Air Sac Perfusion Anaesthesia (APA)

An Anaesthetic Procedure for Surgery in the Head Area and for Ophthalmoscopy in Birds

- A practical guideline -

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Air sac perfusion anaesthesia (APA) is an anaesthetic procedure that has been developed for surgery of the head and ophthalmological investigations in birds (Korbel et al. 1993, 1995, 1996, 1997). In contrast to conventional head chamber inhalation anaesthesia, it ensures free surgical access to the head and neck, and is thus suitable for operations on the head, eyes and beak, including the oral cavity, as well as the upper gastrointestinal tract. Furthermore, APA is an integral element of avian ophthalmological investigations for preventing excitation shock during protracted examination methods e.g. Shirmer tear test, (Korbel and Leitenstorfer 1995), Electroretinography (Korbel and Stütz 1997) and gonioscopy (Korbel et al. 1998). It is also particularly suitable for anaesthetic induction of mydriasis as a preliminary to routine ophthalmoscopy (fundoscopy) because mydriatics commonly used in mammalian ophthalmology are ineffective in birds on account of the striated intraocular muscles(Korbel 1998 in press).

APA is conducted by retrograde perfusion of the lung-air sac system with an isoflurane-nitrous oxide mixture through a special air sac catheter which is introduced into the left caudal thoracic air sac. The required puncture of the air sac is performed under conventional head chamber inhalation anaesthesia analogously to the procedure for endoscopic sex determination. After making a skin incision about 3 to 4mm long along the cranial border of the thigh (sartorius muscle) on one side, and in the middle of the femoral shaft on the other, the left caudal air sac is punctured by blunt perforation of the intercostal muscles and fascia or of the last intercostal space, or behind the last rib using angled blunt forceps. The subsequently introduced sterilisable Korbel silicone air sac catheter (COOK VETERINARY PRODUCTS), has an overall length of 100cm and a standard Dräger fitting for easy connection to standard respiratory gas tubing systems. It has a diameter of 2mm and a number of lateral openings at the tip to avoid obstruction by the air sac. In addition, the first 6cm of the catheter are graduated (1 mark equal to 0.5cm) to give the surgeon an indication of the penetration depth into the air sac. The flexible tip of the catheter is rounded to prevent injury of the air sac walls and other internal organs. In contrast to other types of catheters, the Korbel air sac perfusion catheter is suitable for universal use in almost all fancy and predatory birds weighing from 30 to 5000g treated in Veterinary practices. The puncture site in the thoracic wall is sealed by drawing together a purse-string cutaneous suture inserted before the procedure. For switching from conventional head chamber administration to air sac perfusion anaesthesia, the carrier gas-perfusion volume (oxygen-nitrous oxide mixture 1:1) is reduced to 0.3 l/min/kg body weight to ensure a virtually physiological blood pH. Higher perfusion volumes increase CO_2 wash-out and thus cause hypocapnic alkalosis with associated cardiac arrhythmias. After about 8 to 15 seconds APA induces APA-specific reversible apnoea which is attributable to perfusion-induced, subphysiological arterial CO_2 partial pressure ($PaCO_2$) with loss of stimulation of the respiratory centre. For example, the minimum $PaCO_2$ measurable by pulse oximetry for stimulating the respiratory centre in domestic pigeons (*Columba livia* Gmel., 1789, *var. domestica*) is 38mmHg. By using a modified anaesthesia machine with integral low-flow measuring columns (minimal flow 0.01 l/min), APA can be used for birds with a body weight as low as 30g (e.g. budgerigars). The low-flow flowmeter can be used as an exact measuring instrument for ensuring unimpeded perfusion of the lung-air sac system. Thus a slight or complete fall of the bobbin indicates partial or complete obstruction of

Air sac perfusion anaesthesia (APA) with an isoflurane-oxygen-nitrous oxide-mixture delivered via a specially designed air sac catheter inserted into the left caudal thoracic air sac. This allows a free surgical access to the head for head and eye surgery, immobilisation of the patient and induces an ophthalmoscopically useful (here: binocular indirect ophthalmoscopy) mydriasis in a domestic pigeon (Columba livia Gmel., 1789, var. dom.). Routine anaesthesia monitoring with pulse oximetry using paedriatric probes located above the gastrocnemius muscle is essential.

perfusion which may be due to blockage of the catheter tip by coagulating blood or inflammatory products or kinking due to inserting the catheter too deeply. Any subcutaneous emphysema that develops immediately after switching to air sac perfusion is generally due to malpositioning of the air sac catheter, excessive perfusion volume, or obstruction within the lung-air sac system.

