THE RESPIRATORY DEPRESSANT EFFECTS OF BARBITURATES AND NARCOTIC ANALGESICS IN THE UNANAESTHETIZED RABBIT

BY

A. R. HUNTER, BARBARA J. PLEUVRY AND J. M. H. REES

SUMMARY

The effects of ten narcotic analgesics and three barbiturates have been investigated on respiratory rate, respiratory minute volume and blood Pco₂ in the unanaesthetized rabbit. Both groups of drugs produced respiratory depression, and whilst the pattern of depression was similar for drugs of the same group, there were three main differences in the pattern of depression between the narcotic analgesics and the barbiturates. (1) In the case of the narcotic analgesics the relationship between the log dose and depression of minute volume was fairly steep and was linear over a wide range, whilst in the case of the barbiturates there was a distinct plateau in this relationship. (2) The log dose-response for depression of respiratory rate was linear for both groups, but that produced by the narcotic analgesics was steeper than that produced by the barbiturates. Rabbits tolerated severe depression of respiratory rate when it was produced by a narcotic analgesic, whilst fatalities occurred after barbiturates with doses which produced far less depression. (3) Narcotic analgesics produced a dose-dependent elevation of blood Pco₂ which paralleled the changes in respiratory minute volume. Barbiturates produced little Pco₂ elevation, and fatalities occurred with Pco₂ elevations which were relatively insignificant. The implications of these findings are discussed.

There is little doubt that the primary cause of death after overdosage of both narcotic analgesics and barbiturates is respiratory failure. Although circulatory and renal failure can complicate the treatment, artificial ventilation is often adequate for resuscitation both in experimental animals and in human subjects whose respiration has failed. In the case of the barbiturates it is surprising to read in many clinical reports that both the blood barbiturate level (Matthew and Lawson, 1967) and measurement of respiratory minute volume (Stretton and Howell, 1967) are of relatively little importance in assessing either prognosis or the need for artificial ventilation, although a respiratory minute volume of less than 4 l./min is commonly used as the dividing line (Matthew and Lawson, 1967).

It seemed worthwhile, therefore, to investigate the pattern of respiratory depression produced by both narcotic analgesics and barbiturates to determine whether the lethal effects of both these drug groups could be ascribed to a similar degree of respiratory depression.

METHODS

Groups of rabbits, of mixed strain, and of either sex were used.

Measurement of respiratory minute volume and respiratory rate.

These were measured by the method of Gaddum (1940). The recorder was calibrated on each occasion by means of a depressed level flowmeter and suction pump. The method differed slightly from that originally described in that the face mask was applied to the rabbit intermittently for periods of about a minute—a procedure which the rabbits tolerated better than continuous application. No change in respiratory rate followed the application of the mask.

Measurement of blood Pco₂.

This was performed by the Astrup technique on arterialized blood obtained from the marginal
vein of the warmed ear. The full details of the method and results have appeared elsewhere (Rees, 1967, 1968; also Pleuvry and Rees, in preparation).

Experimental design.

Two patterns of drug administration were used. First, drugs were administered at a given dose and the effects measured until control values were regained. This method was used for the barbiturates and some of the narcotic analgesics. Second, a cumulative pattern of drug administration was used. A dose of drug was administered \((x)\), and the effects followed until a peak response was recorded. At this point a further dose of \(x\) was given (giving a total dose of \(2x\)) and the new peak response observed, at which point a further dose of \(2x\) was administered and the effect of a total dose of \(4x\) recorded. This method was used for most of the narcotic analgesics.

In most instances a cross-over method was used in which different narcotic analgesics were administered to the same animal. The interval between successive investigations was always at least one week, and in a few animals in which the same narcotic analgesic was administered on more than one occasion, there was no appreciable development of tolerance to the respiratory depressant action of the drug.

Drugs used and number of animals in which each drug was investigated.

The number of rabbits in each group was never less than four. The total number of rabbits in which each drug was investigated and the experimental design was as follows \((i = \) investigation of independent log dose-response relationship; \(c = \) cumulative method).

Narcotic analgesics, respiratory rate and minute volume determinations: alphaprodine hydrochloride \((c,6)\); etorphine hydrochloride, M99, Reckitt \((c,4; i,34)\); dextromoramide bitartrate \((c,8)\); dihydrocodeine bitartrate \((c,6)\); dipipanone hydrochloride \((c,8)\); heroin hydrochloride \((c,12)\); levorphanol tartrate \((c,9)\); methadone hydrochloride \((c,7)\); morphine sulphate \((c,23)\); pentazocine lactate \((c,4; i,5)\); pethidine hydrochloride \((c,9)\); 1-phenadoxone hydrochloride \((c,9)\).

