Pet Fish Anesthesia and Surgery

Helen E. Sweeney, DVM

There are many conditions requiring surgery in private pet fish practice. Some of the same indications for surgery in other pet species also exist in pet fish. These include:

- Traumatic injuries resulting in fin and tail tears and open wounds
- External mass removal (biopsy and histopathology)
- Surgical exploration of the coelomic cavity. Elective gonadectomy may also be requested for some species to prevent overpopulation in the tank or pond or to prevent spawning behavior and/or egg binding.
- Wound and cutaneous ulcer management
- Ophthalmic disease management
- Wen reduction in fancy goldfish
- Microchip implantation
- Laparoscopic exploration
- Intracoelomic catheterization
- Buoyancy disorder management

Koi and goldfish are relatively hardy fish and make good surgical candidates. Other pet fish species can vary in their sensitivity to anesthesia and the stress of surgery. A minimum database (MDB) should be completed in all fish cases. In addition to an extensive verbal history (including questions on appetite, weight loss if applicable, behavior in the pond or tank, duration of presenting problem and prior medical conditions) and a thorough physical examination of the patient, the clinician should also perform water chemistry testing and wet mount cytologic exam for external parasites of the skin and gills. Water quality issues should be addressed in addition to medical and surgical treatments.

Other diagnostic techniques such as radiography and ultrasonography may help to give further information prior to surgical exploration. Preoperative blood testing can be performed as with other species. Septic, cachectic, anemic, or lethargic patients do not make good surgical candidates. Stabilization should be attempted whenever possible to reduce the risk of perioperative complications, including death.

The surgeon should be familiar with the normal anatomy of the patient. In the event the species presenting is a novel one, anatomy reference texts should be consulted if available.

Analgesia and anesthesia

Analgesia is defined as relief from pain. There is much debate on whether fish perceive pain but most fish health professionals agree it is better to administer analgesics than not. Several compounds have been used to provide analgesia in fish. These include ketoprofen, flunixin, carprofen, morphine, butorphanol, and buprenorphine. These compounds are often administered as a single injection pre- or post-operatively, but
could also be used in treating traumatic injuries that do not require complicated surgical procedures. Lidocaine has also been used by some practitioners as a temporary, local anesthesia. Exact dosing and pharmacokinetic studies have not been done on most analgesic compounds and doses used are generally extrapolated from other species. There are no approved analgesics for use in fish and these drugs should never be used in food fish. NSAID side effects are largely unknown for many fish species and can be unpredictable. Side effects include: the possibility of gastrointestinal ulceration, poor hemostasis, etc. Informed consent from the owner must be obtained.

In my practice, surgical fish patients receive butorphanol and/or carprofen preoperatively or immediately postoperatively.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dosage Range</th>
<th>Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butorphanol</td>
<td>0.1-0.4mg/kg IM</td>
<td>Surgery, Traumatic injuries, Cutaneous ulcers</td>
</tr>
<tr>
<td>Carprofen</td>
<td>2-4 mg/kg IM</td>
<td>Surgery, Traumatic injuries, Cutaneous ulcers</td>
</tr>
<tr>
<td>Flunixin meglumine</td>
<td>0.25-0.5mg/kg</td>
<td>Same as carprofen</td>
</tr>
<tr>
<td>Ketoprofen</td>
<td>2 mg/kg IM</td>
<td>Same as carprofen</td>
</tr>
<tr>
<td>Meloxicam</td>
<td>0.1-0.2 mg/kg IM</td>
<td>Same as carprofen</td>
</tr>
<tr>
<td>Morphine</td>
<td>0.3mg/kg IM</td>
<td>Used in research</td>
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There are several anesthetic agents to choose from for use in fish. Only MS 222 is FDA licensed for use in finfish as an anesthetic agent. MS 222 (tricaine methanesulfonate, “triple two“, TMS) is available as Tricaine (Syndel USA, Ferndale WA). It is a water soluble, white powder that is made into a liquid anesthetic solution. MS 222 must be buffered as it creates an acidic solution. Sodium bicarbonate (baking soda) is the most widely used buffering agent. A ratio of 1:1 or 1:2 (TMS: NaHCO₃) based on the pH and buffering capacity of the source water. Saltwater has a high buffering capacity compared to freshwater and may require no additional buffering agent when mixed with MS-222. Distilled water can be used when making up a stock solution, although the use of the fish’ own pond or tank water is preferred.

