FISH AND AMPHIBIAN ANESTHESIA AND ANALGESIA

Darryl J. Heard, BVMS, PhD, Diplomate ACZM
Associate Professor of Zoological Medicine
Department of Small Animal Clinical Sciences
Box 100126
College of Veterinary Medicine
University of Florida
Gainesville, FL 32610-0126

Fish and amphibian anesthesia requires an understanding of comparative anatomy, physiology and pharmacology. MS222 (tricaine methyl sulfate) is the anesthetic drug of choice in most species.

**Fish**
The fish heart is located in the midline immediately behind the gills, anterior to the coelomic cavity. There is a single ventricle and atrium. Unoxygenated blood flows from the heart through the gills where gas exchange occurs.

The ECG of fish is unique and related to the cardiac anatomy. As in other vertebrates, cardiac output = stroke volume x heart rate. It is increased with increasing temperature. Cardiac output (CO) is decreased in hypoxic water due initially to a reflex bradycardia. Severe hypoxia will produce a profound decrease in CO.

The intrinsic heart rate is species-specific, temperature dependent, and modulated by resting cholinergic and adrenergic tone. The maximum heart rate able to be attained is rarely 2x resting (rarely > 120 bpm). The athletic tuna and related species can develop heart rates of 180-240 bpm.

Vagal tone is modulated through muscarinic receptors. Resting tone increases with environmental hypoxia, initiation of burst swimming and from visual and olfactory stimuli.

Adrenergic control occurs through both Beta and Alpha receptors. Agonist stimulation of B-receptors increases heart rate (epinephrine > norepinephrine). Stimulation of A-receptors decreases heart rate (norepinephrine > epinephrine).

Since heart rate cannot increase as much as mammals, stroke volume is very important for maintaining cardiac output (can increase 2-3 fold). Inotropy increases with temperature, B-adrenergic stimulation, extracellular calcium or a variety of compounds (arginine, vasotocin,
adenosine, prostacyclin, histamine). Negative inotropy occurs with hypoxemia, acidemia, acetylcholine or A-adrenergic stimulation.

Breathing involves gill ventilation, branchial diffusion, blood oxygen transport and tissue diffusion. Water is moved across and through the gills by the buccal force and opercular suction pumps. The combination of these pumps can produce a continuous flow. Rhythmic contraction of the gill arch musculature facilitates even flow.

The gill lamellae are the basic units of gas exchange and lie perpendicular to blood flow. There are only a few layers of epithelium between the water and blood, thus facilitating gas exchange. Gill surface area and diffusion distance are related to life style. The number of lamellae perfused are related to activity; 60% in resting trout. Diseases that affect epithelial surfaces and thickness will alter gas exchange, especially oxygen, and certain drugs and electrolytes.

Primarily PaO2 controls ventilation. Ventilatory flow = frequency (RR) x depth (stroke volume or SV). RR in juvenile and adult fish is about 30-70/min. In truly resting fish tit may be intermittent. It is monitored visually. Unfortunately, many fish stop ventilating under anesthesia for a variety of reasons.

Ventilatory flow rates in juvenile to adult fish > 100 g is 100-300 ml/kg/min. This approximation can be used to determine flow rates in anesthetized fish. Active respiration ceases at high swimming speeds (20-60 cm/sec).

Oxygen is transported both dissolved in plasma, as well as bound to hemoglobin. MCHC is approximately 30 g/100 ml; PCV 15-40%. The latter is the primary determinant of oxygen carrying capacity. Splenic sequestration of RBCs can occur.

As in other animals, pH is maintained at a stable internal level for normal cell function. Plasma PCO2 and bicarbonate are much lower than in mammals. Hydrogen and bicarbonate ions are exchanged at the gills.

**Fish Anesthetics**
Only certain drugs are licensed for use in food fish.

“Inhalation” anesthetics include MS222, clove oil, carbon dioxide and halogenated hydrocarbons. Parenteral anesthetics include ketamine, medetomidine/ketamine, propofol and alfaxalone. Uptake, duration of effect and excretion of “inhalant” anesthetics are determined by water solubility (pH), ventilation, diffusion, temperature, blood flow and excretion.
MS222 (tricaine methane sulfonate) is a local anesthetic and comes as a white powder. The sulfonated side-chain makes this drug very acidic in solution – it must be buffered back to a neutral pH before being used in live animals. Failure to do so is inhumane. It is much more soluble than benzocaine.

MS222 has a good safety margin when used appropriately, but a narrow therapeutic index. It is less safe in warmer water and small fish. Similarly, potency is increased with warm water and low hardness – dosages must be adjusted accordingly.

The physiological effects of MS222 include acidemia, RBC swelling, hypoxemia, hypercapnia, hyperglycemia, hyperkalemia, hypernatremia and hemoconcentration.

In boney fishes the induction dosage is approximately 50-150 ppm (mg/liter), while maintenance is 50-75 ppm. To make induction safer, but slower, use 50-75 ppm. After mixing in solution (preferably same water as from tank) check pH (3-4), and buffer with bicarbonate. Also check water temperature and oxygen levels.

During induction the fish will lose their orientation in the water column. They are usually ready to remove to a maintenance solution when they fail to respond to being lifted by the base of the tail. Use gloved hands for manipulation, as well as nets. For prolonged procedures and surgery an anesthetic system can be used. This requires continuous infusion of water passed the gills.

Anesthetic monitoring includes depth, heart and respiration rates, as well as water temperature, pH, oxygen and flow rate across the gills.

The fish are recovered in clean drug-free, oxygenated water. Some animals will require assisted ventilation until fully recovered.

Clove oil contains approximately 70-90% eugenol. Recovery is dose dependent and longer than MS222. In some fish species it has a narrow margin of safety associated with respiratory collapse. Physiological effects are similar to MS222, although it may produce less analgesia.

Carbon dioxide (sodium bicarbonate) are used to produce short term immobilization. Gas is either bubbled or a sodium bicarbonate tablet is added to the water. The dosage is difficult to control, requires high dissolved oxygen content and produces a marked respiratory acidemia.

Halogenated hydrocarbons are bubbled through the water, but have limited effect because of poor solubility. They also contaminate the environment and are difficult to administer.
In general, fish are very resistant to the effects of ketamine and ketamine combinations. Propofol requires intravenous administration, but can be used at dosages similar to those in mammals.

**Amphibians**

This group of animals includes anurans (frogs and toads), salamanders and caecilians.

When restraining amphibians use washed latex gloves. Maintain good disease control principles to prevent transmission of chytridiomycosis and other potential pathogens. All anurans possess parotid venom glands that may be toxic to personnel, as well as other animals in the environment. Amphibians are very slippery; can use clean small plastic containers for handling and visualization. Some (e.g. horned toads) can bite.

Anesthetic and analgesic drugs can be administered IM, into the lymph sacs, ventral abdominal vein, topically and by inhalation. Anesthetic regimens used in amphibians include MS222, topical isoflurane, eugenol and inhalation anesthesia. Parenteral anesthetic drugs are usually ineffective.

MS222 is the drug of choice, but the concentrations required for anesthesia are much higher than those used in fish. Induction and recovery is also much slower. For amphibians with gills use 250-500 ppm (mg/L), in frogs and salamanders 1-2 g/L and for terrestrial toads 2 to 3 g/L. As for fish, the dissolved MS222 must be buffered back to neutral pH. They will also stop breathing.

**Reference**