Narcotic analgesics, \(P_{co^2}\) determinations: dextromoramide bitartrate \((i,10)\); etorphine hydrochloride \((c,4; i,34)\); morphine sulphate \((i,23)\).

RESULTS

Changes in respiratory minute volume and respiratory rate are expressed in terms of percentage depression of control values that were established for each animal during the hour prior to drug administration. Changes in blood \(P_{co^2}\) are expressed in terms of elevation of \(P_{co^2}\) (in mm Hg) from similarly determined controls.

Narcotic analgesics and respiratory parameters.

All the narcotic analgesics investigated with the exceptions of pethidine and pentazocine produced a dose-dependent depression of respiration. Nine of these drugs \((A \text{ to } I \text{ in fig. 1})\) were investigated in an identical manner (cumulative method), and their effects on respiratory minute volume are shown in figure 1. The relationship between log dose and response was almost linear over the range investigated \(20 \text{ to } 80\% \text{ response}\), and all the drugs had a similar log dose-response slope. Etorphine \((J)\) was investigated by the independent method, and although a full account of its respiratory pharmacology will appear elsewhere (Pleuvry and Rees, in preparation), some values have been included here to demonstrate that there is no significant difference between the slopes of log dose-responses when investigated by either method.

Figure 2 shows the log dose-response slopes when changes in respiratory rate are plotted in the same way. It is to be noted that in the case of etorphine \((J)\) doses were investigated which depressed respiratory rate by about 95 per cent. Of four animals investigated at a dose of 8 \(\mu g/\text{kg}\), one animal died.

Of the nine drugs investigated by the cumulative method there was no consistent effect on
EFFECTS OF BARBITURATES AND NARCOTIC ANALGESICS

FIG. 1
The percentage depression of respiratory minute volume produced by various doses of narcotic analgesics in the unanaesthetized rabbit. Limits are ±SE.
Key: A, dihydrocodeine; B, morphine; C, alphaprodine; D, levorphanol; E, methadone; F, dipipanone; G, heroin; H, l-phenadoxone; I, dextromoramide; J, etorphine.

FIG. 2
The percentage depression of respiratory rate produced by various doses of narcotic analgesics in the unanaesthetized rabbit. Limits are ±SE.
Key: A, dihydrocodeine; B, morphine; C, alphaprodine; D, methadone; E, levorphanol; F, dipipanone; G, heroin; H, l-phenadoxone; I, dextromoramide; J, etorphine.
tidal volume. Two drugs produced a slight increase, three a slight decrease and four no change.

Since each drug was investigated in animals for which the response to morphine was known, a potency ratio against morphine was established for each drug by measuring the log dose ratio in each instance. These values are shown in table I.

The effects of pethidine and pentazocine differed from the general pattern characteristic of the other narcotic analgesics. Doses of 4, 8 and 16 mg/kg of pethidine all produced approximately 50 per cent depression of respiratory rate, and convulsions were often observed. Similarly when incremental doses of pentazocine were injected there was no progressive depression of respiration with dose, and convulsions appeared at dose levels which only produced slight depression of minute volume (10 per cent).

With neither of these drugs was there a terminal increase in respiratory depression. Further observations on these results have been published by one of us elsewhere (Hunter, 1968).

Narcotic analgesics and blood Pco₂.

Full accounts of investigations in which morphine, phenazocine, dextromoramide and etorphine were investigated have appeared elsewhere (Rees, 1967, 1968; also Pleuvry and Rees, in preparation). Figure 3 shows the maximum change in blood Pco₂ at various doses of three of these drugs. They all produced a dose-dependent elevation of blood Pco₂, and the log dose-response slopes were parallel.

Barbiturates and respiratory parameters.

The effects of the three barbiturates are shown in figures 4 and 5. It will be seen that the pattern of respiratory depression after barbiturates follows a completely different pattern from that seen after narcotic analgesics.

In the case of respiratory minute volume, there was no progressive change in response with dose. Initially there was a depression which in the case of pentobarbitone (A) and amylobarbitone (B) reached a plateau during which increasing the dose had little effect. At doses approaching the LD₅₀ further increases in dose caused a sudden increase in response. In the case of barbitone (C), the log dose-response slope was very shallow, for doses close to the quoted LD₅₀ (see below) produced only a 40 per cent depression of minute volume.

