs and as surrogate parents. It may be difficult to obtain adequate soft tissues for stump coverage with distal amputations.

■ Vascular Access Devices

In avian patients, intravenous catheters are viable only for short-term therapies. Avian veins are relatively small, thin-walled and fragile, with a propensity for hematoma formation following venipuncture. The intraosseous placement of a needle provides access to the vascular space for administration of fluids and therapeutics for up to 72 hours. Vascular access devices provide a route for long-term administration of therapeutics into the vascular system.^{8,17} They have been used for long-term administration of amphotericin B in a Cassin's Auklet¹⁷ and Magellanic Penguins and for total parenteral nutrition in pigeons.⁸

Vascular access devices are subcutaneously implanted devices with a reservoir that is accessed through surgically prepared skin using a non-coring

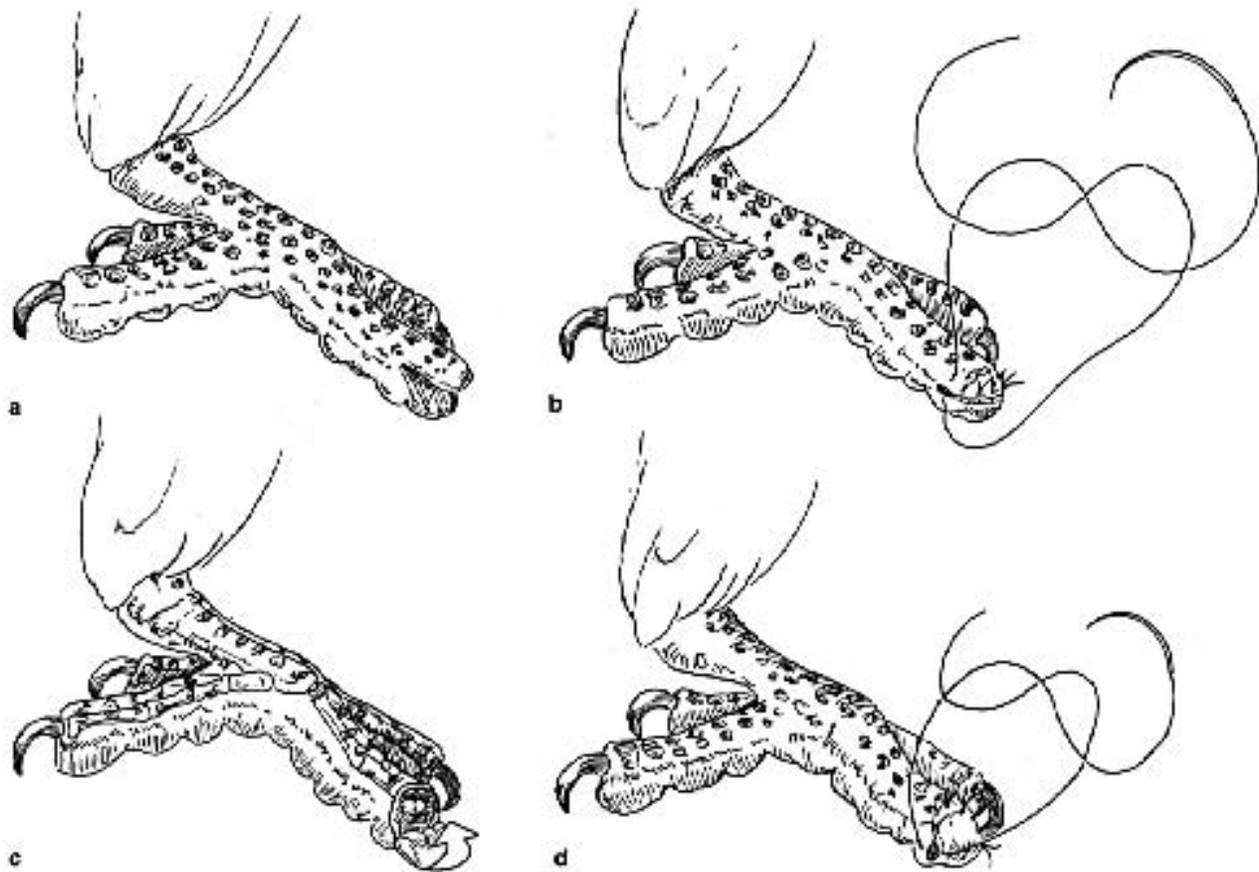


FIG 41.22 Two techniques may be used for toe amputation: **a,b**) The skin may be incised, creating a semicircular flap on both the dorsal and the plantar surfaces of the digit. This skin pattern will provide adequate tissue for closure over the distal end of the bone. **c,d**) Alternatively, the plantar skin may be incised to create a flap of plantar skin that will cover the end of the bone. The plantar skin is somewhat stronger than the dorsal skin, providing additional protection over the end of the bone. Because the metaphysis and epiphysis of the phalanges are larger than the diaphysis, it may be beneficial to remove the exposed joint surface with rongeurs prior to skin closure. The skin is sutured as described for the repair of toe necrosis (see Figure 41.1).

needle (Huber point needle). Risk of sepsis and thrombosis is minimized because the catheter is not exposed to the environment. These have been maintained in humans for years and in birds for up to 12 weeks.¹⁷ Vascular access devices have a number of synonyms, some of which are proprietary names, such as portacath, infusaport, dome, vascular access port and subcutaneous port.

The material, construction, surface finish and tip configuration influence the thrombogenicity of the catheter. Silicone and hydromer-coated polyurethane are considered the least thrombogenic materials currently in use. The catheter can be implanted into a vein, artery or other hollow organ and connected to the reservoir.

The right jugular vein is the preferred site for implantation. The patient is positioned in left lateral

