Anaesthesia for open chest surgery

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ABSTRACT
Anaesthesia for open chest surgery is discussed, including premedication, induction of anaesthesia, provision of intermittent positive pressure ventilation, anaesthetic maintenance, neuro-muscular blocking agents, and post-operative analgesia. Although sophisticated techniques aid surgery, simpler methods may prove adequate where facilities are limited. Emphasis is placed on the complications which may arise at any stage due to the pre-existing pathology of the patient, as it is the anticipation of such complications, coupled with careful monitoring before, during and after the procedure, which has the greatest influence on morbidity and mortality following clinical thoracic surgery.

INTRODUCTION
Thoracic surgery in the healthy animal presents few special difficulties other than the provision of an adequate means of intermittent positive pressure ventilation (IPPV) while the chest is open. Sophisticated techniques have advantages but any combination of anaesthetic drugs which provides anaesthesia, adequate relaxation, minimal cardiovascular depression, and allows a rapid post-operative recovery is suitable. Often the clinical case which requires thoracotomy is complicated by respiratory, cardiovascular, and fluid deficit problems associated with the original condition. During anaesthesia the patient will receive maximum support and attention but pre-operative and post-operative care are of equal importance, although these aspects are frequently neglected. The problems encountered in such cases therefore may be considered under the following headings: (1) Pre-operative preparation and premedication; (2) induction; (3) IPPV and maintenance; (4) recovery and post-operative period.
(1) PRE-OPERATIVE PREPARATION AND PREMEDICATION

To anticipate the difficulties which are likely to occur at the induction of anaesthesia and thus to allow pre-operative precautions to be taken where possible, accurate diagnosis of existing respiratory and cardiovascular disease is essential. For example, many cases of oesophageal dysfunction are complicated by an inhalation pneumonia which can be treated with antibiotics pre-operatively. Any space-occupying lesion in the pleural cavity is a hazard because after induction of anaesthesia it is often impossible to ventilate the animal adequately until the pleural cavity is opened and the space-occupying material removed. For this reason, wherever possible, air or fluid should be drained from the chest under local anaesthesia, and in cases of ruptured diaphragm prior clipping and cleansing of the surgical site will reduce the delay before the surgeon can remove the abdominal viscera from the chest. The advantages, however, of such preparation have to be balanced in each individual case against the dangers of delaying surgery or of distressing a severely hypoxic animal.

An intravenous infusion is useful at this preparatory stage, not only to correct existing fluid deficits, but also to be certain of having an open vein available should fluid or drugs be required during surgery, because once hypotensive premedicant or anaesthetic drugs have been given it is much more difficult to insert a suitable intravenous cannula.

For premedication atropine should always be given, but sedative (e.g. acepromazine) or analgesic (e.g. pethidine) drugs are used with care as their sedative and respiratory depressant effects can lead to an increased risk of hypoxia. Where such drugs are used the animal must be carefully watched so that appropriate support can be given should oxygenation become inadequate.

(2) INDUCTION

Often, the greatest risk for an animal suffering from thoracic disease is during the induction of anaesthesia. For example, in animals which have oesophageal obstruction food and fluid which have lodged anteriorly to the obstruction can be passively regurgitated as soon as the animal becomes recumbent, and care has to be taken to prevent inhalation of this material before the airway has been secured by the passage of a cuffed endotracheal tube. The classical method to reduce this danger is to lower the patient's head so that any regurgitated material will drain from the mouth. However, if before induction of anaesthesia, the patient is placed in sternal recumbency with the head higher than the body, and this position is maintained during and after induction until the endotracheal tube is in place, then passive regurgitation cannot occur at all. Obviously, this method does not guard against active vomiting, and should this occur the head must be lowered at once. Whichever method is used it is essential to have some form of suction apparatus available should the precautions taken fail and inhalation of the regurgitated material occur.
Hypoxic animals benefit from administration of oxygen by mask before anaesthesia, but if this is resented and causes distress, then it may do more harm than good by raising the oxygen requirements. In such cases a mask should be kept available at induction so that oxygen can be given if necessary without delay. It is essential to use an intravenous method of induction of anaesthesia followed rapidly by endotracheal intubation so that the animal can pass from the stage of ‘minimal interference’ to ‘maximal support’, including IPPV if necessary, as quickly as possible.

