SOME RESPIRATORY EFFECTS OF A MODIFIED KNEE-ELBOW POSITION DURING ANAESTHESIA

BY

L. V. H. MARTIN

SUMMARY

A modified knee-elbow position which facilitates the repair of vesico-vaginal fistulae is described. Some respiratory effects consequent on the assumption of this position were investigated. In twenty-seven conscious male subjects the vital capacity was reduced by an average of 16.3 per cent on assuming the position. In twelve patients under light anaesthesia with halothane there was no difference in mean values for respiratory rate, minute volume, arterial carbon dioxide tension and oxygen saturation obtained in the modified knee-elbow and in the supine position. It is concluded that the use of this position in patients with healthy lungs does not increase the hazards of the operation if respiratory muscle function is not impaired by deep anaesthesia or the injudicious use of muscle relaxants.

In underdeveloped countries where obstetric services are inadequate, vesico-vaginal fistulae still commonly occur. At University College Hospital, Ibadan, Nigeria, approximately 150 new cases are seen each year in the Department of Obstetrics and Gynaecology. Vesico-vaginal fistulae can be classified according to the site of the fistula and placed in four categories, viz. juxta-cervical, mid-vaginal, juxta-urethral, and massive, which is a combination of all three. Surgical repair of juxta-cervical fistulae can be carried out in the lithotomy position but it is found that visualization and access in the remaining three categories are greatly improved by the adoption of the knee-elbow position. A modification of this position suitable for anaesthetized patients has, therefore, been developed and has been in use in Ibadan for many years (Lawson, 1967).

This modified knee-elbow position is shown in figure 1. The patient is placed prone on the operating table which has a 20° head-down tilt. A pillow is placed under the chest and a cotton-wool pad supports the symphisis pubis. The abdomen is thereby raised from the table and abdominal respiratory excursion permitted. The patient's legs hang over the end of the table and are supported in stirrups suspended from lithotomy poles. The flexed thighs rest against the table and prevent the patient from sliding down it.

From the point of view of the anaesthetist, this position would appear to present difficulties. It has long been realized that posture can affect respiratory function and it has been generally assumed that, under anaesthesia, many of the commonly used operative positions produce deleterious effects on respiration and circulation. The Trendelenburg position has been condemned on these grounds by Inglis and Brooke (1956) and Swain (1960). Slocum, Hoeftlich and Allen (1947) have described a number of cases of respiratory and circulatory failure associated with various extreme postures.
A study of some of the respiratory effects of the modified knee-elbow position, therefore, seemed indicated.

METHOD
In the first part of this study the vital capacity of a number of young, fit, male, Nigerian medical students was measured, using the McKesson "Vitalor", in the standing position. Three measurements were made at minute intervals and only those students who produced consistent results were accepted. There were twenty-seven such students and they were then placed on the operating table in the modified knee-elbow position and, after a period of 3 minutes, the vital capacity measurements were repeated.

In the second part of the investigation, twelve Nigerian women admitted for repair of vesico-vaginal fistulae were studied. They were aged between 19 and 35 years and showed no clinical or radiological evidence of cardiorespiratory disease. They received premedication of atropine 0.6 mg together with either papaveretum 10–20 mg or pethidine 50–100 mg given intramuscularly 1–1½ hours pre-operatively. Immediately before induction the arterial carbon dioxide tension was estimated according to the rebreathing method of Campbell and Howell (1960), estimations being carried out using saturated sodium hydroxide as the absorbing fluid, as recommended by Bray and Burtles (1961). An arterial blood sample was taken and oxygen saturation was determined using a Brinkman haemoreflector.

Anaesthesia was induced using thiopentone 250–300 mg and intubation was accomplished with the aid of suxamethonium 40 mg, anaesthesia being continued with nitrous oxide 4 L/min and oxygen 3 L/min administered through a Boyle Mark II circle absorber. Paralysis was maintained with further increments of suxamethonium. The patient was positioned and the operation commenced with infiltration of the fistula site and neighbouring vagina and bladder with not more than 50 ml of a 1:100,000 solution of adrenaline. Twenty minutes after the infiltration of adrenaline, 1.5 per cent halothane was introduced from a Fluotec vaporizer placed outside the circuit and muscle tone was allowed to recover. The patient thereafter breathed spontaneously for the remainder of the procedure.