The corresponding changes in respiratory rate (fig. 5) show no plateaux, but the slopes are not as steep as those produced by the narcotic analgesics.

The quoted intravenous LD₄₀ doses for the three barbiturates in the rabbit are: amylobarbitone 75 mg/kg; pentobarbitone 45 mg/kg; barbitone 350 mg/kg (Barnes and Eltherington, 1964). From our experiments the value is excessive in the case of amylobarbitone. All animals given 75 mg/kg died. The degree of respiratory depression produced by these doses of barbiturates was much less than that produced by high doses of narcotic analgesics—doses which produced no fatalities. It is evident, therefore, that degrees of

<table>
<thead>
<tr>
<th>Drug</th>
<th>Number of experiments</th>
<th>Log dose ratio ± SE</th>
<th>Dose equivalent to 1 mg/kg morphine (mg/kg)</th>
<th>Range (calculated from anti-logarithm of SE range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dihydrocodeine</td>
<td>3</td>
<td>0.467 ± 0.090</td>
<td>2.93</td>
<td>2.38-3.61</td>
</tr>
<tr>
<td>Morphine</td>
<td>23</td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Alphaprodine</td>
<td>4</td>
<td>0.520 ± 0.054</td>
<td>0.302</td>
<td>0.267-0.343</td>
</tr>
<tr>
<td>Methadone</td>
<td>9</td>
<td>0.627 ± 0.067</td>
<td>0.236</td>
<td>0.202-0.276</td>
</tr>
<tr>
<td>Levorphanol</td>
<td>8</td>
<td>0.709 ± 0.048</td>
<td>0.195</td>
<td>0.174-0.218</td>
</tr>
<tr>
<td>Dipipanone</td>
<td>5</td>
<td>1.064 ± 0.095</td>
<td>0.0863</td>
<td>0.070-0.107</td>
</tr>
<tr>
<td>Heroin</td>
<td>8</td>
<td>1.112 ± 0.060</td>
<td>0.0773</td>
<td>0.0673-0.0887</td>
</tr>
<tr>
<td>1-Phenadozone</td>
<td>7</td>
<td>1.126 ± 0.087</td>
<td>0.0748</td>
<td>0.0612-0.0914</td>
</tr>
<tr>
<td>Dextromoramide</td>
<td>4</td>
<td>1.990 ± 0.079</td>
<td>0.0102</td>
<td>0.00853-0.0123</td>
</tr>
</tbody>
</table>

* The dose of morphine to produce 50 per cent depression of respiratory minute volume was 3.02 mg/kg based on 23 experiments.
respiratory depression produced by barbiturates are not tolerated as well as those resulting from administration of narcotic analgesics.

Table II shows the changes in tidal volumes after barbiturates. Unlike those seen after narcotic analgesics, there was a significant increase.

Barbiturates and blood $P_{CO_2}$.

The maximum elevation of blood $P_{CO_2}$ in a group of rabbits given 10 mg/kg pentobarbitone was $+2.6 \pm 1.8$ mm Hg. This dose of pentobarbitone depressed respiratory minute volume by about 40 per cent, and rate by about 60 per cent.

**FIG. 3**
The maximum extent of blood $P_{CO_2}$ elevation produced by various doses of three narcotic analgesics. Limits are ±SE.

Key: A, morphine; B, dextromoramide; C, etorphine.

These readings are selected from Rees (1967) and Pleuvry and Rees (in preparation).

**FIG. 4**
The percentage depression of respiratory minute volume produced by various doses of barbiturates in the unanaesthetized rabbit. Limits are ±SE.