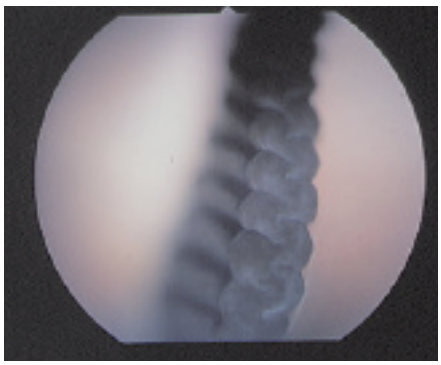
The isoflurane concentration required for maintaining surgical tolerance is slightly higher than with conventional head chamber administration. Thus different species-specific isoflurane concentrations are required, ranging from 1.0 ± 0.2 (e.g. Alexandrine Parakeet (*Psittaula eupatria* L., 1766) to 2.4 ± 0.2 Vol.% e.g. domestic pigeons (*Columba livia* Gmel., 1789, *var. domestica*).

The carrier gas/anaesthetic mixture that escapes through the beak and nostrils should be scavenged by an extractor integrated in the operating table. The addition of nitrous oxide to the carrier gas (caution! danger of emphysema in birds with "air sacs" without open communication to the lung-air sac system, e.g. pelicans), potentiates isoflurane by around 11% (Korbel et al. 1996).

APA is ended by interrupting the flow of isoflurane and nitrous oxide. However, the bird is perfused with pure oxygen for a further four minutes to shorten the recovery phase by rapidly washing isoflurane out of the air sac system and preventing nitrous oxide diffusion hypoxia. On average, spontaneous respiration restarts 3 to 3.5 minutes after ending O_2 perfusion once physiological CO_2 partial pressure is restored and stimulates the respiratory centre. Therefore, the patient is occasionally awake, but not breathing. Immediate induction of spontaneous respiration after ending APA is possible by adding 1% CO_2 to the respiratory gases, i.e. increasing the $PaCO_2$.

Due to the lack of spontaneous respiration and absent peripheral tendon and ocular reflexes (or local anaesthesia for eye surgery), pulse oximetry is obligatory for monitoring anaesthesia (Korbel et al. 1997) during APA (sensors applied to the lower leg over the gastrocnemius muscle). In order to avoid an excessive infusion-induced drop in body temperature, a (heated) respiratory gas humidifier is used to avoid cooling by condensation off the large surface area of the air sacs (Korbel et al. 1998) in addition to exogenous heat from a heated pad.

Besides its controlability and suitability for long-term anaesthesia, the special benefit of APA compared with conventional head chamber anaesthesia is free surgical access to the head and a reduction in the isoflurane consumption (and thus sparing the surgical team expired anaesthetic gases) by a factor of 5 to 7. The reversible apnoea achieves complete immobilisation of the patient - particularly beneficial for microsurgical procedures. Furthermore, a stable reduction in intraocular pressure (IOP) by a mean 20% (from 14.8 ± 2.1mmHg [domestic pigeons] or from 16.0 ± 3.0 mmHg to 12.9 ± 2.1 or 11.6 ± 2.4 mmHg [common buzzards]) is achieved, which is essential for intraocular surgery.



Ophthalmoscopical image of the fundus oculi in a Short-toed Eagle (Circaetus gallicus Gmel., 1788) showing the so called "bridge" at the top of the pecten oculi, a heavily pigmentated chorioidal projection into the vitreous. Mydriasis and immobilisation of the patient induced using APA.

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TORTOISE ANAESTHESIA USING COOK ENDOTRACHEAL TUBE

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The intubated land tortoise pictured is a 2.7kg female adult specimen of a Mauritian land tortoise (*Greece tortoise*). The tortoise was premedicated by using 50mg/kg ketamine hydrochloride. The reflex to withdraw the tongue was noticeably reduced after 20 minutes in an ambient temperature of 28° Celsius. A COOK VETERINARY PRODUCTS V–PAT–20 endotracheal tube was then introduced into the tracheal opening up to the first thickened site. The tube was secured to the jaw using an adhesive tape. Balloon catheters are not recommended, because the trachea of reptiles has a very sensitive ciliated epithelium.

To ensure correct pulmonary aeration, careful positioning of the tip of the endotracheal tube is important. The tip should be placed proximal to the tracheal bifurcation which occurs approximately 1/3 of the way along the trachea.

This tortoise was anaesthetised to surgically remove an inflamed part of the tortoise's amour. This is a painful procedure, therefore a narcosis was indicated. Anaesthesia was maintained using the anesthetic isoflurane. No problems occurring during extubation, and no postoperative irritation of the respiratory tract was identified . ■

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