Blood loss during the operation was estimated gravimetrically and was usually 100–200 ml, although one patient lost 500 ml. This patient and two others received an intravenous infusion of dextrose/saline. There was no evidence of hypovolaemia in any patient.

At the end of the operation the patient was left in situ. The expiratory minute volume was measured with a Wright respirometer placed in the circuit between the endotracheal tube and the expiratory valve and the respiratory rate counted over a period of a minute. This was repeated at 3-minute intervals until a steady state was reached. At this stage the patient had been breathing 1.5 per cent halothane for at least 20 minutes. The average of the last three readings was taken and recorded as the prone minute volume and respiratory rate. Arterial carbon dioxide tension was then measured by the rebreathing method and an arterial sample taken for estimation of oxygen saturation. The patient was then placed in the supine position and the above procedure repeated. A steady state was reached in 10–15 minutes, and the recordings were then made. The same Wright respirometer was used for all measurements in the series, but previous calibration was not carried out.

RESULTS
It was found that placing the twenty-seven conscious male subjects in the knee-elbow position reduced the vital capacity by a mean of 16.3 per cent (table I). However, the observations made on the twelve anaesthetized patients show that there was no significant difference between the parameters measured in the knee-elbow and in the supine positions (table II). In both positions there was some degree of respiratory depression, as shown by the raised arterial carbon dioxide tension and low minute volume and there was a moderate degree of tachypnoea. There was no evidence of undersaturation in any specimen, all values for oxygen saturation falling within the range 96–99 per cent. These findings are to be expected in

<table>
<thead>
<tr>
<th>Table I</th>
<th>Vital capacity of twenty-seven male Nigerian students.</th>
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<tbody>
<tr>
<td>Standing:</td>
<td>Mean of 27 mean readings</td>
</tr>
<tr>
<td>Knee-elbow:</td>
<td>Mean of 27 mean readings</td>
</tr>
<tr>
<td>Reduction on assuming knee-elbow position</td>
<td>16.3 %</td>
</tr>
</tbody>
</table>
**TABLE II**

**Mean values for respiratory rate, minute volume and arterial carbon dioxide tension.**

<table>
<thead>
<tr>
<th>Position</th>
<th>Respiratory rate (b.p.m.)</th>
<th>Minute volume (l./min)</th>
<th>Arterial CO₂ tension (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supine, conscious</td>
<td>—</td>
<td>—</td>
<td>41.28 ± 0.89 (3.10)</td>
</tr>
<tr>
<td>Knee-elbow, anaesthetized</td>
<td>27.1 ± 1.7 (6.1)</td>
<td>4.68 ± 0.94 (1.23)</td>
<td>52.66 ± 1.02 (3.61)</td>
</tr>
<tr>
<td>Supine, anaesthetized</td>
<td>26.0 ± 1.8 (6.2)</td>
<td>4.29 ± 0.93 (1.02)</td>
<td>52.24 ± 0.93 (3.21)</td>
</tr>
</tbody>
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Values are expressed as the mean ± standard error of the mean with standard deviation in parentheses. There was no significant difference between the mean values for minute volume for the knee-elbow and supine position ($t = 1.05; P > 0.05$).

DISCUSSION

In 1919 Haldane, Meakins and Priestley showed that when the supine position was assumed a slowing and deepening of respiration followed and that, if this deepening was prevented, hypoxaemia, as indicated by the occurrence of periodic breathing, was produced. Since that time various aspects of respiratory function have been studied by a number of workers. In 1939 McMichael and McGibbon measured various lung volumes and capacities in twenty-five patients in the sitting and supine positions, and they found a decrease in total lung capacity of 5.5 per cent and in vital capacity of 4.4 per cent on assuming the latter position. This was largely produced by a diminution of 23.3 per cent in the functional residual capacity. Altschule and Zamcheck (1942) published a study of the Trendelenburg position in six patients and reported similar findings. Vital capacity was further reduced in assuming this position, being 4.6 per cent less than the supine position, and the functional residual capacity was reduced by 17 per cent; they also noted an increase in inspiratory reserve volume of about 2.9 per cent.

