Rehabilitation

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INTRODUCTION

Reconstituting an injured raptor to a state of recovery sufficient to release it back to the wild consists of two major elements: (1) specialized veterinary care that ranges from first aid, emergency procedures, and internal medicine, to specialized diagnostics and orthopedic surgery; and (2) long-term recovery and reconditioning for release to the wild, or rehabilitation. Associated with these core activities are: (1) recovery, (2) convalescent husbandry and management, (3) disease- and injury-prevention, (4) preparation for release, and, finally, (5) the release itself. The aim of this chapter is to provide readers with an overview of the legal and organizational framework in which rehabilitation is conducted and information concerning the expectations for equipment, facilities, knowledge, and access to veterinary resources that people conducting rehabilitation should have at their disposal. We also provide information useful in dealing with members of the public who may be calling on such professionals for advice or assistance in resolving an encounter with an injured raptor. Owing to the sheer volume and detailed nature of the information, this chapter is not intended to be a "how-to" manual for rehabilitation. Nor is it a medical-procedures manual. That said, some material relating to medical procedures will be presented for the purpose of defining the contemporary state of the art for reference purposes.

LEGAL FRAMEWORK

In the United States, all birds of prey are protected by one or more pieces of Federal Law including the Migratory Bird Treaty Act, the Endangered Species Act, and the Eagle Protection Act (see Chapter 25). Depending on the species of raptor under consideration, one or more federal permits are required in order to conduct rehabilitation work. Elsewhere in the world, applicable pertinent legislation specifies what is needed for compliance. In the U.S., individual states have regulations pertaining to rehabilitation, and permits must be acquired. Some states (e.g., Minnesota, New Jersey, New York, Pennsylvania, and Wisconsin) have well-developed permitting procedures that require testing, sponsorship, education, define different levels of participation that specify certain allowable activities, may limit the species that are allowed to be held by a given individual, and require continuing education and annual reporting procedures in order to maintain the permit. These permitting systems have been developed with input from wildlife management interests as well as organizations such as the National Wildlife Rehabilitators Association (NWRA; www.nwrawildlife.org) and the International Wildlife Rehabilitation Council (www.iwrc-online.org). These

organizations have promulgated codes of ethics that guide rehabilitators in their decision-making. An example of guidelines for the state of Minnesota can be found at www.dnr.state.mn.us/ecological_services/nongame/rehabilitation/permits.html.

ASPECTS OF RECOVERY OF INJURED RAPTORS — PROCEDURES AND RECOMMENDATIONS TO BE MADE TO THE PUBLIC

The Recovery Encounter

Often, the initial encounter a wildlife professional has with rehabilitation is a call from a citizen who has unexpectedly encountered an injured raptor during their everyday activities. In most cases, they are awed by, as well as apprehensive about, the circumstances, but feel strongly compelled to have something done in the interest of the bird's health and well-being. Thus, begins the process of recovery.

Equipment for Recovery

The essential requirement at the outset is to get the bird into protective custody as quickly as possible. This is necessary to prevent disappearance of the bird, injury by dogs or other predators, or exposure to the elements. Depending on the size of the bird and the ability and confidence of the person reporting the problem, advice on containment may be given. General recommendations are to corner the bird to prevent its escape by running, to throw a blanket, jacket, large towel or a landing net over it, and finally to place the bird in a confined area, be it a quiet room in a building, a box, or some kind of animal carrier. If persons are judged unwilling or unable to perform this task, they should be advised to keep the bird under direct observation until someone with necessary equipment and expertise can arrive on the scene.

Capture of an Injured Raptor

Methods of capture vary depending on the species of bird, the extent of its mobility, the location (e.g., alongside a road, on a window sill, in an open field, etc.). Resources that should be available in order to provide reasonable coverage of possible circumstances include a pair of leather gloves (welding gloves for most of the larger birds, hand gloves for smaller birds), blanket or bath towel, protective eye wear to reduce risk of a scratched cornea from a flapping wing, a landing net of the type used in sport fishing, an appropriate container, and one or two assistants.

The actual capture should be done with speed, agility, and due concern for not adding to the injury of the bird or injuring a person. Rescuers should avoid prolonged chases of the bird as this can lead to a condition known as "capture myopathy" which can cause serious damage and sometimes ruptured muscles. It occurs as a result of extreme physical exertion coupled with the physiological responses to fear of being captured. The rescuer should bear in mind that the talons are a raptor's primary defense. Most injured raptors, when approached and, especially, if cut off from escape routes by objects or other people, will assume a defensive posture with wings spread and facing what they perceive to be the greatest threat. Many raptors, particularly juveniles, will "surrender" by lying down, often rolling on their back and presenting their feet. Once pushed to this point, presentation of a towel or blanket often results in them grabbing it intensely, burying their talons into the fabric. In doing so, the bird renders itself relatively defenseless and it is now possible to wrap a free end of the fabric around their body. Alternatively, another towel can be draped over them. Once the head is covered, wings can be folded against the body. The towel can now be used to wrap the bird up like a "burrito" and restrain it for placement in a suitable container. A landing net or dip net also can be used to good effect, particularly if the bird is able to evade capture by running or flying short distances. Removal from the net can be difficult as they typically grasp at the mesh and entangle themselves. Ideally, the captured bird would be extracted from the net and wrapped in a towel for placement in a transport container. Once in container, the bird can be left wrapped in the towel or the towel gently removed, providing they have loosened their grasp with their talons. The latter is preferred in order to prevent overheating, although sometimes it is much less stressful on all parties to leave the bird in the box clinging to the towel. The bird is now ready for transport. Be certain that the container has adequate ventilation and, in the case of a cardboard box, that the flaps are secured.

