A METHOD OF ANAESTHESIA FOR THORACOTOMY IN EXPERIMENTAL ANIMALS

With Special Reference to the Study of Oesophageal Activity

BY

G. S. MULLER BOTHA AND J. F. NUNN

Department of Surgery, Queen Elizabeth Hospital, Birmingham

DIRECT observation of oesophageal motility in man and animals has been rendered difficult by the problem of exposure without interfering with swallowing and peristalsis. Although thoracotomy is an everyday procedure in the human subject, it is still hazardous in small animals. Furthermore the usual methods of thoracic anaesthesia either abolish or markedly affect oesophageal motility; the use of relaxants would vitiate any investigation of the part played by striated muscle.

In order to study the physiological activity of the entire oesophagus visually, our anaesthetic technique should fulfil the following conditions:

1. The animal would be certain to remain unconscious when respiration was abolished and the normal signs of anaesthesia were no longer evident.
2. Neither a myoneural blocking agent nor profound general anaesthesia should be used.
3. Satisfactory gaseous exchange should be maintained for as long as may be necessary.

METHOD

In most animal work it is both convenient and humane to induce anaesthesia with a barbiturate or bromethol given either intravenously or into the peritoneal cavity. This secures basal narcosis but for traumatic procedures additional anaesthesia will be required. Eighty per cent nitrous oxide with oxygen, is probably the ideal agent but must be administered without air; this is difficult if an endotracheal tube cannot be used since a close fitting mask presents a problem in animals. Controlled respiration is generally regarded as essential when the pleural cavity is opened; it can be initiated in three ways (Lee 1953):

1. The threshold of the respiratory centre to carbon dioxide may be raised by deep general anaesthesia.
2. The level of carbon dioxide in the body may be reduced below the respiratory threshold.
3. The voluntary muscles may be paralysed by a myoneural blocking agent.

Wright (1956) recommends, for larger animals, hyperventilation after obtaining basal anaesthesia with pentobarbitone. In all the species in the present investigation it was not difficult to reduce the carbon dioxide tension by a short period of controlled hyperventilation; apnoea then supervened and could be maintained indefinitely by moderate hyperventilation. Spontaneous respiration returned promptly if the ventilation was reduced or stopped. Provided that an adequate concentration of nitrous oxide was maintained the animal would remain unconscious, even after the basal anaesthetic had worn off.

For controlled ventilation we have used a simple T-piece arrangement (fig. 1). Although this is wasteful in the larger animals and man, it is quite economical in the smaller experimental animals. It has the advantage of simplicity in construction, maintenance and use. There is no rebreathing, no necessity for soda lime, and the dead space is reduced to a minimum. The constituent parts are all standard anaesthetic equipment for the gas supply from cylinders fitted with Adams reducing valves giving a pressure of 250 mm Hg. This is higher than necessary and may be undesirable since over distension and rupture of the lungs could occur should inflation be unduly prolonged; in practice, however, it is simple to limit the phase of inflation to produce
any required degree of lung expansion. Provided
the flow rate of the fresh gas supply is reason-
ably low and the open limb of the T-piece is
occluded for only the minimum time, there
should be no excessive build up of intrapulmo-
nary pressure; it is possible to fit a safety valve to
prevent any possibility of high inflation pressure.
The method is easier to manage when the gas flow
in small animals is reduced.

The following flow rates were found to be suit-
able: rabbit 1.5 l./min; guineapig 1.0 l./min;
mouse 0.5 l./min.

Usually 80 per cent nitrous oxide in oxygen
was used in all species.

PROCEDURE
Pre-operative starvation is desirable in survival
experiments: a full stomach has never affected our
results in acute experiments. Atropine and mor-
phine depress oesophageal activity and were not
therefore used for premedication. No difficulty
was encountered from salivary and bronchial
secretions.

Induction.

After weighing, each animal received a basal
anaesthetic—in the bigger animals intravenous
or intraperitoneal veterinary pentobarbitone
(Nembutal) 26 mg/kg body weight. Intravenous
administration produces a rapid onset of anaes-
thesia facilitating immediate intubation. In smaller
animals a 1 in 20 solution of bromethol in
amylene hydrate was used intraperitoneally (80
mg/kg body weight). The dosage of these drugs
in animals is extremely variable and the full dose
often produces unpredictable results; it was, there-
fore, found to be safer to supplement a small
initial dose, if necessary.

Intubation.