recumbency, and the area over the right jugular vein is prepared for surgery. In many avian patients, there is no need to remove feathers because there is an apterium in this location. The skin is moved dorsally and an incision is made over the jugular vein. When the skin is released, the incision site will be ventral to the jugular vein and not over the reservoir. The jugular vein is identified and isolated for a distance of approximately 15 mm. Dissection must proceed cautiously as the vein is very fragile. Two ligatures are placed around the vein, one at the cranial extent and the other at the caudal extent of the isolated area. The caudal suture is elevated to occlude blood flow. The jugular vein will distend and the cranial suture is then tied off permanently occluding jugular flow. This does not seem to affect cerebral hemodynamics.

At this point, a small segment of the jugular vein remains distended. Using fine iris scissors and magnification, a transverse venotomy is created in the distended portion of the vein. This incision will not transect the vein but will allow the catheter to be inserted. After the blood from the distended segment is cleared, the end of the catheter is inserted into the venotomy site. The tension on the caudal ligature will have to be loosened to allow the catheter to pass, but enough tension should be maintained to prevent reflux hemorrhage. The venotomy may be widened using fine forceps or a vascular introducer. The catheter is advanced to the right atrium and secured in place by suturing above and below the retention ring at the venotomy site to prevent the catheter from advancing or backing out.

A Huber needle attached to a three-way stopcock and a saline-filled syringe is used to test the ease of injection and withdrawal of a sample. The position of the catheter tip should be evaluated using contrast radiography. Some catheters are radiopaque. With those that are radiolucent, the position can be evaluated by injecting a vascular contrast medium.

A subcutaneous pocket is created dorsal to the jugular vein large enough to accommodate the reservoir, which is placed into the pocket and sutured in place to the fascia of the neck musculature. A 2 to 4 cm loop of catheter is left to allow for neck movements. Subcutaneous and skin closure are routine. During recovery, feathers over the reservoir should be removed and the skin aseptically prepared. The device should then be filled with heparin at 100 IU/ml. Only non-coring needles should be used with these devices. With a minimal amount of practice, these devices can be implanted in 10 to 15 minutes.

The skin area above the port must be aseptically prepared before each use. Chlorhexidine has been shown to be three to four times more effective at preventing bacterial colonization of the catheter than povidone iodine.¹⁷ The individual administering the therapy should wear sterile gloves and use sterile equipment. The non-coring needle is inserted into the reservoir until it hits the base plate and the injection can then be made.