Most fish can be sedated with a 50-100 ppm (mg/L) solution in three to five minutes. Some finfish species may require a higher dose. The initial concentration should be decreased for sick, stressed, or debilitated fish. Likewise, novel species should always be approached with care when anesthetizing for the first time. It is always better to start with a lower dose and increase if needed. The anesthetic powder and sodium bicarbonate should be weighed on a gram scale for accurate dosing. MS-222 at a concentration of 1gm/L can be directly applied to gills with a spray bottle or bulb syringe for fast induction of anesthesia in larger species, such as elasmobranchs.

Cooler water, hard water will result in a longer induction time compared to sedation/anesthesia used in warm or soft water. Gravid fish, older fish, and fish with a high body fat percentage can experience a prolonged recovery.

Tricaine, like other anesthetics in fish, has been reported to cause an increased hematocrit, swelling of erythrocytes, hypoxia, hypercapnia, respiratory acidosis.
hyperglycemia, and changes in blood electrolytes. A working stock solution of 10 g/L MS-222 can be prepared in advance. The solution can be stored up to three months and must be protected from light and excess heat. Gloves should always be worn when handling MS-222 to reduce the potential for mucous membrane irritation and idiosyncratic allergic reactions. Retinal toxicity has been reported as a potential sequelae to long term exposure so protective goggles should be recommended during handling of the powdered form (Bernstein et al, 1997).

Eugenol or clove oil is also a commonly used anesthetic agent in pet fish, although not FDA approved for such use. Clove oil is most often used by koi and goldfish hobbyists to sedate their own fish. Dispersion in water can be improved by initially mixing with warm water and shaking the solution prior to adding to an anesthesia container. Clove oil does seem to have a measurable benefit in reducing short term stress compared to MS-222. Doses used range from 2-5 ppm for sedation and 25-120 ppm for anesthesia. Hobbyists typically use 3-5 drops of the OTC product per gallon (personal observation). Induction and recovery are prolonged in cooler water. Clove oil (a mixture of eugenol, isoeugenol, and methyleugenol) appears to have less analgesic effects compared to MS-222 (tricaine methanesulfonate), has a narrower margin of safety and may be carcinogenic (eugenol, methyl eugenol). For further information, refer to the FDA Guidance for Industry on the use of clove oil and eugenol: http://www.fda.gov/cvm/Guidance/guide150.pdf. Eugenol can also be made into a stock solution, using a 1:10 dilution with 95% ethanol due to its lower solubility in water.

Aqui-S ® (isoeugenol) is currently used in other parts of the world for humane harvesting of finfish and crustaceans, including Australia, Costa Rica, and New Zealand. More information can be found at: http://www.aqui-s.com/en/en_whatsnew.htm#reg and http://ag.an.sc.purdue.edu/aquanic/ncrac/pubs/AQUI-S.pdf. Aqui-S has a zero day withdrawal time in most countries. MS-222 currently has a 21 day withdrawal time, limiting its use in food fish, though this is not a problem in pet fish surgery. Aqui-S® was evaluated extensively for approval in the United States but an exposure study in male mice revealed evidence of carcinogenic activity. As a result, the FDA rescinded the investigational food use studies of Aqui-S.
Currently, Aqui-S®20E (10% eugenol) is being investigated as a possible new drug for sedation and anesthesia of finfish. Aqui-S®20E has a current 72 hour withdrawal time for fish being sent for humane harvest and slaughter. For more information see: http://www.fws.gov/fisheries/aadap/AQUIS-E.HTM.

Benzocaine (Benzoak®) is another potential future anesthetic/sedative for use in finfish. It is also currently being studied under an INAD (Investigational New Animal Drug). The current withdrawal time is also 72 hours. More information can be found at the US Fish and Wildlife Service Aquatic Animal Drug Approval Partnership (AADAP) Program: http://www.fws.gov/fisheries/aadap/benzoak.htm.