Recommendations about Capture

Some dos and don'ts regarding recovery include the following:

1. Do not place or wrap the bird in a gunnysack.
2. Do not place the bird in a chicken-wire cage or Havahart® trap.
3. Do not place the bird in a container bedded with straw, hay, ground corncobs or other organic material that may contain spores of yeasts and fungi.
4. Do not wrap the body in any kind of elastic bandage.
5. Do not attempt to feed the bird unless it must be held for more than 24 hours (see below).
6. Do not "exhibit" the bird or otherwise cause additional stress by having it looked at unnecessarily by other people or domestic animals (e.g., dogs).
7. Do place the bird on soft towels or absorbent blankets.
8. Do use shredded paper as a bed (especially if the bird is unable to stand due to a broken leg or broken back).
9. Do offer the bird water to drink, either in a bowl or from an eyedropper or basting syringe if transport is going to take several hours. Remove the water bowl from carrier during transport to prevent head trauma or sternally recumbent birds from drowning.

Information Collection

An important part of rehabilitation that contributes to addressing the larger issues of morbidity and mortality factors that affect raptors is collecting as much information as possible about the circumstances that led to the injury or debilitation of the bird (Sleeman and Clark 2003). Important pieces of information to be collected at recovery include: (1) the time when the bird was first found, (2) the geographic location (at least to the county and preferably to the township level), and (3) the presence of objects that may have been involved in the event (e.g., overhead wires, highways, windows, barbed wire fences, chain-link fences, wind turbines, sources of intoxicants and contaminants such as pesticides or oil, etc.). It also is important to note the condition of the bird (e.g., whether it is alert and actively resisting capture, or lying prone and not resisting, sitting erect on its hocks, seizuring, gasping for air, etc.). A crime-scene investigation approach to collecting information will aid in caring for the individual bird, and contribute to the overall base of knowledge of factors that adversely affect raptors.

Transport

Transportation of injured raptors most often occurs by car and, occasionally, by aircraft. Rapid transport to a facility for medical care is one of the major factors contributing to the success or failure of rehabilitation. For transport by car or truck, the major considerations are protecting the bird from further stress as much as possible and providing a suitable environment (e.g., adequate ventilation, protection from heat, cold, wind, and minimizing exposure to extraneous noise such as radios or other audio devices). Although sometimes not possible, it is preferable to avoid transport in an open bed pick-up truck for any great distances. In addition, backs of pick-up trucks covered with a tarp or a topper sometimes trap carbon monoxide and should be used with caution.

For transport by aircraft, use of a private airplane typically presents no additional concerns beyond those given to transport by car. Transport by commercial aircraft requires use of a container approved by and outfitted in accordance with regulations for live animal transport (see Live Animal Regulations, 31st Ed., International Air Transport Association, 2004 www.iata.org/ps/publications). Briefly, a solid-walled container (not a cardboard box) is the basic requirement. A suitably sized fiberglass animal carrier is adequate. The container must be outfitted with foam padding on the inside of the top and the ventilation grates on the sides and door should be covered partially with opaque material (e.g., duct tape, burlap, mosquito screen, or muslin) to darken the inside. Carpeting affixed to the floor with duct tape or other adhesive will provide an absorbent surface as well as a good footing. No perches, water or food containers should be placed in the container. The door should be secured with a nylon tie-wrap. Current airline security operations may result in airport personnel opening the door for inspection. They must be advised of the contents beforehand in order to reduce the likelihood of escape. Birds shipped by air must arrive at the cargo facility 2 hours before scheduled flight time. Some carriers require a health certificate issued by a veterinarian. In most cases, it is possible to waive this requirement on the basis of the fact that the bird is being shipped for critical emergency care. In hot weather, airlines will refuse to accept live animals for shipping when the forecast temperature at the place and time of landing exceeds 85°F (29°C). All aspects of getting an injured bird into rehabilitation can be accomplished by working with a licensed rehabilitation facility, of which there are many throughout the U.S. and elsewhere. Contact information for rehabilitation centers in the U.S. as

well as the phone numbers of contact people in each of the Fish and Wildlife Regions that are in charge of rehabilitation permits in their region is available online from NWRA under "Need Help?" on their menu. In the U.S., if all else fails, call The Raptor Center at the University of Minnesota (612-624-4750) to help make appropriate arrangements for the bird. To find rehabilitation clinics in regions or countries outside North America, the internet is the best recourse.