These devices can be maintained for extended periods of time but require some maintenance.¹⁷ Catheters were maintained in chickens for 12 weeks using a 1000 IU/ml heparin lock and weekly flushing. In geese, the catheters were flushed every four days with 1.0 ml physiologic saline and locked with 0.25

ml heparin at 100 IU/ml. When catheters are used daily or several times daily, there is no need for heparin locks, which eliminates the potential for heparinizing the patient. However, there is a higher potential for thrombus formation with small gauge catheters, and a heparin lock may still be necessary.¹⁷

Removal of the device requires a surgical approach to the vein and the reservoir. The sutures holding the reservoir are removed as is the suture holding the catheter in the vein. A ligature is pre-placed around the vein and the catheter is removed. The ligature is tightened to prevent reflux of blood. Closure of the skin and subcutaneous tissues is routine.

■ Perinatal Surgery

Many aviculturists do not seek veterinary assistance with embryonal and neonatal matters, attempting to manage problems themselves. Rarely are these attempts successful. Neonatal tissues are challenging to suture. Compared with adult tissues, they have a high moisture content, making them very friable, with reduced tensile strength. With practice and management, fine suture (8-0 to 10-0) and an atraumatic needle can be used for closure of the umbilicus. However, hemostatic clips are more appropriate for application to the umbilicus than suture ligatures. Featherless neonates are highly prone to developing hypothermia. Anesthesia and surgery time should be less than 15 minutes, and the operating room temperature should be elevated to 75 to 85°F.¹ Body temperature should be carefully monitored throughout the procedure, and supplemental glucose should be provided through an intraosseous cannula as necessary.

Because of their small blood volume, perinatal patients are more likely to require transfusion if major blood loss occurs or if the hematocrit is below 20 to 25%. Respiratory movements may be difficult to observe in perinatal patients, making the use of clear drapes and small non-rebreathing bags essential. The crop of altricial avian neonatal patients is usually full, increasing the risk of regurgitation and aspiration. The patient may be fasted until the crop volume has diminished or the contents may be removed by aspiration. Elevating the head and packing the thoracic esophagus with moist cotton will also help prevent reflux of crop contents.

Yolk Sac Removal

The yolk sac is a diverticulum from the small intestine attached by the yolk stalk and accompanying

vasculature. It is normally internalized prior to hatching. Yolk is absorbed during incubation through the endodermal cells of the yolk sac and, at least in chickens, nutrients are absorbed through a duct that connects the yolk stalk to the intestines. Yolk provides nourishment, minerals, fat-soluble vitamins and maternal antibodies to the developing embryo and the neonatal bird. After the yolk has been completely absorbed, the remnant of the yolk sac becomes the vitelline or Meckel's diverticulum.

A procedure for removal of unabsorbed yolk sacs has been successful in decreasing mortality in affected chicks (see Chapter 48). Candidates for surgery demonstrate one or more of the following clinical signs: abdominal distention, exercise intolerance or dyspnea, weight loss and anorexia, failure to grow or inability to stand or walk. Abdominal palpation and radiography support the diagnosis of unabsorbed yolk sac. Radiographically, the yolk mass displaces the viscera cranially into the thoracic space, compromising the caudal air

sacs. This results in exercise intolerance and dyspnea. Yolk sac removal is most effective if performed before the chick becomes dyspneic. Percutaneous aspiration of the yolk should not be attempted as the yolk sac is very thin and will leak yolk into the coelomic cavity resulting in peritonitis. Injecting antibiotics directly into the yolk sac carries the same risk. Systemic antibiotics are not effective alone.²⁶

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- a. Lorelco, Merrell Dow Pharmaceuticals Inc., Cincinnati, OH
- b. Mucomyst, Mead Johnson, Evansville, IN
- c. Maxitrol ophthalmic ointment, Alcon Laboratories, Fort Worth, TX
- d. Vetalog, Solvay Animal Health, Mendota Heights, MN
- e. Jardon Eye Prosthetics Inc., Southfield, MI
- f. Moto-tool, Dremel, Racine, WI
- g. Gelfoam, Upjohn Co, Kalamazoo, MI
- h. McAllister Technical Services, Coueur d'Alene, ID
- i. Bard Urological Division, CR Bard, Murray Hill, NJ
- j. Norfolk Medical Products, Access Technologies, Skokie, IL
- k. Avian Restraint Collar, Vet Specialty Prod., Boca Raton, FL

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