Intubation without relaxants presented no
difficulty in any of the species studied. Blind
intubation is easy, but may be traumatic, espe-
cially in the smaller animals when it may interfere
with the swallowing reflex; therefore a Shadwell
infant laryngoscope was used at first, but one of
us (G.S.M.B.) designed a modification that was
better adapted to the long narrow palates of the
smaller animals (fig. 2). Standard Magill endo-
tracheal tubes were used: dogs need large cuffed
tubes: intubation was impossible in the smaller
species like the mouse, rat and guineapig, and
tracheostomy was performed using thin rubber
or polythene tubes. The greatest care had to be
taken to avoid injury to the motor nerves of the
esophagus during tracheostomy. It is important
to ensure that the animal cannot occlude the
tube should the bite reflex return before the tube
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Special laryngoscope to facilitate intubation in the smaller species.

is removed; a metal guard over the endotracheal tube is a safeguard which should always be used.

Maintenance.

The incision was made, and any associated abdominal procedure completed with the animal breathing spontaneously either air or nitrous oxide and oxygen. Haemostasis is of considerable importance in smaller animals in view of their small blood volume. Carbon dioxide was reduced by vigorous hyperventilation as the chest was about to be opened: apnoea followed after a few breaths and the pleura was then opened. Ventilation was then controlled at a rate sufficient to keep the carbon dioxide level below the respiratory threshold. One lung could be collapsed completely by deliberately passing the endotracheal tube into the opposite bronchus; this facilitated exposure and reduced the number of retractors required in a very confined area. The depth of anaesthesia could be altered within fine limits by changing the concentration of nitrous oxide.

At the conclusion of operation, if the animal is to survive, there should be no residual pneumothorax; the lungs must therefore be fully inflated when the chest wall becomes airtight. Pleural closure is difficult in small animals and care must be taken not to damage the lungs for a bronchopleural fistula is serious; intercostal drainage is not practicable in small species.

DISCUSSION

This technique has been used for the mouse, hamster, rat, guineapig, ferret, rabbit, cat, monkey, pig and dog. The dose of the basal narcotic, the size of endotracheal tube and the total gas flow varied with species. The low total gas flow in small animals not only provided a very economical anaesthetic technique, but also decreased the possibility of overdistension of the lung parenchyma. One of us performed the intubation (or tracheostomy) but thereafter the anaesthetic could be left in the hands of a technician; the great majority of the experiments were performed with only one assistant. Apart from the basal narcotic, the only physiological transgression was the low carbon dioxide tension with associated respiratory alkalosis and possible changes in serum electrolytes and regional blood flow. There was no apparent interference with oesophageal function and primary peristalsis could be initiated by squirting water into the pharynx. Secondary peristalsis was studied by
introducing balloons into the oesophagus. Oesophageal motility was seen in some species while in others the lightest possible phase of anaesthesia had a depressant action on the physiology of the organ.

The general condition of the animals appeared satisfactory. Those which were intended to survive recovered well and anaesthesia was maintained in the nonsurvival experiments for as long as four hours.

**SUMMARY**

1. An anaesthetic technique is described which can be used conveniently for thoracotomy in many different experimental animals.

2. Although based on current practice in the human subject, no relaxants are used.

3. The apparatus is simple and maintenance of the anaesthetic can be carried out adequately by a technician.

4. Motility of the cervical, thoracic and abdominal oesophagus can be studied directly.

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**REFERENCES**


**BOOK REVIEWS**


It would be difficult to compress more useful knowledge into the 200 pages of which this small volume consists than has been done by the authors Messieurs P. Huguenard and P. Jaquenoud. It begins with an all too short glossary of terms used in the text, this is followed by an example of how to examine and report on a patient who has submitted himself for operation. The authors suggest that the ability to make a report is one of the best tests of a candidate's ability to become a good anaesthetist; certainly if he will master pages 15–25 of this small book, the implications thereof, and put them into practice, he will be well on his way.

Next we come to the problems posed to the anaesthetist by the nature of the operation or of the condition of the patient, for example, the neurosurgical, the abdominal urgency, the badly burned or the diabetic, etc. Two chapters, one on pharmacology and the other on physiology, follow, both dealing with aspects which are very much to the fore just now. The book concludes with a description of a few techniques—how to introduce a tube into the trachea, a catheter into a vein or put a dog to sleep, and an “Extrait du règlement des concours de l’assistance publique a Paris.”


This volume of some 250 pages is divided into two parts. The first gives the seven lectures of the “Cours supérieur d’anesthésie” for 1955–56. Such exciting subjects as “Postoperative pain”, “Causes and treatment of cardiac arrest during operation”, “Indications for tracheotomy” and the “Early treatment of burns” will interest all our readers. General anaesthesia in dentistry and the distribution of water as it varies in the adult and the child will make a more limited appeal.

How, where and when to make intra-arterial injections and the complications that may follow is the subject dealt with by Louis F. Hollender of Strasbourg and is well worth the attention of every anaesthetist.

The second part consists of eleven papers dealing with subjects constantly in the mind of the anaesthetist, such for example as the measurement of CO\textsubscript{2} during anaesthesia, a new cardiac reanimator and the influence of drugs on anoxia.

*E. Falkner Hill*