Case and Stiles (1946), Stephen (1948) and Sokalchuk and associates (1949) all measured vital capacity in conscious subjects in the commonly used operative positions. Although there was a wide variation in the readings obtained for the same position between the three series, which is probably accounted for by variations in the exact positioning of the patients, a general trend emerged. Vital capacity was found to be highest in the sitting and reverse Trendelenburg positions and lowest in the kidney and gall-bladder positions in which rests were used, the reduction being in the region of 12-15 per cent from the sitting value. Case and Stiles also noted a 14.5 per cent reduction in patients in the Trendelenburg position and an 18 per cent fall in the lithotomy position as compared with 9.6 per cent and 8.3 per cent respectively in the series of Sokalchuk and associates. The reduction of 16.3 per cent in vital capacity of students in the knee-elbow position shown in the present investigation is broadly in accord with these earlier results.

From the studies of lung volume referred to it has been concluded that positions in which the movement of the ribs is limited, or in which the diaphragm is elevated by the weight of the abdominal viscera lead to a decrease in vital capacity and a diminution in total lung capacity, largely brought about by a reduction in the functional residual capacity. However, the effect of these changes on lung function is not clearly defined. The results reported by Altschule and Zamcheck (1942) showed no evidence of a consistent change in respiratory rate, tidal volume or minute volume in patients in the Trendelenburg position. Sokalchuk and his colleagues also measured the respiratory rate, tidal volume, minute volume and oxygen consumption of patients in the various positions. They found only slight variations in respiratory rate. Tidal volume was high in the Trendelenburg and lithotomy positions. Minute volume was highest in the lithotomy position. Oxygen consumption was lowest in the reverse...
Trendelenburg and highest in lithotomy. It was also noticed that the extreme positions were associated with a subjective feeling of discomfort in breathing.

Measurements during anaesthesia are infrequent. Jones and Jacoby (1954) measured the tidal volume in an unspecified number of patients and showed falls of 11 per cent and 14 per cent when the prone position was assumed, with and without support, and a fall of 24 per cent when the gall bladder rest was elevated. However, these patients were partially curarized. Henschel and associates (1957) measured minute volume and tidal volume in two subjects anaesthetized with nitrous oxide and oxygen plus a thiopentone drip. A 5 per cent fall in minute volume and a 22 per cent fall in tidal volume followed the adoption of the lithotomy position and 39 per cent and 45 per cent falls followed the use of the kidney position with a rest. Wood-Smith, Horne and Nunn (1961) investigated the effect of posture on ventilation of twenty patients anaesthetized with halothane and found that the kidney, prone jack-knife and Trendelenburg positions each caused 14–24 per cent reductions in ventilation. Lateral, reverse Trendelenburg and gall bladder positions caused 6–10 per cent reductions but lithotomy and prone positions caused no significant changes. These measurements were made for short periods of 1–2 minutes only. Scott, Lees and Taylor (1966) measured respiratory rates, minute volume, arterial blood-gas tensions and pH in six patients under nitrous oxide, oxygen and halothane anaesthesia and could detect no significant difference between the results obtained in the supine and Trendelenburg positions. The results of the investigation reported here are in agreement with those of Scott, Lees and Taylor.

It appears that although the knee-elbow position does place the respiratory muscles at a disadvantage, they are still able to maintain adequate ventilation even when the patient is anaesthetized to moderate depth. Operating in this position, which greatly improves surgical access to difficult vesicovaginal fistulae, does not increase the anaesthetic hazards of the procedure. However, it is appreciated that impairment of function of the respiratory muscles by deep anaesthesia or the use of muscle relaxants would create a different situation, as would diseases producing a marked diminution in lung volume. The former case could be dealt with by means of assisted or controlled ventilation and, in the latter case, careful assessment of lung function would be necessary before deciding whether to use this posture.