Key: A, pentobarbitone; B, amylobarbitone; C, barbitone.
### Table II

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dose (mg/kg)</th>
<th>Maximum change in tidal volume mean percentage increase and SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pentobarbitone</td>
<td>3.75</td>
<td>34.8 ± 7.64</td>
</tr>
<tr>
<td></td>
<td>7.5</td>
<td>42.2 ± 12.64</td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td>66.7 ± 19.82</td>
</tr>
<tr>
<td></td>
<td>30.0</td>
<td>114.7 ± 17.84</td>
</tr>
<tr>
<td></td>
<td>45.0</td>
<td>49.6 ± 7.48</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>20.8 ± 9.42</td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>42.2 ± 12.79</td>
</tr>
<tr>
<td></td>
<td>20.0</td>
<td>60.1 ± 11.01</td>
</tr>
<tr>
<td></td>
<td>40.0</td>
<td>119.8 ± 16.44</td>
</tr>
<tr>
<td></td>
<td>60.0</td>
<td>107.0 ± 20.22</td>
</tr>
<tr>
<td>Amylobarbitone</td>
<td>25.0</td>
<td>8.2 ± 12.72</td>
</tr>
<tr>
<td></td>
<td>50.0</td>
<td>53.2 ± 6.85</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
<td>63.2 ± 8.52</td>
</tr>
<tr>
<td></td>
<td>200.0</td>
<td>102.0 ± 8.52</td>
</tr>
<tr>
<td></td>
<td>300.0</td>
<td>92.0 ± 8.60</td>
</tr>
<tr>
<td>Barbitone</td>
<td>25.0</td>
<td>8.2 ± 12.72</td>
</tr>
<tr>
<td></td>
<td>50.0</td>
<td>53.2 ± 6.85</td>
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<tr>
<td></td>
<td>100.0</td>
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<tr>
<td></td>
<td>300.0</td>
<td>92.0 ± 8.60</td>
</tr>
</tbody>
</table>

The dose of morphine necessary to depress minute volume to this extent was about 2.3 mg/kg, a dose which elevated blood Pco₂ by about 20 mm Hg.

When doses of pentobarbitone in excess of 10 mg/kg were investigated, a systematic investigation of blood Pco₂ became impossible. These doses of pentobarbitone produced a markedly reduced peripheral blood flow and venous stagnation, and blood sampling could not be performed routinely. At a dose of 45 mg/kg pentobarbitone—the quoted LD₅₀—it was possible to obtain blood in only a few instances. Two animals which survived this dose showed maximum Pco₂ elevations of 5 and 17 mm Hg, whilst two animals which died showed Pco₂ elevations immediately prior to death of only 12 mm Hg (12 minutes) and 11 mm Hg (2 minutes). (The figures in brackets refer to the time after injection when death occurred.)

In many instances changes in standard bicarbonate were more prominent than those of Pco₂. The mean fall in standard bicarbonate after 10 mg/kg pentobarbitone 30, 60 and 120 minutes after injection was —1.0, —2.4, and —2.2 m.equiv/l. In one animal the value fell by 6 m.equiv/l 3 hours after injection, at which time there was no change in Pco₂. These changes are consistent with the production of lactic acid as a result of hypoxia.

**DISCUSSION**

The results demonstrate unequivocally that the pattern of respiratory depression produced by narcotic analgesics differs markedly from that produced by barbiturates. These differences may be summarized thus:

1. The relationship between log dose and depression of minute volume and rate is linear over a wide range of doses in the case of the narcotic analgesics, whilst with barbiturates there...
is a distinct plateau respiratory minute volume relationship.

(2) The log dose-respiratory rate slope for barbiturates is much less steep than that seen after narcotic analgesics. A severe depression of respiratory rate of about 95% prolonged for a period of about a quarter of an hour was tolerated when it was produced by a narcotic analgesic, but not when produced by a barbiturate. A dose of pentobarbitone of 45 mg/kg which depressed rate by a mean of 76% produced a fatality, whereas a dose of etorphine which produced a similar degree of depression could be increased eightfold before a fatality was observed.

(3) After injection of narcotic analgesics there was a parallel between changes in respiratory minute volume and those of "arterialized" venous blood $P_cO_2$. In the case of the barbiturates no such parallelism existed and fatalities were observed with $P_cO_2$ elevations which were relatively insignificant. The response to narcotic analgesics deserves little comment since nine different drugs, from different chemical groups, produced a similar pattern of a dose-dependent depression of respiration, and there is little doubt that death is due to this. The two exceptions, pethidine and pentazocine, were predictable. It is well known that the net effect of a narcotic analgesic on the central nervous system depends both on the drug and on the species in which it is investigated. Pethidine and the derivatives of codeine are more likely to produce stimulation (manifested by convulsions) than are morphine or methadone. This explains the lack of correlation between dose and respiratory depression in the case of pethidine.