CONSIDERATIONS FOR MEDICAL CARE OF INJURED RAPTORS

Triage

Triage is an inevitable component of raptor rehabilitation. While decisions as to which birds should be forwarded for rehabilitation are best made on the basis of establishing a minimum database about the bird, there are some situations where it is patently clear that rehabilitation is not a viable option. Given the effort and expense involved in transport, it is useful to define those few situations where the most expeditious option would be humane euthanasia of the bird at the time of recovery with all due consideration to the sensitivities of any members of the public that are involved. Those conditions that are beyond medical treatment leading to release of the bird include missing all or a significant part of a wing or leg, severe beak damage or destruction, fractures of long bones of the wing where there are obvious large open wounds containing whole fragments or shards of broken, dry, devitalized bone, and one or both eyes severely damaged or destroyed. If in doubt, or methods of euthanasia suitable for the circumstances are not available, the interests of the bird and the public will be served better by having the bird transported to a facility where a more informed decision can be made on the basis of physical examination and radiographic evaluation.

Medical Treatment

State-of-the-art delivery of health care to injured raptors entails application of veterinary skill sets, therapeutic products, defined procedures, and technology (Redig 2003). These include, but are not limited to: (1) gas anesthesia to be used for restraint for conducting thorough physical examination as well as analgesia for surgical procedures, (2) radiology equipment, (3) materials and equipment for diagnostic sample collection, including syringes and tubes for blood samples, swabs and culture media for bacteriology, microscope and ancillary equipment for conducting fecal parasite exams, (4) materials, equipment, and skill sets for proper application of bandages and splints as well as orthopedic surgery, (5) reagents and skill sets for conducting critical care of extremely debilitated patients, (6) housing for immediate, post-admission/post-surgical care and for long-term convalescent care and reconditioning for release to the wild, and (7) adequate food supplies and personnel to conduct the entire process. Other pieces of useful equipment include endoscopic units, cardiac monitoring equipment, and general surgical gear. Most rehabilitation facilities will have access to the majority of these items either intrinsically or by virtue of affiliation with an experienced veterinarian.

Gas anesthesia is indispensable for handling of injured raptors. Its use reduces stress on the patient and enables the clinician to conduct detailed physical examination and collection of diagnostic samples. The agent most in use is Isoflurane® (Minrad, Inc., Bethlehem, PA); Sevoflurane® (Abbot Laboratories, Abbot Park, IL) is used by some clinicians. The desirable characteristics of these agents include rapid induction, minimum depression of heart and respiratory rates, widespread tolerance, and rapid recovery. Severely injured and compromised birds may be anesthetized safely and often experience a reduction in the extreme state of their condition when rendered unconscious by the gas. Administration requires a precision vaporizer suitable for isoflurane or sevoflurane, an open-breathing system (e.g., Ayres T-piece, Banes circuit), and a mask that can be placed over the entire head (Fig. 1). Induction is accomplished by placing the head of the restrained bird in the mask with an elasticized-material dam (e.g., Vetrap® [3M Animal Care Product Division, St. Paul, MN]), sealing off the neck and setting the vaporizer to 5% and the oxygen flow meter to 1 liter/minute for birds in the 1–4 kg range. Smaller birds can be induced and maintained at lower oxygen flows. No pre-anesthetic agents, such as atropine, are used. After 1–2 minutes, the effects of the anesthetic may be seen as a general loss of consciousness and general-body relaxation. The gas concentration can be reduced to a maintenance level, typically between 2% and 3%. Respiratory rate and character should be monitored and gas concentrations adjusted in accordance with maintaining the required depth of anesthesia. Intubation is recommended for procedures lasting more than 30 minutes. Lubri-

Figure 1. A Bald Eagle's (*Haliaeetus leucocephalus*) head has been placed inside a cone for induction of gas anesthesia. Note the conforming elastic dam made from Vetrap® that provides a partial seal around the bird's neck.

cation should be applied to protect the eyes during anesthesia. Flattening of the globe may occur in the ventrally positioned eye when the bird is placed in lateral recumbency. The globe should re-inflate 15–30 minutes after recovery. For recovery, the gas is set to 0%, the delivery system purged with oxygen, and the bird is maintained on oxygen until it shows signs of regaining consciousness, whereupon the tube or mask is removed. The bird should be restrained vertically until completely recovered (5–20 minutes), with attention paid to preventing aspiration of regurgitated stomach fluids.

Some cautions about use of gas anesthetics include presence of food in the gastrointestinal tract, hyperexcitement, and extreme dehydration. If anesthesia is elective, the bird should be fasted for 6–12 hours. If that is not possible, care must be taken during recovery to prevent aspiration if stomach contents are regurgitated. Generally speaking, anesthesia is avoided completely if the bird has a large volume of food in its crop or stomach. Severe dehydration should be mitigated by intravenous or subcutaneous administration of fluids prior to induction.