Quinaldine (2-4 methylquinoline) is an inexpensive, oily yellow liquid that must be dissolved in acetone or ethanol and buffered with sodium bicarbonate prior to use. Corneal damage and skin irritation have been reported with its use. Quinaldine sulphate is a water soluble powder but is more expensive compared to quinaldine and tricaine. Both are more potent in warm water and in water at higher pH levels, and less potent in soft water. Dosages reported for koi are 12-37 mg/L (ppm) and up to 200 mg/L for tropical fish. Veterinary practitioners may be asked about this “new” anesthetic due to the recent increased OTC sales through fish retailers for use in koi, although it was first reported for use in tropical fish in 1975 (Blasiola, 1975).

Aquacalm® (metomidate hydrochloride) has been used in Canada and other countries outside the U. S. as a sedative or anesthetic in ornamental fish for over 15 yrs. It is currently one of the new “indexed” drugs and is available OTC in the US. Metomidate is a rapid acting, water-soluble, non-barbiturate hypnotic that does not have analgesic properties. Metomidate hydrochloride is absorbed from the water via the gills into the bloodstream where it produces its sedation or an anesthetic affect on the central nervous system. Conversely, anesthetics such as Tricaine-S® act first on peripheral nerves and then secondarily on the central nervous system. In addition, metomidate has been shown to suppress parts of the biochemical pathway involved in cortisol synthesis.

PVMA Fall 2017 H Sweeney
but its use is not considered to be stress-free. Color changes and transient twitching have been reported in several species. Dose for sedation: 0.1 – 1.0 mg/L and dose for anesthesia: 1.0 – 10.0 mg/L (Jim Brackett, personal communication, 2009).

Other agents have been tried with varying success in fish. Propofol, ketamine, and isoflurane are examples.

Fish undergo a similar transition through stages of anesthesia as terrestrial animals. Observation of opercular movement (gill excursions), heart rate, and body movements can help determine anesthetic depth. If the anesthetic plane is deemed to be too deep, fresh water can be flushed over the gills.

**Stages of anesthesia in fish:**

- **Stage 0 Normal**
- **Stage 1 Light sedation**—will react to external stimuli, normal equilibrium (adequate for handling and transport in most species)
- **Stage 2 Deeper sedation**—less reactive to stimuli, normal equilibrium
- **Stage 3 Light anesthesia**—some analgesia, partial loss of equilibrium
- **Stage 4 Moderate anesthesia**—loss of equilibrium, slight reaction to strong stimuli
- **Stage 5 Deep anesthesia (surgical anesthesia)**—no reaction to any external stimuli
- **Stage 6 Respiration ceases, cardiac arrest, death.**

**Surgery**

**Wound Closure:**

The aquatic environment of the patient should be considered when choosing suture material and a closure technique. Most incisions can be closed with a single layer. In some larger koi patients, a two layer closure technique can be employed. Absorbable suture material is not readily absorbed in most fish species. A study by Hurty et al (2002) evaluated the tissue and skin response to several suture materials in koi. The study found monofilament polyglyconate to cause the least reactions in koi, while organic suture materials such as silk, chromic cat gut caused the most severe reactions. Monofilament suture is preferred over braided suture materials due to the potential for tissue reactions and bacterial infections that may occur due to wicking with braided sutures. Monofilament sutures also exhibit less resistance passing through fish skin. A cutting needle works best on fish skin, which can be fairly tough. The author uses polyglyconate (Maxon®, Covidien, Norwalk CT) polydioxanone (PDS II®, Ethicon,
Cincinnati OH), poliglecaprone (Monocryl®, Ethicon, Cincinnati OH) and nylon suture materials. Suture size is determined by the size of the patient and the procedure performed. Patterns of suture are generally a personal preference but should be chosen based on effectiveness, time involved, and ease of removal. Sutures are generally removed in 2-6 weeks, depending on appearance and healing of the incision. Healing can be enhanced by keeping fish in water temperatures at the upper limits of their preferred range and preventing infection of the surgical site.

Suture material should be monofilament and of adequate size. The use of surgical glue (cyanoacrylate) for closure is not recommended due to the potential for dehiscence, inflammatory effect on the skin, and loss of effectiveness in water.

Sutured incision (arrow) following mass removal on a Bristlenose Plecostomus, Ancistrus sp.