The narcotic antagonists depress respiration and produce analgesia in man. It has recently been reported that pentazocine will depress respiration by the same extent as equi-analgesic doses of other narcotic analgesics (Dyrberg, Henningsen and Johanssen, 1968). This is quite a different pattern from that produced in the experimental animal. We have observed that 5 mg/kg intravenous nalorphine injected alone into the rabbit will have no effect on respiration, yet this dose is sufficient to abolish completely the respiratory depressant effect of 4.8 mg/kg morphine when injected simultaneously (unpublished results).

Substantially the same phenomenon is now reported for pentazocine.

The differences between the results obtained with pethidine and pentazocine, when compared with those observed for the other nine narcotic analgesics, do not detract from the fact that respiratory depression produced by narcotic analgesics differs substantially from that produced by barbiturates. The importance of our results is that these two groups of respiratory depressant drugs differ, so it is unlikely that the unusual pattern produced by barbiturates is a response peculiar to the rabbit treated with any respiratory depressant drug.

This unusual pattern of respiratory depression after barbiturates is of interest. The results show that depression of minute volume does occur, for the plateau recorded in figure 4 represents appreciable depression. The questions which arise from this relate to the three differences outlined above, and especially to the relative intolerance of the animals to the consequences of barbiturate-induced respiratory depression.

Several explanations of the situation are possible. The first of these is that barbiturate narcosis is accompanied by hypothermia. This would lead to reduced carbon dioxide production and a lowered respiratory minute volume would suffice for the elimination of the smaller amount of carbon dioxide produced. This is an unsatisfactory explanation of the observed anomalies for several reasons. Barbiturates can depress body temperature in the small laboratory animal (Sollman, 1957), though our own observations would suggest that in the rabbit body temperature is not depressed by more than 0.4°C. Hypothermia and depressed metabolism would be more likely to protect the animal from the lethal effects of severe respiratory depression rather than aggravate them, and also there would be inadequate time for body temperature to fall appreciably in the short time before death occurs.

An alternative explanation may be advanced in terms of concurrent cardiovascular depression, a complication which frequently occurs in man. The fact that severely depressed animals can be revived by artificial ventilation would indicate that cardiovascular depression cannot be the direct cause of death. But the hypotension could have several indirect consequences.
The lowered cardiac output combined with the shallow respiration could lead to ventilation perfusion anomalies in the lung which exaggerate the normal shunting from the venous to the arterial side with the result that quite appreciable arterial hypoxia develops. Cardiac arrest secondary to this hypoxia could occur, but it is our experience that heartbeat continues for some minutes after respiration has ceased, an observation which is similar to that of Gruber (1937) who investigated thiobarbiturates. There would, however, be profound tissue hypoxia, indicated by the fall in standard bicarbonate and this could certainly contribute to the lethal effect of high doses of barbiturates, although the extent of bicarbonate fall noted in our experiments in no case indicated a really serious metabolic acidosis.

It is known that of the principal respiratory control mechanisms, the peripheral chemoreceptors, which are sensitive to hypoxia, are those least affected by the barbiturates (Goodman and Gilman, 1965). The ensuing stimulation of the medullary respiratory centre would tend to flatten the log dose-response slope, which could also contribute to the plateau.

Whilst an explanation of the differences between narcotics and barbiturates in terms of concurrent circulatory disorders would seem more reasonable, especially since the narcotic analgesics cause few circulatory effects, we consider that such an explanation is unconvincing. Further work is at present in progress in which the activity of the respiratory centre is being examined more closely.

The treatment of barbiturate overdosage, which is at present so successful, involves artificial respiration and, when necessary, correction of the hypotension and forced diuresis. The important implication of our findings is that the measurement of the respiratory parameters and blood $PCO_2$ may be of little use as a guide to the condition of the patient, or as an indication as to whether artificial ventilation is or is not necessary.

ACKNOWLEDGEMENTS


LES EIFFETS DEPRESSEURS SUR LA RESPIRATION DES BARBITURIQUES ET DES ANALGESIQUES NARCOTISANTS SUR LE LAPIN NON ANESTHESIE