Physical Examination and Establishment of Minimum Database

The minimum database required to diagnose the extent and degree of injury or debilitation in a raptor includes physical examination (a head-to-toe examination wherein the entire body surface is palpated, long bones are felt for fractures, joints are checked for range of motion, and external orifices (mouth, glottis, ears and cloaca) are illuminated and examined. Owing to the high frequency of head injuries in raptors, a full ophthalmological examination, including a fundic exam using either direct or indirect ophthalmoscopy (Figs. 2–4), is essential. Mydriasis (dilation of pupil) cannot be accomplished with atropine in birds as it is in mammals, however either dimming of room lights, isoflurane anesthesia, or both, will provide sufficient opening of the pupil for examination. Often, birds with fully repairable fractures are ren-

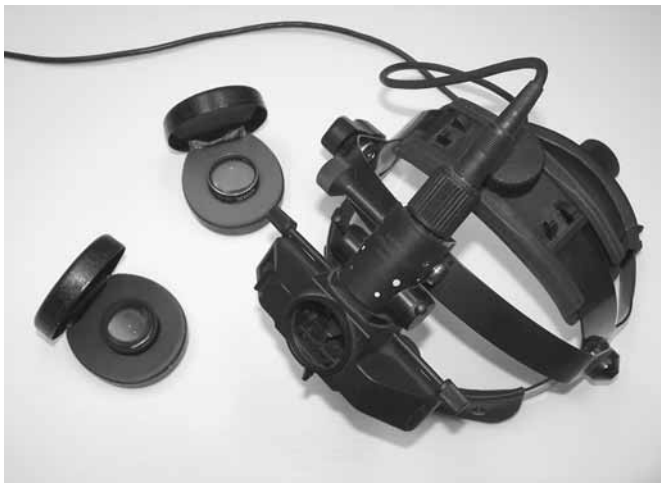


Figure 2. The headset and lenses used in "indirect" opthalmoscopy — see figure 4. This form of opthalmoscopy gives the operator a greater operating distance from the subject and allows for full viewing of the fundus.

Figure 3. An examination of the fundus with a focused light source called a transilluminator. The visual axis of the operator's eye is nearly parallel with the axis of the light source. Owing to the magnification provided by the patient's lens, very large and detailed views of the retina may be had.

Figure 4. The use of the direct (a) and indirect (b) ophthalmoscopes in the examination of the fundus of a Great Horned Owl (*Bubo virginianus*). The direct scope has a series of lenses on a rotating disk, operated by the index finger of the examiner, which enables focusing on objects of varying location within the eye.

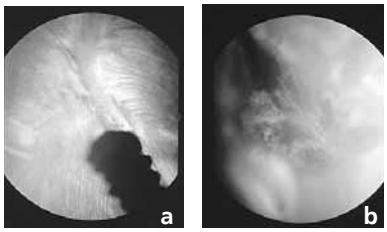


Figure 5. Normal (a) and traumatized (b) pectens.

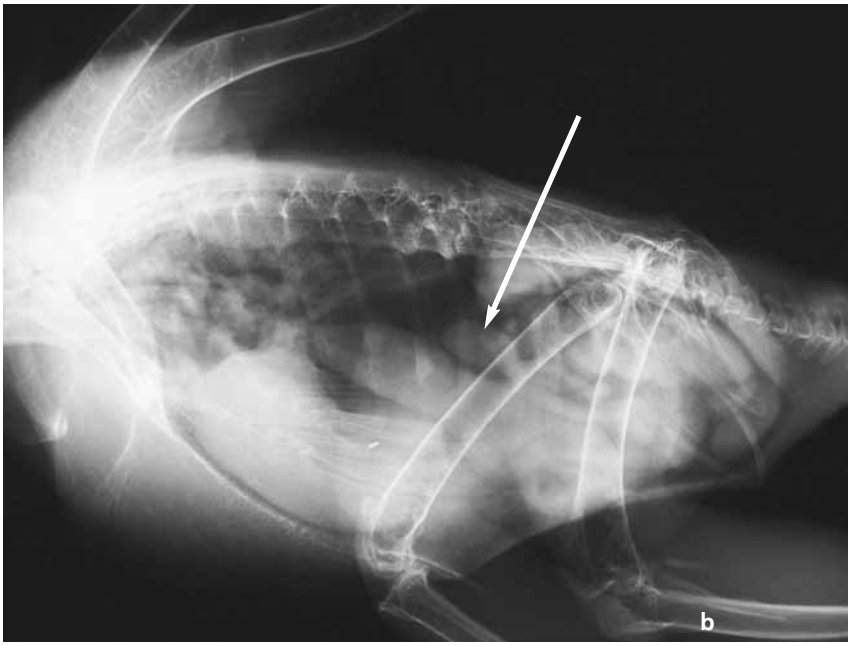


Figure 6. Ventro-dorsal (a) and lateral (b) radiographs. In a, the arrows point to hyperinflated abdominal airsacs, indicative of expiratory restriction in the upper respiratory system. In b, the arrow points to a swollen spleen, suggestive of an active viral infection.