The cardiovascular changes associated with this position have not been investigated but in no case did the condition of the patient give rise to any anxiety in this respect.

ACKNOWLEDGEMENTS

I wish to thank the members of the Department of Obstetrics and Gynaecology, University College Hospital, Ibadan, for permission to study the patients admitted under their care, and Professor J. B. Lawson for help and encouragement in the preparation of this paper.

REFERENCES


**QUELQUES EFFETS RESPIRATOIRES D'UNE POSITION GENOU-COUDE MODIFIÉE AU COURS DE L'ANESTHESIE**

**SOMMAIRE**

L'auteur décrit une modification de la position genou-coude, qui facilite la chirurgie réparatrice des fistules vésico-vaginales. Quelques effets sur la respiration, consécutifs à la prise de cette position, ont été étudiés. Chez 27 sujets masculins consécutifs, la capacité vitale dans cette position était réduite d'en moyenne 16,3 pour cent. Chez 12 patients sous anesthésie légère à l'halothane, il n'y avait pas de différence entre les taux moyens de la fréquence respiratoire, du volume-minute, de la pression artérielle de gaz carbonique et de la saturation en oxygène, lorsqu'on compare la position genou-coude modifiée et la position couchée. On en conclut que cette position n'augmente pas les risques de l'opération chez les malades avec poumons sains, à condition que la fonction des muscles respiratoires ne soit pas inhibée par une anesthésie profonde ou par l'emploi de relâchants musculaires.

**EINFLÜSSE AUF DIE ATMUNG BEI EINER MODIFIZIERTEN KNEE-ELLBOGENLAGE WÄHREND DER NARKOSE**

**ZUSAMMENFASSUNG**


**CORRESPONDENCE**

**TWO BENZODIAZEPINE DERIVATIVES—CHLORDIAZEPoxide AND DIAZEPAM**

Sir,—It is most heartening to read that Professor Dundee is giving serious attention to the use of Librium (chlordiazepoxide) and Valium (diazepam) for premedication.

However, by giving these drugs intramuscularly he is missing much of their advantage and enormously increasing the cost: 20 mg of Valium is little short of a dose which will induce anaesthesia if given intravenously.

We would like to stress once again the advantages of oral tranquillizers given for at least 24 hours preoperatively, and preferably for longer, and also the avoidance of any further premedication. We feel the avoidance of the opiates is especially beneficial both to the patient and the anaesthetist.

Further it is most important to ensure for the patient a good sleep during the night before operation. With the extended premedication of oral Librium or Valium, Mogadon (nitrazepam) seems a most fitting hypnotic, and in practice is most effective and free from side effects.

We hope the Professor will soon put the oral use of the drugs to the test and publish his results, which we feel sure will be of interest to many as well as ourselves.

J. McN. Inglis
M. E. H. Barrow
Birmingham

**REFERENCE**


**A copy of this letter was forwarded to Professor Dundee, who replied as follows:**

Sir,—I agree entirely with Drs. Inglis and Barrow that it is most important to ensure for a patient a good night's sleep before operation, and admire their work on oral premedicants. Regrettably our facilities for clinical studies at present do not permit an investigation along the lines which he suggests but should the opportunity arise we will certainly be prepared to do so.

Our interest in the drugs given before anaesthesia is mainly concerning their clinical pharmacology rather than their eventual use in clinical practice although this is certainly of importance for us. This was the reason why we tried both doses of diazepam. We would not, however, agree that 20 mg dose is "a little short of the dose which will induce anaesthesia" for in our own hands (Brown and Dundee, 1968) doses more approaching 1 mg/kg were required to induce sleep even in patients given opiate premedication.

JOHN W. DUNDEE
Belfast

**REFERENCE**