SOMMAIRE

Les effets de dix analogiques narcotiques et trois barbituriques ont été examinés par la fréquence respiratoire, le volume respiratoire minute et le $PCO_2$, sanguin chez le lapin non anesthésié. Les deux groupes de médicaments produi- sens une dépression respiratoire et alors que le genre de dépression était analogue pour les médicaments d’un même groupe il y avait trois différences importantes dans le genre de dépression produit par chaque groupe de médicaments: (1) Dans le cas des analogiques narcotiques le rapport entre la dose et la dépression du volume respiratoire minute était rapide et restait linéaire la plupart du temps, alors que pour les barbituriques on notait un plateau distinct pour ce rapport. (2) La réponse à la dose utilisée pour déprimer la respiration était linéaire dans les deux groupes, mais celle produite par les analogiques narcotiques était plus rapide que celle produite par les barbituriques. Les lapins tolérent une dépression sévère de la fréquence respiratoire produite par les analogiques narcotiques, alors que des morts survinrent avec les barbituriques par des doses qui produisaient des dépressions beaucoup moins accentuées. (3) Les analogiques narcotiques produisirent une élévation de la $PCO_2$, dépendante de la dose avec des variations parallèles du volume respiratoire minute. Les barbituriques produisirent une faible élévation de la $PCO_2$, et des morts survinrent avec des $PCO_2$, augmentées d’une façon insignifiante. Les problèmes soulevés par ces résultats sont discutés.

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Zehn narkotische Analgetika und drei Barbiturate sind hinsichtlich ihrer Wirkungen auf Atemfrequenz, Atemminutenvolumen und CO₂-Spannung im Blut geprüft worden. Beide Arzneimittelgruppen riefen eine respiratorische Depression hervor; während der Depressionsart für Substanzen der gleichen Gruppe ähnlich war, zeichneten sich im Depressionsmuster von Barbituraten und narkotischen Analgetika drei Hauptunterschiede ab. (1) Bei den narkotischen Analgetika war das Verhältnis zwischen der jeweils verabreichten Testdosis und der Verminderung des Atemminutenvolumens über einen weiten Dosierungs- bereich ziemlich steil und linear, während es bei den Barbituraten zu einer deutlichen Plateaubildung kam. (2) Die auf die Testdosis erfolgende reaktive Herabsetzung der Atemfrequenz war für beide Wirkstoffsgruppen linear, aber die durch die narkotischen Analgetika hervorgerufene Reaktion (skurve) war steeper als die der Barbiturate. Kaninchen tolerierten eine sehr starke Herabsetzung der Atemfrequenz, wenn diese durch ein narkotisches Analgetikum ausgelöst wurde, während Todesfälle nach Barbituratdosendosen auftraten, die eine weit geringere Depression der Atemfrequenz hervorriefen. (3) Narkotische Analgetika bewirkten eine dosisabhängige Erhöhung der CO₂-Spannung im Blut, die mit den Veränderungen des Atemminutenvolumens parallel lief. Barbiturate produzierten nur eine geringe Erhöhung, aber es kam schon bei relativ unbedeutenden Erhöhungen der CO₂-Spannung zu Todesfällen. Die möglichen Folgerungen dieser Befunde werden diskutiert.

BOOK REVIEW


The aim of this book is not only to cover the syllabus for the examination in anaesthesia for Membership of the Institute of Operating Theatre Technicians but also to provide additional information for the technician who is already qualified. The contents are divided into eight chapters and seven appendices. The titles of the chapters are: "The role of the technician when he is assisting the anaesthetist"; "Anaesthetic apparatus"; "Measuring and monitoring equipment"; "Automatic ventilators and explosions"; "Pharmacology"; "Principles of anaesthesia, general and local"; "Resuscitation and intravenous therapy"; and "Sterilization and care of apparatus". The text is illustrated with 99 figures which enhance the description of apparatus and principles.

It is obviously extremely difficult in a manual intended for operating theatre technicians to decide what anatomical and physiological considerations should be incorporated. However, since they are so intimately concerned with the principles and practice of anaesthesia, it is perhaps unfortunate that they are not described in greater detail. This is particularly true of the respiratory system, isolated details of which are scattered throughout the text so that a fundamental understanding of the problems of pulmonary ventilation may be difficult to grasp.

Due to the selection of titles of the chapters, there is some reduplication of material. Thus intubation is described in similar detail both in the first and sixth chapters. This may have been intentional so as to emphasize the important role that the technician plays in this manoeuvre. Little mention is made of the British Standards Specifications which now influence so many types of anaesthetic equipment.

The appendices contain some useful data on lengths and sizes of endotracheal tubes and a list of drugs with approved and trade names. Perhaps a glossary of scientific terms might usefully have been added.

Undoubtedly the authors have produced an eminently readable book that should be in the possession of every operating theatre technician. It will be particularly appropriate in those localities where there is no properly organized course for the Diploma of the Institute of Operating Theatre Technicians.

Gordon H. Bush