dered unsuitable for release due to hemorrhage, detachment of deep structures, or both (Fig. 5). Vision impairment can be detected only by examination of the interior portions of the eye. In addition to these examination procedures, blood should be collected for (1) hematology (see chapter 16), minimally entailing determination of packed cell volume, total protein, along with total and differential white cell count, (2) collection of plasma for toxicological analysis (especially lead in Bald Eagles [*Haliaeetus leucocephalus*]) and (3) serology (detection of antibodies against specific diseases). Collection of microbiological samples from open wounds or scrapings from lesions (e.g., oral trichomoniasis lesions), and examination of freshly passed feces by direct smear and flotation methods for detection of eggs from internal parasites provides additional useful information. Lastly, full-body radiographs taken in both ventro-dorsal and lateral projections (Figs. 6a,b) are essential. With suitable facilities and the bird under anesthesia, the collection of this suite of samples can be accomplished in under 20 minutes. Radiological and basic hematology (PCV and TP), ophthalmological exam findings, fecal examination and physical examination are immediately available data that will allow decisions to be made about triage, treatment, or both.

Initial Critical Care

It should be assumed that any injured or ill raptor is in a state of dehydration. The minimum detection level of dehydration is around 5% of body weight. The upper end of the range compatible with life is in the range of 12–14%. Determination of dehydration is subjective, and is based on (1) skin elasticity, (2) appearance of the eye with dehydrated birds exhibiting a sunken globe and dullness to the cornea, and (3) moisture content of oral mucous membranes, usually assessed by palpating oral mucus membranes with the examiner's index finger. From a practical point of view, assuming a 10% level of dehydration is useful clinically. This means a 1-kg Red-tailed Hawk (*Buteo jamaicensis*) at 10% dehydration is missing roughly 100 cc of fluid from spaces within and without the vascular system. This volume needs to be replaced over several days, usually 4, while meeting contemporary daily fluid intake needs, generally 50 cc/kg.

Immediate replacement fluid needs are best met by intravenous or subcutaneous fluid administration. In extreme cases where subcutaneous absorption would be too slow and venous access is not possible owing to collapsed veins, fluids can be given intraosseously with uptake nearly equivalent to intravenous administration (Aguilar et al. 1993). This is accomplished by insertion of an 18- or 20-gauge needle through the distal end of the ulna and into the marrow cavity and infusing fluids via this route (Fig.7). Regardless of the route of administration, the goal is to replace 50% of the estimated deficit in 24 hours while at the same time meeting contemporary needs and assuming no further losses as in hemorrhaging. Thus, the 1-kg Red-tailed Hawk would need 100 cc of fluid in the first 24-hour period. A typical schedule would consist of four treatments each consisting of 12–15 cc given subcutaneously, and a similar volume given by oral infusion with a crop tube every six hours. The remaining deficit is made up on successive days, wherein one half of the remaining deficit is given daily along with meeting contemporary needs. All fluids should be heated to where they are warm to the

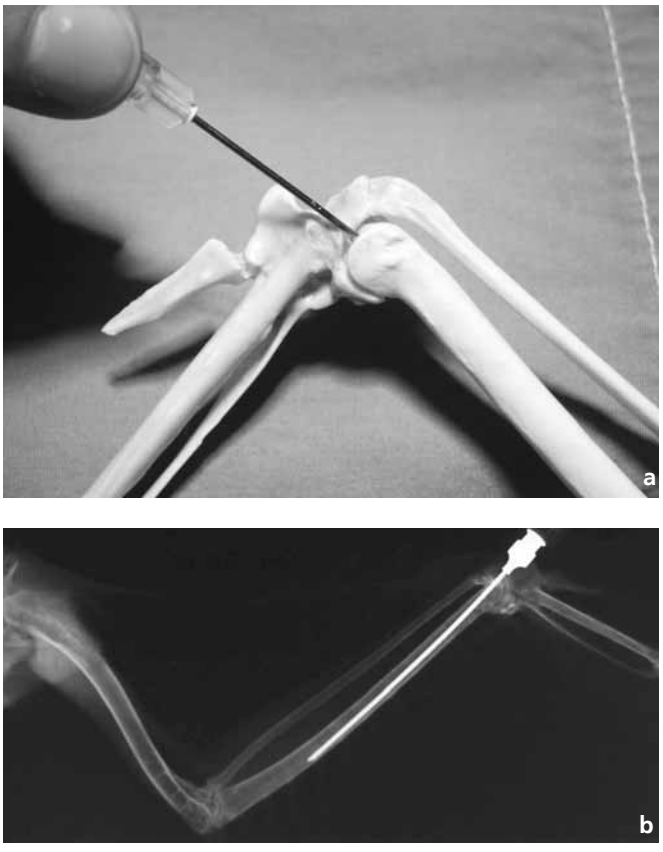


Figure 7. The installation of an intraosseous catheter. Above (a), the insertion point at the distal end of the ulna, lateral surface, is shown. Below (b) is a radiograph in which the full insertion of the needle into the marrow cavity is seen. For the short duration of time that such catheters are left in place (2–3 days), no permanent damage to the joint is typically seen.

touch before administration. In many cases, severely debilitated birds will show remarkable response to this simple regimen of fluid replacement within one to two hours of first administration.