In dogs intubation is simple but in cats it is complicated by the need for greater relaxation of the vocal cords than is obtained by intravenous induction agents alone. One method of overcoming this problem is to spray the larynx of the anaesthetized cat with local anaesthetic when, provided sufficient time has elapsed for the spray to have taken effect (at least 30 seconds) the vocal cords relax and intubation is simple. However, many anaesthetists prefer to use the short-acting muscle relaxant, suxamethonium (2-5 mg). This drug is administered intravenously after induction of anaesthesia, and causes initial muscle fasiculations before relaxation of all skeletal muscles, including the vocal cords, occurs and intubation can be carried out. As the respiratory muscles are also paralysed it is necessary to apply IPPV until spontaneous respiration is resumed after about 5 minutes. Whichever method is used it may be useful, particularly in the hypoxic cat, to administer oxygen by mask immediately after induction of anaesthesia so that the cat is well oxygenated during the intubation procedure. In cats and small dogs the passage of a non-cuffed endotracheal tube provides a much larger airway than if a cuffed variety is used. Despite the lack of a cuff with suitable sized tubes (5.0 mm–5.5 mm for the average adult cat) there should be an adequate seal to allow IPPV. If necessary this seal can be reinforced with a pharyngeal pack to prevent the inhalation of foreign materials.

(3) IPPV AND MAINTENANCE

Some means of mechanical ventilation of the lungs is necessary whilst the pleural cavity is open to atmospheric pressure. This may be provided simply by squeezing the reservoir bag of the anaesthetic circuit or by some form of automatic ventilator. The best circuit for use in cats and small dogs is an Ayres T piece with a Jackson-Rees modification (i.e. an open ended bag on the expiratory limb of the T piece which can be squeezed to ventilate the animal). An unmodified T piece should not be used as when IPPV is applied by temporary occlusion of the expiratory limb of the circuit too great an inflation pressure may be obtained resulting in rupture of the alveolae and pulmonary oedema. The Magill circuit is also unsuitable for prolonged IPPV because during the positive phase of the cycle the expired gases are forced back into the animal, leading to an accumulation of carbon dioxide. IPPV may be applied using to-and-fro, or circle, carbon dioxide absorber circuits, but these introduce extra problems when anaesthesia is maintained with volatile
agents, as the changing concentration of such agents in the reservoir bag of these circuits makes it very difficult to be certain of the concentrations of anaesthetic which are being delivered to the patient. In particular, care must be taken when using nitrous oxide in such circuits as the rate of uptake of this gas by the patient rapidly decreases with time, leading to its accumulation and to a fall of oxygen in the circuit. To guard against this either a lower concentration of nitrous oxide should be used or the circuit regularly flushed out with fresh gases. Where a system with an in-circle vaporizer (such as a Stephen’s machine) is employed the vaporizer must be removed from the circuit, otherwise the concentration of volatile anaesthetic agent will rapidly reach lethal levels.

Various automatic ventilators are available. The simplest of these, such as the magnetic miniature ventilators (e.g. the Minivent), and the more reliable Manley ventilator, are driven by the pressure of gas from the anaesthetic machine. There are also many complicated and expensive electronically driven ventilators available.

During spontaneous ventilation the pressure changes in the thoracic cavity relative to atmospheric pressure change from negative to zero, thus not only drawing air into the lungs, but also assisting the return of blood to the heart (thoracic pump). During positive pressure ventilation, however, the pressure changes are reversed and the positive pressure applied to drive the gas into the lungs also tends to restrict the venous return to the heart. For this reason the positive inspiratory phase should be kept as short as is necessary for adequate ventilation and in general a ratio of inspiratory period to expiratory period of 1:2 is employed.

The use of neuromuscular blocking agents for thoracic surgery does not greatly facilitate the work of the surgeon, as the main limitation is the size of intercostal space that can be obtained rather than the degree of muscular tone. However, in dogs muscle relaxants will decrease the resistance to mechanical ventilation and thus reduce the positive pressure required while improving the venous return. This factor is not so essential in the cat and is of reduced importance while the chest is fully open.