Equipment:

Simple and quick surgical procedures, such as fin repair, can be accomplished with minimal equipment. Many times these procedures can be accomplished pond side, sometimes with an audience! For more complex procedures performed in the clinic, specialized equipment should be used. This would include monitoring devices such as an ECG and Doppler pulse oximetry; surgical instrumentation appropriate to the patient size; an adjustable anesthetic delivery system; clear, sterile plastic drapes; and proper suture selection. Lewbart and Harms (1999) gives an excellent description of an adjustable anesthetic system. There are several variations on this device. Many practitioners develop a device that can be easily suited to their own needs and their patients. Currently, there are no commercially available devices.

Tanks and vats should be available for both induction and recovery from anesthesia. The size depends on the size of the patient. Plastic Tupperware® or Rubbermaid® containers are ideal for smaller patients. These containers should allow direct visualization of the patient, aeration of the water, prevent the patient from jumping out, and be easily cleaned and disinfected. For larger patients Rubbermaid® stock tanks can be set up. The tanks can be easily cleaned and stored for future use.

Patient Preparation:
As with other species, choice and preparation of the patient can minimize morbidity and mortality directly related to the surgical procedure. Food should be withheld for 24-48 hours if possible. Blood collection can be done as in other species. A minimal database could include a PCV (packed cell volume, a measure of the red blood cell count), total protein level, and selected chemistry values. Serum BUN may be used as an indicator of gill dysfunction. In house testing using the VetScan® (Abaxis Inc, Union City, CA.) for plasma biochemical values has recently been explored (Palmeiro et al, 2007).

The patient is positioned using moistened towels or chamois (lateral recumbency), bubble wrap, or a foam positioning device (dorsal recumbency). Be sure there is enough area for gill excursions in the foam pad. Unlike terrestrial animals, the skin should not be vigorously scrubbed in preparation for surgery. This procedure would adversely affect the mucus layer and may impair post operative healing. Scales can be removed, if needed, at the incision site. This does provide microscopic openings in the dermis but allows for easier cutting of the skin in large fish. Large amounts of mucus and debris can be removed by swabbing the site gently with gauze soaked in sterile saline or a dilute Betadine or Nolvasan® solution using standard sterile techniques. A final rinse of the area with sterile saline should be done. A clear, sterile drape can be kept in place during the surgical procedure with a thin layer of petroleum jelly. The drape helps retain moisture and prevents contamination of the sterile field.

Koi positioned for exploratory coeliotomy

**Coelomic exploratory:**

- The patient is placed in dorsal recumbency.
- The surgical site is prepared (as described above).
- The initial incision is made caudal to the pectoral fins extending just past the pelvic fins.
- Fish body walls are inflexible and tissue retractors can be used to improve visualization of the surgical field.
• Koi and goldfish have multiple intra-coelomic tissue adhesions, this is common.

• Closure can be accomplished with one or two layers (body wall or muscle and body wall) using an appropriate suture material.

• Sutures should be removed in 3-6 weeks. Fish held postoperatively in warmer water will heal faster than those kept in cooler water.

Post Operative Concerns:

As with other patients, fish should be placed in a recovery area that can be easily observed, limits “escape” opportunities (tanks should be covered), and is in a quiet location to minimize stress.

Water quality should be closely monitored in recovery tanks as this may impact post operative healing and mortality. Salt (sodium chloride) can be added (0.1-0.3%) to aid wound healing and to improve osmoregulation. Temperature should be maintained in an optimum range needed for proper wound healing. Equipment, such as nets, should be disinfected between patients. The entire recovery tank and filtration should be cleaned and disinfected between patients to minimize disease transmission. This is particularly important with regard to viral pathogens. A single injection of antibiotics may be given immediately postoperatively (in addition to supplemental pain management if needed). The author may also give a single injection of ascorbic acid (50-100mg/kg IM) to aid in healing.

Summary:
Pet fish owners are increasingly seeking the services of veterinarians for their pets’ health concerns. Surgical treatment is part of the complete care of the pet fish patient, and with a few novel pieces of equipment and supplies, can easily be added to the repertoire of the private practice fish practitioner.

References and further reading:


Nematollahi a,* A.S. Bigham b, I. Karimi c, F. Abbasi. 2010. Reactions of goldfish (*Carassius auratus*) to three suture patterns following full thickness skin incisions. Research in Veterinary Science 89 : 451–454