In general, the major task of rehydration (i.e., re-establishing circulating blood volume), can be met by use of lactated Ringers solution for subcutaneous, intravenous, and intraosseous administration, and readily available rehydrating solutions such as Pedialyte® or Gatorade® for oral use. There are many refinements on this theme in terms of selection of fluids, determining state of dehydration and monitoring the response to treatment using Doppler blood pressure equipment, and tailoring the dosing schedule to exactly determined needs that will enhance the ability to deliver optimized treatment to the avian patient (Lichtenberger 2004).

Beyond fluid administration, calorie intake is a key ingredient in the treatment of all injured or debilitated raptors. If the bird is unable or unwilling to eat on its own, it is important to deliver food into the gastrointestinal tract immediately, and no later than 24 hours after admission. For debilitated birds, this generally requires feeding through a crop tube, a stainless steel feeding tube or a rubber catheter affixed to a syringe. Materials to be fed range from a puree of easily digested food stuffs (quail breast, liver) mixed with sufficient fluid to pass through the tube (this fluid becomes part of meeting the daily requirement for fluid). Commercially available products that are more suited toward the needs of the debilitated animal in terms of digestibility, absorbability, and known assay in terms of nutrient and calorie content include Oxbow Carnivore Care® (Oxbow, Murdock, NE), Lafeber's Critical Care for Raptors® (Lafeber Company, Cornell, IL), and Eukanuba Max-life® (The IAMS Company, Dayton, OH).

Debilitated birds require approximately 250 kcal/kg intake per day to meet the hypermetabolic needs associated with injury, stress, and illness. Assuming a caloric content of 2 kcal/ml (typical of prepared diets), a 1 kg bird would need 125 ml of such a diet. Typical crop volumes are in the order of 25–30 cc/kg, so, again, four treatments in a 24-hour period, each consisting of 30 cc of the material, would meet caloric requirements. Such treatment should be maintained until the bird has demonstrated a consistent daily weight gain and begins to show a keen interest in eating offered whole food items (e.g., mice, quail).

Fracture Treatment

State-of-the-art treatment for long-bone fractures entails surgical implantation of fixation hardware to attain the greatest overall success rate in recovery. A device known as the intramedullary-pin external skeletal fixator tie-in has a well-established track record of stabilizing fractures of the humerus, radius, ulna, femur, and tibiotarsal bones (Redig 2000). This device consists of a suitably sized and properly implanted intramedullary pin, 2 or 4 partially threaded positive profile acrylic interface half pins (IMEX, Imex Veterinary, Inc., Longview TX), and an acrylic connecting bar (Fig. 8). The key to this device's effectiveness lies in a link that is established between the intramedullary pin (IM) and the external skeletal fixator pins (ESF) by bending the end of the IM pin to 90 degrees and aligning it with ESF pins. A latex form is placed over the pins (Penrose drain), and while the fracture is held in appropriate reduction, the latex form is filled with liquid acrylic material (Technovit®, Jor-Vet, Loveland, CO). Properly applied, this fixator provides stabilization against rotational, bending, sheer, compression, and traction forces

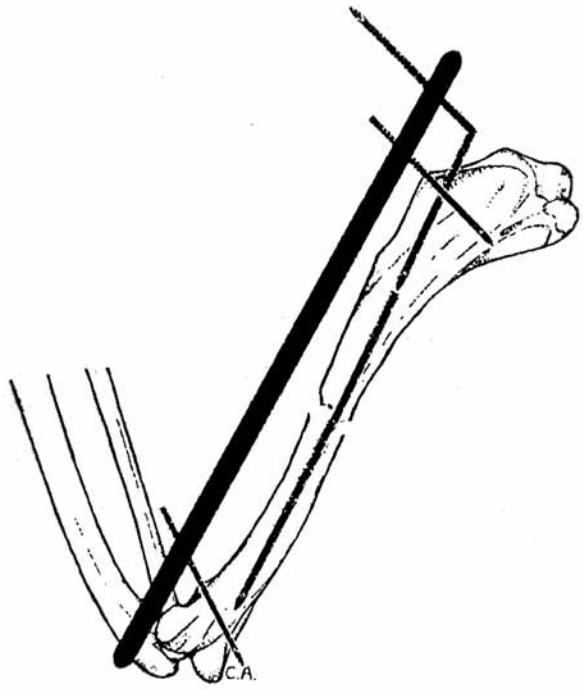
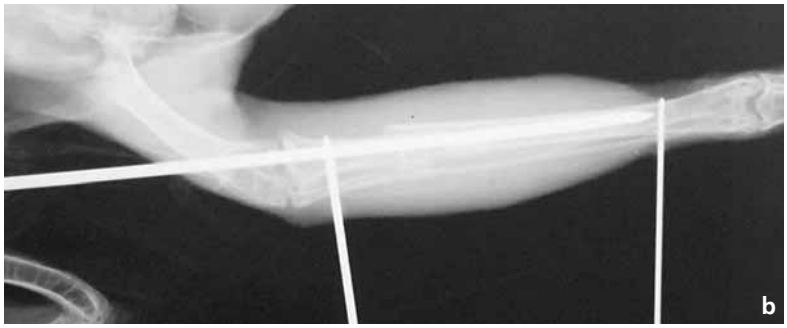