In the dog, the depolarizing relaxant suxamethonium chloride (0.3 mg/Kg) gives about 20 minutes’ relaxation, after which spontaneous respiration is resumed with no other drug treatment. If further doses are given there may be difficulty in re-establishing spontaneous respiration, and if a longer period of relaxation is required it is better to use one of the non-depolarizing drugs such as pancuronium bromide (0.06 mg/Kg) which will be effective for about 30 minutes, and of which further doses (0.03 mg/Kg) can be given as required. The action of the non-depolarizing relaxants is reversed with the anticholinesterase drug neostigmine, the dose required depending on the degree of ‘residual curarization’ and the depth of anaesthesia. As overdosage with neostigmine leads to further neuromuscular blockage, it is advisable not to attempt to reverse the relaxant for the first 20 minutes after administration, and even then care is needed if doses of neostigmine greater than
0.1 mg/Kg are employed. It is usual practice to administer atropine both intravenously before, and mixed in the syringe with the neostigmine in order to block the stimulation of the autonomic nervous system which the anticholinesterase would otherwise cause. Even if spontaneous respiration is present at the end of surgery, it is still advisable to give a small dose of neostigmine after the use of non-depolarizing relaxants as any ‘residual curarization’ will increase the risk of post-operative hypoxia.

Anaesthesia may be maintained with any suitable agent. However, if animals are to be ventilated with volatile anaesthetics, it is easy to overdose, so these should preferably be delivered from a calibrated temperature compensated vaporizer via a non-rebreathing circuit (e.g. modified Ayres T piece, co-axial or via a gas-driven ventilator) when the exact concentration of anaesthetic delivered is known, and indeed this is essential if volatile agents are to be used when muscle relaxants are employed as the usual reflex indications of depth of anaesthesia are abolished. When muscle relaxants are employed it is often safer to maintain anaesthesia with 70% nitrous oxide in oxygen (50% nitrous oxide if an absorber circuit is used) supplemented intravenously when necessary with small incremental doses of the induction agent or of a powerful short acting analgesic such as fentanyl. Despite the use of relaxants, should analgesia be inadequate the animal will respond to stimulation by faint reflex movements such as curling the tongue. Other signs of returning consciousness are an unexplained rise in pulse rate or evidence of vasovagal syncope. Should these occur supplementary anaesthesia in some form must be given. However, the judgement of depth of anaesthesia under muscle relaxants requires considerable experience, and it is essential that a veterinary surgeon should supervise the anaesthetic under these circumstances.

(4) RECOVERY AND POST-OPERATIVE PHASE

As the chest is closed at the termination of the operation all air and fluid must be removed from the pleural cavity. The anaesthetist can use positive pressure to hold the lungs in expansion while the chest is sealed, but this is rarely adequate and it is preferable before closing the chest to insert a drain which may be attached to some form of continuous drainage such as underwater seal or Heimlich valve. Where the lungs have been collapsed for a considerable time, they should be allowed to re-expand slowly as the use of too great a force may damage the alveolae and lead to pulmonary oedema. The drain is left in place as long as air and fluid remain in the pleural cavity which in uncomplicated surgery may only be a few hours. However, if there is an air leak from damaged lung the chest must be drained until the leak has stopped, and in cases where there is a continuous production of fluid into the pleural cavity, drainage may be required for several days post-operatively.

Once surgery is complete, spontaneous respiration restored and the animal recovering consciousness, careful monitoring should be maintained to ensure that respiration is adequate so that IPPV or oxygen therapy can be applied if required.
In dogs the endotracheal tube can be left in position until it is seen that the patient is maintaining itself on room air. In cats this may not be possible as the endotracheal tube must be removed before laryngeal reflexes return in order to reduce the risk of laryngeal spasm occurring at this stage. However, oxygen can be administered by mask after extubation, and for any species it is essential to have at hand the necessary apparatus to enable ventilation with oxygen by mask, and for rapid re-intubation to be performed if required.

Thoracic surgery is painful, and as pain inhibits chest movement the administration of narcotic analgesics (such as pethidine 1–2 mg/Kg) post-operatively may improve respiration. Post-operative restlessness, which may prove troublesome if the patient is still on continuous drainage, is reduced by the relief of pain, and also by administration of diazepam (1 mg/Kg IV). After the use of narcotic analgesics the animal must be observed to ensure that the analgesic action outweighs the direct depressant action of the drug.