Figure 8. A line drawing (not to scale) of a tie-in fixator implanted on the humerus. The intramedullary pin should fill, but fit loosely into the marrow cavity. It is bent 90° to align it with the plane of the external skeletal fixator pins. The connecting bar is made of acrylic injected into a latex rubber mold (penrose drain) of a size roughly equivalent to the diameter of the bone. Note the placement of the ESF pins and the exit point of the intramedullary pin, none of which interferes with joint surfaces.



while allowing normal range of motion of the limb. Typical fracture healing times, to the point of removal of the hardware, range from 3 weeks for humeral fractures to 5 weeks for tibiotarsal fractures with an expected return to full function of 65–70% of all attempts (Redig 2000; Figs. 9a–d).

Fractures of the major metacarpus and the metatarsus require a different approach to treatment. Both are characterized by having scant soft tissue to provide blood supply to the bone and the metatarsus is rendered more difficult by virtue of being a weight-bearing bone. Fractures of both of these bones have a higher chance of healing if surgical repair is delayed several days to give the soft tissues time to recover from the insult of injury. Oral administration of peripheral vasodilating agents such as isoxuprine or pentoxyphylline is highly recommended. Light splinting of these limbs, a "figure-8" bandage for the metacarpal and a Robert-Jones or Schroeder-Thomas splint for the metatarsus will protect them prior to surgery. Stabilization of metacarpal fractures is best achieved with a Type I external skeletal fixator, while metatarsal fractures are managed with a Type II external skeletal fixator (Figs. 10a,b).

An essential component of fracture management is post-operative physical therapy. This is conducted under general gas anesthesia (to provide analgesia and prevent against uncontrolled movements that may cause the fixator to become loosened) and consists of passive-range-of-motion and stretch-and-hold procedures (Fig. 11). These are started within the first week post-operatively and continued on a twice-weekly basis, each session consisting of approximately 5 minutes of activity. These serve to improve blood flow to muscles, prevent ligaments and tendons from tightening, and to protect the integrity of joints. With the tie-in fixator or Type I external skeletal fixator, there is no impediment to movement of the joints or danger of unwanted motion of fracture fragments.

Figure 9. This series of radiographs depicts the repair of a proximal tibiotarsal fracture with a tie-in fixator. In this sequence, (a) pre-operative radiograph, (b) intra-operative radiograph to check alignment of pins, (c) 3 weeks post-operatively at which time abundant callus can be seen (arrow), and (d) 5 weeks post-operatively where the intramedullary pin has been removed, leaving the external skeletal fixator elements in place for another week to support the maturing callus.

Figure 10. Gross (a) and radiographic images (b) of a Type II external-skeletal fixator (esf) as applied to the tarsometatarsus are shown. Note the acrylic bars on both sides of the leg and the placement of two pins proximal to the fracture and two pins distal to the fracture.

Figure 11. The "stretch-and-hold" mode of passive physical therapy. Note that the tie-in fixator, applied to the ulna in this case, does not interfere with the full extension of the elbow. These exercises are begun within the first post-operative week and are conducted two to three times per week for 5 minutes throughout the healing period. As shown, these exercises are conducted with the bird under general gas anesthesia.

Long-term Care

Another key component of convalescent management of injured or ill raptors is housing and feeding. Early convalescent housing is best provided by temperature- and light-controlled environments, in cages that are quiet (not stainless steel dog cages), padded, designed to prevent injury in the case of a hyperactive patient, and easily cleaned.

Later stages of convalescent recovery can be provided in large flight rooms or outdoor enclosures if weather conditions permit. Placed in these after fixation hardware has been removed, birds can begin to move around and regain some strength in the wings, legs, or both. Arent (2005) provides recommendations for which species of birds can be housed together in group settings. When individuals are capable of reaching perches placed at higher elevations on the walls, they are ready to enter the final stages of preparation for release, flight conditioning.

Flight Conditioning

Raptors depend on their athletic abilities to survive. A critical component to complete the rehabilitation process is to recondition the birds until they reach a level of fitness comparable to that prior to their injury. Two common methods used to provide reconditioning are termed "pen flying" and "creance flying". The former requires a long enclosure (100 ft [30.5 m] long recommended for birds the size of Red-tailed Hawks) with perches placed on both ends. Birds are then encouraged to fly back and forth repeatedly from one to several times per day until they are mechanically sound and have adequate endurance. Endurance needs vary by species, as some birds are fast-flyers (falcons), sprinters (accipiters), long-distance migrants (Ospreys [*Pandion haliaetus*], Broad-winged Hawks [*B. platypterus*]), or have a more static life-style (many species of owls).

Creance flying is a technique that involves removing birds from their housing enclosure, attaching leather straps called jesses to their lower legs and then adding a line (creance) to the straps (Arent 2001). The birds are then transported to a large open space with grass for soft gentle landings and encouraged to fly. The success of this technique has been measured using lactic acid production as an indicator of aerobic fitness (Chaplin et al. 1989, Chaplin 1990). Eight to ten 200-ft (60-m) flights without rest is the general goal for most species. Exercising a raptor 3–4 times per week for 4–6 weeks using this technique is an average reconditioning time following recovery from a wing fracture.

Long-term Convalescent Management Considerations

A variety of problems and maladies may befall the rehabilitation patient during the long period of convalescence. Included among them are aspergillosis, bumblefoot, abrasions of carpal joints, broken feathers and overgrown beaks and talons. It is incumbent upon those caring for birds to anticipate and proactively manage the cases so as to reduce the risk of occurrence of management-related problems. Simply put, cases are made or lost on the basis of the quality of the convalescent care. Comprehensive coverage of all of these, except aspergillosis, is presented by Arent (2005).

The fungal disease, Aspergillosis, is a serious complication among raptors held in captivity for rehabilitation purposes. While caused by a ubiquitous fungus in the environment, its occurrence is either management-related or due to lack of preventative measures. In particular, juvenile Bald Eagles, Northern Goshawks (*Accipiter gentilis*), Red-tailed Hawks, Roughlegs (*B. lagopus*), Golden Eagles (*Aquila chrysaetos*), Gyrfalcons (*Falco rusticolus*), Snowy Owls (*Bubo scandiaca*), and northern boreal forest owls with lead poisoning, are prone to developing a respiratory infection with this fungus. The disease does not manifest itself until it is markedly advanced and usually beyond treatment. The approach to prevention entails prophylactic treatment with antifungal drugs at the time of admission. The agent of choice is itraconazole (Sporonox®, Janssen Pharmaceutical Products, Titusville, NJ) administered orally at a dose of 7 mg/kg twice a day for 5 days, followed by once a day for the remaining time period. This schedule is continued for the first 3 weeks the animal is undergoing rehabilitation. Beyond prophylactic treatment, avoidance of steroids, especially dexamethasone, which is severely immunosuppressive, is a factor in reducing overall incidence of this disease.

Release Criteria

If the rehabilitation effort is to be deemed fully successful, then careful choices and decisions must be made as time for release is approached. The major criteria that should be met include (Arent 2001):

1. The bird's illness or injury must be resolved completely, and pose no sign of long-term physical threats (such as arthritis, a growing cataract, etc.).
2. The bird must have achieved an adequate level of fitness and proper flight mechanics.
3. The bird must have a full complement of flight and tail feathers.
4. The bird's feet must be in good condition and its talons sharp.
5. The bird's basic clinical values should fall within an acceptable range (packed cell volume, total protein, total and differential white cell counts, and fecal exam). Further care must be taken throughout rehabilitation to avoid exposure to novel pathogens from domestic sources that may be introduced into free-living birds (e.g., highly pathogenic strains of avian influenza).
6. A bird admitted at a young age (less than four months old) should demonstrate its ability to catch live prey.
7. Birds with unilateral visual deficit should be given careful consideration about their ability to catch prey and avoid objects before being released.
8. Bird's released in times of cold weather should be given 2–3 weeks of acclimatization in captivity prior to release.
9. If possible, consideration should be given to releasing the bird at its recovery location. This may not be possible owing to time of year, territoriality of resident breeders, replacement as a member of a breeding pair, and migration status. Regardless, the release site chosen must have appropriate habitat for the species and its normal prey, must not be in the territory of a known breeding pair during the breeding season, and if close to or during migration, the site should be near a normal migration route for that species.

SUMMARY

The successful recovery of injured raptors requires the application of complex medical procedures, long-term convalescent care, and active physical rehabilitation. The goal at all points is full restoration, rendering the patient virtually indistinguishable from a bird that has not sustained any injury. The release of a bird back to the wild that is not in full possession of all of its faculties or that is not athletically conditioned will likely end in a short survival period, with death resulting from

starvation, accidental injury or predation. As rehabilitation of individual birds has little impact on the population of any raptor species, it is incumbent on those engaging in rehabilitation to (1) ensure that birds being released are in peak physical and mental condition, (2) extract information about causes of injury, parasites, and other medical conditions from each individual case for the sake of increasing our knowledge base, and (3) use examples drawn from actual rehabilitation case materials to educate the public about the types of problems raptors are facing in the ever more human-dominated environment.

Information gleaned from the rehabilitation of individual birds can have direct benefits for populations when that information is used to formulate public policy, pesticide regulations, disease prevention, and control plans. Many of the facilities conducting rehabilitation work are networked via the Internet, thereby making readily available sources of information accessible anywhere in the world. Much has been learned about medical problems and medical care of raptors in the last three decades. This knowledge and the ability to exchange it readily through informatics systems may be useful in addressing problems that affect raptors at the population level.

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